

No.157

MILLING • DRILLING • TURNING • GRINDING

MODEL ENGINEERS' WORKSHOP

THE PRACTICAL HOBBY MAGAZINE

NOVEMBER 2009

COVER ARTICLE

FLYCUTTING PROFILES

LEARN HOW

- TO REBUILD A TOM SENIOR MILL
- TO DO DIVIDING IN THE LATHE

HOW TO MAKE

- AN ALTERNATIVE FOUR-JAW CHUCK
- A WOBBLE BROACHING TOOL
- AN EDGE FINDER
- A SIMPLE DIE HOLDER
- MILLING ADAPTORS



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A selection of Flycutting form tools. See article on page 44. Photo by Mick Knights



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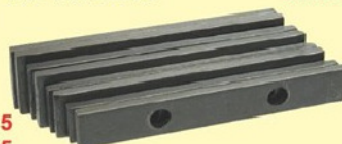
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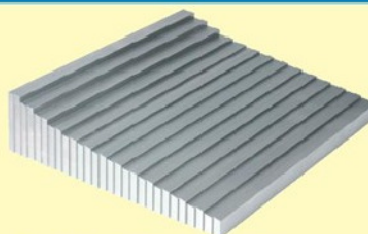


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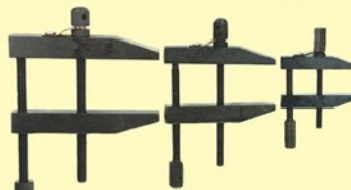
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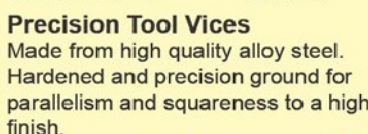
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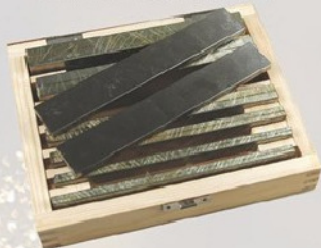
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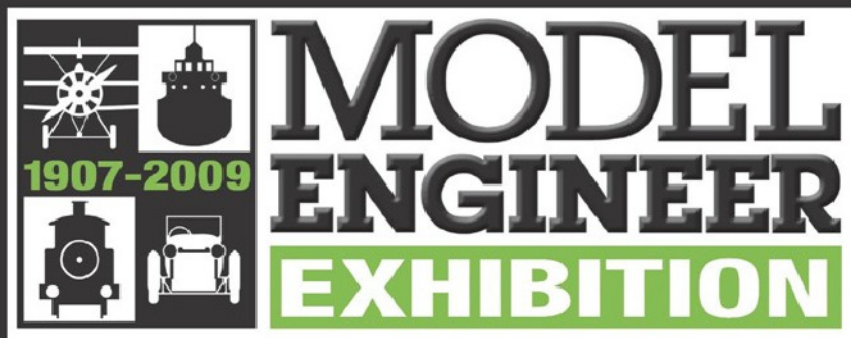


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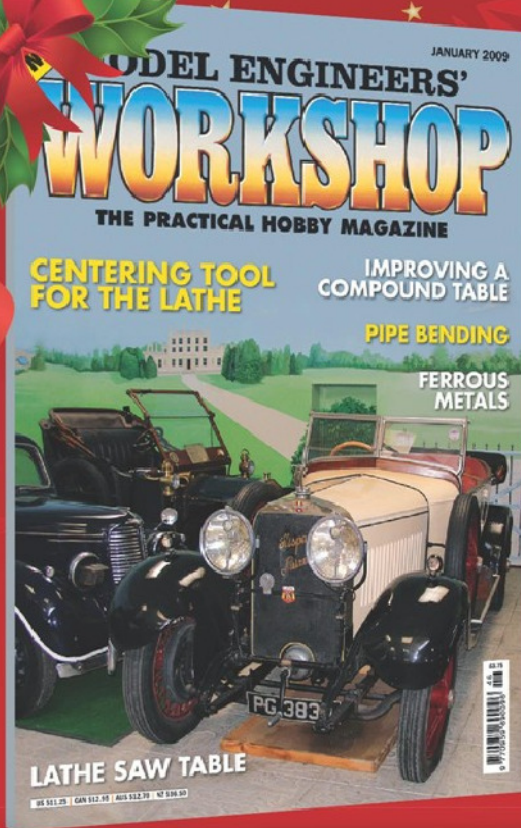
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David Clark

ON THE EDITOR'S BENCH

Cover photo

For this issue, I have selected a cover photo that is related to an article inside the magazine. I hope this will please readers who want the cover to be relevant to what is in the magazine.

Articles wanted

I could do with some more articles for MEW. Although I have many in stock, most of them are shorter articles. I would like a few longer articles or short series. I don't get many articles through the summer but usually receive many through the Autumn, Winter and Spring. Contributors notes are available and we do pay well for articles so please get writing.

Writing three editorials a month is a bit of a challenge. For the first two years I only had MEW to worry about but since last January, I have had Smoke Rings in Model Engineer to do as well. Although this page in MEW is called Ed's Bench, I have not had much chance to go into the workshop this year. I have had two accidents that have stopped me going into the workshop and although I have had the plaster removed from my hand my thumb is still badly swollen although editing is no longer affected.

I have just (early October) plugged in the dehumidifiers to remove excess water from the two workshops. One of the original dehumidifiers has been replaced with a new one as the old one did not cut off when filled with water. Harold Hall has written an article on heating the workshop in this issue which makes interesting reading. Fortunately it does not get very cold in the part of Scotland where I am, I don't need much heating in the workshop. If I moved 40 miles south, it is very cold through the winter and the workshop would be a no go area.

I hope to spend a bit of time in the workshop in the near future. I have just purchased some 6mm plastic handles with steel inserts to make the George Thomas pillar tool. I also purchased a couple of 8mm ball nose cutters to start using the CNC mill again.

I have also cleared out some of the unused items of tooling from the workshop as I need a bit of bench space. The bench was totally covered with tools and equipment I would probably never get round to using.

Practical Engineer

I hope to carry on with the Practical Engineer page soon and various setups to machine castings are planned starting with pillar tool castings mentioned earlier. My methods will be similar to what I would use in a production environment where it is important that each stage of machining is correct before the next operation is started.

Although I have an Oldack tapping machine for tapping threads, it is more for production tapping than small BA taps. For the various sets of steam engine castings I want to build, I think the pillar tool is essential. I also have the castings and materials for George's drilling head and hope to make this at the same time.

The editor's current projects

I am building two Stuart engines, a 10 V (vertical) and a 10 H (horizontal). The machining sequences have been written up in Model Engineer although not for the last couple of issues due to my bad thumb. When these two are finished, I will be building a Stuart Victoria steam engine and will describe the sequence in Model Engineer. The kit is to hand and it looks very interesting. I have a lot of kits (probably about 10) stashed in drawers in the workshop to build and I must refrain from buying any more at the Model Engineer Exhibition in December. I have been quite good this year, the only additions being the Stuart Victoria and an unmachined kit for the Stuart Williamson engine. This is a very interesting engine and it has long been one of my favourites.

Model Engineer and Model Engineers' workshop overseas supply

We have changed distributors (not the subscription company) to Comag who are a worldwide distributor of magazines. Supply to certain countries has increased drastically and I welcome all the new readers who are probably reading Model Engineers' Workshop for the first time having found it on their newsagent's shelves.

If you are in the USA, you can get both Model Engineer and Model Engineers' Workshop by asking in your local Barnes and Noble store. If they don't have it in stock, they will get it for you and they will also stock future issues for you. So, don't delay, order your regular copy at Barnes and Noble today.

Rogue traders

It is difficult for me to mention specifics but I have been contacted by a reader who is having problems with a trader. (The trader no longer advertises with either ME

or MEW.) The trader will not take credit cards, only taking cheques. Several months and several excuses later, the goods still do not arrive. One excuse used more than once is "The parcel slid off the back of the delivery van and the Post Office returned it to us for repacking."

I have mentioned this before but please use a credit card (not a debit card) to pay for items by mail order. You at least have a basic cover from the card company and stand a chance of getting your money back. If the trader will only take cheques, ask at your local club if anyone has been having problems getting their goods. I do realise that not all traders have credit card facilities so at the end of the day you have to make your own decision. If the trader promises you the earth and it sounds too good to be true, it probably is.

Model Engineer Exhibition

I would like to ask all of you who are thinking of entering the Model Engineering Exhibition to send your entry forms in as quick as possible. This is because of the threatened postal strike. The sooner you get the entry in, the less worry it will be for you. You are quite welcome to scan the entry form and email it direct to me to avoid delays in the post. I will acknowledge entry forms as soon as I receive them. If you have not heard within 24 hours, feel free to phone me to see if I have received it, 9am to 9pm 7 days a week. I work from home so if there is no answer, please leave a message on the answer phone. I will phone you back as soon as possible.

Win a Stirling Engine

Model Engineer is running a competition to win a Carl Aero twin Stirling Engine. This is not a kit but is a fully assembled working engine worth £260. Entry forms are in the current issue of Model Engineer. Subscribers can enter online at www.model-engineer.co.uk although I am unsure if all subscribers or just Model Engineer subscribers can take part. It will only take you a couple of minutes for you to find out. Sorry, UK readers only.

Cutting edge competition

Morris Lubricants have agreed to supply a 5 litre tin of Cora B neat cutting oil as a major prize per month for the next 12 magazines. Details of the competition will appear next month. We will also be running a similar competition in Model Engineer for two bottles of MCT Liquid. Each entry will be valid for two issues of Model Engineer. Subscribers can also enter on our website www.model-engineer.co.uk

HOW TO MAKE A FOUR JAW CHUCK ALTERNATIVE ①

Harold Hall looks at a different type of work holder.

In MEW issue 52, page 24, I provided an article which I titled Keats Alternative. This consisted of two fixed square posts bolted to the faceplate against which the round workpiece could be placed. Then a third post having a clamping facility was fitted enabling the workpiece to be firmly clamped, replicating approximately the way a Keats would work, **photo 1**. However, I found it a little difficult to set the work to run true and decided that a four post system would be an improvement as having two fixed posts plus two with clamping facilities it could then first be set central across one pair and then secondly across the other axis.

The system worked well and would certainly be adequate for many applications where a Keats angle plate would be used and it had the major advantage of being able to work with much larger diameters. It did though have one disadvantage and that was as the clamping forces were also acting on to the faceplate this could distort if one was over ambitious with the spanner. I did also propose that all four jaws could have a clamping facility permitting small adjustments to the workpiece position to be easily made being similar to using a four-jaw chuck.

At the time I felt that if the faceplate were replaced by a more substantial item then a device with all the advantages, and more, of a four jaw chuck would result. The plus points being able to:

- 1) Work with larger diameters.
- 2) Fit more or less jaws.
- 3) Fit a mix of jaws and conventional faceplate clamps.
- 4) Have a greater jaw depth.

The result of this is that larger and more complex shapes can be held. Now, over ten years later I have at last got round to trying the idea; **photo 2** shows the result.



Photo 2. The modified design is similar to a conventional four jaw chuck.

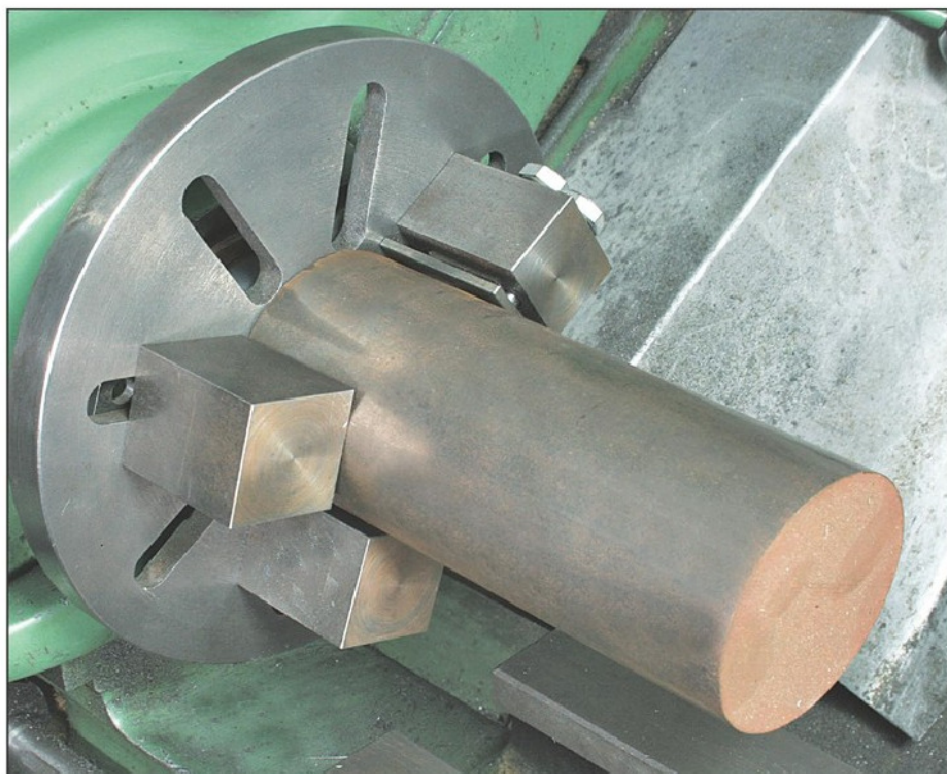


Photo 1. The Keats angle plate was difficult to set up which resulted in the design of this three point alternative.

The drawings I have included suit a Myford series seven or any other similar size machine but in this case changes may have to be made to suit the lathe's mandrel nose. The design though is so simple that it should be easily adaptable for both smaller and larger lathes. Some who may use a four jaw only very occasionally may even make one in place of purchasing a commercial chuck.

The body (1)

This is made from a piece of 150mm diameter cast iron bar which I chose in favour of mild steel as it would be easier, if dirty, to machine the tee slots using my

homemade silver steel tee slot cutter (**Ref. 1**) having done this a number of times previously although I did eventually use a purchased cutter.

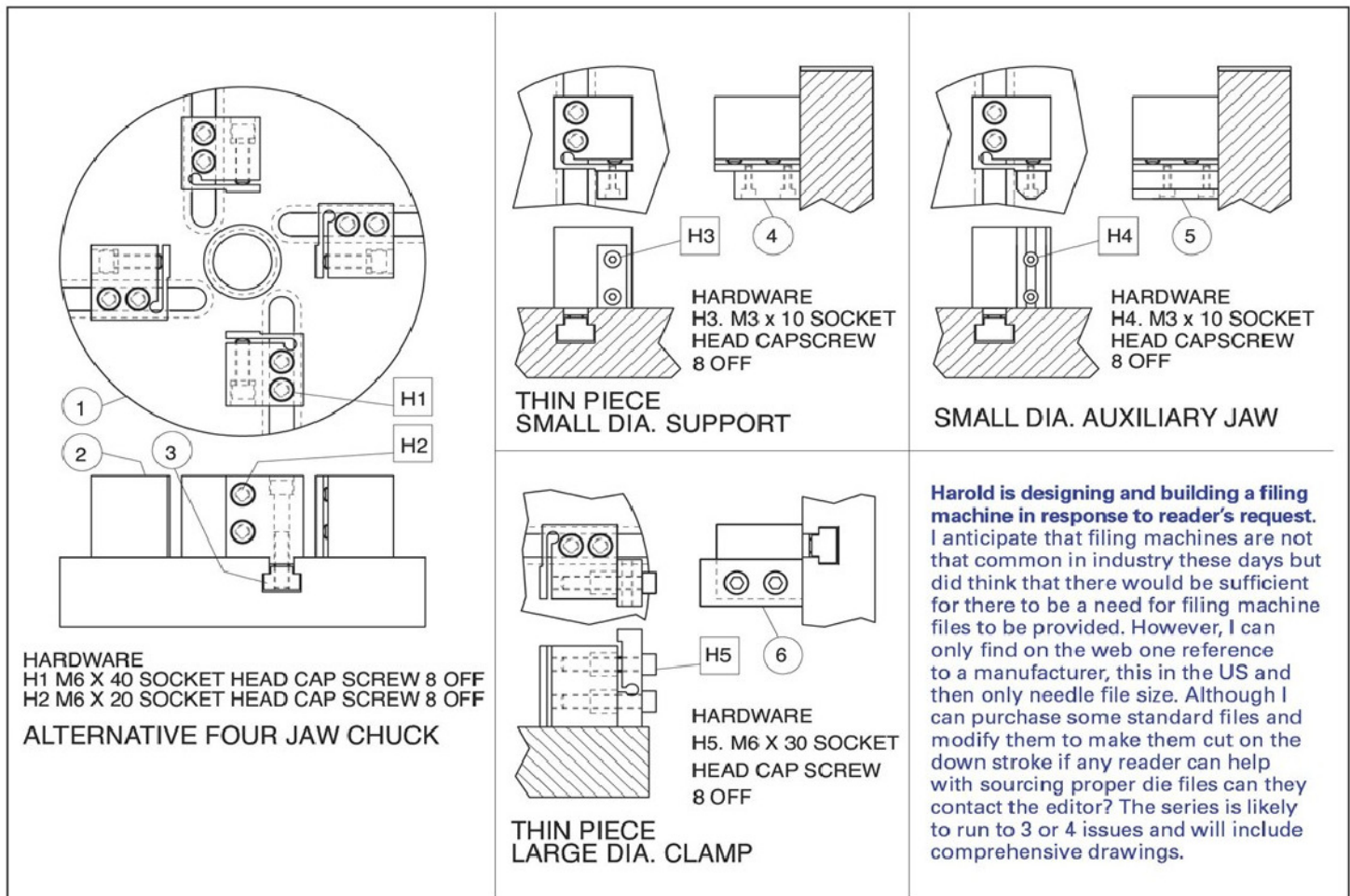
Drill and tap four M6 holes on a 100mm PCD and use these to secure the material to the lathe's existing faceplate, do though check these dimensions against your faceplate before proceeding. Also, ensure that the face is reasonably flat though in the case of a very small error the faceplate itself will distort, not the material with this being much thicker. However, if the error is substantial then machine it flat on the milling machine, though as the material will be sawn from a bar such an error is unlikely. When mounting the material on the faceplate, space it off with thick washers, say 5mm minimum, as this will permit the boring and thread cutting tools to break into the gap, **photo 3**.

Machine what will be the rear of the body and then bore and thread to suit the lathe's spindle nose. It is all but essential that you make a gauge to test the locating diameter and whilst a little less critical a gauge for the thread also would be a good idea. The thread is a little less critical as it needs to be slightly on the large size to ensure that location of the finished body will be on the locating diameter and unaffected by the fit of the thread. If you would like guidance on this operation see my article in MEW issue 155 page 12.

Now remove and fit to the lathe's mandrel and machine the face flat and also skim the outer diameter and lightly



Photo 3. The body in its initial stages of being machined.



chamfer the two outer corners. This completes the turning requirements for the time being. I have given dimensions for the outer diameter and body thickness but there is no need to work to these slavishly; once the surfaces are clean that will suffice.

Before producing the Tee slots a decision has to be made whether to make just the four for the jaws or also to include the additional ones to provide extra facilities for holding the eventual workpiece. The reader will see from the photographs that I have included all eight as once one is set up for making the slots making the four additional ones is a relatively quick operation. My advice therefore is to make the eight slots and will describe the operations on that basis.

Machining the Tee slots

If the reader has a rotary table large enough to use for positioning the slots then this is obviously the way to proceed but as I consider most will not have this facility then another method has to be used. At first, this would seem a rather daunting task with the cutter having to be accurately located and table stops set for each slot individually. However, the method I eventually came up with avoided such a problem and the slots were made very easily, probably as easy as using a rotary table. The secret of its success is in the way the body is mounted onto the machine table enabling it to rotate.

Marking out at 45deg

First, the body must be marked at its edges at 45deg. intervals and rather than explain here how this is achieved I have included the explanation in **Sk.1**, (see

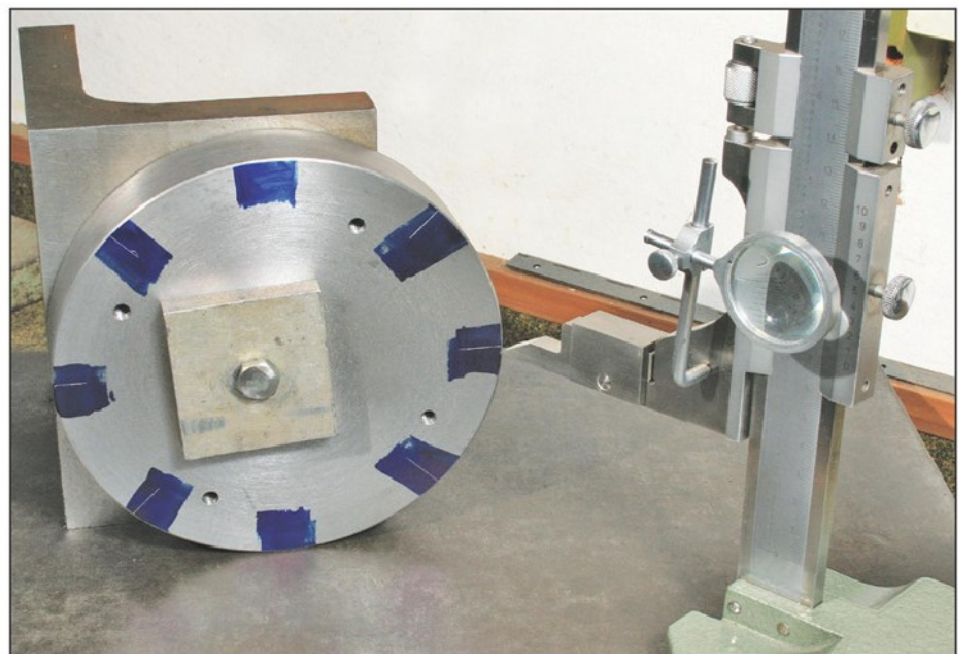


Photo 4. Marking the body out in 45deg. increments.

also **photo 4**). I would just emphasize the importance of placing one of the original fixing holes 16mm above the centre line on the right hand side as this ensures that they are machined out when the slots are eventually made.

Positioning on the table

So that the body can be easily rotated for each individual slot turn a disk a close fit in the parallel bore in the rear of the body

and fasten this to the milling machine table as in the left of **photo 5**. Next, take a length of rectangular bar, say around 300mm long and align one edge with two of the diagonally opposite markings, clamping this to the body using a small workpiece clamp and one of the M6 tapped holes.

Place the body over the disk on the machine's table and line the bar up with the table's axis. A high level of precision is

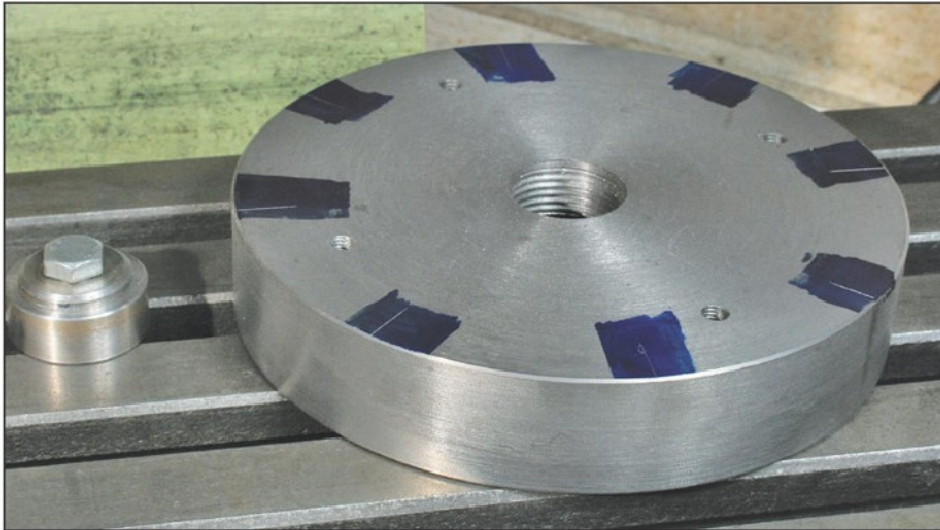


Photo 5. The body is aligned by the disk clamped to the machine table and rotated for individual slots.

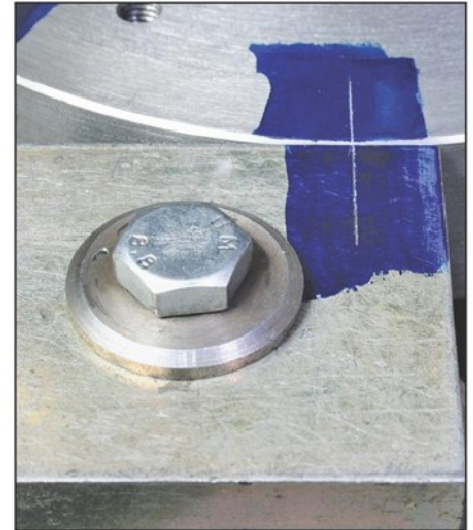


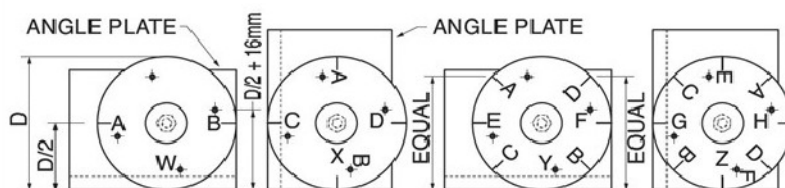
Photo 7. The mark against which the body is aligned for each individual slot.



Photo 6. Positioning the body accurately on the machine table.



Photo 8. Lining up the machine spindle with one of the marks on the body.



- W 1. FIX ONTO AN ANGLE PLATE WITH THE OUTSIDE OF THE BODY LEVEL WITH THE BASE AND ONE SIDE. ALSO ONE OF THE FOUR FIXING HOLES 16MM ABOVE CENTRE HEIGHT ON THE RIGHT HAND SIDE, CHECKING WITH A RULE WILL BE ADEQUATE. SEE DRAWING!
2. SET HEIGHT GAUGE TO HALF THE BODIES MEASURED DIAMETER.
3. SCRIBE LINES A AND B. ENSURE THEY GO COMPLETELY TO THE EDGE OF THE BODY
X TURN ANGLE PLATE ONTO ITS END AND SCRIBE LINES C AND D
Y 1. REPOSITION BODY WITH THE OUTER ENDS OF LINES A AND D AT THE SAME HEIGHT. CHECKING WITH A RULE WILL BE ADEQUATE.
2. SCRIBE LINES E AND F
Z TURN ANGLE PLATE ONTO ITS END AND SCRIBE LINES G AND H

NOTE THE LINE REFERENCES HAVE NO RELEVANCE TO THE ULTIMATE OPERATIONS, THEY ARE ONLY TO ASSIST WITH THIS EXPLANATION

SK1
MARKINGS TO AID THE POSITIONING OF
THE GROOVES IN THE BODY

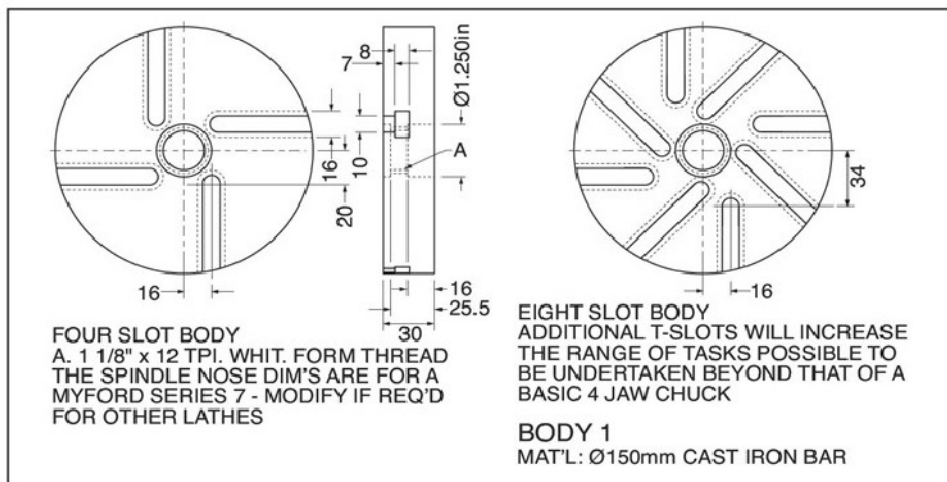
not required so there is no need to use a DTI, using a surface gauge with its locating pins against the front edge of the table and checking both ends of the bar will be perfectly adequate. With that done clamp the body to the table in that position, **photo 6**. Do though fit a second clamp as seen in later examples.

Set up an index position

Take one of your workpiece clamps or some other suitable item and clearly mark it with a line and pack this up on the machine table to the height of the body. Position this so that the line accurately lines up with one of the lines on the body, I would suggest the 4.30 position, see **photo 7**.

Aligning the mill spindle

Set up a needle point centre finder and align this with the body marking in the 9.00 position, **photo 8** ensuring this is done with the table moving towards the rear to take out the backlash in the correct direction. If you are not conversant with the needle point centre finder it is held at the top in a friction held ball joint and



obviously when the mill is started up it is very unlikely that the point will run true. With the mill running a block of metal is held on the machine table and against the needle being advanced very gradually until the point appears stationary. With this done the point is perfectly in line with the machine spindle irrespective of the accuracy of the chuck holding the device. Of course, when the needle point is used to locate the workpiece the machine is not running.

Setting the slot position

Having aligned the needle point with the 9.00 position set the machine dial to zero and move the table 16mm to the rear and lock the table firmly in this position so that the setting is maintained until machining of all the T slots has been completed.

Setting the slot length

Lay a rule on the body aligning the left hand edge with the 12.00 and 6.00 marks, then using a second rule traverse the table until the needle point is 20mm from the rule's edge, as shown in **photo 9** and set the table stop to this point. It may be visible in the photograph that the measurement being set is just 18mm but I decided that the T slot might break into the parallel bore at the back and moved it back 2mm, but this was after I took the photo.

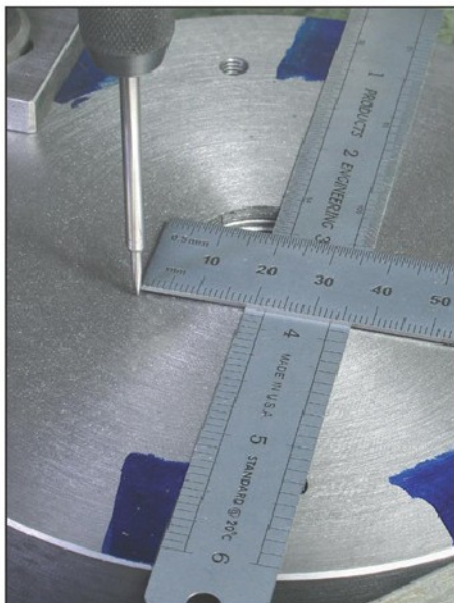


Photo 9. Locating the position for the end of the slot so as to set the table stop.

Machining the long Tee Slots

Fit a 10mm slot drill and machine to a depth of just less than 15mm which of course has to be accomplished in stages. The table stop having been set, this will fix the slots length. Having completed the first slot, loosen the clamps holding the body and rotate by 90deg, that is miss one mark, and then carefully align the two marks, re fasten and make the second slot. Repeat for slots 3 and 4, **photo 10**.

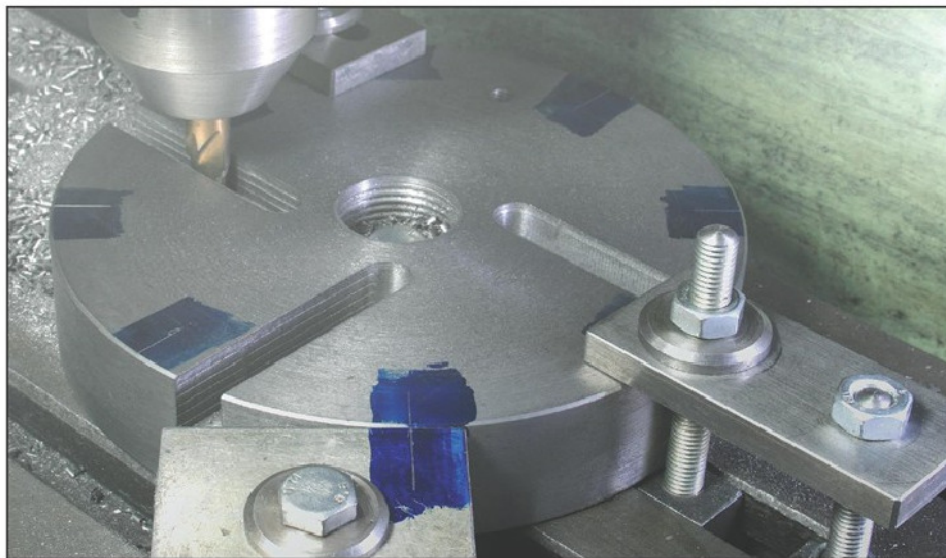


Photo 10. Machining the first stage of the T slot.

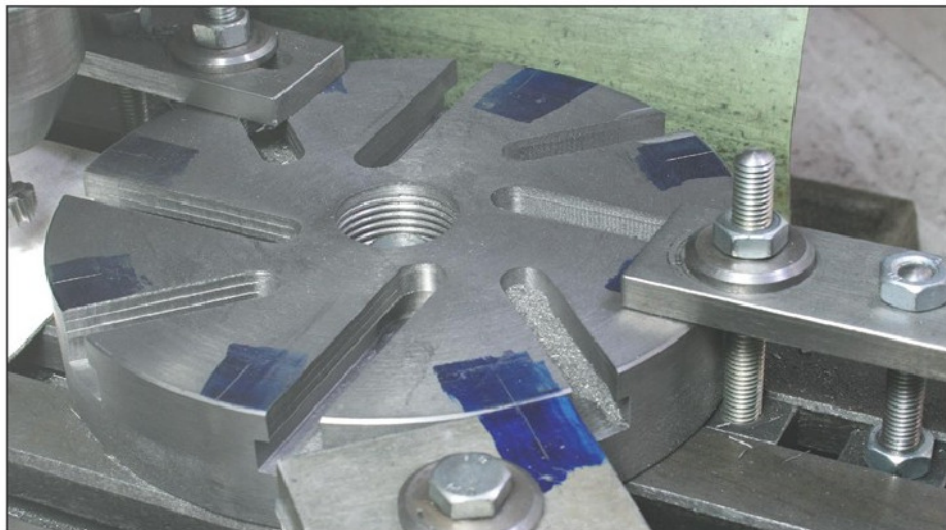


Photo 11. Completing the T slot.

Machining the short Tee Slots

Set the body to one of the intermediate marks and commence to make one of the shorter slots but using a distance piece 14mm long between the table stops to limit the travel. When at the required length remove the distance piece and reset the table stop to this position and with that done make the four shorter slots in the same way as was done for the longer ones.

Finalising the Tee slot

Replace the slot drill with the T slot cutter and commence to make the shorter slots first as the table stop is already set for that length. Having made the shorter slots, move the table stop, again using the 14mm distance piece, and make the four longer slots, **photo 11**.

With that done the body is virtually complete and whilst relatively large it is a simple component to make if using the above sequence. In the next issue we will discuss the other parts and provide a few examples of the device being put to use. [To be continued...](#)

References

Ref. 1. Tee Slot Cutter MEW issue 106 page 20.

A USEFUL ADDITION TO A KENNET TOOL AND CUTTER GRINDER

Ray Henshaw makes his Kennet tool and cutter grinder easier to use.

At long last I finally got around to completing my Kennet tool and cutter grinder recently. Although it is a nice little machine and easy to use I did find it a bit fiddly to set the angle of the work table because the setting scale is tucked away under the table and is out of sight, **photo 1**. Changing the angle means crouching down to look underneath the table whilst adjusting it and also operating the clamp lever at the same time. This is not ideal, especially if you are of mature years! In any case the scale is not all that easy to see because of its position, **photos 2 and 3**. It occurred to me that if the scale could be illuminated and visible whilst I was standing up at the machine life would be a somewhat easier.

A suitable lamp was needed but I couldn't find one small enough around the workshop. The problem was solved when I next went out in the car and realised that I already had the answer on my key ring - one of those tiny push button LED lights which are readily available for less than £1.00 on a well known auction site.

I cut a piece of double sided tape to fit the back of this light and after a few tests to find the best position, stuck it to the underside of the lower worktable. Now a small mirror was needed. I had some plastic mirror tiles and cut a piece about 50mm square. Holding this just off the end of the top table at an angle gave the reflection of the LED illuminated scale. However, it was not really clear because of

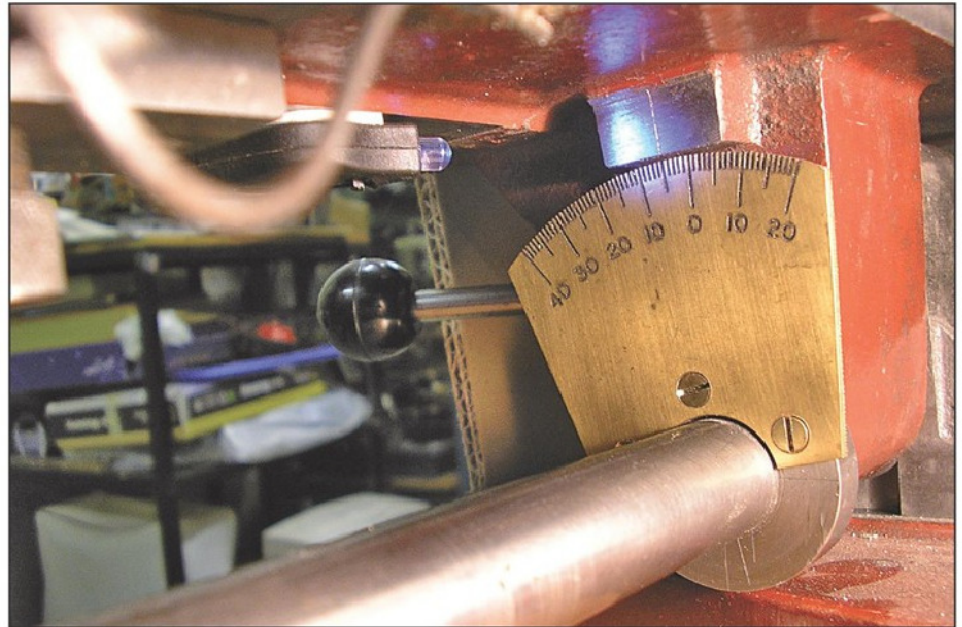


Photo 1. Close up view of setting scale underneath the table.

surface imperfections on the tile. A proper glass mirror was required and was eventually found in the shape of one of my wife's discarded (I hope) old powder compacts. I cut a piece from this, approximately 2.0 x 1.25 inches and smoothed the edges with an oilstone. I had some $\frac{1}{16}$ in. soft iron wire and a small piece of brass shim was soft soldered to a length of it and the shim fixed to the back of the mirror with superglue. The other end of the wire was glued with Araldite to a small circular magnet. This assembly was positioned under the lower table and held in place by the magnet, **photo 4**. When placed so that the mirror was close

to the stop rod holder a nice clear image of the scale was obtained, **photos 5 and 6**, problem solved!

A word of advice here to anyone who decides to make a similar device - make sure that you get the sort of LED light that has a little slide switch that holds the light on; many of those on sale do not have this and only stay on while you keep the switch pressed. This was a quick, cheap, project and well worthwhile since angle setting is now much easier and neither of the attachments gets in the way when using the machine. The mirror assembly is a bit crude but I will make a neater version one of these days. ■

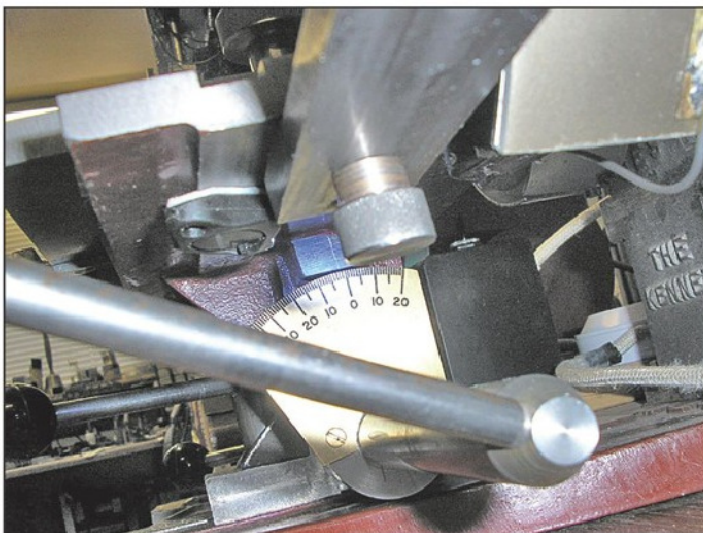


Photo 2. Another under table view.



Photo 3. Close up of view of illuminated scale.



Photo 4. The underside of the table.

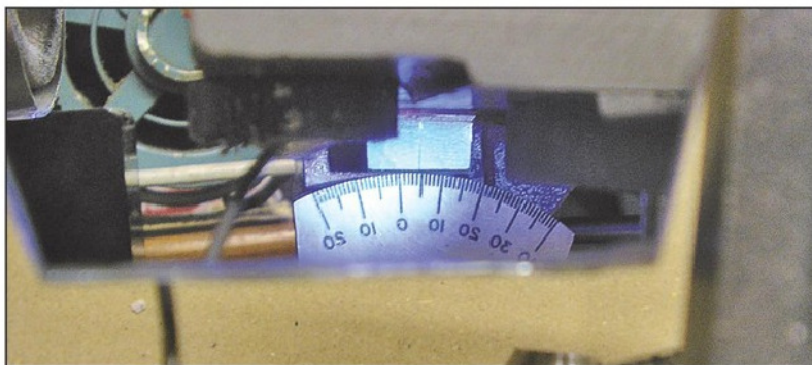


Photo 5. A view of the illuminated scale using the mirror.

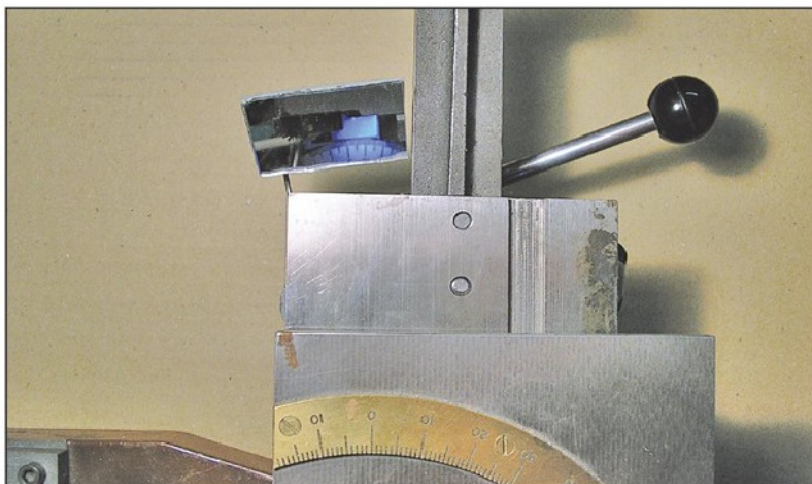


Photo 6. A mirror's eye view of the scale.

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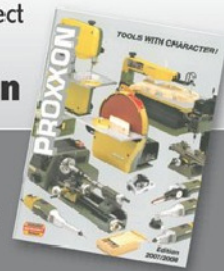
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MAKING A WOBBLE BROACHING HOLDER

Jock Miller throws a wobbly

No this is not an alcoholic yachtsmen's ramble but the description of a very clever tool that has been about for many years.

Many readers will be aware of the frustration in making the odd hexagon cap screw (female) or the square hole in a small locomotive steam valve or regulator handle using a needle file or special punches.

On looking through a USA workshop tooling catalogue recently, a special Wobble Broach tool holder and broaches were noted. It looked as if this could be a challenging exercise in tool making and solve an awkward set of problems. **Photo 1** shows my homemade version.

What is wobble broaching

To understand how it works: - if you imagine a piece of 10mm diameter rod say 100mm high stood vertically on a flat horizontal surface. If you then incline the rod at a small angle (1degree say) from vertical and then move the top of the rod around in a circle without rotation of the actual rod, the bottom squared edge will bite into the flat surface. This is the basic principle of operation. If the end of the rod is hexagon, square, oval etc the indentation of the flat surface mirrors the end profile of the rod.

Components of the tool

The three principal components of the tool holder are:

- 1) A flanged shank.
- 2) A spindle housing.
- 3) A rotation broach holder spindle.
- 4) Special broaches to suit.

Photo 2 shows the completed tool.

Broaches were made from commercial round HSS either $\frac{1}{16}$ in. or 8mm with the larger ones made from damaged HSS end mills, **photo 2**.

The use of a tool and cutter grinder with an indexing tool holder and the ability to carry out limited cylindrical grinding would be required. (No doubt a 'Quorn' or a 'Stent' would suffice.) In the writer's case a facsimile 'Clarkson' tool and cutter grinder was available.

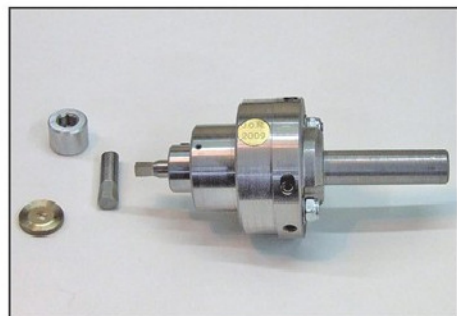


Photo 2. The completed tool.



Photo 1. The tool in its fitted box.

General

Internet information indicated that these tools (commercial) can operate up to 2000 rpm with all sorts of materials and be used in pillar drills, lathes, mills, CNC machines etc with either the job or the tool rotating.

Opening out the pilot hole to A/F size plus 0.05mm eases the work of the broach. It is best to keep the depths of profile up to A/F dimension as a maximum. It was noted that if the hole profile is too deep the form can slightly spiral. Detailed geometric analysis will confirm this but is beyond the writer.

Machining is fairly straightforward and comprises the following:

- The flanged shank
- The flange face after turning is milled or ground 1degree off square in the plane of the M6 clamping studs/nuts.

- The spindle housing requires accurate turning to fit the ball races (push fit).

The spindle

This requires careful turning to fit the ball races (push fits) and must be bored true to $\frac{1}{16}$ in. or 8mm dia to fit (light push fit) for the broaches. The spindle is tapped M6 for an adjusting stop screw to axially locate the broach for the desired 16mm broach protrusion beyond the front face.

Broaches

The smaller size of hex or Square broaches were ground from commercial $\frac{1}{16}$ in. or 8mm dia. HSS round tool steel. The larger were first ground to shank size and then profiled for hex or square all exactly 32 mm long (if all are the same length it is easy to set up for different sizes). The side faces of the profile need to have 2degree side relief (net 1degree



Photo 3. Broaches made from HSS.

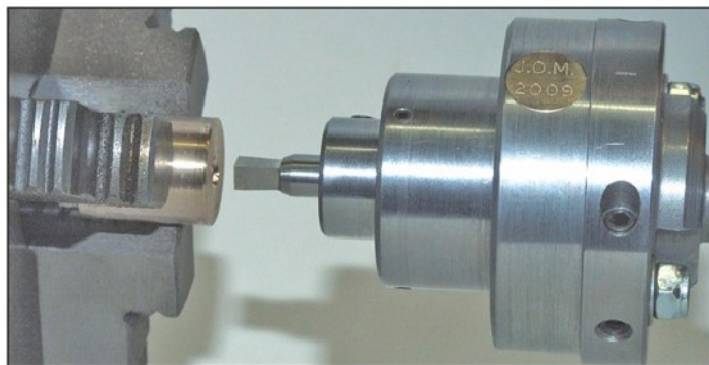


Photo 4. The tool set up ready to use.

clearance in operation) and the across flats dimension should perhaps be plus 0.03 mm oversize for subsequent sharpening.

Setting up

Once all the components are assembled (greased bearings) and bearings pre-loaded slightly, set up the tool in the lathe in a true chuck and with a cylindrical blank broach set with 17 mm protruding from the spindle and with a DTI acting at 16 mm protrusion adjust all the M6 adjusting screws to runout better than 0.02 mm with the M6 Nyloc nuts tight. The holes in item 1 may require opening out and spot facing parallel to the 1 degree face.

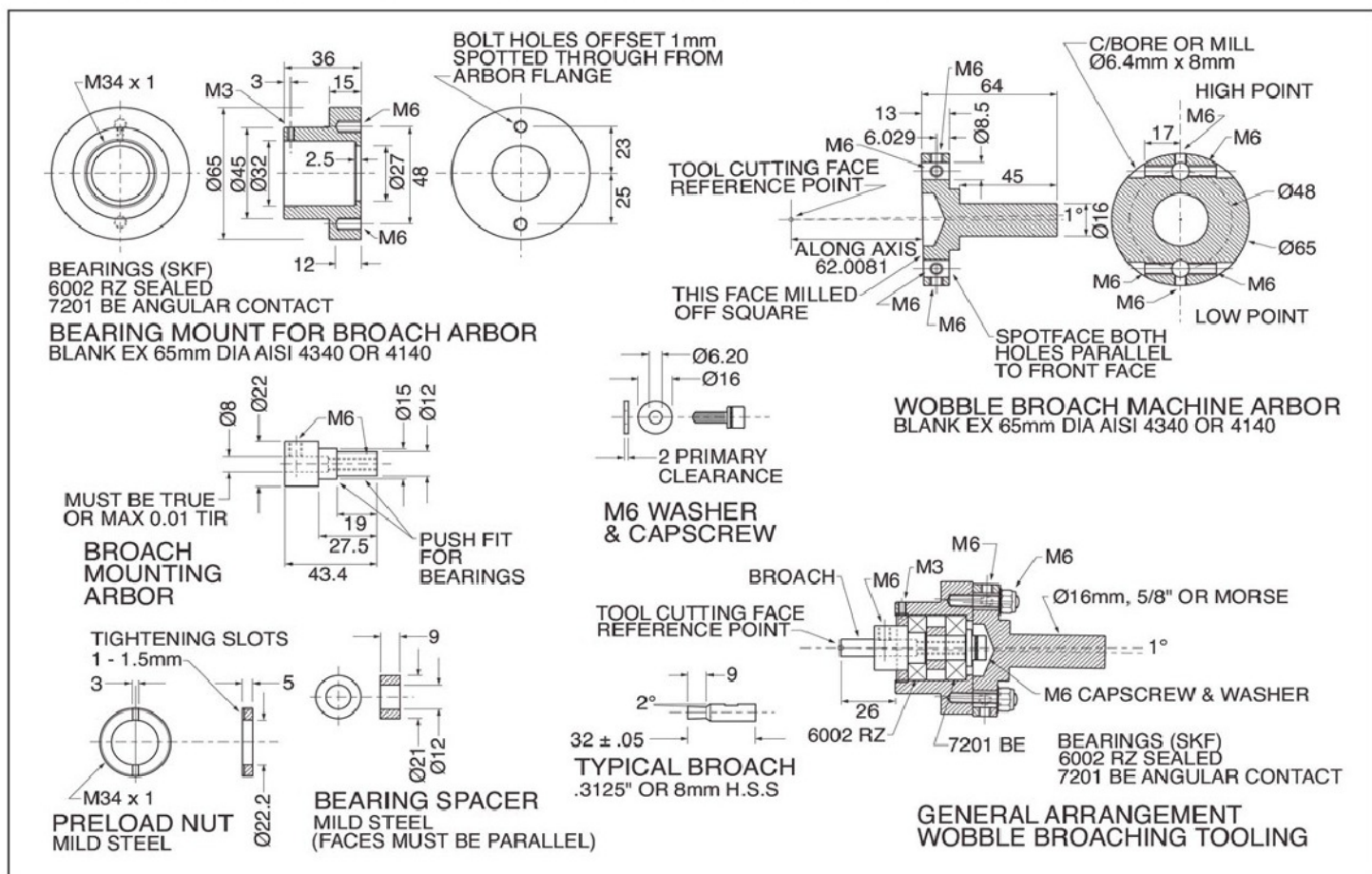
When first set up as above and the lathe rotating it looks horrible until you observe the front cutting face of a broach which should now be running true.

Operation

The job should have a 45degree chamfer to just greater diameter than broach across corners to enable easy location

- Metric Hex 3 - 10 mm A/F.
- Imperial Hex 1/8in. to 3/8in. A/F.
- Imperial Square 1/8in. to 1/4in. A/F.
- A blank ready for grinding. ■

Editors note: From using a wobble broach in industry, I never suffered hydraulic lock but thinking back, the components were drilled through. Oil was found to be necessary when cutting but more so when removing the broach as often the cutting edge would chip without oil. We used the tool on an old Ward 2 capstan lathe and used a fine power feed to feed into the job. I think we also used the power feed reversed to get the broach out. From memory, quite a bit of cutting pressure was needed but we were broaching a high spec steel that had possibly been heat treated.



MAKING A SIMPLE DOUBLE ENDED TAILSTOCK DIEHOLDER FOR THE MINI-LATHE

Dave Fenner makes another attachment for a Mini-Lathe

Background

Back in the early 90s, there was a short spell when work for the shop was thin on the ground and I decided to look at the feasibility of producing tailstock die holders. The project got as far as a trial batch machined principally on the manual Herbert 2D capstan lathe, the thinking being that if serious volume might be required then the turning work could be split between the automatic and manual machines.

The design was kept as simple as possible, the intention being that it would be mounted via a bar in the tailstock chuck, thus avoiding any need for Morse tapers. A set of three old parts is shown in

photo 1. The body is bored at one end to accept $\frac{1}{16}$ in. and at the other, 1.000in. diameter dies, then being drilled through to match the mounting bar. It is also cross drilled to take a 6mm tommy bar. Although I was using industrial weight machinery at the time, the gadget can be easily made in the amateur setting. As an exercise for this article, I turned up a new, slightly shorter body, this time using the Mini Lathe.

Manufacture

The two minor components are really easy; just saw two pieces of bright steel bar, one 6mm diameter and the other



Photo 1. One set from the earlier batch, body has black oxide finish, bars are zinc plated.

12mm, to roughly 80mm in length, then face and chamfer. Some pundits advocate a combined facing and chamfering tool, but now that quick change toolposts have

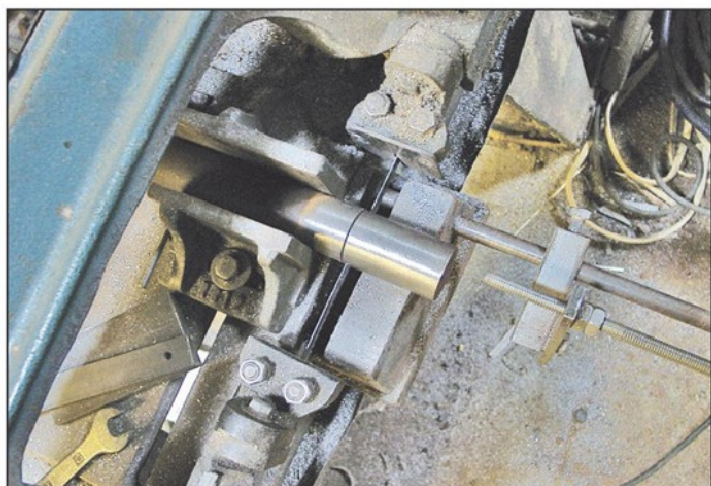


Photo 2. A bandsaw takes the hard work out of sawing 35mm diameter.

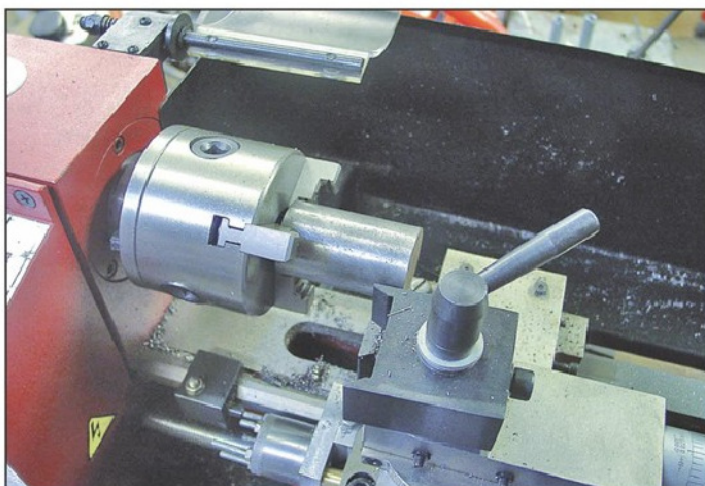


Photo 3. As a quick dodge to true up the work, it is pushed gently with the toolpost.

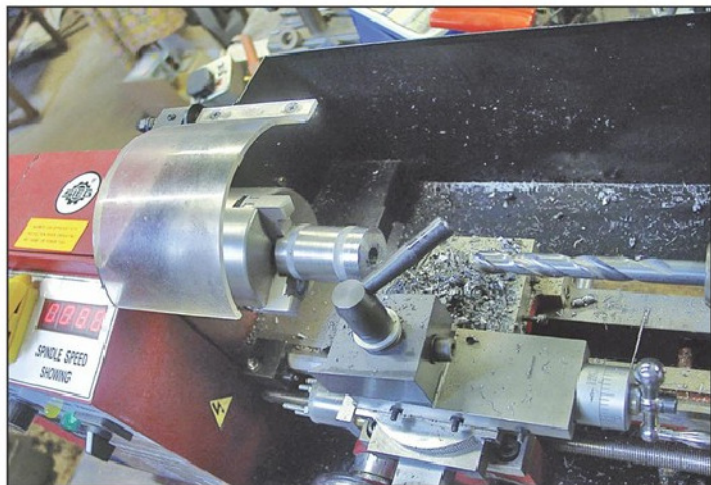


Photo 4. The through hole is drilled in stages on a lightweight machine.

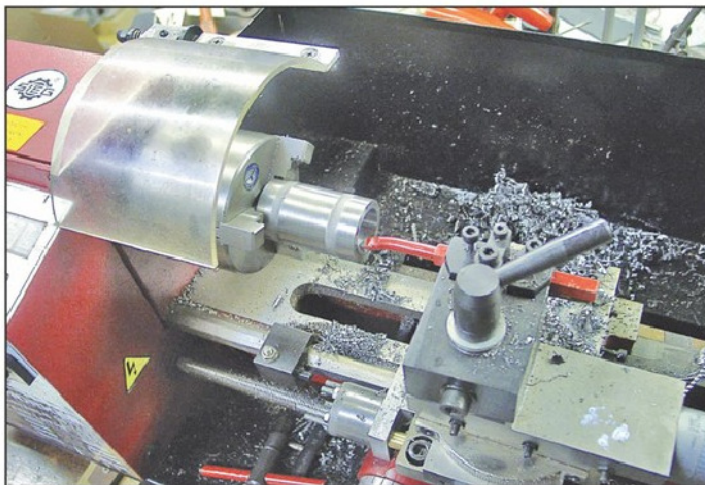


Photo 5. Housings are bored to fit dies.

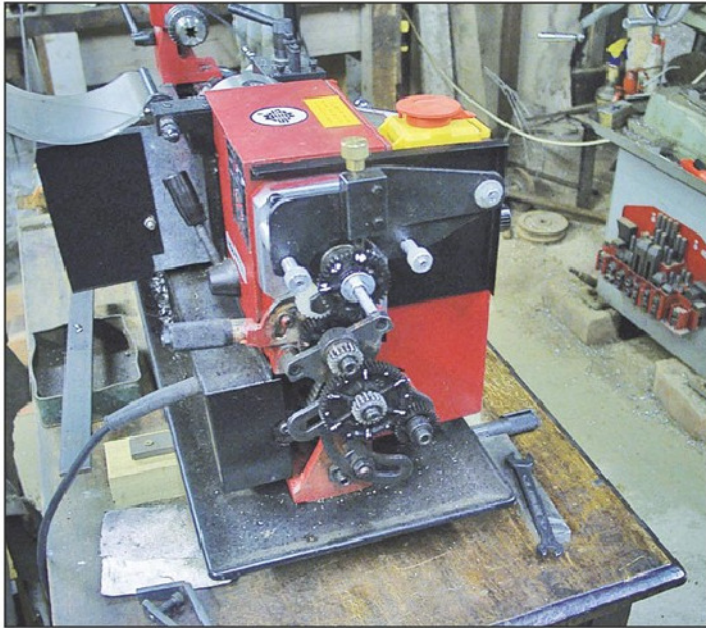


Photo 6. Headstock dividing attachment fitted to Mini Lathe.



Photo 7. Angular positions scribed with Vee tool on side.

become popular, I favour the use of a separate tool for each operation. If your normal tailstock chuck has a capacity of less than 12mm, then reduce the diameter of one end of the mounting bar to allow it to be gripped.

The body starts life as 35mm diameter BMS bar, from which a piece about 56mm long is sawn, **photo 2**. It should be noted that using the four jaw chuck would probably give a better grip, but I just fitted the alternate jaws for the three jaw. To get the work running true at its outer end, it was first nipped lightly and the lathe run at low speed. The toolpost was then gently backed into the work gradually pushing it into a true running position, **photo 3**. The chuck was then tightened fully and the sequence of turning operations commenced.

Here it might have been better practice to fit a steady, however the facing work was undertaken with no problems using light cuts. It was then centred and supported with a tailstock centre. It could

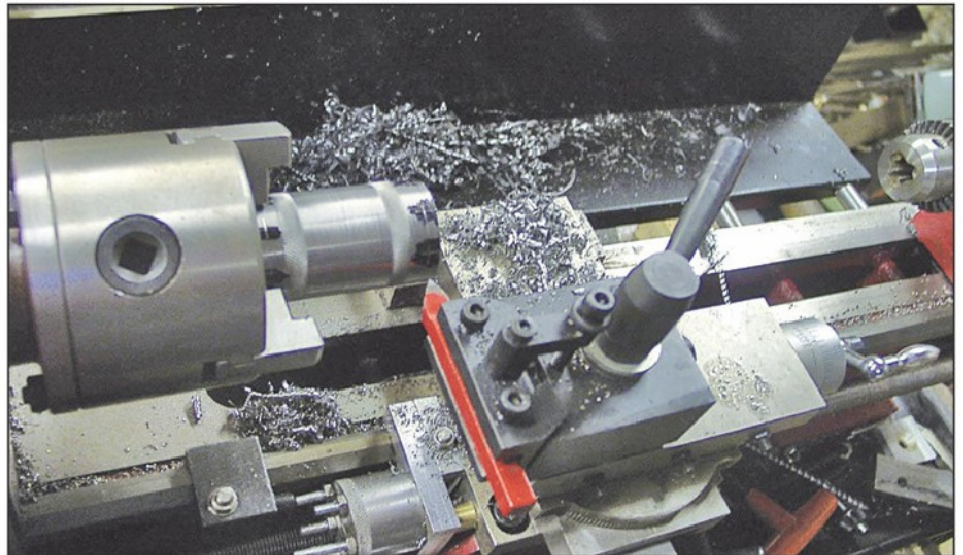
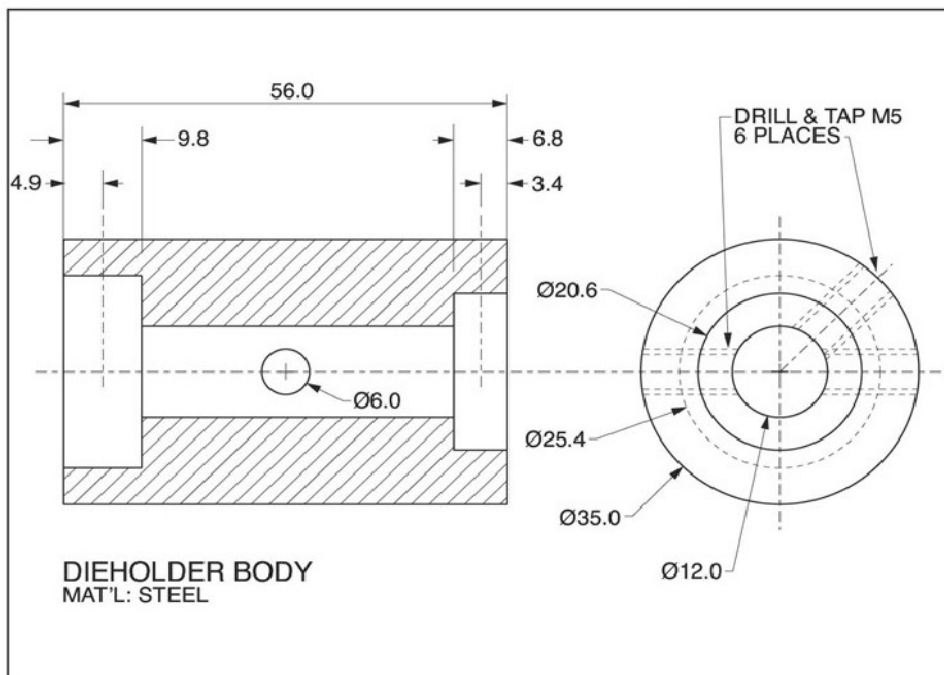


Photo 8. Scribing axial positions.

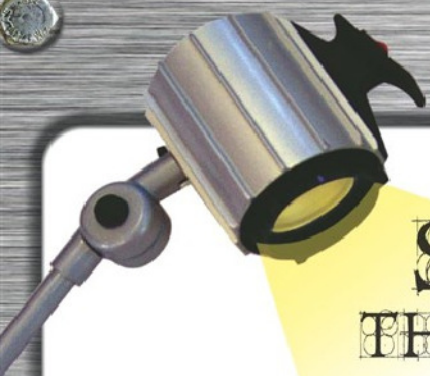


then be knurled using the Arc Euro Trade straddle knurling tool. The method adopted was to plunge feed across at the required position. This size of material is probably a bit much for this set up, and it shows in the quality of the knurled finish. Nevertheless, it does give a reasonably grippy surface. As the diameter at the ends was turned down slightly at a later stage, it might have been a better approach to turn down and then apply the knurling tool to a narrow width first before feeding axially to gain width.

Both ends of the job were treated in the same way, after which the drilling and boring was undertaken.

The Mini Lathe is of course not a powerful machine, so the hole was drilled in two stages, first with a 9.5mm drill then opening up with a 12mm one, **photo 4**.

As noted previously, two sizes of die would be accommodated, $\frac{1}{8}$ in. and 1.00in diameters. I believe that the nominal thicknesses for these die sizes are $\frac{1}{4}$ in. and $\frac{3}{8}$ in. respectively. However, measuring a sample from the tool box, I found that for the smaller size, the thickness ranged up to about 6.7mm and



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MAKING AN EDGE FINDER

Mel Martin makes a useful tool

I have a traditional wiggler edge finder and that works great except that to use it I have to swap the Mill tool holder (R8 or collet) for a chuck and on one occasion I was using some very short milling tools in a collet so not only did I have to swap the collet for a chuck but I also had to raise the Mill to get enough clearance to use the wiggler and consequently lost register.

The size of the wiggler and chuck meant that I had very little vertical movement to complete the work. It would be great if I could have a wiggler that fitted into the mill tool holder. I then remembered an edge finder one of the people at the Society of Model and Experimental Engineers (SMEE) had shown me, some time in the distant past, that used a Light Emitting Diode (LED) to indicate when the device was in contact with the work piece. Other than that I could not remember any details but I was sure I could make something similar to fit my tool holder.

The electronic part was no problem; the circuit is very simple as shown in Fig 1, just a battery, a LED and a resistor to limit the current through the LED. The outline design I evolved is shown in Fig. 2 and the finished item mounted in my lathe chuck is shown in photo 1. The device is inserted into the chuck or collet and makes contact with the circuit at A. The circuit at B is connected to the bottom part of the edge finder and when this comes into contact with the workpiece the circuit is completed through the body of the mill/lathe and the LED lights.

I have found the operation to be very sensitive and to require very little movement to go from "off" to "on". Much less than I can read on my digital read out. The accuracy of the device depends entirely on how accurately parallel you can make it and measure its diameter and also the accuracy of your collet/chuck holder.

Fig. 3 shows where errors may occur.

Design constraints

The main design constraint is the battery and if the device is to fit into a mill tool holder the battery will need to be small. Even the AAA size battery is much too big. Fortunately hearing aid batteries are small (0.3inch or 7.8mm diameter) and are readily available. There may be some watch batteries that are smaller but these will cost more. The LED does not require much current and it will only be "on" when in contact with an edge so the battery should last for a reasonable length of time.

The battery and resistor need to go inside the body of the edge finder, which needs to be robust so that it does not bend when brought into contact with the work piece. It therefore needs to be 1 mm or more in thickness. With a battery of 7.8mm diameter this means that the absolute minimum diameter will be about 10mm. The battery and other bits will be held in place by a retaining screw. The size of that was dictated by my collection of taps and dies (a random selection of BA, Whitworth, and metric). The nearest size I had that might do the job was 10mm. Thus the smallest collet I could use with the device would be my 12mm collet. Making it to fit larger collets (15 mm, 1/2in. etc) would be much easier. In fact none of the measurements are critical except those determined by the target collet and the size of the battery. Most of the dimensions thereafter were determined by being made "to fit" and were only measured so that I could write this article. Consequently you may find that the photographs and measurements given on the drawings are not entirely consistent but if you follow the



Photo 1. Finished edge finder in mill.

design logic and use common sense you should be able to make one that serves your purpose. I have now made three versions and they are all slightly different.

In this project I started with metric units, as I wanted the edge finder to fit a 12mm collet, but ended up mixing units as I eventually bought a 3/16in. tap and die to make the retaining screw. A 10mm tap and die was OK for size but the thread was too coarse. Mixing units is not unusual for me as I have lived through 4 changes of measurement, Imperial, CGS (centimetre gram second), MKS (Metre kilogram second) and finally (?) metric based on the SI units (Système international d'unités) in which millimetres seem to be the preferred unit of length. Furthermore I have a mixture of tools, old and new, therefore I often end up using a mixture of units in a project. That is I use the units

Fig. 1

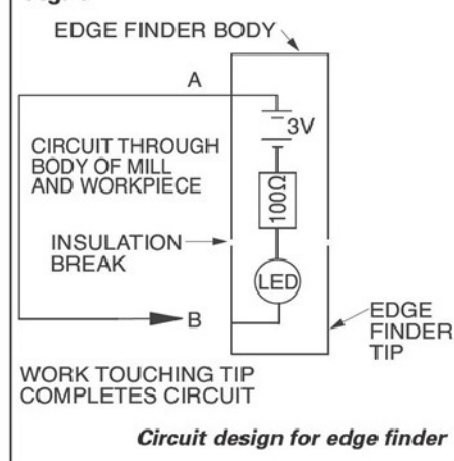
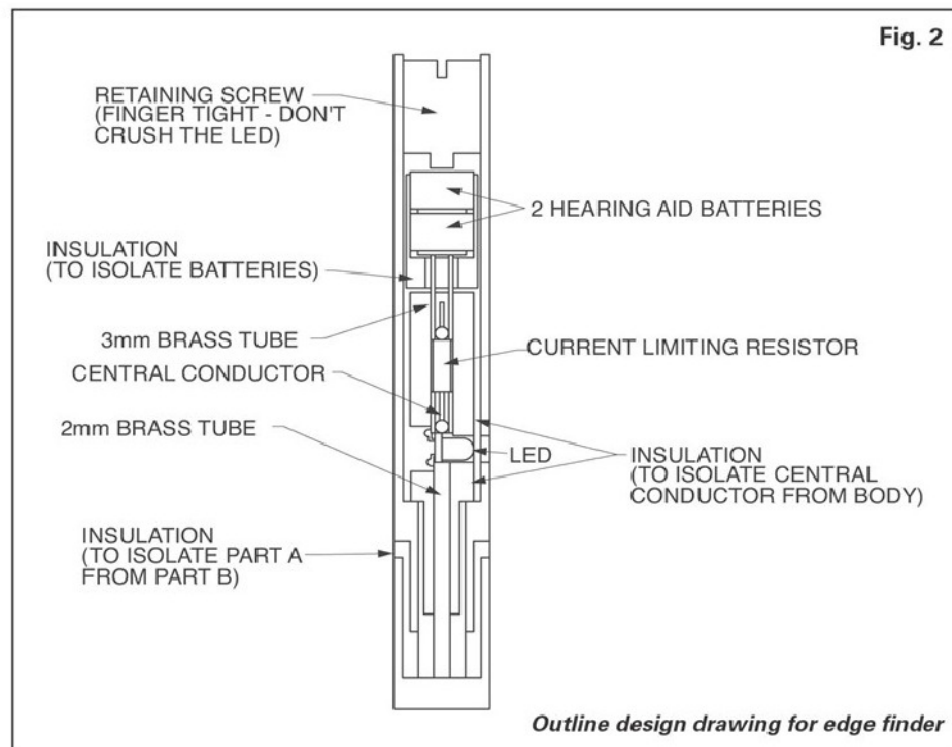
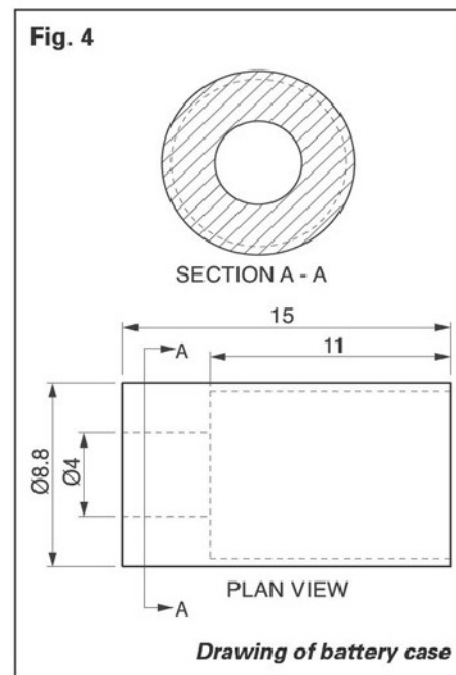
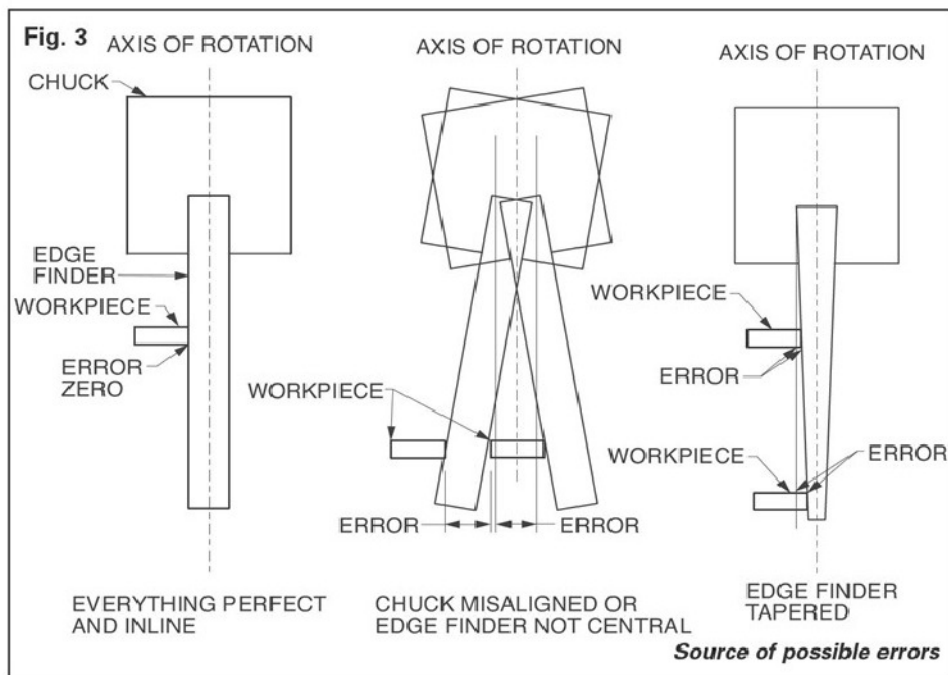


Fig. 2





which best match the size of an item or the tool I am using. I should also note that I am not an engineer by trade and my tools and methods may not be the best possible, in particular getting the unit be parallel and to fit my 12mm collet proved to be difficult, perhaps the editor can suggest how best this can be achieved?

How I made the device

My first problem was to decide how to electrically isolate the bottom contact from the top part of the unit and provide a robust mechanical joint. Simply putting an insulating washer between the upper and lower unit would not provide any degree of strength.

Fig. 2 shows how my design achieves this using a coaxial insulating washer.

The end cap

This is part B in the outline design. I first chose a bar with a diameter greater than my desired 12mm final diameter, the material is not critical, I used stainless steel but brass, aluminium or any other steel would do just as well. I first faced off the end and drilled a hole 10mm in diameter to a depth of about 15mm and then parted off at about 20mm. This will form the base of the unit, which makes contact with the work to complete the circuit. The exact sizes are not critical; provided you don't drill all the way through it will be fine. **Photo 2** shows the finished end cap.

Insulating washer

For the insulating material I used a piece of acrylic which I roughly turned to a diameter

of about 13 or 14mm. I drilled a hole 9mm in diameter to a depth of 12mm and parted off at 20mm from the end, **photo 3**. I found that the plastic is very brittle and prone to shatter if machining is too aggressive. It is also prone to melt and cause drill bits to break unless they are very sharp and the swarf is removed frequently. The swarf comes off in very long strands and can quickly get wrapped round the work and must be removed frequently, **photo 4**. The plastic I used goes by the name of "crushed velvet" and comes in a range of colours and is sold in pieces about 6in. by 1/2in. square to wood turners who use it to make pens, **photo 5**. Most shops that sell to wood turners stock this material. However, any plastic that can be turned and glued with superglue would be OK. Polythene or nylon would not be suitable, as they do not bond well to super glue.

Top unit

This is part A in the outline design. I then placed the remainder of my bar in the lathe and turned a spigot 10mm long on the body to give a good fit into the hole (9mm) in the plastic, **photo 6**. The finish is not critical and indeed a slightly rough surface will give a better bond. I then



Photo 2. The end Cap, part B in the outline design.



Photo 3. Parting off the centre insulation.



Photo 4. Showing accumulation of plastic swarf.



Photo 5. Crushed velvet as used for pen making.

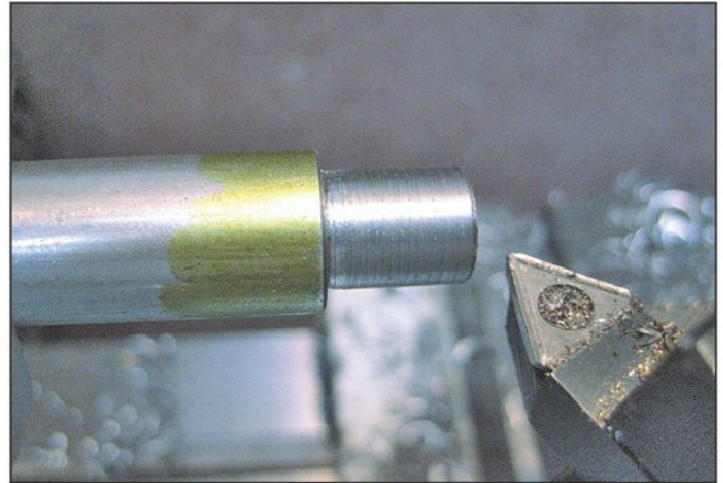


Photo 6. The spigot on part A.

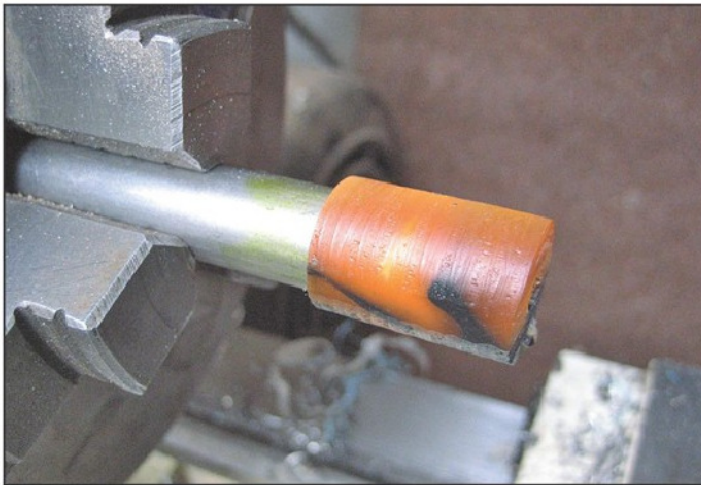


Photo 7. Plastic insulation super glued in place.



Photo 8. Turning the insulation to shape.



Photo 9. The end cap super glued in place.

applied superglue and pushed the plastic onto the spigot and applied pressure until the glue had set **photo 7**.

A spigot was then turned on the plastic with a diameter of about 10mm to within 1mm of the metal, **photo 8**. The end cap made earlier should be a sliding fit onto the plastic spigot.

Then I drilled a 5mm hole 20 or 30mm deep into the spigot and applying super glue pushed on the cap I made earlier and waited for it to set, **photo 9**.

I then turned the body down to 12mm. This must be parallel and accurately match the 12mm collet. This step is critical and will determine the accuracy of the device and the ease of holding it in the collet.

I then drilled a 9mm diameter hole from the opposite end until it was about 60mm deep. It should not be so deep that it reaches the plastic insulation but should leave about 5mm of metal next to the plastic. The hole should also have made contact with the 5mm hole drilled previously. This hole will be filled with a piece of 5mm outside diameter, 2mm inside diameter plastic tube, which will insulate the central conductor from the body of the top unit. The 9mm diameter hole needs to be wide enough to accept the batteries and container.

I then made an internal thread on the first 30 or 40mm to take the compression screw. On my original edge finder I used a 10mm tap as that was all I had at that time but I found the thread very coarse and so purchased a $\frac{3}{8}$ inch x 40 tpi tap for the mark 2 version.

I then mounted the unit on the mill and cut a facet and a central hole to allow the LED to be seen.

A grub screw with a $\frac{3}{8}$ inch 40 tpi thread completes the metalworking.

The internal bits and electronics

I have a number of LEDs, which have been accumulated over the years, and one, which was 3mm by 5mm did just fine.

A little experimentation showed that it required 1.8 volts and was bright enough to be seen when passing about 10ma, **photo 10**. Reducing the current will dim the LED but extend the battery life. Exactly how long the battery will last will depend on the current used, the battery capacity and how long the LED is "on". Since the LED will only be "on" when in contact with the work, I do not think that battery life will be a problem. Indeed the original batteries are still going strong.

The exact specification of the LED is not critical; a LED recovered from some old electronics will do just fine. Alternatively Maplins, Radio Spares and other

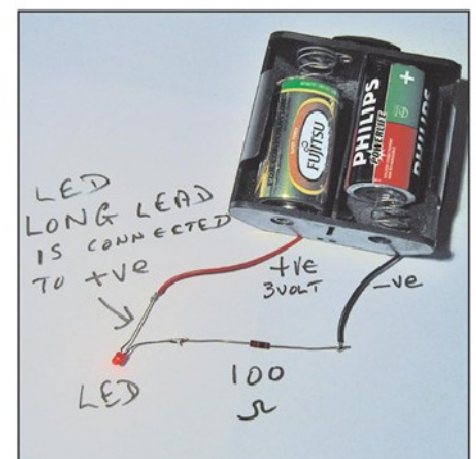


Photo 10. Testing the LED and resistor.



Photo 11. The battery case

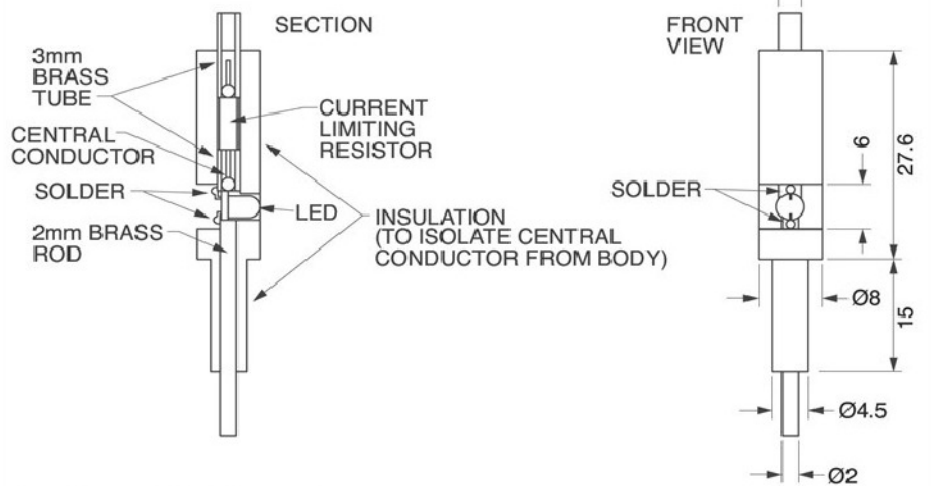
component suppliers sell a range of LEDs. The only real requirement is for it to be small enough to fit in the edge finder and be bright enough to be seen in the workshop. A small low power LED is ideal and will not drain the battery unduly.

Battery case

As noted earlier I chose to use hearing aid batteries, which are the smallest I have found that are readily available. I measured these to be 7.8mm in diameter and 5.25mm long. Since I need two in series to give the required 1.8 volts to light the LED they need to be insulated from the body of the edge finder. My solution was to turn up a case out of plastic, **photo 11**. The diameter of the case must be small enough to slide into the top unit whilst the hole in it must be wide enough to allow the batteries to slide in and out. The final diameter ended up at 8.8mm and the wall thickness 0.4mm, **Fig. 5**.

To make this item I mounted a piece of plastic rod in my lathe and drilled a hole using a 7.9mm drill to a depth of 18mm,

Fig. 5



Drawing of MK2 LED and resistor mounting

photo 12. I then very carefully removed material from the outside until the item would slide inside the edge finder. I found that I needed to have a very sharp tool and to take off only a few thou at a time as I approached the final size. The first time I tried it the plastic broke. The second time I was successful. I found that rather than turning the full length to the required diameter it was safer to turn it down in sections so that the overhang was small and hence reduced the stress in the thin section, **photo 13**.

I then drilled a 3mm hole to allow contact with the battery from below and parted off. **Photo 10** shows the finished item. For those who have difficulty machining or hand turning such a delicate item an alternative would be to wrap a layer of sellotape round the batteries.

LED mounting unit

I initially mounted the LED and dropping resistor onto a small piece of Vero board.

And to make contact with the batteries and bottom of the edge finder I used 2mm



Photo 12. Drilling the hole for the batteries.



Photo 13. Turning the battery case to size.



Photo 14. The battery case ready for parting off.

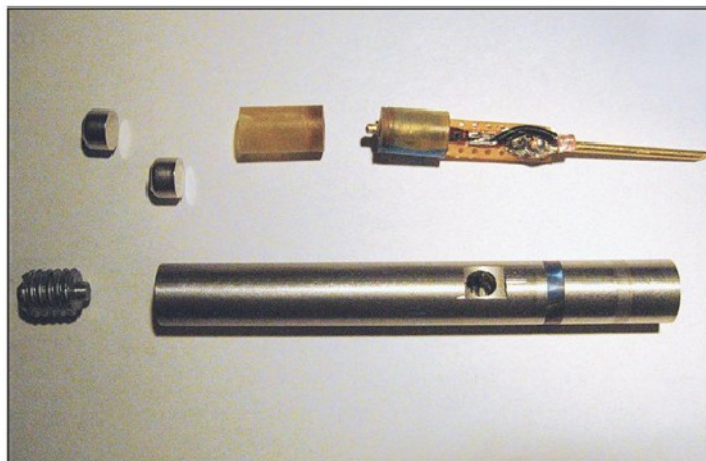


Photo 15. Components of the Mark 1 version.



Photo 16. Turning the LED mounting to size.

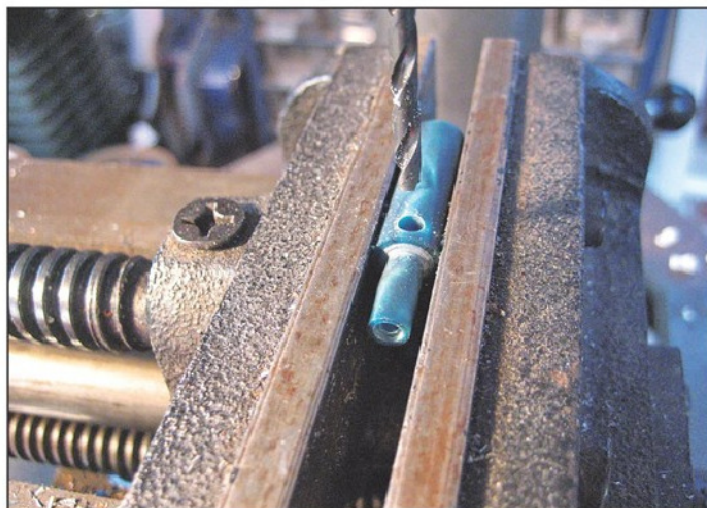


Photo 17. Drilling a hole to accept the LED.



Photo 18. Expanding the hole to allow room to solder the LED and resistor.

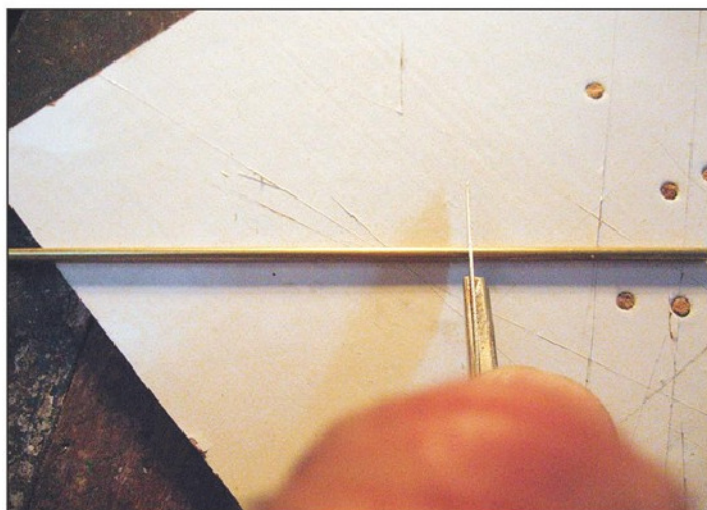


Photo 19. Cutting brass tube to length.

($\frac{1}{16}$ in.) brass rod but found that it was difficult to locate the board in the centre. This is shown in **photo 15**. To overcome this problem I used a coaxial construction in the MK 2 version. This is shown in **Fig. 5**.

I first turned a piece of plastic with a 5mm diameter spigot so that it slid into the inside of the edge finder, **photo 16**. Then I drilled a 2mm hole all the way through to give a tight fit on to a 2mm brass rod. I then measured the diameter of the resistor and opened the hole up to accept the resistor.

I then drilled a 3mm diameter hole to accept the LED 5mm from one end, **photo 17**. This was then opened up to 5mm to just over halfway through, **photo 18**. Alternatively hacksaw and file away

enough material to give access to solder the LED and resistor to the central conductor.

Cut two pieces of brass tube (10mm and 15mm) to slide over the ends of the resistor to form a rigid construction that will slide into the hole in the plastic centre unit. I find that using a sharp craft knife and rolling the tube back and forth is an easy way to cut off small lengths of thin brass tube, **photo 19**.

The resistor wires were cleaned with emery paper, tinned, soldered into the tubes and the excess wire was cut off, **photo 20**.

The wires on the LED are cut very short, tinned with soft solder and inserted into the LED mounting unit along with the

resistor unit and the two soldered together, **photo 21**. A short length of 2mm brass rod was inserted into the other end and soldered to the LED. This operation required a steady hand and a soldering iron with a small tip, **photo 22**.

At this point I had lost track of which wire of the LED was the cathode and which the anode. No matter, I needed to test the unit to make sure the contacts were good. I connected the contacts at the ends of the unit to two 1.5 volt batteries in series (3volts) as illustrated in **photo 10**. I made a note of which way round the battery was when the LED was "on" so that I knew which way round to put the batteries in the battery case. If the LED does not come "on" at all then the solder has not made a



Photo 20. Fitting the brass tube to the resistor.



Photo 21. Cutting the LED wires very short.



Photo 22. Showing the LED and resistor soldered to the central conductor.

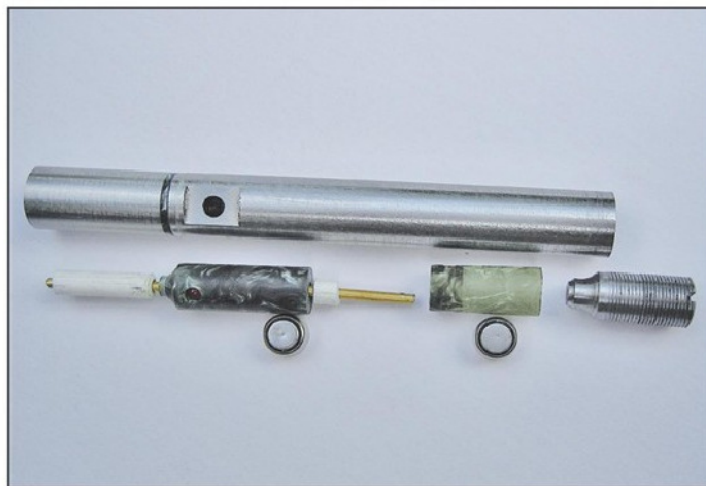


Photo 23. Mark 2 component parts.

good contact and needs to be redone, but first make sure the batteries are not dead.

Photo 23 shows all the component parts. All that is now required is to insert the electronic bits into the edge finder, making sure to align the LED with the viewing window and that the batteries are inserted the correct way round then gently screw in the retaining screw until finger tight, do not crush the batteries. The unit is now ready for use however a quick test to confirm it is working is worth doing.

Trouble shooting

The LED should light if a wire or piece of metal is used to short the top unit to

the bottom unit. Simply laying it on a metal surface should cause the LED to light. Indeed in use I found this to be a little trying as every time I put it down it seemed that the surface was metal and the unit would light up and waste battery power. This caused me to make a wooden container, but that is another project.

If the LED does not come "on" then the batteries are probably in the wrong way round, just remove, reverse and reassemble. If it still does not light then check that the LED/resistor unit works as described above. If that is OK then check the batteries with a voltmeter. They should each read about 1.4 volts. If all is well then the

only remaining possibility is that the brass conductors on the LED/resistor unit are not making contact with the battery or end cap. This may be because they are too short or there is some insulating swarf in the hole. Remove the insulating tube and clean the hole with a long drill and reassemble.

I now have an edge finder that fits into a 12mm collet, is accurate, easy to use and was very cheap to make, **photo 1**. Making one to fit larger collets will be easy; just start with a thicker bar and turn down to the desired size. However, to make one that will fit into a smaller collet will present more of a challenge and I am still working on that. ■

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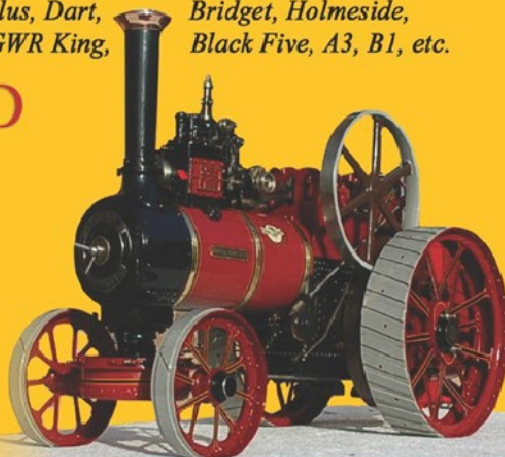
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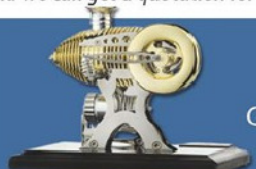
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FIRST STEPS IN DESIGN



Modelling pipe runs,
belts and castings

6

The objects created in part six have moderate complexity



Using the previously described foundation of basic modelling techniques, this series will now focus on creating types of engineering components. On occasion, a new trueSpace tool or feature may be introduced if it is needed, but mostly the modelling will use only those functions shown so far. In this sixth part, I'll give some examples of building models of moderate complexity. These will also show some new ways of exploiting some trueSpace tools. Many of the examples show one approach for each modelling task, but this won't be the only way of achieving a similar result. Usually, there are two or three main ways, and dozens of variations, for building every model. I hope, though, that you will find the examples useful while you develop your own working methods.

You will probably now be getting familiar with the mechanics of using trueSpace, so from now on I'll leave out some of the steps required to use the tools (omitting details like clicking [Object Tool] to finish a subtraction operation, for instance, or whether the Keep Drill option is set or not). Also, some of the steps will be shown more concisely. So, for example, [Cube:XL7/YS3.8] means add a [Cube] and set its X location and Y size to 7 and 3.8 respectively in the Info Panel. Parameters such as Longitude and Latitude will now be given only if specific values are needed, otherwise I'll leave these to your own judgment.

Preparation

The models in this part are generally a little more complex than those shown before. When many steps and several different tools are needed to make a model, it is usually more effective to do some planning first before jumping straight in with the 3D modelling (not that I'm always very good at following my own advice!). At the start of a new project, an approach I use at times, which you may also find helpful, is to make some initial preparatory sketches, possibly drawing these on graph paper if any precision is needed. Next, as TrueSpace is not always suited to working out specific engineering design details, I occasionally make a 2D CAD or manual drawing. This will, however, usually remain unfinished and contain only enough detail to complete the 3D modelling.

Pipe runs

The techniques shown in this section are also useful for building other objects - bent wire components for example. In summary, the method begins with a 2D shape or an object face, then a series of Sweep and Lathe operations are applied, creating an extrusion over a specific route. For pipes, the 2D shape will probably be circular, but any starting shape can be used.

Begin with a symbolic boiler and standard:

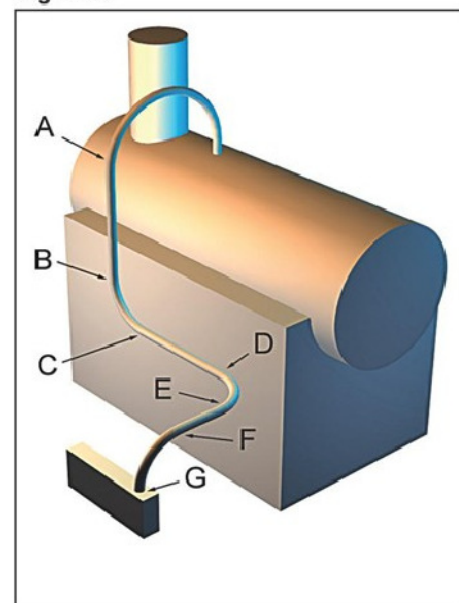
[Cylinder:ZL7.0/XR90/XS5.0/YS5.0/ZS13.0]
[Cylinder:YL4.5/ZL11.0/ZS4.0]

[Cube:ZL3.5/XS7.0/YS11.0/ZS7.0]

[Cube:XL9/YL4/ZL2.5/XS0.6/YS3.6/ZS1.4]

A pipe run will now be created which will look like this:

Fig. 134



Start the pipe with:

[Cylinder:YL1.5/ZL9.5/XS0.3/YS0.3/ZS1.0]

The next step - making this cylinder into a tube - is optional, and is only really needed if the ends of the pipe can be seen in the model, or for some other reason (creating a cross-section through the pipe perhaps). [Copy] the cylinder, and [XS0.2/YS0.2]. Subtract the smaller copy from larger cylinder to get a tube.

Select the top annular (or circular) face of the pipe with [Point Edit: Faces], then left-click and right-click [Lathe]. In the Lathe Property panel type: Segments:18, Angle:180, and Radius:2.25 (Helix and Rotation:0). Click [Lathe] to arrive at stage A.

Left-and-right-click [Sweep], and set Z:3.8 (Enter) in the Sweep/Tip panel (stage B).

Continue using the Lathe and Sweep tools in this order:

Stage C:
[Lathe] - Segments:9, Angle:90,
Radius:1.5, and Rotation:90

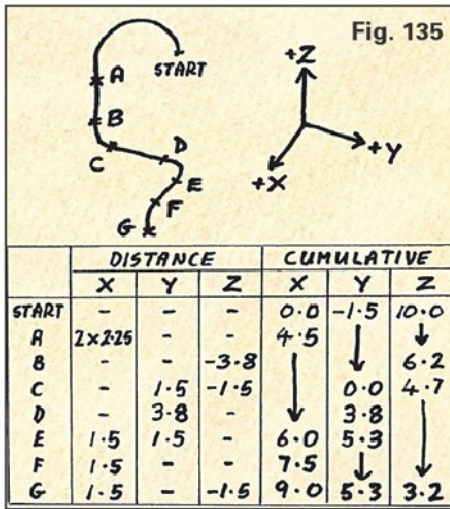
Stage D:
[Sweep] with Z:3.8

Stage E:
[Lathe] with Rotation:90

Stage F:
[Sweep] with Z:1.5

Stage G:
[Lathe] with Rotation:90
Finish by clicking [Object Tool].

This example is fairly straightforward as all bends are at 90° or 180° and are revolved around one only of the X, Y or Z axes. The position at each stage can therefore be determined by simply adding or subtracting each bend radius or sweep distance in turn from the starting location. A little mental arithmetic is often all that is needed to keep track of the route as it is planned. For a pipe run which is long and complex, it may be helpful to draw a quick sketch first and make a list of the cumulative X, Y and Z positions, like this one for the example above:

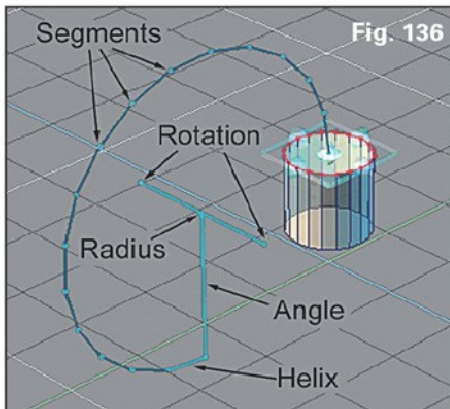


When a pipe run includes bends at arbitrary angles, possibly around more than one axis, working out a route can soon get complicated. In such situations, it is often best to plan a route with a CAD or manual drawing. An example of this is shown later. Alternatively, a list like that shown above can be produced, but which makes extensive use of trigonometry and a calculator (or spreadsheet).

Freehand pipe forming

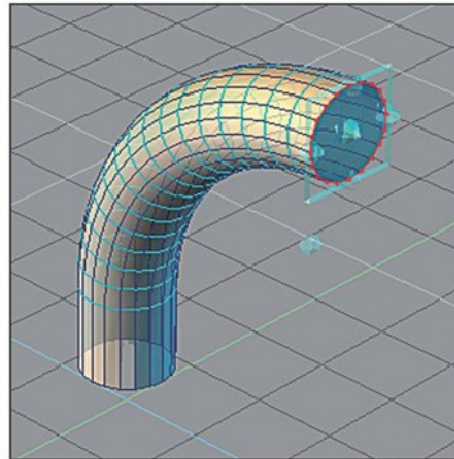
The previous example is perhaps a little artificial. The pipe need not have followed any well-defined course, as long as it looked neat. The route could alternatively have been formed in a freehand way, using the mouse alone, and without typing in any lathe or sweep values. This is a quick way of creating pipe runs when precise positioning is not required. A disadvantage is that it does take a little practise to become adept with this way of modelling. Here is an short overview of the technique which you may like to try:

Start with [Reset View], and add a [Cylinder]. Press the 'c' keyboard key - this shortcut activates the [Object Scale] tool. Hold both mouse buttons down and drag until the cylinder's size values are roughly 1. Select the top cylinder face with [Point Edit: Faces], then click [Lathe]. Right-click [Lathe], and set Segments:16, Angle:270, Radius:2, Rotation:0, and Helix:0. This step is done so that you start with the default lathe settings for this example only - usually with this technique the Lathe Panel would not be used at all. I mentioned in part four that the Lathe tool can be used interactively with the mouse by clicking and dragging the lathe guidelines. This diagram shows which lines and points affect which Lathe parameters:



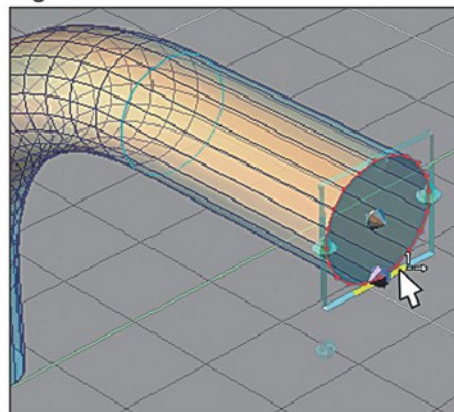
Click the Angle line and drag the mouse to the left until the line is vertically above the crossbar (the Lathe Panel Angle value should be about 90°). Drag the Radius point to the left until the radius has a value of, say, 3. Next, drag either of the Rotation points to the right to make the rotation about 270°. Unfortunately, the Lathe Panel values are not updated interactively when the control lines or points are dragged, so you may want to release the mouse periodically to see the values. If you want, you can also drag any of the segment points to increase or decrease the number of segments in the lathe operation. Click [Lathe] and you should have something similar to this:

Fig. 137



Click [Sweep] to start an extrusion. There are several ways of increasing the extrusion distance with the mouse. Perhaps the most controllable way is to drag parts of the square control frame that surround the end face of the extrusion. Drag the yellow highlighted section of the control (in the next diagram) to the bottom-right corner of the screen until the extrusion is about three grid squares long.

Fig. 138



Next, try adding further stages to the pipe by applying the Lathe and Sweep tools in any combination and using the mouse manipulations described above. As you do this, it may be necessary to continually alter the viewpoint and/or use subsidiary views to get a clear impression of the pipe as it is formed in 3D space. With freehand mouse control, any pipe route imaginable is possible:

Fig. 139



Scale as you go

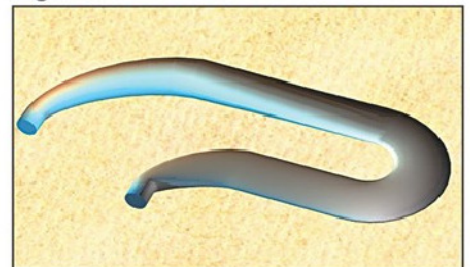
There is no restriction on keeping a constant cross-section size throughout a pipe run. The pipe can be resized by scaling any lathe or sweep stage. Maybe this would not be done regularly for pipes, but it can be very useful when building other components. Here's an example:

[Reset View], and [Cylinder:XR90]. Select the nearside cylinder end face with [Point Edit: Faces]. Use [Lathe] with Segments:9, Angle:90, Radius:5, Rotation:0, and Helix:0. After clicking [Lathe] a second time to apply the tool, and before any subsequent extrusions are added, all the segments in the Lathe operation can be scaled proportionally by changing some of the sizes in the Object Info Panel. For this example, type [YS4/ZS4]. The position of the end face, and with it all lathe segments, can also be altered by changing the location values. In this case, typing [XL12] will create a smooth transition between the cylinder and the expanding lathed section.

Next, add an extruded section with [Sweep], and set [XL30/XS5/YS1]. This has extended the extrusion distance, and created a thin ellipse shaped end face by applying different scaling values to the height and width.

Add a straight [Lathe] section with Segments:18, Angle:180, and Rotation:180. Follow this with an unscaled [Sweep:XL20], and [Lathe] with Segments:9, Angle:90, [XL15/YS2/ZS2]. Finish with [Sweep], [YL-6], and [Object Tool].

Fig. 140



Ok, this is not a real engineering component, but I hope it shows the modelling potential of the technique. This object is solid, but it could just as easily have been made hollow by starting with a tube instead of a cylinder. There is, however, a small problem which may or may not be important. If the end of a tube is scaled, all parts of the face will be modified in proportion, thereby changing the component's wall thickness. If you want to build a hollow component with a constant wall thickness, you can create a solid object with the correct outside shape,

and then use the trueSpace Shell tool. The Shell tool, however, will only work if the object is simple. For complex shapes, there may be no alternative but to extrude separate outer and inner shapes, and then subtract the latter from the former (but see the next section for another possible method).

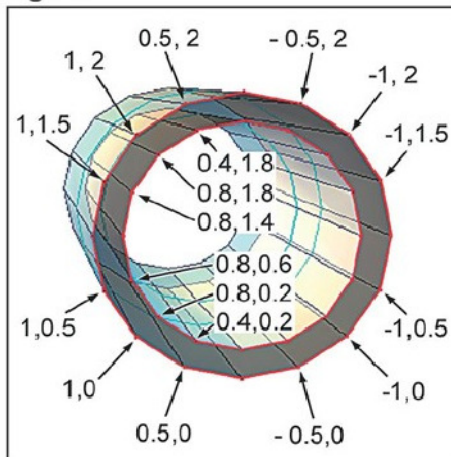
Instead of typing Object Info values, scaling and modifying a pipe can also be done freehand with the mouse. This follows a similar procedure to that described in the Freehand pipe forming section, but makes greater use of the square blue selection control at the extruded face. I won't go into this further, but you may like to experiment with it for yourself.

Reshaping a pipe

In the next example, a pipe's cross-section shape will be changed from circular to square as it is extruded. The technique shown involves moving individual points, and although the procedure can be time consuming, it does give you the ultimate degree of control.

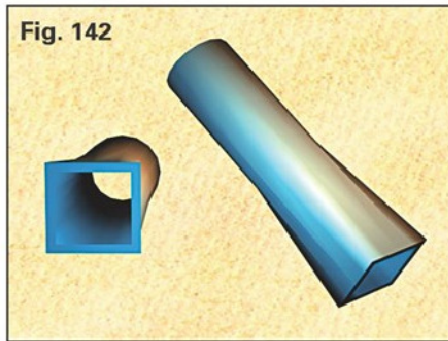
[Reset View], and for this example set **Longitude to 16** in the Cylinder Property Panel, then [Cylinder: XR90/ZS4]. [Copy], [XS1.6/YS1.6], and Subtract this smaller cylinder from the larger one. Select the nearest end face of the tube with [Point Edit: Faces], then extrude with [Sweep], and [YL6]. Next, adjust the viewpoint to see the end face of the extrusion clearly. The inner and outer rings of the face both have 16 points each, and 24 of these points will now be moved, transforming the extrusion into a square cross-section. Click [Point Edit: Vertices], and pick one of the labelled outer ring points shown in the next diagram. Change its location values to those given; the X value is the first in the pair, and the Z value second (the Y location is unaltered, keeping the face planar). Repeat this procedure for the other eleven labelled points in the outer ring.

Fig. 141



Next, change the locations of the corresponding 12 points in the inner ring. To keep the diagram uncluttered, I've labelled only six inner points, but the rest can be deduced. The end face should now be square, and the wall thickness the same as in the circular section (0.2 grid squares). If you want, you can now continue adding further sections to the pipe with [Lathe] and [Sweep], the new extrusions will retain the square cross-section. Here are two views of the object at its current stage:

Fig. 142

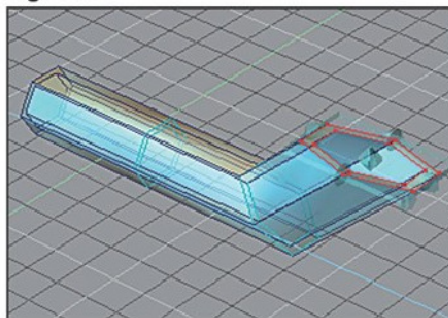


Adding sharp bends

In this final example on pipe runs, a sharp right-angled bend will be created. For variety, the pipe will have a hexagonal cross-section, but the method is the same for any other shape.

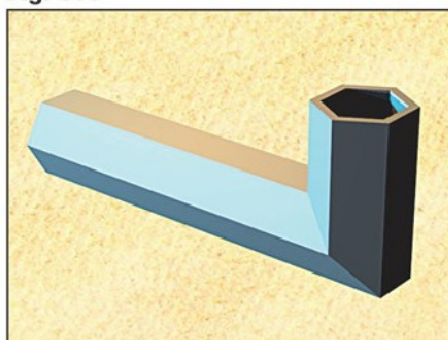
[Reset View], set the cylinder **Longitude to 6**, and [Cylinder: XR90/ZS4]. [Copy], and type *0.8 Enter after both the X and Y size values in the Info Panel. This will create a smaller hexagonal prism shape, scaled equally in the X and Y object axes. Subtract the small shape from the larger to make a hexagonal tube. Click [Point Edit: Faces] and select the nearest end face of the shape. Extrude this with [Sweep] and [YL6]. Form half of a sharp right-angled bend with [XR45]. This operation has also reduced the size of the extrusion, but this can be restored by increasing the Y size by a factor of $\sqrt{2}$. Do this by typing *1.414 Enter after the YS value. Click [Sweep], and note that trueSpace has remembered and used the previous Sweep operation parameters, creating a sharp 45° bend. This is the object at this stage:

Fig. 143



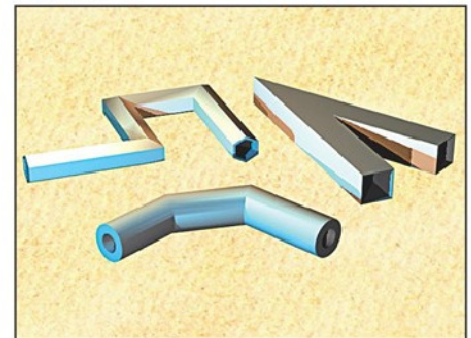
To make the bend a right-angle, move the face back to the previous Y position with [YL6], and reduce the shape to its starting size by typing /2 Enter after the YS value. This cancels out both $\sqrt{2}$ size increases of the two Sweep operations.

Fig. 144



You may like to experiment by adding further extrusions with sharp bends to the pipe. When you start each new extension, you will usually want to stop trueSpace from applying the previous Sweep parameters which have been remembered. This can be done by clicking [Point Edit: Faces] before starting a fresh bend. Sharp bends can be formed at any angle, but some trigonometry will often be needed to find appropriate scaling factors.

Fig. 145



To finish this section, I'll just mention that the techniques used with Paths (described in part four) can simplify the making of pipe runs in some situations.

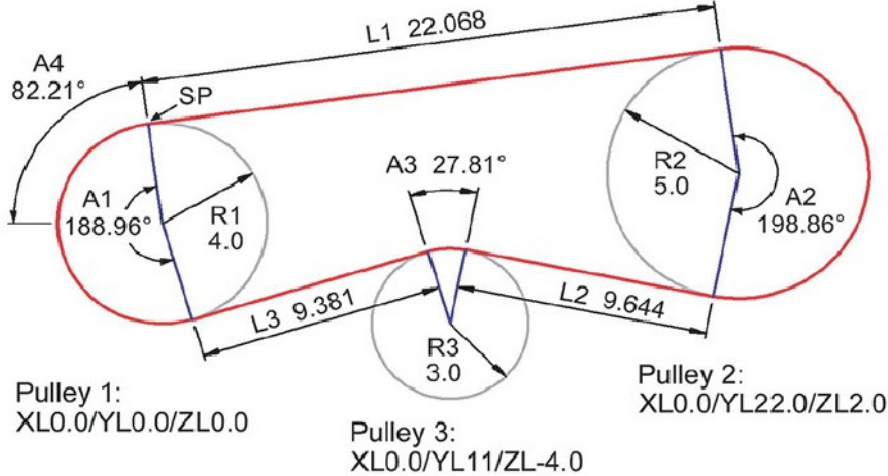
A pulley V-belt

The example shown next is made with the same extrusion techniques as those used in pipe forming, but in this case the route followed by the object is more complex. It is possible to do the modelling entirely within trueSpace - either freehand with the mouse, or, for greater precision, by using the Object Info Panel. The example is, however, a good illustration of how making a CAD or manual drawing first can save some modelling effort.

The red line in Fig 2 represents the route of a belt around three unequally sized pulleys. This is an imaginary line running centrally through the belt cross-section. The labelled lengths and angles (L1, A1 etc.) are those needed to model the belt in trueSpace. An overview of making a diagram like this is as follows: Beginning with a set of dimensions (designed or measured) the three circles are drawn at the pulley centre positions (expressed in fig 2 as trueSpace location values). The circle radii (R1, R2, R3) are the distances from the pulley centres to the centre of the belt cross-section (not the pulley radii). Next, three tangential lines are drawn between the circles, and then their lengths (L1, L2, L3) measured. For each circle, two lines (shown blue) are drawn from the circle centre to the ends of the tangential lines. The angles between each pair of lines (A1, A2, A3) are then measured. In this example, SP will be the chosen starting point for modelling the belt in trueSpace. As the belt lies in a vertical plane (the YZ plane), angle A4 is measured from the horizontal to the radial line at SP.

With all values now determined, the modelling in trueSpace can begin. The numerical values in fig 2 will be used in this example; the distances are in terms of grid square units (here representing centimetres). I won't create fully modelled pulleys in this example, but you can add some if you prefer by using the pulley

Finding the route for a V-belt

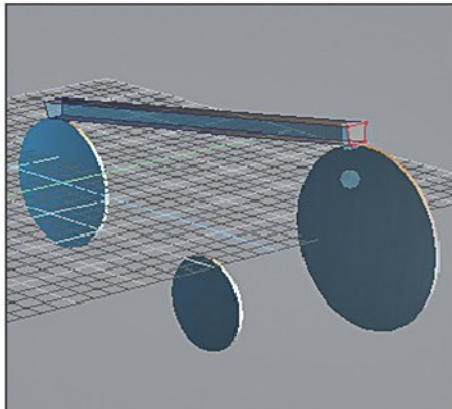


building steps shown in part four. The three following shapes, at the pulley centres, will act as a visual reference, and help to show up any modelling errors: [Cylinder: ZL0/YR90/XS7/YS7/ZS0.2] [Copy: YL22/ZL2/XS9/YS9] [Copy: YL11/ZL-4/XS5/YS5]

First, a 2D shape for the belt cross-section will be made. As a change to the method used in previous articles, this will be made from a flat plane. Click [Reset View], then [Plane: XS1.2/YS0.9]. Select the nearest right-hand edge with [Point Edit: Edges], and [XS0.9], then [Object Tool] to finish.

Move the shape from its present position at pulley 1's centre to [YL-4] (a distance of R1 grid squares). The shape will now be moved to the starting position SP, and at the same time it will be given the correct starting orientation. Click [Axes], [Normalize Location], [Axes] (moving the object's axes to the pulley centre). Type [XR82.21] to rotate the shape by angle A4. Make the first straight extrusion stage by left-and-right clicking [Sweep] and set Z:22.068 (distance L1) in the Sweep/Tip Panel. You should have this:

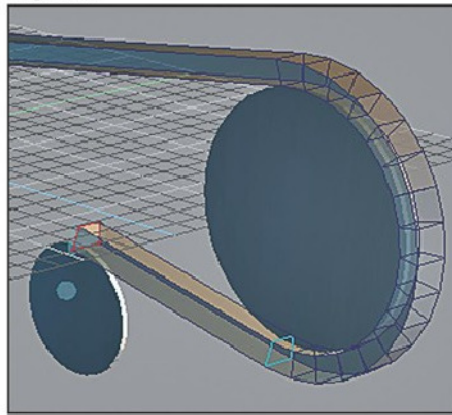
Fig. 146



For the first rotational extrusion: [Lathe] - Angle:198.86 (=A2 in fig 2), Radius:5 (=R2), Rotation:270, and Segments - whatever you like!

Next, [Sweep] with Z:9.644 (=L2), this should be the result so far:

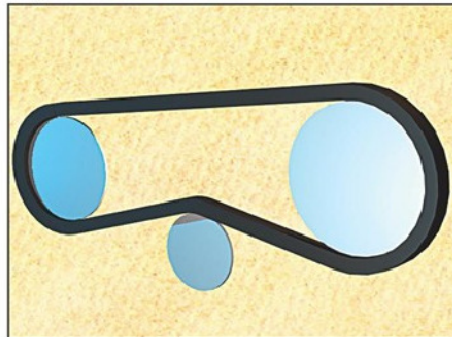
Fig. 147



The last three extrusions are:
[Lathe] - Angle:27.81 (=A3), Radius:3 (=R3), Rotation:0.
[Sweep] - Z:9.381 (=L3), and
[Lathe] - Angle:188.96 (=A1), Radius:4 (=R1)

Click [Object Tool], and you should have a V-belt with no gap or overlap at the starting point.

Fig. 148



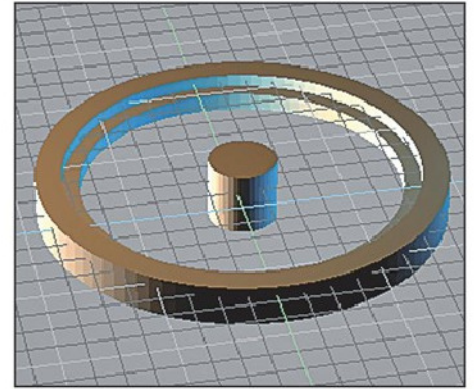
A flywheel

Components made from castings can be some of the more difficult engineering objects to model. To finish this article, I'll show a couple of examples of such components, the first of these is a large flywheel.

[Reset View], then start with a boss: [Cylinder:XS2.5/YS2.5]. For the rim, set

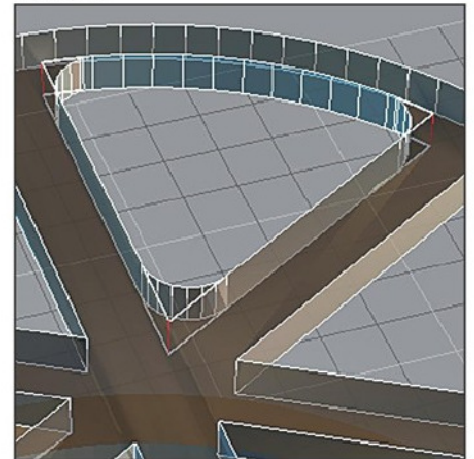
Longitude:96 (a large number divisible by both 4 and 6), and [Cylinder:XS15/YS15/ZS1.5]. [Copy:XS13/YS13], then [Copy] again. Subtract one of these smaller copies from the larger cylinder (no change will be visible in Solid Render Mode). Select the second copy and type [ZS0.6], then [Copy:XS11.8/YS11.8]. Subtract the smaller cylinder from the larger. There should now be a boss and two rim objects like this:

Fig. 149



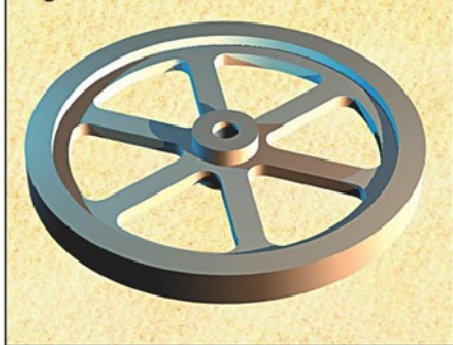
Add a [Cube:XS12/YS1.0/ZS0.6], then two rotated copies: [Copy:ZR60] and [Copy:ZR-60]. Select the innermost ring of the flywheel rim, and join it to the three cuboids with [Object Union]. To see the next modelling stage clearly, temporarily move this object upwards with [ZL10], and adjust the viewpoint so that the six triangular openings fill the whole screen. Right-and-left-click [Fillet Tool] and set Radius:0.6 and Division Angle:15. Click the vertical edge in each of the three corners of one triangular opening, producing rounded fillets like this:

Fig. 150



Continue adding fillets to the other 15 corners in the other openings, then [Object Tool] to finish. The filleting operations have also left some undesirable sunken faces in the corners. However, the object can be cleaned up with [Cube:ZL10/XS16/YS16/ZS0.4], followed by using [Object Intersection] with the cuboid and the imperfect object. Restore the original object's thickness with [ZS0.6], and its position with [ZL1]. Finally, [Object Union] the three objects together, and subtract this object: [Cylinder:XS1/YS1/ZS3] to make the bore.

Fig. 151



Modelling in inches

Most of the examples in this series have been chosen to demonstrate specific 3D modelling techniques. The final object this month is different, as it shows the steps needed to model a real-world component. The example is based on a drawing of a driving wheel from Martin Evans' 'Metro', with some additional details determined by looking at photographs of the same model. It's possible that there are some mistakes in the modelling (I know little about locomotives), but the approach should at least give you a starting point for making an improved virtual model.

This example is also a departure from all previous models because it is created from inch measurements. TrueSpace works equally well with imperial or metric systems, and even vulgar fractions can be handled without too much difficulty. Such fractions can be typed into the Object Info Panel (almost) directly without the need to convert them to decimal fractions first. So, for example, half an inch is typed as $\frac{1}{2}$ (one divided by two), and twenty-three thirty-seconds of an inch as $\frac{23}{32}$. A measurement consisting of both whole and fractional parts does have to include an addition sign, however, so five and thirteen sixteenth inches is $5+\frac{13}{16}$. Unfortunately, this convenient input feature is not available when typing numbers into the tool parameter panels, so, for these values, vulgar fractions will have to be converted to decimal equivalents first. In the modelling steps shown for the driving wheel, I'll use both vulgar fraction ([XS5+1/2]), and decimal fraction ([YS4.4]) values, depending on whether these were taken from the drawing or estimated from photographs.

When specifying an object in inch values, each grid square in the TrueSpace work area will represent one inch. The example wheel model will therefore be at a different scale to the other models in this series, where one grid square equals one centimetre. My personal preference is to have all models at the same metric scale, so on completing the wheel I would convert it to make one grid square equal to one centimetre by multiplying the object's sizes by a factor of 2.54 (by typing *2.54 Enter after the X, Y and Z size values in the Info Panel). If there were more than one object in a particular model, all X, Y and Z location values would also need to be similarly multiplied by 2.54, or, perhaps more simply, the objects could be made into a single large group and modified with a single change to XS, YS and ZS. Conversion is also possible in the other direction if you would prefer to have imperially scaled

models. You could create a model using the values given in millimetres on a metric drawing, and when finished convert it to inches by dividing its size (and location) values by 25.4.

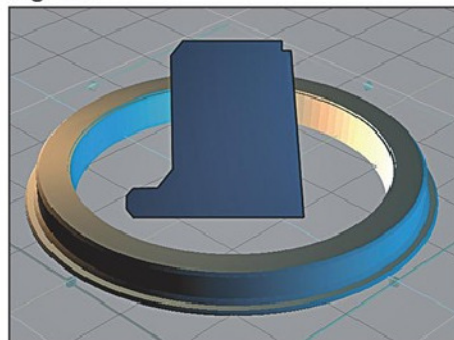
A locomotive wheel

I had planned to start the modelling in this example with cylinders, which would then have fillets applied. Unfortunately, the Fillet Tool does not always work correctly (when object's are thin, I think), so this simplest of methods could not be used. Instead, I'll start the wheel with a cylinder, and build up the shape with extrusions and bevels.

[Reset View], and set a large cylinder Longitude (I used 96, i.e. six segments for each of the 16 spokes). Add a [Cylinder], then [Axes], [Normalize Location], [Axes], and [XS5+3/4;YS5+3/4;ZS1/32]. (I'll use semicolons between the parameters in this imperial example, to avoid confusion between the previously used "/" character and division signs). Select the top cylinder face with [Point Edit: Faces], and [XS5+13/16;YS5+13/16]. Use the [Sweep] tool with Z:0.0313 ($=\frac{1}{32}$ inch). Right-and-left-click [Bevel] set the Bevel value to 0.0442 ($=\sqrt{2} \times \frac{1}{32}$ inch), and Angle:45. Click [Object Tool], [Point Edit: Faces], and select the top surface again. (This step is needed otherwise the following operation won't work correctly). [Sweep], and then type [ZL3/32;XS5+9/16;YS5+9/16]. Use the [Bevel] tool with Bevel:0.0884 ($=\sqrt{2} \times \frac{1}{16}$ inch) and the Angle unchanged. Then once again [Object Tool], [Point Edit: Faces], and reselect the top face. [Sweep], and [ZL33/64], [Bevel] with Bevel:0.0663 ($=\sqrt{2} \times \frac{3}{64}$), and [Object Tool] to finish.

To complete this part of the wheel, two modified cylinders will now be subtracted. (These steps can be seen more clearly in Wireframe display mode). Click [Cylinder], [Axes], [ZL2], and [Axes], which moves the axes to the top face. Type [ZL9/16;XS4+9/16;YS4+9/16;ZS1/32]. [Copy:XS4+1/2;YS4+1/2;ZS9/16], then pick the lowest end face of the cylinder with [Point Edit: Faces], and type [XS4.4;YS4.4], [Object Tool]. The sloping side of this object, when subtracted from the wheel, will create a 5° draught angle. Finally, Subtract these two objects from the wheel. Here's the model so far, together with an enlarged cross-section through one side of the wheel:

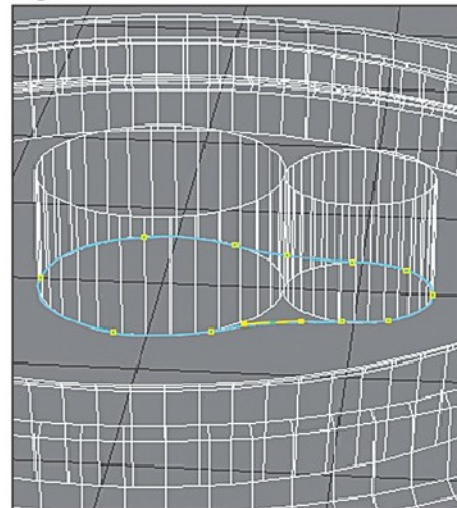
Fig. 152



The hub will be drawn freehand, using two cylinders as a guide. Make the first with [Cylinder], [Axes], [Normalize Location] and [Axes]. Then [XS5/4;YS5/4;ZS21/32], followed by [Copy:YL1;XS3/4;YS3/4]. Change to

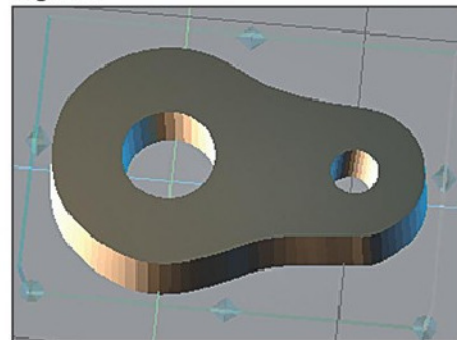
Wireframe mode, and click [Add Curve]. Left-click about 12 equally spaced points around the base of the two cylinders, as shown in the next diagram, then use a right-click to close the curve. Edit the 2D shape to get a good fit around the cylinders by clicking and dragging individual nodes (points). The ends of the yellow bars can also be clicked and dragged to adjust the sharpness and smoothness of the curve. This next picture is a perspective view, but it is perhaps easier to draw the curve in a top view.

Fig. 153



When you're satisfied with the shape, click [Sweep], [Object Tool], and type [ZS21/33]. Add a sloping side to the object by selecting its lower face with [Point Edit: Faces], and typing [XS1.35;YS2.1], then [Object Tool]. Pick the larger guide cylinder, and [XS1/2;YS1/2], then make the smaller cylinder [XS1/4;YS1/4]. Subtract the two cylinders from the new shape to give:

Fig. 154



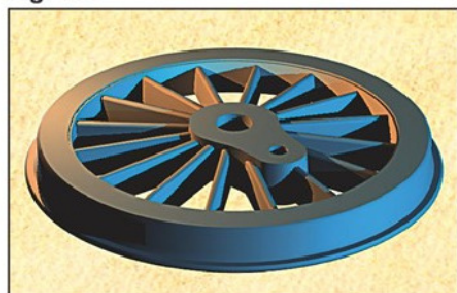
And finally - the spokes

Click [Cube], then [Axes], [XL1;ZL0], and [Axes]. Move and resize the cube with: [XL-9/16;ZL1/16;XS7/4;YS3/16;ZS1/2]

With [Point Edit: Faces], select the cuboid's top face, and type [YS1/8]. Adjust the viewpoint to look at the outermost end face of the spoke, and pick the topmost edge of the face with [Point Edit: Edges]. Reduce this edge's length, and lower its position with [XS3/32;ZL15/32], then [Object Tool]. Right-and-left-click [Fillet Tool], set Radius:0.04 and Division Angle:30, and click both of the two longest edges on the top face of the spoke, rounding it over. Click [Object Tool].

With one spoke completed, it will now be copied with an object array. Right-and-left-click [Create radial array of objects], and click once in the workspace near the centre of the wheel. In the Radial Array Options Panel, make # Segments:16, Center X:0, and Center Y:0 (the first two buttons in the panel should be depressed). The spokes are now complete, but one spoke overlaps one of the holes in the hub. To correct this, click [Convert an array to a group of objects], press the Down Arrow keyboard key, then pick the relevant spoke. Select the innermost end face on the spoke with [Point Edit: Faces], and type [YL5/4], then [Object Tool], and the Up Arrow key. To finish the wheel, combine the spoke group with the other two wheel objects using either [Glue as Sibling] or [Object Union].

Fig. 155



The large number of steps needed to build the wheel is typical of modelling a component of moderate complexity. A long written description was needed, but with practise the modelling itself should not take long; many of the steps can be implemented quickly, almost without thinking about them. With many components like this one, the time needed for designing and choosing measurements is many times longer than doing the actual modelling. You may be pleased to read, though, that this is the most complicated object that will be shown in this series!

The wheel shown in the last diagram this month has balance weights with rivets, and in addition the ends of the spokes are filleted. There isn't space here to describe this modelling, but if you want to try it for yourself, perhaps the quickest way to make the weights (using only techniques described so far in this series) is to draw a 2D shape with [Add Polyline], then extrude it with [Sweep]. Making filleted ends for the spokes is more tricky. I did this by making gaps between the spoke ends and the two other objects, then applying an outward bevel to the ends. The outer gaps were created by intersecting the spokes with a 16 sided cylinder, and the inner gaps by subtracting an object made with [Add Polyline] and [Sweep].



Fig. 156

Next Month: In part seven there will be a temporary break from model building. Instead, some techniques and tips for creating realistic images of your models will be shown.

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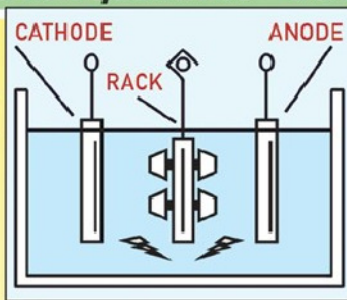
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HOW TO REFURBISH A TOM SENIOR M1 HORIZONTAL MILL ②

Mick Whittingham
rebuilds his mill

STRIPPING THE SUB-ASSEMBLIES

Coolant pump

The pump is of a cylindrical design and has a sliding vane type action. A line diagram of the pump is included. Fig. 5 illustrates the layout and operation of this type of pump. First remove the drive pulley via its Allen grub screw. This reveals that the pump shaft/rotor is made of bronze. The end cap is secured by four Allen screws and when these are removed the rotor and vanes can be seen. Or not as in my case the pump was seized solid with rusty coolant from who knows how long ago. After a good soak in white spirit and a gentle wire brush the rotor came free. The rotor sits within a cylindrical chamber and is mounted eccentric to the casing walls. The vanes consist of two separate steel plates fitted in a slot cut in the rotor. They are free to slide within the slot and are held apart and in contact with the chamber walls by a thin leaf spring. This had rusted away in my pump and so I replaced it with a sliver of 10 thou feeler strip cut to size. Rotating the shaft demonstrates how the pump works; each vane sliding in its slot and varying the amount of space available between the rotor and chamber walls. This change in volume creates a pumping action. The vane type pump is not self-priming and so a squirt of oil down the pick up tube prior to first operation will get the flow moving. The pick up tube, which falls vertically down into the coolant sump, has a gravity type ball valve fitted. This acts as an anti back siphon device so that when the coolant flow is shut off the system does not drain back to the sump and therefore require



*As advertised,
in need of some
attention.*

VANE TYPE PUMP CONSTRUCTION

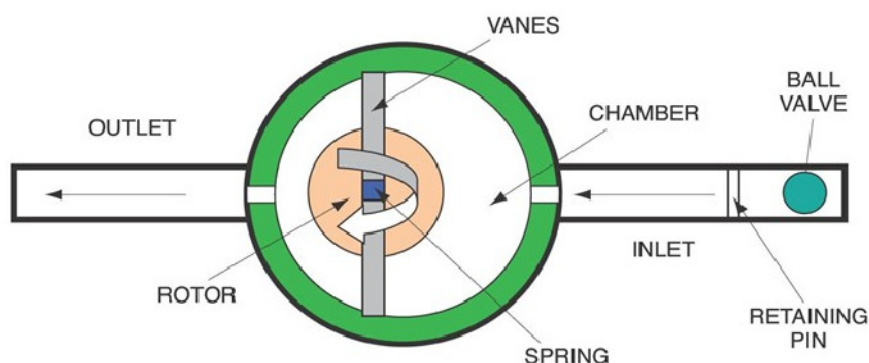


Fig. 5

priming each time the pump is operated. The ball is prevented from entering the pump by a retaining pin tapped through the pick up pipe. I replaced the rusted ball with a stainless steel one and a stainless set screw as a retaining pin. A new gasket is required and the pump can be rebuilt ready for re-fitting.

Power feed gearbox

This is a small three speed and neutral sliding mesh gearbox which transmits power via a Vee belt drive from the spindle shaft. This arrangement allows the operator to select 36 different feed rates, this being the twelve belt selectable spindle speeds, multiplied by the three ratios available through the gearbox, **photo 11**.

Gears are selected via a small lever, which acts on a gear cluster free to slide on the input shaft. This in turn transmits drive to the lower output shaft and on to the saddle via a sliding shaft assembly.

The oil level is checked by way of a sight glass or in some cases a dipstick located in the top filler bung. A drain plug in the bottom of the unit allows the old oil to be drained before removal. I did this a day or so before removing the gearbox from the column so that as much oil as possible could drain.

Four Allen screws secure the front plate of the gearbox. A cork gasket held the cover firmly in place and was unfortunately destroyed while separating the two. When the front plate is removed it reveals the selector lever assembly. The lever acts on a brass selector fork, which moves the sliding gear into mesh. It also has a sprung ball detent which sits in corresponding hollows in the cover plate to hold the lever in each ratio or neutral. Removing the lever by slackening the collar retaining grub screw will allow the assembly to be removed.

If the gearbox is to be repainted, remove the information plate and keep it safe. Some units may have a transfer type label rather than an aluminium plate and you may need to make a waterslide transfer of such labels if the originals are going to be destroyed. I have included a version of this type of label in the article on Label Making in the last issue.

The input shaft is removed by slackening a grub screw on the collar on the output side of the housing, then withdrawing the shaft from the input side of the housing whilst supporting the sliding gear.

The output shaft has a sintered bronze bush at the output side. If the shaft is pressed out toward the input side it can be withdrawn, releasing the bush and gear cluster.

Garter type oil seals are located on either end of the input and output shafts and these can be removed and replaced very cheaply. The two sizes are: input ends 1 3/8 in. x 7/8 in. Output ends are 1 in. x 5/8 in.

The gasket can be made up from an appropriate material or an instant gasket compound used, as you prefer.

Saddle

The saddle carries the X axis table and also contains the power feed dog clutch mechanism. This can be of slightly differing construction so I will describe the setup on my machine and any deviation from that should be easy to deal with on individual machines.

The saddle has an integral oil sump and this is filled, depending on the year, by either a sprung lid cup on the front face of the saddle or a small filler cap on the top surface, both conveniently labelled, **photo 12**. The oil level is checked by a sight glass window in the front face of the saddle. This is usually stained with old oil but can be cleaned effectively by standing the saddle on its front face and injecting white spirit through the holes in the casting, a good soak and the glass will be much cleaner.

The oil sump is painted white and this helps in checking how contaminated the oil is. Two access plates are fitted to the right hand side of the saddle and these allow access to the worm and wheel drive mechanism of the power feed. An oil drain

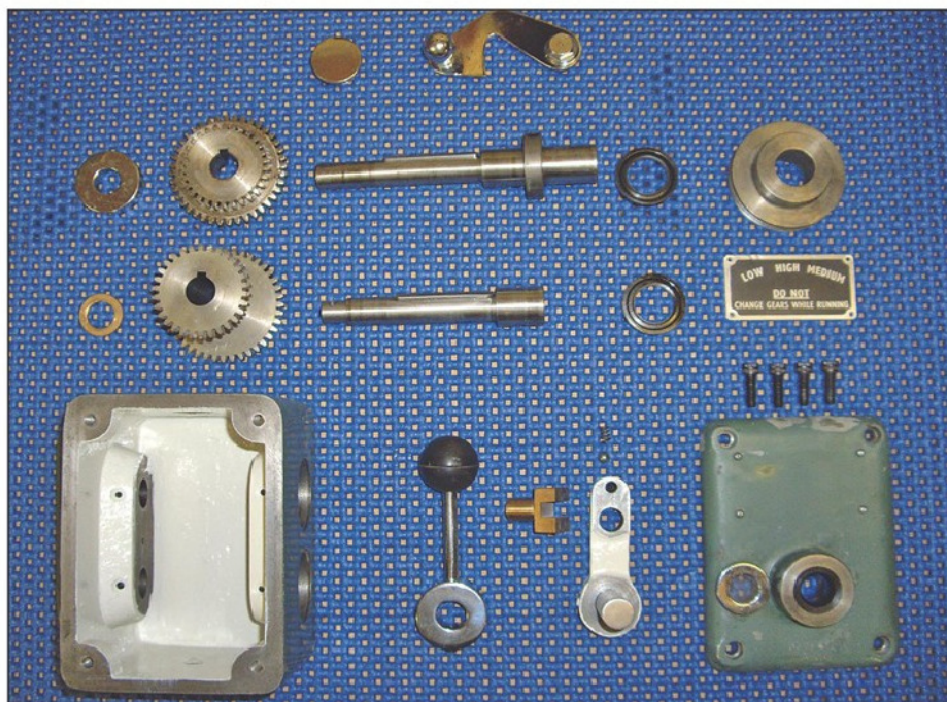


Photo 11. Exploded view of gearbox.

plug is screwed into the bottom face of the lower plate.

The worm wheel is secured to a hollow shaft, which transmits rotary motion from the power feed worm via a dog clutch, which is keyed onto the X-axis leadscrew. The dog clutch unit is released once the leadscrew is withdrawn and so will be sitting in the well of the oil sump. Removing a grub screw in the bronze worm wheel will allow the hollow shaft to be drifted back toward the oil sump, thus releasing the worm wheel and in turn the worm itself. The worm can be withdrawn from the saddle complete with the power feed sliding shaft after first removing a grub screw in the end face of the saddle which holds a bronze bush in place and a grub screw which holds the inner section of the cover tube.

The power feed engaging lever on the front face of the saddle is secured by two Allen set screws in the front face of a square collar. An Allen set screw, which is counterbored into the top face and a "torpedo" shaped disengage rod must also be withdrawn prior to easing the lever assembly from the saddle. The lever itself has a spring detent in the square collar.

A sliding "dead stop" dog is located to the left of the power feed lever which assists in accurate table travel for slot cutting etc. This is secured by a knurled knob and may be seized in due to lack of use.

Knee

The knee is simply a cast unit with dovetail slides for fitting to the column and saddle. It does however house a crown wheel and pinion gear arrangement to operate the table raise leadscrew. The pinion is fixed to the handwheel shaft by a tapered pin. The leadscrew itself is secured to the knee by a countersunk Allen screw located beneath a metal plate accessed through the top face of the knee casting. Unless there is any significant wear in the bronze bushes carrying the leadscrew or handwheel shaft there should be no need to disassemble this unit.



Photo 12. Gearbox filling detail.

Swarf tray

This is a pressed steel construction with punched and profiled holes for coolant drainage and bolting through. My example was in good condition and needed only light straightening and rubbing down prior to priming. I have seen examples with a modification to allow the machine to be sited in a corner space, chopping away sections of the rear corners, re-folding the edges and welding to make good. I have not seen the access that siting the machine in this way would allow and before getting out the angle grinder I would seriously consider if such major surgery is necessary. The machine needs about 15 inches of clearance between the rear face of the column and any wall it is placed against to allow for the belt cover to be swung fully open and to allow withdrawal of the draw bar (I forgot about this and had to move the machine when it was completed). I am not sure that good access to the belts etc. would be available if the machine was placed in a corner.

Base

The base is fabricated from steel plate but at first glance looks like a substantial casting. This is partly because of the



Photo 13. Coolant tank painted up.

excellent welding job and partly because of the filling and finishing of the unit which gives it a cast appearance. In common with many of the renovation projects I have undertaken the stand had suffered the most corrosion and paint damage. Perhaps because it is in contact with the floor and any dampness etc. that might allow or perhaps because it is not smothered in lubricant and coolant oils like the majority of the machine is. In any event my example required completely stripping back to bare metal prior to filling and painting. The top of the base forms a shallow coolant tank and after a good clean this section should be primed and painted to effectively contain cutting oil. I painted the area immediately below the knee in white gloss enamel for no other reason than I thought it a good idea in case I dropped something in the drain holes. I think the light colour would allow me to see to retrieve it from the murky depths or neat cutting oil, we shall see if this works when the time comes, **photo 13**.

The base has a drain hole for spent coolant consisting of a 90 degree bent pipe threaded into the right hand wall with a "stop end" cap screwed on the outer end. This may need removing and clearing out if old coolant has solidified inside it.

Belt covers

The rear belt cover is a simple alloy casting and needs nothing more than a rub down and clean, filling any dings before repainting.

A "J" shaped catch located on the top of the power feed gearbox holds the cover closed when working by locking round a chromed steel pin fixed to the top of the belt drive cover. This pin needs to be masked when painting, as it does not appear to be removable.

The column door is cast iron and mine needed a good deal of filling and sanding to make it look good prior to painting. The chromed doorknob is grub screwed to a shaft through the door, which acts on a cam shaped latch that pulls the door shut in operation. This can be removed to aid painting. The information plate is affixed inside the column door and as previously mentioned this was removed to assist the painting process.



Photo 14. Column filled ready to rub down.

The insides of the machine were painted an off white colour. I had a 1 litre tin of "Renault" white machine enamel doing nothing and this proved to be just the ticket for sprucing up the interior.

All inner surfaces of the saddle, column, knee, belt guards, PF gearbox etc. were treated with several coats of this paint to give an oil resistant, wipe clean finish I can keep on top of when the machine is in use.

Column

Although we left the column as a bare casting during the stripping phase it still requires some attention to prepare it for the re-build, **photos 14 and 15**.

Several different electrical systems and other attachments have left my column with an excess of holes drilled into it. Not wishing to take advantage of their limited addition to cooling of the workings I filled all unwanted holes with sanding filler and sanded them smooth. The motor had been changed at some point as there were four extra mounting holes on the top of the column and these were filled to avoid dirt getting into the heart of the machine.



Photo 15. Gearbox joint for rubbing down.

I also dealt with the myriad of gouges, dings and surface imperfections by copious filling and sanding. This might seem like a lot of trouble but if you consider the amount of care that was originally put in to the surface finish of Tom senior products then I feel it is only right to try and emulate that. If the machine is in so many pieces then it would be folly not to go the extra mile and make the effort.

The dovetail slide of the column runs the full length of the machine, top to bottom. One of the features Tom Senior was rightly proud of was the hand frosted finish of the dovetail and bright parts of their machinery, **photo 16**. This finish looks like a series of squiggles etched into the surface of the metal and I believe it is achieved by hand scraping. I intend to read up on and practice this "black art" but understand it is rather difficult. If I have any success I will be sure and share it. In the meantime it may be necessary to gently clean any surface rust from the slide whilst doing your best to leave the hand frosting intact. A very mild scouring pad will brighten the finish without damaging the delicate patterning.

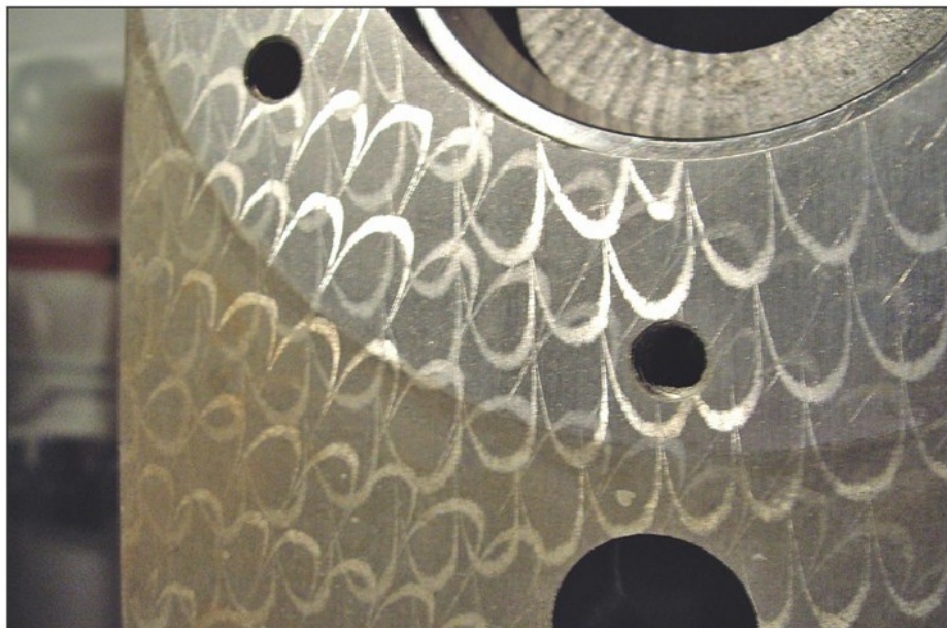


Photo 16. Detail of original hand scraped finish.

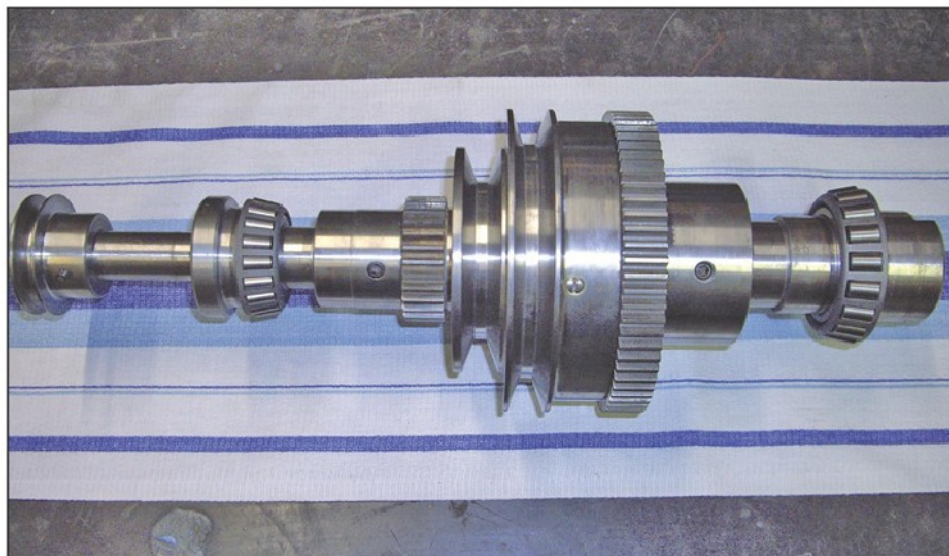


Photo 17. Main shaft cleaned up.

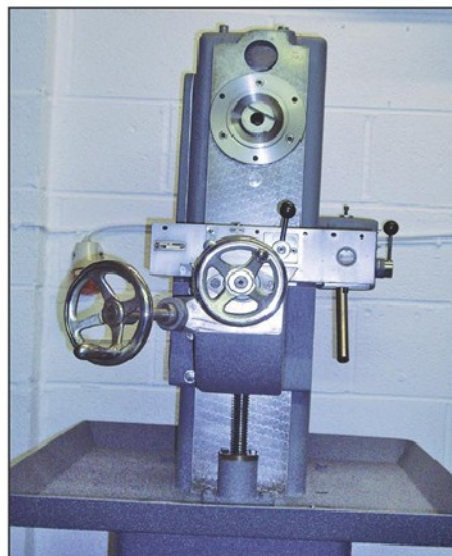


Photo 18. Part built and in primer with bearing covers fitted.

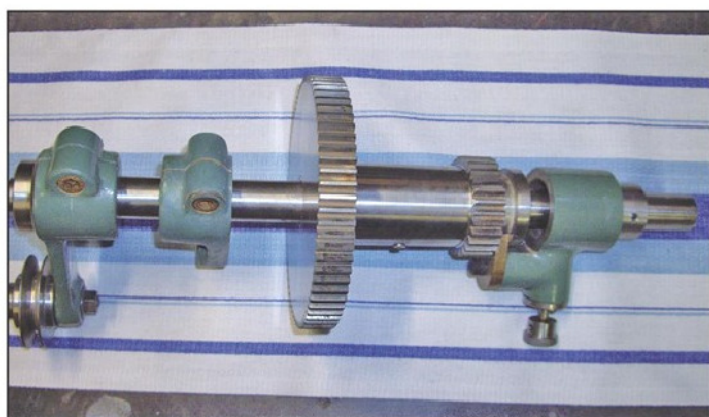


Photo 19. Layshaft cleaned up.



Photo 20. Counter shaft cleaned up.

Once the major sub assemblies have been cleaned, filled and prepped the rebuilding process can begin.

The ideal way to begin the rebuild is to site the machine where it will ultimately stand in the workshop. This will prevent the machine having to be moved when it is substantially complete and obviously much heavier. As long as there is sufficient room to work around the machine in its proposed location I would choose to rebuild it there. Also remember the clearances required to open the rear belt cover and remove the drawbar. I put my machine three inches too close to the wall and had to move it when it was rebuilt, Doh!!

First the base unit should be sat on anti-vibration pads or specially made adjustable feet as you see fit. If you are moving the machine later then you may skip this step and deal with the mountings when the machine is finally sited.

Next, the swarf tray is seated over its mounting holes and the four securing bolts screwed home tight. At this point I made three metal lids to sit in the larger drain holes of the tray to stop me losing objects down them while the rebuild went on.

The column casting is then lifted into place over its mounting holes and lined up using a "podger" or tapered spike to get the holes in line. All four securing bolts should be started on their threads before the column is finally tightened down. At this point I repainted the inside of the column with a few more coats of white enamel. This

reinforced the finish and also sealed the column to the swarf tray so that any oil dripping into the bottom of the column would be held there for easy cleaning.

I then fitted the power feed gearbox to the column. As mentioned before this item will require a degree of filling to smooth the joints prior to painting.

The mounting boss and raising leadscrew is fitted to the base so that it can be painted into the swarf tray to achieve an oil proof seal around its base.

At this stage the joints between column and base and the power feed gearbox are filled with P38 type sanding filler and rubbed smooth. This work results in the whole unit looking like one casting and is well worth the extra effort. Several coats of grey primer were applied and rubbed down between coats to prepare the surface for the finishing colour. When all was thoroughly dry I began painting with the Senior Green colour obtained specially for the job. Several coats are required with light rubbing down between each coat to provide a key. I do this before refitting any of the major components to avoid getting paint all over them. This means care has to be taken when fitting parts to the newly painted machine to avoid damage.

When the basic machine is painted and has had a few good days to harden off completely then the job of refitting the sundry items can begin.

Essentially it is the reverse process of removing them and making sure

everything fits and slides as it should. The builder can choose which of the major assemblies to start with but for me I decided to finish the column and test the running gear before proceeding further.

The Spindle shaft, **photo 17** was fitted first, the roller bearings were re-packed with a high grade bearing grease and the shaft re-inserted into the column. Each element of the back gear cone and pulley cone has to be threaded onto the shaft as it is passed into the column, remember to place the spindle pulley belt over the shaft before pushing it through the back bearing housing, (fiddly but you will kick yourself if you forget and have to take the shaft back out to fit the belt). The bearing and retaining nut can then be slid onto the shaft and tightened gradually to pull the bearing onto the shaft. I adjusted my bearing initially to remove any play but will monitor and re-adjust it as the machine is run in. The front and rear bearing covers can be re-fitted at this stage to keep dirt out of the newly greased bearings, **photo 18**.

The backgear shaft, **photo 19** is next and this is passed from the rear to the front of the column, threading on the idler and selector assembly as you go and making sure the belt goes around the whole assembly. The front end of the shaft lies flush with the dovetail column and the anchor plate can be refitted and tightened once the shaft is in position.

The lower idler pulley, **photo 20** is last to be re-homed and it is a simple matter of placing the inner pulley and adjuster assembly within the column and sliding the outer eccentric bush over the shaft and into place on the adjuster before bolting it in place. The drip feed oil cup can be refitted to the adjuster and the belt eased over the pulley into place. If the belt is too tight to allow this, the eccentric can be adjusted by slackening the Allen grub screw located on the casting and allowing the eccentric to turn till the belt will fit. This feature may need some future adjustment as the belt wears in.

The outer pulleys can now be refitted to each shaft and the power feed gearbox input shaft fitted. The Y shaped idler assembly can be replaced on the backgear shaft but do not fit the belt yet as the motor belt must go on first.

The coolant pump is refitted to the column but again its drive belt should be connected between its drive pulley and the main idler after the motor drive belt has been fitted.

The motor should be next on the agenda and I modified the mounting slightly, which appeared to be an earlier modification of an earlier modification of a

previous bodge. I made large thick washers which sat between the mounting studs and the motor feet rather than the 6mm thick plates which had been previously used. They look better and disguise the fact that the new stud holes were drilled off square, **photo 21**.

With the motor in place and the main drive belts fitted and tensioned I ran the motor to see if all was well, just a few minutes in lowest backgear to settle my mind that nothing serious was wrong. Remember that the direction of rotation for the cutter spindle is Anti-clockwise so wiring the motor must take this into account. If the spindle runs clockwise the power feed will run in the opposite direction so it is essential to set up the motor to run correctly.

At this stage the subsidiary drives for the power feed and coolant pump can be fitted and run to check their operation, **photo 22**. Remember the drive belt for the suds pump should be left off if the machine is being used without coolant, otherwise the pump could be damaged.

With the basic machine now working attention turns to the knee, saddle and table assemblies. Assuming they have all been painted prior to the rebuild, the

process is straightforward and a systematic approach will see the unit rebuilt in a short time.

The knee is positioned onto the dovetail of the column and lowered onto the raising leadscrew, where it will sit quite comfortably whilst the sliding dovetail gib piece is slid into place and secured with three square headed adjusting bolts. Remember to make sure the brass locking piece is in the gib strip before you fit it. The leadscrew retaining washer and screw can be refitted and the cover plate replaced ready to fit the saddle. A little gasket compound on the cover plate will stop coolant getting into the leadscrew assembly and is a worthwhile addition.

The saddle is next but before it can be sat on the knee dovetail slides the power feed drive shaft must be fitted to the gearbox output shaft by means of the tapered pin, **photo 23**. The worm is still attached to the saddle end of the shaft and as the saddle is sat on the knee dovetails the worm should be fed into the saddle gearbox. The bronze bush is secured by a grub screw in the saddle and the inner section of sliding shaft cover is held to the saddle by a second grub screw. The universal joints of the drive shaft should



Photo 21. The motor mounts.

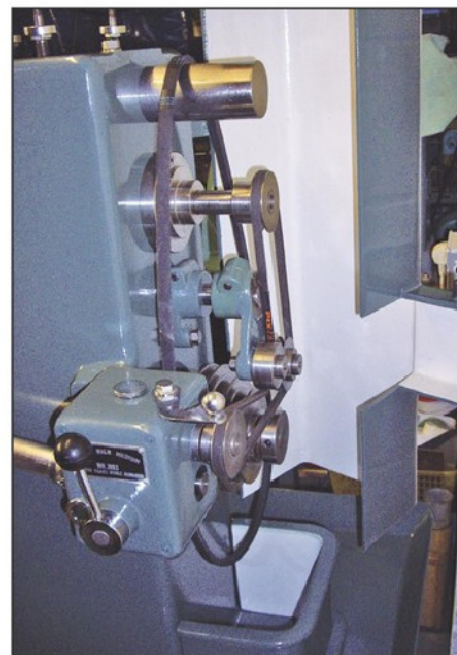


Photo 22. Drive belts have been fitted.



Photo 23. Gearbox and shaft refitted.

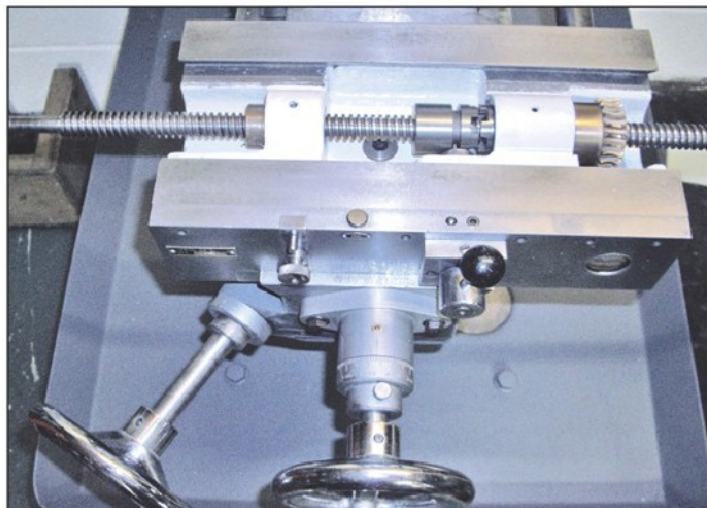


Photo 24. Leadscrew fitted to saddle.



Photo 25. Table fitted, machine nearly finished.

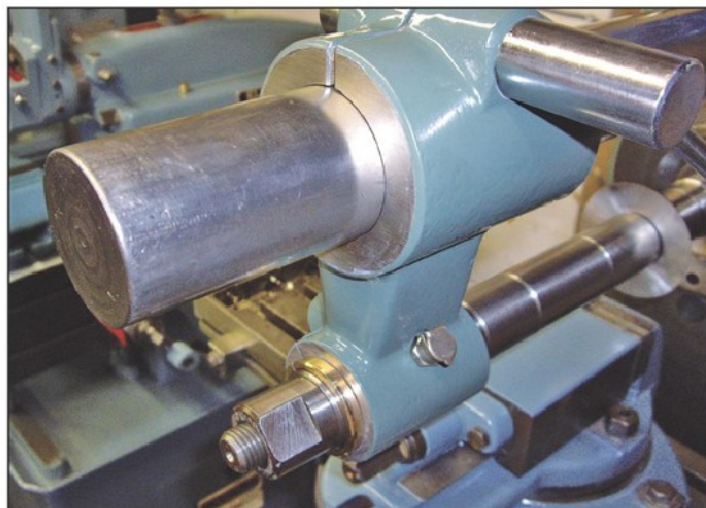


Photo 26. Detail photo of the new split bush.

be well covered in grease before the cover tube is finally fitted over it.

The sliding gib piece can now be refitted to secure the saddle to the knee and the cross slide leadscrew can be wound into its nut and secured to the saddle. The worm wheel and dog clutch mechanism for the table traverse can be refitted to the hollow shaft and the power feed drive tested under power to see that all works. The leadscrew can be fitted without the table, threading it through the worm wheel shaft and sliding the dog clutch drive onto the keyway before winding the screw into the bronze nut. With this in place the whole power feed system can be seen working, **photo 24**.

Once you are happy with the saddle assembly the table can be slid into place and the end plates and gib strips adjusted and secured, **photo 25**.

Now that the machine is essentially together there are a few other parts to attend to before the miller will be ready to use;

The overarm support bar should be fitted, placing the cotter pins in their holes prior to sliding the bar into the head of the column and securing it with the cotters.

The belt covers can be refitted and any other sundry items attended to such as coolant hoses, lights, guards etc. that your machine may or may not have included.

The Cutter Arbor

The cutter arbor is surprisingly delicate and should be treated and fitted with great care, as it needs to be accurately seated. Even small amounts of dirt, debris or even lint from wiping cloths can cause deflection of the cutter arbor if allowed to sit between the mating faces of the spindle, spacers or cutters. It is a precision ground unit and should be treated with respect.

I have taken instruction from Karl Moltrechts Machine Shop Practice manual regarding the assembly procedure and here is a condensed version of how fitting up an arbor should be done;

All mating parts must be scrupulously cleaned immediately

prior to assembly, wiping them with the bare hand to ensure cleanliness. The Morse socket and the Morse taper and seating faces should be cleaned and the arbor inserted before the draw bolt is screwed in from the rear of the column to pull the taper into the socket.

When fitting a cutter and spacing collars the same level of cleanliness must be observed to avoid damaging the arbor. The face of the arbor flange and the face of each spacer in turn must be cleaned prior to assembly. This ensures the arbor is not bent or deflected when the locking nut is tightened up.

The milling cutter should be cleaned and slid onto the shaft in the appropriate position (bear in mind the arbor will turn anti-clockwise) and further spacers fitted along with the support bearing collar

(slightly larger diameter than the regular collars and designed to run in the brass support bearing). The arbor nut should then be cleaned and screwed on but NOT tightened. Doing so before the arbor support is fitted could bend the arbor and ruin it!

The arbor support should be placed over the support arm and bearing and the upper securing lever locked to the support arm. The reservoir should be filled with machine oil and then the arbor nut can be tightened as the arbor is firmly supported and cannot be bent by force applied with the wrench.

The arbor support bearing is slit and has a pinch bolt to take up wear in the bearing. The slit portion of the casting should contain a thin steel spacer shim to prevent the pinch bolt being overtightened, this

spacer should be removed and surface ground to reduce its thickness when the need to tighten the bearing up arises.

I manufactured a new brass bush for my machine using a commercially available bush which needed turning down to outside diameter before drilling for oil and retention holes and slitting to allow adjustment, **photo 26**.

Conclusion

And that is about it, the Tom Senior Miller taken from its present state to a cleaner and hopefully better adjusted and useful condition, **photo 27**. As I mentioned at the beginning I am a hobby level engineer with no special knowledge of the machine or its operation. The methods I have used may not be to everyone's liking and there must certainly be better ways of doing some of the things I have described. I will bend to others knowledge and experience in the matter but can say that the things I did worked for me and should work for you.

I thoroughly enjoyed the project and look forward to using the TS in anger at some future time. I now have to master the Clarkson T&C grinder I obtained as a partner to the mill; apparently sharp milling cutters are a must. ■



Photo 27. Ready to Mill again, have to wire it up first?

FLY CUTTING OF RADIAL FORMS 1

Mick Knights looks at advanced Flycutting

From time to time, the home machinist will have the need to generate radial forms, both concave and convex, onto workpieces. Radial forms on turned components are relatively easy to produce by grinding the required form on a HSS tool bit either by plunge cutting, or generating using the cross and compound slides, until the full form is achieved.

Milling is not quite so straightforward as the form tool has to rotate around the workpiece. Ball nose cutters are not that much more expensive than a conventional end mill, but concave milling cutters are a different matter altogether. The cost is far greater, obviously due to the complicated geometry involved in the grinding of four cutting faces. It is therefore impractical and costly to have to buy a radiusing cutter, for what might only turn out to be a single use.

The quick and inexpensive solution is single point fly cutting. It is probably worth taking a little more time and effort and producing a suitable tool holder, which can be mounted either in an Autolock chuck, or directly in the machine spindle, by means of a spindle collet. This will then enable a wide range of different machining applications and setups to be achieved. By committing to a standard size of cutter blank, a batch of different size cutters can be produced on the same setup, at one time.

For rigidity, it's always best to select the largest collet available. In most cases this will be the 16mm or $\frac{5}{8}$ in. one depending on the system. For these purposes, I have selected 16mm.

To determine the machining dimensions for the tool holder, Fig. 1 simply reproduce the sizes of a standard, screwed shank end mill which in the case of our 16mm cutter is: an overall shank length of 1.750in. (for conformity, metric cutters are identical to imperial with the obvious exception of the



shank diameter) a screwed length of 0.562in. and a major thread diameter of 0.625in. and of course a shank diameter of 16mm. The body is made from one inch diameter stock, with a length of 1.375in.. All that is now required is to identify the pitch of the thread. An imperial diameter would suggest an imperial pitch. This is confirmed with a 20 TPI Whitworth thread gauge, photo 1. The thread gauge also has the appropriate thread diameter stamped on it, in this case it's $\frac{1}{4}$ in. Whit. so the



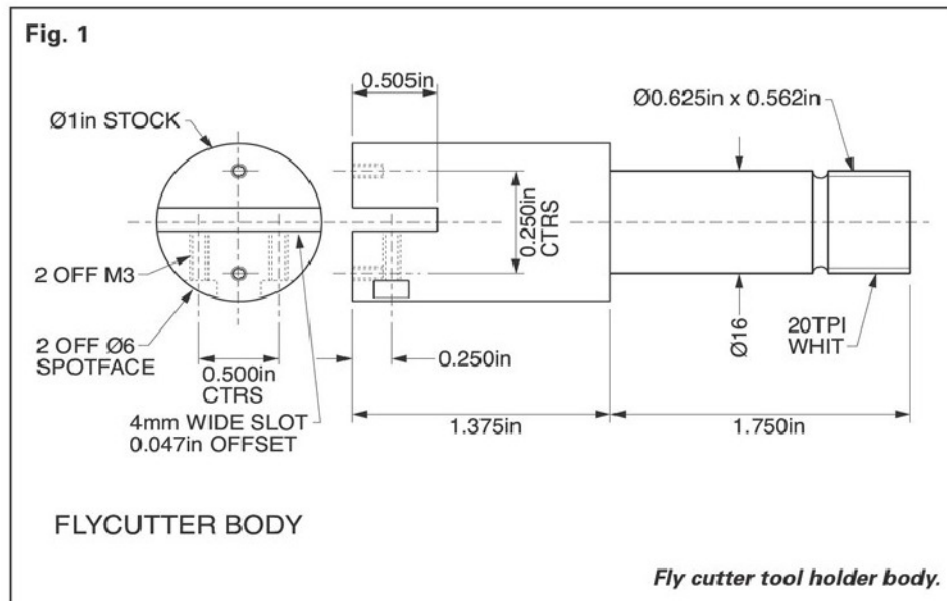
Photo 1. Establishing thread pitch at 20 TPI Whitworth form.

thread is identified as, a $\frac{1}{4}$ in. Whit. form on a $\frac{1}{4}$ in. diameter. The thread depth for screwcutting and any other relevant information can be obtained from a set of workshop thread charts, for $\frac{1}{4}$ in. Whit.

Turning the tool holder

It's a good idea to prove the thread on a surplus piece of stock before screwcutting the tool holder itself, photo 2 especially when change gears are introduced into the gear train to obtain the correct pitch. If this is the first time screwcutting has been attempted on a particular machine, then the manufacturer's instructions should be consulted, to see whether any changes may need to be made to the gear train, in order to achieve an imperial pitch. The majority of machines these days are supplied with a metric lead screw and a 127 tooth gear already in place, so usually, only the two change gears required for the 20 TPI pitch

Fig. 1



Fly cutter tool holder body.

will need to be introduced into the gear train, according to the manufacturers data charts. These are usually found either on the body of the lathe, or in the instruction manual. With some older machines, the operator might have to determine the change gears by calculation. I seem to remember this was extensively covered in a recent issue of MEW.

Position the billet in the chuck, with at least two inches protruding. As long as it runs reasonable true, it will be fine for our purposes as the body will be turned true to the shank in a latter operation.

The end should be faced off and lightly centre drilled. As well as acting as a support while screwcutting, the centre cone will also act as a location in the Autolock. The cone needs to be only a couple of millimetres deep, but must have a good surface finish. The 16mm diameter has to be a snug fit in the collet and therefore must be spot on size. As some hobby lathes have a rather coarse range of feeds, a smooth finish cannot always be guaranteed. If this is the case, then it's a good idea to leave between 0.03mm to 0.05mm for final polishing to size. This is achieved by using a strip of medium (120 grit) emery tape, supported by a flat file, or polishing stick. At this stage I must point out, that if you are new to turning, the perceived wisdom is that, you should never use a file on the lathe while it's running. So I shall have to leave this bit to your own judgement, as in the current

climate of health and safety we must all take responsibility for our actions! Any files employed in this fashion should have a solid wooden handle securely fitted, which will result in a positive feel and safer application. Looping the emery tape round the diameter and running it up and down, will only polish the turning marks deeper into the metal. You also run the risk of trapping your finger between the job and the emery tape. Once done, never repeated!

The emery tape, supported on a flat surface, produces a cutting action, which will then result in a smoother finish. As the majority of bed wear occurs close to the chuck, it's always a good idea to place a piece of paper or card, directly beneath the component being polished, as this will stop any stray carborundum getting under the saddle bed wipers, **photo 3**.

The 0.625in. dia. is then turned for a length of $\frac{5}{16}$ in. This is to ensure that the minimum length of thread of 0.562in. is achieved allowing for a pull out at the end of each pass. A radial undercut at the base of the thread also insures the 16mm dia. is not scored at the end of the pass, **photo 4**. Better too much threaded length, than not enough.

Once the screwcutting lever on the saddle apron is engaged, it shouldn't be disengaged until the screwcutting operation is completed, irrespective of whether the leadscrew is metric or imperial, as this will always ensure the

tool is in the correct synchronised position at every pass. The saddle is returned to the starting position using the lathe's reverse motion. Screwcutting will be made easier by the application of cutting paste at each pass.

When approaching finish depth, the thread should be checked for fit with the Autolock collet. When the thread is just starting to enter the collet, a series of final cuts at the same depth, should allow the two components to fit together snugly, **photo 5**. These passes are known as spring cuts as they allow the cutter to remove the tiny amounts left in the thread form caused by any cutter deflection.

To machine the holder body true to the shank, the Autolock chuck is fitted into the Morse tapered headstock nose. As the chuck is mounted on a holding taper, a draw bar should not be required. The tool holder's shank can then be secured in the Autolock chuck in the same way you would a milling cutter. That is, to screw the locking ring into the body of the chuck, till hand tight. Then screw the tool holder into the collet, until the cone in the shank tightens against the locating centre in the chuck. Release the locking ring one third of a turn. Screw in the tool holder until hand tight against the locating centre. Then finally tighten the locking ring with the spanner.

Face and finish turn the holder, removing the minimum amount of metal to clean up the diameter, **photo 6**.

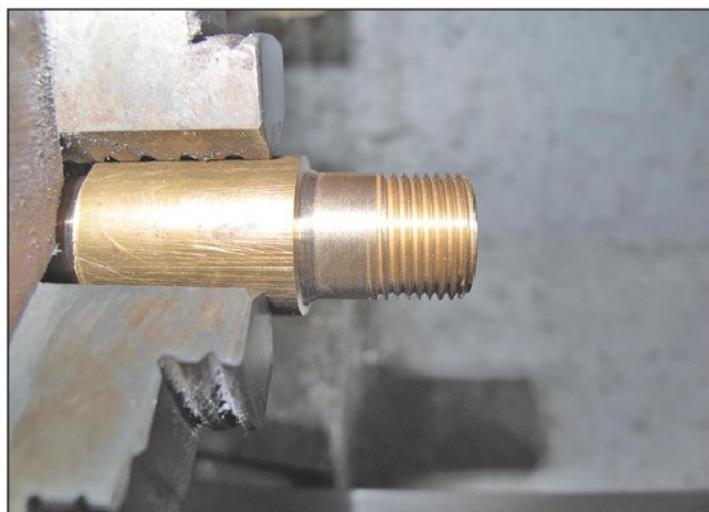


Photo 2. Ensuring correct thread pitch.

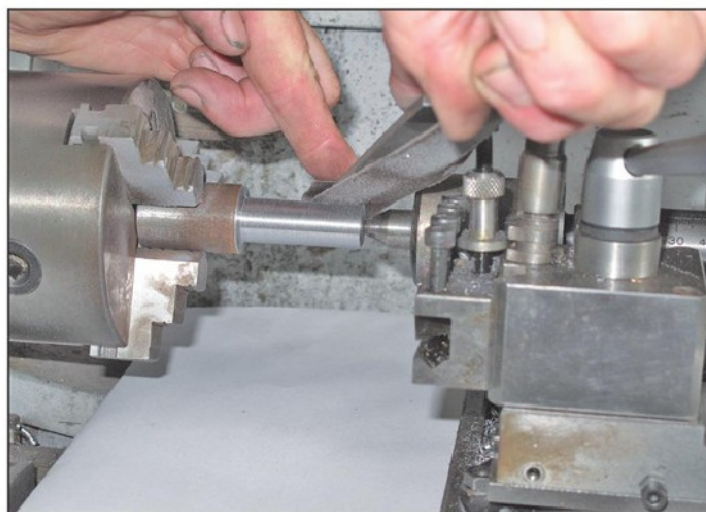


Photo 3. Polishing surface finish, and diameter to size.



Photo 4. Holder ready for screw cutting.



Photo 5. checking thread with the collet.



Photo 6. Turn holder body true, by holding in the Autolock.

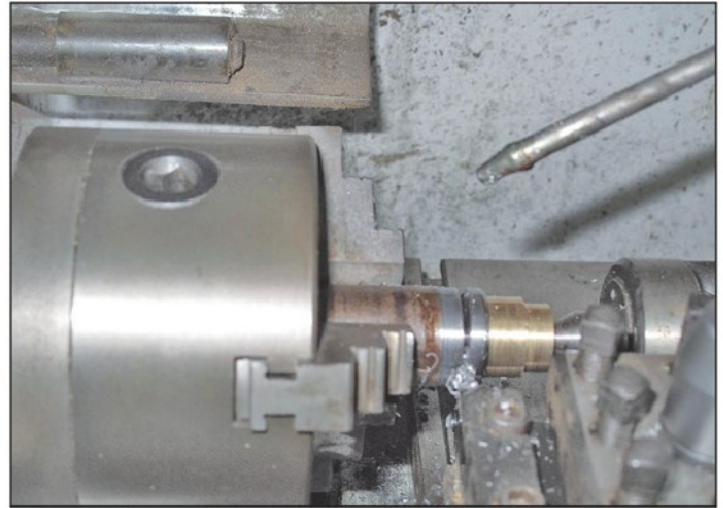


Photo 7. support plate being parted off, with the aid of a pressure pad.

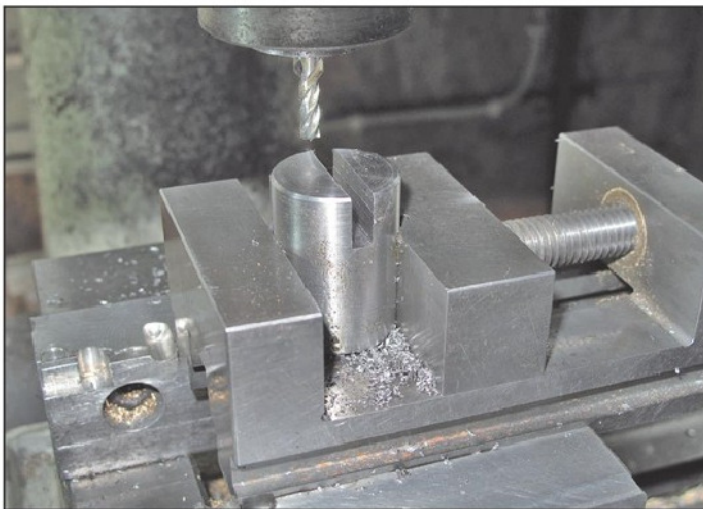


Photo 8. Milling the offset slot.

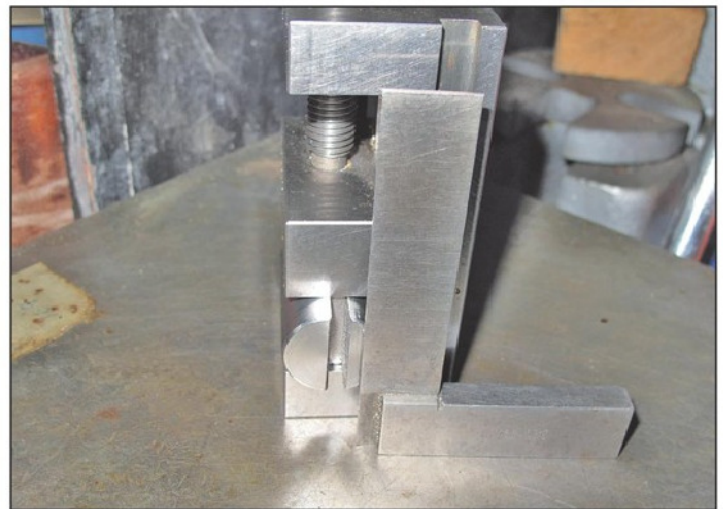


Photo 9. Setting holder to the horizontal plane.

The bottom support plate, **Fig. 2** now needs to be produced from the same diameter mild steel as the holder. The diameter of this plate needs to be turned to the same size as the cleaned up diameter of the tool holder. This is then parted off at 0.187in. thick. Parting off on a hobby lathe can, at times, be a bit tricky,

as smaller lathes are obviously not as robust as their larger cousins. To help absorb any vibration and judder when parting a larger diameter, the workpiece can be supported by means of a pressure pad, held in place by a rotating centre, **photo 7**. The pad need only be a piece of brass with a machined face and a through

hole drilled in it. Enough pressure should be applied to obtain rotation. The pad should not be unduly overtightened. When the parting tool reaches the centre point the pressure releases, but the pad is still held captive by the parting blade and the back centre. Coolant, in this case, is delivered by means of a hand held oil can.

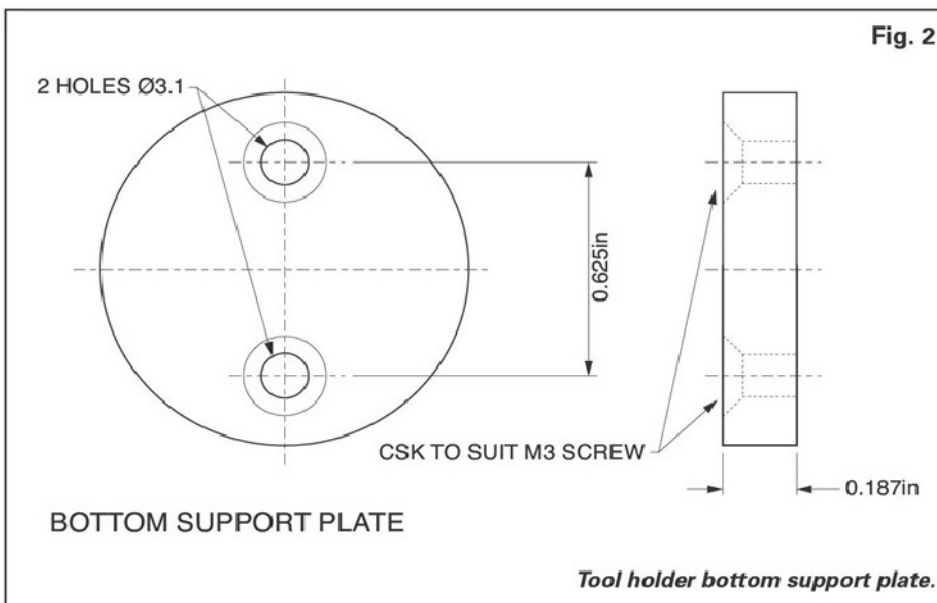


Fig. 2

Milling

The fly cutting tools are produced from $\frac{1}{8}$ in. x $\frac{1}{8}$ in. gauge plate, a.k.a. ground flat stock. As the cutting face needs to be exactly on the centre line of the holder, the locating slot needs to be offset. With a 4mm wide slot, the distance either side of the centre line is 0.078in. so for a cutter of 0.125in. to sit on the centre, the offset has to be 0.047in. (0.125in. - 0.078in.)

The tool holder is clamped in a toolmakers vice, which is located in freshly machined registers in aluminium soft jaws. Using this method will insure that the toolmakers vice relocates in exactly the same position every time, when it is removed to change the position of the tool holder. To allow easy removal of the cutting bits, the slot is milled to a depth of 0.500in. + 0.005in, **photo 8**.

The tool holder is then set in the horizontal plane, so the positions for the clamping screw holes can be spot faced and centre drilled, **photo 9**. As well as clamping, the M5 grub screws are going to

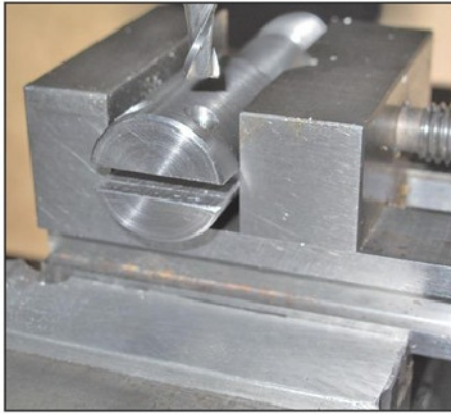


Photo 10. Spot facing, prior to centre drilling.

locate the cutting bits, so the position of the hole centres are important and need to be accurately positioned at 0.250in. in from the face and 0.250in. either side of the centre line, **photo 10**. The holes are machined on the bench drill and tapped through M5.

The screw holes for the support plate now need to be centre drilled. Both the tool holder and the support plate can be drilled on the same setting. The hole centres are drilled at 0.312in. either side of the centre line, **photos 11** and **12**. The tool holder body is drilled and tapped M3 while the support plate is drilled 3.1 dia. clearance and countersunk to accept the head of an M3 countersunk screw, which needs to sit slightly below the surface of the plate.

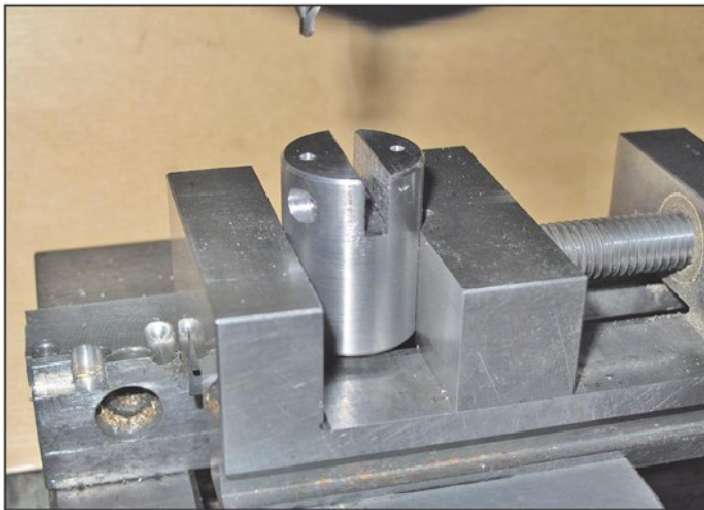


Photo 11. Holder body centre drilled at 0.500in. centres

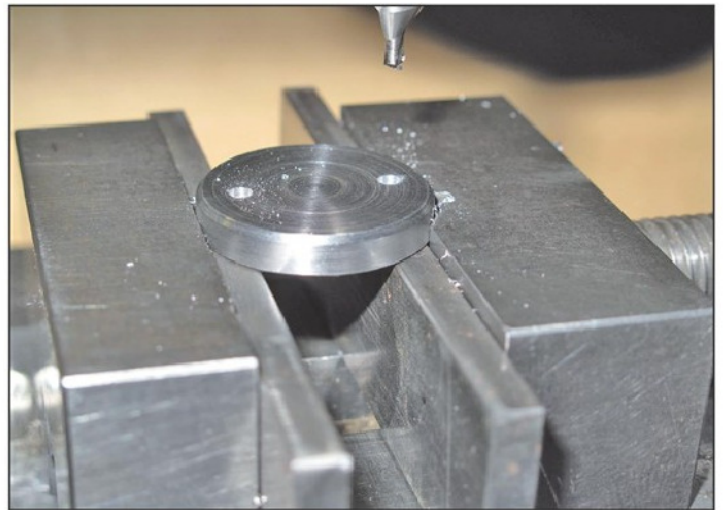


Photo 12. Support plate centre drilled at 0.500in. centres



Photo 13. Squaring off one end of the cutter blank.

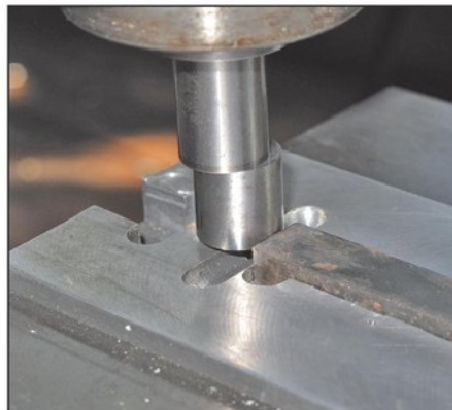


Photo 14. Establishing absolute zero in X using an edge finder and hardened and ground parallel.

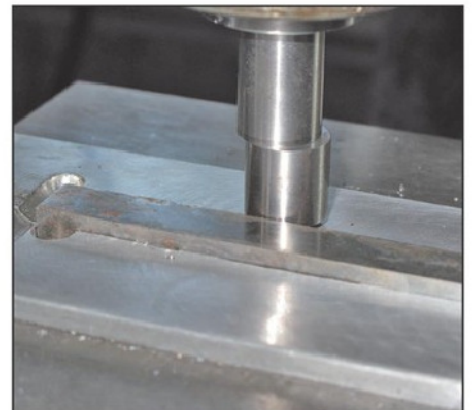
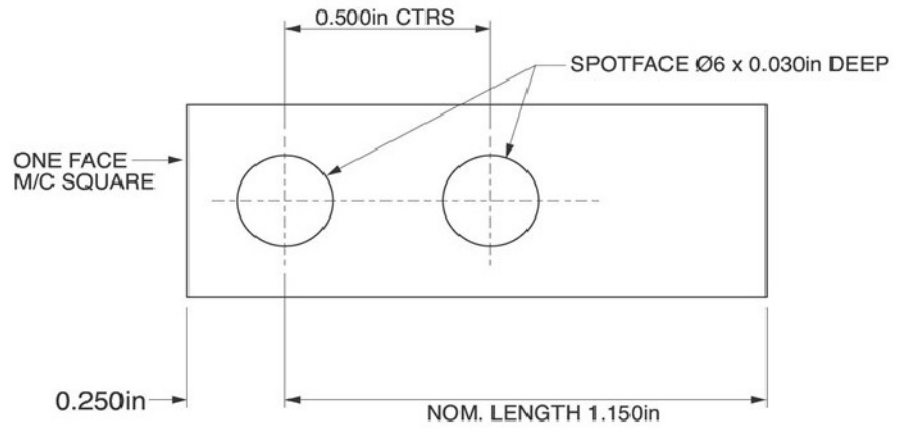


Photo 15. Establishing absolute zero in the Y axis.

Fig. 3



FLYCUTTER BLANK

Fly cutter gauge plate blank.

The fly cutters

At this stage, it's just as easy to produce a batch of cutter blanks, **Fig. 3** some to be fully machined and the others kept in hand for future applications. The gauge plate was supplied in nine inch lengths. Bearing in mind that the cutting faces should not protrude too far from the tool holder, and to make the most economical use of the steel, the cutter blanks where sawn at 1.450in. One end was then machined square, to clean up at a nominal 1.400in, **photo 13**.

The blanks now need to have 6mm dia. spot faces machined in them, plus the centre drilled positions for the reamed holes, which will eventually become the concave cutter forms. These positions are important and require accurate locating. To this end an absolute zero position is established in the soft recessed jaws, **photos 14** and **15**. Using soft recessed jaws facilitates quick and accurate location of workpieces and does away with independent back stops and tapping down components on parallels.

Fig.4

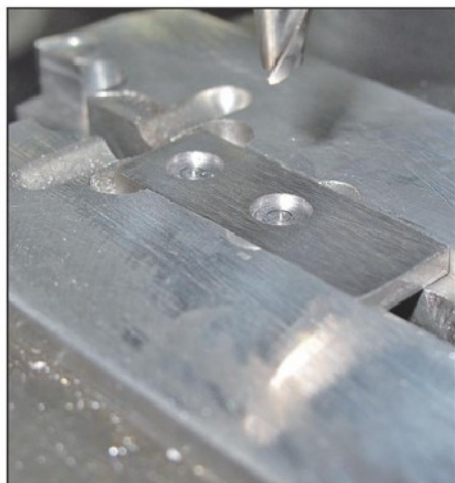
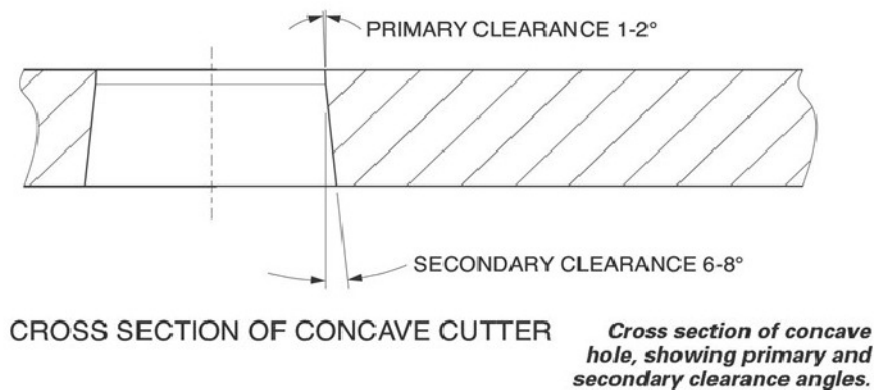


Photo 16. Machining two 6mm spot faces.



Photo 17. Centre drilling concave radius positions.

Two 6mm diameter spot faces are machined 0.250in. from the datum face and at 0.500in. centres on the centre line, **photo 16**. These spot faces perform three important functions.

Firstly, to positively locate the cutter. If the cutter needs to be removed, say for stoning the cutting face, it can be accurately relocated in the holder with the minimum of resetting.

Secondly, with the grub screw biting into a recessed spot face, there will be no bruising on the surface of the cutter, which in time, might impede removal.

Lastly, they provide a quick visual check as to the orientation of the cutting face. This is important as it's difficult to determine which face of the concave cutters has the primary clearance angle, especially with small diameters, **Fig. 4**.

As it is intended to produce a set of five cutters, five blanks need to be centre drilled for machining the concave cutters, **photo 17**. The position from the end is a nominal 0.200in. but the centre drilled cone needs to be spot on the centre line to assist future machining operations.

Machining the radius

Generating a dead size hole obviously has to be the main aim if a true radial form is to be machined when using these fly cutters. The smaller the diameter, the greater is the problem. On smaller diameters 0.062in. to 0.250in. I incorporate a primary and a secondary clearance angle.

As producing a continuous clearance requires the relief to be filed right up to the cutting face, either before hardening with a standard fish back, needle file, or the preferred choice after hardening with a diamond file, when the oxidised surface of



Photo 18. Taper broaches.



Photo 19. Fast or continuous fluted taper reamer.

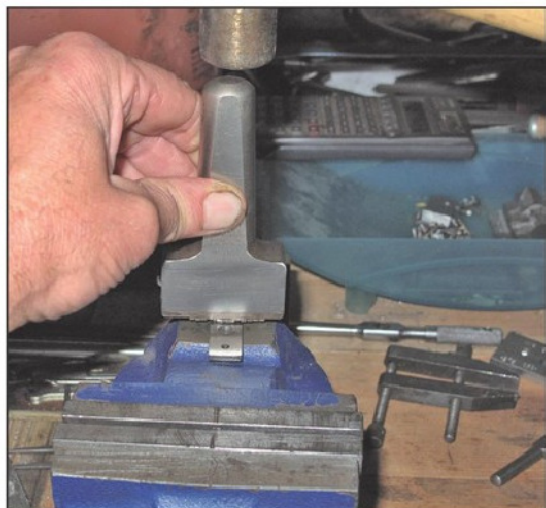


Photo 20. Stamping for identification.



Photo 21. Cutter identification number.



Photo 22. Hand broaching the primary clearance angle.



Photo 23. Sizing the 0.125in. hole with silver steel.



Photo 24. Using a fast fluted taper reamer mounted in the bench drill.



Photo 25. Measuring the wall thickness to establish total material removal.



Photo 26. Milling to the centre of the hole.



Photo 27. Working out the side clearance angle.

the cutting face acts as a clear reference for filing the clearance angle. Without the primary clearance on smaller diameters, it would be easy to damage the cutting face with a slip of the file and thereby affect the radial form of the cutter.

The primary clearance is produced with a taper broach, **photo 18** or taper pin reamer. With the reamer option the best type to use is the fast, or continuous fluted taper reamer, **photo 19**. With the comparatively thin section of the fly cutter, a standard straight fluted reamer might tend to dig in and judder, thus producing an un-round hole. The continuous fluted reamer, as the name suggests has a smooth continuous cutting action.

A pilot hole is first drilled in the blank. This needs to be about 0.005in. under finished size. At this stage it's probably a good idea to stamp the size of the finished diameter on the blank to avoid any later confusion, **photos 20** and **21**. The broach is held in a tap wrench and reamed, starting from the underside of the cutter. By holding the blank in the other hand, any resistance, can be easily detected, **photo 22**. A little tapping paste will help to create a smooth hole. The hole size is checked by using a piece of silver steel or a size drill shank also introduced from the underside of the fly cutter, **photo 23**.

For diameters above 0.187in. hand held broaching becomes impractical as misalignment can occur, especially in such a thin section. These blanks should be held in a drill vice clamped to the table. The chuck is rotated by hand, with gentle pressure on the spindle handles, **photo 24**. These larger

holes can however be machined with a standard reamer, as on larger diameters it's not so important to produce a primary clearance as the area to be diamond filed after hardening is greater, thereby reducing the risk of damage. Try to avoid filing off any machining burrs, as no damage or marking should occur to, or around, the cutting faces. Rather, remove any burrs with a circular motion on an oil stone, or a strip of emery tape stapled to a piece of smooth wood.

All that needs to be done now is to mill clearances on the blank to create the radial cutting form. The blank is relocated in the recessed jaws and a light cut taken across the face. After the cut is taken, digital readouts, or mechanical dials, need to be zeroed. The wall thickness between the

size hole and the newly machined face is measured, **photo 25**. The amount of material to be removed will be the wall thickness plus half the hole diameter. The subsequent amount of stock can then be removed in suitable increments until a light finishing cut can be taken to the centre line of the radius, **photo 26**.

To determine the side clearance angle, the distance from the centre line of the radius and the body of the tool holder need to be measured, **photo 27**. The measurement obtained was 0.207in. with a radius of 0.187in. leaving 0.020in. As the 0.375in. dia. hole is set precisely on the centre line, we know the opposite and adjacent, so the angle can easily be calculated.

$$\frac{0.020}{0.250} = 0.08 \tan = 4.2 \text{ degree}$$

Zero a digital angle indicator on the machine table and clamp the cutter blank in the toolmakers vice, place in the machine vice and incline at an angle of 4.2 degrees, **photos 28** and **29**.

To digress slightly, this digital angle indicator is far and away the best £22 I have ever spent. After a working life of struggling with sine bars and vernier protractors, sometimes positioned in precarious situations, it's a joy just to set this simple device and achieve an accurate result as good as the hobby machinist will probably ever need to set.. **To be continued...**



Photo 28. The digital angle gauge.



Photo 29. Setting the cutter angle.

DIVIDING ON THE LATHE

Roy Smalley has a different approach

Introduction

Having read Harold Hall's article in MEW Issue 125, I thought I would like to share with other readers some of my thoughts on this topic. This article relates to dividing in the lathe, **photo 1** using a worm and wheel to rotate the mandrel by the required amount. I have no intention of going into detail regarding making such a device. Numerous designs have been published over the years, and all are suitable to particular applications. On my own lathe - a Smart & Brown 'Sabel', I can remove the worm wheel, **photo 2** leaving the dividing head in situ, **photo 3** and the lathe is ready for normal use.

Part 1 - Theory

(a) The boring bit but don't ignore this just because it might be boring! Try to grasp the concepts, even if it means reading it through more than once. It is very useful.

My approach to deciding what division plate is required is first of all, to factorise the number of divisions required. If you have forgotten this process (or never learned it in the first place), here is a brief resume:

'Factorising' means working out all the prime numbers which will divide exactly into the given number. (A prime number is one which can only be divided by '1' or itself) As an example, the factors of 24 are: 1 (x24), 2 (x12), 3 (x8), 4 (x6), 6 (x4), 8 (x3), 12 (x2), and 24 (x1). All numbers are divisible by 1, and we can ignore this factor. Some of the factors can be further divided by smaller primes, e.g. 4 can be divided into 2 x 2, and 6 can be divided into 2 x 3, and so on. The factors '4' and '6' etc are not prime factors. It is helpful to divide the original number by 2 repeatedly, until no further divisions by 2 are possible, then to divide by 3 as many times as possible, then 5 (the next prime), then 7, etc. This gives the prime factors of 24, which are: $2 \times 2 \times 2 \times 3$, or $2^3 \times 3$. (2^3 is read as 'two cubed', or 'two to the power three', and means three '2's multiplied together'). Note that 6, 8, and 12 are contained within these primes. To divide a circle by 24 requires all these primes to be obtained, either from the worm and wheel assembly, or from a division plate.

The worm and wheel ratio should also be factorised. If you use a 60:1 ratio, which is a very common and very useful choice, the factors are: $2 \times 2 \times 3 \times 5$, or $2^2 \times 3 \times 5$. If 24 divisions are required, (i.e. $2^3 \times 3$), the worm/wheel will provide only $2 \times 2 \times 3$, and the remaining '2' will have to come from the division plate. The plate will therefore need an even number of holes.

Similarly, if you required 36 divisions, $36 = 2 \times 2 \times 3 \times 3 = 2^2 \times 3^2$. The 60:1 worm/wheel would provide $2 \times 2 \times 3$, and the other '3' would have to come from the division plate, which would therefore need 3 holes, or any multiple of three.

If you required a larger prime number of divisions than the worm/wheel could provide, they would all have to come from the plate. So if 23 divisions were required,



Photo 1. Dividing head on end of lathe mandrel.

the plate would have to have 23 holes, or a multiple thereof (46 may be available). If you wanted 127 divisions, you would need a 127 hole plate - but more of that later (in the exciting bit!)

If factorising is completely new to you, I recommend that you practise factorising a few numbers. Start with small numbers - 6, 10, 12 - and work up to larger numbers gradually. When you get the hang of it, it is quite rewarding, and almost as entertaining as Sudoku!)

(b) The slightly less boring bit (but just as important!)

To work out the rotation of the worm for a given number of divisions, divide the worm/wheel ratio by the number of divisions required. As an example, using a 60:1 worm and wheel to produce 24 divisions:

Number of turns of worm = worm-wheel ratio / No. of divisions required $= 60 / 24 = 2.5 / 1 = 2.5$ turns (using the normal rules of arithmetic to simplify the fraction). This means: 2 full turns, plus 1 hole of a 2-hole plate. The last bit: '1 hole of a 2-hole plate' can be 10 holes of a 20-hole plate, or 33 holes of a 66-hole plate, or any other suitable combination to give half a turn of the worm.

This example is fairly trivial, and is used to illustrate the principle. Suppose you need 125 divisions (for a feedscrew handwheel for an 8 tpi thread, perhaps):

Number of turns of worm = $60 / 125 = 12 / 25 = 12$ holes of a 25-hole plate (or any similar ratio, such as 24 holes of a 50-hole plate). Is it beginning to make sense now?

My own dividing head for the lathe mandrel has a 70:1 ratio, because I had a redundant 70 tooth wheel when I made it. For me, therefore, for 125 divisions: Number of turns of worm = $70 / 125 = 14 / 25$. That is: 14 holes in a 25-hole plate (or 28 holes in a 50-hole plate)

(The 'bull' wheel on my lathe has 76 teeth, the factors of which are $2 \times 2 \times 19$, which are of somewhat limited use for most divisions, hence the use of the 70 tooth wheel, which was lurking in the scrap box!)

(c) The exciting bit.

Suppose you have just made your dividing head with 60:1 ratio, and you have, as yet, no division plates. You can very easily make a 60-hole plate. All you need is a fixed mark to tell you when you have turned the worm a complete revolution, and the wheel will have turned

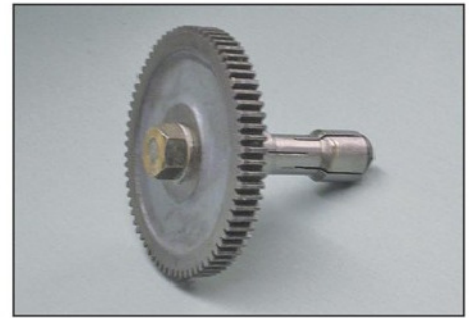


Photo 2. Gear after removal from mandrel.

$1/60^{\text{th}}$ of a revolution. Drill a hole, make another complete turn of the worm, drill another hole, etc, until you have a complete ring of 60 holes. This plate will provide factors of $2 \times 2 \times 3 \times 5$, which, together with the worm/wheel ratio will give you $2 \times 2 \times 2 \times 2 \times 3 \times 3 \times 5 \times 5$. You can now produce any number of divisions which can be obtained from a combination of any of these factors. (Of particular interest may be 360 and 400, if you wish to make circular scales, with or without a vernier.)

However, suppose you need a factor of 7, perhaps to produce 28 or 56 divisions. Can you use the 60-hole plate to give a multiple of 7? Well, not exactly. But, if you have read Harold Hall's article in Issue 125 of MEW, you may recall that the errors in the plate are divided by the worm/wheel ratio. Hence, small errors can be made much smaller by making 2 or 3 generations of division plate.

Consider the following; for making a 63-hole plate (which is a useful multiple of 7 - factors $3 \times 3 \times 7$) from your 60-hole plate using your 60/1 dividing head.

Each division requires the spindle to advance $360/63$ degrees, i.e. 5.71429 degrees (to 5 decimal places) and therefore the worm must rotate 60 times this amount for each division, (using a 60/1 worm/wheel ratio), i.e. $60 \times 360/63$ degrees. With the 60-hole plate fitted, a movement of 60 holes will advance the spindle by $360/60 \times 60/60$ degrees = 6 degrees. ('360/60' is the degrees advanced by the mandrel for a complete revolution of the worm. This complete revolution is represented by '60/60', i.e. 60 holes advance on a 60-hole plate). A movement of 58 holes will advance the spindle by $360/60 \times 58/60 = 5.8$ degrees. A movement of 57 holes will advance the spindle by $360/60 \times 57/60 = 5.7$ degrees. Therefore, moving the worm by either 57 or 58 holes will produce an acceptable '1st generation' 63-hole plate. Table 1 shows the results of advancing the worm by 57 and 58 holes, and the maximum error is 0.043 degrees (to 3 decimal places), i.e. less than $1/20^{\text{th}}$ of a degree. The pattern in the table is repeated until all 63 holes are drilled, and the errors repeat cyclically every 40 degrees. If this plate is then used to produce another 63-hole plate, the errors will be reduced to $1/60^{\text{th}}$ of the errors in the first plate, i.e. less than $1/1000^{\text{th}}$ of a degree maximum theoretical error in the second generation plate. Errors in machining the workpiece for which the dividing head is being used

are likely to be at least as great as this, and in any case will be reduced yet again by the worm/wheel ratio, so the division plate is not the limiting factor, with regard to accuracy.

Table 1

HOLES	ADVANCE	ANGLE REQUIRED	ERROR
57	5.7	5.71429	-0.01429
57	11.4	11.42857	-0.02857
57	17.1	17.14286	-0.04286
58	22.9	22.85714	0.04286
57	28.6	28.57143	0.02857
57	34.3	34.28571	0.01429
57	40.0	40.00000	0.00000

A similar argument can be used to produce any number of holes using a plate which is close to the number required. For instance, the 63-hole plate just made can be used to produce an accurate 126-hole plate. To produce a 127-hole plate to make a metric conversion gear would now be reasonably simple, using the same method.

Quick and accurate

I have never seen this method in print before. I believe it is much quicker and more accurate than either paper strips wrapped round the chuck/faceplate, or using X and Y coordinates, and for some division numbers, better than the use of a rotary table. It is also quite quick and easy to produce the figures, using either a computer or a calculator.

Part 2 - practical issues

I am not going to give a detailed account of how to make a dividing head for your lathe mandrel; there have been numerous such designs in MEW and ME over the years. I suggest using either the bull wheel, if it has a 'useful' number of teeth, or mounting a suitable gearwheel on the end of the mandrel. In either case, a worm will have to be meshed with the chosen wheel, and arrangements made to rotate this worm by a suitable increment, determined by holes in a division plate. The use of 'fingers' to define this number of holes is well worth the effort of making them, and most designs include this feature, **photo 3**.

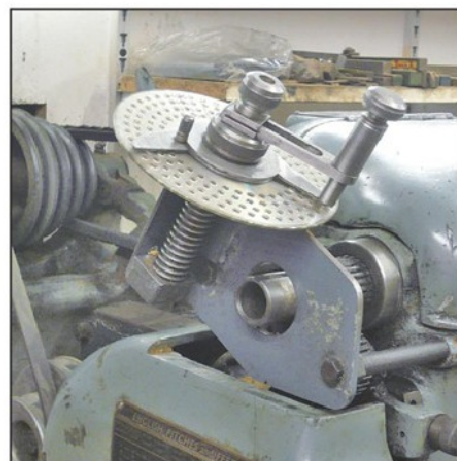


Photo 3. End of mandrel with gear removed.

The worm

A lot has been written about gear ratios to produce worms to fantastic accuracies to suit gears of various tooth pitches. The purpose of the worm in this application is twofold: to advance the wormwheel by one tooth pitch per revolution of the worm (assuming a single-start worm), and to lock the wormwheel whilst the machining operation takes place. At that time, the force on the worm is minimal, and the speed is zero.

The important points are that the wheel tooth pitch should be uniform, which all machine-cut wheels should be, and that there is no backlash in either the engagement of the worm/wormwheel teeth, or in the worm end-thrust bearings. If there is backlash, it can still be taken care of, by always moving the mandrel as far as possible in the same direction and locking it in some way, (e.g. a weighted string wrapped round the chuck! Editors note: unplug machine if doing this. But rotate the work so as to raise the weight each time, if possible). Hence, if the worm pitch is slightly different to the wheel tooth pitch, it doesn't matter greatly. If the worm pitch is too small, it will grip the wheel on both sides of one tooth, and if the worm pitch is too large, it will grip the wheel on the inner faces of two alternate teeth. (Draw a sketch if you don't understand me). In either case, the wheel will be advanced by one tooth for each revolution of the worm, and will be



Photo 4. Drilling a division plate in progress.

locked securely if there is no backlash. (Make the worm and wheel mesh tighter than the theoretical distance.)

In order to make division plates, a toolpost-mounted drilling facility is required. Mine consists of a bracket bolted to the cross-slide, into which I clamp my electric pistol drill, fitted with a Slocombe centre drill, **photo 4**. The bearings on these drills are not high-precision, but remember that any error in the hole position will be divided by the worm/wheel ratio when the plate is in use. If you have a toolpost mounted drilling spindle, so much the better. After all, the holes are drilled with the pilot end of the centre drill and it is an easy (and accurate) matter to enlarge them to any desired size on the drilling machine.

Redundant CDs

If you want to make division plates to commercial standards, you first have to find some suitable plate, then cut it out, then machine it to produce a suitable blank. I use redundant CDs! I made my dividing head to accommodate the diameter and bore of CDs, and by sticking two or three together, adequate stiffness can easily be obtained. I realise that they would not be satisfactory for industrial use, but for the kind of use they get in the average amateur workshop, wear is not going to be a problem. I mount a piece of wood or MDF on the faceplate, screwing it from the back, and skim it true. A shallow recess bored to the correct size makes positioning the disc easy, and it can be held in place by 3 or 4 woodscrews just outside the edge of the disc. Drilling the holes is very quick, once the dividing head is set up, and after making a 1st generation 'not-100%-accurate' plate, it can very quickly be moved onto the dividing head and used to make one 60 times more accurate (assuming 60:1 ratio) **photo 5**. If I am making a 1st-generation plate, I use just a single CD, which I then use to produce a more robust plate using 2 or 3 CDs stuck together. It's almost quicker to make the plates than it is to write about it!

I hope the ideas given here prove to be useful to at least one reader! Dividing in the lathe is a fascinating and rewarding activity, and overcoming problems, like not having the right number of holes in a plate, brings great satisfaction, and makes the workshop that much more enjoyable. There is one minor snag - there always is - the CDs don't play very well afterwards! ■

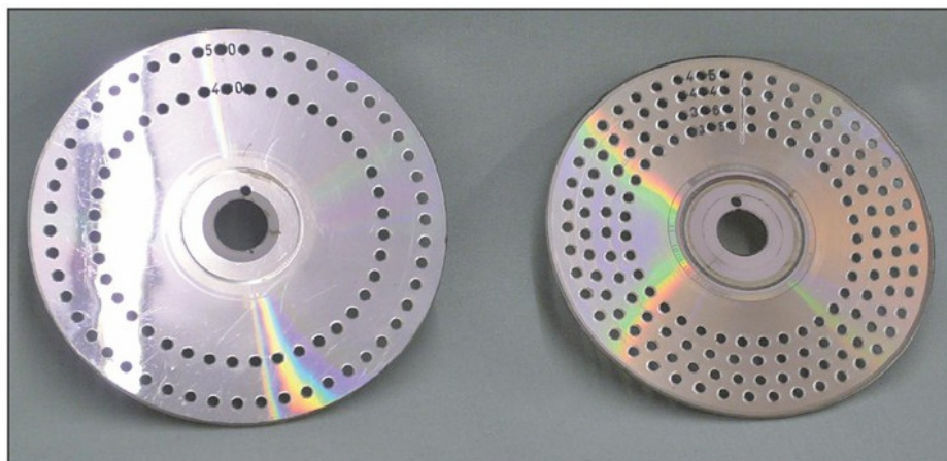


Photo 5. Sample division plates.

Photo 1. The garage workshop.



WORKSHOP HEATING COSTS

Harold Hall looks at workshop heating

It was Chris Haupt's letter in Scribe a line, issue 131 page 52 that has prompted me to write this short article on the subject of workshop heating costs. In his letter he referred to my Metalworkers' Workshop series in which I commented on the subject of condensation, issue 127 page 15. In this I suggested that the only easy way of avoiding condensation was to keep the workshop heated to avoid wide variations in ambient temperature. Chris felt that this was an expensive solution, feeling that the option was only one for the super rich such as Rolls Royce owners. Whilst I did admit to it being expensive I did not feel it quite fitted into that category, especially for the reader with a relatively small workshop.

I feel that possibly his comments are largely based on assumptions but in fairness to him so are mine when it comes to actual cost. If I were to be asked what does it cost to heat my workshop I would have to reply I do not know and if then asked to give an estimate, again I would have to say, no idea. I am though aware that a typical winter quarter bill is much higher than one for a summer quarter but we do use a lot of lighting and also a little in house electric heating. More important though, I keep a largish green house, 5M x 2M, frost free, also, as woodworking machines are very noisy I try to restrict my cabinet making activities to the winter months when neighbours have their windows closed and are not out relaxing in the garden. This results in me using the garage, perhaps for as much as six weeks, using two 2Kw fan heaters to keep me reasonably warm.

With this combination of costs it is all but impossible to estimate a cost with any degree of accuracy and because of this I have decided to run some tests.

The workshop

It would though still be rather meaningless to give a figure of X pounds without giving some details regarding the workshop, size, insulation, etc.

The workshop, seen in **photo 1**, was originally 12 feet by 8 feet but during my time as editor I decided to extend this to 18 feet by 8 feet. The additional 6 x 8 is in the form of an annex with the original door opening leading into the smaller workshop. This featured as John Steele's workshop starting in MEW issue 24.

The inside of the original workshop is lined with 10mm insulation board with the resulting space between that and the outer cladding filled with glass fibre insulation with the roof being lined with 25mm polystyrene.

If we consider the average external temperature during the colder months as being 5C and attempting to maintain an internal temperature of 8C we are insulating for an average difference of just 3C. This is far less than the difference within the house of 16C (5C to 21C). This relatively limited insulation is not therefore unreasonable. The 5C average temperature is I must admit an estimate on my part and in any case will vary with location. For example, the editor's new workshop in the far north of Scotland will certainly see a lower value than his earlier workshop in southern England. Editor's note: I find it no colder than living down south. If anything, the winter is actually warmer than down south. If I lived 40 miles further south then it would be a lot colder.

The annex is insulated with 25mm polystyrene to both the walls and roof. The walls are covered with wallboard (thin ply with a knotty pine finish). The polystyrene in the roof has no added covering being the same as in the main

workshop. I am a little concerned regarding the fireproof limitations of this and intend to cover the polystyrene with white faced hardboard at some time.

The outer face of the roof was finished with conventional roofing felt but failed some months back and not wishing to strip and re-felt, I have covered it with corrugated bitumen sheets ("Onduline") directly on top of the roofing felt. This has a guaranteed life span of 15 years and should see my needs out. The corrugations provide an air gap between the sheet and the felt that must help insulate a little but the corrugations are left open at the ends so the effect will be limited.

The workshop has two sets of windows, the main ones having a surface area of 2 SqM and face the midday sun and a smaller one on the side of 1 SqM. The windows are covered with roller blinds when not in residence that gives a small degree of added insulation though this is not their main purpose, this being discussed later in the article.

The floor is timber and obviously raised so there is an air gap below.

The Heating

For background heating I have two oil filled radiators, one of 0.75Kw rating and the other 0.6Kw. I have two fan heaters for raising the temperature when in residence. However, not wanting to confuse the tests that are for background heating only, I limited the use I made of the workshop during the tests and therefore the fan heaters were not used during this period. Oil filled radiators, providing they are not too highly rated, will not cause the large swings in temperature that fan heaters are inclined to do, minimising the possibility that the heating may cause sufficient temperature fluctuations for condensation to form.

The tests

I used one of the very economically priced meters shown in **photo 2** which are capable of indicating a wide range of measurements, mainly, Supply Voltage, Frequency, Current, Power factor, Kilowatts, Kilowatt-hours, to name but a few. If you have a day/night rate it will even tell you the kilowatt-hours for each period. This all for around £20, amazing when you think only 20 years ago, or less, more than one meter would be required and at a total cost of a few hundred pounds. The meter is a Brennenstuhl PM230 and is widely advertised on the Internet but I have also seen other makes on offer. Both heaters were fed via the one meter.

I have taken readings over four consecutive periods, each of four weeks, starting on the 14th January and finishing on the 5th May. Over the first and last four week periods I took readings daily of the total Kwh taken to that date, also maximum and minimum inside and outside temperatures for the individual day. For the two middle four week periods I just left the meter connected and took values for the total power consumed at the end of each period.

The Costs

In round figures I am charged for a Kwh of electricity 17p, 10p and 5p depending on the time of day and the amount of electricity used. Daytime units are initially charged at 17p but beyond a given usage this reduces to 10p. As other demands would in any case run us into the 10p band it is reasonable to calculate workshop heating at 10p per Kwh for the daytime units, 5p being the figure for the night-time period.

The total usage over the period was 650 Kwh of which 394 Kwh were daytime units and 256 Kwh nighttime.

Based on this usage the cost of electricity would be £55. That includes + 5% for the

tax which is chargeable. If then we assume a similar period usage and cost, mid September to mid January, an amount of £110 is arrived at.

I feel that considering the above figures Chris will feel justified in his comments, but a Jaguar owner may have been more appropriate than a Rolls Royce owner. However, Chris's suggested size of workshop of 8' x 6' being one third the size of mine a figure of half that above (£55) would seem a reasonable estimate, and again I would say that I did indicate that heating was only an option for the owner of a small workshop. Even so, considering how much some spend on equipping their workshop and then eventually funding the projects they undertake, even £110 for the benefit of a rust free workshop may be considered perfectly acceptable and at £55 even more so.

The Readings

Having taken so many readings, publishing them all would be more than the magazine could justify. Here though are a few interesting facts.

The first period was mid Jan to mid February and the fourth period early April to early May.

The total power consumption for the first (and last four week) period was 175 Kwh (112Kwh) and during this time the maximum for a single day was 10Kwh (8Kwh) with the average over the period being 6.3Kwh (4Kwh).

During these periods, the minimum temperature within the workshop was 7C (7C) with an average minimum of 8.3C (9.4C). The variation between the minimum and maximum for the majority of the days was only about 3C (5). On a few days the variation though was rather more, the reason being discussed later. The average minimum external temperature was 5.1C (6.4).

Blinds

On a number of days, particularly in the final four week period, the maximum internal temperature was in excess of the maximum external temperature (taken in a shaded position), sometimes by as much as 5C, a situation that at first would not seem possible as the heating would be turned off well below these temperatures. The answer to this is of course that the sun shone brightly on these days warming the workshop using the sun's radiant heat, particularly that through the windows.

I have mentioned on a number of occasions the problem that can occur, particularly if the sun breaks through after a long period of clouded sky. In this case the internal workshop temperature can rise rapidly, much more rapidly than the metalwork in the workshop and condensation becomes very much more likely, especially if there is no background heating and there has been a very cold night. To minimise this effect I have added the blinds.

In retrospect, it would have been good to attempt to include in the experiment some tests to determine the effectiveness of having the blinds, though no doubt such tests would be difficult to set up. I did though on one day, around early march, work in the workshop for most of the day but not wanting to affect the results I was

collecting I did not turn on the main workshop heating but did open the blinds to increase the natural lighting.

During the early afternoon the sun started to shine and I noticed the temperature became much more comfortable. Unfortunately, I did not record the temperature but remember it was well above figures I had taken during the first four weeks, being in the order of 20 to 25deg.C. What I do remember was that when the sun eventually became obscured by a large tree the temperature dropped by 4deg.C within 20 minutes. As such temperatures were not recorded either in the first or last period then I must assume that the blinds are limiting the internal temperature swings by a substantial amount. Readers who have workshops similarly positioned should I think consider adding blinds of some form.

Day/Night consumption

Cheaper night time electricity is available over a seven hour period and the meter was set to record the consumption over this and the daytime periods. With the total power consumed being 650Kwh the night time value would be 190Kwh if taken as 7/24ths of the total but the actual night-time power consumed was though 256Kwh. For the reader who does not have cheaper night-time units an additional cost of £20 would result, or £10 for the smaller size workshop.

Making Economies

There is very little that can be done easily to reduce the cost but turning down the thermostat a degree or so would obviously make a worthwhile saving but this would increase the temperature differential for each day and one only needs one day for machines and tools to go rusty.

Chris referred to the damp winter months but this overlooks the fact that more moisture is carried by warm air so the summer months are those where the air is most moist. Because of this the moisture within the structure of the workshop will be greater during the autumn months. Living in a bungalow, which for some reason are more affected than houses, and with single skin glazing I am very aware of this fact. At the first night frosts, probably mid October, all the widows in the morning will be totally misted, running with water on some occasions. The situation diminishes until by mid December it is only the bottom 200mm of the window that is affected and some windows not at all. Obviously the property is drying out but the cycle will repeat itself come next October.

What then is the significance to the workshop? I have also noticed that any tendency for rust appears more likely over the same period and keeping the temperature up during this time and turning it down from the New Year on may be worth attempting. For my part though, unfortunately, one of my heaters is set at its minimum setting making it impossible to lower the temperature further.

Having suffered with rust in the workshop over many years, working now with a virtually rust free situation is for me money worth spending, though I fully appreciate that there is a limit to which the individual workshop owner can accept, as there is for me, please do not ask me how much this is though! ■



Photo 2. The meter for checking electricity usage.

ADAPTERS FOR PARALLEL SHANK MILLING CUTTERS

Harold Hall
makes holders for
commercial cutters

Way back in MEW issue 91 the trade page detailed a set of indexable end mills available from Chronos, Ref. 1. With a price of £29.95 for the set of three it was described as "Too good to be true", **photo 1**. As a result, I was tempted and a set purchased. Unfortunately, the shank size of 3/4in. is likely to be too large for the chucks available in most home workshops, which it was in my case. To overcome this, a 3 Morse taper collet with a 3/4in. diameter bore from the same source was suggested and which would overcome the problem quite cheaply. Editors note: The cutters are still available from Chronos and the price is £29.31. Spare tips are also available.

Not to save money, but to provide an interesting project, I decided to adapt them by adding taper shanks, **photo 2**. I suspect that many will prefer to go down the collet road but have provided this article as it will equally apply to other milling cutters, having numerous shank diameters that can be purchased from car boot sales, market tool stalls or the second hand tool stalls at the various model engineering exhibitions.

The essential requirement is that the taper and the bore to take the cutter are accurately concentric. For this to be achieved relatively easily both must be machined without removing the part from the lathe. This necessitates that the taper is machined with the narrow end nearest the chuck permitting the bore also to be made without removing the part. With a shank diameter of 3/4in. it is too big for any adapter smaller than no. 3 Morse taper, though as I will explain later there is a way round this problem.

Making the adapter

Cut a length of steel having a diameter a little larger than the largest end of the taper being made, say plus 1mm minimum. This should also be longer than the taper portion of the adapter by 32mm. Set the top slide to the angle required for the taper and in the direction that produces the narrow end nearest the chuck. **Photo 3** shows the method I use to set the top slide. Done with care this method is foolproof, checking with its mating taper should be just a formality.

For a number 3 Morse taper the two right hand faces (when turning a taper with the smaller end nearest the headstock) should be 0.7969in. apart to give a difference in the diameters of 0.040in. For those with a metric machine the faces should be 19.922mm apart to give a difference in diameter of 1mm. Note these are not conversions of the imperial dimensions but chosen to give an easily readable difference, that is, 1mm.

I realise that the distance between the faces quoted needs a higher degree of accuracy than is achievable in the home

Photo 1. The complete kit, one cutter already having been fitted to its adapter.



workshop. Because of this aim for a value on the low side, say 0.796in. - 0.0in. + 0.001in, which will make the taper very slightly greater than standard and ensure that it is tightest at the outer end. This is obviously best. Doubling the two values would enable a more accurate result to be achieved. For greater detail on this method of setting up for turning a Morse taper see Ref. 2.

Mount the material in the three jaw chuck and centre drill the outer end. Whilst carrying out turning this far from the chuck would be taboo, centre drilling only should be perfectly acceptable. Support

the outer end with a tailstock centre and make the reduced end making it 15mm long. The reduced end can be seen in **Photo 2**. Withdraw the tailstock centre, fit the fixed steady on the portion just turned, re-engage the centre and set the steadies arms. Remove the centre and drill and tap for the draw bar.

Remove the part from the chuck, rotate, and refit in the chuck holding it now on the reduced diameter just made. Again centre drill the outer end and support with the tailstock centre. Now turn the taper, small end against the chuck. This should still leave a length of unmachined material at

the tailstock about 15mm long, again see **photo 3**. Lightly skim this to ensure it is concentric with the taper. Fit the fixed steady to support this parallel portion doing this with the tailstock centre engaged whilst the steady is being set. Remove the tailstock centre and bore the end to take the cutter shank, **photo 4**. Make the bore about 0.05mm greater than the cutter shank to allow a space for a film of adhesive. Do not use any cutting lubricant of any type so as to ensure that the bore is free of grease or oil. Using a long series drill, drill through to give an escape passage for the trapped air when fitting the cutter. I would suggest a diameter of between 4 and 6mm. However, any size will do providing that it is not larger than the tapping size for the draw bar.

Fitting the cutter

The cutter shanks are soft so they could have been reduced in diameter whilst mounted between their drilled centres so as to suit existing chucks. However, I have chosen to go down the adapter route as I feel this will be more rigid when in use. This is desirable as the cutters are capable of heavy duty machining. As the shanks are soft, use a coarse file to roughen them. Do this using strokes along the length of the shank as the axial marks should provide a better key to prevent the tool turning in its adapter. Use a coarse round file to roughen the bore, again doing this axially. Do make sure that the shank is completely free of grease or oil.

Mix up a portion of two-part resin adhesive, the slow setting type and lightly cover both the inside of the bore and the outer diameter of the shank. Push the cutter home in the bore at the same time turning it a few turns to make sure that the shank is covered with adhesive completely around its periphery and that it is held centrally in the bore.

The slow setting adhesive is reputed to be stronger than its rapid counterpart and that this strength is also enhanced by the application of gentle heat. Leave it therefore somewhere warm; say the hot water tank, for 24 hours to gain maximum strength before putting it to the test.

Adhesive, why?

You may ask why am I proposing using adhesive rather than a grub screw onto the flat on the cutter's shank that would then allow one adapter to provide for all three cutters. First, as proposed, the projection from the machine spindle is very small as most of the cutter's shank is in the taper portion of the adapter. With the shank being $\frac{3}{4}$ in. diameter the



Photo 2. The three end mills fitted to their new shanks.

thickness of the wall at the point where the flat exists is only in the region of 2mm. This would be far from sufficient to provide an adequate clamping screw.

To provide a wall thickness sufficient for a substantial clamping screw the adapter would have to project some way from the machine spindle, thereby enabling it to be locally larger in diameter. However, this added projection would have a negative result in terms of rigidity and because of this I consider the proposed method to be superior.

The finished task

Photo 1 shows the complete kit with one cutter already fitted to its adapter and with the other two adapters prepared. I have provided this article not on the basis that you will use it with the Little Hogger end mills, though some may, but that it will enable you to make use of those bargain cutters so often seen on the tool stools at the exhibitions or at car boot sales. If your cutter has a hardened shank then it could be roughed a little to aid adhesion using the offhand grinder.

Smaller adapters

I have already mentioned that these cutters have soft shanks and they are also centred at each end. This would enable them to be mounted between centres and their shanks easily reduced in diameter as required. However, these cutters are capable of some substantial machining so would not be happy with a much reduced shank being held in a milling chuck with some of the

shank still being in fresh air. I do believe that an adapter is still the best approach with a number two Morse taper. In this case, the bore in the adapter must be deep enough to take the full length of the reduced diameter.

I would though add that it is some time since I purchased the cutters and just possibly their shanks may now be supplied hardened so as to improve the quality. If you therefore are considering going down the route of reducing the shank diameters it would be advisable to check the situation with Chronos before purchasing them.

Having completed the holders and used the cutters a number of times, often taking heavy cuts on cast iron castings, I am very pleased with the results and am convinced that a major reason for the success is the minimal overhang of the cutter from the machine spindle, a situation that would not be possible if the cutter was held within a collet chuck, say of the ER collet type.

I do hope you will have found this article at least interesting, but hopefully, also useful. ■

References

1. LITTLE HOGGER INDEXABLE ENDMILL SET Ref. LHS. Chronos Ltd. Unit 14 Dukeminster Estate, Church Street, Dunstable, LU5 4HU Phone 01582 471900. E-mail sales@chronos.ltd.uk Web www.chronos.ltd.uk
2. Lathe Projects for the Beginner part 9, MEW issue 75, page 29. For greater detail see Turning a Morse Taper MEW issue 6, page 28.



Photo 3. Setting the top slide in preparation for turning the taper.



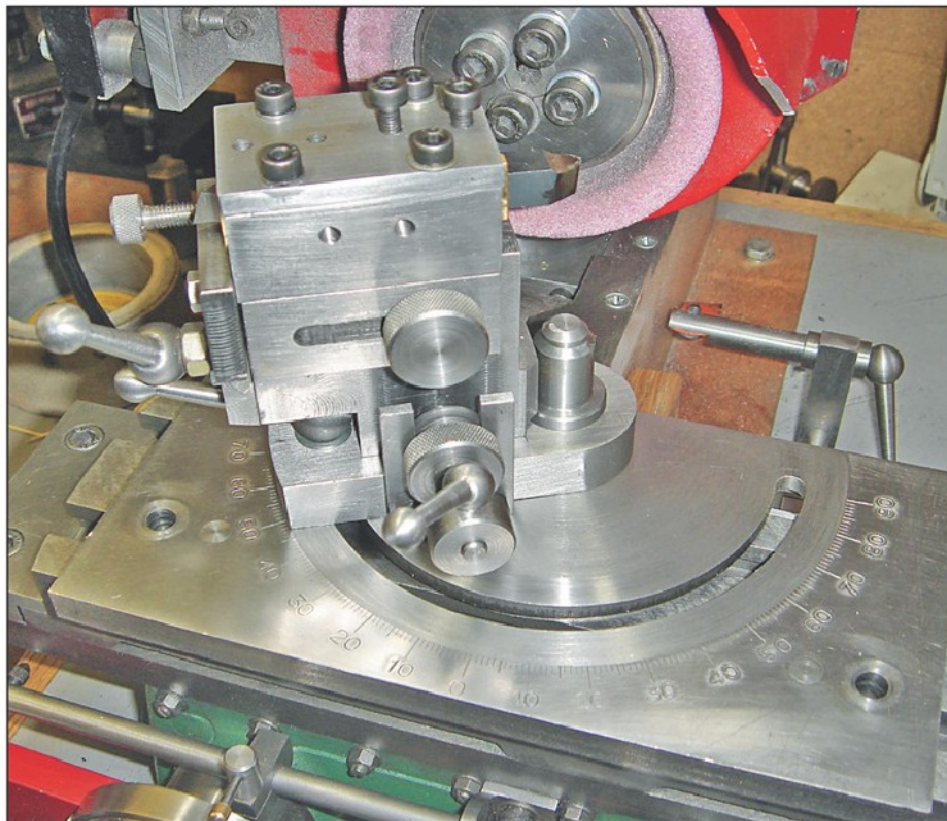
Photo 4. Machining the adapter bore.

LIVING WITH THE STENT TOOL AND CUTTER GRINDER 4

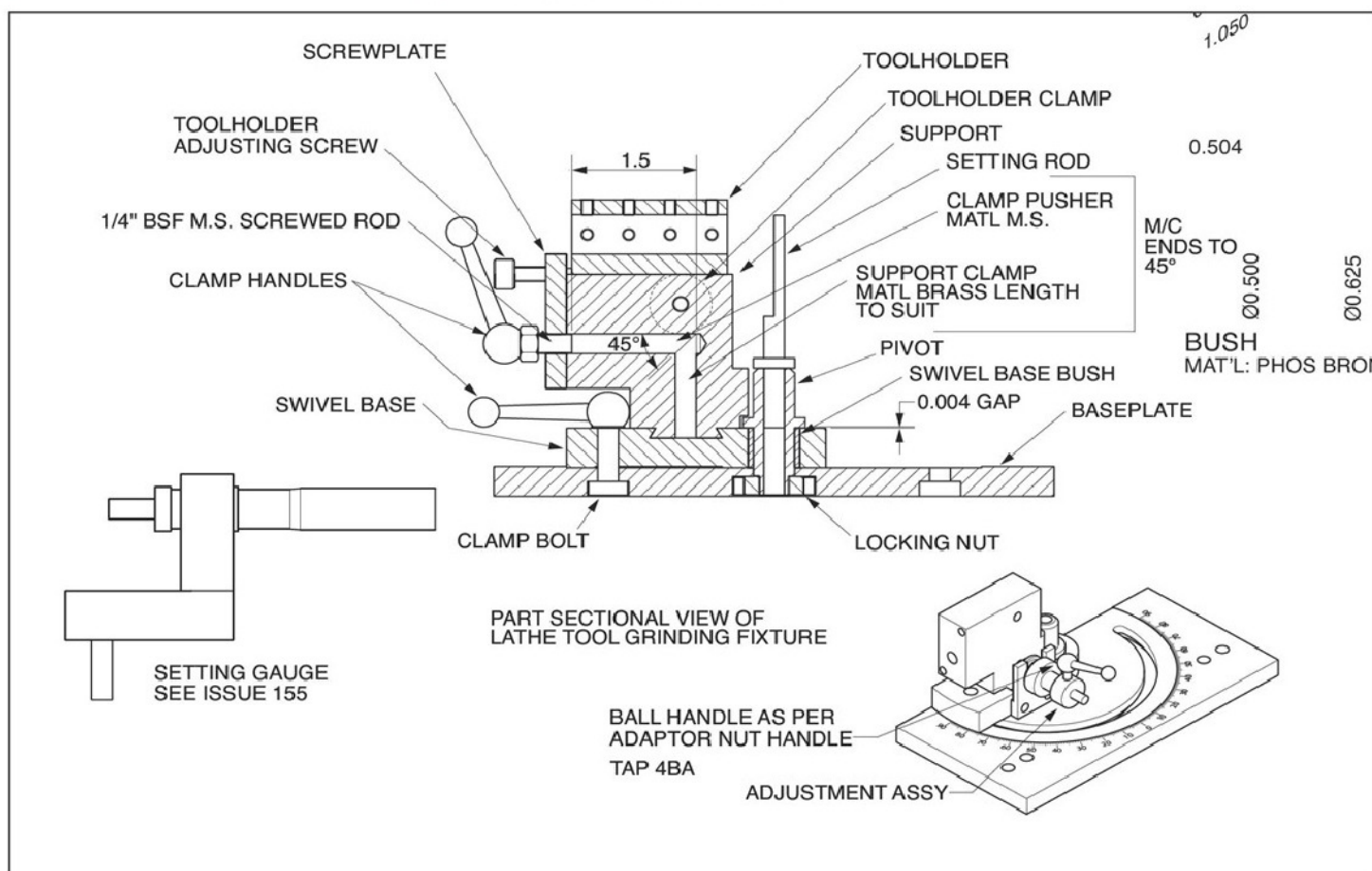
Editor's comments: We have reached the last part of this series and all that is left is to describe the radiusing attachment. This article has a lot of drawings. This is unavoidable and I hope readers don't mind. The radius attachment is used for grinding a radius on a turning tool for use in the lathe. The setting micrometer has already been drawn and is not repeated here.

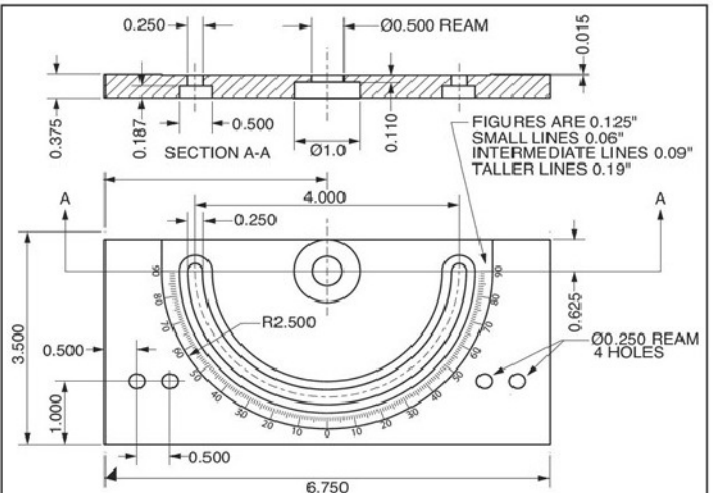
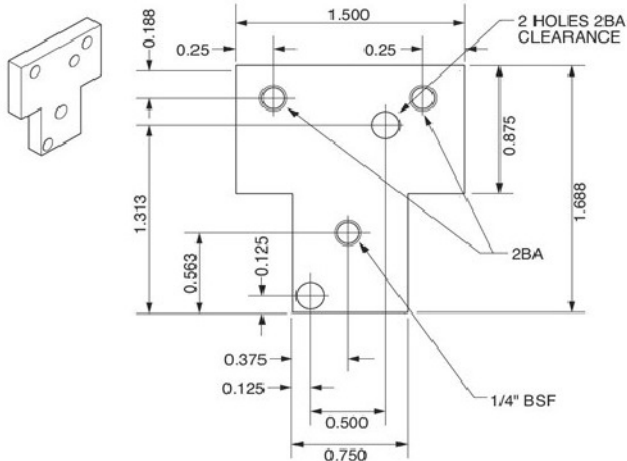
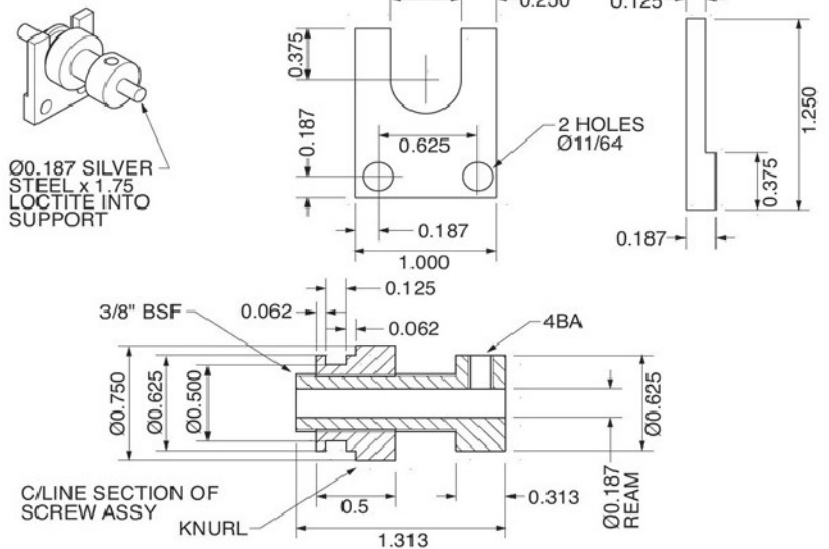
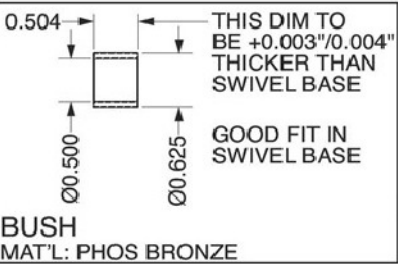
I am not sure if readers realise the size of the Stent but it is quite a small machine. Saying that, it is a very versatile little machine and is well worth building for use in the home workshop. I noticed a part finished Stent on, I think, the SMEE stand last year at Ascot. I hope it is on display this year. The castings are available from Black Gates if you wish to build one. I think perhaps it will take slightly larger cutters than the Quorn although possibly the Quorn will be better at making very small milling cutters; after all, I believe that is why Professor Chaddock made it in the first place.

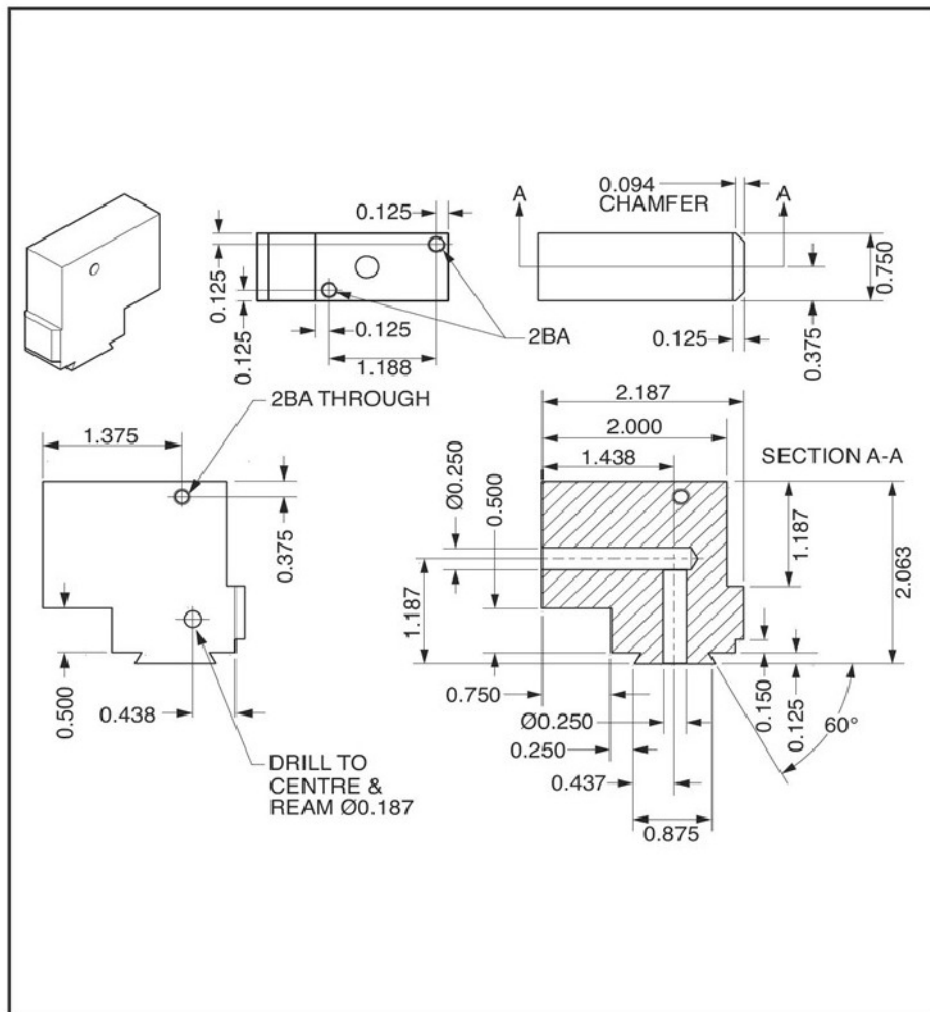
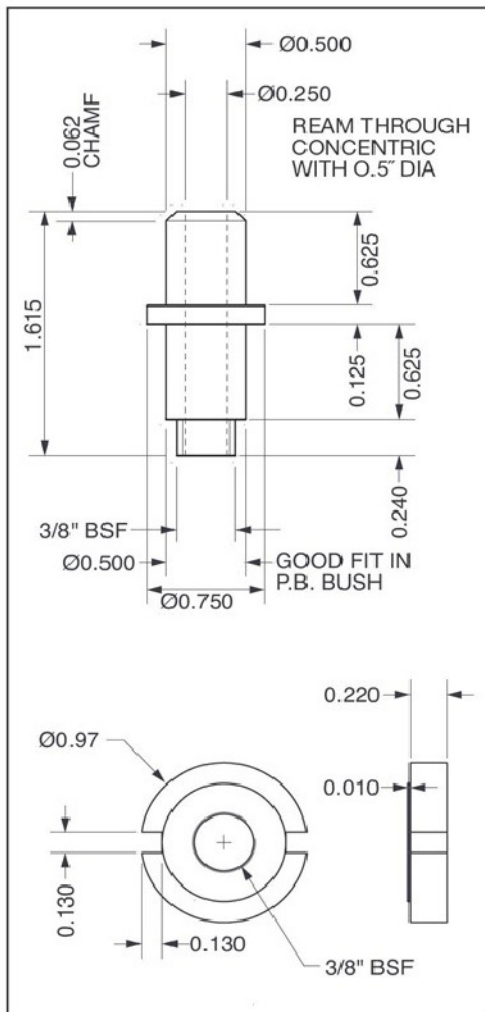
Whatever way you go, either the Stent or the Quorn, a small cutter grinder is an essential item of workshop equipment. I hope readers have enjoyed this series, I know I have.



The lathe tool grinding fixture.

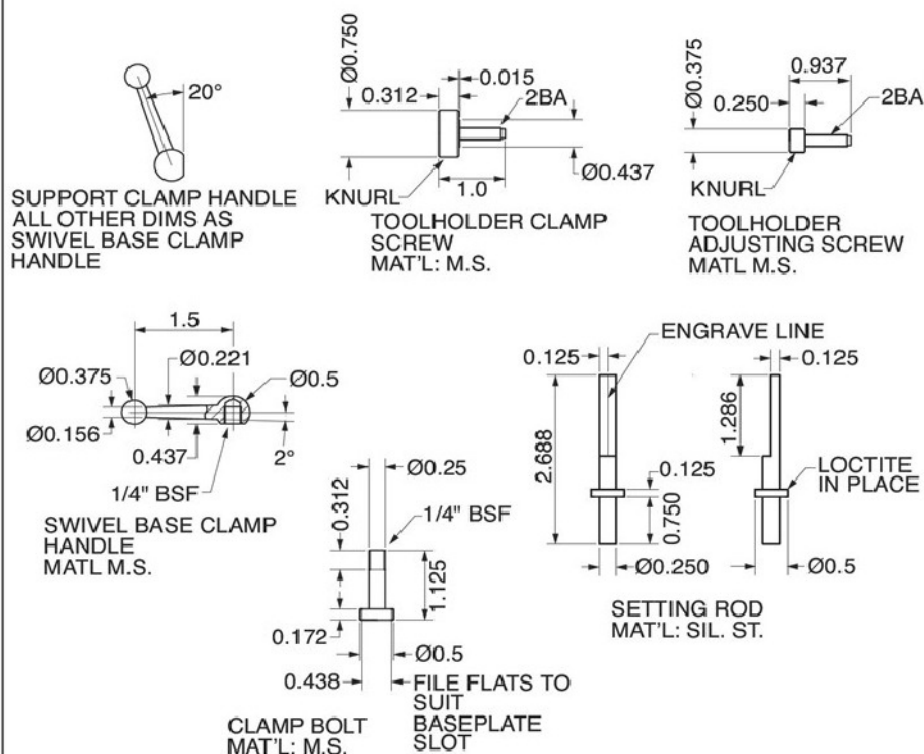






The entries for the Model engineer Exhibition are arriving but I have only seen one entry for tooling. This is for a lathe clutch by Ken Wilson. Although called the Model Engineer Exhibition, tools and tooling are equally as welcome as models. So, please enter that bit of tooling in the Exhibition. An Exhibition finish is not required, just a finish sufficient for the purpose for which the tool is used.

Please send your entry forms in as soon as possible to avoid problems with the threatened postal strike. You can email me the form at the editorial email. The Exhibition is progressing well this year, the move back to Sandown has been well received by the public and trade alike. Please ignore any rumours that the Exhibition is being cancelled through lack of support. This rumour starts every year; I can't imagine who starts it? Can You?



SCRIBE A LINE

YOUR CHANCE TO TALK TO US!

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Phillip Bellamy - an apology

Firstly I would like to apologise to Dave Fenner with regard to my letter, which you printed in the MEW. Originally I wrote the letter by hand then shortened and rewrote it again with the computer. In this process the error occurred, for which I apologise.

For your information the second hand knurling tool cost me nothing, as I was able to swap it with one of my late wife's parrots!

Equally I would like to thank Stuart Walker for his positive letter, which I have just read, as well as giving a very fair appraisal of the situation. I must also state that I have had several very positive comments as well as requests for more information on knurling, often from persons that I have not previously known.

The main reason that I do not write for the magazine, especially with regard to tooling, is that the many tools that I have built myself are only the standard designs that have generally appeared in the Engineering in Miniature and Model Engineer over the years. Typically I have built a Quorn, a Stent and a Worden tool and cutter grinders. Many of the others being from the late George Thomas, all of which I have found very good.

I now spend my time writing articles for the Quarter Deck, which is the house magazine of the Surface Warship Association. My main interest in Radio Controlled Models goes back to before 1948, which was the year that I joined the now extinct Radio Controlled Models Society. I still have the radio controlled DUKW which we built in 1949. It was written up in the ME 1950 and 1951. All this has little to do with tool making!

Phillip T. Bellamy

The editor replies: This correspondence is now closed. I would like to thank Mr Bellamy for his letter and hope we can put this behind us and continue on with positive matters.

Screw threads

With reference to the letter from Mr. Graham Bennett in Canada, on the subject of substitution of threads for B.A. sizes in the Issue 156, The Autumn edition of the Model Engineers Workshop. I would recommend that he looks in the Model

Engineers Workshop for July/August 1996 pages 12 to 16 inclusive. This gives, in my opinion, a very comprehensive insight into different thread sizes arranged by (1) Series (2) TPI & (3) Outside Diameters.

I have these same pages in plastic wallets hanging for reference in my workshop. If Mr. Bennett is unable to trace this back copy of MEW I would be only too pleased to send him a copy of mine.

Tony Morris by Email.

Central Lubrication System

David White's article is good and the end result will be much better than "now and then" lubrication. However a number of points arise.

Firstly the oil channels in the slideway are I believe normally at an angle to the directions of travel, this ensures a better spread of oil and more importantly, helps to prevent the creation of a ridge down the centreline as well. David's cross channels are I presume there to assist the distribution but will not prevent a ridge in due course.

Secondly, without metering valves, the allocation of oil, although better than no system at all, will tend to follow the path of least resistance, which may lead to much less oil at some points. His check valves are most interesting and I conclude that they work well from his statements. Commercial metering valves are not a check valve as such, but dispense a predetermined "shot" of oil, the shot size being determined by the use of an appropriate sized valve. The operating pressure of these commercial valves can be up to 10Bar.

I have an experimental Myford S7 carriage and cross slide lubrication system in hand at present.

Ken Wilson by Email

Superglues and engineering adhesives

As a (fairly) regular reader of Model Engineers Workshop, and a retired Materials Scientist I should like to make some comments about the feature 'An Introduction to Superglues and Engineering Adhesives' contained in Issue 155.

I found the bulk of the article to be informative and essentially accurate;

Tangential tool holder

I have made the tool holder as described in the latest issue, and in seems to work very well.

To make life easier after resharpener the tool bit, after finding the correct height of the bit, I found a spare piece of metal and milled a piece of one side away to the height of the bit above the holder. By holding this on top of the tool holder I can now easily reset the tool height.

Clive Swinney



however, I would like to make two comments about epoxy resins (Adhesive Class 3)

1) Some amine cured epoxy systems are prone to poisoning when used on copper containing materials (e.g. copper, brass, bronze), which can lead to extended cure times, or, in extreme cases, no cure at all. At the least it can lead to unsightly green/blue discolouration at the joint substrate interface. I would advise making a trial joint with the user's adhesive of choice on some scrap material prior to use as a structural joint.

2) The Rapid Cure epoxies (typically thiol modified), have much poorer resistance to water, (especially hot water), than conventional epoxy systems. Their use in water wetted systems should be restricted to temporary joints only, as they may be prone to sudden failure.

Patrick Bayford by email.

Engineers wanted

I'm trying to find out the numbers of small engineering hobbyists in the north of England, specifically County Durham. I'm hoping to start a small club where we will provide a space for engineers for model making to larger projects (a domestic wind turbine for example).

We will provide larger lathes, milling machines, tool etc than most people will have access to or indeed have the space to install them or the money to buy them.

However, in order to gain a grant towards the start up funding, I need to justify the numbers of people I hope to attract to the project. I was wondering, if you could print this letter so I can get an idea of the possible number of people I would be catering for in the North of England. Readers can reply to Bagophnuts@gmail.com

Nick Ramsay by email

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■ Bridgeport vertical milling machine, 42in. bed, Varispeed head, Heidenhein DRO on X and Y, nice condition ex toolroom machine,

three phase but easy to convert to single phase, £1200.

Tel: 01450 376435 Carlisle.

■ Warco variable speed vertical milling/drilling machine, 3 Morse taper, instruction manual, tools, £180. **Tel: 01453 823783 Gloucester.**

■ Warco BV20-1 screwcutting lathe with imperial and metric changewheels, near new condition, £400 ONO. Portass lathe with cast iron stand, offers?

Tel: 0161 4392021 Stockport.

■ Colchester Student lathe, single phase, well equipped, £1400. Surface plate, 18in. x 18in. £100. Small flypress on bench, £150. Silver steel and gauge plate, offers?

Tel: 01435 830722 East Sussex.

■ Warco C3 Mini-Lathe, metric, 3 and 4 jaw chucks, 13mm Morse 2

drill chuck, changewheels, vertical slide, new March 07, on wooden stand, VGC, buyer collects, £350. **Tel: 01229 470364 Barrow-in-Furness.**

■ Myford lathe, 12in. centres with chucks, vertical slide ETC, Zyto lathe similar with chucks, four way toolpost, quick change toolpost, clutch ETC, reasonable offers. **Tel: 01476 591213 Grantham.**

■ Conquest lathe spares, new lead screw and half nut, new 4in. 3 jaw chuck with internal and external jaws and backplate, £35 +P&P at cost. **Tel: 0161 6522404 Oldham.**

■ Topslide for 4 1/2in. Boxford with 4 way tool post, £30, tailstock £40, compound gear, 100/127T, £30, buyer collects or pays P&P. **Tel: 01269 591210 Ammanford.**

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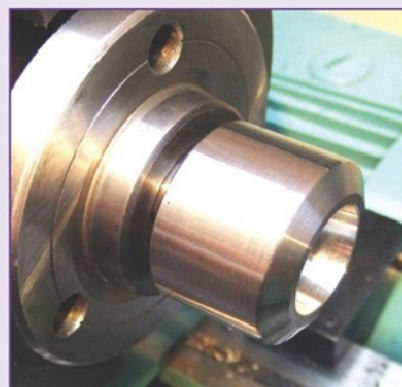
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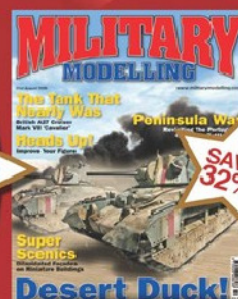
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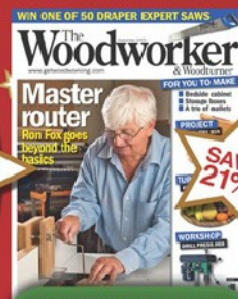
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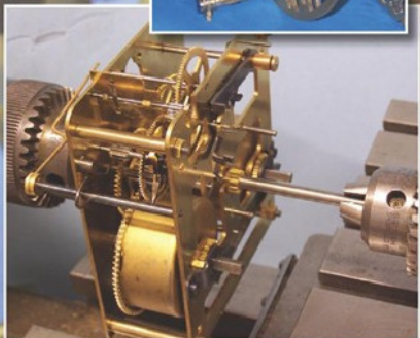
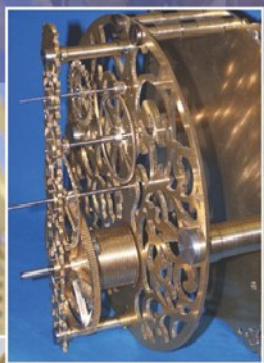
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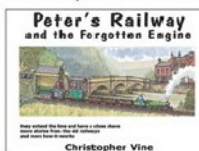
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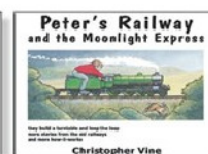
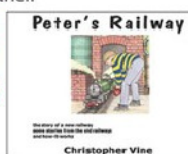
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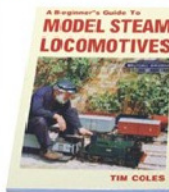


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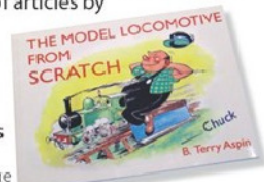
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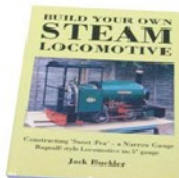
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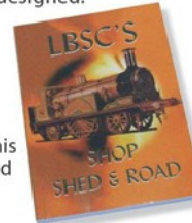
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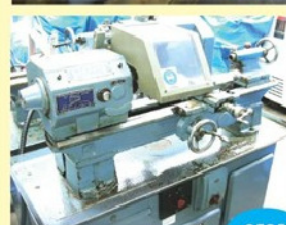
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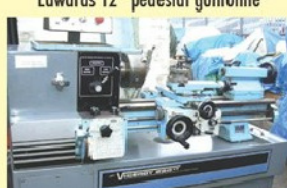
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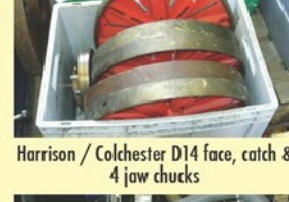
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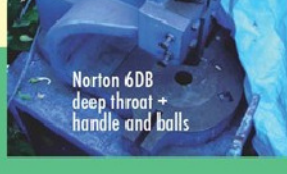
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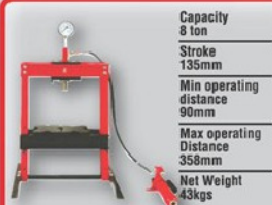
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