No.266

DIVIDING HEAD PLAN - SHEET TWO IN THIS ISSUE

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APRIL 2018

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- Repairing a Lang Lathe
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On the Editor's Bench

Chain Hoist Tripod

I received an email from John MacDairmid regarding the feature in the last issue. He suggests that the tripod could be improved by fillets between the baseplate and tubes, nutting the top of the u-bolt to the plate and welding the nuts in place, he also advises adding spreader bars and taking precautions to make sure the feet are securely placed and can't sink on soft ground. For further advice he suggests readers visit the HSE website and consult the Lifting Operations and Lifting Equipment Regulations 1998 (LOLER).

Carrying Acids

I am sure that all MEW readers are as horrified as I am to hear of the terrible acid attacks – where it is used as a 'weapon' by muggers and in domestic violence. The government has reacted by announcing that concentrated acid will be defined as a "highly dangerous weapon" to allow harsher punishments of up to six months in jail for carrying it in public. The Home Office has announced "We will shortly announce our response to last year's consultation on new legislation banning sales of corrosives to under-18s and introducing a new offence for possessing corrosive products in a public space". This is going to be combined with voluntary arrangements to stop the sale of corrosive products to under eighteens.

A question this raises is what are the implications for those of us who want to use products like this for legitimate purposes that are an integral part of our hobbies? Pickling, de-rusting, plating and anodising are just three uses for strong acids, let alone topping up lead acid batteries. Other corrosives, such as caustic soda and ferric chloride, have many workshop uses. Like many readers I have several such chemicals in my workshop (all stored in clearly labelled and sealed containers!)

Current legislation greatly restricts the purchase and carrying of knives without preventing people from buying things like fishing and kitchen knives and moving these between their places of use. Let us hope that a similar common-sense approach is taken to implementing this new law. In my view it would be good to see plain and simple guidelines issued for people on how they can continue to use these materials safely and without getting on the wrong side of the law.

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040-011-00013	0.2-13mm	B16	100.6mm	49mm	931g	£24.00
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060-010-00200	19pc Metric Set 1mm to 10mm x 0.5mm increments	£9.98
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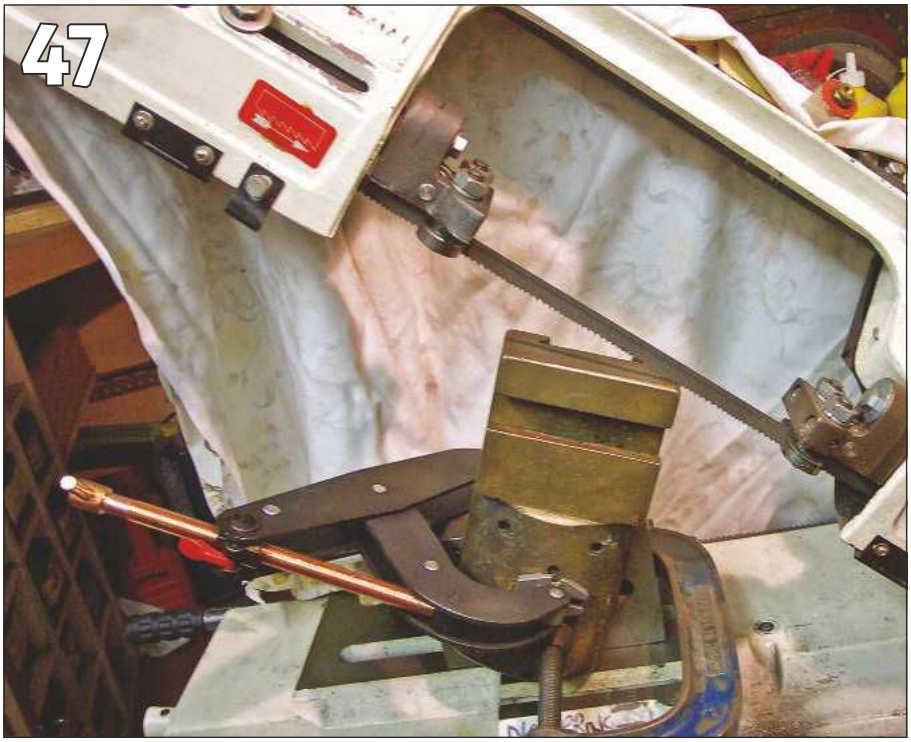

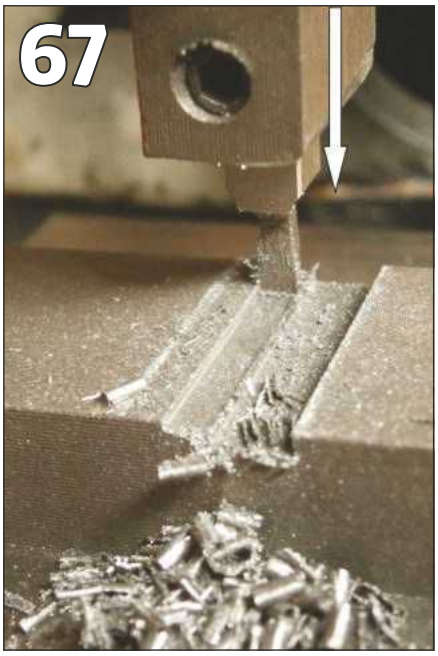

See page 52 for details.

Coming up...

in our next issue

Coming up in our next issue, MEW 267 another rewarding read.

Regulars

ON THE COVER

This month's cover features the new-build steam locomotive 60163 Tornado, a 'peppercorn' pacific freshly turned out in primer for the A1 Steam Locomotive Trust, see Ian Howitt's article in this issue where he recounts some of the workshop lessons from his involvement with many full-size loco builds, including Tornado

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THIS MONTH'S BONUS CONTENT

Log on to the website for extra content

A Visit to Chesterfield MES - have you ever wondered what workshop facilities and other benefits a model engineering club offers it members? The editor visited the Chesterfield club and found out. **www.model-engineer.co.uk/chesterfield**

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

So, why not come and join one of the busiest and friendliest model engineering forums on the web at **www.model-engineer.co.uk?**

Replacing Water Gauge Cocks
- What is the best packing for full size gauge cocks?

Atom Minor Mk III
- Deciding the best fuel to use for Edgar T. Westbury's historic four-stroke aero engine design.

The Workshop Progress Thread (2018)
- Find out what others have been up to and share your latest work.

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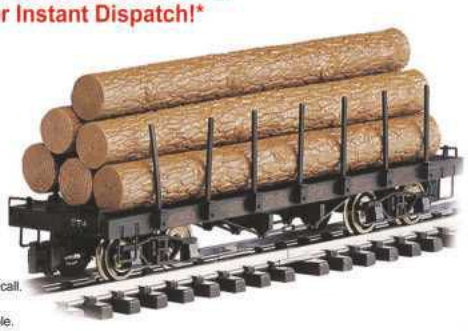

*In stock as of 06/03/18, please note these loco's may no longer be available, check stocks online or call.
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Some Minor Lathe Modifications

Howard Lewis looks at a range of ideas applicable to many different types of lathe.

It is often said, with a great deal of accuracy, that there is no ideal lathe. I am in the fortunate position of owning two lathes but found that both would benefit from minor additions and modifications.

Soon after receiving my Engineers Toolroom BL12 – 24 (very similar to the Warco BH600 or Chester Craftsman). It seemed that a few small changes would improve its usefulness.

Similarly, as many others have found, the mini lathe can benefit from extra accessories or alterations.

What follows is an account of, what seemed to me, to be improvements.

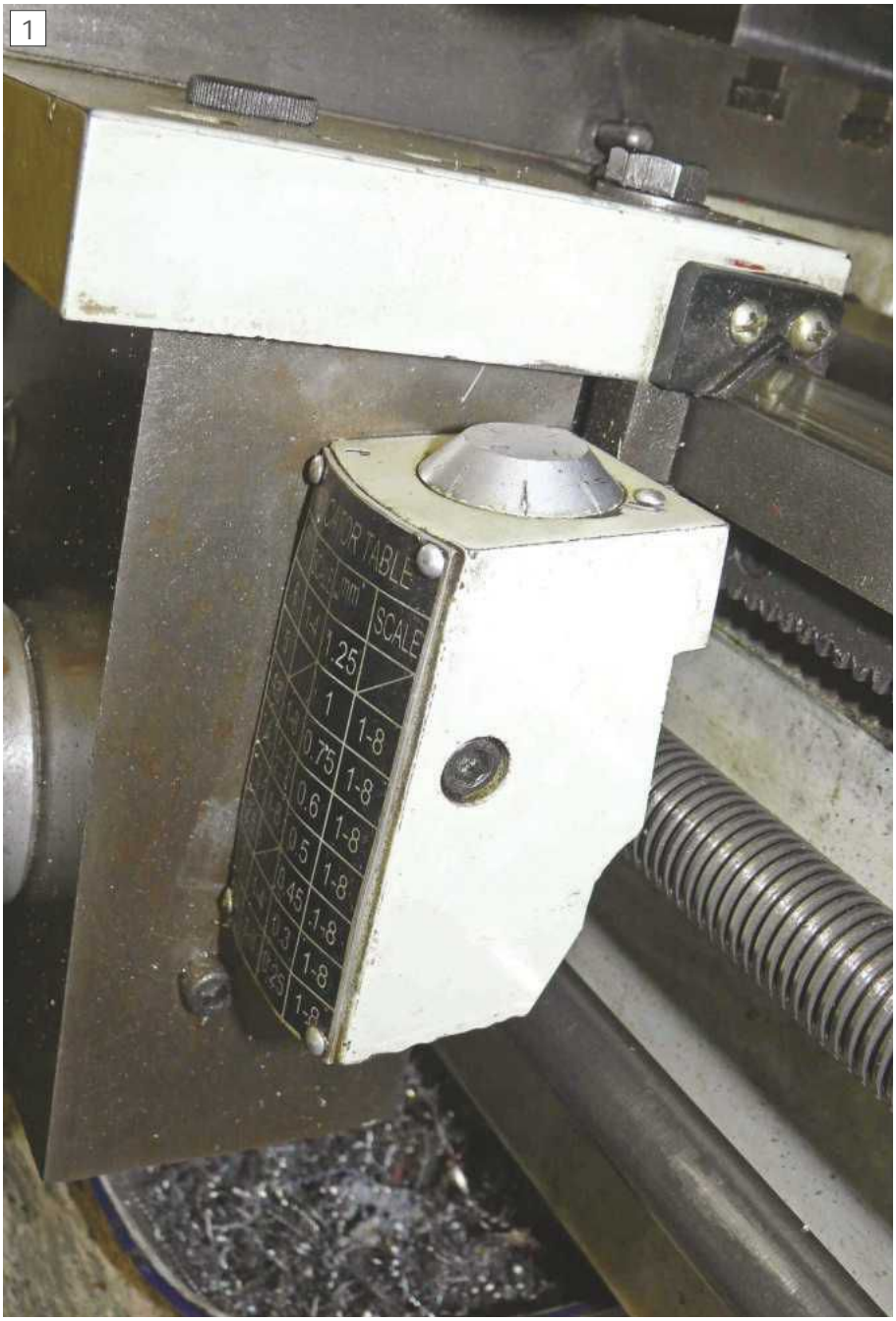
Some, or all of these, may well be applicable to other machines; either directly, or with adaptation, so precise dimensions have not been quoted.

Engineers Toolroom BL12 – 24

The first modification was to relocate the thread cutting dial from the headstock side of the apron to the tailstock side. This would allow the saddle to approach the headstock more closely, (too closely as I later found to my cost!)

The position of the new tapping in the rear face of the apron was found by the crude method of locating a piece of card against the lathe bed and marking the position of the tapping in the front face. The card was then turned over and used to mark the rear face for drilling and tapping to take the capscrew.

It immediately became clear, that once in position, it would foul the rear bearing block for the leadscrew and power traverse shaft. The thread indicator was stripped, and what was now the rear side of the housing, profile milled to clear the bearing block. **Photograph 1** shows the result after cleaning and reassembly.



Moved and modified thread indicator

> With some trepidation, the control block was removed, and the oiler removed from the top surface.

The next thing that became obvious was that the ball oiler for the power traverse selector mechanism, beneath the cross slide handwheel, was totally inaccessible. With some trepidation, the control block was removed, and the oiler removed from the top surface. The hole was filled with a brass plug, and a 6mm hole drilled in the front face to take a new oiler. Once this had been done and

›

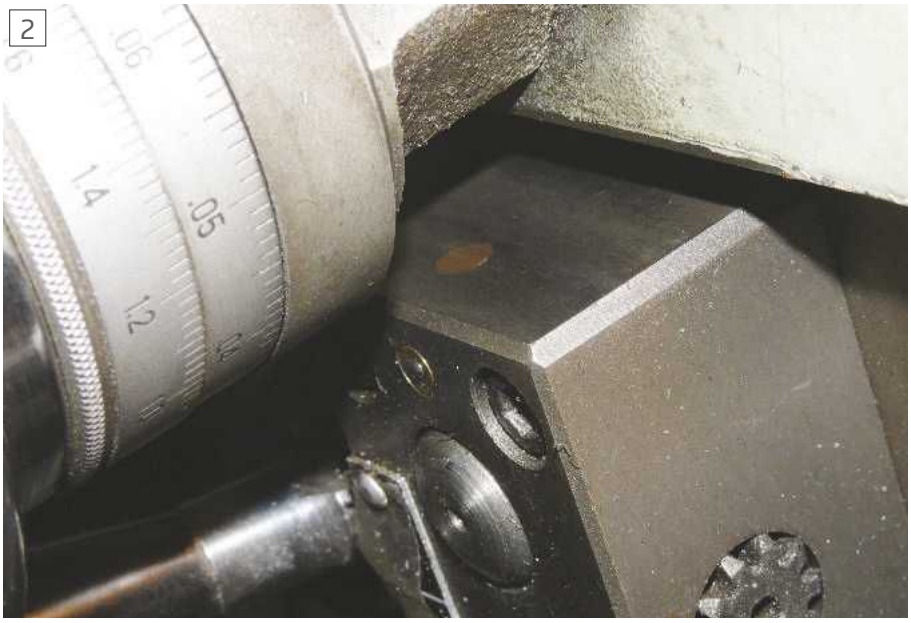
everything cleaned up, the block was replaced, as shown in **photo 2**.

Rear toolpost

Having found a rear toolpost to be so useful on my previous Myford, I resolved to make an even better one for this lathe. Fortunately, the cross slide was tee slotted.

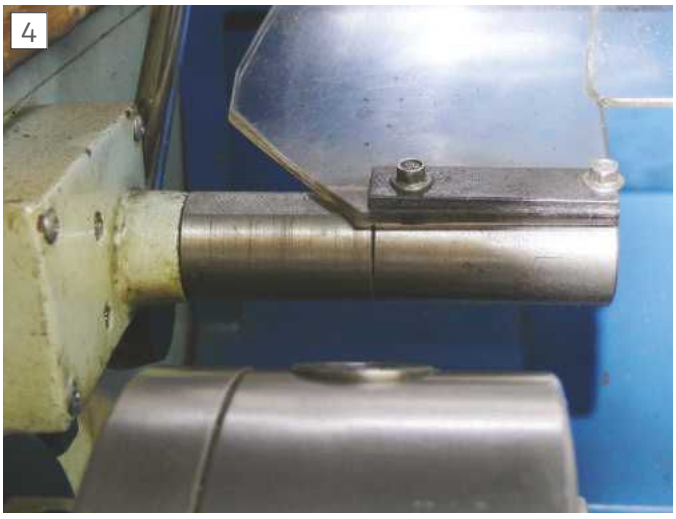
The raw material became available in the form of a (free!) metre length of steel that had been fine milled to 25 x 75mm.

After a lot of headscratching, a design was finalised, (and unusually, drawings made, rather than the usual sketch on the back of an envelope). The rear toolpost was made by laminating five pieces of steel, each one machined differently from the others, and held together by three long internal capscrews. The fourth corner was reserved for the silver steel dowel which located each of the four positions. The clamping handle was made to look, as much as possible, like that for the front toolpost. Half inch square steel proved to be the ideal size of material for making the M10 tool clamp screws. The base was located against the back of the cross slide by two small silver steel dowels. The tee nut to clamp the toolpost to the cross slide was made as one long piece, with two m8 studs loctited into it.



Relocated oiler

Rear toolpost



Modified guard mount

Photograph 3 shows the toolpost in place. Since it carries front and back chamfering tools as well as a parting tool, it is very rarely removed.

Chuck guard

The rear toolpost now created the problem that it fouled the shaft for the chuck guard when working with a collet chuck in place of the three or four jaws chucks. The chuck guard could not just be removed, since it operated a microswitch as part of the safety interlock system.

The solution adopted was to remove the chuck guard, and the cover over the shaft operating the microswitch.

The guard was removed from the sleeve carrying it, which was in turn removed from the shaft.

The microswitch was wedged, temporarily with a washer, and the shaft parted off, to leave a length, at the microswitch end, to which a new longer sleeve could be attached. The sleeve carrying the guard was reduced to less than that the length of the piece of shaft that had been parted off. The sleeves were drilled and tapped to take capscrews, so that the new sleeve could be clamped to the short end of the shaft, and to the "long" end of the shaft, carrying the shortened original sleeve ready to take the chuck guard again, **photo 4**.

After reassembly, it was found that there was a foul between the guard and the belt tensioning lever, so the guard was cut away to provide clearance, **photo 5**.

Tailstock DRO

The tailstock was the next to receive attention. This was in the form of adding a DRO. For this, a piece of aluminium was cut, and bored to a snug fit on the tailstock barrel, before being split on one side. It was drilled and tapped for a clamping screw on the rear side, and to take the end fittings for the DRO on the vertical front side.

The tailstock body was drilled and tapped to carry the bracket for the DRO readout. The end result, after a long time of use is shown in **photo 6**. Beneath the scale of the DRO, the tailstock bears the marks of a previous, failed, attempt!

Catchplate and backplates

Additionally, a catchplate has been made, as have backplates for ER25 and ER32 collet chucks. All these entailed fabricating parts and then screwcutting 2¼ inch x 8 tpi whit form threads to suit the mandrel.

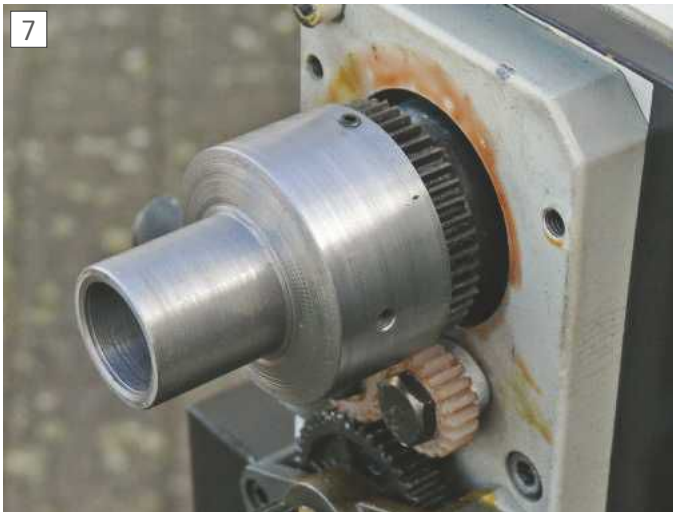
The ER collet chucks were aligned by coating the backplates with Loctite and then gently tapping the chucks with a mallet until the taper bore ran true to within 0.0005 inches, before finally tightening the securing setscrews.

A home-made mandrel handle also resides on the shelf behind the lathe, awaiting use when needed.

More recently, the lathe seemed to be afflicted, increasingly, by belt slip, and I

Modification to prevent fouling tension lever

Tailstock DRO



Mandrel extension

Enlarging cover hole with hand-held chuck and step drill

dreaded having to replace the secondary drive belt to the mandrel. Fortunately, it became clear that the lever, operating the belt tensioner was "sloppy". Investigation showed that the internal lever that moved the layshaft, was loose on its shaft.

Tightening the grubscrew made little difference, so the shaft was removed. This revealed that the dimple was too shallow. A few minutes in the mill/drill soon produced a recess which would locate the grubscrew without fear of movement. Reassembly (including the difficulty of refitting the large pivot pin) has restored belt tension, and drive to original levels.

C3 mini lathe

Having acquired a C3 mini lathe, it was apparent that it had been manufactured with cost very much in mind, and therefore lacked features that would be considered to be desirable.

Mandrel extension.

The first job was to make an extension to the mandrel, to carry swarf outside the cover, and so prevent it from falling into the plastic gears.

This was a simple turning job, entailing boring a piece of bar to match that of the mandrel, followed by boring so that it would fit over outer end of the mandrel. The OD (outside diameter) was turned to a give a wall thickness that would allow it to be drilled and tapped for two or three equally spaced small grubscrews to attach it to the end of the mandrel. The other end of the OD was reduced to leave a thin wall to the bore, to about 3mm short of the end of the mandrel. **Photograph 7** shows the extension in place.

To clear the extension, the hole in the plastic gear cover needed to be enlarged. A stepped drill was used for this, **photo 8**.

The handles on the handwheels were rather a slack fit on the bolts which they run, because of the draft angle of the bore moulding.

Setting the handle in the chuck of the lathe, a 9.8mm drill just cleaned up the bore, which explained the loose fit on the M8 setscrew.

Since high precision was not envisaged, the three jaw chuck sufficed for all this work.

There just happened to be some 1/2 npt brass plugs waiting to come in handy. Since the length of two plugs was about 3mm less than the length of the handle, the raw material for bushes was at hand.

Pairs of plugs were centre drilled, and progressively opened up for each handle, the M8 setscrew did pass through quite easily! Both ends were internally chamfered, and checked that the 7.9mm drill passed through, (more or less as a deburring operation)

Once mounted on a nominal 8mm arbor, and secured by a sacrificial nut, each plug was turned down to 9.8mm OD, taking a series of progressively smaller cuts.

Each bush was then pulled into the bore of the handle, using the m8 bolt and nut, with a flat washer interposed between the nut and the bush. Any sign of a loose fit would have been the recipient of an anaerobic adhesive.

Once assembled, operation of the handwheels, felt so much better!

Mandrel handle

The next addition was a mandrel handle, to allow threads to be cut manually.

A piece of hexagon bar was drilled through, and the end bored to a twenty-degree internal taper, before being turned, for most of its length, to be a snug fit in the bore of the mandrel.

Beyond the end of the tapered section, the o d was reduced in diameter, deliberately to make it more flexible. Once

›

Milling slots in taper

these operations had been done the bar was parted off to leave a short hexagon section, **photo 9**.

It was transferred to the mill/drill to have a slot milled into the end of the hexagon portion.

It was then reversed in the vice and a slitting saw used to produce slits in the internally tapered end. **Photograph 10** shows the main body, when completed.

An externally tapered "bung" was made up, (intended, eventually, to expand the internally tapered main body) and tapped M8 to take a length of studding.

The handle was made from material that came to hand. The handle had been the arm of a door closer, and the roller had once been part of the handle of a defunct lawnmower. The head of a long washerfaced M8 bolt was reduced in diameter, to fit into the counterbore in the brass bush set into the end of the roller. The bolt was locked into the tapping in the handle by means of a M8 nut. **Photograph 11** shows the handle parts prior to assembly.

Photograph 12 shows the parts ready for assembly, and **photo 13** is the completed item.

Tailstock clamp

Having to use a spanner to clamp and unclamp the tailstock seemed a bit of a nuisance and being too tight fisted to buy a lever clamp tailstock, some thought was given to speeding up operations.

A piece of bar was drilled and tapped M10, and then mounted on an M10 threaded mandrel to turn the taper to match that of the clamping handle for the tailstock barrel. On the tapered portion a hole was drilled and tapped M6.

A piece of 8mm bar was tapered down to 6mm and an M6 thread cut, to make a handle.

The height of the M10 threaded nut is such that whilst the tailstock is free with the handle at the rear position, it is clamped with a small rotation. The height of the M6 handle allows it to pass beneath the upper part of the tailstock when clamped, but the tailstock is free with the handle moved backwards.

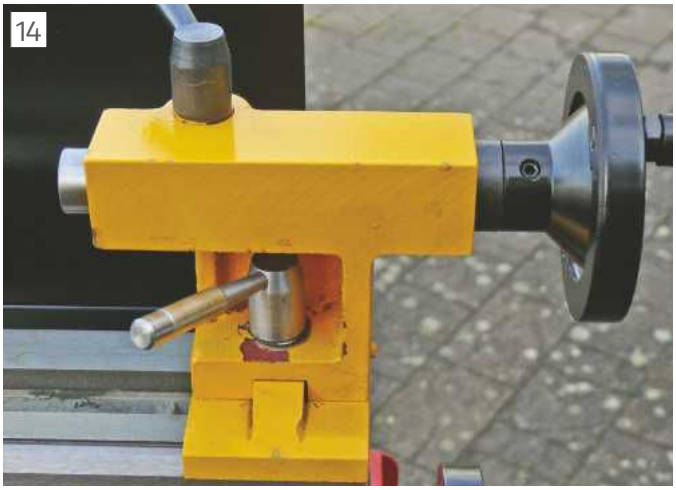
If the handle interferes with the cross

Main body of the handle

Handle parts

Components before assembly

Assembled handle



Tailstock clamp

Leadscrew bearings

slide, when the tailstock is clamped, it can be unscrewed.

It may be necessary to turn material off the bottom of the taper nut, or to pack it with one or more washers to ensure that the tailstock is free with the handle in the rearmost position but provides adequate clamping when moved in the direction of the saddle.

One way would be to fit the clamp nut and tighten it by hand so that the tailstock is only just free the position for the handle, in the rearmost *free" position can then be marked ready for drilling and tapping. **Photograph 14** shows the modified clamping arrangement.

The inspiration for most of the later modifications, if only in principle, if not in detail, came from others. Alistair Sinclair, Mike Cox, Neil Wyatt, and a fellow member of the Peterborough Society of Model Engineers all aroused my interest in their additions.

One Christmas present was a handwheel for the leadscrew on my Chester Conquest, and after some time, a set of parts was made up to allow it to be used as a graduated handwheel.

One of the means of producing the lathe at minimum cost seems to be to dispense with any obvious means of lubricating the leadscrew! Later versions do not seem to suffer quite so badly in this respect. (My early mini-lathe has oiling points at both ends of the leadscrew – the minor variations between models and factories are uncountable! – Ed.)

Although not visible in **photo 15**, a ball oiler was fitted to feed oil into the brass bush, and leadscrew bearing block. To minimise leakage, a non-setting jointing compound was smeared over the face, before tightening the M4 screws holding the extension to the tailstock end bearing block for the leadscrew.

The graduated sleeve is shown reversed, to indicate how it fits over the brass bearing to support the extended shaft for the handwheel. Not being totally confident in friction dials, mine is clamped by a M6 grubscrew pressing a small brass plug against the shaft. The 60 divisions, combined with a 1.5mm pitch leadscrew, provide an interval of 0.02mm. The sleeve was made as large a diameter as possible, so as to maximise the width of the divisions.

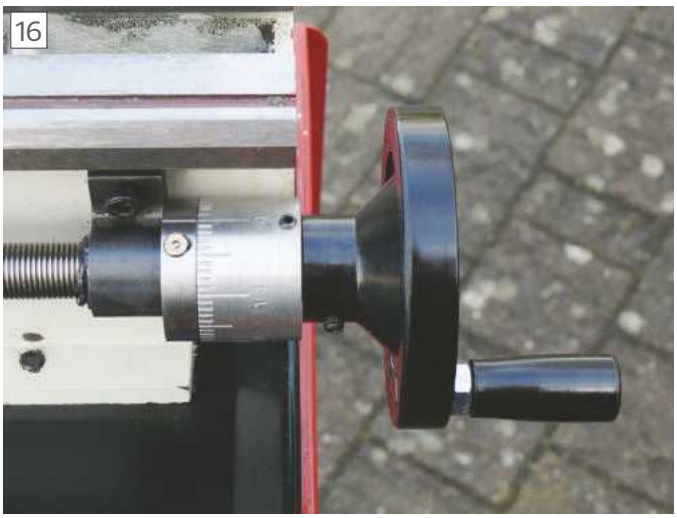
Photograph 16 shows the graduated handwheel in situ. With hindsight the datum mark on the sleeve would probably have been better sited further down on the front of the sleeve.

Whilst the leadscrew was out, the headstock end bearing block was drilled, for a 6mm ball oiler, as an aid to lubrication. Any burrs were removed with a small hand scraper, **photo 17**.

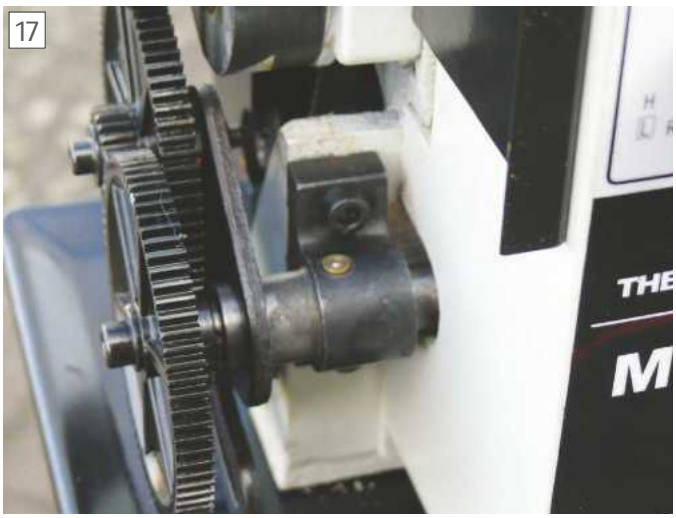
One feature that was lacking was a saddle lock. The figures quoted are those which suited my machine, others may vary. This one was made from a piece of ½" square bar. It was cut to 75mm long, with a 4.5mm hole drilled 6mm from each end. 37.5mm from the end, a 6.6mm hole was drilled, and counterbored to take a M6 capscrew.

Originally, it was envisaged as being a "clamp on" accessory, but it was decided to

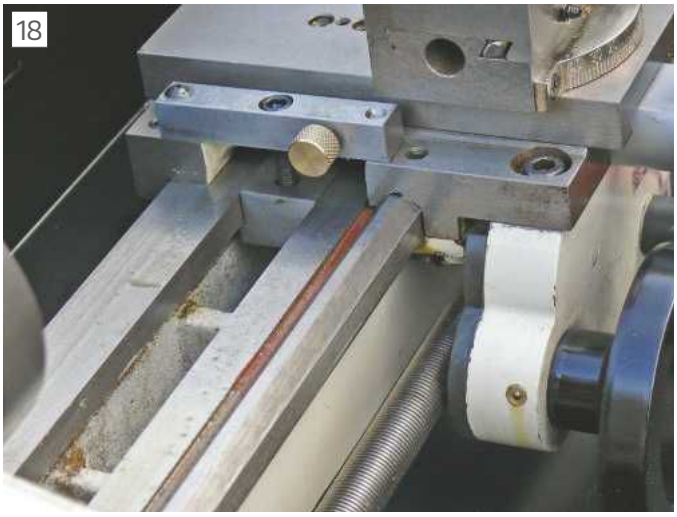
One of the means of producing the lathe at minimum cost seems to be to dispense with any obvious means of lubricating the leadscrew!



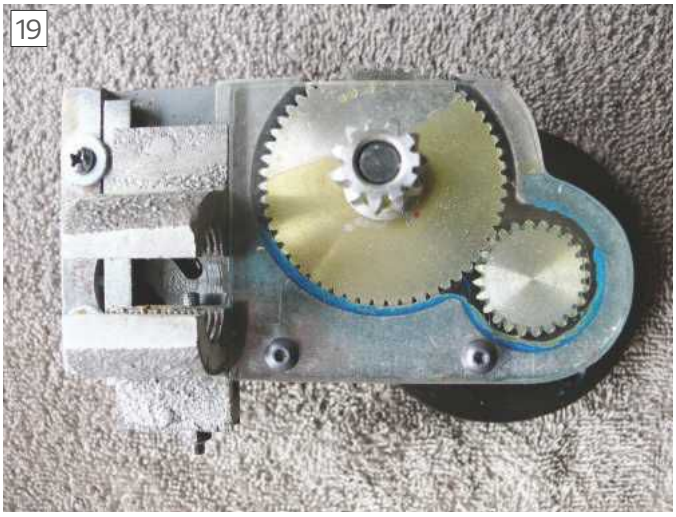
Leadscrew handwheel



Oiler for leadscrew bearing



Cross slide lock screw



Apron oil and swarf shield

fix it to the saddle, to enable it also to be used as a lock for the crosslide.

The tee-nut was a piece of rectangular bar milled to 35mm wide, and with a rebate 5mm deep, and 5.5mm wide milled into each side. A hole was drilled and tapped m6, on the centreline,12mm from one end. To allow the tee-nut to rotate, when lowered between the ways of the bed; diagonally opposite corners were chamfered 2mm deep at 45 degrees.

The saddle was marked for drilling by clamping the lock into position, with the face level with the front of the "legs" of the saddle. A 4.5mm drill was used to dimple the saddle, before it was removed.

The far side of the saddle was drilled 3.3mm and tapped M4. The front side of the saddle was drilled 3mm. This drilling just emerged at the side of the vee on the underside of the saddle.

Because I had not planned far enough ahead, the operator end of the lock had to be located by a stepped dowel (3mm at the lower end, and 4.5mm diameter at the upper end).

The cross-slide lock is a knurled brass knob with a 20mm long m4 thread. This is screwed into a horizontal M4 tapping at 12mm from the operator end of the lock, as shown in **photo 18**.

This also shows the ball oiler added to the apron, to lubricate the shaft of the pinion for the saddle traverse, as well as the transparent cover for the apron gears.

The apron had been removed during the modifications to the leadscrew and saddle, so this was a good opportunity to fit a cover over the gears, to prevent the ingress of swarf.

A piece of acrylic, some 5.5mm thick was cut to 90mm long by 65mm high. The lower face of the apron, and the side of the half nuts, were used as datum faces to measure the position of the spindle carrying the saddle traverse pinion. The acrylic was then bored out to be a tight fit on the traverse pinion.

This effectively provided a dowel to position the cover. One millimetre or so had been milled from the half nut side, to prevent a foul, whilst two 4.5mm holes were drilled, 6mm up from the lower face, and 9mm and 54mm from the datum edge.

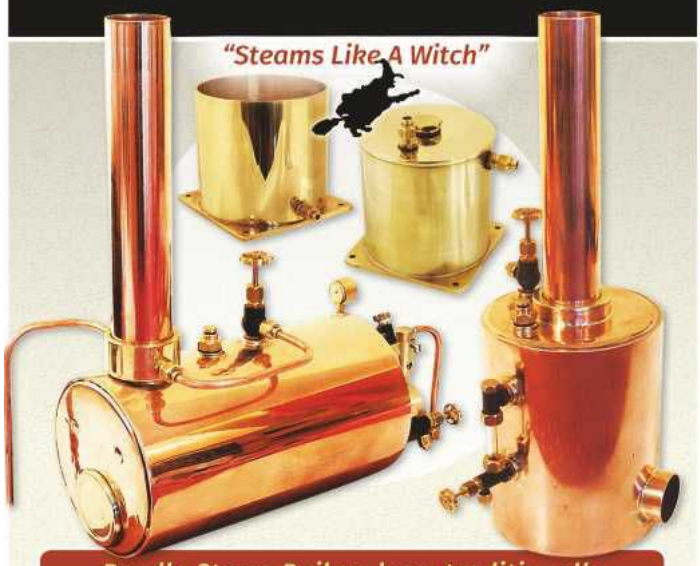
The acrylic was then refitted to the apron, and, with the lower edge aligned with that of the apron, clamped, and used to spot the position for the two M4 tappings, 15mm deep. At the same time a line was scribed around the profile of the apron.

The acrylic was then replaced in the mill/drill and by co ordinated use of the x and y handles, most of the material removed to give an approximation to the profile of the apron. The finishing touches were made with file, and then emery.

Once finished, the acrylic was fitted to the apron, with a smear of non-setting jointing compound (Hylomar) applied up to the level of the handwheel shaft. The intent was to seal the unit so that it would fill with oil and act as a reservoir to lubricate the gears, and with the fervent hope that some of the oil carried up would drain down the large gear and onto its spindle. **Photograph 19** shows the saddle ready for refitting to the lathe.

So far, the acrylic seems to have been stiff enough not to flex, and the sealant to have retained the oil. ■

Pendle Steam Boilers



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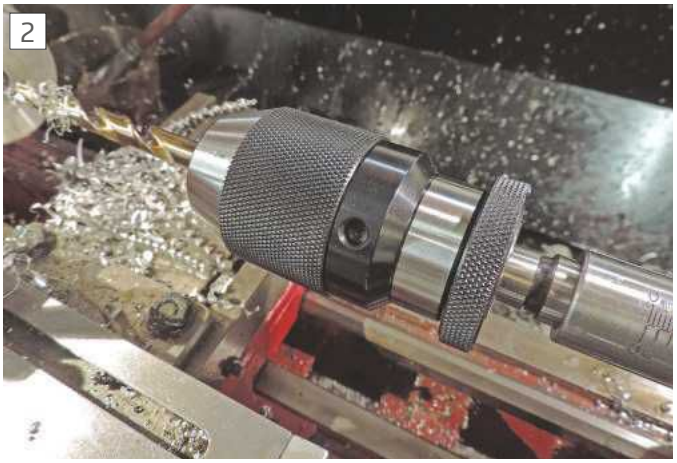
BriMarc TOOLS & MACHINERY

Lathework for Beginners

PART 4 - MAKING HOLES

This ongoing series will build into a complete guide to using an engineering lathe. This month Neil Wyatt takes a closer look at cutting tools.

A selection of keyed chucks with capacities 3-16mm, 1-10mm and 0-6.3mm.



This 13mm capacity keyless chuck is a pleasure to use and has excellent grip.

So far in this series I have covered some of the main turning operations, but I promised I would return to this topic in detail and cover the fascinating subject of boring! Boring is only possible when you have an existing hole to open out, so let's start by looking at drilling and reaming.

Drilling

When drilling with a hand drill, pistol drill for a drill press you will secure the work by putting it in a vice or clamping it down, then make the hole with a rotating drill bit. Normally when drilling on the lathe we turn this on its head by using a stationary drill and a rotating workpiece, and this normally means holding the drill in a tailstock chuck.

I won't go into too much detail about drills themselves. A good start is to get a decent quality TiN (titanium nitride) coated set in 0.5mm increments. A full set from 1mm to 10mm in 0.1mm increments is a great asset, but if you can't afford it stick with the smaller set and buy additional sizes when you need them for purposes such as tapping drills or pilot holes for reaming. Sharpening drills is beyond the scope of this series, but it is well worth buying (or making) an accurate drill sharpener as quality drills are an investment that will last many years if looked after properly.

The most affordable tailstock chucks are keyed ones like those in **photo 1**. This selection of chucks covers several different size ranges. If you only have one chuck, however, a 1mm to 13mm is probably the most useful size, as this will hold both small (but not very tiny) drills up to one large enough a boring tool – see below.

Hole in keyless chuck for c-spanner.

It is well worth getting a decent quality keyless chuck, such as that in **photo 2**, unless you have a very small lathe as they are rather longer than keyed chucks. They have the advantage of tending to self tighten, so they are less likely to let the drill slip under a heavy load and are also a genuine pleasure to use. It's probably best to avoid very cheap plastic bodied keyless chucks as often found on pistol drills, they rarely offer the accuracy and grip of a proper full size keyless chuck. If a keyless chuck tightens itself in use you should be able to find a holes that allow to loosen it using a C-spanner or a snug-fitting bar as lever, **photo 3**.

Whatever type of chuck you get, it will probably require to be fitted onto a taper arbor. This arbor should match your tailstock, so typically a Morse taper - MT2 for the Arc SC4-510 and most 'bench' lathes. The taper at the chuck end might typically be one of the B-series (e.g. B12) or a Jacob's taper (e.g. JT6) and your supplier should be able to supply a matching arbor, **photo 4**. To fit the arbor, make sure the socket in the chuck and the matching taper are completely clean. Wind the jaws of the chuck right in and rest the 'nose' of the chuck on a wooden block. Insert the arbor into the chuck and tap (not wallop) the end of the arbor with a wooden mallet. If you haven't got a wooden mallet use another piece of wood to protect the arbor and use a medium hammer. If you ever need to part the chuck from its arbor, you can get pairs of matching wedges that are squeezed in from the sides.

B16 taper and matching socket on a chuck and a rolling centre.

The rotating chuck fitted to its arbor.

To use the chuck, simply push it into the (clean) tailstock barrel socket with firm hand pressure. Under normal loads the chuck should not be in any danger of slipping. On most lathes you can eject the chuck simply by winding the tailstock barrel right in.

Drilling a hole is as simple as starting the lathe and running it at the right speed for work the same diameter as the drill. To create the hole the drill is fed in using the tailstock handwheel or, if present, a tailstock lever or capstan. If the drill starts to 'squeal' or you feel increasing resistance, back the drill off and clear any swarf from the flutes.

The feed rate for drilling holes is best found by feel. It is often hard to run the work fast enough for small drills, in which case you will probably find that you don't want to feed the drill in too fast.

One aid to drilling small holes is a free-rotating tailstock chuck, such as that in **photo 5**. The technique to use this is to hold it gently in your left had as you feed it in with your right hand, so that if the drill 'grabs' it can spin in your grasp. This makes 'peck' drilling to regularly clear the flutes of a small drill much easier. Such a chuck can also be used for tapping blind holes and even to steady the end of long thin work.

On many lathes the tailstock barrel is graduated, photo 6, this allows you to drill holes to a reasonably accurate depth. The SC4-510 includes a graduated dial on the tailstock handle to allow very accurate depth control, **photo 7**. This is something of a luxury, as it is rare that you will need to drill holes to an accuracy greater than about 1mm.

Now earlier I stated drilling a hole is as simple as fitting the drill and feeding it into the work. While this will usually give you a hole, we normally want to maximise the chance of the hole being accurately on centre and size. To do this it is best to start off using a rigid spot drill or a centre drill, **photo 8**. I prefer spot drills for this task as they are less fragile in smaller sizes. You just need to make enough of an indentation to take tip end of your normal drill, so it only has to cut on its flutes.

In Part 2 I made a simple top-hat shaped test piece by drilling it in three steps, centre drill, 10mm and then 13mm. Step drilling

Boring Small Holes

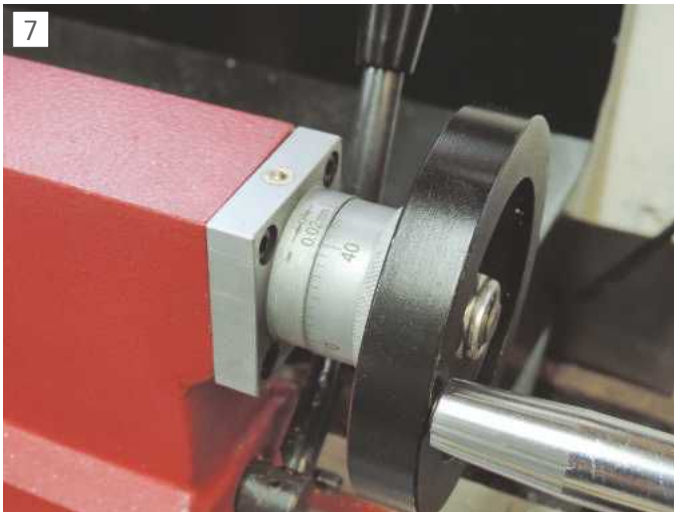
Understandably, the makers of boring tools generally try to make them as rigid as possible and one of the consequences of this is that they can often have a lot of metal underneath the cutting edge. By carefully grinding away some of this material into a curve it is possible to allow the boring bar to enter a much smaller existing hole without significantly affecting the bar's rigidity.

Sometimes it is not obvious that a boring bar is too large for a hole, but a tell-tale effect is that the bored surface is rather poor and often ridged. This is caused by the tool rubbing beneath the cutting edge and can often be avoided by grinding away a very small amount of material as shown in photo 15.

The ideal shape for very small boring bars is a semi-circle, as such a tool can work in a hole only slightly larger than its own diameter.

These can be easily made by grinding away half the thickness of a piece of round HSS. A suitable holder can be a block of steel held in the toolpost drilled and reamed to take the bar. The bar can be held in place with a pair of screws or the block can be split along one side and squeezed tight on the bar by the toolholder screws.

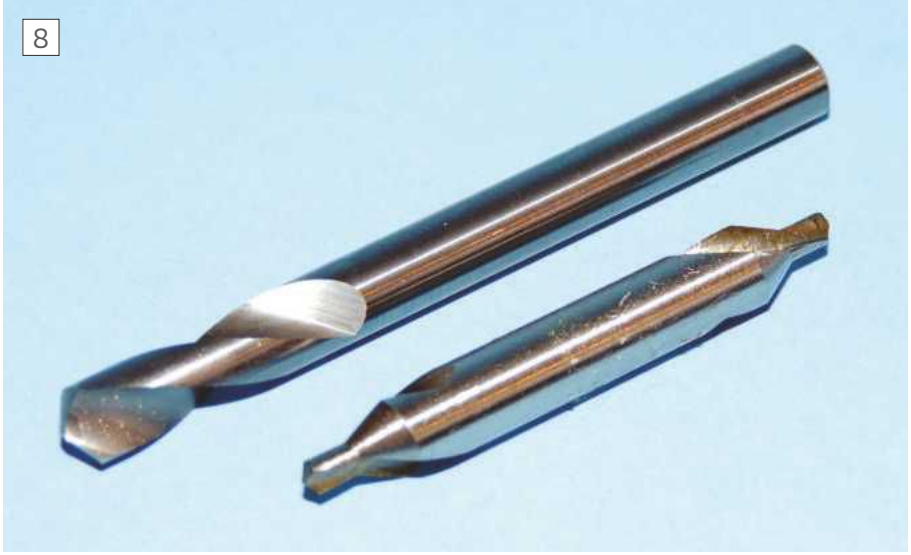
A clearly graduated tailstock barrel is a great asset on any lathe.



The SC4-510 benefits from an adjustable tailstock index dial.

like this reduces the loads on the drills but also helps ensure the hole remains central. For maximum accuracy I would probably have started with an even smaller drill, say 5 or 6mm. It's worth remembering that as the drill size increase, you need to slow the work down.

For really large holes, it is worth having a few large drills. "Blacksmith's drills" have a reduced shank to fit in a normal chuck, but I have a few large drills with Morse taper shanks. It's rare you will want a hole the exact size such a drill gives, but this is a great way to remove metal quickly in preparation for boring an accurate hole.



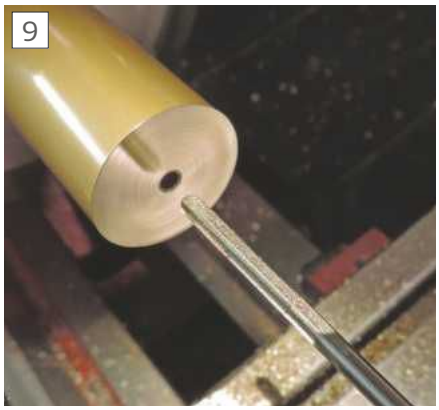
A carbide spot drill (rear) and an HSS centre drill.

Reaming

No matter how good your drills are, you should not expect them to give you perfectly accurately sized holes. Drills are designed to prioritise rapid removal of material over exact size, in fact they will usually drill slightly oversize. In contrast, reamers, **photos 9** and **10**, are designed to remove small amounts of material but to give well-finished and accurately sized holes, they are used to open out undersize holes to finished diameter. Reamers are available in different tolerances, the the commonly supplied h8 tolerance will give a close sliding fit on stock material and is a good 'general purpose' reamer.

Hand reamers have a gentle taper on the end and typically have a square to allow them to be turned using a (sizeable) tap wrench, while machine reamers do not have a taper and usually have a morse taper shank. In practice I use both types of reamer in a lathe, holding 'hand' reamers with a drill chuck.

Reamers need to make a proper cut to work well and avoid excessive wear, so the hole to be remade should not be too close to finished size. A pilot hole for reaming should ideally be about 0.1 to 0.4mm undersize, the smaller figure for holes of a few millimetres increasing to the larger figure for 25-30mm. Cutting speeds for reamers are about a third of the speed you would use for a drill of the same size. Although they only remove small amounts of material, small reamers can clog easily so they should be withdrawn regularly during a cut. Never, ever, reverse the lathe when withdrawing a reamer as this will rapidly blunt the tool.



A hand reamer being used in the lathe, it has about 15mm of taper on the end.

An H8 machine reamer, note the short, steep taper at the tip.

Boring

Boring is, essentially, 'internal turning' and can be used to open out drilled or pre-existing holes to an accurate size. The cutting edges of boring tools (often called boring bars) are essentially the same as those of ordinary lathe tools, and they come in all the different styles we looked at last time, **photos 11**, **12** and **13**. In addition, boring bars which take high-speed steel (HSS) inserts are commonly seen.

Because boring bars are inevitably greatly overhung compared to ordinary tools it pays to use the biggest boring bar you can get in the hole for maximum rigidity. Because of this' you will probably find you end up accumulating an impressive collection of boring bars.

The hardest part of boring is that you cannot see the cutter directly to monitor how the cut is going or check that you are using appropriate speeds, feeds and depth of cut. This makes it especially important to pay attention to things like handwheel dial settings and listening (and feeling) for the feedback that all is proceeding well.

Give particular attention to what will happen when the tool 'runs out' at the end of a cut. Ideally it will emerge into thin air.

Blind Holes

The basic approach to boring blind holes is simple enough – drill a hole to the required depth, then open it up to the diameter you need with a boring bar. The challenge is to make sure that each pass of the boring bar goes to the same depth. There are various ways of doing this:

- Make a mark on the boring bar and 'eyeball' this against the edge of the hole – you can be accurate to a fraction of a millimetre this way.
- Use a stop attached to the lathe bed and advance the saddle until it just touches the stop on each pass. It is difficult to do this accurately under power.
- If your lathe has a graduated dial on the saddle handwheel, like the SC4, set this to zero at the required depth. With fine feed it should be possible to stop the lathe to an accuracy of about 0.05mm.

Whichever method you use, use your ears... if you advance the tool too far you will hear it make a different (often unpleasant) noise as it 'bottoms out'. If you have any doubt about your ability to stop auto feed at the right point, stop the tool early then finish the cut cautiously by hand.

You will generally find that all of these approaches leave the hole with a poor finish at the bottom. If your hole needs a good finish at the bottom or a very accurate depth, bore it slightly shallow and finish it by taking a facing cut across the bottom with the boring tool. If the tool is too large to allow this, then change to a smaller tool and take several small cuts.

In some cases, you may need to space the work away from the chuck jaws in order to ensure there is room for the cutter to emerge from the end of the cut without fouling the jaws. A mark on the tool shank can help you judge this, **photo 14**. It is very important to keep a close watch on what is happening, so close the workshop door and switch your phone on silent – you don't want to get distracted!

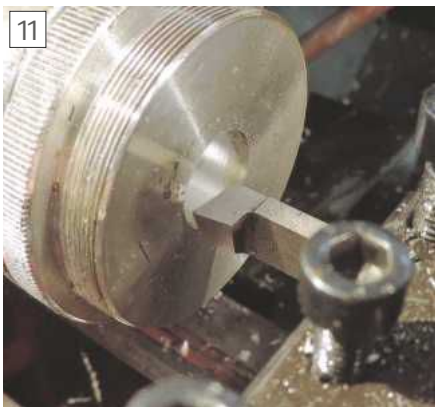
These issues are even more pertinent when boring a 'blind' hole to depth, see the box for a detailed discussion of how to do this.

Setting boring bars on centre height is particularly important in order to make sure the bottom of the cutter does not rub as this will spoil the finish and remove any chance of achieving accuracy (see 'boring small holes'). Boring bars with round shanks, such as those in **photo 15**, should be rotated to give top rake to suit the material in hand, but bear in mind that too much rotation may cause the cutter to rub.

The overhang of boring tools means that they are inevitably more flexible than normal lathe tools. This can cause them to cut undersize, especially when using small boring bars with smaller lathes. It is common practice to repeat a finishing cut with several passes at the same setting to 'work the spring out of the tool'. This approach tends to work better with HSS than carbide which tends to rub when making light cuts with heavier duty inserts.

A down side of this approach is that it makes it difficult to work predictably to a certain size. One way around this is to perform this exercise consistently each time before you measure the bore. When you are boring holes to suit a matching part that you will make yourself, another and simpler strategy is to make the bore first, and then turn the matching part to fit.

Finally, especially when boring smaller holes, you will notice that the swarf often tends to build up in the bore, and if it gets dragged into the cut or clog the bore surface finish will suffer and accuracy will be lost. Either remove the bar from the hole to clear the swarf or use a metal rod (soft steel tig welding rods are ideal) with a slightly hooked end to draw the swarf away from the hole. Never use your fingers to pull swarf from a moving lathe.



Using an HSS boring bar

A set of 10mm shank boring and internal threading tools to suit the SC4 510 lathe.

A boring bar fitted with a tungsten carbide insert.

Using a mark of the tool shank to judge the depth of a hole. The top slide has been swung over to create a tapered hole.

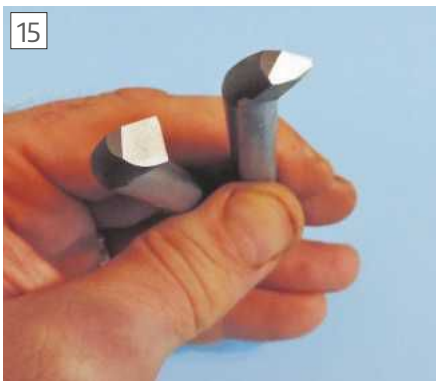
Tapered holes

There are many different ways of turning a taper, which we will look at later, but the simplest way of boring a tapered hole is to angle the top slide as in photo 14. This means you can't use power feed to take the cut as you have to turn the top slide handle by hand. This will highlight any slack in the top slide gib, often by giving a 'striped' appearance to the cut surface, but even when lathes are perfectly adjusted the uneven rate of cut from turning of the handle is enough to give a visible effect. This is one reason why such slides have a 'balanced' handle, try and develop a turning technique that uses both ends of the handle and where you use both right and left hands for complete each turn of the handle. It's easier to do than describe!

Many lathes have an angle scale on the top slide. Such scales are not accurate enough when you need to make a taper to an exact angle and should generally be treated as guide. For jobs which require matching tapers to be made, such as a bore and plug, the easy solution is to leave the top slide at the required angle. We will look at taper turning in more detail in a later instalment. ■

*The SC4-510 lathe is available from Arc Euro Trade, **http://www.arceurotrade.co.uk**, who also sell the smaller SC2-300 and SC3-400 mini-lathes.*

As well as boring tools Arc can also supply drills, reamers and a wide range of chucks with arbors to suit.



Round shank tool, these are actually for internal threading. Note how one has been ground to allow it to be used inside a smaller hole.

On the Wire NEWS from the World of Hobby Engineering

The NAME Editor's Cup

Many in the model engineering fraternity will remember Alan Bibby who passed away late last year.

Alan was a long-standing member of the Leyland Society of Model Engineers and designed many excellent models – particularly of the Lion, organising the annual Lions Meet for the OLCO – as well as workshop equipment. He was also an officer for the Northern Association of Model Engineers (NAME) and was Newsletter editor for their website **(www.nameng.org.uk)**.

In his will, Alan has left a sum of money which he asked to be used 'to provide a suitably engraved trophy to be known as The Editor's Cup with a cash prize, to be awarded annually to the editor of the best model engineering club newsletter as determined by the officers of NAME'.

It has been decided that the annual cash prize should be the sum of £50, payable to the newsletter's editor, rather than to his Club and that this will be presented together with a suitable trophy. The award will start in 2018.

In the first instance Editors should send a copy of their newsletter to the NAME Chairman, Frank Cooper, either by email to **yorkhouse.flyer@btinternet.com** or by snail-mail to him at 47 Holmes Road, Stickney, BOSTON PE22 8AZ. The 2018 entries will close on 30 November 2018 and the winning newsletter will be announced in the ME press towards the end of the year.

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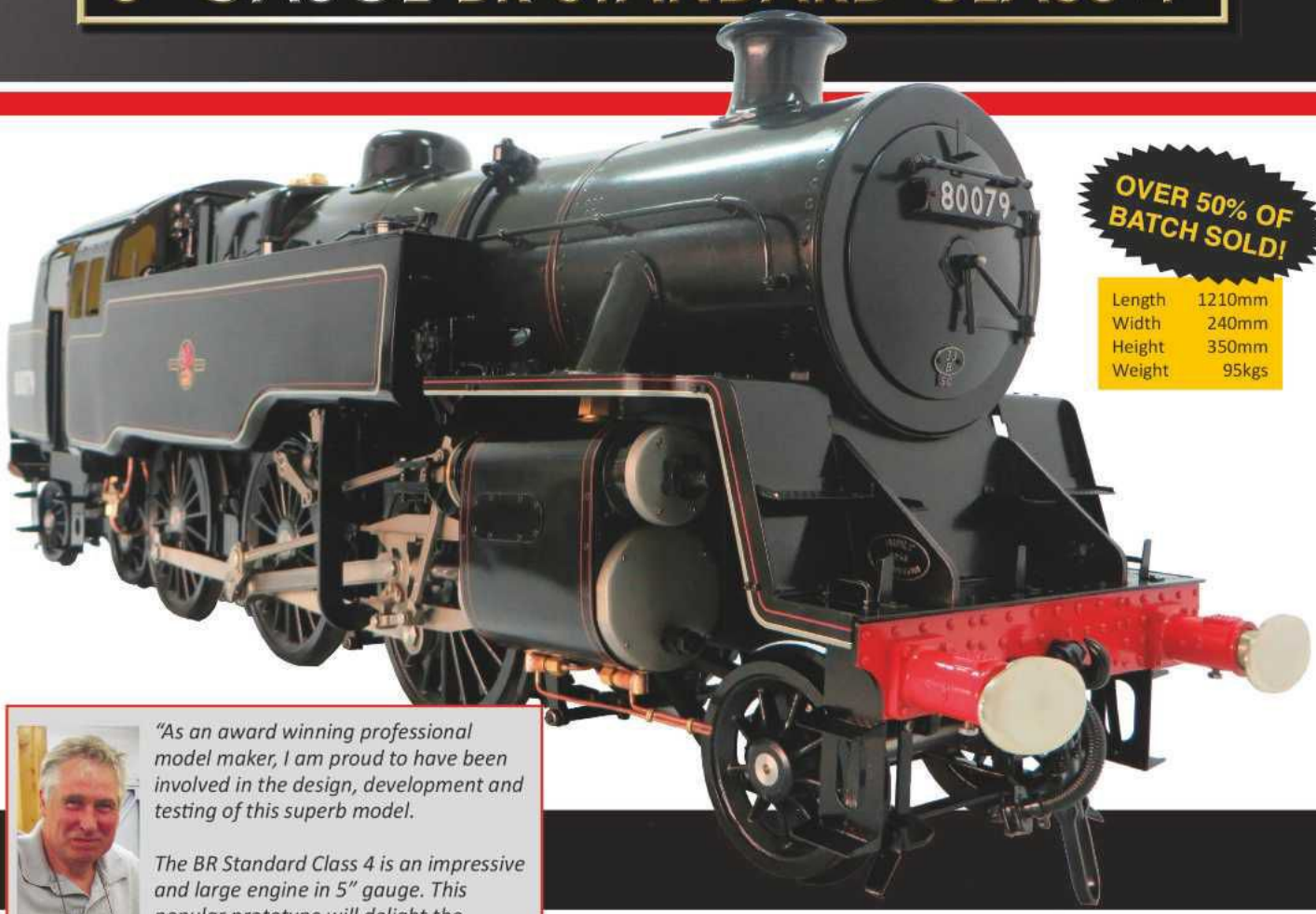

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A Cure for Worrisome Wobbles

Mark Noel describes a novel approach to curing bad vibrations.

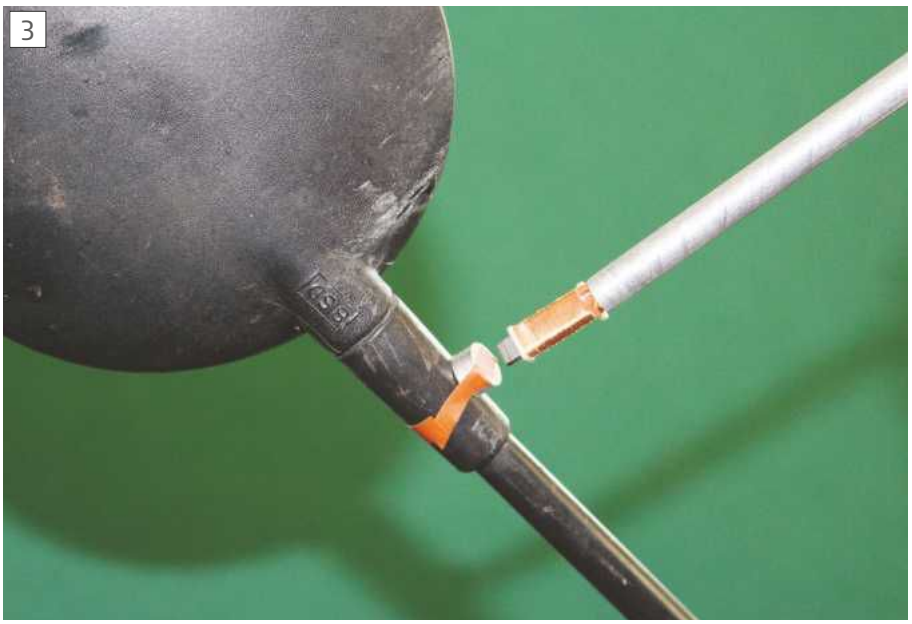
I was intrigued to read Graham Astbury's article in MEW 253 describing the steps he had taken to reduce vibrations that were affecting his lathe. His solution was to locate and then minimise rotational imbalances that were the source of the problem, followed by adding anti-vibration feet. Cancellation of imbalance is central to the good design of all reciprocating machines leading, for example, to the addition of flywheel bob weights or the counterbalance shafts incorporated in some modern motorcycle engines. Motors such as a 90° V-twin or the Ariel Square Four are theoretically perfectly balanced, yet still suffer from residual vibration arising from valve trains, etc. Anyone who has ever ridden a vintage Moto Guzzi 90° V-twin will be well aware of this!

A few years ago, I decided to re-visit my leather-clad youth by yielding to the temptation of a new Royal Enfield 500cc Bullet motorcycle, now manufactured using the original British tooling in India. The bike's gleaming chrome, polished alloy and faultless paintwork certainly impressed, and the beat from the shiny exhaust rekindled those Rocker years. But the vibration. Oh dear, the vibration. No doubt about it - here was a non-surgical alternative to a vasectomy! An air seat provided a medical cure but then there was something much more serious, because at speeds of between 30 and 50mph the mirrors vibrated so much in harmony with the motor that rearward visibility was impossible, and I felt unsafe on the road. A number of solutions were

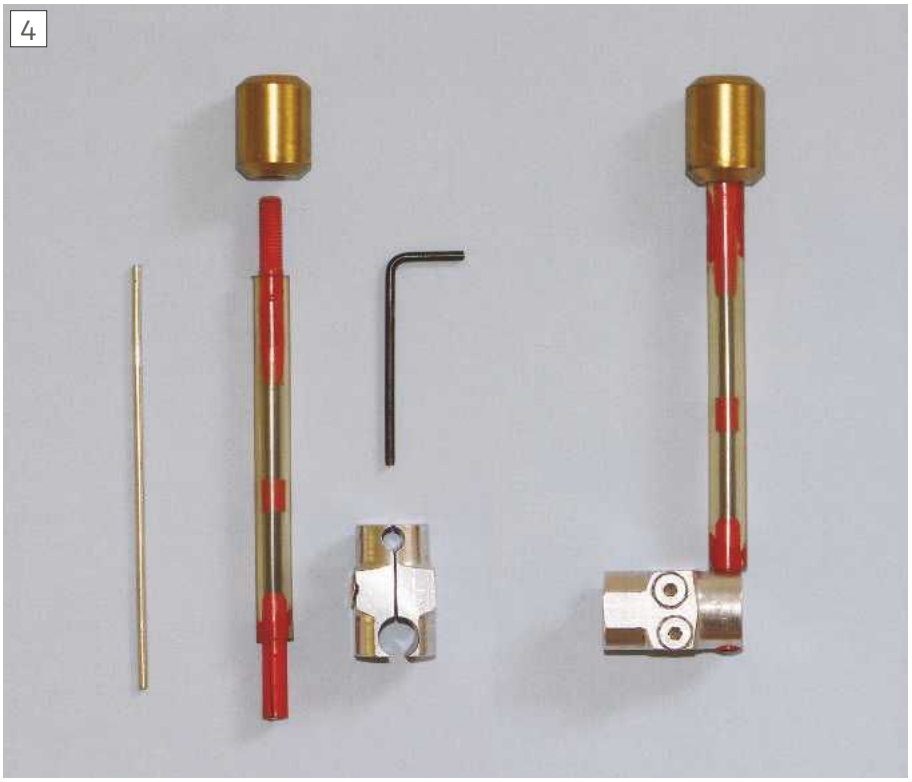
Oh dear, the vibration. No doubt about it - here was a non-surgical alternative to a vasectomy!

Tuned mass damper fitted to my motorcycle's mirror.

Stockbridge dampers attached to suspension cables on the Severn Bridge, UK. Image courtesy of Quintin Lake.



Arrangement of coil and magnet used to measure the mirror's vibration frequency.



Right: Assembled carbon fibre damper and Left: Wire insert of the type used in the prototype damper.

contemplated: a rearward facing camera and handlebar-mounted monitor; a helmet-mirror or perhaps Google Glass spectacles linked via the Internet to live satellite traffic updates. Neither seemed practical and I contemplated a life of forever riding my pulsing steed outside its 'vibration zone', to ensure a clear view to the rear.

Then I had a brainwave. One day while crossing the magnificent Humber Bridge I noticed some peculiar appendages attached to the suspension cables, each resembling a set of dumbbells. Similar objects are fitted to cables on the Severn Bridge, **photo 2**. My research identified these as 'Stockbridge Dampers', sometimes referred to as 'Dogbones', for obvious reasons. I am sure that people drive past these curiosities every day quite unaware of their purpose in keeping the respective bridges safe, particularly in high winds. An isolated, taut cable exposed to an airflow sheds eddies which excite vibrations in the wire, rising in amplitude as the wind speed increases, fatiguing the cable and mounts, thus reducing the lifespan of the bridge. Each dogbone is carefully designed to oscillate with an intrinsic frequency matching that of the cable, but with sufficient losses to ensure that energy is absorbed to damp the cable wobble. The dogbone is therefore a type of 'tuned mass damper', another example of which is now fitted to the underside of the Millennium Footbridge in London to cure the uncomfortable swaying that was initially experienced by pedestrians crossing the Thames.

> However, after only ten miles the unit fell off when the piano wire snapped due to metal fatigue.

Bridge engineers have carried out considerable research to optimise the design of Stockbridge Dampers. Factors to consider are the primary oscillation modes of the cable and the proportion of the energy that must be absorbed from each mode to obtain a safe operational envelope at the specified wind speeds. Some dampers are simple single-mode devices that wobble only in one plane, while others may be asymmetric to move in more than one plane and/or at differing frequencies to maximise the damping effect over a range of wind conditions (see references).

It seemed to me that a suitable tuned mass damper might be the solution to my Bullet's trembling mirrors. First I had to find the range of frequencies (i.e. engine r.p.m) over which the mirror vibrated. The Bullet is not fitted with a rev counter (the design dates from the 1950s after all!) so instead I measured the natural vibration frequency of the mirror, with the engine off, using the simple magnet-coil sensor arrangement shown in **photo 3** with the coil connected to an oscilloscope. The mass of the magnet was negligible compared to the mirror assembly and therefore did not significantly alter the frequency.

Armed with this information (about 42Hz) I puzzled as to where to incorporate the damper. Inside the mirror casing would have been the most elegant solution but the Indian engineers had foiled this approach by welding the two halves together. During my monthly bath (in retro-biker style) I conceived the prototype design shown in **photo 4** in which a brass weight is attached to a length of piano wire sheathed in PVC tube. I varied the mass of the brass bob until the vibration frequency of the unit was close to 42Hz. The plastic tubing provides the vital damping. This damper was clamped to the upper end of the mirror stem and the results during a road test were quite remarkable - a clear

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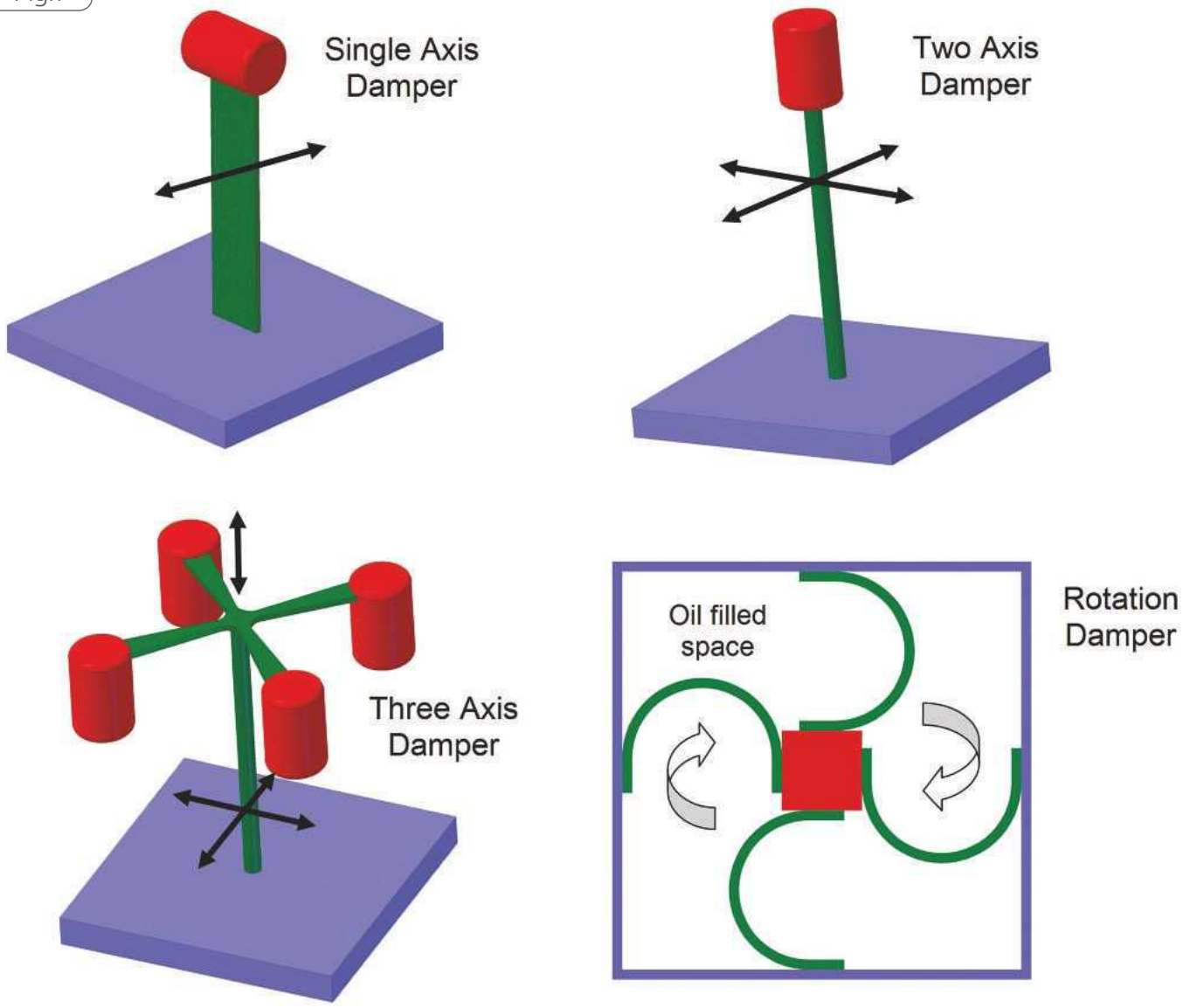
Fig.1



Ideas for tuned mass dampers: Blue is fixed to the object whose vibration is to be damped, Green is the flexure and Red is the moving mass. Flexures would be coated with inelastic material, such as plastic, to provide the damping effect.

rearward view at all speeds! Between 30 and 50mph the brass bob vibrated vigorously as it absorbed unwanted motion of the mirror stem. However, after only ten miles the unit fell off when the piano wire snapped due to metal fatigue.

Another month and another bath yielded the final solution in which the wire was replaced with a 3mm diameter pultruded carbon fibre rod, again sheathed in PVC tube (photo 4). This revision finally produced a highly effective damper and one that has survived several hundred miles on the road (**photo 1**).

Readers may wonder what relevance this tale has to the hobby of model engineering. In some machines it may not be possible to cure troublesome vibrations at source or, even if they can be, it may be desirable to attenuate residual vibration further in order to improve the cutting performance of a lathe for example, or to improve the 'feel' of an engine. In some cases a single-mode, single-plane tuned damper may be sufficient for the task, while in others the vibrations may be more complex and a multi-mode, multi-plane damper is needed. There is plenty of scope for experiment here and **Fig. 1** shows some ideas that could be explored. Still, it is always best to cure the problem at its heart, since vibration accelerates wear, as my GP also advised! ■

Still, it is always best to cure the problem at its heart, since vibration accelerates wear, as my GP also advised!

References

Various Tuned Dampers:
https://en.wikipedia.org/wiki/Tuned_mass_damper

Pultruded carbon fibre rod and tube:
www.carbonfibreprofiles.com

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Thoughts on New Build Steam Locomotives

How big do you build? Ian Howitt, whose company were the lead contractors in the build of the 'peppercorn' A1 locomotive Tornado, gives us a workshop perspective on new locomotives with valuable lessons for anyone restoring or building at full size.

These notes have been put together by me to help potential new build projects. They are based on fifty years of deep involvement in railway preservation and earning a living in heavy engineering, much of it running my own company. Locomotive work over the years has ranged from 2ft gauge locomotives and traction engines, to standard gauge mainline, including 10 years involvement with TORNADO as lead contractor.

General Observations

Today, there are more than twenty 'New Build projects' for steam locomotives, ranging from narrow gauge 0-4-0s to standard gauge Pacifics and 2-8-2s (Note that I am not considering anything less than 2 ft gauge here as I regard these as model engineering.)

The scope of these covers complete new builds, where everything is being made from scratch through to some of the Great Western locos, where other classes of locomotive are cannibalized to provide major components and of courses there is the leader of them all in the A1 Steam Locomotive 'Tornado' which shows what can be achieved, **photo 1**.

Although in many enthusiasts' eyes there is a degree of mystique and magic involved in this work, it is in fact merely a series of well know engineering processes carried out in the correct order to achieve the desired result. While in the past all of these processes were available on one site in works such as Doncaster, Crewe, Swindon etc. and were developed to a fine art such that most processes were routine, today, although the processes are still used in industry you may have to look to more than one sector of engineering to find all that is required.

Over the last thirty years a number of organizations have come into being to service the burgeoning railway preservation business for repairs and rebuilds. Many of these are capable of and indeed some are building new locomotives. Although the refurbishment of parts generally uses the same machines as the manufacture of parts, this is not always true, especially if modern manufacturing methods are taken into account at the planning stage.

Showing what can be achieved - Tornado

A Few Myths

Whilst it is certainly true that, until the first world war, the railway industry was a trail blazer in many fields, especially engineering, witness the people who trained at a railway works and made a mark in other fields of engineering (W.O Bentley and H.F.S Morgan of cars fame, and R.J. Mitchell of Spitfire fame, although others from the private locomotive industry spring to mind), this lead was gradually lost from the 1930s onward, due to lack of money for investment.

Whilst there were odd exceptions to this, the Great Western under Collet still kept ahead of the pack in manufacturing technology, though even they were lagging by the 1940s and, although the second world war provided a spur in some areas, the industry, again, began to lag behind the more progressive businesses in the motor car and airline fields. This of course not only applied to the railways but to others such as ship building as well.

During the phenomenal growth of railway preservation in the last 40 years a myth has grown up about the construction of steam locomotives, particularly how every one who worked at a favourite locomotive works was a highly skilled craftsman who took a pride in his work and was glad to be working on locomotives. Although there were certainly some clever and highly motivated people at work, the vast majority would see the daily grind purely as a job and had very little interest in the wider field of the work. The same applies today in most industries.

Another myth is that a steam locomotive is a precision machine. The steam locomotive was not and never has been what could be described in engineering terms as precision, and very few locomotive works would have had micrometers outside of the tool room and one or two

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special areas such as axle turning and valve spindles. Indeed, locomotive builders never talked in terms of 'thous' but in 1/64ths (I have seen one drawing that actually had a dimension of 1/128ths) and comments on the drawing such as 'bare', 'full' and even one classic of 'this item to be made with special care'. This is not to denigrate the builders of the past but to put the engineering requirements into perspective. There are one or two special processes, but the majority of the work is just routine engineering. I am sure that in most cases today, of both new build and rebuild, much of the work is carried out to a much higher standard than in the past. Beware making everything too tight, it will seize up.

As an aside, my father, who served an apprenticeship at Fowlers in Leeds during the 1930s said that the only micrometers they had were in the toolroom and that the works used calipers and gauges. He left there in 1948 having become toolroom foreman, and went next door into the jig and tool drawing office at McLarens. They were no different and in fact, still had gas lighting throughout much of the works and offices.

Many of the processes that today are regarded as special were in the past regarded as semi-skilled occupations and were often carried out by ex footplate staff who had failed the medical for driving or firing, but were otherwise fit and, after a short period of training were accepted by the unions as semi skilled. Before the advent of the welfare state the railways were quite good at looking after their employees as long as they had kept their noses clean and toed the line. Examples of these processes were white metalling, tube expanding, and brake gear fitting and, shock horror, during the war, some of these operations were carried out by women. In the days when nearly every fitter had a 'mate' many of these were also ex-footplate staff and would carry out much work that today we would regard as skilled. They of course also did the grot jobs, which today are often carried out by volunteers with no special skills.

The Manufacturing Philosophy

There are several ways of going about building any major capital engineering project, ranging from the 'pay someone to do it for us' to the 'we are going to make everything ourselves' and both have their supporters in major industries.

The 'pay someone to do it for us' means you only have to select the right organization and be in a position to honour the cheques you write and sometime later you have the end result.

The 'we are going to make everything ourselves' approach means you need a full engineering facility and the necessary skills to run it.

If you need a lot of whatever it is you are considering then the second approach can work out much cheaper and was the most common approach used by the Railway companies of old for obvious reasons, although even then they would often buy in standard parts and specialist items such as brake systems and boiler fittings.

I suspect that most people, when they embark upon a new build project, will steer a course somewhere between the two extremes, designed to make the end result as cheaply as possible. Even then, there is a wide latitude to what you make and what you buy often dictated by the personal preferences of those who are running the project.

I imagine that most people who decide that a new build steam locomotive is for them want to be involved to a greater or lesser extent in the building of it and so would tend to the 'lets make everything ourselves' approach, tempered by the needs for machinery required to make small quantities of complex parts, where such could be sourced from specialist suppliers, without having the capital cost, or indeed often the struggle to find suitable labour to make said item 'in house'.

Small parts can be made by volunteers or by any one with model engineering interests or a home workshop can also do these, **photo 2**. Obviously, you need someone to organize this work and sometimes it is easier not to bother, although it does give a sense of involvement. However, realistically this is a very minor contribution.

This involvement is the philosophy that I will consider. Whichever way is chosen it cannot be stressed too highly that the eventual, successful outcome of the project relies very heavily on good project management.

The use of modern methods of manufacturing can often make significant economies if producing certain parts, examples are fabrication in place of castings for small quantities of components and water jet cutting or wire eroding for forming shapes that would otherwise involve complex machining processes. One of the main difficulties is finding forgings for motion and similar parts. Fortunately, modern methods and materials obviate the need for most of these, **photo 3**.

These methods need to be used with care when considering certification for mainline running. It may well be the case that a component made in the traditional way will be granted 'grandfather rights' for use on the main line, whereas the same component made by a new method, even though it is as good and in some cases better than the original may not be


2

Small components can be made by volunteers or in the home workshop


3

A component that would have traditionally been forged, made with a combination of flame cutting and cnc turning


4

An Ideal place to build a steam loco. Just needs the pit

acceptable without a new safety case or series of design calculations. Unfortunately, once you get into this case the cost of proving the obvious superiority can well exceed the savings that can be made by the new method.

Whilst talking of the philosophy of manufacture, the thorny problem of whether to use imperial or metric units in the manufacture of the locomotive and thread sizes on nuts and bolts should be considered.

In practice it does not really matter. Assuming that original drawing are obtained from the NRM, they will obviously be done in inches and it would be ridiculous to redraw them just to change the units. Any decent machine shop will be able to bore a hole to 19 inches just as easily as one to 482.6mm What will be needed, especially for items it is intended to make outside the organization, is notes to accompany the drawings giving limits and tolerances on components. In the past this information would have been carried in the shop foreman's little black book, or be known off by heart by the machinist.

Looking at material sizes, again it does not matter, a plate size of 1 ¼" is as near as a plate thickness of 32mm, possibly needing some minor adjustment to a mating part but nothing to cause any problems.

Whitworth, BSF and BSP taps, dies are still readily available (Indeed BSP has been adopted as an ISO standard.)

Obviously, a certain amount of redrawing will be required, but, none of it should be because of the imperial/metric decision.

The substitution of modern materials should not present too much difficulty. Although all the major railways had rigid specifications for the materials they used, none of them were of a national standard and each railway had its own system. Description such as 'Best Yorkshire Iron' or 'yellow brass no 3' do not sit well with the modern BS or EN standards, although it is not too difficult to determine suitable materials from the range available today. The coming of British Railways did achieve much in the way of standardization of materials, but even so many of their standards are uncertain in todays world. The materials used were generally not very sophisticated and it is not difficult to choose a suitable material from the modern range of materials. Do not fall into the trap of using a higher strength steel than is necessary. Quite often ductility and elongation are as important a factor as ultimate strength. This is where the engineering knowledge comes in. The full version of the Locomotive Manufacturers Association Handbook, gives specifications related to British Standards. This information will enable a competent engineer to choose a modern equivalent. Indeed, for anyone not sure about the machining size of components it should be your bible.

One problem that arises, is that building a steam locomotive is a different exercise to maintaining one. Although often the same machine tools are required, building a locomotive is simply an exercise in producing an engineered capital asset, albeit to certain standards laid down by the operating department. The requirement for staff is that they should be familiar with modern workshop practices, rather than have an intimate knowledge of steam locomotives. Obviously, the person in charge needs a foot in both camps, but the overwhelming requirement is engineering rather than railway biased.

A deciding factor in how much work is to be done by the organization may well be the plethora of employment legislation and the necessity for training in everything from slinging and lifting to such simple things as use of ladders.

No mention of boiler manufacture is made, since it is assumed that this will be bought in from an outside manufacturer. Anyone with the facilities to build a boiler will not need any guidance from me. Do not overlook the fact that the boiler is simply a fired pressure vessel and if the locomotive is a recreation of an old design of riveted

5

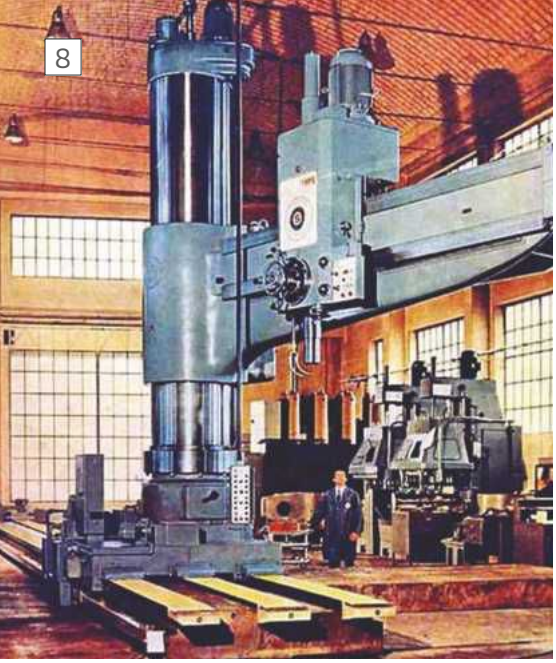
A set of synchronized lifting jacks makes the wheeling easy

6

I don't suggest you need a wheel lathe, but a smaller centre lathe is essential

7

A 2ft gauge pony truck, showing the versatility of a Bridgeport



You don't need one as big as this, but a modest radial drill is useful if you are doing any serious loco building

construction then the 'thermal' design work is already done. If a change from riveted to welded construction is decided upon then design work will be required to comply with the latest pressure vessel regulations and other requirements of operating authorities, to prove the integrity of the new boiler. Do not forget that as well as the well known 'heritage' boiler works there are also many other pressure vessel manufactures who may well be willing to take the job on once the design work is done.

With regard to the philosophy of building, from an engineering point of view, try and resist the trap that everybody falls into of making the cab, smokebox and nameplates first. The cab is a low value item that is a pain to have lying about the place. If you have lots of room, then it can sit in a corner out of the way. If not, you finish up putting it on the frames and taking it off to get at something on the frames. Same applies to the smokebox, that ought to come with the boiler. With regard to the nameplate – whoopee we have made a nameplate!

I know that the publicity people regard these bits as photogenic and want them for publicity and you may have to compromise.

I would also resist making the main frame side plates until the stretchers, drag box and buffer beam are made. The inside cylinders, if any, and the horn blocks should be made before the frames. When these are done then the plates can be made and the whole assembled. This saves the frames cluttering the work area in the earlier stages.

It is assumed that items such as cylinders, wheels, axles and the main castings/fabrications, in most cases, will be sourced from sub contract engineering shops, of which there are still plenty about. You will probably want to commission the manufacture of patterns and supply of the castings to these shops yourselves.

Make friends with a good pattern making shop. You will need them a lot.

As a rough estimate you need £100,000 in the bank to make a worthwhile start on a standard gauge loco. Do not forget that the fund raising is actually more important than the engineering and will determine the rate of build.

Premises

It is assumed that the new build is to be a stand-alone project, not using existing facilities in a heritage railway workshop. If an existing workshop can accommodate the project, then much of what follows will not apply.

Obviously the first essential is somewhere suitable to build the engine, **photo 4**. The size of the building will be determined by the manufacturing philosophy adopted.

The 'pay somebody to do it for us' only needs an office to handle the paperwork.

The size of the building obviously depends on the amount of work to be carried out in it and the number of machine tools to be accommodated, to make those items that are to be done on site.

As a minimum, just to erect a large mainline locomotive, I would suggest a minimum of about 3000 sq ft (100ft x 30ft) Although a large locomotive would be some 60ft long and 9 ft wide the above is really the minimum size that should be considered. It is amazing how much space bits like cabs, bogie and especially boilers need when they are off the frames.

The above size allows a small amount of space for an odd machine tool (a lathe is essential even if most items are bought in).

It goes without saying that the building should be in good structural condition, well insulated with modern heating and lighting. I know much has been achieved in less than ideal conditions, but the provision of decent working conditions is vital to ensure continued good work. A pit between the rails is almost essential, particularly for a three cylinder or inside cylindered engine. The building obviously needs to be high enough to accommodate the engine with suitable door to get the engine out. A level concrete floor of adequate thickness is worth its weight in gold (If only!)

The building should have sufficient yard space to allow lorry deliveries and mobile cranes to operate, as well as space for a low loader to take the engine away (Rail connection is a luxury that you can well live without as far as building the engine is concerned.) A separate stores area for patterns, material and components waiting to be used will be found useful to keep the main assembly area free of clutter.

Gas, water, sewerage and electricity are obviously vital. The electricity should be a modest three phase supply to enable machine tools to be readily connected. The welfare facilities necessary for the number of people expected to work on the project at any one time should not be overlooked.

Lifting

One thing that most people overlook is the amount of lifting involved in building a locomotive.

Traditionally any decent locomotive works were well served with overhead traveling cranes, usually, in this country, up to a maximum of fifty tons and generally two of these per bay, as well as many smaller ones. The two large ones would lift any locomotive, often high enough to pass over another one on the ground.

Whilst it would be lovely to have the above facility it would be something of an indulgence just to build one locomotive.

Apart from the boiler and the frames, there is virtually nothing on a British locomotive that weighs more than 5 tons and I would suggest a 5-ton overhead crane is essential. I know many locomotives are overhauled and indeed have been built with nothing more than jacks and a hand operated lifting gantry. Trust me, this is false economy.

The ability to single-handedly pick up and move something as 'small' as a connecting rod or crosshead, which may well weigh

A small hydraulic press, pressing in a bush in a combination lever

getting onto a quarter of a ton (no metric nonsense here) at the push of a button saves an inordinate amount of time, and would indeed, over the building of a locomotive, pay for itself many times over.

Depending on the building, a small forklift truck can be worth its weight in gold especially for unloading wagons.

If a set of synchronized lifting jacks can be obtained they are well worth having to lift the frames for wheeling etc., **photo 5**.

Don't forget that with the amount of 'just try this bit on' or we want to get a publicity photo of 'this bit on the frames', you will finish up erecting the equivalent of several engines.

Machine tools

If the loco is being built at an existing railway workshop then much of the following will not apply.

Obviously, if even the smallest amount of manufacture is to be undertaken, machine tools are essential.

Assuming the intention to buy in the major components such as wheels, cylinders, etc from outside engineering firms, not necessarily from within the railway movement, then the need for the more specialized machines such as horizontal borers, bed type millers (Planers, much as I like them myself, are old hat), wheel lathes can be left to others, although a decent horizontal borer with a table about 4 to 5 ft square and a 4" spindle is a very versatile machine, assuming you can find some one to operate it well.

Many of my machines have been bought at auction, in the days when you went and did the bidding in person whilst having a couple of bacon sandwiches. You could also pick up a lot of smaller items at silly prices. The internet auctions are nothing like the fun.

The problem that all groups working with steam engines have is that there is a limited amount of money available and the members want it all to be spent on the locomotive. When acquiring machine tools, do not fall into the trap that cheap is good, free is better. Decent machine tools will always be a worthwhile investment.

The project needs to be run on strict commercial lines, with each hour of work being costed at a minimum of £25 per hour. This means that the machines should be modern types, designed for modern cutting tools to minimize the time spent on any operation (Again this includes the labour on the project. If you are paying staff you want to maximize their output.)

Do not become awestruck by CNC machines. In terms of building a steam loco, with very few exceptions, CNC machines are not essential and any that are needed, such as for manufacture of repetition parts (fitted bolts spring to mind) can usually be found in most sub contract engineering shops, to be found in most towns at reasonable rates. There seems to be a mis-conception that CNC machining is more accurate than manual machines. Whilst this may be true for specific operations, in steam engine terms it is irrelevant. All a CNC machine does without a capable operator is enable you to make scrap much quicker.

A horizontal borer. Although much work could be done on this a slightly larger one would be better for standard gauge

Lathes.

It is essential to have a centre lathe of a minimum of about 8 inches centre height and a minimum of 30 inches between centres, **photo 6**. This will cover much of the turning work required in making special bolts, bushes and spacers, which really need to be done on the site of the building.

If a large amount of any items (fitted bolts etc) is required, then there is always a local machine shop looking for small CNC turning at competitive rates.

If any serious manufacture is contemplated then larger lathes, milling machines and borers come into the equation. Don't forget that these larger machines will need to be served by the overhead crane. If you have the room, a modest vertical borer of 4 to 6 ft table can be useful, especially if you intend doing axleboxes.

If money were no object I would have a Butler Elgamill like a shot. One of these would make short work of machining frames, stretchers, horn blocks and much else besides.

If you are aiming to do much of the machining work yourself, a horizontal borer would be worthwhile. One with a 4 to 5ft table and 4 in spindle would be ideal.

I regard the provision of digital readout as essential for anyone carrying out commercial machining and they are now dirt cheap; I have just bought a 3-axis set complete with all brackets etc for a horizontal borer for less than £250 at 2017 prices.

Milling Machines

A small milling machine is also extremely useful. Although the Bridgeport type of turret mill is designed for toolroom type work and is a bit light weight, what it lacks in rigidity it more than makes up for in versatility and would be a useful addition, **photo 7**.

If any serious manufacture of items such as axle boxes is contemplated, then much better and bigger machines will be required. The building will also need to be bigger. Again, larger machines will need the services of the overhead crane.

The use of CNC, whilst not essential can ease the manufacture of many components, but again the skills and tooling required are best hired in from outside.

Drilling Machines

A small bench or pedestal type drilling machine is not very expensive and indispensable. A decent radial drill of about 5ft arm is also a useful adjunct, **photo 8**.

As with all machines, the provision of good quality cutting tools and equipment enables the best to be got from them, both in terms of the quality of the job done and the speed with which it is completed

In addition to a radial drill, a decent magnetic drill with a Morse taper spindle (No 3 morse is usually the biggest and is the one to go for) is extremely useful and probably comes before a radial. In fact these days I very rarely use my radial drill. Make sure it has a proper Morse spindle. The 'Rotabroach' type, whilst fine for structural steelwork is no good for loco building. You want one that can take drills and reamers.

On the subject of drills, I am a great believer in using 3 or 4 flute core drills for opening up holes. These were originally used for opening cored holes in castings, often with a drill jig. They should not be confused with' Rotabroach' cutters. They will not drill a hole from the solid but are ideal for opening up pilot holes, which you will have lots to do. With the sizes 1/32" below nominal they will give you a hole ready for reaming for driven bolts.

Miscellaneous Machines

Smaller machines (bench drills, offhand grinders etc) are self evident and should be of decent quality and kept in good condition. A hydraulic press of up to 50 tons capacity is useful for pressing in bushes and pins, **photos 9** & **10**.

As far as sawing goes a decent power hacksaw or band saw is needed for miscellaneous sawing for the endless number of brackets, spacers etc that need to be made on site.

A simple metal arc welding set and a medium sized MIG welder is also considered essential.

No mention has been made of fabrication or boiler work, it being assumed that the sensible approach is to buy these in from specialists, all of which are available within the UK

The provision of an oxygen /fuel gas set for heating and cutting is as essential in building a steam locomotive as it is in any general engineering business. Propane is cheaper than acetylene. The latter is only required if you contemplate gas welding much of which has been outmoded by MIG or TIG.

Many smaller machines such as pipe benders, guillotines etc will doubtless be acquired as the build progresses.

Other Issues.

The above is the minimum required to assemble a locomotive on a site with no other facilities. If the site were shared with an organization undertaking locomotive repairs then presumably much of the above equipment would be available, along with much more besides that would make life easier.

If it is intended to undertake the manufacture of major items, then obviously much more equipment and labour would be required along with more staff.

With regard to staff, it should be noted that the plethora of employment and workplace legislation and health and safety considerations may well play a part in deciding on the approach to be adopted in the 'philosophy of manufacture'.

Machine Equipment and Hand Tools.

As previously mentioned, the provision of suitable cutting tools is vital along with a supply of hand tools. Although, individually, none of these are expensive, they do add up and should not be scrimped on.

Do not over look some of the equipment considered old fashioned. Often this can solve a problem difficult to more modern methods. Having said that, remember you are building an engineering project and not establishing a machine tool museum.

Also, the provision of decent measuring tackle should not be overlooked. As I would assume the work will be all in proper units and not in the "curse of Europe" the purchase of second hand micrometers should be cheap enough. (I recently bought external micrometers from zero to 18 inches in one-inch increments for less than £150 with some internal mics thrown in as well.)

A windy drill in use drilling balancing holes in driving wheels. Otherwise a job requiring an expensive boring machine with a right angle head.

The big windy drill in **photo 11** cost me a fiver and, as long as you have the air to feed it, it is extremely useful.

Do not listen to the consultants that will come around and tell you that in order to comply with some quality standard or other all your measuring instruments need to be expensively calibrated. They do not. What is needed is correct application of good workshop practice and the knowledge of what the next step is.

Things you do not want

When a project to do anything in the steam engine world is announced, many well meaning people emerge from the woodwork, bearing gifts of "just what you need". They very rarely are but you are usually too polite to refuse, and you get lumbered with them.

These are often obtained from the person's employer and take the form of say a fork lift truck that "just needs a bit of attention". I have no problem with having a fork lift or many other items but keep clear of the free offers unless they really are "just what you want".

Costs.

The above list of requirements is not going to be cheap and I would not expect it to happen overnight, but in the context of a building cost for a large locomotive of £3 to £5 million plus, an expenditure of twenty or thirty thousand pounds on decent equipment would not seem to me to be unreasonable. Obviously, the equipment can be obtained by several means.

The provision of suitable accessories and machine equipment, as mentioned above, should also be allowed for and a regular budget should be available for consumable tools and small equipment.

I know that the attitude is likely to be that people would rather spend this sort of money on a set of forgings for the motion or some other bit of engine, but I am convinced that you would find the money well spent in the long run. There are other people out there building engines and a limited amount of facilities and expertise available and I am sure that you want your project to progress as fast as possible.

I have not discussed the provision of labour since so much depends on the philosophy of the builders. However, the main requirement is for someone to lead the process who understands both the railway and workshop requirements. This probably means someone over 50 years old who has served a recognized apprenticeship in engineering and has some professional qualification. However professional qualifications are not the be all and end all of engineering and some of the best engineers I know have very little in the way of paper qualifications.

However, beware. Many professionally qualified 'engineers' have not done any engineering since their early twenties, having moved into quality, project management, sales, or many of the other ancillary activities associated with engineering. This means that they are likely to be out of date with workshop practice and working to 'how it was done in my day' Even so, when dealing with many of the regulatory bodies you often need a tame chartered engineer if only to decorate the note paper.

Whilst the traditional skills are essential the knowledge of modern workshop practice is vital in order to achieve minimum cost.

The above has rather become a treatise on how to establish a locomotive works and I hope that the comments do not tread on too many toes, they are not meant as criticism of any individual but are really my observations built up over 45 years of involvement with railway preservation and a similar time spent earning a living in various branches of heavy engineering, particularly in machining and also from my position as an "Engineering Enthusiast".

I hope the above will prove of interest to people and look forward to seeing the next loco finished. ■

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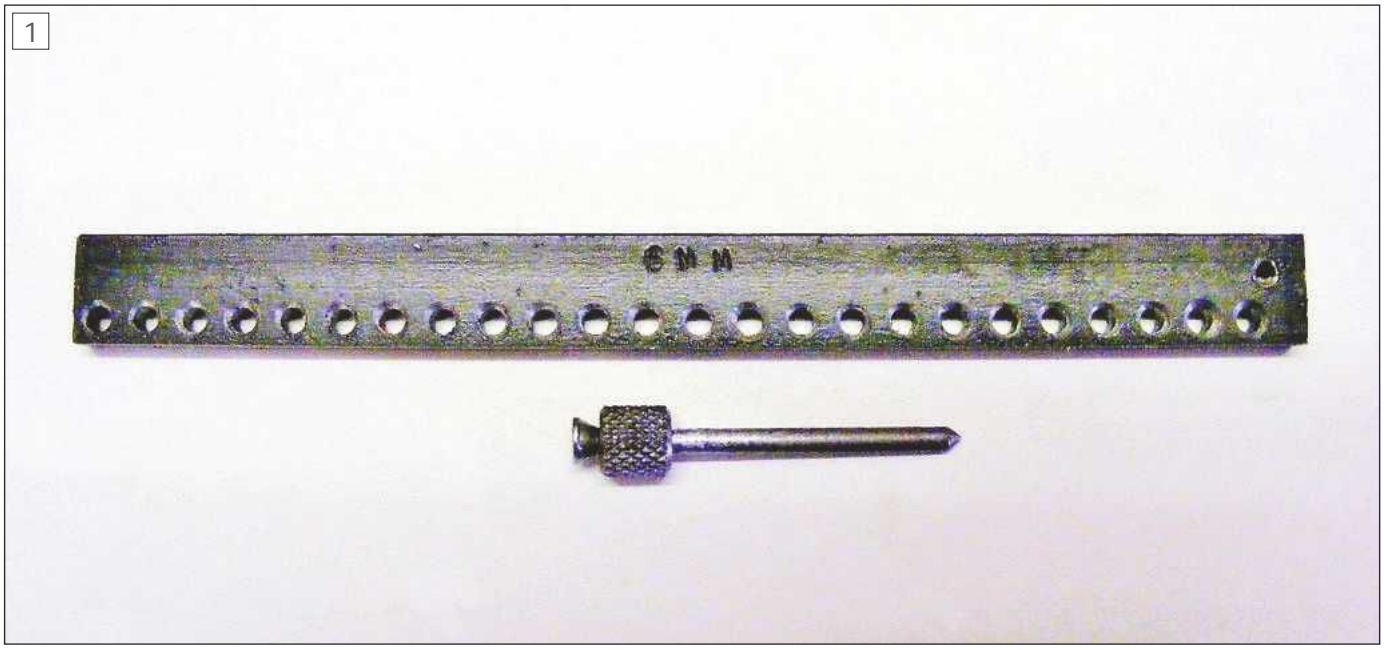
Mike's WORKSHOP

A chain drilling jig

This month Michael Cox describes a simple but effective aid to chain drilling.

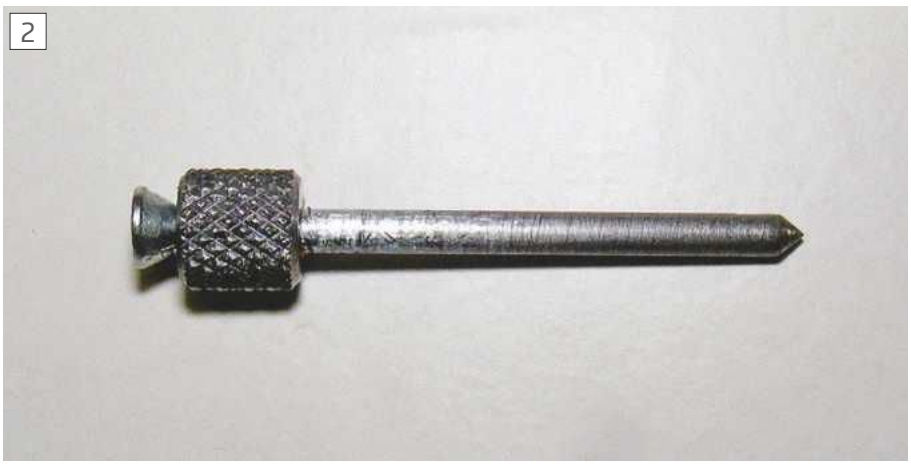


The chain drilling jig and punch.

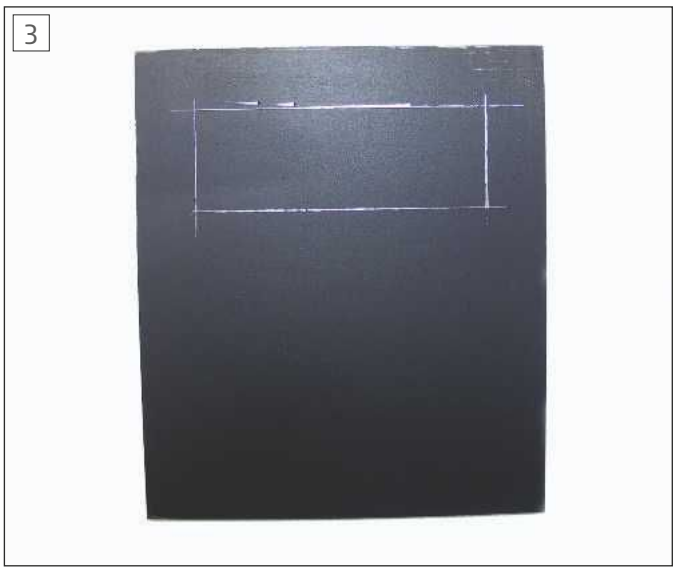
Cutting slots and apertures in metal can be carried out in various ways. Milling is a good way if high accuracy is required. Stamping can be used on sheet materials. A nibbler or shear can also be used on thin materials – or even a jigsaw. All these methods work well but they do require special tools or are impractical in thicker material.

Another approach, requiring the minimum equipment, is to drill a line of holes spaced by the diameter of the drill, along the line of the required slot or aperture. Once the holes are drilled then there will be little or no web of metal between adjacent holes and it is a simple job, with a round file, break though the remaining web. Once the webs have been cleared then a flat file can be used tidy up the slot or aperture. This method is known as chain drilling and it is applicable to metal of all normal thickness and for any shape of aperture or slot.

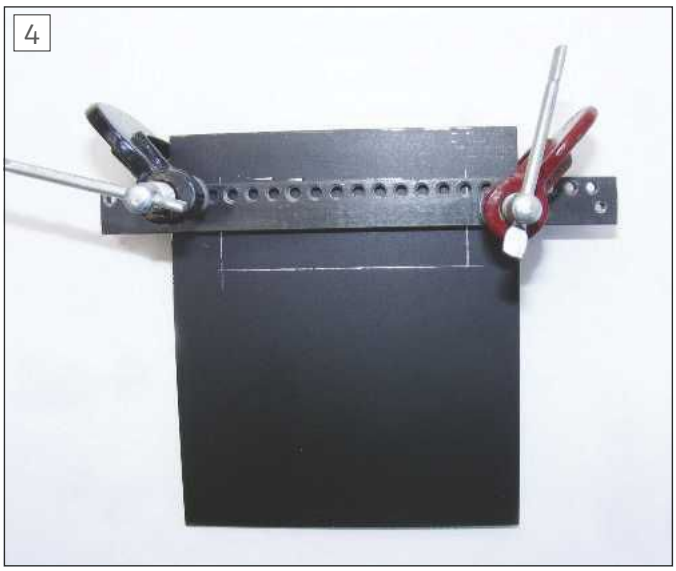
Successful chain drilling depends on accurate placing of the holes. If the holes are less than one drill diameter apart then there is the danger, when drilling the second hole, the drill will wander off and try to follow the line of the first hole. Equally if they are too far apart then a thick web between the holes will be left and this then increases the amount of filing to be done to convert the row of holes into a slot. In practice both of these problems will arise because in a row of holes if one is spaced too closely then on the other side the spacing will be too much.



Close up of the centre punch.



The marked aperture.



The jig clamped adjacent to one of the lines.

In cutting an aperture it is important to space the drill holes half a drill diameter from the required edge. If the line of holes is too far from the edge then much filing will be needed to get to the required line and if they are too close to the line then the finished line, after filing back the holes, will be too far over.

To accurately mark out a long line of holes using conventional marking blue, scriber and rule method is time consuming and tedious. Then the marked positions must be accurately centre punched before drilling can commence. More time is actually spent on the marking out and preparation than is spent on the drilling and filing.

The jig described here is simply made by anyone with a milling machine. It was originally made to facilitate cutting out apertures in plastic boxes for LED displays, meters etc. but it has since been used for many other purposes. It has been used on plastic, wood and metal.

The jig

The jig, **photo 1**, was made from a strip 5 x 14 mm hot rolled steel strip. The piece I used was actually an off-cut that had been cut from the edge of a much wider piece of material. The jig can be made as long as required but for my purpose a piece 150 mm long was sufficient. I would strongly advise the use of hot rolled strip for this jig because there is so much internal stress at the edge of cold rolled steel that it is likely to distort when the holes are drilled.

The punch marks.

In cutting an aperture it is important to space the drill holes half a drill diameter from the required edge.

It is important that the mill vice is set up parallel to the table axis using a DTI before work is carried out on the steel strip. After aligning the vice, the steel strip was set up on a parallel in the mill vice and the edge was milled straight along its entire length. It was then turned through 90 degrees so that the flat face was uppermost in the vice. It was supported on a length of wood 150 mm long and 12 mm wide and 20 mm high. The vice is only 70 mm wide so there was an overhang of 40 mm on both sides of the vice. The position of the milled edge was found. A simple way to do this is to put a 6 mm stub drill in the drill chuck. Run the mill slowly in reverse and then bring the work up to the drill and listen for the click-click sound when the drill just contacts the work. With the mill running in reverse there is no tendency for the drill to cut or mar the milled edge. Having found the edge, the graduated thimble on the y axis was set to zero. The drill was raised, and the work was then moved in a further 6 mm. This positions the axis of the spindle 3 mm away from the edge of the strip. The drill was replaced by a small centre drill and starting at one end of the strip a pilot hole was started. The strip was then indexed along 6 mm and a second pilot hole drilled. This procedure, indexing 6 mm and drilling, was carried out along the whole length of the strip. The centre drill was replaced

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To go with the jig a small 3mm diameter centre punch is required. This was made from a 3 x 50mm masonry nail.

with a 3 mm twist drill and holes were then drilled at each pilot hole location.

The strip now had a row of holes accurately spaced 6 mm apart and 3 mm from the edge. The edges of the holes were de-burred by touching each hole with a rotating countersink bit.

To go with the jig a small 3 mm diameter centre punch is required. This was made from a 3 x 50 mm masonry nail. These nails are accurately round, hardened and slightly tempered. I bought a box many years ago and I have used them for all manner of punches, scribers, pivot pins etc. To make the centre punch one of the nails was chucked in a portable electric drill with the point outward. With the drill running the nail was held against the rotating wheel of the bench grinder to form an approximate 90-degree point. I made a small interference fit knurled collar for the punch. This can be seen in **photo 2**.

The main purpose of the collar is not to make the punch easier to hold but to make it look a bit different from all the other junk that normally resides on my workbench thereby aiding its location. Sharp eyed readers will also note an additional hole drilled in the jig shown in photo 1. This hole is tapped M3 and my original plan was to attach the punch to the jig via a short length of ball chain. The M3 hole was for a screw on the jig to attach the chain to. I am still waiting to find a short length of ball chain!!

6

After drilling.

Use.

The use of the jig is illustrated with the sequence of photos where it is used to make an aperture in a piece of 3 mm steel plate. I sprayed the metal with black paint so that the lines were visible in the photographs. However, the paint chipped off as the lines were scribed so they look ragged but a clearly defined line is visible to the naked eye. The shape of aperture is first marked out, **photo 3**. The jig is then clamped against one of the lines, **photo 4**, and the hole positions spotted through onto the steel, **photo 5**, using the centre punch described above. The spotted positions are enlarged using a normal centre punch and then drilled through with a 6 mm drill, **photo 6**. The webs between adjacent holes are then cut through. This can be done with a round file or a coping saw. For thin sheet the webs can be cut with pointed nose wire cutters and on thick sheet a small cold chisel can be used. After breaking out the centre the edges are cleaned up with a flat file to make the finished aperture, **photo 7**.

This jig is designed for use with a 6 mm drill. Similar jigs could easily be made for other sized drills. ■

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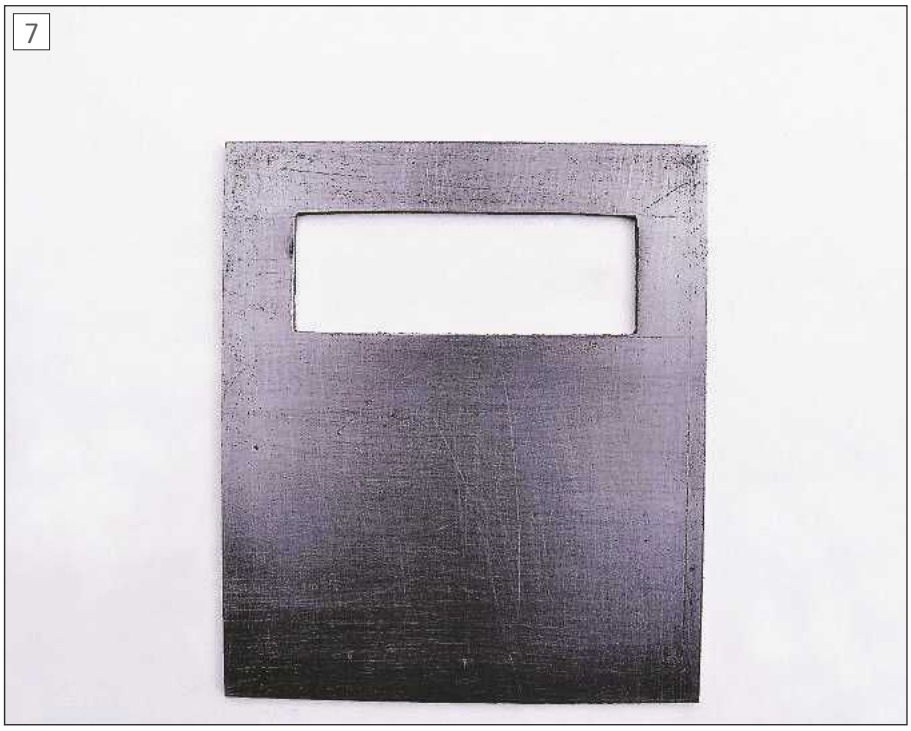
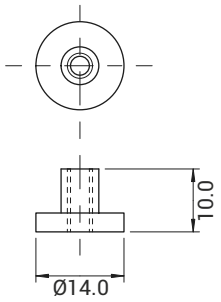
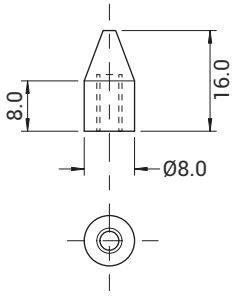


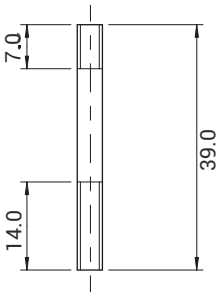
After cleaning up with a file.



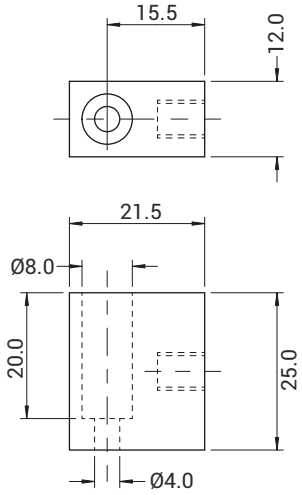
Detent Knob
Knurl
Tap M4



Detent Nose
Tap M4

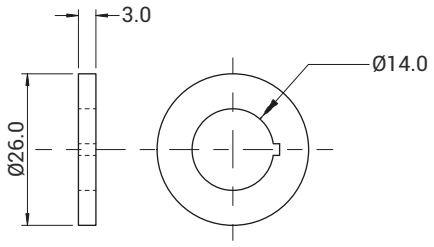


Detent Rod
M4 both ends

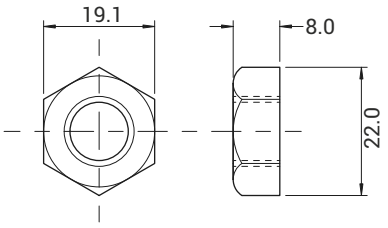


Detent Housing
Tap M6

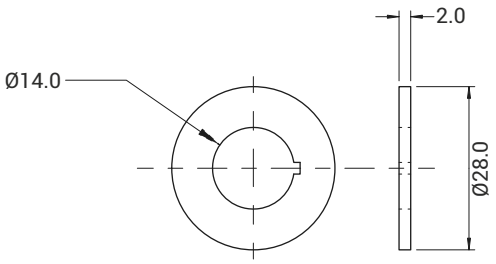
Detent



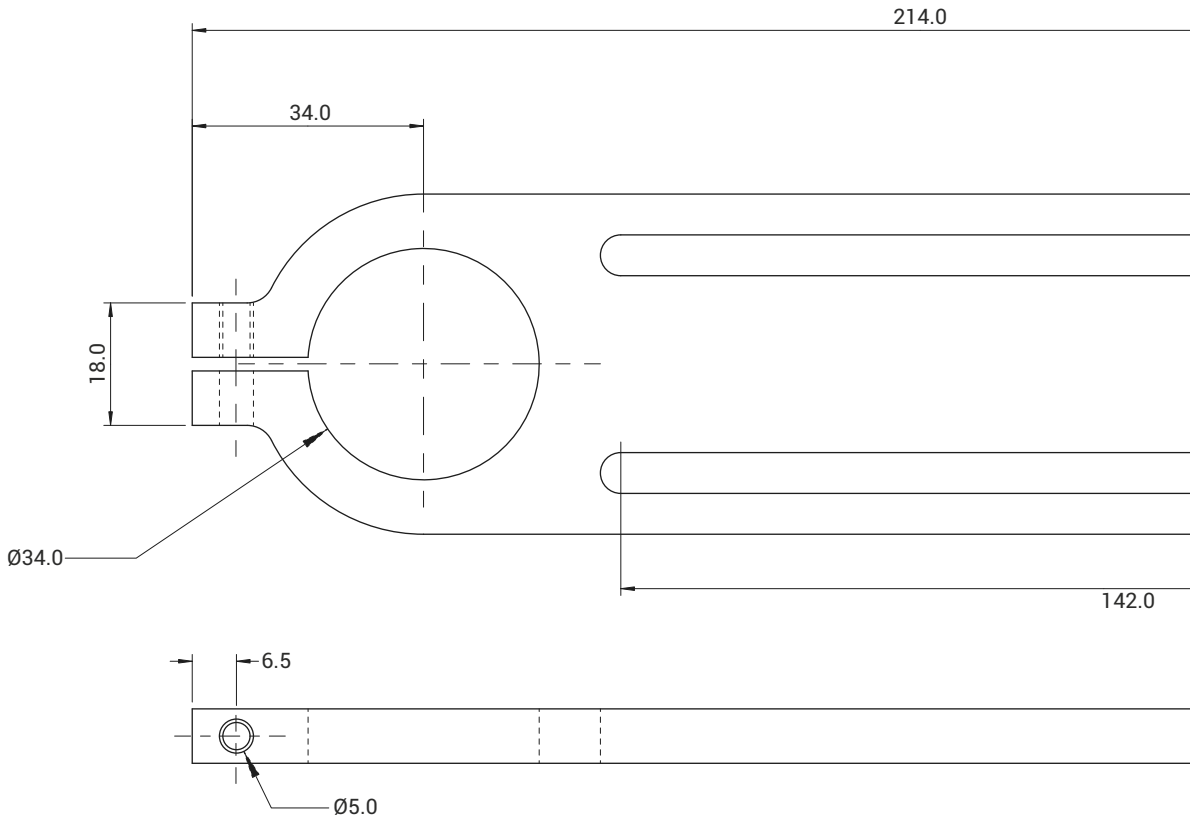
Washer



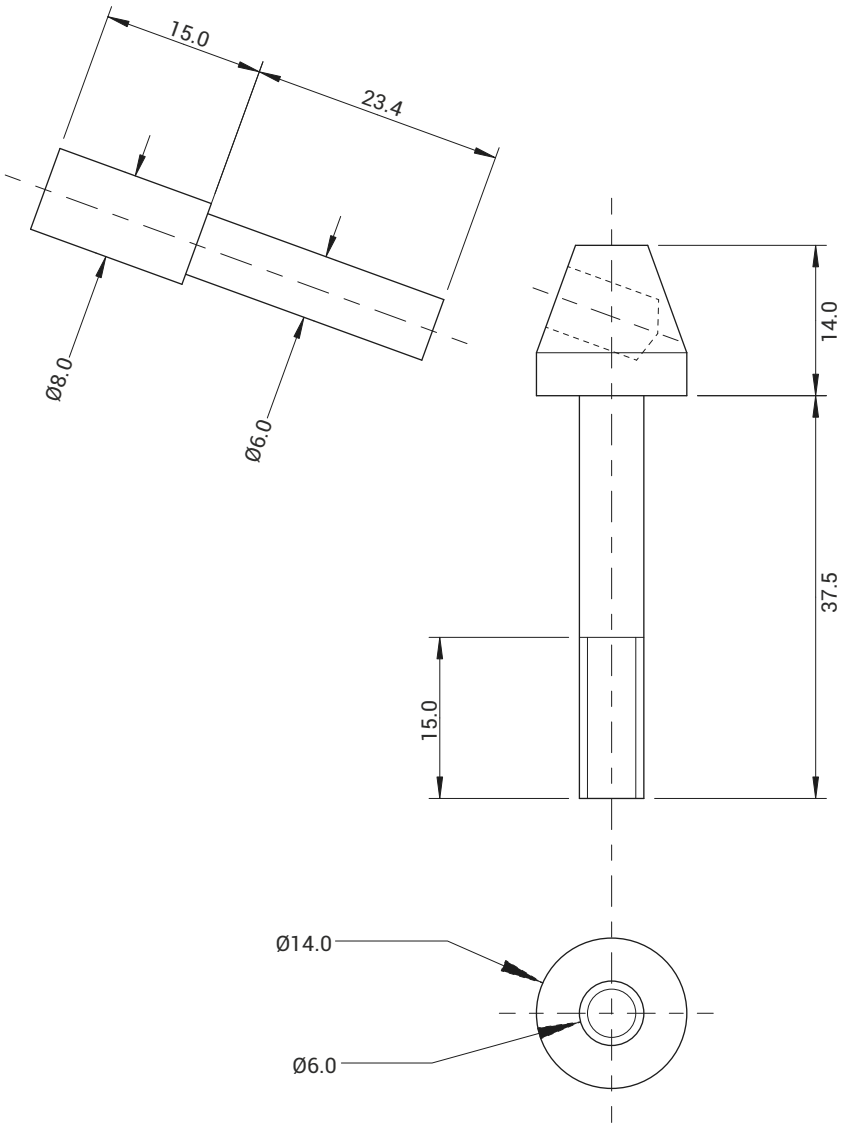
Spindle Nut
M12



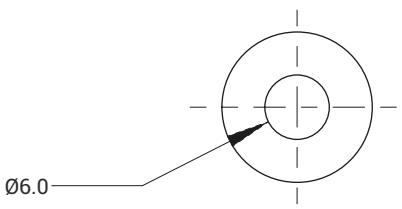
Washer

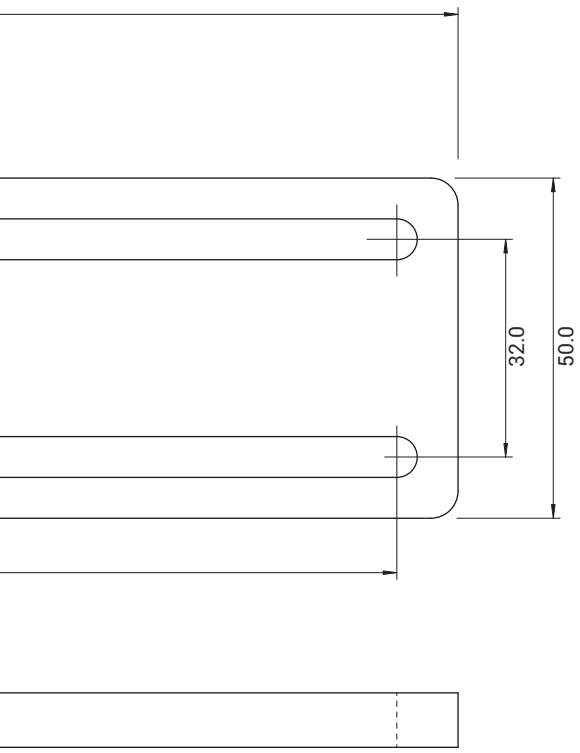


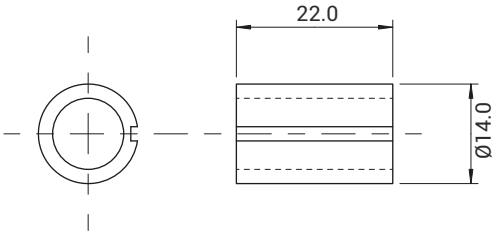
Banjo
Mat'l: 8mm aluminium
Slots 6mm
Tap M5



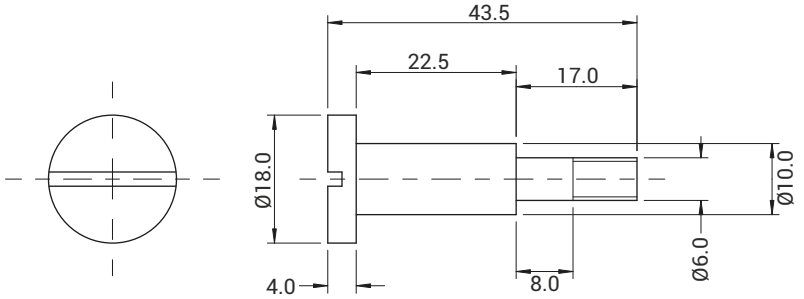
Spindle Lock And Washer
Shaft threaded M6
Drill Ø6mm hole in boss
Secure handle to boss with epoxy



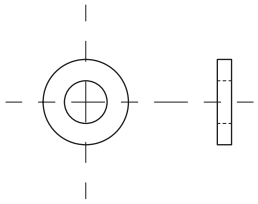




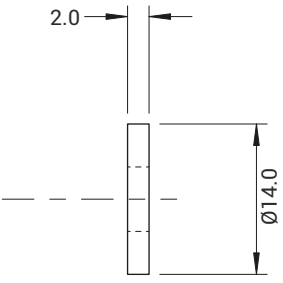
Gear Bush
Provide suitable keyway
Bore & adjust dimensions to suit available gears
2 off



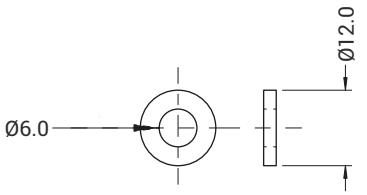
Gear Axle
Thread M6
2 off



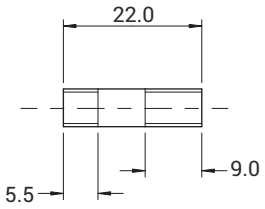
Gear Axle Washer
2 off



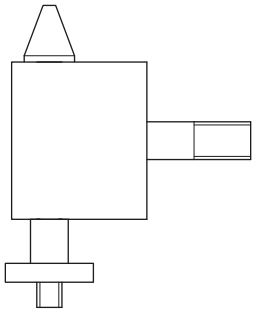
DIVIDING HEAD
By Alex du Pre
Presented with
Model Engineers' Workshop 266



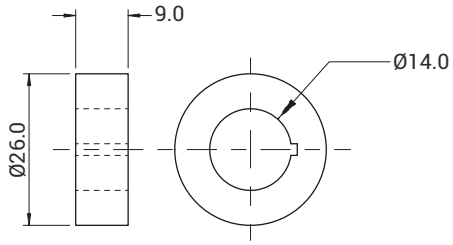
Detent Washer
Thread M6
2 off



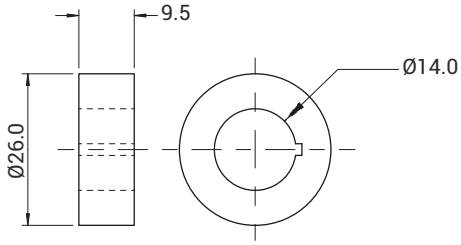
Detent Mount
M6 both ends



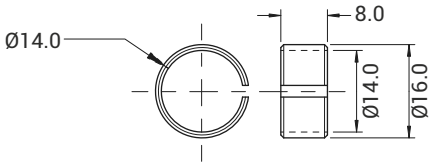
Assembly
Suitable compression spring fitted inside body behind nose



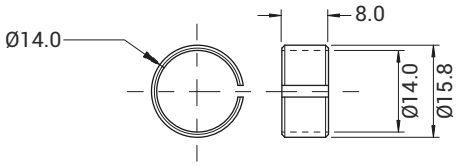
Spacer
For Warco gears
Slot to clear keyway



Spacer
For Myford gears



Bush
For Myford gears
Check diameter



Bush
For Warco gears
Check diameter

Typical Spindle Fittings
Adjust to suit available gears

Accessories for a Unimat Sl1000 – A Fixed Steady

The parallel bar bed of these lathes requires a special approach to making a fixed steady, Terry Gorin shows us how his tailstock raising blocks can be modified for this purpose.

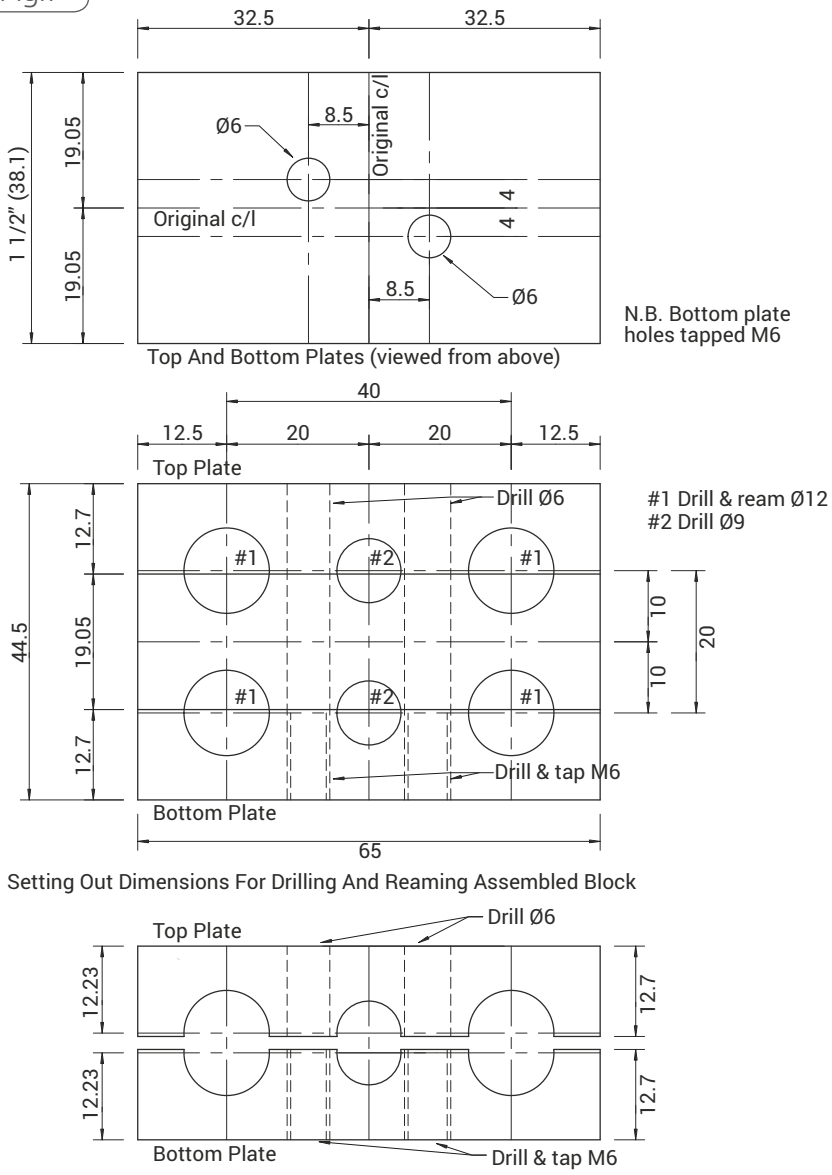
While preparing my previous article, 'Construction of a Tailstock Raising Block for the Unimat SL1000' (**MEW 262**), it also became clear a fixed steady would also be needed, sooner or later, when turning or screwcutting slender components on this lathe. The top and bottom plates from the block assembled in that article for the initial drilling and reaming for the raising block became redundant, at that stage of that article, and were retained for use as plates for clamping a fixed steady to the Unimat's bed rails.

For clarity and understanding of how these plates were further modified, as below, the setting out details for the drilling and reaming of the assembled block and appearance of both redundant plates, at that stage of the previous article, are repeated here in **fig. 1**.

Modification of Existing Plates

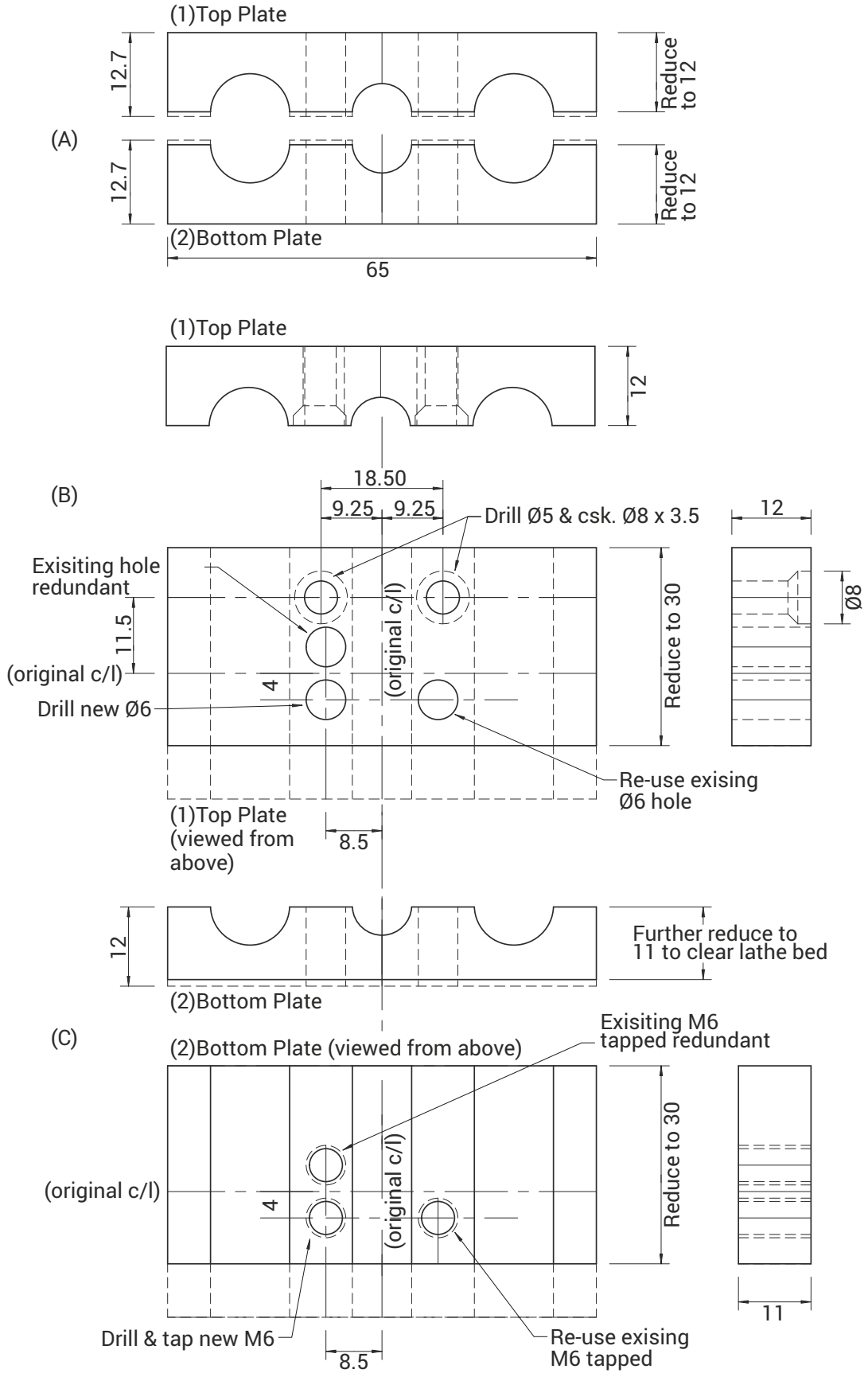
The first task was to modify the plates as detailed in **fig. 2**. The length of each plates remains at 65mm but the thickness

Fig.1



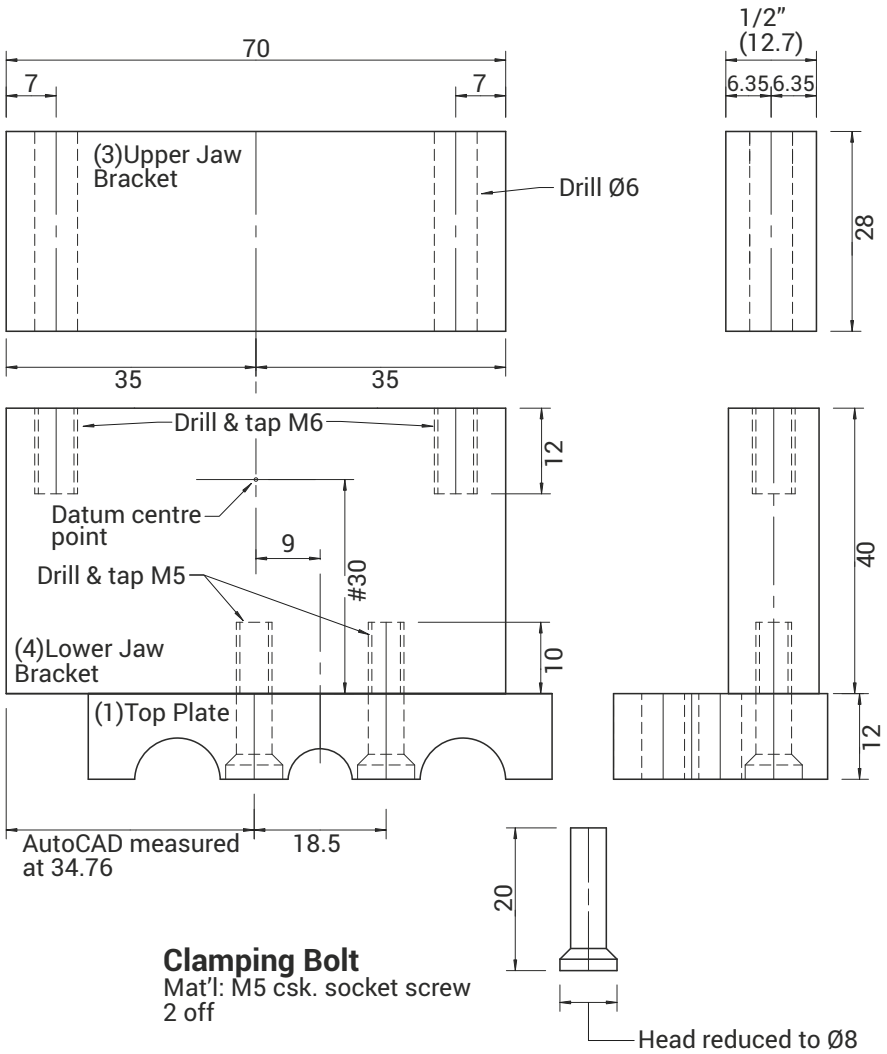
Plates Before Modifiying For Fixed Steady

Fig.2



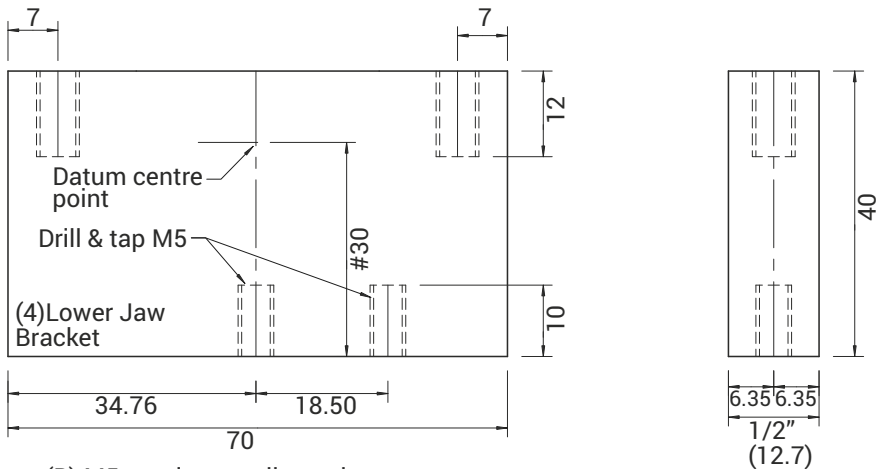
Fixed Steady - Modifications To Top And Bottom Plates
Mat'l: Aluminium, surplus from tailstock raising block machining

Fig.3



(A) M5 tappings spot drilled through Top Clamping Plate

Or Alternative:



(B) M5 tappings to dimensions

Fixed Steady - Jaw Bracket
Mat'l: Aluminium

of both reduced to 12mm as shown at **(A)**. In both cases the material being removed from the machined faces to reduce the rail grooves to just under half diameter and eliminate any 'grabbing' of the bed rail. If the 'original' centre-lines are not already evident as showing in fig. 1 (as recommended in the previous article) these should now be scribed to both faces of each plate.

The top plate was further modified as shown at **(B)** in fig. 2. The setting out dimensions for the new holes are purposely taken from the 'original' centre lines, to centralize the 5mm dia. countersunk holes in the ribs between the grooves and to position the new 6mm dia. hole as a mirror image of the existing. The width of the plate was then reduced to 30mm in the direction shown.

Modifications to the bottom plate are shown at **(C)**. Setting out for the new M6 drilled and tapped hole again taken from the 'original' centre lines to mirror image the existing. The width was reduced to 30mm to match the top plate and, finally, the plate thickness was further reduced to 11mm, from the underside, to clear the lathe bed.

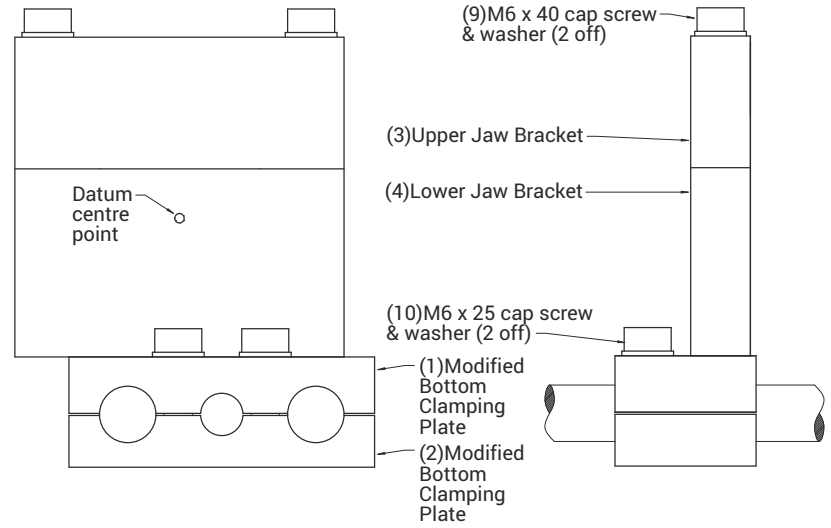
The redundant 6mm dia. hole in the top plate will eventually be partially obscured after final assembly: an unavoidable, but acceptable 'witness' mark! Although not shown, it may be sensible to avoid confusion, when orientating the bottom plate for clamping, to plug the redundant M6 tapping in this plate!

Fixed Steady Construction

To simplify construction, the bracketing for mounting the jaws of the steady, shown in **fig. 3**, comprise upper and lower brackets bolted together instead of the more usually seen hinged arrangement. The spindle centre of the Unimat SL1000 is offset 9mm rearwards of the centre point of the bed rails. In the prototype rest, **photo 1**, the positions of the M5 tapped holes in the lower jaw bracket, were determined by clamping the top plate to the bottom of the bracket and spot drilling through the pre-drilled 5mm diameter holes in the plate. This after carefully aligning, and offsetting 9mm, the bracket and top plate centre-lines, as front elevation **(A)** in fig. 3, and aligning the bracket and pre-drilled hole centre lines in the plate as end elevation **(A)**. The plate and jaw were then separated, the spot drilled holes in the lower jaw bracket tapped M5 and, when drawn for this article, the distance from bracket edge to first M5 tapping measured at 34.76mm, as shown at **(B)**.

As an alternative to my fiddly alignment and clamping, the M5 tapped holes could be set out direct using this dimension, with reasonable accuracy, and positioning the holes at 18.5mm centres along the centre-line of the jaw bracket as (B). When assembled the centre-lines of the bracket and plate are unlikely to be more than a half mm either side of the intended offset. The 30mm height of the datum centre point should be marked out at this stage for reference only. The two halves of the jaws bracket and top plate were then bolted together, as shown in **fig. 4**, and the assembly clamped to the bed rails of the Unimat, close to the headstock, using the bottom plate. The headstock spindle, holding the drill chuck and centre drill, was then advanced to mark the true datum centre point from, which all further holes are set out.

Fig.4



Fixed Steady Part Assembly

● To be continued

In our Next Issue

Coming up in issue 267

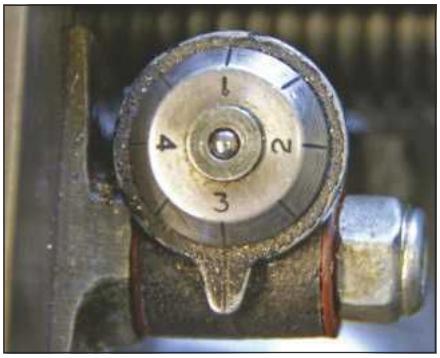
On Sale 20th April 2018

Content may be subject to change

The May issue, number 267, of Model Engineers' Workshop, is shaping up nicely:

Chris Gabel explains how to build a versatile and accurate bench oven for curing and heat treatment

Peter Barker regrinds his chuck jaws



Trevor Hills shines a light on using thread dial indicators with various lathes

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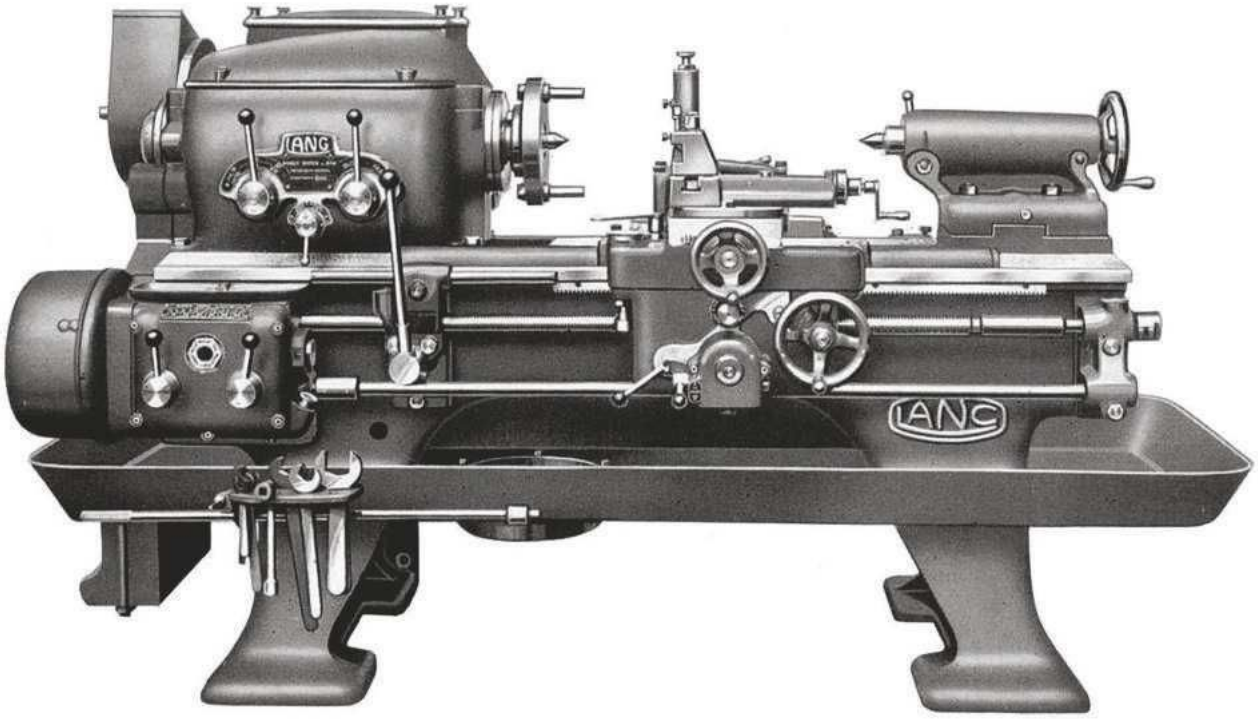
Two repairs on a Lang Junior lathe

Brian Wood recounts a pair of interesting workshop challenges posed by an unusual machine.

1



Catalogue photo of Lang Junior lathe

2

Centre drilling of tear drop handle

Despite the name Junior, all of the Glasgow made Lang lathes were very substantial tool room quality machines and will be rarely seen in the equipment inventory of the average Model Engineer's workshop.

One of the repairs on this lathe was to damage caused when the lathe was delivered by a HIAB truck driver whose working experience was more at home moving blocks of building materials; he was not conversant with the unpredictable nature of top heavy machine tools. The other was more of cosmetic action to restore damage caused by abuse in uncaring hands.

The background story

This particular lathe was purchased by an enthusiastic collector of the more unusual makes of lathes that might otherwise have been destined for the scrap man.

I am now firmly of the opinion that if

›

Finding the centre on the broken thread

Hidden cross pin

he had the space, and funding to match, all of these rescues, there are now six of them that have proved to be irresistible, would finish up in a museum of working examples of machine tool manufacture covering a period of some 70 years or so of the 20th century.

The collection thus far includes lathes from England, Scotland, the USA and Germany, ably supported by a very nice milling machine of Swiss manufacture. The present limit on available storage space has just about been reached.

I am indebted to Tony Griffiths for permission to reproduce here in **photo 1** a catalogue photo of a Lang Junior lathe from his website www.lathes.co.uk.

The lathe shown is of the smallest size 6.5 inch Lang Junior lathe; there were three available in the range. The photo gives a good idea of the solid nature of these lathes; it weighs in at well over 1 tonne and was clearly built to last. The owner had bought an example of this capacity.

The HIAB event allowed the lathe to topple forward, fortunately the only damage discovered so far seems to be to the carriage hand wheel where the tear drop shaped handle was broken off. Unfortunately, I didn't photographically record the wheel and broken handle on receipt, but it is made in cast iron and from memory was about seven inches or so in diameter with a nice hefty one inch thick chrome plated rim.

The hand wheel repair

On the face of it this was fairly simple, but there was a hidden and unexpected construction twist which added some interest to the job.

Photograph 2 shows the handle held inside a 3-jaw chuck into which the tear drop end fitted nicely and well protected with thick card, to centre drill the stump of the original stalk it had been mounted from. The centre hole was then drilled out to tapping size and tapped to accept a 3/8 inch long tensile BSW bolt. This was going to be screwed in later when the rest of the work on the wheel was done and finally locked in place with high strength Loctite.

Photograph 3 shows one of my useful set of transfer punches being used blunt end down to get the best match for the centre of the sheared off handle stalk. The wheel has been bolted down to the milling machine table through the hole in the centre where it fits the shaft into the apron. To prevent rotation during the drilling, the boss of the wheel is sitting in a thick-walled collar.

Centre drilling was followed by opening out the hole in stages to reveal the original internal threading. I'm pleased to say I got that pretty near perfectly in position and was able to pick out the remnants of the old handle thread with the sharp point of a scriber.

During the drilling, I could not understand why the drills were snatching at something deep in the hole. At the same time, a small piece of round metal was being forced out of the side of the rim, breaking out of the chromed finish.

Photograph 4 is a poorly focussed view down the hole to show the remains of a locking pin in the bottom of the hole. It was a completely unexpected feature, there had been no sign of it from the outer rim of the wheel, the chrome being visually unblemished. It had obviously been flush fitted in manufacture, polished and then chromed over to hide it.

More in hope than expectation I was able to use the side of a flat bladed screwdriver to push out what was left of the pin and then complete the thread refreshment all the way to the bottom of the hole. **Photograph 5** shows the recut thread and the stump of the locking pin. Also, just visible as a dark marking against the chrome is the exit hole it made through the rim of the wheel. The handle and the bolt are also ready to fit; they too can be seen in this photo.

Photograph 6 shows the finished job and rather than leave a nasty looking sharp edged hole in the rim, **photo 7** shows the pin, a little shorter than it was, also glued back in place as a plug. Minor

Hole rethreaded

Handle and wheel reunited

The cross pin glued back in place

Compound slides compared

scratch marks in the chromed finish on the head of the pin were aligned to disguise as much as possible where it had come out. I apologise for the poor photo, blame the camera auto focus on a shiny surface!

The compound slide repair

This was a rather larger job. For the work this lathe might actually do in its current ownership the work fell more into the category of cosmetic repair, but it was in a very visible and obvious position and it would certainly affect the value of any future sale. The owner was also keen to restore the damage as it looked both ugly and told a story of abuse, even if it didn't actually seriously affect the working of the machine.

Photograph 8 is a view of the compound slide compared to a version from a Myford ML7 lathe; it gives some idea of the hefty nature of this, the smaller, of the Lang lathes. **Photograph 9** shows the damage the owner was keen to have repaired where crumbling of the underside of the tool post slot is very visible. It was present to about the same degree on both sides of the slot.

He was concerned that the damage might have weakened the upper side of the tool post slide which might lead to break out at some future date. He asked if it might be possible to fill the damage

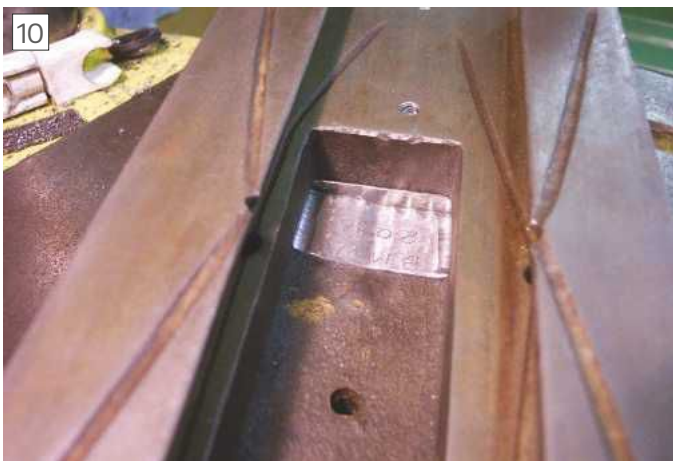
Crumbling on the underside of the tool post slot

with braze metal and re-machine the surfaces back to dimension, having seen You-Tube videos of salvage work on other castings carried out in skilled hands.

My immediate concern was about the problem of getting enough heat into the casting to be able to get the braze to stick and adhere where it was needed, to be followed immediately by a very well controlled slow cooling in a suitable oven to allow the inevitable heating stresses to dissipate properly. My workshop does not have sophisticated heat treatment equipment of this kind.

I was also very doubtful that any such repair would hold together anyway and in any event, other machined surfaces would be very likely to need rework to rectify distortion.

Critical castings are usually finish machined after a period of time spent aging as rough machined parts to allow for any movement to take place and to expect one like this to hold to the initial



Dovetail adjustment oiling grooves

Thought to be how the damage was inflicted

dimensions after major heating was expecting too much.

Even if that didn't happen, the dovetails and undercut edges would remain as prime points of failure from the sharp corners acting as stress raisers.

There was already some locked in stress in this casting that revealed itself as work progressed to be described a little later on.

My recommendation, which was accepted, was that a far better and much easier repair would come from removing the whole top surface right back to the slot and replacing it with a bolted on steel section instead.

This compound slide is rather different from those fitted on other lathes in that the adjustment of fit in the dovetails is made vertically up to the machined surface on the underside of the slide, rather than by the more traditional approach with sideways locking onto a gib strip fitting the dovetails.

Starting the bandsaw cut

At the end of the cut

Cutting seen from below

Photograph 10 is shown here a little out of sequence where the necessary oiling grooves can be seen.

I had not been provided with the mating cross slide component, so I don't know how the method works in practice, but the owner confirmed that to be the case. The pocket that can be seen allows room for the feed nut; the screw is brought in from the bottom of this picture.

I was also curious as to how this damage had occurred; usually the tops of tooling slots break off from over tightening of Tee nuts. **Photograph 11** shows what I think had been done when the original tee slotted tool post bolt anchor had been separated from the tool slide at some time in the past.

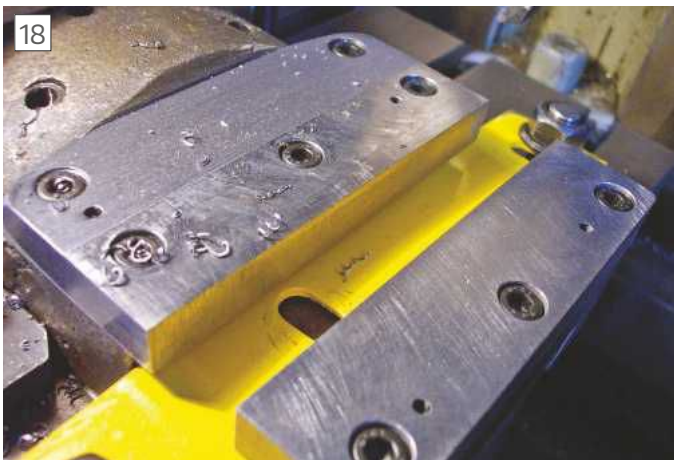
I fitted the largest coach bolt I have available for this staged picture in place of a proper anchor. If that, or something like it had been used it seems pretty obvious that the load concentration on the rim of such a bolt would be more than sufficient to crumble the cast iron.

Photograph 12 shows the tool slide clamped up in my bandsaw to remove the bulk of the metal, it is angled over so

Milling complete

Restoring the feed nut pocket height

First fit of the new steel plate



Finishing cuts on the shaper

that the cut would finish approximately at right angles to the body at the run out of the flat surface of the tooling platform. With a new bi-metal blade fitted to the saw it made short work of cutting off the surplus metal which was all of 100 mm in width. Less than ten minutes was all it took to get down to the chosen finish point, it took a further ten minutes to free off the saw blade where the cut had closed up over it.

My earlier concern about residual stress was clearly justified and to risk adding more to the casting, even after the most careful annealing, would be quite likely to scrap the component when it was found that distortion could not be adequately rectified.

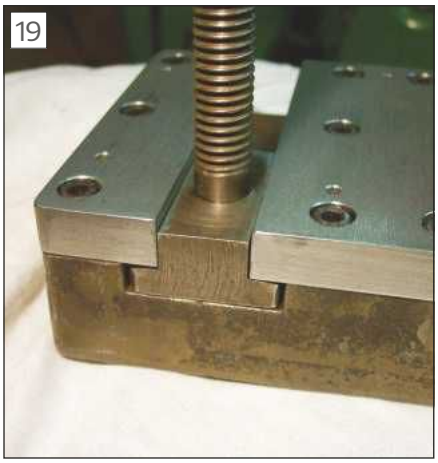
Photographs 13 and **14** are views taken at the end of the bandsaw action and the view as seen from below the blade when the narrow section was just about to be sawn through.

The sawn face was then face milled to remove the residue of the platform down to the top of the slot. As this stage progressed, the pocket for the feed nut was exposed along with a patch of casting porosity that was located nearby but fortunately in a harmless position, it is seen here in **photo 15**, the rest of the casting was very clean.

This was the end of the destructive phase of the job and the work then moved on to the construction stage. The job had been measured before all the work started and there was room enough to replace the whole top surface with a new ½ inch thick steel plate which left a machining tolerance of 1.2 mm for final sizing to restore the platform height to where it was before the job started.

Photograph 16 shows the necessary end milling to extend the containment for the feed nut pocket into the steel platform and **photo 17** shows the full width ½ inch thick steel plate has been attached with eight M5 cap screws at first fix stage to form the new tool mounting platform.

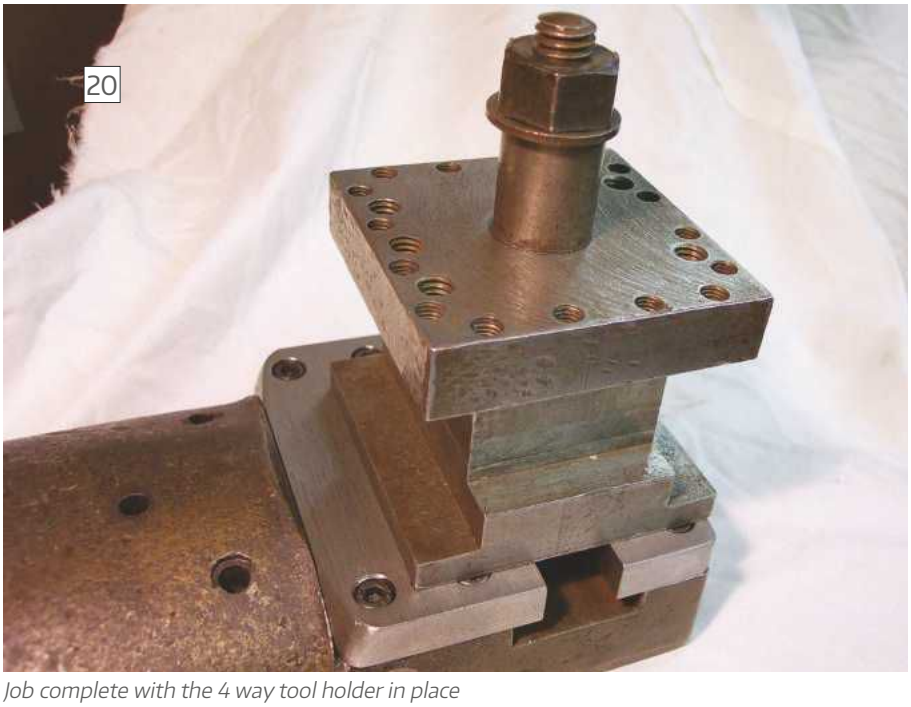
These were fitted in the usual way with spotting holes, drilled out to tapping size and bolted down in one position to clamp the plate, after which the rest of the hole pattern was marked, centre punched and drilled to tapping size. Pockets for the heads of the screws were end milled to just nicely sink the heads below the final height of the platform.



New tool post Tee nut anchor

In the next picture, the slot has been cut through and milled to width; note that each half of the new platform now has twin dowels fitted for added location security. It is shown here in **photo 18** with the shaper being used to bring down the top height of the platform, before final finishing with a fine flat diamond lapping stone to fetch up a nice surface finish.

Photographs 19 and **20** show respectively the new tool post bolt and tee nut shaped anchor made to suit the slot upon which the four way tool holder that was supplied with the lathe on purchase has been duly refitted. This item was not considered to be of genuine Lang manufacture, the containment slots for tools are very badly proportioned, being far too shallow in depth and grossly over-deep to hold tools securely enough on any packing. As purchased, this lathe was fitted with a 4 HP motor, so tool holding would indeed be hard tested and tools would be quite likely to be torn out of the slots. The owner intends to make or fit a more suitable version. ■



Job complete with the 4 way tool holder in place

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Machines and Tools Offered

■ Workshop sale due to ill health. Warco 918 lathe on wheeled cabinet with many chucks and accessories including milling attachment. Plentiful tooling and materials. Kerry industrial bench drill, No. 2 mandrel press, many hand tools files and incidentals. **T. 0121 476 8903. Birmingham**.

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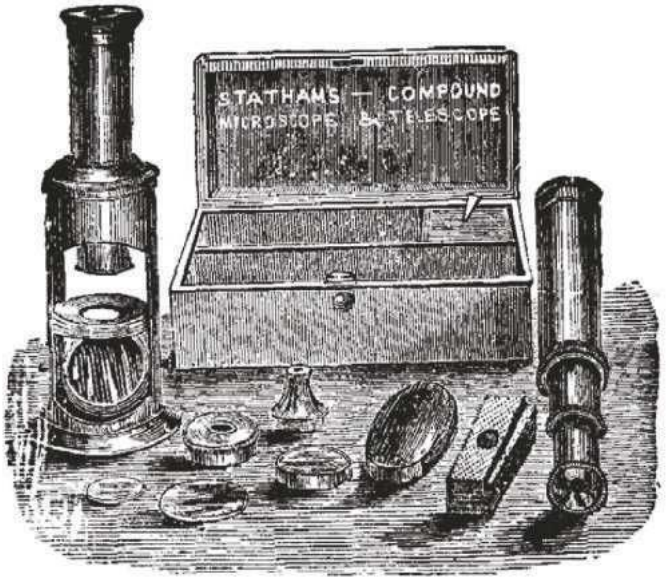
■ Lathe. Emco Maximat V10-P. Good working order. Includes milling post, stand, numerous chucks, rotary table, many lathe tools and drills. Used regularly until last summer by my late son. £1,250 ono. Photos available.
Mike T. 01398332471. Southampton.

Models

■ 5" Gauge Maid of Kent components: Machined smoke box, dome, front bogie, inside GM cylinder block, main wheels, drive axle with Stephenson valve gear. Modest offer please. Maid of Kent Tender needs finishing on suspension, brakes and pipe work, offers. Maid of Kent 'Swindon' built copper boiler, offers please, save it from the scrap man. **T. 01522 794884. Lincoln.**



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Parts and Materials

■ Pandora's box of 3 ½" gauge castings, mostly wheels, some machined. Suit a club to help young MEs, offers over £20. Too heavy to post, buyer collects.
T. 01522 794884. Lincoln.

■ Set of castings, materials and valves etc. for manufacture of 5" gauge live steam 0 6 0 Pansy tank engine, plus drawings. Project never started. Call for discussion, photos etc. **T. 01488 658709. Hungerford.**

Wanted

■ Looking for the following parts for my US - South Bend lathe (model 9a): Bed (x41 inches), Saddle and Compound rest and Apron. If you need more info (item, part, and name numbers please contact me at kopitsass@gmail.com or call at
T. 00306945291638. Athens, Greece.

Readers' Tips

CHESTER MACHINE TOOLS

Skyhook

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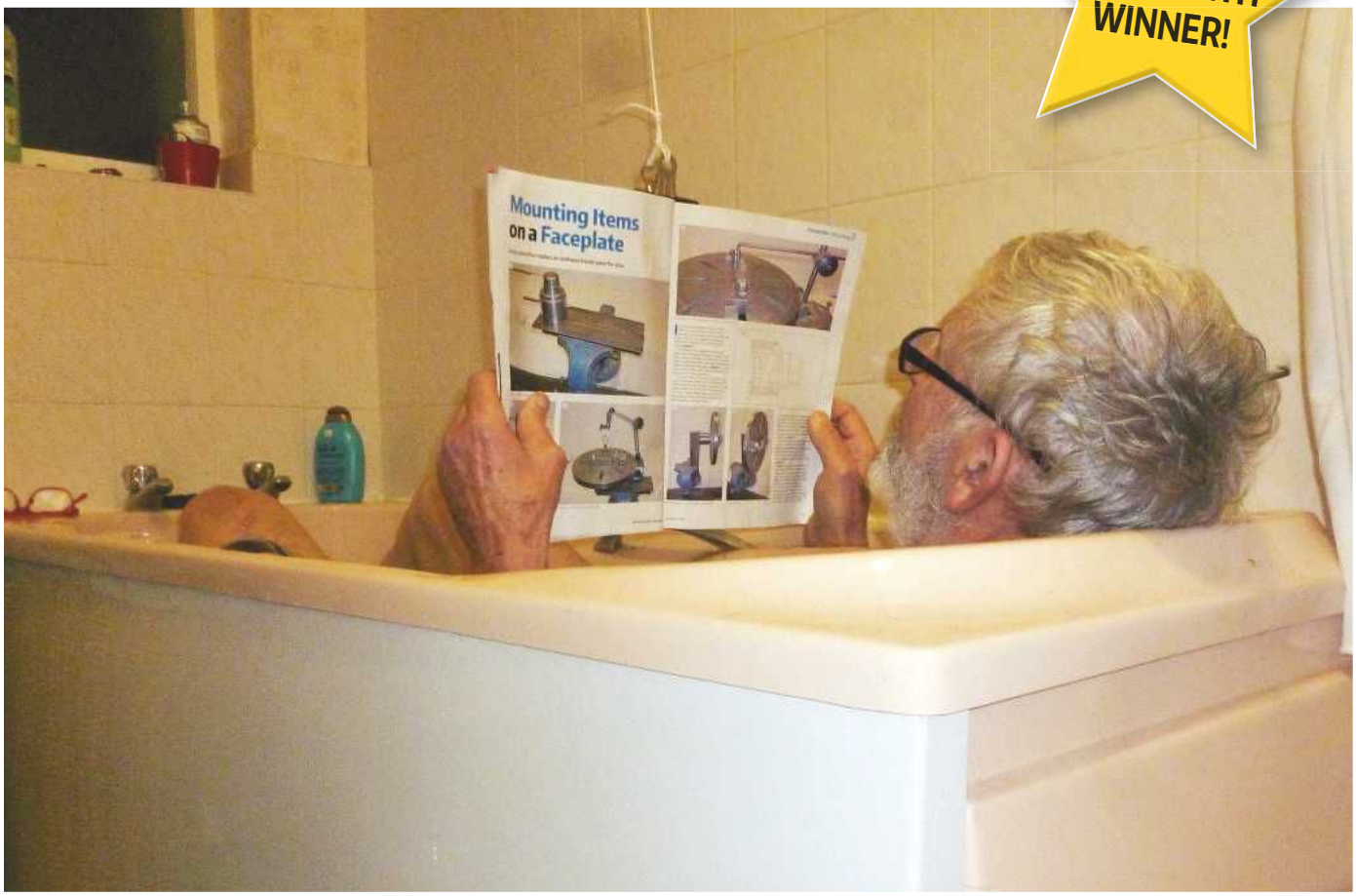


Mike Aireton wins April's Chester Vouchers with an essential tip for keeping your issue of Model Engineers' Workshop in tip-top condition.

To implement this idea it will be necessary, first, to make a firm fixing into a pre-measured point in your ceiling. (See below)

Assuming that your ceiling is of plasterboard it is best if possible to locate a timber joist to hold the fixing. Failing this, a screw anchor will suffice.

If you have a plaster and lath ceiling, you may have to contact your local builder for assistance.

Next, put a medium sized cup hook in the vice and close the hook until it is nearly, but not quite, a closed eye. Screw this modified hook into your joist or anchor.

You will now need to prepare a suitable length of cord with a loop in one end. This should be of a type which is easy to wrap up and put away when not in use. Place the loop over the hook.

You will have ensured, using a plumb line, that your hook is correctly positioned over your bath to give the required point of use.

Fix a strong bulldog clip to the bottom end of the cord at a measured height above your customary level of bath water.

You can now open your M.E.W. at the appropriate page, clip it in the bulldog clip and lie back in the bath to read it. You can relax, safe in the knowledge that if you fall asleep you will not wake up surrounded by a mess of recycled wood pulp.

I am currently working on a clamp to hold my Kindle.

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

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

Anti vibration base

Will Doggett describes his approach to making adjustable supports for a lathe cabinet.

When I got my lathe, that has a built-in cabinet, it just sat on the workshop concrete floor, this was not a problem at the time. I only used it on odd times. It was only when I retired and wanted to use it a lot more and at high speeds that problems occurred. As there was some rocking at high speed I put this down to.the machine not being level Also the garage floor was not as level as I thought it was, it sloped towards the main door, so a solution was required.

Bolting down was not an option so I had to find an alternative. In long and distant past when I used to move machines a lot for the company I was employed by. We used level with shims that we bolted down and then grouted the base gap with cement this was so slow to do. So the grownups, sorry ENGINEERS, got us to use anti vibration pads. This was so much faster to install the machines and they did not require bolting down. The down side of this was the grownups moved the machines in the machine shop a lot more as working practices changed.

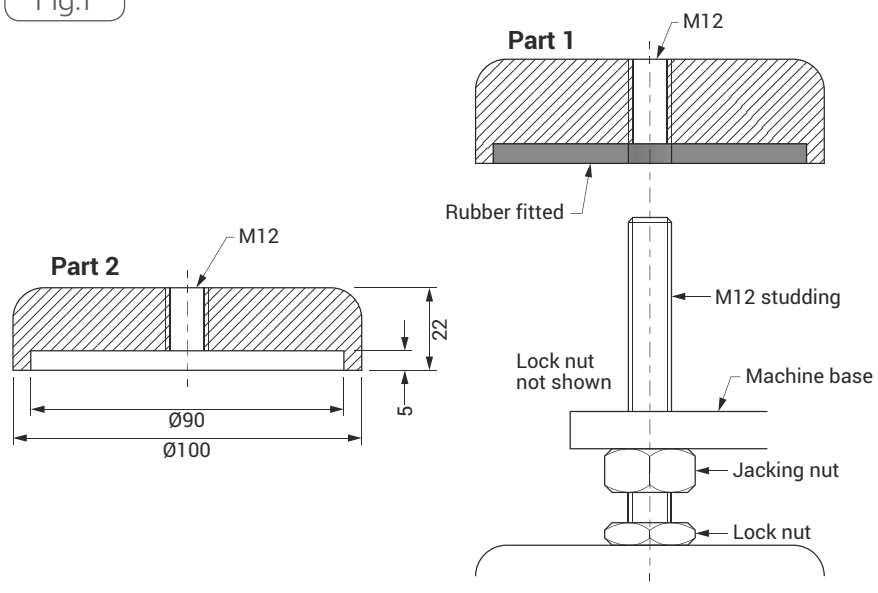
So, I thought adjustable pads for my lathe. When I looked for some they were difficult to get so I made my own, **photo 1**.

Base in position

Construction

First, I needed some discs as the base; this was 4" mild steel round from the odds and sods box, cut to 1" thick – 4 off required.

Fig.1



These were cut on the band saw to length; next the first one was put in the 3-jaw chuck and faced. Then it was centre drilled then drilled through with a 10mm drill. I then put a M12 tap in the tailstock chuck. (As the tap did not have a centre I could not use the tailstock centre and tap wrench.) I started it in the hole; the blank was then put in the Bench vice to finish the thread all the way through, this was also done on the other three. An M12 bolt with a nut on it was then put in the three jaw chuck both the head of the bolt and nut were held by the chuck jaws with about 12mm of thread out of the nut. On this one of the blanks was put on it faced side to the chuck, the other face was then cleaned up and a radius put on the edge. Then the other three were done in the same way and cleaned up with a file to debur all round. I then painted the bases a fetching yellow, this was one of those one-coat on steel paints

The rubber for the bottom was 'insertion rubber', as I know it, that is it has cotton or other fibres in the middle this makes it a lot stronger. It is not that important to use that rubber it was just that I had some. It is about 4mm to 6 mm thick and cut to fit the diameter of the base this is shown in **part 1** on **fig. 1**. The rubber is held in place with some contact adhesive. An alternative is to have a recess in the bottom as show in **part**

2, but the rubber will need to be thicker for this type.

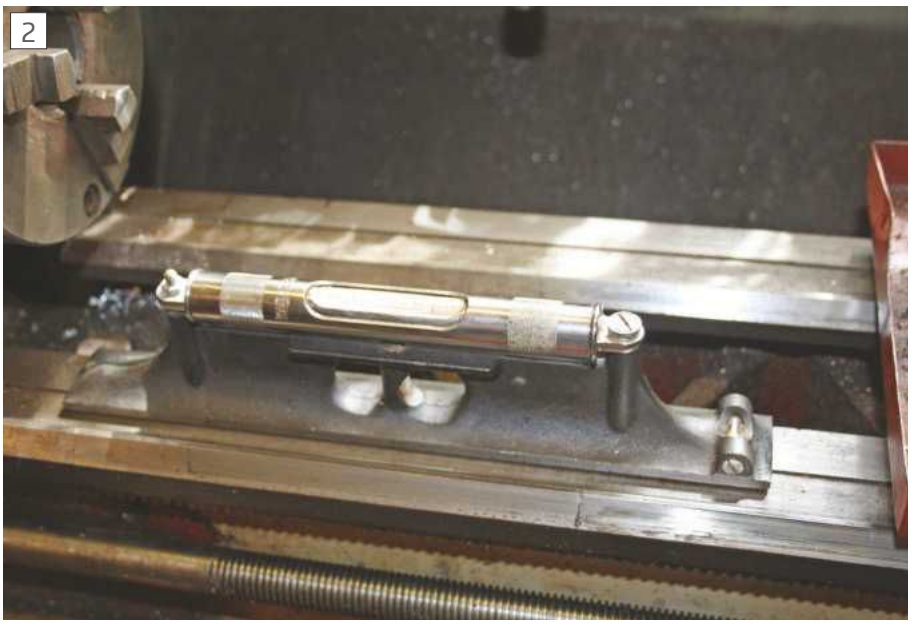
The fixings are M12 threaded rod about 100mm long with a lock nut at the bottom to stop the stud from turning a full nut for height adjustment and a top nut to secure it all.

All that was left to do was fit them; this is shown in the drawing bottom right. Fitting the bases requires the machine to be lifted to get the base underneath. This is done with the help of a large lifting bar onto some packing.

Make sure the machine is stable and is not going to move; this operation is best done with two people for general safety reasons.

The base less the stud is then put under the machine with it lined-up with the hole. The threaded bar is put through the hole of the machine base then screw the jacking nut first then the locking nut on the stud leaving the depth of the thread in the base from the bottom of lock nut to the end of the stud. Now screw the stud into the base and tighten bottom locknut.

If you are using thread lock when the base is in place put the screw through the base of the machine and put the jacking nut on. Then, being careful to keep the thread lock away from the jacking nut thread, put the thread lock on the lower part of the stud and then screw it in to the base omitting the lock nut. Then the rest are done with the same caution as before. After all the bases are in position the packing can be removed so that the machine is now sitting on the jacking nuts in the bases this must be done with the same caution as raising the machine. The levelling was done with a machine level, photo3, from my machine



Levelling

installation days when I went to a place of employment!

The level you use does not have to be as complex as mine, most standard levels will do the job just as well. The jacking nuts are moved up or down to get the machine level or as level as possible. When the levelling is done the top nuts are tightened. **Photograph 3** show the completed job at the other end of the lathe.

Conclusion

Fitting them was a good idea as eliminated all the problems that I had with the lathe. The next job is the mill. But they are only of use to machines that have a cabinet fitted to them. I think it was worth making them as the material was from stock and I managed to get time in the workshop. Also, I had fun making them as the machining and painting was done in less than a day - it was the paint that took the time to dry. It was supposed to be fast drying paint but it was cold in the workshop at the time, so I suppose I can't complain. So, if you machined them in the morning painted in the afternoon, dry over night and you could install them the next day. After making them I did see some on sale from an on-line retailer for about £19 each so they saved me some money which can only be a good thing. I also had the satisfaction of making them. ■

Base at the other end of the machine

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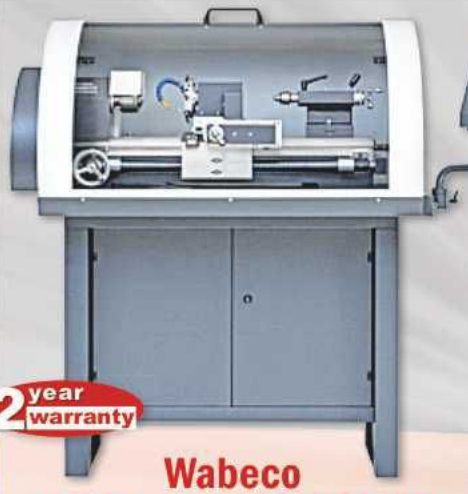

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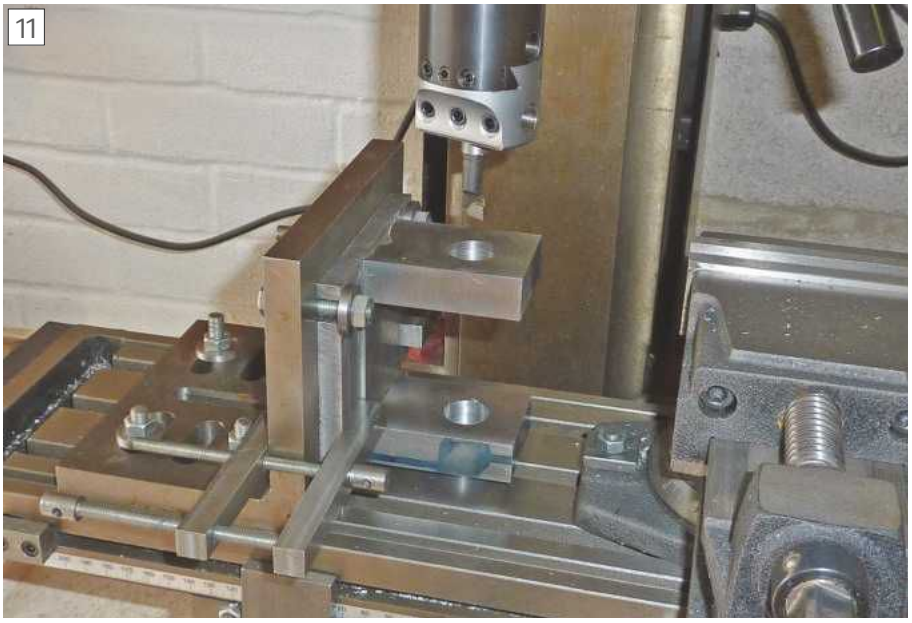
Building and Operating a Dividing Head Part 2

Alex du Pre describes the construction of a useful and practical dividing head. The second sheet of plans is included in the centre of this issue.

At this stage, the bearing housings are bolted to the baseplate. They should be permanently assembled, since future dismantling will result in disturbing the alignment between the spindle and the baseplate. The parts can be assembled with epoxy resin or threadlock before tightening the bolts.

Next the bearing housings are bored to receive the bearings. The dividing head is designed to match the lathe's centre height, so it is best if this operation is carried out on the lathe. The body is bolted to the lathe cross slide clocked square to the lathe's X axis using a DTI along the edge of the base. An engineer's square can be used against the edge of the work table, but the Y movement of a lathe is often not quite square to the X axis, so beware if using this approach. It is essential that the dividing head's spindle is parallel to the edge of the baseplate if accurate setting up is to be achieved in future.

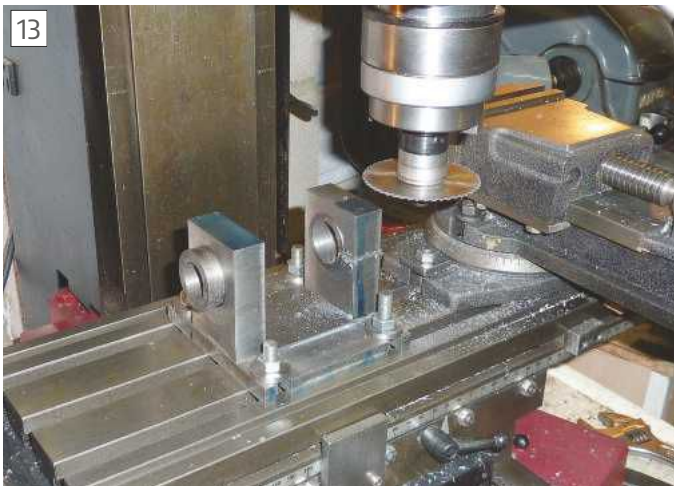
However, since you may not have a selection of drills sufficiently large and long to drill the bearing housings from the lathe headstock, you may need to bore them on the milling machine, as shown in **photo 11**. At this stage, the bores should be left undersize, but they do need to be positioned reasonably accurately.



Boring the bearing housings undersize with a boring head.

To bore the bearing housings to accept the iron bearings, once the holes have been roughed out, the body is mounted onto the lathe cross slide, if it is not already, and set accurately square. A boring bar is mounted between centres and the housings line bored to allow a sliding fit with the bearings, **photo 12**. At this point, the bearings are permanently fitted to the

Line boring the bearing housings using a boring bar between centres on the lathe.



Slitting the front bearing.

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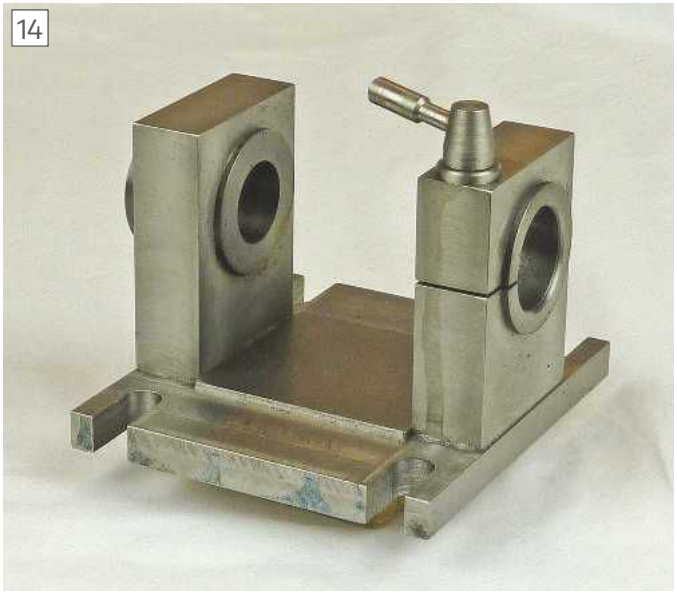


The finished body with spindle lock fitted.

Underneath view of the finished body.

body with epoxy or similar, taking care to get them the right way around and not mixing up the front and back bearing (the bores and lengths are different).

When the epoxy has set, the bearings are bored to a close running fit on the spindle, noting that the bores are different diameters. Measure and cut carefully and test the fit as you approach final size, cleaning the bores carefully to remove the dust-like iron swarf. Several passes at each setting should be made in order to work out the spring in the boring bar. To check the fit on the spindle, it is necessary to withdraw the tailstock and slide the work away from the boring bar. When complete, the spindle axis should be at lathe centre height and parallel to the sides of the baseplate.

To finish the baseplate, the front bearing is split on one side using a slitting saw held in the milling machine, **photo 13**, and then drilled and tapped to accept the locking handle. The completed body is shown in **photos 14** and **15**.

Spindle Lock

The spindle lock, **fig. 6**, clamps the spindle in position for each machining operation. It prevents backlash in the gear train from affecting accuracy of the work and prevents machining forces from being transmitted to the comparatively delicate detent mechanism.

The spindle lock and washer is a simple turning job. Drill the boss to accept the handle, then assemble with Loctite or epoxy, **photo 16**.

Banjo

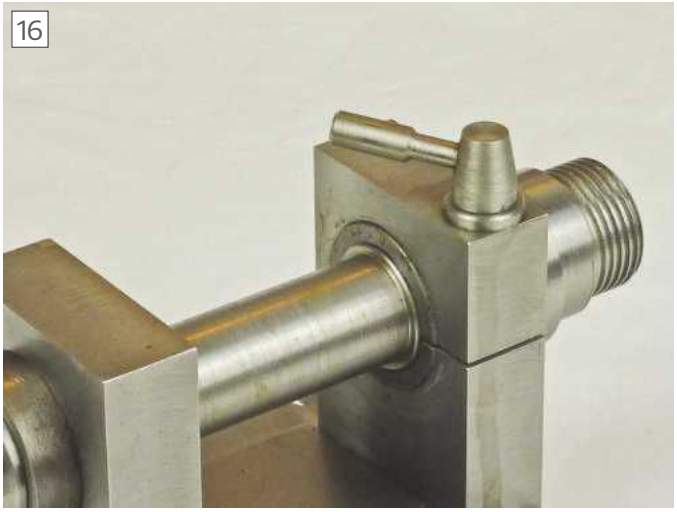
Banjo is the name given to the slotted plate on which the detent and gear fittings are mounted. One end of the banjo, **fig. 7**, is bored to closely fit onto the protruding length of the rear spindle bearing, allowing it to be secured in any convenient position for the work in hand.

Cut the banjo blank from a suitable piece of aluminium flat bar and mark out the positions of the large hole and slots. Machine the rounded end on a rotary table or file to size. Drill then bore the large hole to a close fit on the bearing using a boring head and machine the slots using a slot drill, **photo 17**. Finally, slit the end using a slitting saw and cut the thread for the locking screw.

Gear Axles

The two gear axles, **fig. 8**, need to be able to allow either a single or double gear to be mounted onto them, requiring various spacers and washers. When two gears are fitted to the same axle, they need to be prevented from rotating relative to each other. To achieve this, they are mounted on a bush, which is either splined or fitted with a keyway to match the gears. When a single gear is used, it is again mounted on a bush which rotates on the axle. The splined bushes shown in the photos were supplied with the lathe changewheels and were not made specifically for this project. I have assumed that your changewheels will have similar fittings. If not, some improvisation will be needed to suit your particular circumstances.

The axles themselves are simple turning jobs, but they need to match the bore of the bushes accurately to give a smooth-running fit. The banjo fittings are shown in **photos 18** to **20**.



The spindle lock in place.

Boring the banjo to a sliding fit on the rear bearing.

Gear axle showing longer splined bush for fitting two gears side by side and preventing relative rotation between the gears.

Gear axle showing spacer and shorter splined bush for single gear.

Detent

The spring-loaded detent, **fig. 9**, has a shaped end to fit between the gear teeth. A knurled knob is used to withdraw the detent while rotating the gear to its next position. The detent is made from a steel plunger which must be a very close, shake-free fit in its housing to maintain positional accuracy. Since the dividing head spindle is locked during each machining operation, the plunger does not need to bear any significant machining loads. The detent mechanism is bolted to one of the slots in the banjo, allowing its position to be adjusted to accommodate gears of different diameters.

Machine the detent body square and to size using suitable end mills and holding the part in a machine vice. Alternatively machine each face in the lathe using facing cuts whilst holding the part in a four-jaw chuck. Drill and ream the hole for the ram to ensure a close sliding fit.

The ram is turned from a piece of silver steel bar. The remaining parts are simple turning jobs, requiring threads to be cut using a tailstock tap or die holder as appropriate. Knurl the handle and assemble using a suitable spring, **photo 21**.

The banjo with all its fittings is shown in **photo 22**.

Spindle Fittings

To secure a gear to the outer end of the spindle requires a range of fittings, **fig. 10**. The nut and washer are simple turning jobs. Make the nut from hexagon bar and tap to match the spindle.

Make the key from a short length of square bar. It should be a tight fit, but not a press fit, in the keyway.

If the bore of the gears does not match the outer end of the spindle, make a sleeve to suit. The sleeve must be split along its length to clear the key.

A spacer is required to enable the spindle gear to be fitted in the inner and outer position depending on the gear train used. The spacer is a simple turning job, but it must be slotted to clear the key and the bore must match the sleeve. The length of the spacer should be adjusted to match the thickness of the gears being used.

The spindle fittings are shown in **photo 23**.

Gears

Lathe changewheel gears are ideal for use with this dividing head and you may well have a set of these already. Any other similar gears will be suitable as long as they are accurately made and of an appropriate size. The range of gears you have will determine the range of divisions achievable. You may need to source additional gears to achieve a particular number of divisions.

A set of Myford changewheels typically includes 20, 25, 30, 35, 38, 40, 45, 50, 55, 60, 65, 70 and 75 tooth gears. The prototype used gears from a Warco WMT300/2 lathe consisting of 27, 27, 27, 30, 32, 32, 33, 36, 39, 40, 42, 45, 49, 50, 56, 60, 60 and 63 tooth gears, there being more than one of some sizes.

When direct-dividing with one gear attached to the spindle, this gear needs to be at least 30 teeth, or the detent cannot reach it as the securing bolt will foul the bearing support.

Due to clearance in the keys and gear teeth, all slack needs to be taken up and the spindle and gears rotated in one direction only, otherwise accuracy will be lost due to backlash.

Using the Dividing Head

References 1 and **2** give comprehensive guidance on dividing operations. Basic instructions for the use of this dividing head follow below.

For simple, or direct, dividing a single spur gear is securely fixed to the tail end of the spindle and the detent positioned to engage between the teeth of this gear. The number of teeth in the gear must be equal to, or a multiple of, the number of divisions required on the work in hand. With the detent engaging between each gear tooth in turn, the spindle can be rotated in equally-spaced divisions. Smaller numbers of divisions can be achieved by incrementing more than one tooth at a time.

Compound, or indirect, dividing requires a gear train to be set up on the banjo, with the detent engaging with the outermost gear. This allows a greater number of divisions to be achieved than is possible with just single gears.

Examples of setting up the dividing head for direct or indirect dividing follow.

Setting up for Direct Dividing

A direct dividing set up using a single gear is shown in **photo 24**.

Selecting a suitable gear for the job in hand is very simple. A starting point is to select a gear with the same number of teeth as divisions required on the work, so for example if 20 divisions are required select a gear with 20 teeth and increment the gear one tooth at a time. The same result can be achieved using a larger gear

›

View of gear axle with fittings assembled. The gear slides onto the splined bush.

The detent.

The banjo with all its fittings.

whose number of teeth are a multiple of the number of divisions required, so a 40 tooth gear incremented two teeth at a time will give the same result. This fact is often useful when a small number of divisions are required. Some gears, notably 48 and 60 tooth gears, are particularly useful in this regard. A 60 tooth gear can be used to achieve 2, 3, 4, 6, 10, 12, 15, 20, 30 and 60 divisions.

Direct Dividing Example

If we have a job requiring 12 equally-spaced divisions, the number of teeth in the gear we select must be a multiple of 12. In this case we could use a 12, 24, 36, 48 or 60 tooth gear so giving some options. It is generally better to go for a larger gear as it will reduce the effect of any slight inaccuracy in the tooth spacing and the detent may not be able to reach a smaller gear. Using a 48 tooth gear, for this job we will have to increment four teeth at a time to give the 12 divisions required.

The gear is now fitted to the outer end of the spindle, using any necessary spaces and collars. The detent is bolted into position such that it is pointing more or less directly at the spindle axis.

With the detent engaged, rotate the spindle hand against the detent (always in the same direction) to take up any slack and lock the spindle with the spindle lock. The first machining operation can now be completed, before unlocking the spindle and indexing to the next position. This is repeated until the job is complete. It is a good idea to mark the gear with small blobs of paint to help with counting, as shown in the photo.

Setting up for Indirect Dividing

The spindle and fittings.

It is easier to use a single gear if possible, but a train of three gears, A, B and C, can give a larger number of divisions without having to buy more gears, **photo 25**.

Gears A and B rotate on the same axle, but are fixed relative to each other and gear C is fixed to the spindle. The detent engages with gear A and gear B meshes with gear C.

An idler gear can be placed between B and C if necessary to avoid problems with parts fouling, photo 26. This gear can be any convenient size as it does not affect the gear ratios.

Selecting suitable gears for the number of divisions required requires some calculation and a little methodical trial and error. If we let:

A = number of teeth in gear A
B = number of teeth in gear B
C = number of teeth in gear C
Div = the number of divisions required
N = the number of teeth passed on gear A for a complete rotation of gear C
T = the number of teeth passed on gear A for each division on the workpiece

Firstly, N divided by Div must be a whole number. N is derived from formula 1:

C x (A / B) = N (formula 1)

Various gear combinations can be tried until this condition is satisfied. Having identified a suitable gear combination, the final task is to calculate the number of teeth to be incremented on gear A for each division on the workpiece, using formula 2.

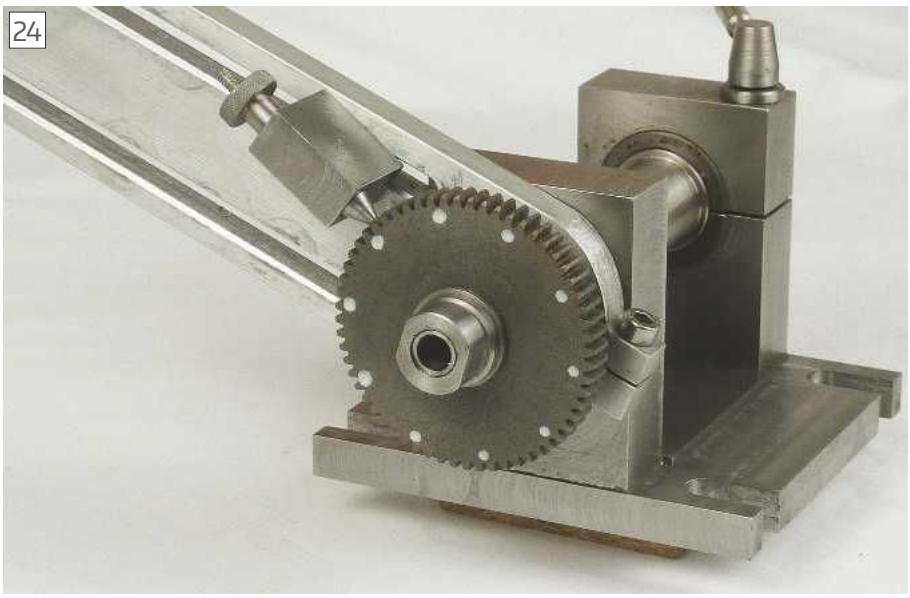
N / Div = T (formula 2)

A worked example should clarify the process.

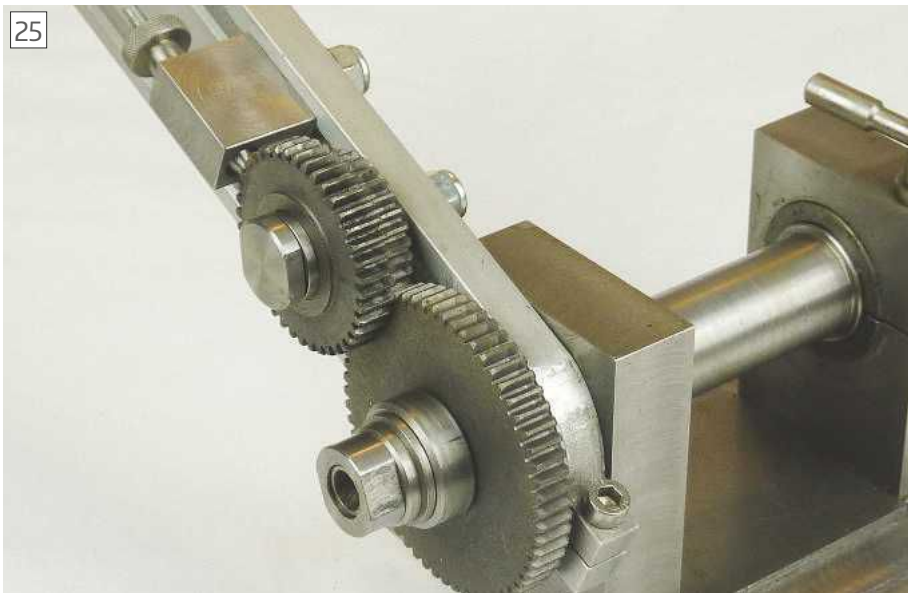
If we want to achieve 80 divisions have 20, 30 and 40 tooth gears available, we can arrange things so that A = 40, B = 20 and C = 30. Using formula 1 gives:

C x (A / B) = 30 x (40 / 20) = 60 = N

However, this arrangement will not work as 60 (N) divided by 80 (Div) is not a whole number. But we use a 15 tooth gear for gear B, we get a value of 80, which is workable. Other workable combinations are likely to be possible using the available gears.



The set up for simple dividing with a single gear.



The set up using a gear train. The two smaller gears rotate together, but cannot rotate relative to each other.

We can now calculate the number of teeth in gear A to be incremented for each division, using formula 2:

N / Div = 80 / 80 = 1

So, in this case gear A is incremented by one tooth for each division.

Indirect Dividing Example

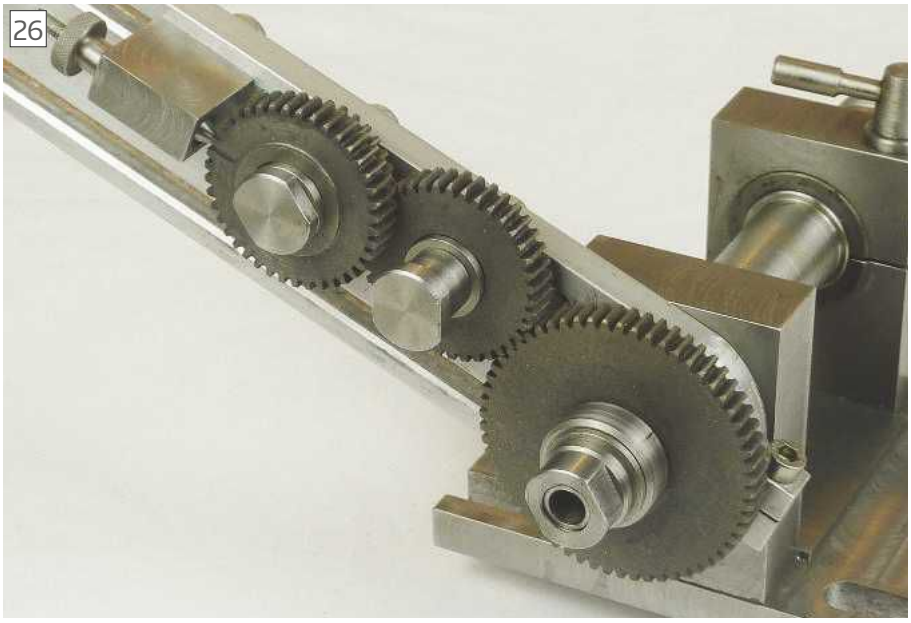
The dividing operation is very similar to direct dividing once the gear train has been set up. Backlash should be taken up in the same direction as before. The starting position should be marked on gear A so that it can be reset if you lose count. Of course, gear A may need to rotate several times and will not necessarily rotate a whole number of turns for one complete rotation of the spindle.

Conclusion

A dividing head will find much use in the home workshop and I hope that you will consider this simple, robust design a suitable basis for a project of your own. Whilst it is not as pretty or sophisticated as some other designs, it is a practical tool and a good exercise in a range of turning and milling techniques requiring some accurate but not difficult work. You will almost certainly need to change the dimensions and some of the details to suit your own machinery and gears, but this will be well within the ability of any model engineer. Please feel free to contact me via my personal website at **ref. 3** if you have any questions or comments. ■

References

1. 'Dividing', Hall, H, Workshop Practice Series No. 37.
2. 'Dividing – Tools and Techniques', du Pré, A.
3. www.amdengineer.com



An intermediate gear being used to prevent clearance problems. The size of this gear does not affect the gear ratios.

Scribe a line

YOUR CHANCE TO TALK TO US!

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

Copper Pipe

Dear Neil, Recently I was making a small twin cylinder steam engine, the text said use 1/8'' copper pipe. I managed to scrounge enough for what I needed and found it is relatively expensive, what isn't? Later I was chatting to a plumber friend, he told me he had just been fitting a new thermocouple to a gas boiler, so I asked him for old one. Using a junior hacksaw, I cut off the sensor end, nicked in 4 places the other end and wriggled it around until it broke away, then carefully slid/removed the centre core.

Half a metre or more of 3mm copper pipe for free, as the couple had been screwed up I annealed it up using my blow lamp ready for future use. I have no idea what material the centre is, but I do know how thermocouple works and what their role is in a boiler or gas fire. Since then I have acquired several other faulty thermocouples and found they vary slightly in diameter from 2.81 to 3.25 so adjust your drill/hole size accordingly. Also car brake pipe is another source of 5mm cheap copper tubing and garages have a lot of short ends, too short for their needs but long enough for many of us model engineers requirements.

Ted Fletcher, Scarborough.

A useful idea, Ted. I'd note that brake pipe comes in different materials so readers should make sure the type obtained suits their needs- Neil.

Sharing Ideas

Dear Neil, I would first like to thank Laurie Leonard for his article 'MEW to the rescue' in issue 265 and his mention of me '' in despatches'' so to speak. I am glad my article gave him the encouragement to deal with his bandsaw gearbox problem using the same surgical route as I did, appropriately adapted as he did to suit his circumstances.

Dispensing information and experience is what writing articles is all about and it is gratifying to see it being used and appreciated by others.

On a second topic in the same issue if I may mention it. Geoff Theasby described a cracking little idea of his called the ''Grog clip'' and I would like to share that idea, if he is amenable of course, with the other panel members in our Harrogate/Ripon Remap group.

It is just the kind of thing that is such a useful, and cheap, gadget for helping people with hand stability problems to drink by themselves. There are pumped drinkers available of course but at cost, Geoff's idea is a real winner and I congratulate him. Long may he enjoy his grog in whatever flavour it takes!

Brian Wood, by email

Oilcans from the Dollar Store

I find I drill and tap a lot of 4,5 or 6mm holes in numerous little projects or repairs around my workshop. It annoys me when even just a squirt of cutting fluid ends up being way more than was required and ends up getting wiped off when done, since literally two or three drops was all that was required. Even on my lathe, I often feel a few drops will suffice, rather than an oil-can squirt!

In Dollar stores here in Canada, you can pick up the pictured clear squeeze bottles for, well, a Dollar or two. I snip the tip off the bottle applicator tip just enough so I can screw in a needle tip inflator nipple such as used to inflate rugby balls, without stretching the plastic tip. The plastic tip will split very soon, if the screw-in fit is tight. Don't ask me how I know.

Instead, I wrap a few coils of thin stainless steel binding wire around the neck and snug it up just enough to not cut into the plastic neck. This works great to drip single drops of cutting fluid exactly where intended.

Stephan Buys, Vancouver BC.

G'day Down Under

I expect to be in the UK later this year and am wanting to know if there are any 1 or 2 week classes in machining, lathe and mill.

I'd appreciate any suggestions readers can provide, thanks.

Joe Venables, Cairns, Australia

Mystery Tooling

Dear Neil, here are some photos of a mysterious (to me) vice that we have received in our workshop.

'We' are the Didsbury Tools For Self Reliance Group in Manchester, one of many groups throughout the Country that receive donations of all kinds of tools from which we select and refurbish items to create specific tool kits to order. These are then sent to identified groups in six or so different countries in Africa. Only two weeks ago we delivered three kits to our HQ in Southampton which will be added to around 200 other kits. These will be packed in a large sea container and shipped, in this case to Uganda. Every tool in this shipment is something that is either unwanted or unused in a shed or garage in this country which, once refurbished, can be given another purposeful life in the hands of another artisan. The range of tools needed goes from an anvil to a sewing machine, with everything receiving an extended life because it was first of all made to last. The moral is ... if you don't use it, don't throw it away, but give it away to someone who can create another working life.

As you can well imagine a rich source or tools for us is the workshop of a deceased craftsman whose widow/family are at a loss as to how they can dispose of a shed -workshop-garage full of tools, avoiding the heartbreak of sending a lifetime's collection of still usable tools to the tip as waste. This vice is something of a conundrum to me in that it is capable of temporary fixing but appears quite able of handling heavy work, with a holding ability whilst also able to drill and tap. My suspicion is that it might be used by a fitter ~ mechanic both in a workshop as well as on site, for in essence it might be a 'multi tool', for suitable bars can be fitted to serve differing?

Do any readers recognise it or know of the manufacturer - I suspect that the name plate might well be a wholesaler/agent.

Trevor L. Jones, Chairman Didsbury, TFSR Group

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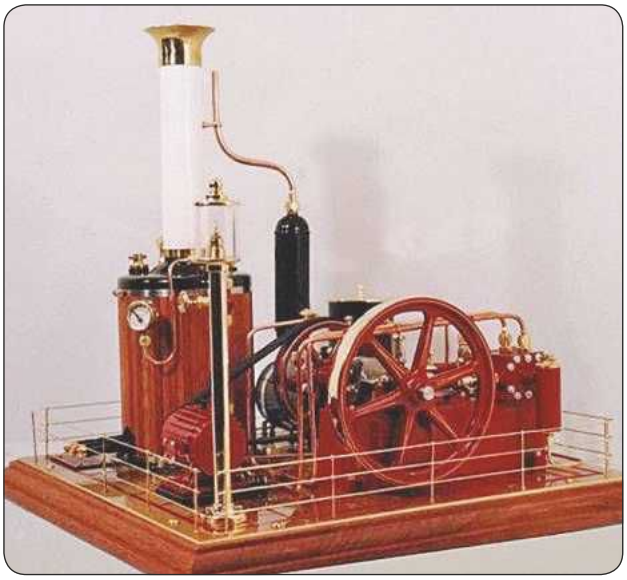

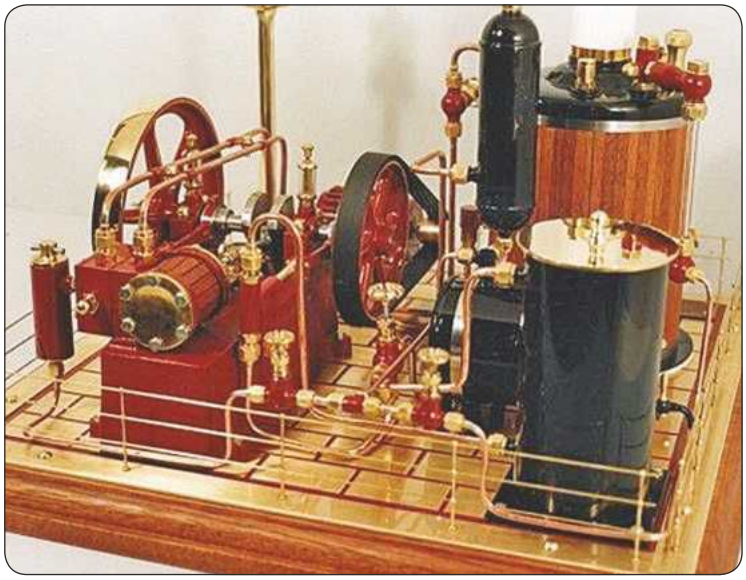

The "Beverley" includes fine rivet detail around the top flange of the boiler and skirt, a working fire door and a full set of fittings including a working whistle. The colour scheme of 2018 is Maroon which looks very attractive against the polished brass parts and stainless-steel boiler bands which hold the hardwood timber planks.

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Shaping up Part 4

Cutting Metal

Bill Morris continues his introduction to shaping machines with some practical advice on their use.

Generating a vertical surface

Roughing out the vee

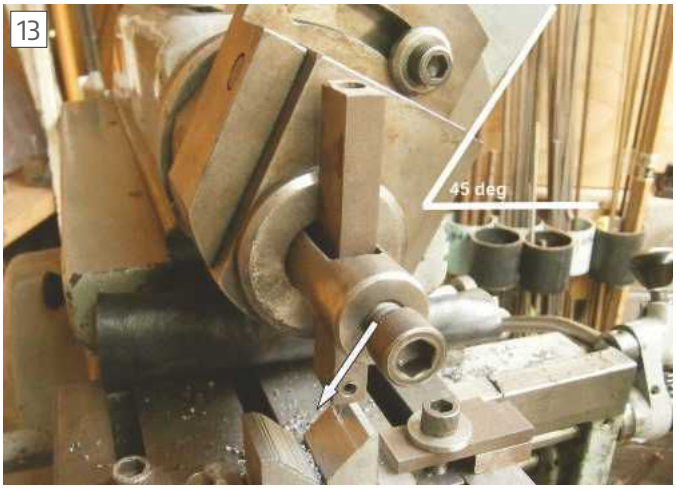
Once surface number 1 has been generated, the machine is stopped, chips brushed off the workpiece, vice (especially the top of the bed) and parallels, and the workpiece is re-sited as shown in diagram "B". Since the bottom is still un-machined, it is simply held down on the parallels by hand while the vice is tightened. The round bar allows the machined surface to rest against the fixed jaw, so that surface number 2 can be generated and, if the vice is true, the angle between the two surfaces will be a right one.

The first surface can now sit on the parallels with the second one against the fixed jaw. We still need the round bar, as it sits on an un-machined surface that might damage the moving jaw, but this time as the vice is tightened the workpiece is tapped down on to the parallels with a soft faced hammer. You then check that the parallels are firmly held by checking that none of the ends can be moved beneath surface number 1. If this is not the case, another firm tap with the hammer may fix it, but if there is a lot of free motion of the parallel, it may be that something is amiss with your fixed jaw, the parallels or both. Very often, simply removing an un-noticed bit of swarf is enough to effect a cure.

Finally, with three plane surfaces generated with two right angles, the round bar can be dispensed with, but the workpiece must be tapped down on to the parallels and the latter be checked for lack of movement before machining surface number 4. This leaves the ends to be squared off. If the work piece is short and stubby, it can be held end up in the vice and checked that it is square to the vice ways using a small square. If it is too long to be held upright a vertical cut has to be made, which is the subject of the next section.

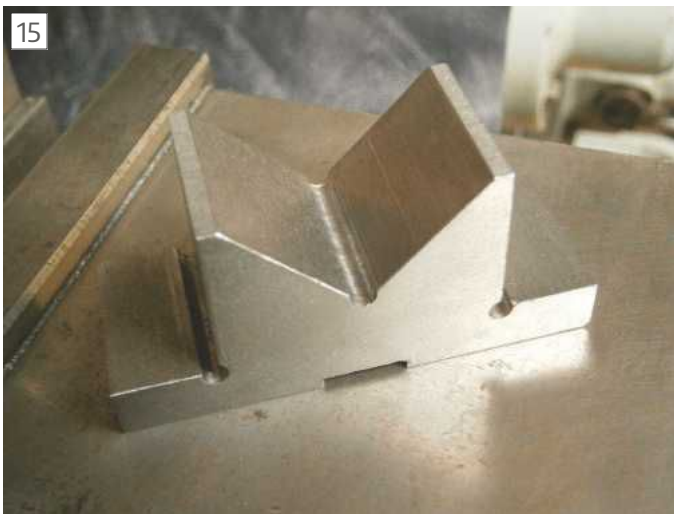
Vertical surfacing

Photograph 11 shows a vertical surface, one side of a vee block, being generated. The tool slide movement is set to vertical

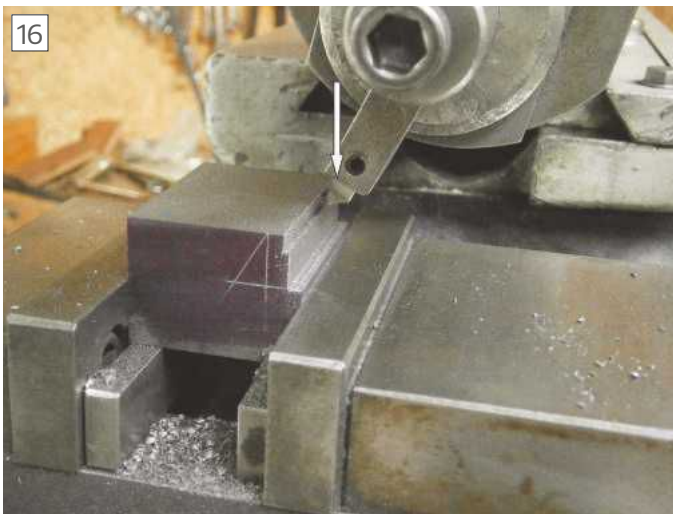


Note the drilled hole which give the tool somewhere to run out at the base of the vee

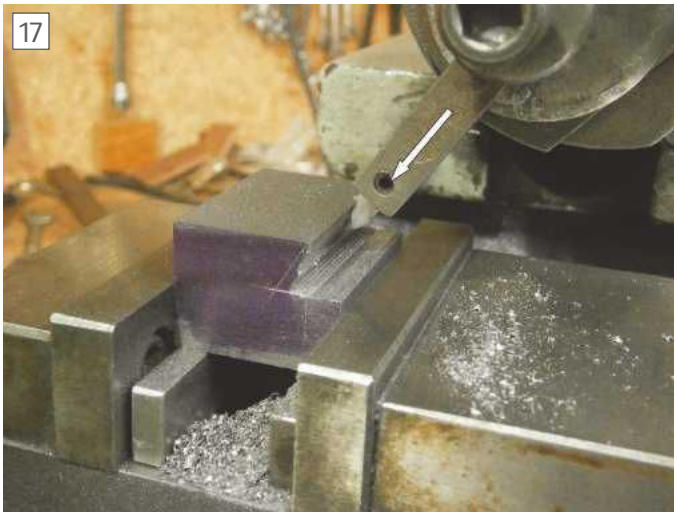
Slotting the base



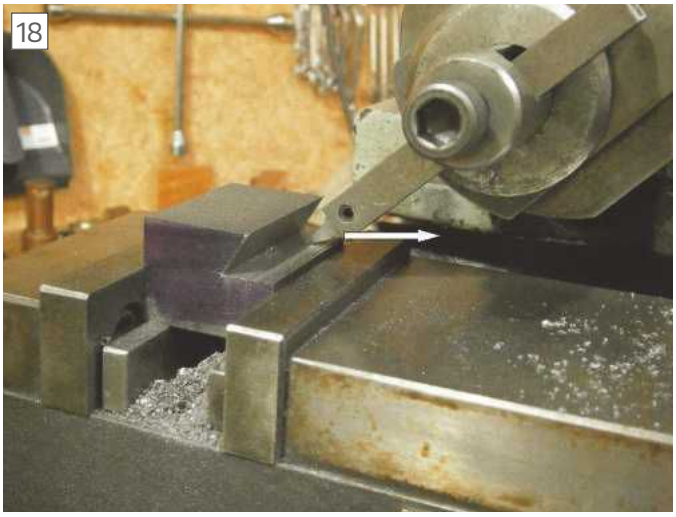
Finished vee-block



Initial cut for edge of dovetail

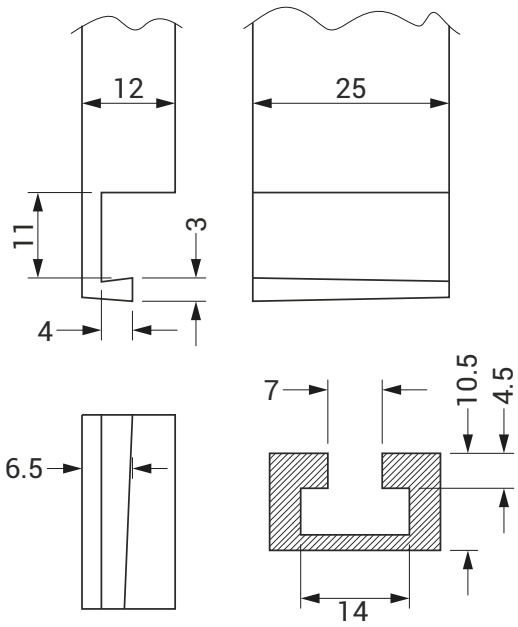


Using the angled slide to cut the dovetail



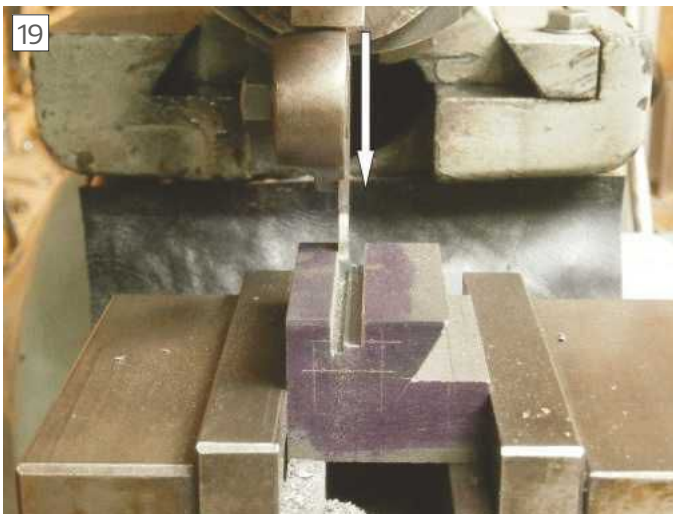
Finishing the horizontal surface

Fig.4



and the clapper box is set over towards the vertical surface. This ensures that on the return stroke the tool will swing off the surface. The tool, which is vee shaped with a 70-degree included angle and slightly rounded end, is set at an angle in the tool post so that there is 10 degrees clearance at the vertical surface and 10 degrees at the horizontal surface. As the feed is to be put on by hand, it is as well to have the stroke length a bit longer and the speed a bit slower than usual, to allow more time to feed the tool down, always on the return stroke. Shock and vibration may cause the tools slide to descend on its own so tighten the locking screw enough to allow smooth feed without allowing the slide to feed itself. In the example shown the vertical surface is to meet a horizontal one, so that when the tool meets the marked horizontal line, the ram is stopped, the thimble on the feed screw set to zero and the tool wound up ready for the next cut, which is put on using the cross feed handle. It is a good idea to set the drive pin of the cross feed in the centre of the driving disc, so that if auto cross feed is engaged as the result of a moment of inattention no feed takes place.

When the cuts have been taken to the marked out vertical line, a fine finishing cut is made and when the horizontal line is reached, the table is wound back by hand to take a fine scraping cut outwards. To do the other end, the tool and the clapper box can be set over in the opposite direction or the work reversed in the vice. If it is essential that the opposite surfaces be truly parallel, it is best to check that the chuck jaws are truly parallel to the table cross movement before starting and to reverse the work in the vice. This counters any tendency to looseness of the ram in its slides which would result in the sides not being parallel.



Initial central part of t-slot

Hinge arrangement

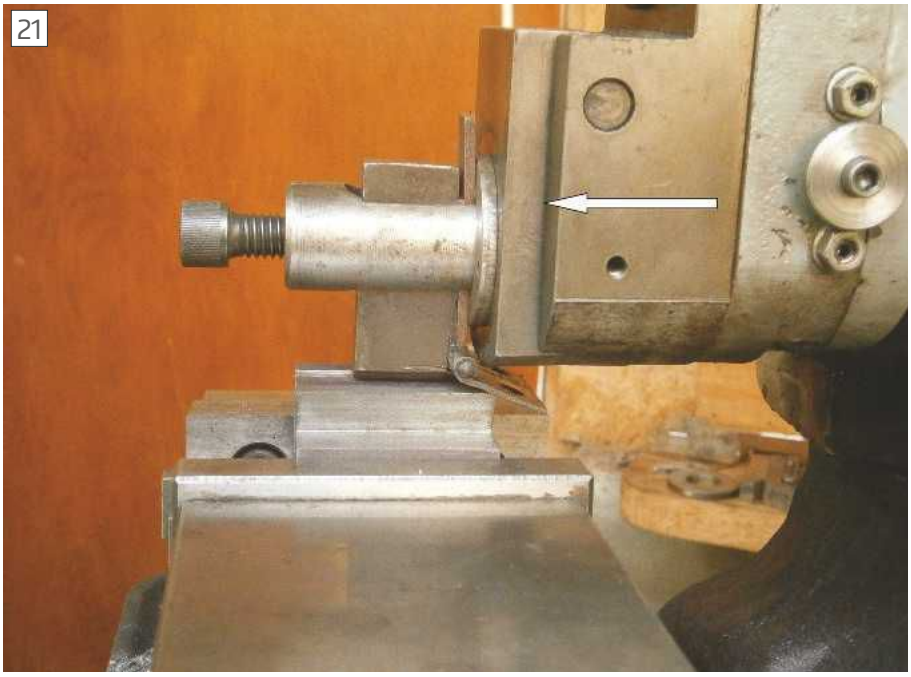
Angular surfaces

After cutting the feet, the vee block can be fixed directly to the table for machining the vee, so that the lever arm of the vice and its base is no longer interposed. A square is used to set the face of the vee block across the table. The clapper box is set vertical again and a 60 degree vee tool with a generous radius at the tip is used to rough out the vee nearly to the marked lines, **photo 12**. Auto cross feed can be used to do this, provided one stays awake and does not accidentally set the feed in the wrong direction. Traditionally, vee blocks seem always to have a square groove at the apex of the vee, but drilling a small hole before cutting the vee both saves time and reduces stress concentration in the cast iron. It also gives the tool somewhere to go during finishing, which is shown in **photo 13**.

The tool slide is set over at 45 degrees, using the graduated circle on its base or, if accuracy is critical, with a protractor off the table or a clinometer off the machined edge of the slide. The clapper box must be set over as usual in the direction of the surface to be generated. I found that the round-nosed vee tool used to rough out the vee also served to produce a fine surface when fed down the vee, doing so on the return stroke of the ram as always. Cut is put on using the handle on the cross slide feed shaft. Once one side has been cleaned up, the tool slide and clapper box are set over in the opposite directions and the second surface finished to the line, incidentally leaving a nicely rounded groove at the apex of the vee.

Slotting the base

Cutting a slot in a surface is often very simple but getting it in the right place and of the right size is less so. **Photograph 14** shows the slot in the base of the vee block being formed, using a tool that is a bit like a broad lathe parting tool, without top rake for cast iron but with side relief. It is fed straight down to a little less than the full depth, withdrawn and then the work is moved across to widen the slot in stages nearly to the marked outline of the slot. If it is necessary to fit something like a key, where shake is not allowed, the slot is then progressively widened taking mere scrapes off each side wall until the key fits snugly. Following the last cut on the walls, the tool is fed down to full depth and then traversed to the other side, taking a fine shaving off the bottom and leaving both corners square. With the tool shown, only a fine finishing cut can be made without hazarding the tool.



Hinge swings clear on cutting stroke

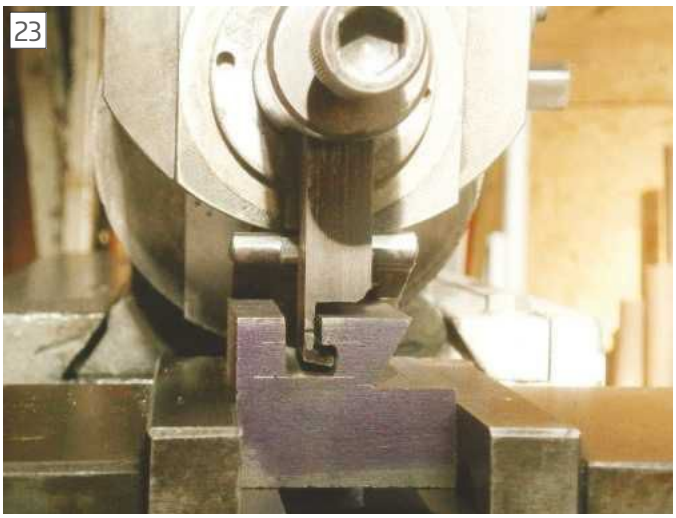
Cutting a blind ended key way in a round shaft is relatively simple, providing it can be properly sited and that a shallow hole is drilled at the end of the slot, so the tool and chips have somewhere to go at the end of the stroke. Needless to say, the ram should be pulled over by hand before applying power, to make sure that the tool has indeed somewhere to go. A key way that is blind at both ends is somewhat more difficult, as a hole has to be present both ends, one of them large enough to allow the heel of the tool to drop into at the end of the backwards stroke. A generous front clearance makes this a little easier and the clapper box is best locked, because the clapper box has very little time to get re-seated at the end of the reverse stroke. **Photograph 15** shows the finished vee block.

Dovetails

Though the cost of dovetail milling cutters has come down, now that China makes ones of very high quality, there is still a place for the shaping machine, as the cutter is as cheap as a scrap of 6 mm square tool steel. I have no current need for a dovetail slide, so to illustrate the method I have used a scrap of cast iron. After cleaning up to square all the angles and marking out, a vertical cut to within, say, 0.25 mm (.010 in) of the base of the dovetail is made first, by feeding the tool downwards **photo 16**.

Next, the tool slide is set over 30 degrees, the clapper box rotated towards the work and the tool slide thimble set to zero when

Hinge lifts cutter clear of work on return



Finishing first undercut

the tool tip rests on the horizontal surface. Using a tool with an included angle of about 50 degrees, to allow 5 degrees clearance each side, it is then fed downwards by hand to rough out the angle until the thimble reads zero with each slice **photo 17**. When the angular line is nearly reached, a fine finishing cut is made to the corner, the tool slide advanced 0,25 mm and a fine finishing cut made to the horizontal surface using the cross feed, as shown in **photo 18**.

Tee slots

Cutting a tee slot with a shaping machine is one of the more demanding tasks. First, one has to make a rather complex tool and then cope with preventing the tool digging in on the reverse stroke, as the tool tip cannot rise off the just-formed surface without fouling the roof of the slot. **Figure 4** shows in the bottom right-hand corner the dimensions of a typical tee slot on an amateur's accessory, such as a vertical slide. A typical tool for cutting such a slot is shown in the rest of the drawing. The tip of the tool has to be able to enter the narrow part of the tee slot and have sufficient breadth to excavate the wide part of the slot. Necessarily, the shank of the business end of the tool has to be slender, a mere 3.5 thick in the 12 mm wide tool, so it pays to have the tool as deep as possible. I made mine out of a piece of hardened and tempered 12 x 25 mm gauge plate 22 years ago, and from the look of it I used a file. The exact clearance angles are not important just so long as they are present!

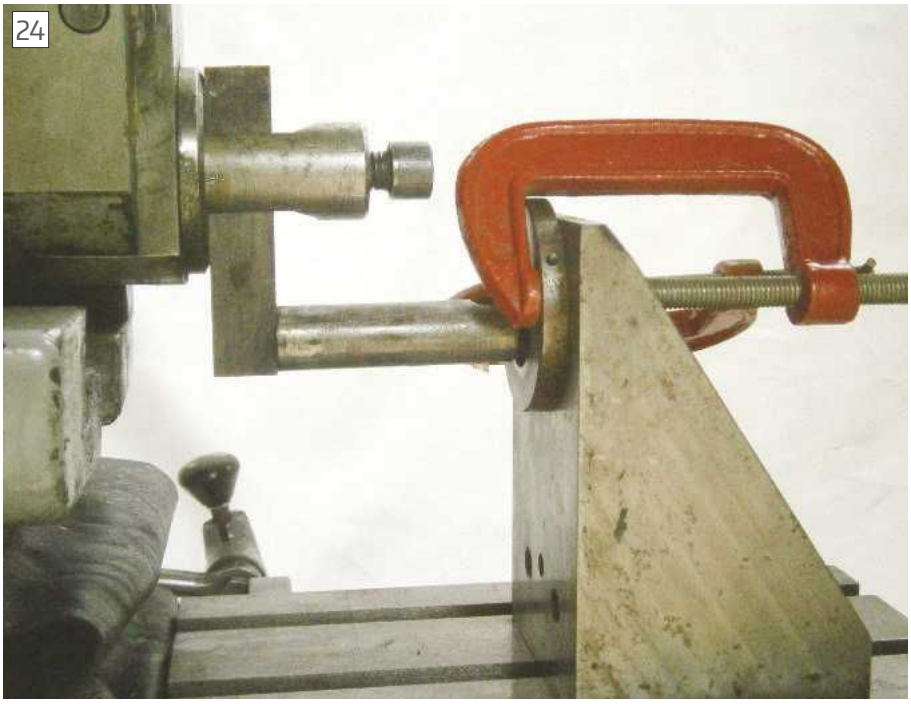
After marking out the slot and settling the part in the machine vice, it is necessary first to create a deep vertical slot to the full depth of the finished tee slot. The tool used has to be a compromise: too narrow and it is prone to flex and break; too wide and the machine may protest by chattering or even ejecting the workpiece from the vice. **Photograph 19** shows that I used a substantial parting tool 3 mm wide and deepened the slot in several steps. The vertical slide should be kept quite tight so that it does not slide down and put on the cut of its own accord. Cutting too deeply may result in an expensive crunching sound, so go slowly. As always, the cut is put on during the return stroke.

There are several approaches to preventing dig-ins on the return stroke when undercutting the slot, ranging from locking the clapper box to elaborate confections of hydraulic or Bowden cable lifters. Locking the clapper box is feasible though the tool will wear rapidly from rubbing. If your locking system gives way, disaster is inevitable. When I first cut a tee slot with the shaping machine I simply set the stroke to be long and lifted the tool clear of the work with my hand on the reverse stroke, but then my reactions were somewhat quicker. Loss of concentration courts disaster and if you feel a senior moment coming on (at any age...) it is time to operate the clutch, switch off the machine and have a break.

Photograph 20 shows a simple way to solve the problem involving nothing more complex than an old hinge, one side of which fits in the tool post under the tool, while the other side, which must be wider than the slot, hangs down to below the tip of the tool

Photograph 21 shows how the hinge trails during the cutting stroke, while **photo 22** shows how it lifts the tool clear of the slot on the return stroke. It is wise to pull the shaper through two full cycles to check that the tool is clear of the sides of the slot and that the lifter is correctly adjusted before applying power, then running the machine as slowly as possible. Just as for the vertical slot, cut must be put on slowly and the undercut generated in several easy steps.

Photograph 23 shows the first undercut nearing completion, after which you can either turn the work around for the other side or set to and make a tool to cut the other side. The first approach is much the quicker one.



Setup for an internal keyway, the angle plate has a hole and the clapper box is locked

Internal keyways

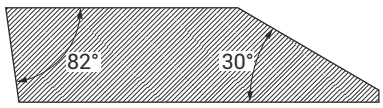
As for the tee slot, the tool cannot be allowed to lift on the back stroke and in this case there is no alternative to locking the clapper box. **Photograph 24** shows the set-up, which consists simply of an angle plate with a large hole in it to allow passage of the cutting tool. The tool holder itself is easily made by turning a spigot on the end of a piece of round rod and gluing it into a hole drilled in a piece of square bar. A cross hole for a tool bit and an axial hole tapped for a locking screw complete the tool. The workpiece does not need to be centred on the hole in the angle plate as long as the bottom of the keyway to be formed is clear of the hole, and the keyway itself must of course be accurately radial to the hole in the workpiece.

Forming

Of the abilities shown in my first article, only form cutting remains. At its simplest, this involves making a tool of the right profile and feeding it into the work. From time to time, I have to make brass corners for the upper lids of chronometer cases. The lid was usually removed to place the chronometer under a window in the chart table and inevitably it was often lost during the life of the ship. Bought corners are not of the right high quality and if you simply fold the corners out of 1.6 mm brass the rounded external angles don't look sharp. Clock makers of old when they wanted a right angle in, say, a balance cock, used to file a right angle nearly through the metal before folding and running a little soft solder into the angle. I use a tool with a 92-degree included angle (the extra 2 degrees to allow for spring back) and make four corners at once, as shown in **photo 25**. Readers wishing for more details and a few tips will find them here: **https://chronometerbook.com/?s=lid**.

Another possibility, probably only for emergencies, is for cutting the teeth (or rather, the space between them) of gear wheels and racks when no other machine is available. The tool is best made from silver steel so that the soft metal can be filed carefully to shape before hardening in water and tempering to a deep straw colour. Some sort of dividing device is needed for gear wheels and the process is very slow because the area of the cut in most cases is very large, so each cut has to be made in several stages. It is wise too to have an improvised stop for the tool slide so that cuts are not accidentally made too deep. Racks are a bit simpler because the tool has straight sides and the cross-slide graduations are used to space the teeth.

Fig.5



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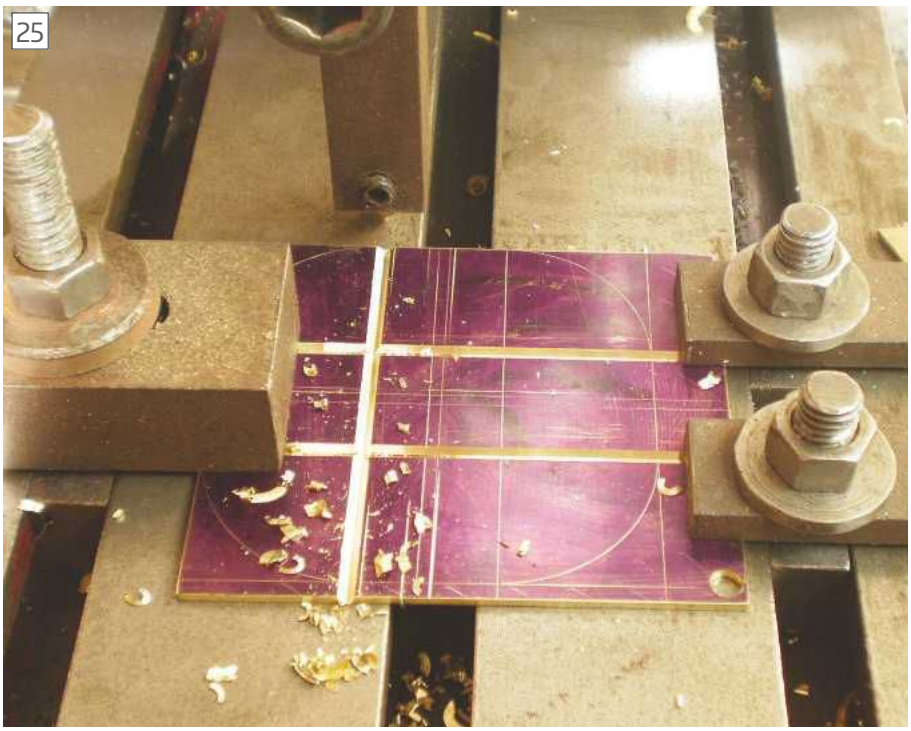
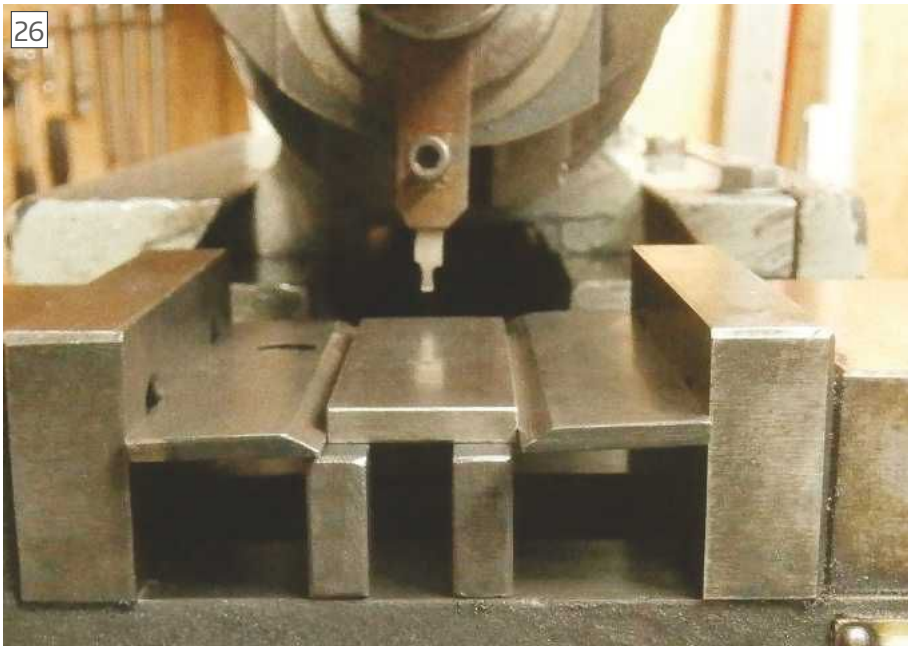


Grooving brass plate for making corner pieces

26



Grippers in use

Grippers

A fairly simple exercise for the shaper is to make a pair of "grippers". These are very useful for holding thin pieces down on to parallels. **Photograph 26** shows them in use, **fig. 5** shows the necessary angles. The 82 degree angle, being above the 30 degree angle, exerts a couple that forces the workpiece down on to the parallel. The larger angle has a tendency to slip up the vice jaw, so the starting point is to have the grippers horizontal or slightly below. It is very difficult to hold them in positon and at the same time tighten the vice, so for peace of mind it is a good idea to ask someone to turn the vice handle for you, although the very athletic might choose to do so using a knee. Once in place the grip is remarkably solid. For occasional use it is not necessary to harden the edges though I did so for mine. ■

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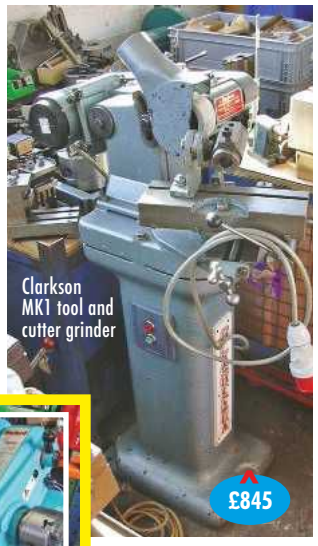
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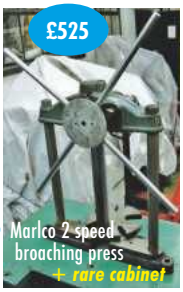
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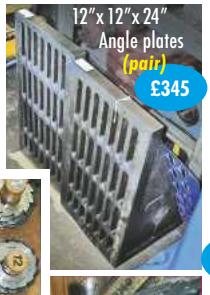
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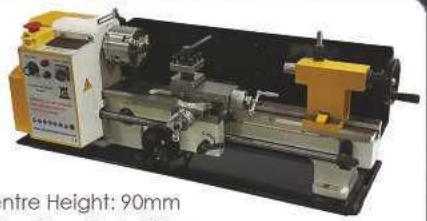

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