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EDITORIAL
Editor: Neil Wyatt
Tel: +44 (0)1689 869 912
Email: neil.wyatt@mytimemedia.com

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

ADVERTISING
Business Development Manager: David Holden
Email: david.holden@mytimemedia.com

MARKETING & SUBSCRIPTIONS
Subscription Manager: Kate Hall

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

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On the Editor's Bench

Australian Bushfires

I know we have many readers and contributors in Australia, and I hope you and your families are and remain safe and secure. From discussion on our forum, I'm aware that at least a few of you have been affected by these terrible bush fires that have caused such terrible destruction. Even readers in New Zealand have been in touch to tell how their skies and snows have changed colour because of the ash. Obviously, life, family and neighbours are priorities, but having to abandon homes and workshops not knowing if they will still be there when you return must be difficult as well.

I'm sure that sure that all MEW readers join me in sending Australian readers our best wishes and hope that these events will draw to an early close and that recovery can begin.

Planning a Move

It looks like I will be making a house move in the next six to twelve months, but at least mine will be planned. Workshop activity is grinding to a halt, and at the moment I'm scratching my head about the best ways to ensure that my machines and tools are prepared for storage. Wherever the final destination, I'll make sure that I have a spacious and well set out workshop set up and ready before I move the machines in.

That could mean a year or more without a big lathe or mill (or lots of other things…) so an option will be to set up temporary workshop, perhaps based around my mini lathe and a drill press. On the bright side this could be an opportunity to finish a couple of small but complex stationary engines – and make some of that large pile of plastic aircraft models all sitting in their boxes.

On the positive side, I will be able to address some of my workshop's shortcomings, even if I end up in another 8 x 16" garage, it could be much better. The biggest issues at the moment are:

- Too much space given over to benches and not enough storage, so things get piled up, rather than put away.
- Poor use of corner space so things that get stored there, stay there.
- Lack of headroom – my false floor could have been a couple of inches lower which would have made a big difference.
- Some benches are too shallow, limiting the space on top and storage underneath.
- Badly thought out shelving that grew organically rather than being planned.

I'll take plenty of photos, keep you updated on progress, and if it interests readers, I may write a few articles on how I design and implement my own version of a 'perfect workshop'.

To help me (and your fellow readers) with ideas I'd be delighted to feature readers workshops in the magazine or even on the cover. This used to be a bit of a tradition in the early days of MEW! Why not send me some photos and a short description of your own workshop as a brief article?

Contents

See page 50 for details.

Coming up...

in our next issue

Coming up in our March issue, number 291, another great read

Regulars

ON THE COVER

Our cover shows the selection of press tools Will Doggett has made for his workshop pneumatic press, find out more on page 46.

HOME FEATURES WORKSHOP EVENTS FORUMS ALBUMS

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THIS MONTH'S BONUS CONTENT

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Any questions? If you have any questions about our recent Alibre Atom3D or current 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 these series.

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Case Hardening

- Thoughts and advice on giving steel items a hard but shallow outer layer forward resistance

Mike Cox's cone drills in MEW 285 - source?

- Overseas readers seem to have found this rather harder to track down than UK readers, some useful leads are given here.

The Workshop Progress Thread 2020

- The perennial favourite threads ride again. Share your workshop stories or just other engineering related adventures.

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Shaping up an Adept

Howard Lewis has some adventures with a classic hand shaper.

The Frame to mount the Shaper

The Adept on the Frame

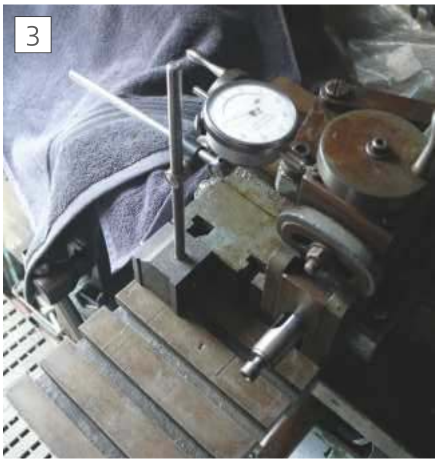
No, this is not about a lathe!

For a long time, I had had a hankering for a shaper. So, when a short time ago, at a club meeting an Adept No.2 was available, I took the chance to become the new owner.

Later, I found that it had once been owned by a one-time Duke of Edinburgh Award winner, who had been Vice President of our club.

For those not familiar with it, the Adept No.2 is a small hand operated shaper, without any autofeeds, or even graduated dials. The table is only about 6 inches square, so it is not a machine intended for heavy cuts on big workpieces. But it will have its uses, I am sure.

Later, I found that it had once been owned by a one-time Duke of Edinburgh Award winner, who had been Vice President of our club.



Checking the horizontal feedscrew pitch

Having carried the heavy weight to my car, and then later into the garage, the following morning a closer inspection of the machine began. It had been coated with oil, a long time ago, so the bright metal was coated with a brown film of congealed oil. But at least it had been protected. The machine appeared to be in very good condition, and now the time had come to know it a little better.

Initial Work

The shaper is intended to be bolted to bench, with the table overhanging the edge. In my fairly small and cluttered workshop, this is not a permanent proposition.

A frame was made up from angle iron, and welded, which could be clamped in the vice (A substantial Record) with a leg carrying weight onto the bench. The Frame is shown in **photo 1**.

The shaper was then bolted to this using some spare 5/16 UNF nuts and bolts. Three of these were quite straightforward, with the nuts underneath, but one required the head of the bolt to be filed away on one side so that it butted against the angle iron, with the nut on the top.

The Shaper, mounted on the frame is shown in **photo 2**.

Checking the vertical feedscrew pitch

Graduating a handwheel

Ready for display

Centering over a Tee slot

Cleaning up a Tee slot

The tool holder did not rotate freely in the clapper box, so this was removed and lightly "stoned" with a diamond file, to remove slight bruising, until it moved freely.

Neither of the two handwheels was graduated, so it would not be possible to know how much of a cut, or a feed had been applied.

Graduating the Handwheels

The first step had to be to determine the pitch of the threads for the two controls. For this, a pencil mark was made on each handwheel, as a rough reference against a similar mark on the machine.

A magnetic base, carrying a DTI was then placed in contact with the slides and the travel produced by one turn of the handwheel was measured. The horizontal travel check is shown in **photo 3**. The leadscrew had a 10 tpi thread, so the handwheel would need 100 graduations, each to show an increment of 0.001".

A toolbit was clamped horizontally in the holder, as a location for the DTI, to check the pitch of the vertical feed screw.

The vertical travel check is shown in **photo 4**. The camera angle makes it look as if nothing is correctly oriented, but it is!

This showed that the leadscrew had a 16 tpi thread. This would call for the handwheel

Trimming the edge of the vice base

Co-ordinate drilling an end plate

Flycutting the end of the slide

Drilling the end of the slide

The series of drilled holes in the slide

to carry 62 divisions and one half size one, to indicate an advance of 0.001" per division.

The revised chart for my HV6 rotary table, understandably, has no provision for 62.5 divisions. Referring to my Excel spreadsheet, from which the revised chart was derived, and inserting a line for 62.5 divisions, produced a result. The result was for each division to need one turn and 18.04 holes on a 41 hole plate. It was decided to use one turn and 18 holes.

The error of 0.04 in 59.04 holes, when reduced by the 90:1 ratio would result in an error of the order of 0.00075%. An error of this magnitude, was deemed to be acceptable, especially considering my eyesight and any variation in the width of the division lines!

Each handwheel was clamped in a small 4 jaw chuck and centred, before being transferred to the mill/drill for scribing. The tool used for scribing was a broken centre drill which had been ground to produce two faces at an included angle of 30 degrees. This was held in an ER collet, with the cutting edge aligned with the X axis travel of the Mill/Drill table.

Milling slots on the underside of the slide

Setting up the moving jaw

Milling the sloping face of the moving jaw

Milling for the clamp screw

Marking out the moving jaw

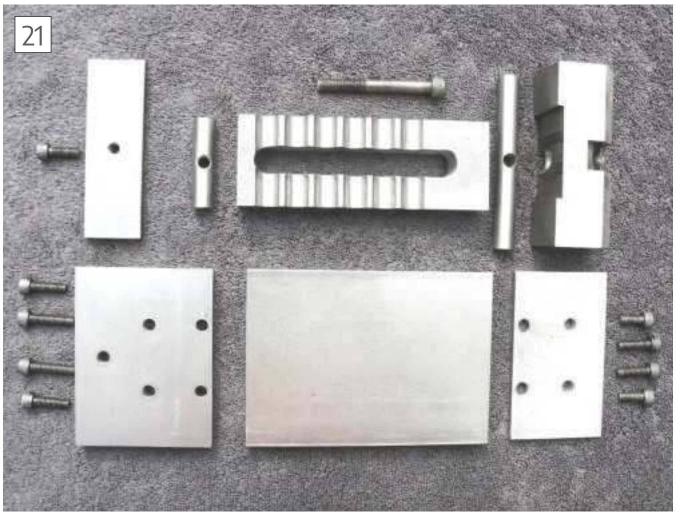
Centering the moving jaw for drilling and reaming

Having measured the thickness of the handwheels, it was decided that each tens division should extend across the full width of the Handwheel, the Fives 2/3 of the way across, and the units, one third of the way, (0.140").

Having touched the scriber on the OD, the table was traversed to allow the scriber to be lowered by 0.010", ready to commence work. The scribing, in progress, is shown in **photo 5**.

The table was then clamped in the normal milling vice on the mill/drill, with the vertical face against the fixed jaw.

Reaming the moving jaw



The parts of the machine vice

The assembled machine vice

Reaming the dowel holes in the Base

Fixing holes and dowels, in place

The 100 divisions for the horizontal feed looked quite normal, but the final smaller gap on the vertical feed wheel looked a little strange between the adjacent 62 full size divisions!

With the handwheels replaced, and aluminium brackets fitted to carry the fiducial lines, the machine now looked to be ready for use. Since it was decided to display the shaper on the Peterborough Society of Model Engineers stand at a small local show, some temporary wooden feet were attached, to stabilise it. The end result is shown in **photo 6**.

Work Holding

With the machine seemingly now ready for use, attention was turned to how to hold work on it.

The T slots in the table had been left as cast. The only machined alignment provided was by a key between the vertical face of the table and the body of the machine. The table was removed from the machine, and the key removed from the vertical face.

The table was then clamped in the normal milling vice on the mill/drill, with the vertical face against the fixed jaw. (Which was known to be aligned with the path of the cutter). Centring the spindle over the T slot, by laying a piece of silver steel over it, is shown in **photo 7**. The sides of the T slots were then cleaned up using a slot drill. Note the use of a magnet under a sheet of newspaper to catch the cast iron swarf. This is shown in **photo 8**.

Without having to relocate and realign the milling vice, it was only possible to trim the inner two slots.

Thought then turned to how work could be held. Because of the expected infrequent use, it was decided to make, rather than buy, a machine vice.

Machine Vice

This was inspired by, but is a cheap homemade version of, the precision vices available from Arc Euro Trade, and was made from whatever material came to hand. The base and one end plate were made from some 100 x 12 mm plate, left over after making a set of bending rolls.

Squaring up the base on the mill/drill using the "infinite vice" is shown in photo 9. Co-ordinate drilling of the fixed jaw end plate is shown in **photo 10**.

What had had once been a piece of angle iron was machined to the same overall width dimension to be the rear end plate. This could be less strong than the fixed jaw, since it would not be subjected to the same clamping forces as the fixed jaw.

The material for the Slide, to carry the moving jaw, was too long to fit safely under the mill/drill, so it was machined, using a vertical slide, (intended for a Seig SC6 lathe) on my BL12-24. It was machined to the same length as the base, to ensure that the end plates would be truly vertical.

The ends were machined using a flycutter, as shown in photo 11. Once the ends had been machined to size, the vertical

What had once been a piece of angle iron was machined to the same overall width dimension to the rear end plate.

To allow the vice to be aligned accurately on the shaper table, the base needed to be drilled and reamed for two dowels and drilled for securing screws.


Starting to make the Tee nuts

slide was used to drill and tap holes, on co –ordinates, **photo 12**.

The slide was then transferred to the mill/drill in preparation for cutting the central slot. To spare the slotting drill, a little, a series of holes were drilled. This is shown in **photo 13**. The slot was finished using a slot drill. The slide was then turned onto its side and a series of slots, 0.375" deep were cut with a ½" slot drill, on a pitch of 0.625", **photo 14**.

Because the slot drill was not long enough to cut the slots through both sides of the slide, it was reversed, and the slots cut using the same co-ordinates. The clamping bars were made from ½ "silver steel.

Attention was now focussed on producing the moving jaw. This started as a 4 inch length of square bar. With the aid of a square, this was set up in the vice on the mill drill, ready to be trimmed to length, **photo 15**. Once to length, it was re-clamped, using a vee block, to mill one side at 45 degrees, this shown in **photo 16**.

The moving jaw was then repositioned, spot faced on the centreline, and drilled for the clamp screw. The moving jaw was then repositioned and a wide slot milled on the underside, to locate it centrally on the slide, and the drilling for the clamp screw machined to become a slot, to allow room for movement of the clamp screw during clamping.

The moving jaw was then marked out for the position of the reamed hole for the bar for the clamp screw, as shown in **photo 18**.

After centre punching, the moving jaw was transferred to the 4 jaw chuck, in the lathe, and centred, using a finger clock and the "two centres" method, **photo 19**. Once centred, a hole, for the clamp bar, was drilled and reamed, **photo 20**.

By now all the parts had been machined and were ready for assembly. These include a piece of gauge plate to act as a spacer and as a hard face for the fixed jaw. The cap screws used to hold parts together are M6 and the clamp screw is M8. Parts awaiting assembly are shown in **photo 21**, the assembled Vice is shown in **photo 22**.

To allow the vice to be aligned accurately on the shaper table, the base needed to be drilled and reamed for two dowels and drilled for securing screws.

The table was measured to determine the width of the second t slot, (the innermost one was too close to the machine to be useable), and the pitch of the slots checked, to enable holes to be drilled for the t bolts to clamp the vice to the machine table. Two dowels were machined to be a snug fit in the T slot, and reduced at the other end to 0.250" diameter, to match holes to be reamed in the base of the vice.

The vice was clamped, inverted, to the fixture used to align the normal vice to the table of the mill/drill, and adjusted to be level in both X and Y planes. Note the machinists jack used to provide support at the outer end, **photo 23**. Working to co –ordinates, the base of the Vice was drilled and reamed for the dowels.

Having set the distance from the fixed


Milling flats on the Tee nuts


Finished Tee nuts

jaw end of the vice, to maintain accuracy, the second hole was drilled and reamed, on the other side of the base, without changing the Y axis setting. Once this had been done, the holes for the capscrews for the tee nuts were drilled.

The base with dowels fitted, and holes for T nut capscrews, is shown in **photo 24**.

To make T nuts, a couple of old rusty ½ BSW bolts were used as raw material, by being turned down and drilled and tapped ¼ BSF, (to keep hardware that is likely to used regularly, Imperial, in keeping with the rest of the machine). The start of modifying the Bolts is shown in **photo 25**. Milling the flats is shown in **photo 26**.

Given that a ¼ BSF thread is capable of exerting a substantial load, it is felt that the form of the T nuts will be adequate for the duties that they are required to perform.

The final results are shown in **photo 27** and the vice installed on the shaper is shown in **photo 28**. A final check with a square showed that the base of the vice was, as required, at right angles to the vertical face of the machine.

The machine should now be ready for work!

In general, the tools will be ground as if for use on a lathe. Being a small and low powered (by me!) machine, cuts and feeds are unlikely to be much greater than a couple of thou in each direction. ■

With the handwheels replaced, and aluminium brackets fitted to carry the fiducial lines, the machine now looked to be ready for use.

The vice on the shaper

In our Next Issue

Coming up in issue 291 On Sale 21st February 2020

Content may be subject to change

Our March issue, number 291, will you looking forward to spring:

Mark Noel is at the Cutting Edge of Model Engineering.

R Finch restores a 'Safe D-Speeder'

Malcolm Leafe describes a simple approach to Rotary Broaching.

DON'T MISS THIS GREAT ISSUE - SEE PAGE 50 FOR OUR LATEST SUBSCRIPTION OFFER

Beginner's guide to tailstock alignment

If you want to turn parallel or drill small holes in the lathe without breaking bits, lining up the tailstock is essential. Pete Barker shows how simple it is.

Setting your lathe's tailstock alignment, **photo 1**, is something any beginner can do by following a few simple procedures. The first step is to determine how far out of line the tailstock is sitting. The second is to adjust the tailstock using the simple mechanism provided on most lathes. The third is to test the result by turning a bar between centres and measuring the diameter along its length, aiming at the same reading at both ends -- and in the middle of course.

Providing your lathe is in good useable condition, needing minor adjustment and not major surgery, the following steps will soon have you turning parallel. It will also help prevent bit breakages if you have to drill small holes.

The quick way

The easiest way to see what is going on between your lathe's centres, the headstock centre and tailstock centre, is to place a thin steel ruler between the points and gently turn the tailstock handwheel until the ruler is firmly gripped, then tighten the barrel lock. The tailstock base clamping lever should be locked before advancing the barrel. If the two points are in line, the ruler will stand up straight vertically, **photo 2**, and lie square across the lathe bed horizontally. This can be judged very closely by eye. If the ruler sits at an angle in either plane, **photo 3**, the tailstock needs adjusting as described in the second half of this article.

1

Tailstock alignment is in most cases a matter of simple adjustment.

If you don't have a second dead centre to put in the headstock, you can use my preferred method of gripping a short length of 1/2" (13mm) bar in the three-jaw chuck and turning a point on it by offsetting the top slide to 30 degrees, **photo 4**. The angle is not critical, nor is the concentricity of the piece of bar in the chuck. With the tool bit set at centre height, the turned point will be bang-on true to the spindle axis.

At the tailstock end, don't use a revolving centre because it can introduce small errors through bearing clearances and machining tolerances. Stick with a dead centre for best accuracy.

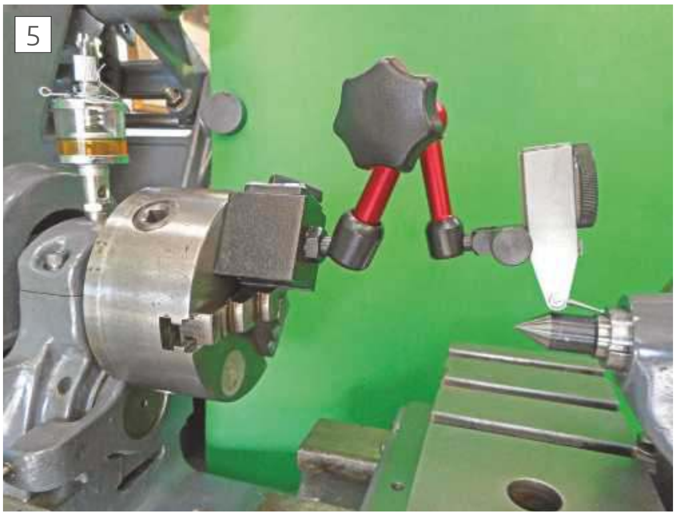
2

Steel ruler between centres stands straight if the points align.

3

Steel ruler shows tailstock is misaligned towards the operator.

Top slide is offset 30 degrees to turn live centre in situ.



DTI is brought to bear on the centre's mounting taper

This steel-ruler test is accurate enough for initial setting of the tailstock, to the point where you can then go straight to the "real-world" turning test.

The measured way

However, while the steel ruler test is usually good enough to set the tailstock for a final turning test, sometimes you may wish to know exactly how far out it is. To find that we must mount a small dial test indicator (DTI) to the chuck, either by its magnetic base, **photo 5**, or on a purpose-built bracket that may have less flex.

Either way, the finger of the indicator is brought to bear on the ground Morse taper surface of the tailstock centre as shown. This gives us the truest reading of the alignment of the tapered hole in the tailstock barrel relative to the headstock spindle. The finger may alternatively bear on the angled front face of the centre, but this may introduce a small error due to machining tolerance on the dead centre, albeit usually a very small one.

The DTI readings should be noted at the 9 o'clock, 12 o'clock and 3 o'clock positions, **photo 6**. There is no need to swing the DTI right around to take a 6 o'clock reading. We are in essence lining up two overlapping circles here: the one described by the DTI pointer as the chuck rotates and the circular ground surface of the dead centre. If the two circles are aligned at three out of the four points within tolerance, the fourth must also be within spec. It cannot be otherwise.

> ...while the steel ruler test is usually good enough to set the tailstock for a final turning test, sometimes you may wish to know exactly how far out it is.

DTI readings are taken at the 3, 12 and 9 o'clock positions.

When adjusting the tailstock alignment as will be described shortly, we aim at getting the DTI reading within one thousandth of an inch (.025mm, between the 9 and 3 o'clock positions, with a little more leeway in the vertical plane at 12 o'clock for reasons that we shall see. One is that the dial indicator mounting is subject to sag under force of gravity in the vertical plane, leading to perhaps one thou of extra reading on the dial. Think your indicator stand is solid? In Edward F. Connelly's book "Machine Tool Reconditioning", considered the bible in the field, he states a piece of 1" (25mm, diameter steel bar sticking 6" (150mm, out of a lathe chuck will have a sag of .00038". That's over one third of a thou sag, for a piece of solid inch bar. Don't underestimate how much a DTI stand could possibly move.

The real-world way

The other problem with the above measured alignment check is that it tests only the static alignment of a machine that operates under motion with large cutting forces transmitted through most of its parts. You can have static alignment that measures within spec, yet the lathe does not cut true. The ultimate check is to turn a test piece between centres and measure it for consistent diameter along its length, **photo 7**. With a properly adjusted tailstock, the measurement will be the same all along, within our nominal tolerance of one thou (.025mm). It is quite possible to get it within a quarter of this on the average lathe and no great trick to get within half a thou, which is original factory specification on many lathes. I often skip the DTI test and go straight to this turning test after checking with the steel ruler method that vertical

7

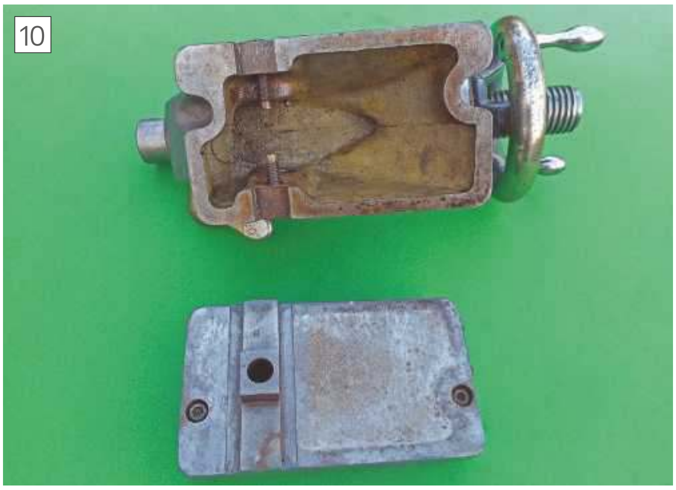
With correct alignment a turned test bar will be parallel for full length.

8

Homemade drive dog for use with live centre in the chuck.

9

Using the turned test bar and dial gauge to check alignment.



10

Mating surfaces of tailstock body showing adjusting screws and base showing tenon.

alignment is acceptable.

Again, my preferred set-up for turning between centres is to turn a 60-degree point on a piece of steel bar as described above, then use a small driving dog I have made that engages with one of the chuck jaws. It is made from aluminium alloy flat bar 1/2" x 2" (13mm by 50mm) that is easily cut with a hacksaw, drilled, tapped and held together with Allen-head screws as shown in **photo 8**. This method keeps the carriage from having to travel off the end of the bed on gap bed lathes such as the Myford. Or if you have a conventional catch plate, dead centre and driving dog for your lathe, you can use them and overhang the top slide if needed.

Either way, a suitable test bar can be made from a piece of 5/8" (16mm) diameter bar, or up to 1" (25mm). It should be about 7" (175mm) long. It should be swung in the three-jaw chuck and each end centre-drilled before putting it up between centres with the driving dog in place.

Take a light cut over the length and measure the bar in three or four places. If it is larger at the tailstock end, the tailstock needs to be adjusted toward the front of the lathe, ie toward the operator. If the piece is smaller at the tailstock end, move the tailstock toward the back of the lathe. Methods for making this adjustment vary slightly but basically follow the procedure in the next section.

When you have finalised your tailstock adjustment and turned a nice parallel test bar, keep it for future use doing quick tailstock alignment by mounting it between centres and running a carriage-mounted dial indicator along it, **photo 9**. You then adjust the tailstock offset to reach a 0-0 reading along the bar. Just one more way of making a quick check.

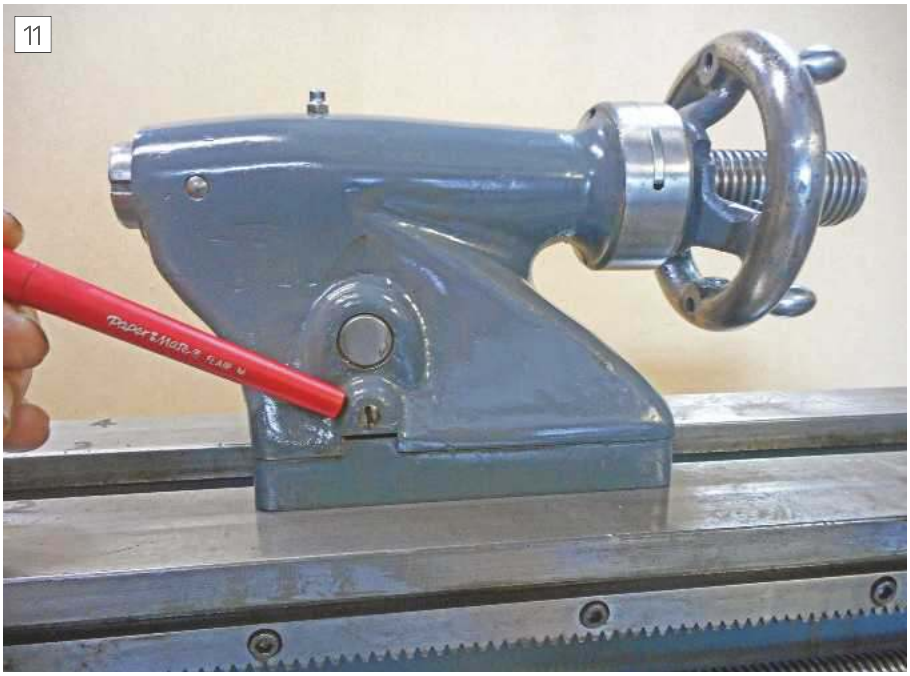
Lateral adjustment

Most lathes have the tailstock made in two pieces, a main body and a base, **photo 10**. The body sits on the base on a machined surface with a tenon sticking up from the base, which engages in a slot in the body. This allows the body to move sideways while the base remains locked to the bed by the tailstock clamping mechanism, usually that large lever on the back. To stop the body from randomly moving side-to-side a small screw in each side of the body engages with a step on the tenon. These two screws, pointed out in **photo 11** and visible inside the body in photo 10, are used to adjust tailstock alignment side-to-side.

Most of your time adjusting the tailstock alignment will be spent turning this pair of screws a tiny bit at a time until either the DTI reads the same at the 6 and 9 o'clock positions, or our test piece is parallel along its full length. Such adjustments should be made with the base clamped firmly to the bed but not so tightly the body can't move across the base under screw pressure. Some tailstocks may have additional screws holding the base and body together. These will need backing off during adjustment. At the end of the process, both screws should be tight against the tenon to stop movement in use.

Tailstock too high

Lateral adjustment is the most commonly performed. But sometimes our ruler test or DTI test will show the tailstock is sitting higher than the headstock spindle. In fact, some lathes are manufactured with the tailstock up to .002" (.05mm, high to allow for wear on the bed and tailstock base over the years. This small vertical misalignment makes no measureable difference to the turning of a parallel job because the surface of the job is virtually vertical where the tool contacts it at the centreline. Add to that another thou (.025mm, for sag in the DTI mounting and you could end up with .003" (.075mm, extra reading here.


11

Lateral adjusting screws, one on each side of the tailstock body.


12

Checking tailstock barrel is sitting parallel to bed.

But if there is significantly more than that, or if our steel ruler in the first test was kicked over at an angle to the left, the remedy may be quite simple. The most common cause is grit, burrs or paint between the tailstock body and its base, even on some newly purchased machines at the budget end of the market. Similar detritus or burrs between the tailstock base and the bed ways can also lift the tailstock that tiny but critical amount. Simply pull the tailstock off the bed, remove the bed clamping plate and remove the tailstock base from body. Carefully run a file over the surfaces shown in photo 10 to remove burrs and any paint, then clean off any grit before reassembly. Check the bed ways for any burrs and gently file them down too.

Test the alignment again and it should be within spec unless there is excessive wear or a manufacturing defect, which requires advanced machining and/or scraping to remedy.

Tailstock too low

Sometimes on worn machines, the tailstock may sit unacceptably lower than the headstock spindle. The only easy cure for this is inserting suitable strips of shim between the tailstock base and body. Once set up to satisfaction, they may be held in place with a dab of superglue on one side to stop them falling out in use.

In cases of both low and high tailstock, it is also worth making a quick check that the tailstock barrel is sitting parallel to the lathe axis in the horizontal plane. This is done by mounting a dial indicator to the saddle, with the indicator plunger bearing on the top of the extended barrel, **photo 12**. Rack the carriage back and forth and note the indicator readings. If not with one thou (.025mm), suitable shim may be added to either end of the base-to-body interface to bring it back level.

Another source of apparent misalignment in the vertical plane can be if the barrel is a slightly loose fit in the tailstock body, it can move by several thou when the barrel clamp is applied. Not much can be done about this, short of replacing the barrel and perhaps body. For turning between centres, set the tailstock with the clamp done up. For drilling, the unclamped barrel will find its own centre, much like a drill press with moveable quill does.

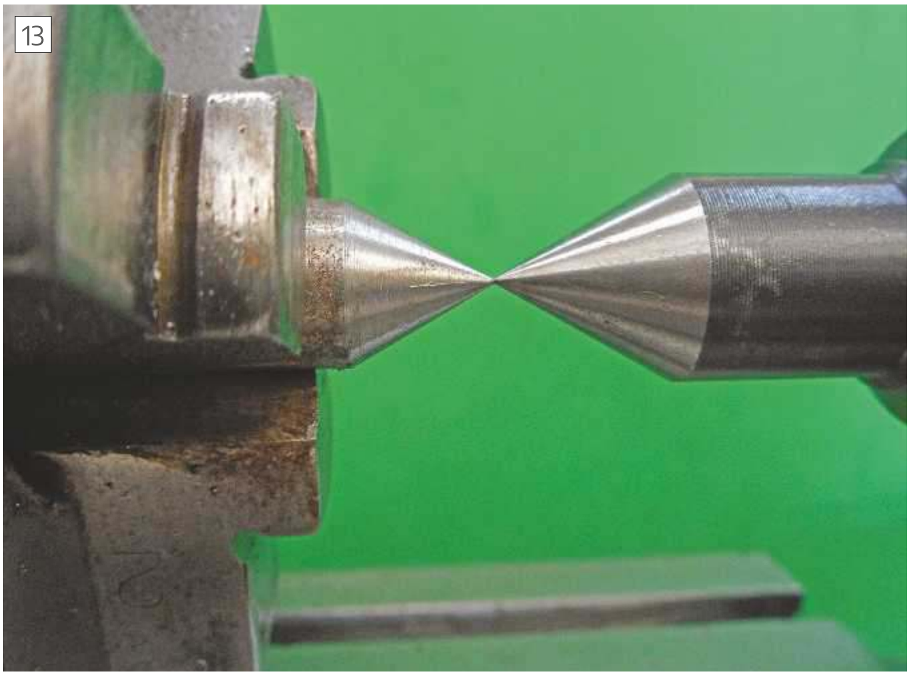
Conclusion: Get it straight

On a lathe in good useable condition tailstock alignment, **photo 13**, can be tested three simple ways: with a steel ruler between opposing centres, with a dial test indicator, or by a real-world turning test of a piece of bar between centres. In most cases, you can start with the ruler test then go straight to the turning test.

Once tested, tailstock horizontal offset can usually be adjusted by two simple adjusting screws between base and body or similar mechanism. Testing is then repeated and further adjustment made as needed.

Vertical misalignment, while not as critical as horizontal offset, is most often remedied by cleaning the mating surfaces between tailstock body, base and lathe bed ways. In some instances, shimming in the same area may be required.

With these simple steps, it can be ensured the lathe turns parallel when a tailstock centre is used and the breakage of very small bits reduced when drilling. ■


13

Spot-on alignment after simple adjustment.

The Simplicity Jig No. 1

John Harding introduces this jig for sharpening end mill cutters, the first of a series of related grinding accessories.

General view

Locating back stop

[Simplicity itself: be extremely easy to do (concise OED)]

Introduction

The feature of this design, **photo 1**, is to allow the cutter to be wiped across the grinding wheel leaving adjacent edges clear of wheel. The jig attaches to a sliding table with screw cross traverse for in feed.

Using a Stevenson collet block and ER collets to hold the cutters eliminates the need for machining. Except for the clamp pillars the jig can be made using only a bench drill and hand tools.

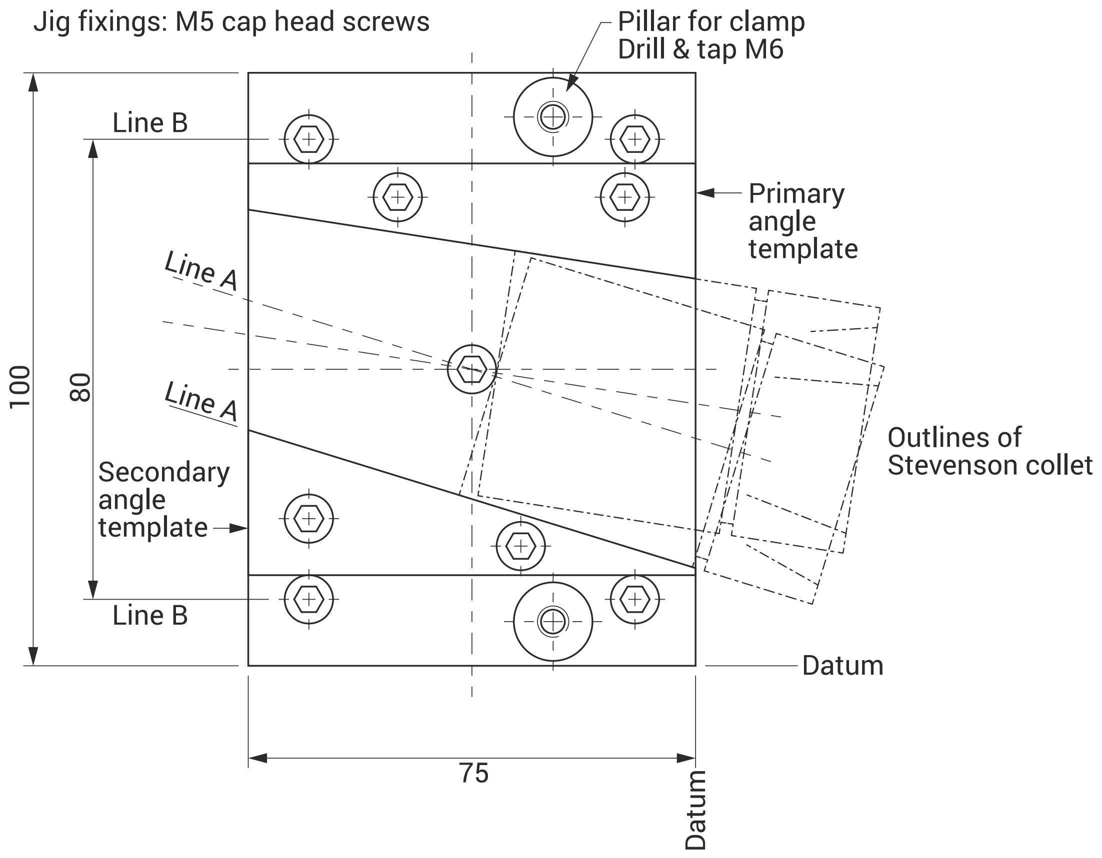
Construction

The main sub-assembly is of two pieces of angle bar bolted together, the upper piece being set to give a 2 degree back rake. This creates the concave end to the cutter.

Figure 1 shows the line A holes spaced to suit angle bar and attached to jig plate from

Clamp, its second purose, guards removed for clarity.

Fig.1



Jig For Sharpening Face Of End Mills

below. The projecting screw threads are filed off flush with surface of plate.

Line B holes must be square to the front edge of the plate and are drilled and tapped to take M5 cap head screws. These cap heads keep the templates aligned.

Templates, I suggest these be cut over length. In conjunction with the collet block the templates can slide against the cap heads to find their relative positions. The templates are in turn clamped in position on the plate with tool makers clamps and drilled through tapping size. The plate is tapped M5 and the template drilled clearance size. Templates are then cut to length. Angles used for templates, primary 5 degrees, secondary 12 degrees.

One way of locating position of backstop is shown in **photo 2**.

The clamp as fig. 1 is also intended to prevent the collet assembly from falling out, **photo 3**. The collet nut is wider than the block resulting in the overhang. The clamp could with advantage be moved forward.

Setting up

Use a try square to line up jig against face of

4

Setting jig square to grinding wheel

5

View from above

View from below

grinding wheel, **photo 4**. For securing the cutter in the block the ball bearing nut has been recommended because the collet does not turn with the nut as it is closed.

Photographs 5 and **6** show the position of the cutter for sharpening.

Photograph 7 shows a result is possible with a centre cutting tool, certainly down to 8mm and probably 6mm. The collet block also finds uses for work holding in the milling machine.

Gashing

Photograph 8 illustrates the problem of gashing large diameter centre cutting tool.

Photograph 9 compares a 14mm centre cutter against a Clarkson type with its deep countersink centre giving good clearance. The other requires gashing from the start and the gash needs to follow the spiral of the flute. ■

Proving

Gashing to cutter in photo 7

Comparison of styles

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WARCO

A Small Shop Sand Blasting Cabinet

Graham Meek makes a versatile cabinet with a modest footprint and a ball joint for the gun which maximises the internal space available.

I would be the first to admit there are quite a number of Sand Blasting cabinets available commercially, so why write an article on making one? Well for one thing most of these manufactured cabinets have a high airflow requirement. The smallest cabinet I came across had an airflow requirement that was double the capacity of my current shop compressor. Having to purchase a new compressor and the sand blasting cabinet puts a big dent in the shop budget. There is also the fact that in most shops this cabinet will get only occasional usage and it can take up an appreciable amount of space on a bench or if it is free-standing. The desire to sand or more correctly shot blast small brass fabrications to make them represent castings became more urgent when I started making a Fiat 702 Tractor and a Clayton Steam Tractor. I first experimented with the shot pick-up attachment for my airline and the first cabinet was an old plywood sided box. A piece of Acrylic sheet across the top and a hole in each side to put my hands through gave the rudimentary, if not very elegant cabinet. The shop vacuum was also attached in an attempt to evacuate the dust caused during the process. I also took the precaution of wearing a proper face mask especially for fine dust, one can never be too careful. Also the first trials were conducted outdoors as an added safety measure.

The first results from my Heath Robinson approach were very good. If I am honest, they were better than I had expected. The rudimentary pick-up worked better than I had hoped. However, the medium impinging on my thinly gloved hand plus the dust/medium trying to get up my sleeves despite having elasticated cuffs, left a lot to be desired. The time was ripe for a more reasoned approach to the cabinet, but what to use. Out shopping with my wife one afternoon we passed by a discount shop selling all sorts of plastic household wares. One thing caught my eye and that was a "Flip top Kitchen Waste bin", but at the time I did not purchase one. Back home some days later I was still mulling over the sand blasting cabinet problem when my mind went back to the waste bin. I started to visualise the flip top lid with an Acrylic window in the sloping face. The angle of this face I thought would make a good viewing aperture, especially with the bin stood on my Black & Decker "Workmate", **photo 1**. The flip top lid also gave a means of getting the items in and out of the cabinet. A few days later the flip top bin, **photo 2**, was purchased and whilst in the shop I noticed some battery powered LED strip lights that can be fixed to a flat surface via some sticky pads. A pack of two were also purchased. One of these lights I thought would provide illumination in the

1

In use unit is clamped to a DIY bench.

2

Flip Top Kitchen bin.

3

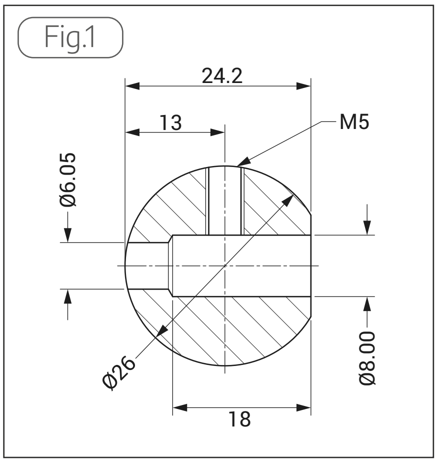
A view through the window.

Inside the top of the bin, note battery operated LED light with protection screen.

cabinet, rather than having to hook up a light to the mains or provide a low voltage version. Evacuated glass lamps, or bulbs, are not the best of things to have in the vicinity of flying debris, they have a nasty habit of going pop at the wrong moment. Unless these glass objects are suitably protected, that then leads on to another item to made, so the LED lights were an added bonus.

A start was made on fitting the viewing aperture and after popping out the lid this was marked out. Marking directly onto the plastic can be a problem both with a pencil or felt tip marker pen. Masking tape was laid approximately where the lines were to go and the marking out was done on this. It also saves a clean up operation, should a marker pen be found that will adhere to the waste bin surface. A hole saw was used for the corner radii and the remainder removed using a Jig, or reciprocating saw. The hole saw used was about 32 mm (1¼") diameter but a larger hole saw would not be amiss. A piece of Acrylic was cut to give a generous overlap all round the aperture. A cardboard template was used to establish the best size. The window was then clamped to the inside of the and the holes drilled through for the fixing screws. The holes were then countersunk to take some Nylon M3 countersunk screws, **photo 3**. The screws do not have to be Nylon, these were used as I had a plentiful supply of this size along with some moulded Nylon acorn nuts. This type of nut will help keep debris out of the threads should a replacement window be required at a later date. Fitting the window to the flip

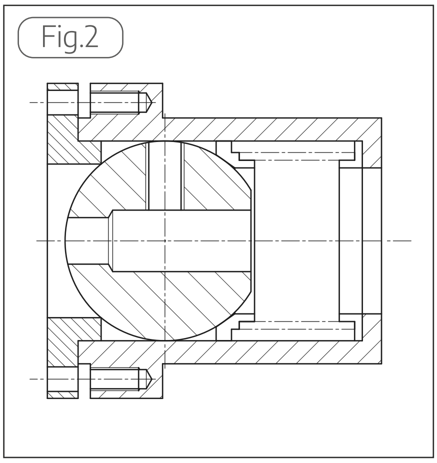
Fig.1



Marking directly onto the plastic can be a problem both with a pencil or felt tip marker pen.

top lid then presented a problem when the lid assembly was re-inserted in the top. The lid stayed open, remember it is designed to open inwards, this is due to the imbalance of the heavy window. With a trial placing of the LED light on the outside of the lid I found this counterbalanced the lid, so problem solved. The light was duly adhered to the inside of the lid towards the rear, **photo 4**. For added security I used two Nylon M3 screws to retain the light. A small portion of moulding in the housing that forms the Bin top is horizontal and is just below where the light was sighted. This provided an anchorage for a horizontal flat Acrylic screen. This screen will stop any debris or medium impacting on the lens of the light and spoiling the light output. The screen being sacrificial and made from some material that was once a clear

Fig.2



box top for Christmas cards or similar.

As the build progressed, I decided I would like to try and make this cabinet from as many commercially available items as I could, but without incurring heavy costs. Some of the items might well be in the "stores" of the average DIY enthusiast. The next requirement was the rubber glove or gauntlet. Whilst most cabinets have two gloves, for the small space involved here one glove would be taking up more than enough space in the cabinet. Besides those cabinets I have used in my professional career fitted with two gloves make holding and operating the blast nozzle very awkward. Therefore, on this design the operating element of the blast nozzle is kept external. Work on the cabinet ground to a halt as I waited for the rubber gauntlets to arrive. In the meantime, I started sketching out how to fit the blast nozzle into the side of the cabinet. I searched in vain for a spherically mounted bushing in a flat plate. Preferably made from Nylon or similar. Most of those I did find gave no details of the construction and as they were originally intended for use on a conveyor system had some form of bearing included. Not the best thing to use in a dust ridden environment that might be under a positive air pressure looking for a way out. Rummaging through my stores a few days later I came across a Phenolic moulded plastic machine knob, **fig. 1.** This I thought would make a good spherical bearing for the nozzle as the medium would tend to

Hunter DS 056 blanking plug.

All the workings, sump pan directs media to suction pipe. Filter protection Baffle at the rear also reflects light from the LED.

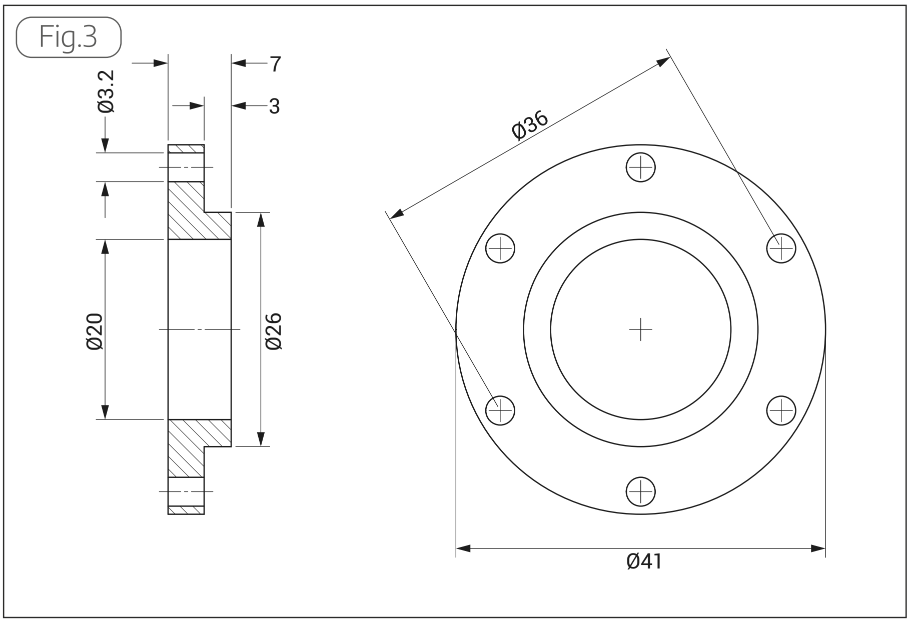
›

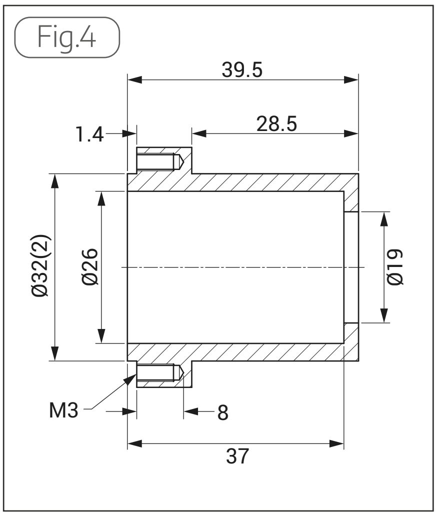
bounce off this surface. Rather than become imbedded in the softer plastic types available, so work commenced on drawing up a suitable housing, **fig. 2**.

By this time the gloves had arrived, and it was time to think about how to hold the cuff of the glove to the side of the cabinet. I roughly measured the diameter of the cuff with my left hand inside the glove, it was to be about 100 mm, 4". Some offcuts of 100 mm PVC drainage in my "reserve stores" provided a good fit around the reversed cuff of the glove. The pipe would provide a means of holding the glove with a large "Jubilee" clip, but how to fit the pipe to the cabinet? Talking the matter over with my friend he suggested one of the blanking sockets used in the PVC drainage systems. "These usually come with a flange", he said, sure enough looking through the DIY catalogues I found the ones shown here. The price on the internet with postage was however eye watering, just for what later was to become two items. Contacting my local building supply yard, I was pleasantly relieved to find the items, **photo 5**, at about a tenth the cost quoted on the internet, so sometimes it pays to shop locally.

These blanking plugs do need to have the blanking part machined away in order for the gloved hand to enter the cabinet. Holding the blanking plug on the outside of the standard chuck jaws in the lathe the offending piece was trepanned out. Be sure the trepanning tool will clear the ends of the chuck jaws when it breaks through. I fitted a bed stop just to ensure I did not have a catastrophe. The edges left from the machining were chamfered to remove any sharp edges which might chaffe the glove. Whilst doing this blanking plug it might save time to do the other for later on. This requires a small portion of the blanking plug surface to be retained to form a small upstand. The trepanned portion is good for the scrapbox, don't forget. A hole was then marked out in the lefthand side of the cabinet to take the outside diameter of the socket plug. It does not want to be too low down the side of the cabinet. The taper on the side of the bin means the space between the two sides is getting less the further you go down the bin. The hole was again cut using the Jig saw, but anyone with a trepanning tool will make a

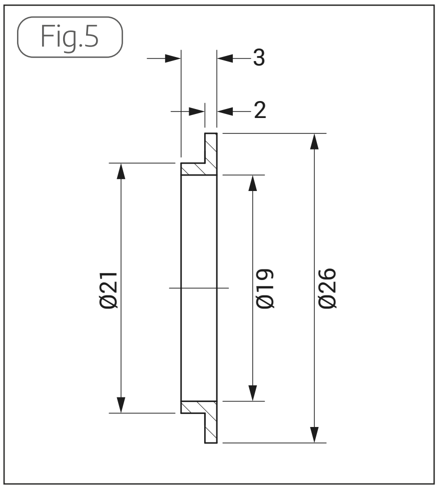
The hole was again cut using the Jig saw, but anyone with a trepanning tool will make a much neater and professional job





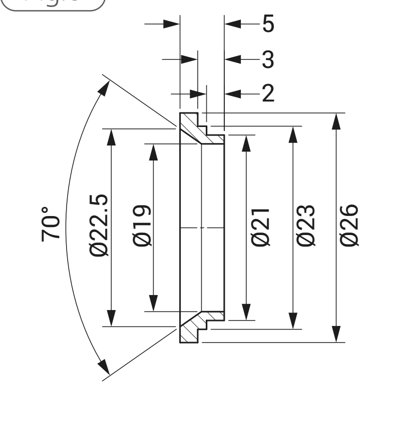
much neater and professional job. Anyone who is left handed might want to put the glove on the opposite side. The plug was offered up to the cabinet from the outside and some masking tape placed on the bin wall under the four flange projections. A piece was also placed on the inside of the plug at the bottom, or six o'clock position. The outline of the flange was then drawn around onto the masking tape at these four places. The plug was then removed and reinserted from the inside which will be its final position. Trying to eye up the flanges with the outside markings is not going to be easy, but the piece of masking tape on the inside will be a quick and easy way to do this. Holes are then marked out for two aluminium "pop rivets" in each flange. These are then drilled to suit the rivets and temporary nuts and bolts used to retain the alignment as the drilling progresses. The plug is then removed, and all the holes deburred using a sharp countersink, but do not over do this. Simply turning the countersink between finger and thumb will remove any burr from around the hole provided the countersink is sharp. Some silicone sealant was then run around the corner where the flange meets the cylinder of the plug. Using the masking tape inside the plug as a guide insert the plug for the last time. Insert a pop rivet to align the plug but do not clinch it until all the vacant holes each have a pop rivet. Just in case one or two holes need easing by having the drill run through again. A ⅛" Penny washer was then placed over the end of the pop rivet to spread the load of the clinch. It is then just a simple case of clinching the rivets to complete this attachment as well as wiping off any excess sealant.

The "Blow Gun" used for the blast nozzle was an Oriental item that was in my spares box. This particular item has the advantage that the nozzle part is only pushed into the blow gun handle. This makes assembly of the spherical bearing much easier. The housing for this was machined entirely from "Delrin" or Acetal, **figs 3** and **4**, with the exception of the small aluminium spring seat that sits in the housing, **fig. 5**. The other spring seat, **fig. 6**, that sits on the Phenolic knob was made from PTFE to help the knob oscillate easier. The spring came form an old vacuum cleaner head, that held a plate in contact with the floor covering. It is large in diameter but with no



An undersize hole in the rubber provides a good fit and a cable tie helps to stop the disc migrating towards the nozzle.

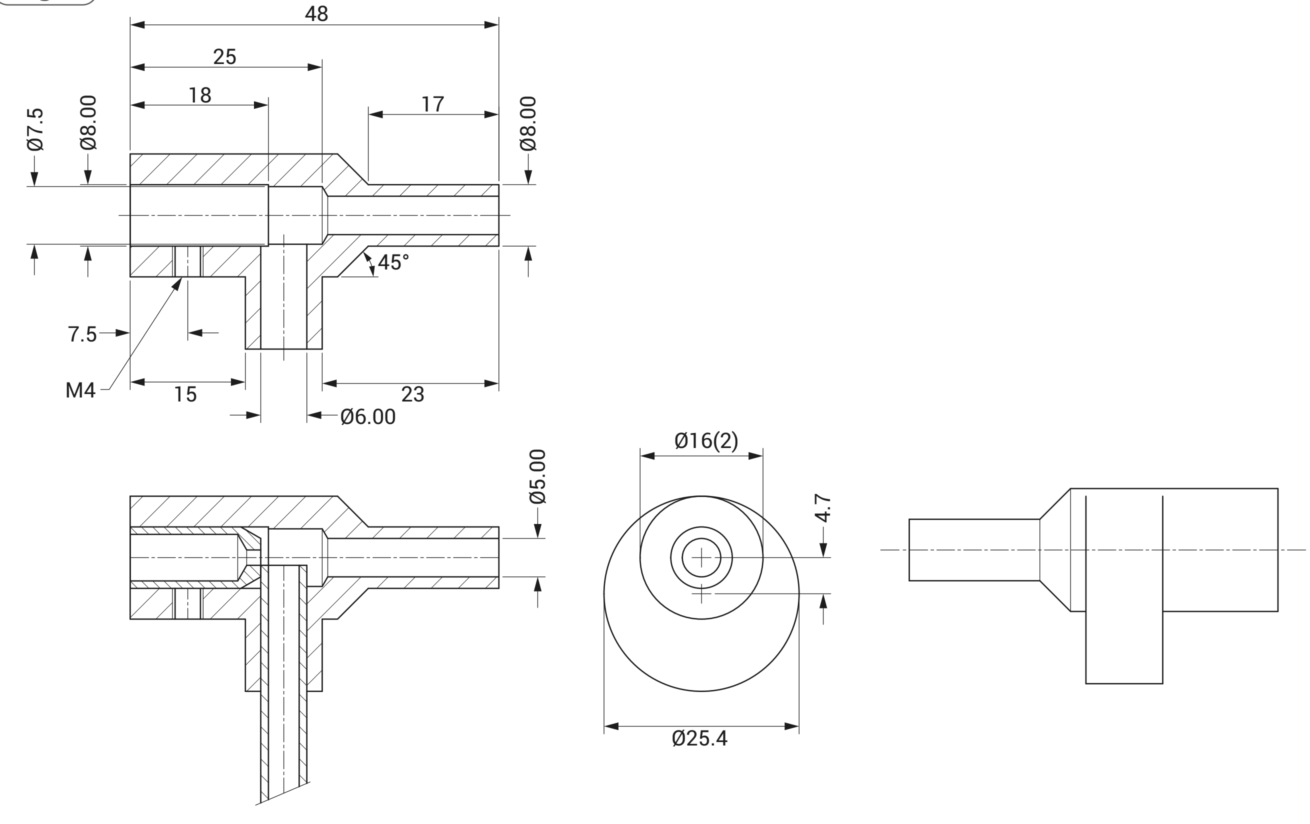
Fig.6



great force. The knob requires machining, and this is best done using soft jaws if the reader has them, if not the standard chuck jaws will have to do. The latter option does mean only point contact will be in operation whilst the machining is carried out. As opposed to line contact when using the soft jaws. Alternatively, a "Top Hat" pot chuck could be made to hold the knob. However, provided care is taken in not over tightening the chuck jaws and thereby marking the bearing surface. Provided there is no attempt to rush the machining process, then everything should be fine. A machine tap to suit the knob thread can be held in the tailstock chuck to ease setting up the knob in the lathe chuck. The portion of the hole which fits around the blow gun nozzle needs to be a good fit, but not tight. The threaded portion of the knob can be drilled out and reamed 8 mm to take a mild steel, brass or aluminium split sleeve,, not drawn. The tube in the blowgun used was not that heavy a gauge material and benefits form the split sleeve, taking the force of the M5 grubscrew. A light facing cut is taken around the tapped hole as this will assist later in setting up in the machine vise to drill and tap the cross hole. The knob used had a slight undercut machined on the diameter, this was probably to remove the original moulding line. It does however make picking up the centre line of the sphere easier when it comes to drilling and tapping the hole. To try and eliminate medium impinging on the spherical bearing a disc of 3mm thick rubber is fitted onto the exposed nozzle. An undersize hole in the rubber provides a good fit and a cable tie helps to stop the disc migrating towards the nozzle. The trepanned disc from the filter housing can be used as a template.

The pick-up nozzle, **fig. 7** was machined from free cutting mild steel. The original was just a plain cylindrical affair but suffered from the supply pipe working its way out due to the small wall thickness. To overcome this the latest nozzle is turned such that an eccentric portion is formed where the pick-up tube enters the nozzle. The hole for this tube wants to be an extremely good fit on the tube. I found that for the 6mm diameter tube I used that the taper portion of a 6mm hand reamer provided a good and permanent fit. The tube extends into the passageway in front of the blowgun adaptor or orifice and it needs to be level with the blowgun orifice, **fig. 8**. A bit of simple maths can give the size of a drill shank that can be used as a gauge to set this setting. The tube was used at this location as it is resilient to wear. A steel supply pipe gets eroded away fairly rapidly at this point and the pick-up rate drops off. An orifice piece was used on the blowgun to ensure a consistent cavity shape and to accommodate the various sizes of blowguns. It also allows a far sturdier section to take the force of the allen grubscrew which holds everything in place. Something the original blowgun would struggle with. The suction pipe is held in the sump tray with a small plastic "P" clip. The end of the pipe being cut at an oblique angle to allow the media to

Fig.7



View from the rear showing rubber glove attachment and filtered air exit.

My compressor.

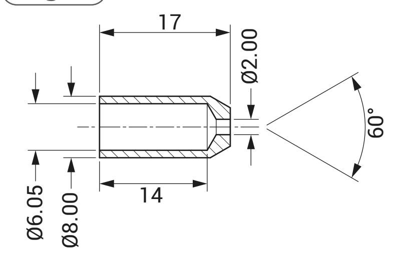
access the end from approximately 3 sides. An angle of about 60 degrees being the optimal angle.

The sump tray sits on a piece of plywood which was contoured to the internal shape of the waste bin, **photo 6**. Luckily there are four ribs in the corner of the "Wham" bin that I used for the plywood to rest on. A piece of cardboard was used as a template for the external shape of the plywood. The centre of the plywood is then removed to form an aperture for the sump tray to sit in. The plywood resembling a picture frame. A cardboard mock-up of the sump was made prior to cutting and folding the aluminium I had earmarked for this item. The sump slopes towards the nozzle side of the bin where it meets a vertical face to which is attached the pick-up pipe. Short wood screws are used to retain sump to the plywood and a bead of silicone was applied around the bin-plywood interface, just to make sure the medium does not go below the plywood and to adhere the plywood to the bin.

A hole was cut in the rear face of the bin to take the remaining blanking plug which is attached in the same way as that for the rubber glove, **photo 7**. This forms the exhaust outlet which is filtered. Two pieces of perforated steel mesh were cut to be a good fit in the plug. Sandwiched between these two pieces of mesh is a piece of filter foam, as used in UV garden pond filters. This comes in various densities and the best one for this particular application is 30 ppi. Anyone with a hot wire foam cutter will make short work of cutting out a piece for the blanking plug. Alternatively marking around an off cut of 100 mm soil pipe with a felt marker and then using a craft knife worked for me.

The assembly is retained in the blanking plug with a flat section clip. The clip was originally a piece of stainless steel used to stiffen a wiper blade. A piece was cut using Pi, and the diameter of the blanking plug, long

Fig.8



Another view of the sand blaster cabinet.

enough to make the clip. This was then rolled up using a George Thomas type bending rolls. This does not want to be an exact fit, otherwise it will just drop straight back out. Rather the clip just wants to be circular and well oversize, the springiness of which will help retain the clip in place when inserted.

To stop the medium and debris from boring a hole in the filter. A piece of aluminium sheet was cut and attached with a couple of M5 screws and two wing nuts. Two short pillars form an air gap between the sheet and the filter housing. The top edge was folded over at about 45 degrees to stop the medium from direct access to the filter. The aluminium sheet also provides some protection to the bin itself while also reflecting the light form LED's. A further refinement which can be added is an outlet to accept the shop vacuum. This can make use of the under sink drainage pipework fittings in the form of a 90 degree bend and a suitable turned up adaptor flange. I do not think gluing this item to the bin would give a very good service life. The compressor I use with the cabinet is an Air Master Tiger as shown in **photo 8**.

If the reader does decide to make this mini sand blasting cabinet, **photo 9**. I hope they have many happy hours using it. In total it took less than a couple of days to make. One person who saw my cabinet actually copied it, but in the form of a spray booth for painting his miniature steam wagons. A modified airbrush replacing the blow gun and a rotating manipulator to hold the item to be painted in place of the glove. ■

One person who saw my cabinet actually copied it, but in the form of a spray booth for painting his miniature steam wagons

On the Wire NEWS from the World of Hobby Engineering

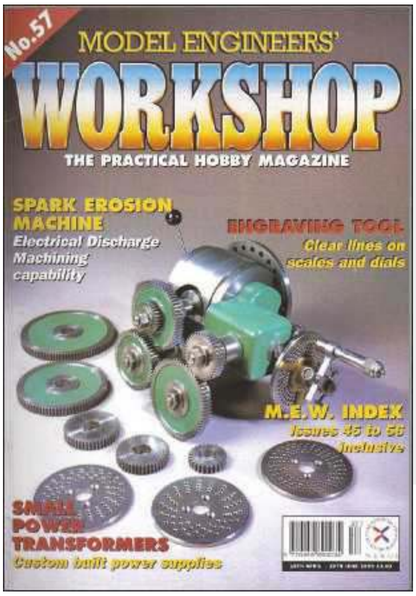
Top award for young Engineer

Jake Knight, Head Engineer at Axminster Tools & Machinery, has recently been chosen as a 'Young Pioneer' and joined The Manufacturer magazine's Top 100 list. Jake received his award at a gala reception in Liverpool earlier this month.

The Manufacturer Top 100, in partnership with Cranfield University, is a showcase for the most inspiring individuals in industry who exemplify the enthusiasm and commitment present in modern manufacturing. Awardees come from all walks of UK industry, from the shop floor to the top level. The 100 individuals have been nominated by customers, team members, their leaders or by those they lead. They are among the very best that UK manufacturing has to offer. The 100 are also catalysts for change, striving for innovation, the newest technologies and pioneering business models. They are the driving force behind the UK's manufacturing industry.

When asked to give one interesting fact about himself which not many people would know, Jake's reply was: "I built a CNC milling machine in my home workshop. The project took more than a year and I had to source the parts from different countries, but mainly from China. I really enjoy messing around on this machine, making different bits and pieces such as engraved name plates".

On receiving the award Jake said: "It came as such a surprise to me both being nominated and then going on to win. I'm thrilled to bits. I'm very happy that hard work is recognised, and it motivates me even more. Another positive outcome is that I can now nominate two people for next year's awards, which is really exciting".



Model Engineers' Workshop Index Gremlins

It's always the way ... the dreaded gremlins duplicated a number from the line above giving an incorrect issue for the index to MEW issues 45-56. It actually appeared in issue 57.

Thanks to Geoff Warner for spotting that we could only have published it in issue 33 with the aid of a time machine. You can find a corrected version of the index of indexes at **www.model-engineer/mewindex**.

Mike's WORKSHOP

Depth Gauges

This month Mike Cox suggests a source of cheap depth gauges.

Depth gauges are useful in the workshop for all manner of things such as measuring the depth of blind holes and grooves. However, dedicated depth micrometers are quite expensive. Most digital calipers can be used as depth gauges but the probe width is quite large at around 4 mm which limits there use to fairly large holes

Digital tyre depth gauges are readily available online at prices starting from around £3.

Two types seem to be available. Some have plastic probes that are around 5 mm diameter with a chisel end to poke into the tyre tread. Others, like the one shown in the photo, which is 1.5 mm diameter at the end, but this increases to 3mm after the first 10 mm of the probe length. This second type makes very good depth gauges for use in the workshop. The give repeatable results and have a resolution of 0.01 mm. The one shown in photo 1 cost £4.30 and I have been using it for two years without problems. ∎

The inexpensive depth gauge.

MODEL ENGINEER
NEXT ISSUE

- ***Josephine***
  Brian Rose, of the Eastleigh Model Boat Club describes a 45 inch, gas fired Windermere steam launch.
- **Bramah and Maudsley**
  Geoff Theasby attends a Bramah/Maudsley Symposium in Sheffield and learns more about these two remarkable engineers.
- **Moseley Railway Jubilee**
  Mark Smithers attends a Jubilee Gala at the Apedale Valley Light Railway to celebrate 50 years of the Moseley Railway Trust.

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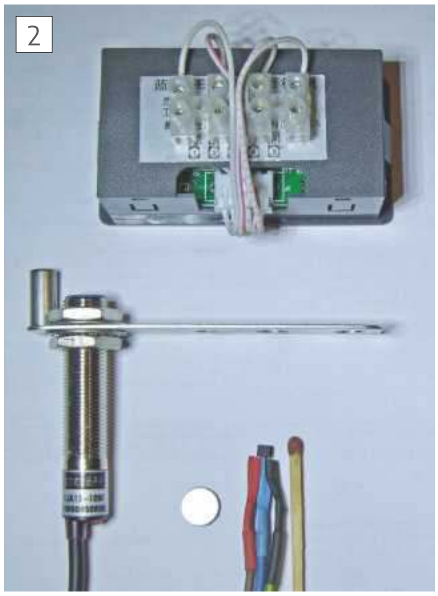
More Thoughts on Tachometers

Noel Shelley follows up on Andrew Carruther's recent article

1

LED at rear of sensor.

2



Supplied sensor compared to bare hall effect IC.

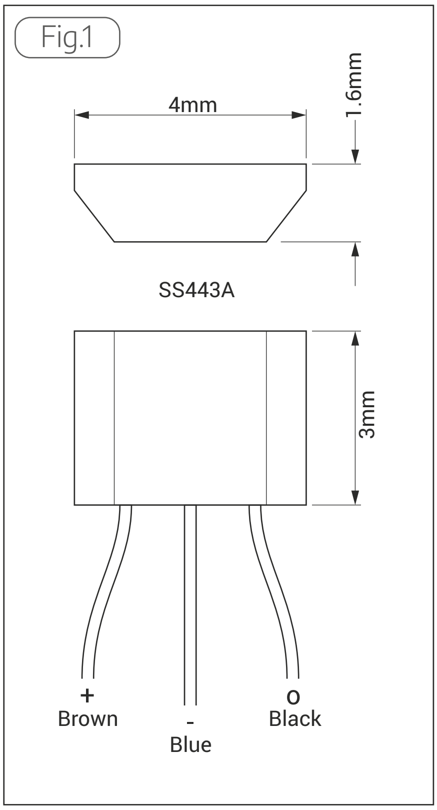
The following should be read in conjunction with Andrew Carruthers interesting article on a mill rpm display in MEW 288. Whilst setting me thinking and strong on aesthetics it was lacking in information on the display unit's type, model number or cost. The wiring diagram only referred to the unit he had (though it would appear to be common to many) and the DC negative is not earth. Since the power supply is 240v mains this incorrect terminology could be dangerous. If a spare power supply is to be reused, check that it is DC and not AC although it is a simple task to rectify the ac with a bridge rectifier and smoothing capacitor. Also check on the polarity of any fitted plug, the centre is not always POS +.

Putting "hall effect tacho" into a search engine will result in numerous suppliers online. The pictures in this and Mr Carruthers articles will identify the right unit and prices seem to vary from £7 upwards. The one I purchased came with all that was needed, including the mounting bracket for the sensor and a magnet for £11. The unit needs a power supply of between 8v and 24v DC, about £6, if needed. Setting up the supplied sensor and magnet is easy. On the rear of the sensor is an LED, **photo 1**, that glows when powered up and increases in intensity when the magnet triggers the hall effect device. Fitting the magnet to the shaft, pulley or whatever and rotating it will show if the magnet is the right way round and aligned before it is permanently mounted. I had carelessly forgotten that the small and very powerful magnets used are very brittle and will shatter if allowed to smack onto steel. No prizes for guessing how my memory was refreshed!

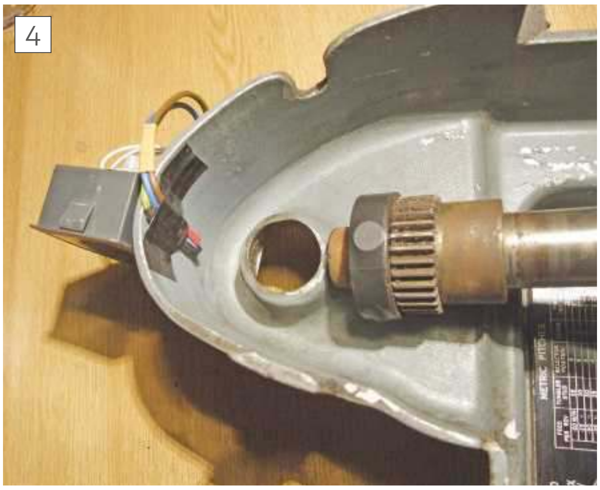
For those who do not have the room for the 2½" long supplied sensor, a hall effect device of the SS400 family(unipolar SS443A) has the dimensions of 4mm wide, 3mm deep, & 1.6mm thick with 3

3

Test setup.



leads(it's half the size of a matchhead). **Photograph 2** shows the supplied sensor, with the mounting bracket and magnet, also the display unit with connector block fitted. The hall effect device(SS443A) can be seen at the end of the 3 wires with a matchstick to show how small it is. It can be soldered on to wires of suitable length or mounted on a small piece of veroboard. It is a wise precaution to encapsulate it in resin to protect it, it can then be mounted, ideally using nonmagnetic materials almost anywhere close to the rotating magnet to operate the display. The SS443A is a Honeywell product, priced at about £2 and is available from any good electronics component supplier (CPC, Farnell, RS). **Photograph 3** shows the two types of sensor both reading the speed of the motor. The magnet has been taped to the shaft of a 1425 rpm motor. Both sensors are



Hall effect IC fitted inside S7 gear cover.

giving a reading of 1496 rpm, an impressive zero error. Due to a flicker effect between the camera and display you will have to take my word for it that the missing digit is a 9! The reading is interesting in that unloaded the motor is running at only 4 rpm below its theoretical synchronous speed. **Figure 1** shows the shape of the SS443A package and identification of the leads, the smaller front face must face the magnet. For simplicity it is a good idea to use brown wire for the POS +, blue for the NEG – and black for the "O" output. These will correspond with the colours on the display unit. When soldering wires on to the leads of the SS443A, hold the leads in pliers or a damp cloth to draw the heat and use as little as is needed to make a sound joint, which can then be covered in shrink sleeve, though care must be exercised not to cook the device in this operation. Using a 4 segment piece of strip connector which can be screwed or bolted to the rear of the display, the connections can easily be made to the very thin wires of the ribbon cable and make fitting or removing the unit simple. It should be noted that wire number 4 is not used and DC negative – is wire number 2.

The sensor operates by closing in the presence of a magnetic flux. The number of times this happens is counted over a set time and extrapolated to read rpm. The SS443A is unipolar, triggered only by the S pole, it will not work on the N pole.

Once the electrics have been sorted, fitting the unit to a machine tool is simple. To fit to a Myford Super 7 the magnet can be taped to the collar on the end of the mandrel and the SS443A being so small can be attached to the inside of the gear cover on it's wires with tape or resin, approximately 1 3⁄16" in from the edge, **photo 4**. The wires can pass through the gap between the gear case and head stock. The distance between the sensor and magnet will have to be arrived at by experiment but should be 1/4" to 3/8". The display can be mounted on the gear cover with adhesive. The fitting has been achieved without drilling any holes, **photo 5**.

Many of the imported drilling machines have a hinged pressed steel cover over the belt drive. Drill a small hole through the cover so as to line up with the pulley on the spindle just inside the largest belt groove. Open up the hole in the cover to take the censor and make a shallow indentation 11mm diameter in the pulley to glue the magnet into. Fit the supplied sensor into the cover and adjust the clearance to 1/4" to 3/8" above the magnet. The display can be mounted on top of the cover with adhesive, **photo 6**.

In both cases the method of mounting the sensor and display does not prevent the cover being opened. The DC power supply can be left with enough slack to allow opening and secured using self adhesive cable clips. The mains to DC converter can be secured to the machine and wired to the motor side of the supply removing the need for a switch.

The type of enclosure, power supply, whether to fit a switch, how to mount the hardware and so on is left to the discretion of the constructor, the above are just a few suggestions that I found worked. ■

Display mounted on gear cover.

Setup to fit tachometer to drilling machine.

The Modular Dividing Head

Ted Hansen makes a flexible system for dividing using standard change gears, including an explanation of its use with various popular lathes.

The Worm:

The first requirement is a single start worm to match the indexing gears.

If yours is a "basic" lathe without the quick change threading gearbox, it will be possible to set up a gear train to cut a thread very close to the pitch required to match your lathe change gears. Myford change gears are 20 Dp, while lathes based on the older 9" South Bend (Boxford, Hercus and others) use 18 Dp gears. As the accompanying chart shows, 5.75 Tpi is 18 Dp to within .001" while 6.5 Tpi is only .003" larger than the exact pitch for 20 Dp. Most lathes can cut 5.75 TPI even if it is not on the screw cutting chart; it is just ½ of the imperial 11 ½ tpi standard imperial pipe thread and can be obtained by adding a 2:1 step up gear in the feed train to the gearbox. If you (or a friend) have a metric lathe, 4mm thread is 20 Dp within a half-thou.

The popular 7" "mini-lathe" uses metric Module 1 change gears which are only .001" less than 1/8" (8 tpi) pitch.

A pitch error of .003" per tooth may sound like a lot and indeed it might be a problem if we were cutting a thread where the cumulative effect of the error could cause interference over a long thread engagement. With a worm, however, only one tooth is in actual engagement, although the two adjacent teeth may be in partial contact. Provided the pitch of worm is a close enough match to the indexing gear to give a decent engagement, it will be satisfactory. Each full turn of the worm will move the indexing gear by exactly one tooth of the gear even if the pitch of the worm is not an exact match for the gear.

At first, I found it difficult to believe that an inaccurate worm could produce an accurate division but here is another way of visualizing it.

At the beginning of one full turn, point "x" on the worm will be in contact with tooth "1" on the indexing gear. At the completion of one turn, the same point "x" will be the contact point with the indexing gear, but it will now be in contact with tooth "2" of the gear. The gear, therefore, must have moved exactly one tooth spacing. It follows that, at 1/2 (or any other fraction) of a turn of the worm, the indexing gear will have moved that fraction of a tooth spacing.

One problem is that many lathes today have a quick change gearbox for cutting threads instead of a manual change gear set and therefore may not capable of being set up to cut the correct pitch ...not because the pitch is inaccurate but because it is below the range of threads available from the gearbox. Myford users are fortunate because the Myford gearbox can be set up to cut the required 20 DP by using a 55 tooth tumbler gear and a 35 tooth input gear, but users of other lathes may not be able to make a similar change.

On the other hand, if you have a QC gearbox, you are not likely to have separate change gears anyway so perhaps the easiest solution is to "go metric" and use 1 Module metric gears. 8 Tpi is a close match for Module 1 and Module 1 spur gears are readily available as replacement gears for the 7" mini lathe. They can be purchased in metal or in plastic and you will only need a few to cover most of your indexing requirements.

A normal indexing head with a fixed 40:1, 60:1 or 90:1 gear set requires a large number of indexing hole circles to cover the range of desirable divisions. These are usually carried on two or three different plates which means that the head must be designed so that changing plates is reasonably convenient. The MDH, on the other hand, is based on a selection of easily exchangeable gears, so it is possible to use only one indexing plate with relatively few hole circles and exchange the gear instead of the plate to extend the range of divisions. This greatly simplifies the design of the attachment.

The MDH is intended to be a practical workshop tool and the primary focus of the design is to provide those divisions which are going to be useful in actual practice. It is not intended to go to a lot of effort to try to

Table 2

Gear Pitch Equivalent – Imperial Threads

TPI	pitch (inch)	Diametral Pitch	nearest actual Dp	Dp pitch	Diametral pitch error	Metric Module	nearest actual Module	Modular Pitch error
4	0.2500	12.566	12	0.2618	-0.0118	2.02	2	0.0026
4.5	0.2222	14.137	14	0.2244	-0.0022	1.8	1.75	0.0058
5	0.2000	15.708	16	0.1963	0.0037	1.62	1.5	0.0145
5.5	0.1818	17.279	18	0.1745	0.0073	1.47	1.5	-0.0037
5.75	0.1739	18.064	18	0.1745	-0.0006	1.41	1.5	-0.0116
6	0.1667	18.850	19	0.1653	0.0013	1.35	1.25	0.0121
6.5	0.1538	20.420	20	0.1571	-0.0032	1.24	1.25	-0.0008
7	0.1429	21.991	22	0.1428	0.0001	1.16	1.25	-0.0117
7.5	0.1333	23.562	24	0.1309	0.0024	1.08	1	0.0096
8	0.1250	25.133	25	0.1257	-0.0007	1.01	1	0.0013
9	0.1111	28.274	28	0.1122	-0.0011	0.9	1	-0.0126
10	0.1000	31.416	32	0.0982	0.0018	0.81	0.75	0.0072

Table 3

Gear Pitch Equivalent – Metric Threads

mm	pitch (inch)	Diametral Pitch	nearest actual Dp	Dp pitch	Diametral pitch error	Metric Module	nearest actual Module	Modular Pitch error
6	0.2362	13.299	14	0.2244	0.0118	1.91	2	-0.0111
5.5	0.2165	14.508	15	0.2094	0.0071	1.75	1.75	0.0001
5	0.1969	15.959	16	0.1963	0.0005	1.59	1.5	0.0113
4.5	0.1772	17.733	18	0.1745	0.0026	1.43	1.5	-0.0084
4	0.1575	19.949	20	0.1571	0.0004	1.27	1.25	0.0029
3.5	0.1378	22.799	23	0.1366	0.0012	1.11	1	0.0141
3	0.1181	26.599	27	0.1164	0.0018	0.95	1	-0.0056
2.5	0.0984	31.919	32	0.0982	0.0003	0.8	1	-0.0253
2	0.0787	39.898	40	0.0785	0.0002	0.64	0.75	-0.0140

Gear tooth designations

Imperial systems use the Diametral pitch system for gear teeth. A "Diametral Pitch" (Dp) is the number of teeth on a gear of 1 inch pitch diameter (note... NOT outside diameter), thus an 18 Dp gear with a 1 inch pitch diameter would have 18 teeth. The metric equivalent is the "Module" system but, as with many derived units in the metric system, the calculation is inverted. The "Module" is the pitch diameter (in mm) of a gear having x number of teeth. In other words, M = Pitch Diameter divided by the Number of teeth whereas Dp = Number of teeth divided by the Pitch Diameter.

obtain extra divisions which likely will never be used. Many of these, such as 43, 59 or 122, require an exclusive hole circle even on a universal dividing head. If a really odd division is required, a method of creating it will be described later.

I considered it essential to provide indexing for:

-all numbers up to 12 except 11
-50, 100 and 125 for graduating dials
-180 and 360 for working in degrees
-as many other divisions up to 100 as reasonably practical

Generally, this can be achieved with only two or three gears in combination with a hole plate with no more than three rows of holes.

Cutting the worm is just another screw cutting operation but with a coarse-pitch

Table 2
Cutter Proportions for Worm Threads

Pitch Size	Included angle of sides	Width of flat on the end (inches)	Depth of tooth (inches)	Infeed at ½ of included angle (inches)
16 Dp	29°	0.0723	3.43	3.53
18 Dp	29°	1.63	3.00	3.15
20 Dp	29°29°	1.47	2.74	2.82
24 Dp	29°	1,22	2.29	2.36
32 Dp	29°	0.92	1.70	1.78
Module 1 (Mini Lathe)	40°	0.762	2.31	2.44

18

Shaping the toolbit for cutting the worm.

29° included angle thread form (for 14 1/2° pressure angle gears) instead of the normal Vee. The 20° pressure angle Module 1 worm to match the mini lathe gears will require a 40° included angle.

The first requirement is a properly ground tool bit. Grind the sides of the tool bit as exactly as you can to the appropriate angle, then grind the end flat back until the width of the flat matches the specification, see table 2. This width is quite critical because it determines the width of the tooth, so be as accurate as you can. Be sure and leave at least 8 to 10 degrees flank clearance angle because the helix angle of the worm does significantly reduce the actual clearance angle.

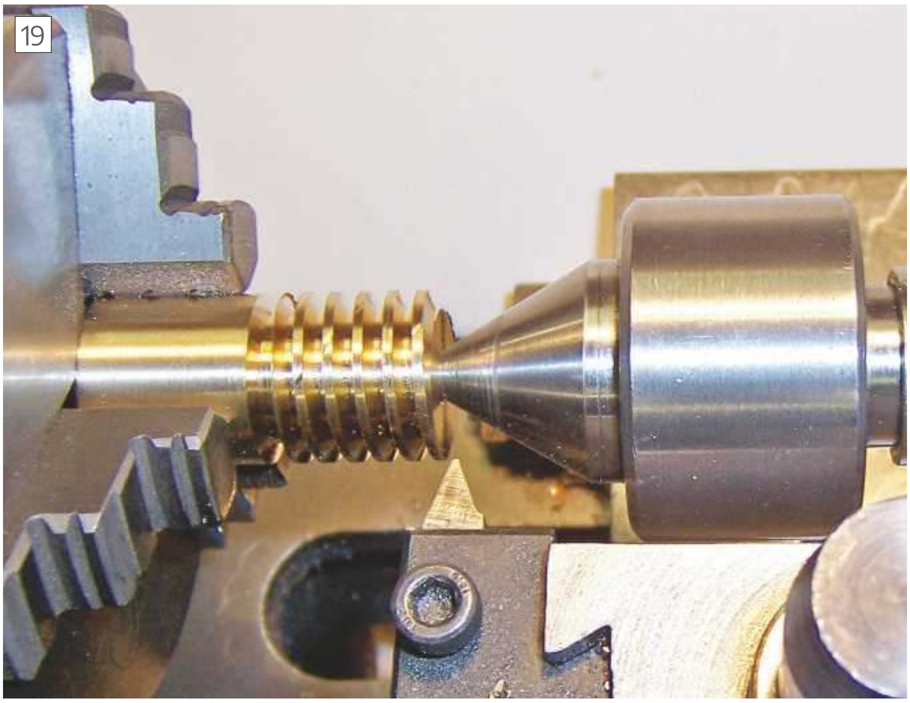
Depending on your tool sharpening equipment, you may want to make a couple of jigs to get the angles correct and the tool really sharp. If your only tool sharpening equipment is an offhand grinder, I would go so far as to suggest that you need to make some improvements... as a bare minimum, mount a flat rest with a guide slot in it on the grinder and make up some wood guide blocks to get the angles correct. Historically, it was exactly this job that caused me to build the sharpening device shown in **photo 18**) It is based on a design by the master himself, George Thomas. It appeared (although it was not actually described) in the 21 April 1978 issue of Model Engineer Magazine and is, in his own words "capable of doing some very fancy tool grinding operations."

The worm is not made integral with the shaft. This allows the worm to changed at will or made from a different material, but the biggest advantage is that it breaks up the assembly into a series of small parts, some of which (the shaft for instance) are just standard stock. An error in any of the 4 or 5 machining operations required for an integral worm and shaft part might result in scrapping the entire part, whereas the separate worm has only two machining operations, one of which is an almost fool proof drilling/reaming operation.

Chuck a piece of material for the worm blank, face off the end and put in a centre hole for tailstock support. Turn to the outside diameter, then reduce the centre portion to slightly less than the root diameter of the thread to create a run out clearance area at the end of thread. This run out area is absolutely necessary. Things will be happening really fast even at minimum lathe speed and there must be room for the lathe to come to a stop before crashing into the uncut metal past the end of the thread.

Use a good quality cutting fluid and a very fine feed. My preference for thread cutting fluid is the brown cutting oil used in power pipe threading machines.

This is a really heavy cut, about as coarse as can be cut on a small lathe without resorting to milling, **photos 19** and **20**. It will need tailstock support and a generous amount of material for gripping in the chuck. It will tax the capability of a mini-lathe even in easily cut bronze. In steel it will be impossible unless a hand crank is used to drive the spindle. This is actually a lot more practical than it first



Cutting a bronze worm on a mini lathe.

appears. It takes only 5 or 6 turns per pass, speed control is perfect, starting and stopping is instantaneous and with a radius of 8 or 12 inches on the crank there is plenty of torque available. A long time ago, hand power was the norm for jobs like this on a lightly built amateur's lathe. The crank was usually locked into the spindle bore with an expanding split sleeve tightened by a tapered bolt.

I firmly believe that the best way to cut threads is to feed in with the top slide set at the flank angle of the thread rather than feeding straight in with the cross slide. Set the compound rest to just slightly less than the half angle of the thread. Set the cross feed dial to a recognizable, repeatable point (I used "0" with the handle pointing straight down on my old South Bend with its non-adjustable dials) then advance the top slide until the tool tip just contacts the work. All the depth of cut will be put on with the top slide, the cross slide is used only to withdraw the tool from the cut at the end of each pass. Zero or note the reading on the top slide dial. Since this is an odd pitch thread, it may not be possible to disengage the half nuts during the cutting procedure. Tape the half nut lever closed with duct tape to avoid an "oops" resulting in a ruined work piece.

Do a trial pass without actually cutting to check the pitch setting. Advance the top slide by a slight amount and start the cut. It may be possible to start with as much as 10 thou infeed at first but the cut per pass must be reduced as the depth is increased, in the final stages only about 2 or 3 thou per pass. Use the cross slide to withdraw the tool and run the lathe in reverse to back up the tool while leaving the half nuts engaged. Add a little more infeed with the top slide and repeat. Refer to Table 1 for the proper amount of infeed. If in doubt, cut the thread a little too deep rather than not deep enough as it is probably better to have the tooth be slightly

Checking the mesh of a steel worm for a South Bend lathe.

too thin rather than too thick.

For mini-lathe users, **photo 21** shows the gear train setup to cut 8 tpi to match the module 1 gear pitch with the 16 tpi lead screw. The half nuts may be disengaged for the return passes, but re-engagement must be done at exactly the same point on the threading dial or else you will end up with a 16 tpi worm instead of 8 tpi.

If you have the 1.5mm metric lead screw the gear combination of 50-30 and 35-45 will give a satisfactory pitch of .126" and you will have to leave the half nuts engaged at all times.

An issue that may arise is chatter and poor surface finish. This is primarily an indication of overloading the lathe and can be due to a dull tool, too high a cutting speed or just plain overloading.

One way to deal with a surface finish problem is to use a different material. Using free cutting steel instead of regular mild steel may help or bronze could be used instead of steel. Bronze may be too soft for a power transmission application, but it is not likely that excessive wear will occur in a lifetime on a home shop indexing head (bronze should be ideal for a worm, Ed.)

The Bearing Block:

This is just a rectangular block with a couple of holes in it. Although I used steel, this really should be made of a good bearing material such as cast iron or bronze. The outside dimensions are not critical but do try to insure that the faces are flat and square to each other. Ream or bore the hole for the worm shaft to get a good fit on the shaft.

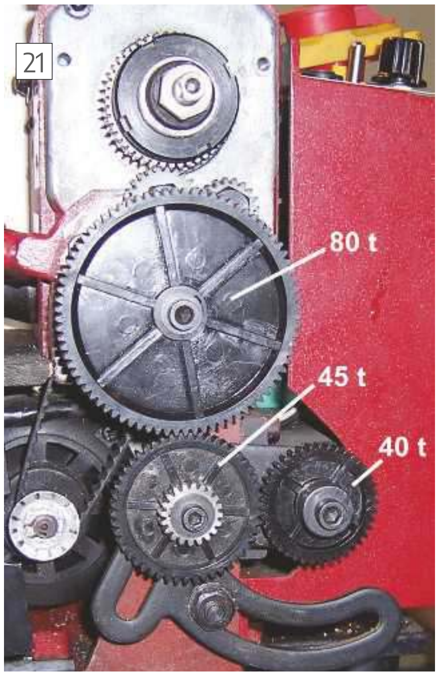
Do not drill and tap the two holes for attaching the index plate at this time; these will be located from the plate itself.

The Shaft and Overarm Sleeve:

The shaft is just 12mm stock. Thread M12 x 1.75 for about 15mm from one end.

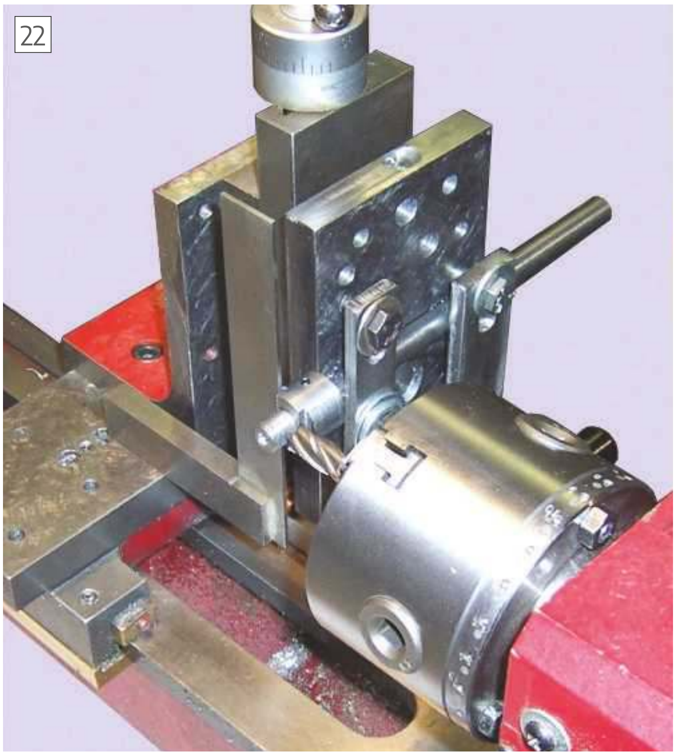
Turn the overarm mount sleeve to the dimensions given then permanently mount to the shaft using either a spring pin or a taper pin to secure the two parts together. Cutting the flats for the overarm mounting is done with these pieces assembled, **photo 22**.

Photograph 23 shows the flats being cut in a vertical mill using the basic MDH to index the work. Two bushings quickly turned up from scrap adapt the shaft to the 15mm hole in the indexer so that it can be used as its own spindle. It may be necessary to split one of the bushings so that the clamp screws will clamp the shaft tightly. An old gear was be bored out to use as an index. It was clamped to the shaft with brass screws to avoid marring the work.



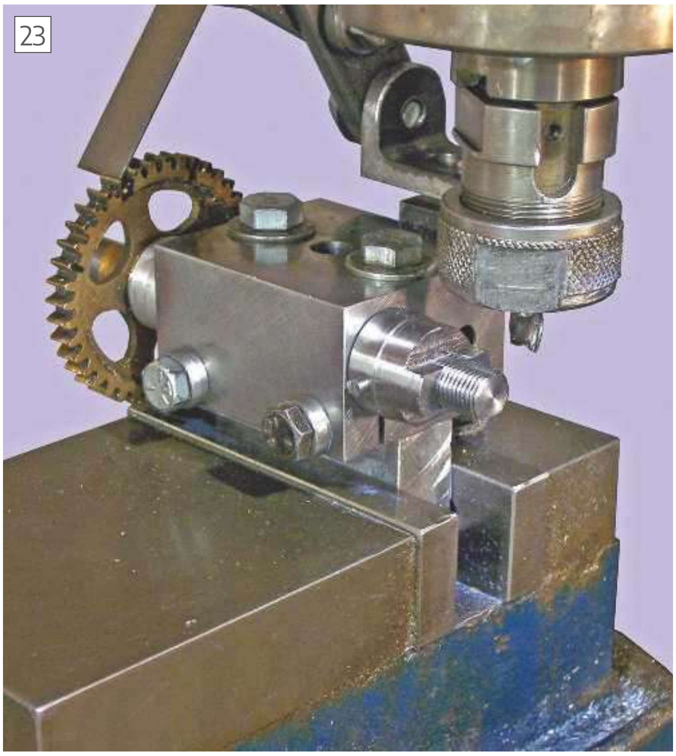
The change gear setup to cut 8 tpi.on a mini lathe.

22



Milling the flats on the overarm support sleeve and worm shaft with the work clamped to a vee notch on the vertical slide. Note the square to insure that the flats are parallel.

23



Cutting the flats on a vertical milling machine with the shaft held in the MDH.

Index Plate:

Two index hole patterns are shown in the drawings. One is for lathes which have a change gear set that goes up in steps of four such as the South Bend, Boxford and Atlas. The other is for change gear patterns that go up in steps of five like the Myford and the mini-lathe.

There was some discussion of the 'best' choice of gears for direct indexing earlier which resulted in a recommendation for the most useful set of gears for each of the change gear pattern sets.

For South Bend/Boxford type lathes this is a 36-40-42 tooth gear set. With this gear set, the essential divisions can be obtained with just two hole circles, one with 36 holes and one with 25.

The next most useful addition is a 22 hole circle which adds all the various multiples of the prime number 11, such as 22, 33, and 44.

In fact, this combination of just three gears and three hole circles provided:

- all numbers up to 12
- all even numbers up to 32 except 26
- 42 different divisions up to 100 plus 125, 180 and 360

With this combination a total of 54 divisions are available in the range of interest. Additions for special purposes can be obtained by changing the index gear. Graduating an angular vernier scale for instance, will need 400 divisions which can be obtained using the 36 hole circle with a 100 tooth gear.

Note that this choice uses the same principle of maximum number of factors outlined earlier with the 25 providing the factor 5 and the 36 providing the 2's and 3's. The next prime number, 7, is in the 42 tooth gear.

The 36 and 22 hole circles can be indexed using the 36 and 44 tooth gears included in the change gear set for these lathes. Unfortunately, these change gear set do not include a gear which will allow direct indexing of the 25 hole circle so builders will have to find or borrow one. Note that it is only required to have 25 (or some multiple thereof) teeth, it does not have to match the pitch of the other change gears.

24

Drilling the holes in the index plate using a centre drill to put a small countersink on the hole at the same time.

For Myford, mini-lathe and similar gearsets which go up in steps of five, the "direct indexing" recommended set consists of only two gears, one with 40 teeth and one with 60. With an index plate having hole circles of 35, 40 and 45 holes a total of 44 divisions including all of the "essential" divisions except 125 can be produced. A 50 tooth gear will add 125 to the list, while adding a 38 tooth gear from the Myford set or a 57 tooth gear from the mini lathe series will add an additional 5 more. Finally, a 55 tooth gear will bring the total up to 58 available divisions in the range of interest.

The divisions required to produce these plates can all be obtained from the change gear sets.

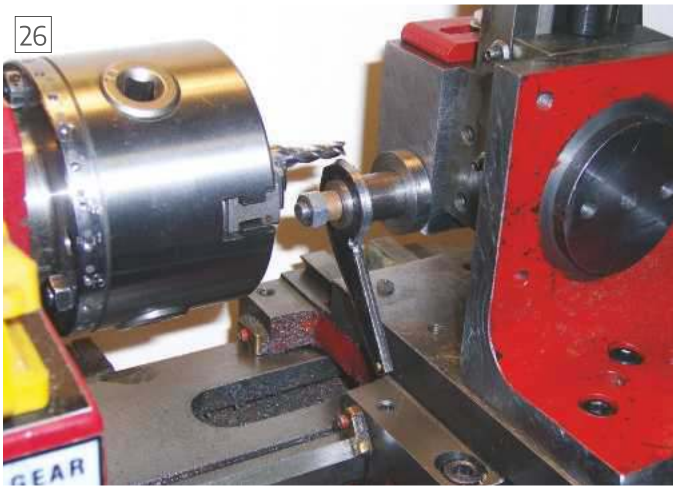
To make the index plate, first rough cut the plate from 1/8" (3mm) steel plate. Ordinary low carbon black steel is a better choice than cold finished "shiny" material for this. Not only is it cheaper, it has less built in stresses from the manufacturing process so is less likely to warp. The black oxide finish can be left on or it can be removed using a sander or a heavy duty wire wheel in an angle grinder.

The centre mark will be lost when the centre hole is made so the location of the two holes for the mounting screws and the hole circle radii must be marked out before doing the centre hole.

Ream the centre hole then mount the disc

25

The sector arms roughed out.


Profiling the sector arms using the basic dividing head to cut a series of flats.


Smooth the profiled edge with a file.

on a threaded indexer spindle. Chuck the assembly in the lathe and turn the outside diameter. Radial infeed cuts (as in facing) work better than axial turning for removing large amounts of material in the early stages. The culprit here is workpiece deflection... the relatively large diameter plate is not very thick and will flex in the axial direction which may allow the toolbit to dig in.

Transfer the spindle with the plate still attached to the dividing head and mount the assembly on the cross slide or vertical slide in the lathe, **photo 24**. Drill the indexing holes using a centre drill while indexing for the hole locations with the MDH. Control the hole depth using a travel stop on the lathe bed. Set the depth to give a small countersink to each hole.

The final operation is to drill the two holes for attaching the plate. Drill pilot holes in the plate first then clamp the plate to the body using the worm shaft to insure correct alignment of the centre. Extend the pilot holes into the body then open these out to tap drill size and tap the holes. Drill out the holes in the plate to clearance size for the mounting screws and countersink until the mounting screws are recessed slightly below the plate surface. It may be necessary to face off the screw heads slightly, but the screws must not protrude above the plate as the plate surface is a bearing surface for the sector arms.


Boring the sector arms.

The Sector Arms:

The blanks for both arms are identical and are initially cut excessively long then trimmed at assembly, **photo 25**. Fasten the two arms together with a rivet in the waste area near the end of the arms. Drill the centre hole to a size for which you have made an indexing spindle then use the indexing head to profile the arc, **photo 26**. The straight sides of the arms can be cleaned up with a file in less time than it would take to set them up for milling, **photo 27**.

The arms should fit in the three jaw chuck for boring the central hole out to size, **photo 28**. If they will not, clamp them to a faceplate using a wood backing. Separate the arms then bend the upper arm as indicated in the drawing. There should be enough thickness for three full threads in a threaded assembly so the “clamp support pad” must be added to the lower arm to achieve sufficient thickness for the thread.

Solder or epoxy the pad to the lower arm then drill and tap the hole for the inner clamp screw. Bend the tip of the lower arm, trim the bent part to length and drill the hole for the outer clamp screw.

Assemble the arms to the index plate and body and mark the location of the bend at the outer end of the upper arm 2mm past the edge of the index plate. Now make the end bend, you will have to use a hammer to get a nice sharp bend so do the hammer work on the bent over end where any marks can be easily filed smooth. It does not matter if the resulting gap is not exactly 2mm, just drill the hole for the clamp screw in the centre of the gap and adjust the size of the clamp screw nut to fit.

Table 4

Cutter Proportions for Worm Threads				
Pitch Size	Included angle of sides	Width of flat on the end (inches)	Depth of tooth (inches)	Infeed at ½ of included angle (inches)
16 Dp	29°	0.0723	3.43	3.53
18 Dp	29°	1.63	3.00	3.15
20 Dp	29°29°	1.47	2.74	2.82
24 Dp	29°	1,22	2.29	2.36
32 Dp	29°	0.92	1.70	1.78
Module 1 (Mini Lathe)	40°	0.762	2.31	2.44

The Overarm and Mounting Bracket:

The only difficult part of making these parts is cutting the slot. For slotted holes such as this I recommend removing most of the material by drilling before milling the slot because drill bits remove material faster and easier than milling cutters and are much easier to re-sharpen. The basic MDH will do an excellent job of profiling the outside end radius.

The Plunger Assembly:

Turn the upper part of the plunger body first, then grip by this surface and drill/ream the holes for the plunger and cut the 10mm thread all at the same setting. The final operations are to thread the hole in the side for the lift stop

Table 5

Divisions Chart for Myford & Mini						
Holes	35		40		45	
Gear	40	60	40	60	40	60
2	20t	30t	20t	30t	20t	30t
3		20t		20t	13t 15h	20t
4	10t	15t	10t	15t	10t	15t
5	8t	12t	8t	12t	8t	12t
6		10t		10t	7t 30h	10t
7	6t 25h	9t 20h				
8	5t		5t	8t 20h	5t	
9					4t 20h	7t 30h
10	4t	6t	4t	6t	4t	6t
11						
12		5t		5t	3t 15h	5t
14	3t 30h	4t 10h				
15		4t		4t	3t 30h	4t
16			3t 20h	4t 30h		
18					2t 10h	3t 15h
20	2t	3t	2t	3t	2t	3t
21		3t 30h				
22						
24				3t 20h	2t 30h	
25	2t 21h	2t 14h	2t 24h	2t 16h	2t 27h	2t 18h
27						2t 10h
28	1t 15h	2t 5h				
30		2t		2t	1t 15h	2t
32			1t 10h	2t 35h		
33						
35	1t 5h	2t 25h				
36					1t 5h	2t 30h
40	1t		1t	2t 20h	1t	
42		1t 15h				
44						
45					40h	1t 15h
48				1t 10h		
50	28h	1t 7h	32h	1t 8h	36h	1t 9h
54						1t 5h
55						
56	25h					
59						
60		1t		1t	30h	1t
63						
66						
70	20h	30h				
72					25h	
75		28h		32h	24h	36h
77						
80			20h	30h		
81						
84		25h				
88						
90					20h	30h
96				25h		
99						
100	14h	21h	16h	24h	18h	27h
120				20h	15h	
125						
360					5h	

Table 6

Divisions Chart for Myford & Mini						
Holes	35		40		45	
Gear	40	60	40	60	40	60
2	20t	30t	20t	30t	20t	30t
3		20t		20t	13t 15h	20t
4	10t	15t	10t	15t	10t	15t
5	8t	12t	8t	12t	8t	12t
6		10t		10t	7t 30h	10t
7	6t 25h	9t 20h				
8	5t		5t	8t 20h	5t	
9					4t 20h	7t 30h
10	4t	6t	4t	6t	4t	6t
11						
12		5t		5t	3t 15h	5t
14	3t 30h	4t 10h				
15		4t		4t	3t 30h	4t
16			3t 20h	4t 30h		
18					2t 10h	3t 15h
20	2t	3t	2t	3t	2t	3t
21		3t 30h				
22						
24				3t 20h	2t 30h	
25	2t 21h	2t 14h	2t 24h	2t 16h	2t 27h	2t 18h
27						2t 10h
28	1t 15h	2t 5h				
30		2t		2t	1t 15h	2t
32			1t 10h	2t 35h		
33						
35	1t 5h	2t 25h				
36					1t 5h	2t 30h
40	1t		1t	2t 20h	1t	
42		1t 15h				
44						
45					40h	1t 15h
48				1t 10h		
50	28h	1t 7h	32h	1t 8h	36h	1t 9h
54						1t 5h
55						
56	25h					
59						
60		1t		1t	30h	1t
63						
66						
70	20h	30h				
72					25h	
75		28h		32h	24h	36h
77						
80			20h	30h		
81						
84		25h				
88						
90					20h	30h
96				25h		
99						
100	14h	21h	16h	24h	18h	27h
120				20h	15h	
125						
360					5h	

screw and drill the 4mm hole in the side of the flange. This hole is for inserting a short piece of rod for leverage when tightening into place.

I confess I did not wind a new spring for the plunger, instead I just used one from the "collection".

There is no reason the plunger could not be made in two pieces if desired using a length of 5mm rod threaded into a piece of 8mm material provided reasonable care is taken to insure the two parts are concentric.

The handle can be made from any suitable material - steel, brass, aluminium or even plastic will work. Knurl the outside first, drill & bore the holes and part off. Drill & tap for the set screw and mill the slot for the lift stop screw. The slot dimensions are not at all critical, it is just a cut-away to clear the lift stop screw when the plunger is in the down position, **photo 29**.

The mounting brackets, sector arm clamp screws, and other small parts to complete the attachment need no special instructions.

Be sure to minimize end play when assembling the worm shaft because any free play in the worm may have a direct effect on the accuracy of the indexing operation.

Using the Attachment:

Mount the worm attachment on the MDH with the worm firmly engaging the indexing gear with a minimum of free play. Always

The plunger assembly.

rotate the workpiece in the same direction during the indexing operation, and always lock the spindle of the the MDH prior to making a cut.

The basic principle for indexing with the attachment is very simple – the worm is used to measure fractions of a turn. For example, if you are using a 60 tooth indexing gear and you want to make 180 divisions each division will be ⅓ of a turn of the worm. You could, therefore, use any set of holes on the index plate which is divisible by 3 to measure out the 180 division, for example 15 holes of a 45 hole circle.

Determine the indexing interval needed for the operation, **tables 5** and **6** offer guidance. For illustration purposes I will use 12 divisions and I will use the 40 tooth gear. Table 6 (Indexing chart for South Bend type lathes) gives the required interval as 3 turns plus 12 holes ("3t 12h" on the chart) using the 36 hole circle and a 40 tooth gear.

First, set the overarm so that the plunger engages the 36 hole circle.

The sector arms are used to avoid having to count out the number of holes each time. Set the arms so that there are 12 spaces between the arms (i.e. the sector arms will span 12+1 = 13 holes) and lock the arms together using the inner locking screw.

For this example, assume rotation of the worm will be in the clockwise direction.

Set the arms so that the plunger is against the leading (most clockwise) arm. This is important. One possible source of error is that you will lose track of whether or not the arms have been advanced. The way to avoid this is to establish a procedure for advancing the arms and always follow it. My procedure is to first advance the sector arms, then move the plunger, then make the cut. This means that each cut will always be made with the plunger set against the leading (most clockwise) arm. If the job is interrupted for some reason, I only have to look at where the sector arms are to know where I left off. If the plunger is against the trailing arm, I am in the process of advancing the worm and I have moved the sector arms but not yet moved the plunger. If it is against the leading arm, it is in position to make the cut and I only have to look at the work piece to know if the cut has been completed.

●To be continued

Readers' Tips

CHESTER MACHINE TOOLS

TIP OF THE MONTH WINNER!

Consistent Stamping

This month our lucky winner of £30 in Chester gift vouchers is Trevor Hills with a useful guide to achieving consistency with number and letter stamps.

Peter Shaw's recent article (MEW 285), which included marking a micrometer dial ring with number stamps, pointed out the difficulty of striking the stamps to get a consistent impression. This reminded me of how I overcame this problem by modifying an automatic centre punch—the sort that uses a spring-loaded device to deliver an impulse to the tip of the punch.

I dismantled the punch and made a flat-ended replacement for the business end. I just used mild steel, but I found that after a bit of use the end splayed a little, so it would be better to make the replacement from silver steel and harden and temper the end.

My punch delivers a sufficient impact to make a good mark on aluminium alloy with 2.5 mm stamps and this is consistent each time. But it is a cheap tool without an adjustment for impact. If a deeper impression is needed several applications of the punch can be used if a staking tool is used to hold the stamp steady. All that is needed is a bit of angle held in the toolpost or a vice. This also helps to get the stamp perpendicular to the work. In principle, at least, the strength of the blow should take into account how 'dense' the number or letter is. An '8' has more metal to displace than a '1', for example, so should need a bigger blow. But this is probably only important for a decimal point which would otherwise be hit too hard and hence be too deeply impressed.

The picture shows the partly disassembled punch, with the replacement part above.

Another thing I found was that choosing the right stamp and getting it the right way up took a good deal of care and was prone to error. So, for number stamps at least, I put a bit of paint on the top side of each stamp, coloured using the resistor code.

Trevor Hills

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

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Spindle Hold Wiring

Dear Neil, it seems that the gremlins got into the publishing software as photo 19 is captioned correctly but the picture is actually photo 18. Could I ask that you print photo 19 with its caption? Also, perhaps readers seeing the correction would go back to the article in Issue No.289 and write a note in the magazine that there is a later correction? It is important that the microswitch connections are done correctly.

R. Finch

Abrasive Blasting

Hi Neil, regarding 'abrasive blasting', a word of warning to all who plan to undertake it : - do not use "crushed glass" or any "sand" (particularly 'silica Sand') /any grit containing silica. It is illegal to use such for the job as the fine dust is ingested when breathing and results in "silicosis" – a singularly horrible way to die! Commercially crushed "garnet" has been used for a very long time. The family glass business in London (frosting patterns on 'pub' windows) used only 'garnet' and had extensive air extraction equipment to vast cloth filter bags in a sealed chamber – the reason for the filters was the glass dust produced which has lots of silica in it. I have seen the ghastly sight of "old men of 28 years or so with 'blue' faces" who had worked in a mine, the product of which produced fine silica dust... being young and bolshie they had not worn the masks they were supplied with.

Peter King, New Zealand

The Sight of a Lifetime

Dear Neil, I've had an eventful life thus far. Born in the late 1920's I plan kicking on for a while yet. The following adventure was precipitated by my being an employee of a large US computer company and I was on my way home after a training course in the states. The dire straits of the three Apollo 13 crewman after their shattering message -"Houston. We have a problem" had the world transfixed; particularly in the USA.

Leaving the US I diverted to Auckland on the way to Sydney and chanced to observe a once in many lifetime's occurrence.

With the cabin lights out we waited expectantly. A brilliant fire ball, like a massive Very light appeared over the horizon ahead of our path! Travelling horizontally, an incandescent, silver plume of brilliant light, leaving a blazing trail of constant width behind it, arced in from the west at an altitude that didn't appear to be much higher than ours. The silver phosphorescent tail it left behind seemed to retain its brilliance as a curved band of luminescent material while the leading body continued at constant velocity across our path leaving the magnificent arced trail behind it. When it died out, a minute red dot continued on the east-bound path, curving out of sight over the Eastern horizon. This was the command module with its glowing heat shield that had survived the impossible inferno and miraculously had living humans inside it. I would guess that the whole display lasted four to five minutes.

Seemingly moments later the captain said that a successful recovery was in progress some thousand or so kilometres away in the Eastern Pacific; prompting applause from us passengers. Several minutes afterwards day began to break, and the trail of vaporized metal was visible hanging in the upper atmosphere for the next twenty minutes or so affording me the chance to photograph it as it hung there. The next morning the Auckland Star newspaper carried a photograph of the re-entry proclaiming that the passengers on our flight had been the sole witnesses to "The Sight of a Lifetime". It seemed that their photographer was lucky enough to get it right too! Perchance he used the settings I'd given him?

Peter Gabelish, Australia

Peter got in touch after reader Andre Rousseau told him about our Apollo cover last year. A full version of Peter's story will appear on the website – Neil.

Faircut Lathe

Dear Neil, I have just read an article by Andy Coulson on his Faircut lathe rebuild. I bought my lathe in 1976 from the widow of the previous owner who I believe had bought it from new. During the years it has had quite a few mods carried out. These include 2 Perspex belt covers; a round bar beneath the cross slide; auto stop on leadscrew; plate on front of cross slide for chippings; Brass plug on left of plate; oil cleaner for leadscrew; tailstock for ease when drilling etc. The black handle on the motor will reverse it. The cross slide has also been repaired.

Brian Morehen,by email.

Nutcracker

Hi Neil , I was wondering if my efforts at a better nutcracker would be of interest !

I harvested some black walnuts last year , and found them to be too hard to crack with ordinary nutcrackers, so I am using my old pipe vice!

It worked very well!

Jim Simpson, by email

Hi Jim, ingenious but not quite what I was thinking of with 'design a better nutcracker'!

Scrolls Saw and Filing Attachment

Dear Neil, I am interested in making the Combined Scroll Saw & File attachment for the Lathe from the article printed in 3 consecutive magazines. However, there are pieces of information missing.

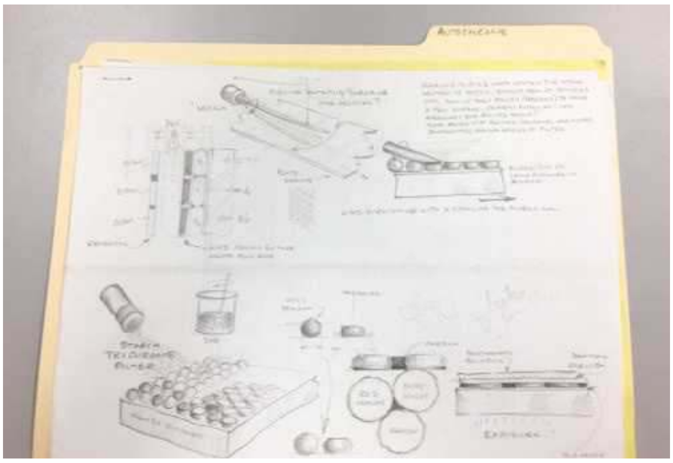
Issue 286 references 'Figure 5' and photos 22 to 28 (these are not printed in this issue).

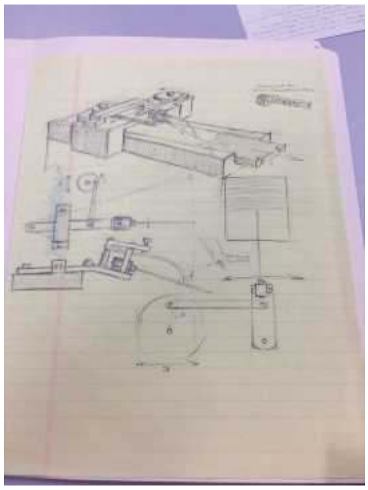
Issue 287 starts with Figure 6 and photograph 29 - leaving a gap in the information required.

Barry Hansell

Hi Barry, you are one of a number of readers who spotted the 'deliberate mistake', thanks for letting me know. The missing photos and figure appear in this issue – Neil.

Autochrome Press





Dear Neil, I work as an Art Handling Technician at the National Portrait Gallery in London. One of my areas of interest is early photographic processes and currently I am involved in a self-directed project to recreate an early colour technique called the Autochrome. I have there's an article here describing the process: en.wikipedia.org/wiki/Autochrome_Lumière' Part of the manufacturing required the colour filter to be compressed and this was achieved using a mechanical press built using an adapted planer/thicknesser. I've attached some images of what it looked like and how it worked. I was hoping in order to carry out my project whether a replica could be built on a reduced scale? I thought by contacting yourself that you might be able to suggest any firms or individuals who would be able to take on such a project? I am sure that this may be one of the more esoteric emails that you will receive today but I look forward to hearing from you soon.

Peter Norman, National Portrait Gallery

If readers could email neil.wyatt@mytimemedia.com with their ideas or suggestions I will happily pass these on to Peter – Neil.

Workshop Press Tooling

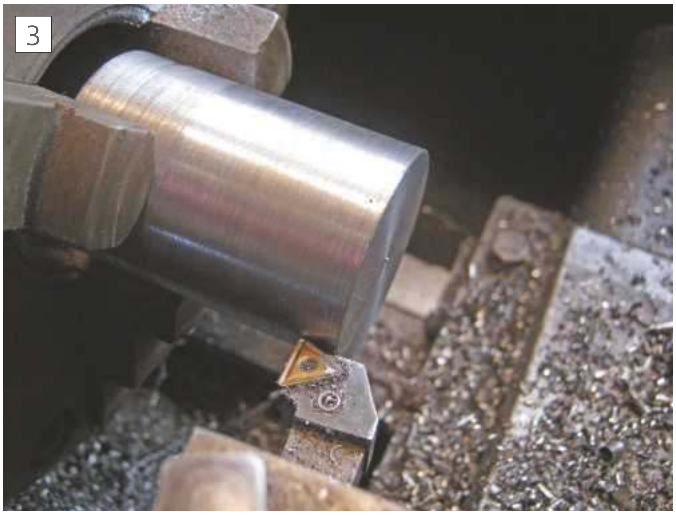
1

Complete set of tooling

2

Finished chuck

3



Turning to size

Will Doggett makes a set of tooling for his press tool described starting in issue 285

The complete set of tooling is shown in **photo 1**.

Having made the press some tooling is required; this is how the parts were made for specific jobs that I want to do on the press.

The first thing was to work out how I could hold the upper part of the tools that I wanted to use as some of the tool required to be lifted up after the down operation. The alternative is to use a set of return springs and locating post as in commercial tooling this would require a lot more work than I required for mostly simple tasks.

The idea of a screw chuck holder arrangement came to mind, I would use the M8 thread in the end of the ram to secure it in position so that the part returned to the upper position with the ram.

The screw chuck holder was the first part to be made, this would be a piece of round steel that at one end a M8 piece of stud to fix it to the ram and at the other end a hole with a pair of screws in the side to hold the part that was inserted in the main hole.

The hole is what I will call universal as the other parts will be made to fit this one by direct fitting or have parts made to fit them the universal hole as required.

The general idea of the chuck is shown in the press screw chuck sketch.

Manufacturing the chuck

To make the chuck, **photo 2**, I put a piece of 42mm steel in the lathe chuck and machined it to a diameter of 40mm overall, **photo 3**. I then cleaned the face up and deburred, it was then centre drilled the hole was then opened up to 8mm tapping to a depth of 12mm and then tapped M8 this tapped hole is for the 8mm studding to hold the chuck to the ram.

This end was then reduced to 1¼ for 25mm to match the ram size.

4

Reaming the hole

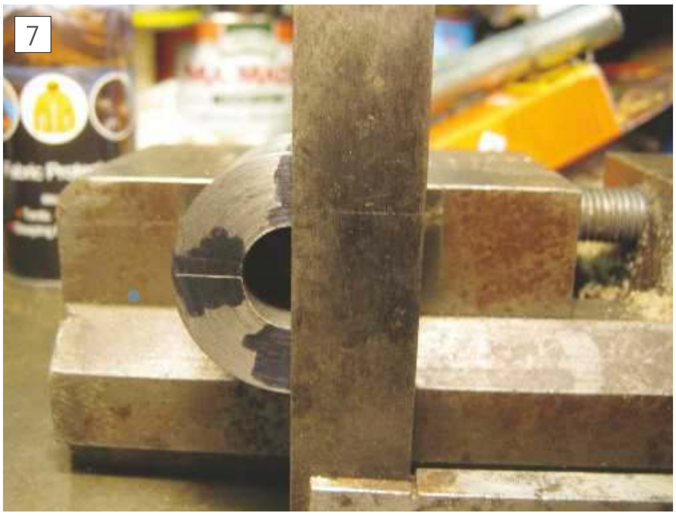
5

Semi finished chuck

6

Marking out for holes

7



Lining up the chuck

Marking lines on side of chuck

Drilling for threads

The chuck was then put in the lathe chuck the other way around and machined to a length of 55mm then this end was also centre drilled and drilled, but this hole was reamed ⅝ inch to a depth of 25mm **photo 4**. This end was also deburred at this point I put a knurl on the chuck but decided to machine it off as it didn't help much.

The choice of ⅝ inch for the hole was the material was readily available and in the shop.

The chuck was then removed from the lathe, it then had the piece of 8 x 35mm studding fitted and held in place with thread lock. The semi finished chuck is shown in **photo 5**.

To find the position of the chuck's clamping screws the chuck was screwed on to the ram and hand tightened, then front of the chuck that was facing me was marked with a felt tipped pen on the vertical centre line. The chuck was then removed from the ram so that the hole positions for the clamping screws could be marked out.

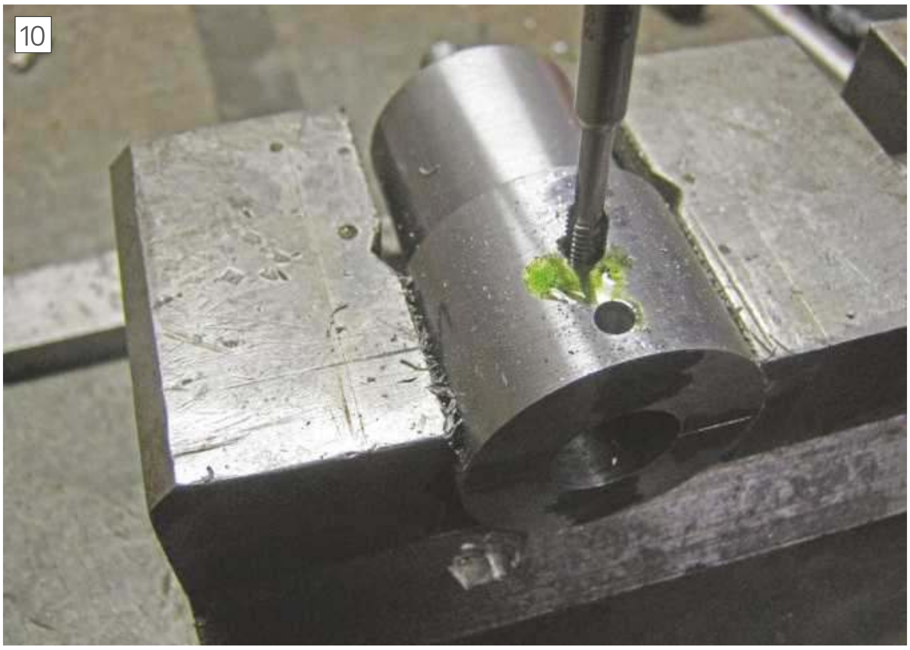
Marking the chuck out was done by holding the chuck in a toolmakers vice and using a felt tip pen to mark out the end and sides ready for marking. Then a centre finder was used to the line up the felt mark made earlier and the first line was marked over the end of the chuck.

The centre finder was then moved 90deg and using a small square to help line-up to the first line the second line was then marked. **Photograph 6** shows lines on the end of the chuck before they are marked on the side.

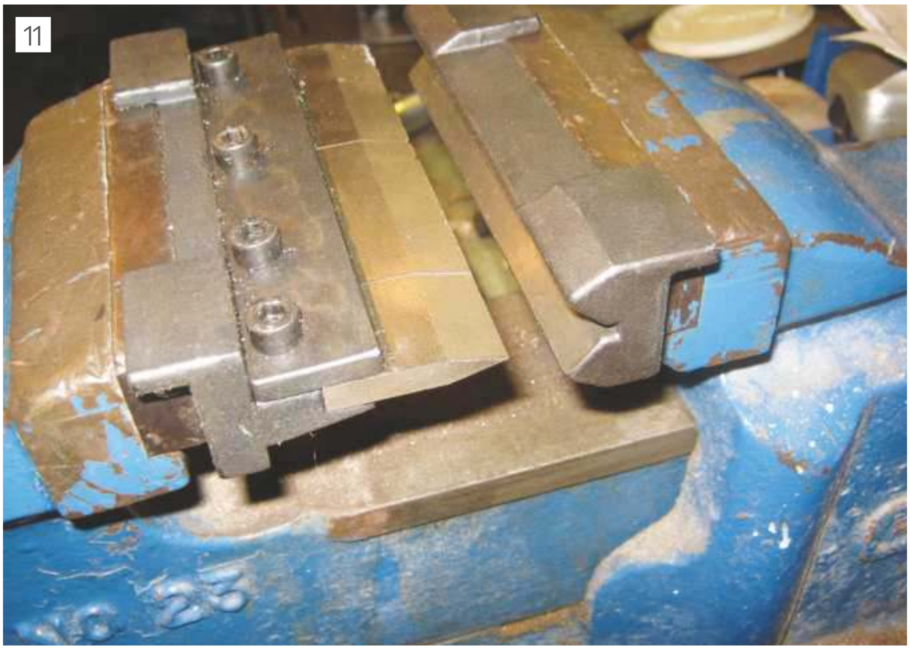
To mark the lines on the side of the chuck it was put the toolmakers vice and the lines were then transferred from the end line up three sides with a vernier height gauge the centre set of holes are for the main holding screws, the two sets are 'just in case'.

To make this operation easer I used a square to line up the vertical line on the end of the chuck, **photo 7**, and then used the height gauge to mark the side lines, **photo 8**.

The position for the two holes on each line were then mark 5mm and 15mm from the bottom of the chuck all 6 hole positions were then centre punched, using the lines on the end of the chuck to line it up for drilling these 6 holes were then drilled, **photo 9**, and then

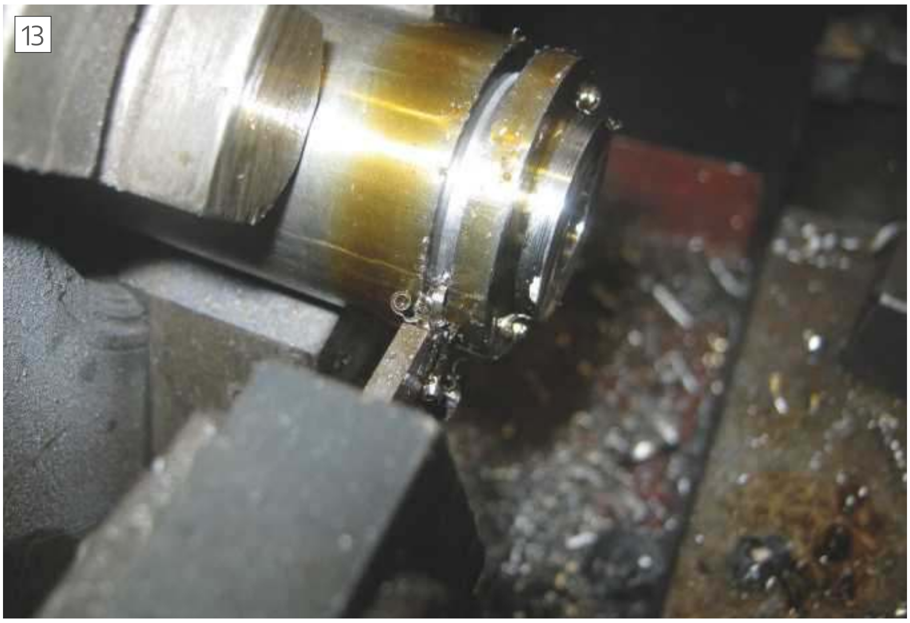


Tapping thread



Vice mounted bender

Sawing bottom packing



Parting of bush

tapped 2 BA, **photo 10**. After a skim over and a clean up the fixing screws were fitted, photo 2 shows the finished chuck.

The square bending tool

Now I have made the chuck to hold the tooling and return the tools to the top of the jack's travel, I can start making the other tooling that I want, the first of these is a bending tool or brake press.

This was going to be a straightforward job as I already have what is known as a magnetic vice mounted brake also known as a bending tool this was purchased some years ago this tool is designed to be used in a bench vice. The problem with using it in the vice you are limited to the length of the part on the lower side by the depth of throat in the vice this means only relatively short parts can be bent in this way, this can be seen in **photo 11**, but using this tool in the press the throat issue is not a problem.

To hold the two parts of the bending tool I am going to use the magnets on the top and bottom tools to hold the top and bottom parts to steel backing pieces which in turn will be fixed to the press base with adaptor and a screw through into the backing steel and to the ram via the chuck for the top of the tool.

Bottom packing piece

To hold the bottom part to the press table I cut a piece of steel to the length of the base this was 125mm long. This was cut from a piece of steel off unknown origin that was 60 x 20mm. The 60mm width was then cut to 25mm to finish with a piece 20 x 25 x 125mm long. The cutting was done on the bandsaw and held on a plate with a clamp fitted to it so that parts that are too small to hold in the machine vice can still be cut on the saw as shown in **photo 12**.

After cleaning up with a file the bottom part was marked out in the centre all ways on the 25mm face, then drilled and taped M8 to a depth of 12mm.

To stop the base part from moving in the large hole in press base a bush was required this was turned to fit the hole and with a shoulder for the clamping nut to work against and stop the base from moving when being used, **photo 13** shows the part being parted off, a piece of M8 studding is used to hold the parts together.

●To be continued

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Repairing a Bicycle Crank

Alex du Pre tackles an unusual workshop task

Apart from providing the means to fulfil the satisfying hobby of model engineering, owning a well-equipped home workshop often allows you to tackle the other little jobs that life throws up from time to time. Sometimes, the workshop can even help with other hobbies. As well as a model engineering, I also enjoy cycling and one such task recently came my way when I managed to strip the thread on my pedal crank. The root cause of this was temporarily fitting a cheap replacement pedal with a poorly-formed thread, thus also acting as a reminder of the old adage 'buy quality, buy once'. Neither my local bike shop nor the internet was able to come up with a like-for-like replacement crank, so I thought I would attempt a repair in the workshop. As this was an interesting machining challenge with some learning along the way, I thought I would share it with you.

The Challenge

The crank in question was the left-hand crank of a Trek road bike. The crank is an irregularly-shaped alloy forging. Critical dimensions are the throw, which is the distance between the pedal axle and the crank axle (175mm in this case) and the offset, which sets the lateral distance between the two pedals. The pedal axle must be parallel to the crank axle.

The standard pedal thread is 9/16in x 20 TPI Cycle Pitch. The left hand crank has a left hand thread to prevent the pedal from unscrewing in use. The right hand crank has a right hand thread.

The challenge was to find a way of holding the work and then to bore out and replace the ruined thread whilst retaining the necessary dimensions and parallelism and giving a result that could withstand the pedalling forces.

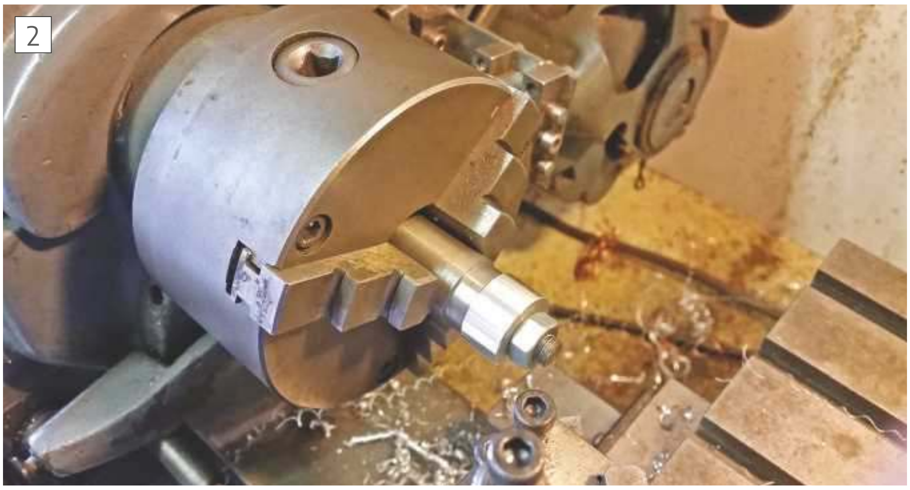
The Repair Job

Before starting, I bought a suitable tap, at no small expense, but forgot that I needed a left-hand thread. So, I went back for the correct tap, mulling another adage, 'check twice, buy once'.

I started by cleaning up the damaged thread by passing the tap through, leaving the tap in place to help with alignment on the milling table.

Fortunately, the rear face of the crank boss has a flat surface machined

The workholding set up on the mill table.



Machining the insert on the lathe.

Boring the insert on the mill, using a boring head.

perpendicular to the crank axis. A clamping bolt was passed through the square taper, holding the machined face hard against the mill table, ensuring that the pedal axis was parallel to the mill spindle. Before tightening the bolt, the shank of the tap was held loosely in the mill's drill chuck, aligning the mill spindle with the pedal axis (this could also have been done by clocking against the tap shank). When everything was aligned, the clamp bolt was tightened and the mill table was locked, **photo 1**.

A machine jack was placed under the crank, as near to the outer end as possible but clear of the pedal thread. This was to prevent the crank deflecting downwards under machining forces. To prevent lateral movement, the crank arm was braced with dogs (or stops).

Moving to the lathe, an aluminium HE15 thread insert was made, **photo 2**. This was

4

Applying the retaining compound to the bore.

5

The insert fitted to the crank with retaining compound.

in the form of a ring, 13.5mm long, 21mm diameter and bore 10mm (smaller than the tapping drill diameter).

Back to the mill, the old thread was machined away using a boring head, **photo 3**. The bore was opened out to 21mm, ensuring a light press fit on the insert just made.

The bore and the insert were coated with Loctite 620 high-strength retaining compound and the insert was pushed into the bore, tapping it into position lightly with a hammer, **photos 4** and **5**. Loctite 620 is intended for high temperature applications and is not necessarily the most suitable grade for this application, but it was the one I had in stock at the time.

The Loctite was left to harden overnight, and the excess was wiped away, **photo 6**.

The insert's bore was opened out slightly using the boring head to ensure concentricity

6

The insert ready for boring and tapping.

Drilling the insert to tapping size.

Starting off the tap in the mill to ensure squareness, rotating the mill spindle by hand.

with the mill spindle. It was then drilled out in 0.5mm stages to 13mm, which is tapping size for the thread, **photo 7**. The drill had to be run slowly at these diameters to avoid chatter. I should have bored the final diameter.

The tap was then started using the milling machine chuck to ensure squareness, rotating the spindle by hand and remembering to turn it anti-clockwise for the left hand thread, **photo 8**. The thread was then finished by hand using a tap wrench, backing the tap off a quarter turn every half turn. I used tapping fluid and a good, clean thread resulted, **photos 9** and **10**.

I had been dubious about the use of the retaining compound, but it at least withstood the tapping forces, which was a good start.

Finishing the thread by hand.

The crank was then brought inside to harden the Loctite further, before fitting to the bike for testing, **photo 11**.

The Result

So, was it a success? Well, partially. After several months of regular use, I noticed that the insert was slowly working its way out of the crank. So, I pressed it out, cleaned it up, textured the joining surfaces with a rough file and refitted it with Delta 66 stud grade retainer, which I also had in my potions cupboard. For good measure, I made two blind M4 holes across the join and screwed in a pair of grub screws, fitting them with the Delta 66. Since then, I have cycled another 2000 miles or so in all weathers with no further failures, so consider the problem to be permanently and successfully fixed.

It would have been better for the thread insert to be threaded on its outside diameter and a suitable thread tapped into the crank. This would have required the purchase of a large and expensive tap and die pair, probably left handed, so I opted for the cheaper route. Welding the insert in place would also have been a good option, but I lacked the means to weld aluminium. I think my experiment highlights the good performance of engineering adhesives. ■

The repaired crank ready to be fitted to the bike.

The crank back on the bike and ready to go.

A Combined Scroll Saw and File Attachment for Your Lathe

In Issue 286 there were extra photos and a figure for Mogens Kilde's attachment that we couldn't fit in alongside the text. Several readers have got in touch to point out they haven't appeared yet, so with due apologies, here are photos 22 to 28 and fig. 5, which 'fit in between' issues 286 and 287.

22

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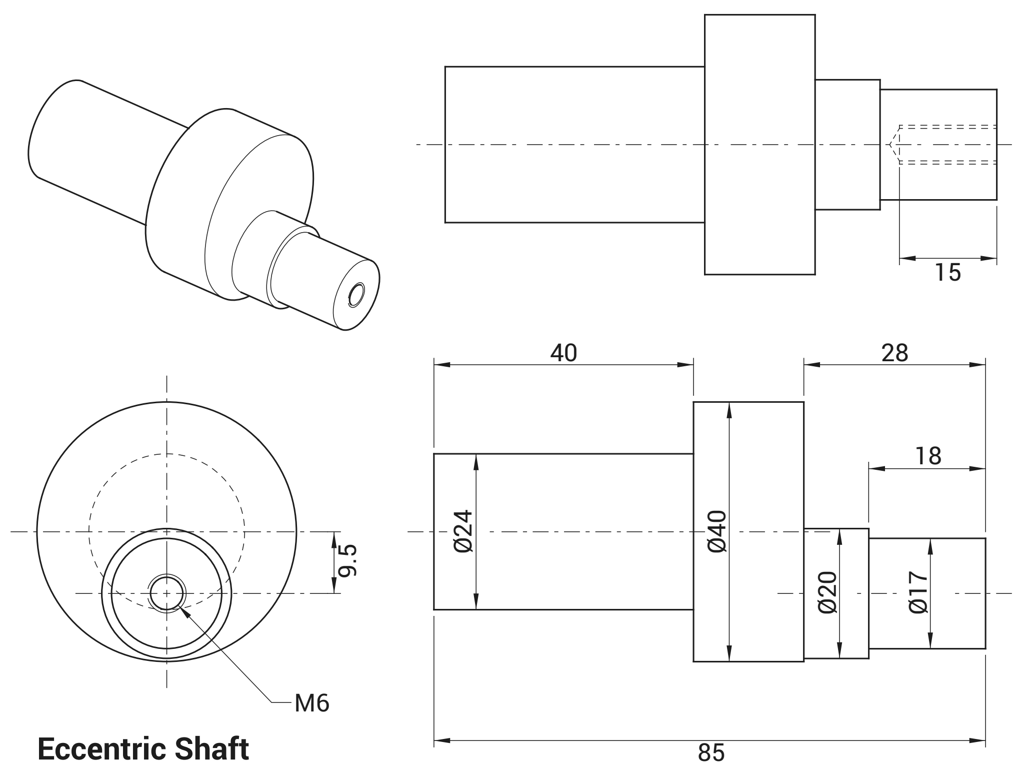
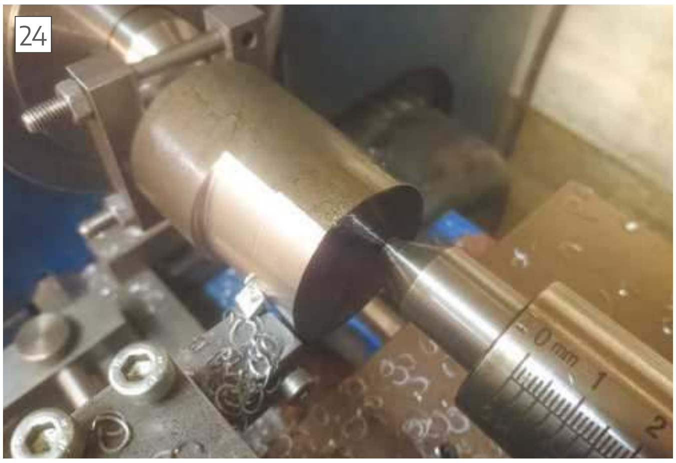
Fig.5



Eccentric Shaft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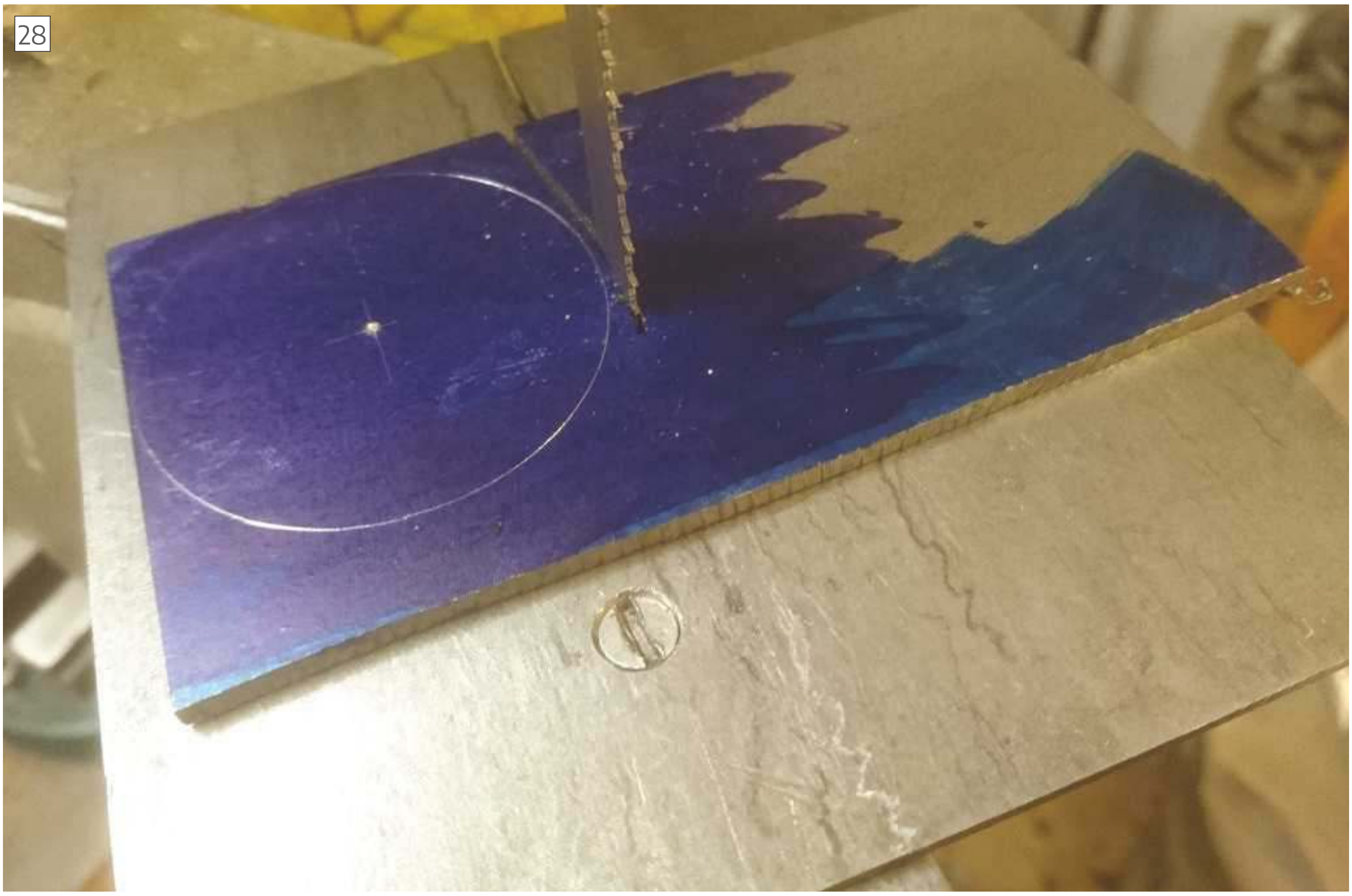
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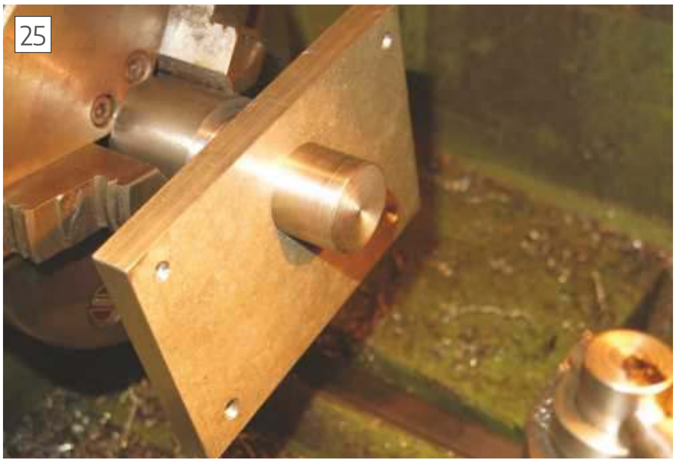
A guided power feed for a Warco bandsaw Part 2

Richard T. Smith makes a pneumatic accessory for a vertical bandsaw.



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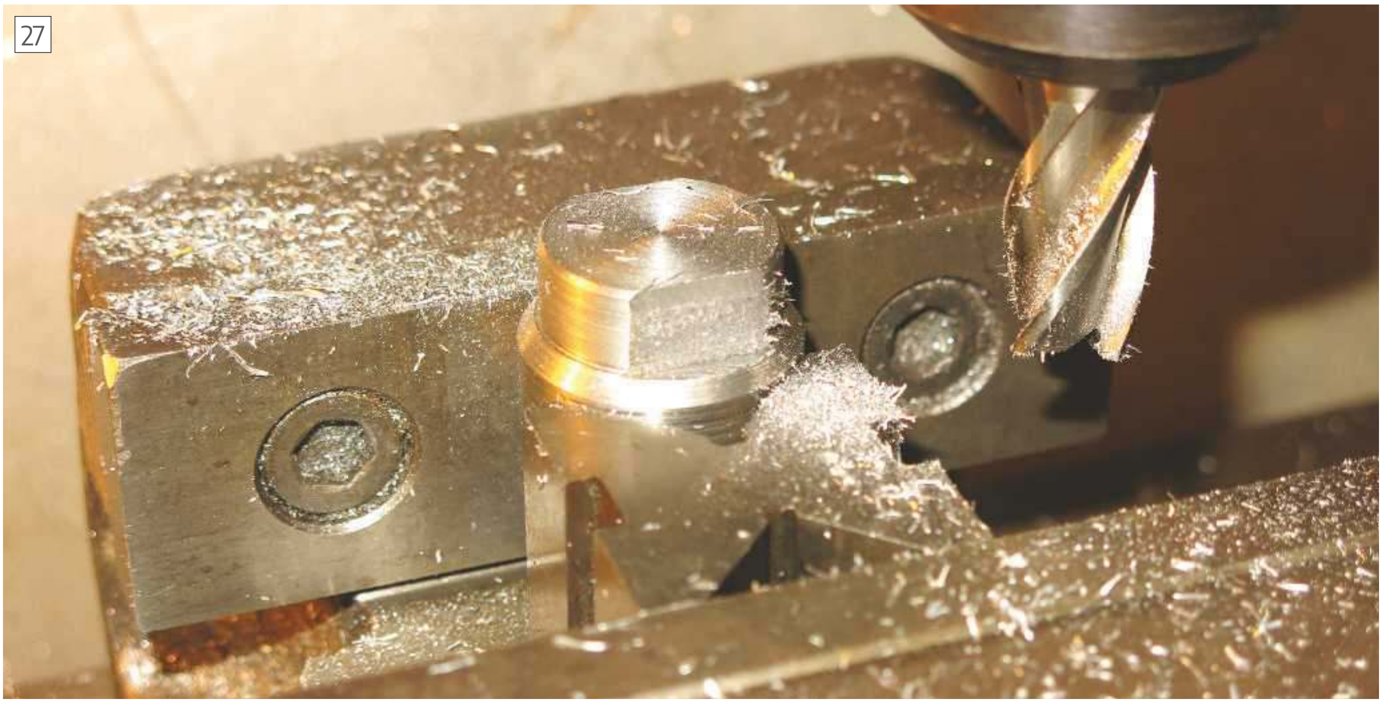
The lockbolt was next. I turned the end of some 44mm diameter bar down to fit closely in the hole in the saw mounting plate, **photo 25**. The problem was to make the thread as I still have no idea what it is. My metric dies don't fit the existing knob, and neither do my Whitworth, although one came fairly close. Just as I was despairing, I remembered some old dies of my fathers and one of those fitted perfectly. Unfortunately, it's rusty and the size unreadable. Anyway, I turned the diameter down to match that on the knob and cut the thread and shaped the top of the bolt before parting off, **photo 26**. After cleaning up the end I mounted it in the mill vice and machined two flats, **photo 27**.

Now it was time to add the two tapped holes to the saw adjustable bracket right, so I removed the saw table and the first bracket. I marked the position of the



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adjustable bracket right on the saw before removing it so I could put it back in the same place. I clamped the bracket in the vice on the mill, screwed in the lockbolt, **photo 28** and centred the spindle on it. I used some scrap to pack the saw attachment plate up to locate on the lockbolt, and some more packing to clamp it all down, **photo 29**. I checked that the attachment plate edge was inline with the X axis and set the mill stops for the two hole positions, **photo 30**. Now I could drill right through with the M10 tapping drill, then just through the plate with a 10mm drill, remove the plate and packing, and tap the two new holes, **photo 31**. Replaced the bracket in the saw in its usual position, screwed in the new lockbolt tightly, and fastened the plate on with two M10 capheads, **photo 32**. Solid as a rock. Assembled the adjustable angle plate, the adjustable plate, and the top angle bracket, and G clamped the support plate on top, **photo 33**. Adjusted things until the blade and table were square and the table edge close to and in line with the blade. Marked through the top bracket onto the support plate then removed the table subassembly and drilled and tapped where marked. Also drilled a hole through the support plate for the air hose and mounted the control valve. Bolted all back together, **photo 34**. Trimmed the top bracket corner slightly to be inline with the support plate.

I should explain that although the cylinder is double acting, I am using it as a single acting so only one air line. I was lucky with the control valve as I found a brand new one cheaply online. The valve has three ports and either feeds or exhausts the cylinder so that there is either a thrust on the table or it is totally free. I later added a

small regulator with pressure gauge in front of the regulator.

To set the table square to the blade you use the adjustments provided by the adjustable angle bracket. When making adjustments use a small square on the table and align it with the actual direction the adjustment moves in. In practice I found adjustment awkward because of the weight of the table assembly and decided to add jacking screws. I also made a temporary swarf deflector, **photo 35** but soon realised that swarf is also dropped on top of the table from the blade as it comes down so something more comprehensive was needed.

Rather than removing the whole assembly to use the horizontal mode I realised that I only needed to take off the table subassembly. The rest of the bracketry is not in the way and clears the saw base. To make this easier, I fastened a strip of aluminium directly under the top angle bracket which supports the table subassembly while I put the two holding bolts in, **photo 36**. I could slot the two holes in the top angle bracket to provide extra adjustment between table and blade but so far, I have not needed to.

The two jacking arrangements each consist of a screw and a bracket with a tapped hole, **fig. 4**. The brackets are cut from the 40 x 40 x 5mm angle and **photo 37** shows one held against the fence and being shortened, dead easy. Two countersunk holes were added for mounting and an M8 tapped hole for the screw, **photo 38**. The screws were turned from some rusty bar as it was the only stuff I had the right sort of size. To my surprise it turned quite well and I threaded it with a die guided by the tailstock, **photo 39**. Turned the head to 10mm diameter and parted it off. I decided on an 8mm square head and **photo 40** shows this being machined and **photo 41** shows a completed screw and bracket. The second pair were made similarly and **photo 42** shows them fitted. Both screws push


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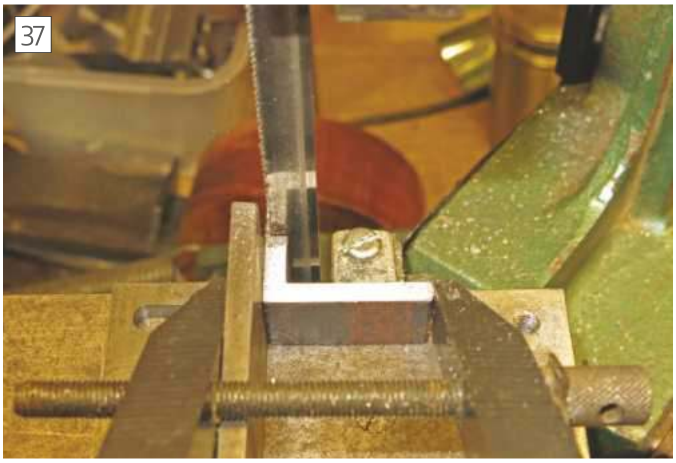

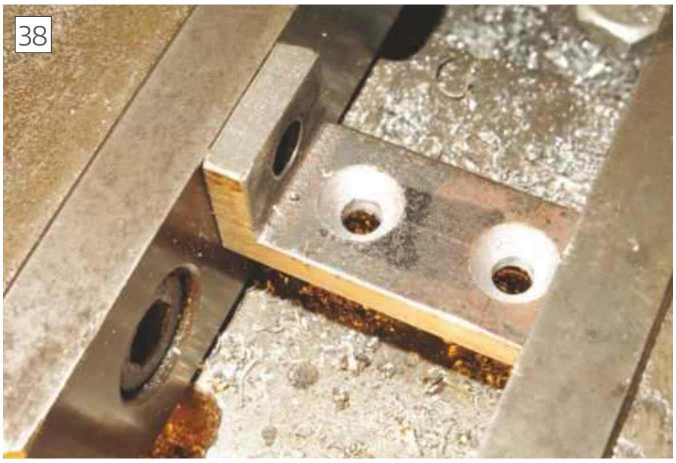

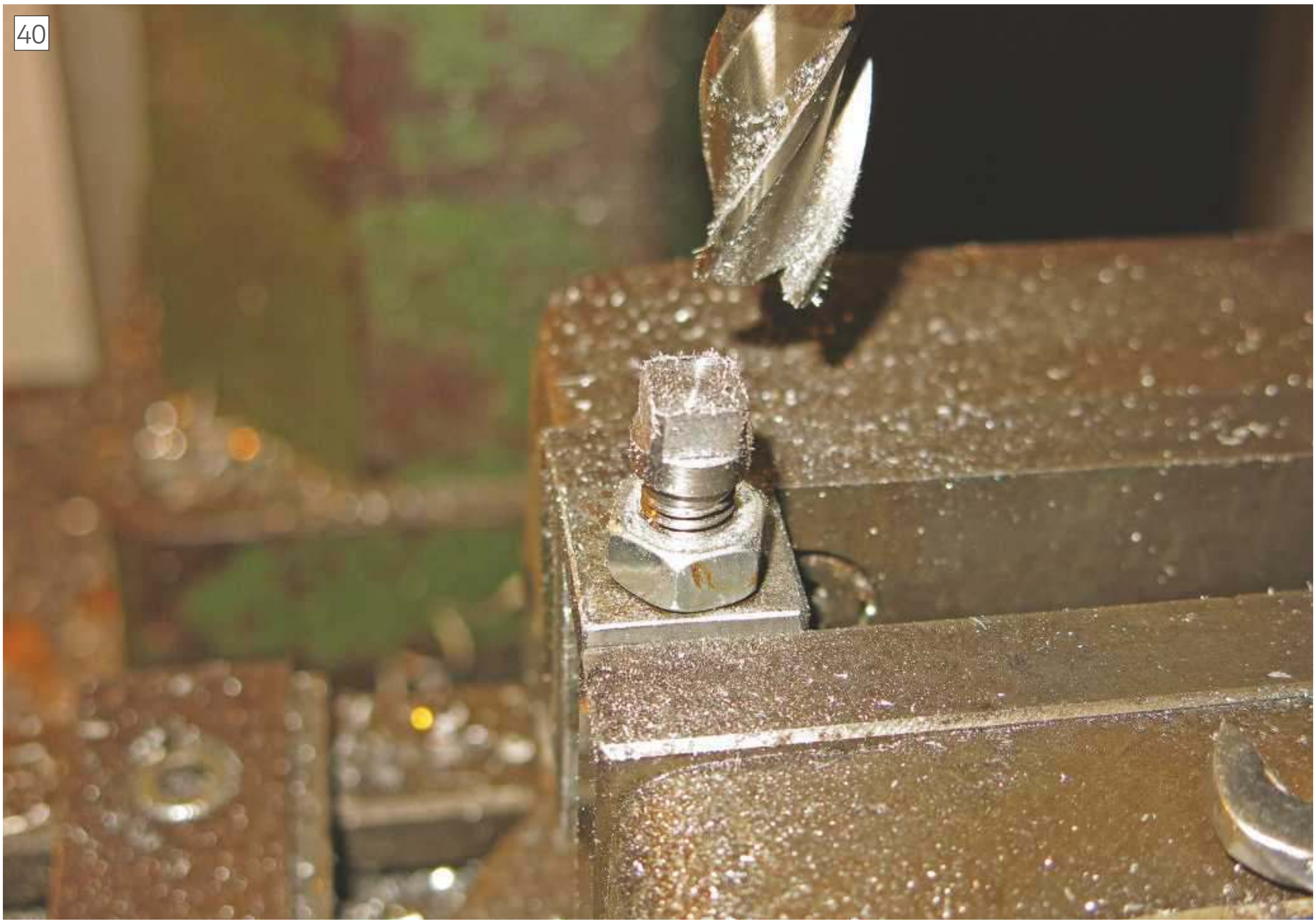


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against the weight of the table sub assembly. Adjustment is now easy and precise.

To keep the swarf off the slides I used the saw to accurately cut some thin aluminium and bent it to form an angle which fitted closely between the bearing blocks nearest the saw blade. Back on the mill with the support plate in the flat strips I positioned the guard and drilled through for two screws. Tapped the table, opened up the swarf guard and screwed it in place, **photo 43**. Another piece of the aluminium was cut and bent to a U shape and fastened to the underside of the table with two screws, **photo 44**. This arrangement should keep the swarf away from the slides but still let them be oiled.

Screw shortening

Needing to shorten some screws I cleaned up some angle and drilled and tapped holes from M3 to M10 close to the top edge and used two screws to attach it to the table. **Photograph 45** shows it in position together with a shortened screw. **Photograph 46** shows how easy it is to measure the final screw length before tightening the locknut and making the cut.

In use

Because I made the first bracket to be able to try the concept out, I was able to use it to make the final bracket. This included cutting thin aluminium, ½" aluminium, 40mm angle and 20mm thick mild steel. I found it really useful. The cylinder has enough force to cut through them all and in fact I have not so far found the air pressure to be critical. The thin sheet I fed by hand just using the guiding for accuracy. I have an actual cutting stroke of about 75mm which is enough for what I envisage at present. I am finding this device very useful.

Possible developments

The table size was dictated by the material to hand. A bigger table could offer support both sides of the saw blade which could be useful. I might well go for a 200 x 200mm table with a full grid of tapped holes on a 20mm pitch. You can always use the cylinder to hold the table in the extended position if you are hand feeding.

The fence arrangement is fairly basic, and I use a square off the

43

44

table edges to set it. Separate lengthways and crossways fences could have the setting guide incorporated. When setting to an angle I have so far been able to use one of the tapped holes and screws to secure the blade side end, and then either clamped the other end directly or clamped something to act as a stop to prevent it moving. It might be worth making a clamp to screw into the tapped holes in the table to hold this end.

It might be good to be able to mount a small vice, especially for round material which is more difficult to clamp so that the saw doesn't rotate it.

This attachment is intended to mainly make cuts that you will want to watch rather than right through cuts, so you can turn off the air before it can hurl the table down the slides. The cylinder is double acting but only used as single acting and I have thought about turning the unused end into a hydraulic damper. It would be fun but not really worth the effort. ■

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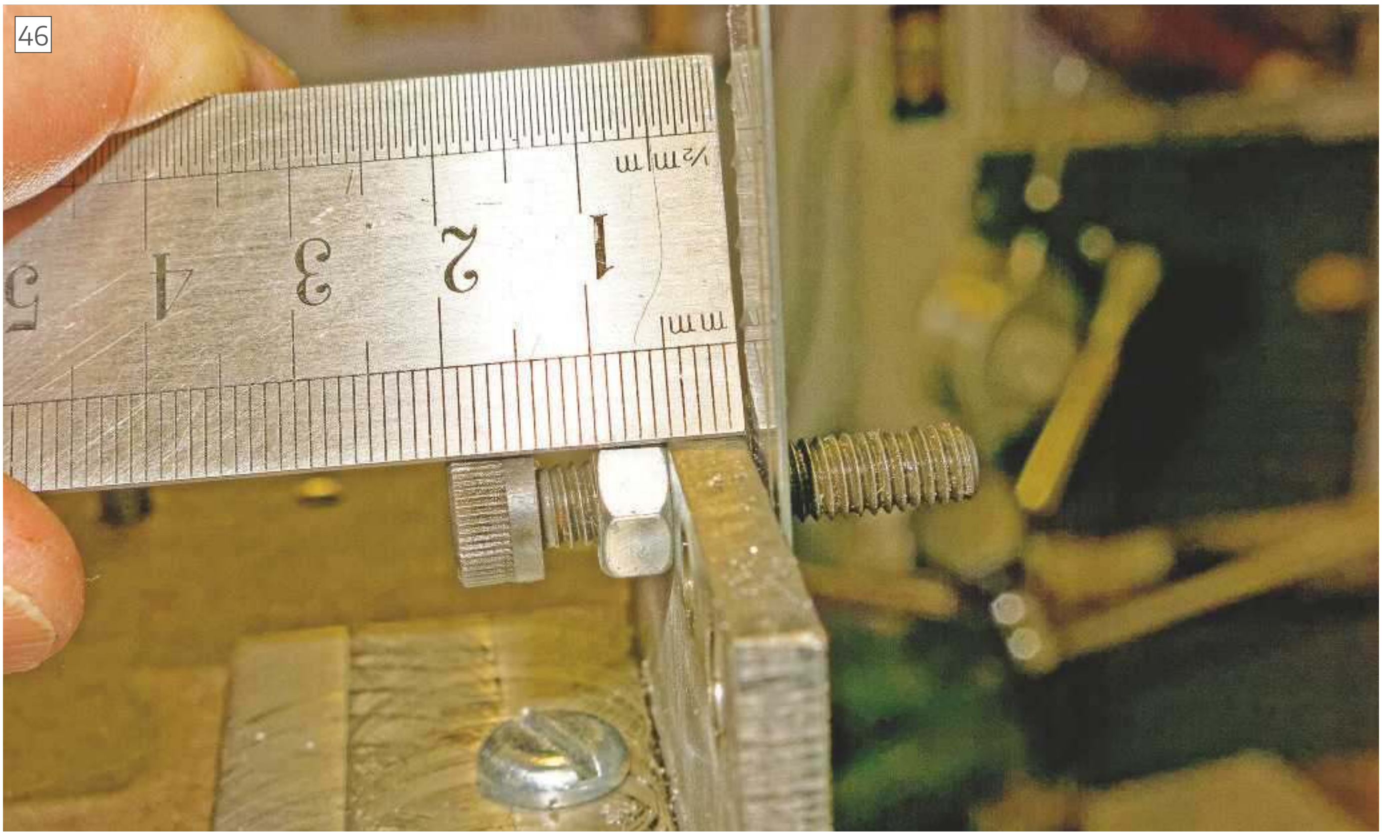

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An Exercise in CAD, or How to Draw (Internal) Gears.

Peter Shaw takes readers through his approach to drawing gears on a computer

Introduction

Some years ago, I was having trouble visualizing how epicyclic gearing would work and came to the conclusion that perhaps if I drew it out using CAD, including all the teeth, I could gain a better understanding. This I managed to do, and I produced some figures which appeared to show how it worked.

Unfortunately for me, I eventually discovered that the figure for the internal gear was wrong, even though it appeared to work on paper. I therefore resolved to attempt to improve matters. This article is the result of those improvements, and **fig. 1** shows an epicyclic gear system consisting of a 40T Sun wheel, two 20T Planet wheels and an 80T annulus or internal gear wheel, all drawn using the methods outlined below.

I should point out that this article does not set out to be a definitive guide to figure gears, nor does it set out to be a definitive guide to using CAD. Instead, it is merely a description of how I managed to produce figures of gears which are based on something resembling actual practice and which helped me to understand the hows and whys. The article is offered to perhaps help others who may be having similar problems.

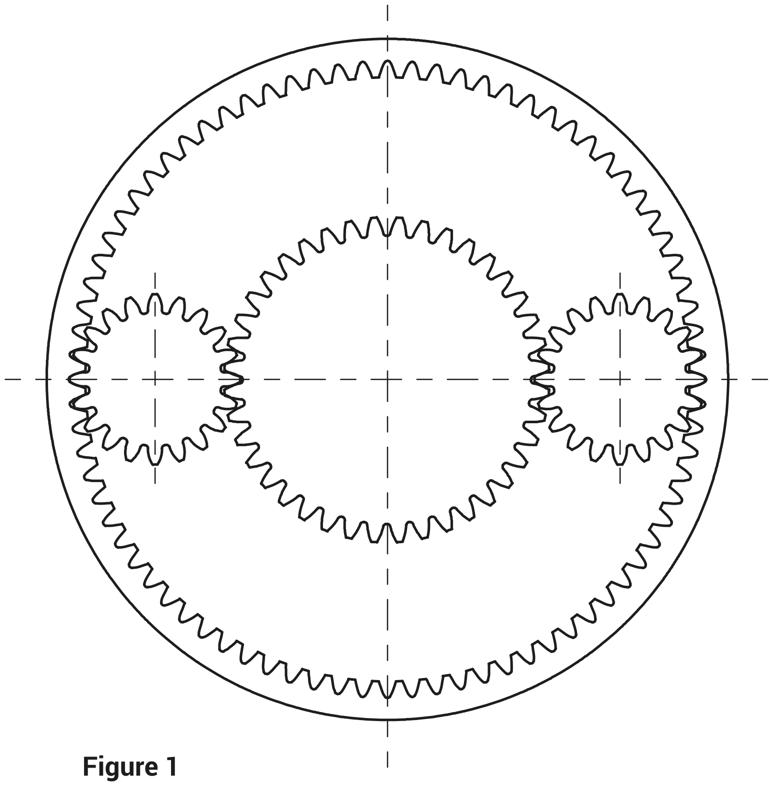


Figure 1

Literature on Gears & Gearing.

When I first looked into this subject, the only information I could readily find was that published by Ivan Law in his book Gears and Gearcutting (Workshop Practice Series (WPS) 17), together with a series of articles by Dave Lammas in Model Engineer (ME) starting 21 January 1990. Law does not cover internal gears, whilst Lammas devotes only a few paragraphs to this sub-division, and even then, it is based on how to cut the gears rather than the theory behind them. I did find a very complex set of articles by Len Snell in ME starting 26 September 1997.

By the time of my second attempt, Harold Hall had produced his Metalworkers Data Book (WPS 42) which gave formulae in both DP format and MOD format, the latter being for metric use, but still only for external, i.e. spur gears. I also found various articles on the internet about internal gearing, but again, they were rather complex.

Compromises

As I looked more and more into this subject, I began to realise that there was a lot of compromising going on. For instance, a complete set of commercial cutters for one pressure angle consists of eight cutters, each cutter covering a range of teeth. From which it follows that any one cutter can only be correct for one particular tooth value and that for all the others within that range, there must be an error, an acceptable error it is true, but still an error. Hence any commercial gear cutter is a compromise.

I also came to realise that internal gears to the involute profile were also a compromise as the teeth are “adjusted” to eliminate the probability of interference between a spur and internal gear pair. Which is what Lammas’ method of creating an internal gear effectively does.

Furthermore, Law says that the use of an arc in place of the involute curve not only simplifies matters for the amateur but introduces less error than that caused by the use of one cutter for a range of teeth. Yet another compromise.

A further problem is that for some combinations of number of teeth and pressure angle, the base circle from which the involute curve starts lies between the Pitch Circle and the Working Depth Circle. This means that the involute curve has to be extended backwards, something I found impossible to do. Using an arc to replace the involute curve overcomes the problem.

All in all, then, there is a strong case for creating a compromise figure using Law’s arc replacement method for spur/external gears and something similar to Lammas’s method of making internal gears.

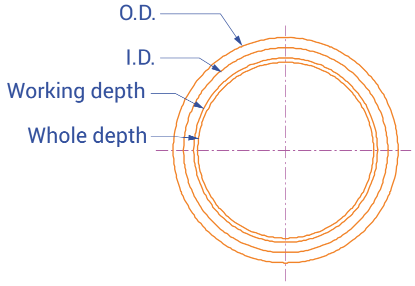


Figure 2

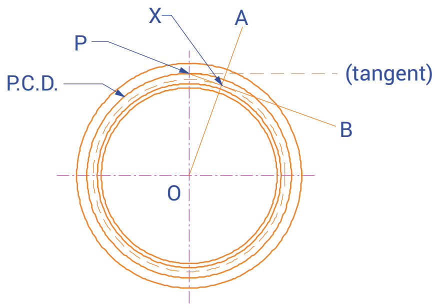


Figure 3

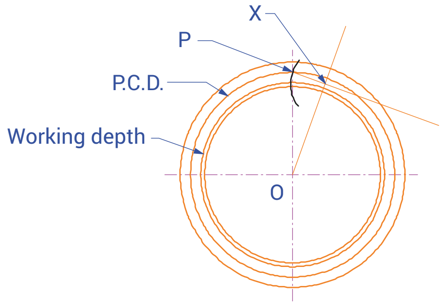


Figure 4

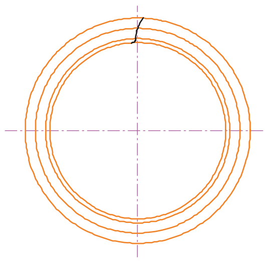


Figure 5

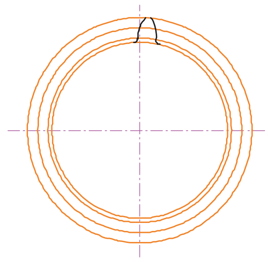


Figure 6

External Spur Gears

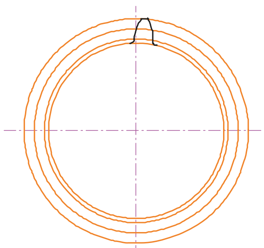


Figure 7

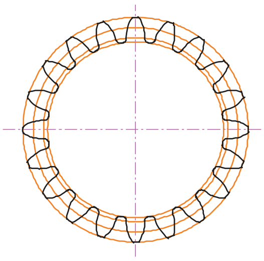


Figure 8

CAD

The CAD program that I use is DesignCAD 3D Max version 17.2 (DC17) dating from 2007 and is thus obsolete. Also, I use Linux rather than Windows and hence have to use an intermediary program called Wine in order to run DC17. There are a few problems with this arrangement, but nothing that cannot be worked around, the result being that I find this arrangement satisfactory and have no intention of either upgrading DC17 or replacing it.

This does mean that there is a problem in that the commands I use in DC17 in all probability will not be exactly transferable to other CAD programs. Where I feel necessary, I have therefore tried to describe what the various commands do in addition to using the actual commands: it will be up to you to translate those descriptions into commands suitable for your CAD program.

It is worth pointing out that the procedures to be described involve the figure of temporary construction lines which will be deleted once the need for them is done. It will also be necessary to show and hide various lines as the figure proceeds. It is therefore suggested that use be made of the layer facility if provided as this will enable various lines to be hidden or shown at will. Furthermore, the use of different colours for the layers will aid identification. For what it's worth, I use the layers thus:

- Layer 1 (black, solid lines) for outlines, ie the final figure
- Layer 2 (pink, dash dot dash dot lines) for centre lines
- Layer 3 (red, dashes) for hidden details
- Layer 4 (green, solid lines) for dimensions
- Layer 5 (medium blue) for figure texts
- Layer 6 (dark blue, solid lines) for frame and figure titles
- Layer 7 (orange, solid lines)*
- Layer 8 (grey, solid lines)*
- Layer 9 (turquoise, solid lines)*
- Layer 10 (dark green, solid lines)*

* for constructional purposes

The use of colour for the individual layers and functions in a figure may be controversial, especially as we are used to a single colour, usually black, however D.A.G. Brown in his book "CAD for Model Engineers" (WPS No.29) discusses this very point and gives a clue to his colour scheme. Needless to say it is different to mine, but he does say (in respect of colour): "Sort out in your own mind a plan of campaign and stick to it." For myself, I find it very helpful to be able to use colour to identify the different layers and to be able to easily hide one or more layers on demand.

Mathematics and Precision

There is no escaping from the fact that some relatively simple mathematics is required, however this is nothing more than the ability to use the standard four functions as long as you use purely graphical construction methods. There are instances where you could use pi, sines, cosines or tangents to calculate various parameters, but why do that if it can be avoided? It may be thought that using graphical methods may not be sufficiently precise, but it is probable that your CAD program will have an internal precision far exceeding what is required and therefore graphical methods will be just as precise. For what it's worth, DC17 is able to use and display up to 15 decimal digits, but since my equipment cannot measure more precisely than 0.01mm, I usually set DC17 to display two, or occasionally three, decimal digits whilst remaining secure in the knowledge that the internal precision is far greater.

I should mention that I only use metric units, hence the comment above re 0.01mm. This also means that instead of using diametral pitch (DP), I use module (MOD), a metric term defined as the Pitch Circle Diameter in millimetres divided by the number of teeth.

How to draw External or Spur Gears using the Simplified scheme

There are a number of different tooth forms available, but for most people, it is likely that the involute form will prevail. Furthermore, it seems that involute teeth using a pressure angle of 20 degrees are most prevalent, but alternatives such as 14½ degrees may be found. For more information on both of these subjects please refer to Ivan Law's book. For the purpose of this article I have concentrated on MOD1 involute teeth with a 20 degree pressure angle. I have also used information from Harold Hall's book, especially where this information appeared simpler.

It is likely that for most people, decisions on the number of teeth (N) and size of teeth (ie MOD) will already have been made. If not, then you will have to decide these factors first.

Start by selecting Layer 2 and draw both vertical and horizontal centre lines. These should be longer than the diameter of the outside diameter of the teeth. Switch to Layer 7 and draw the outside diameter circle (OD), the pitch circle (PCD) and the whole depth circle as shown on **fig. 2**.

Outside Diameter (OD) = (N+2) x MOD

Pitch Circle Diameter (PCD) = N x MOD

Whole Depth circle diameter = OD - (2 x H) where Whole Depth (H)=
2.4 x MOD (MOD less than 1.25) or
2.25 x MOD (MOD =1.25 and coarser)

The fourth circle to be drawn is that showing the working depth of penetration of a tooth on an engaging gearwheel. This is not normally required, however for the purposes of this article it will be needed when figure the fillet in the bottom of the tooth space. This is:

Working Depth Diameter = PCD - (2 x MOD)

Note that the distance between the working depth circle and the whole depth circle represents the tooth clearance gap in the bottom of the tooth space and is usually represented by "f".

Another circle which may be drawn if desired is the base circle but unless you are figure the true involute, it isn't needed. (I have shown it dashed on fig. 3.) What is required though, is it's radius drawn along a line from the centre of the circles at an angle away from the vertical equivalent to the pressure angle. It's radius can be calculated from:

Base circle radius, OX = cos(pressure angle) x pitch circle radius.

However we are trying to use purely graphical methods. Refer to Fig. 3. Start by drawing the line OA from the centre of the circle and offset from the vertical by the pressure angle. Now draw the line PB at an angle equivalent to the pressure angle to cut the line OA at point X,. This will be the radius of the base circle. In DC17, this requires either a negative angle of -20 degrees, or a positive angle of 340 degrees. Note that the length of lines OA and OB are indeterminate, just sufficiently long enough for the drawing. Also note that the tangent to the pitch circle, although shown, does not need to be drawn.

> Normally, one would expect to use calculations based on the Pitch Circle, however CAD programs offer graphical methods which in this instance are far easier.

At this stage one would start the construction of the involute curve, however, in the simplified form all we need to do is draw an arc centred on point X and with a radius equal to PX. I found that the easiest way to do this was to draw a circle of the required radius, cut the circle in two places and delete the majority of the circle leaving just the arc as shown in **fig. 4**. As this becomes part of the final drawing, place this arc on Layer 1.

To complete this side of the tooth, we need to firstly trim the arc level with both the outside diameter, OD, and the working depth diameter, and secondly, to create a fillet from the bottom of the arc to the whole depth circle. In DC17, the Trim command does the job.

To create the fillet, first create another whole depth circle on top of the existing circle but on Layer 1. Hide everything except for Layer 1. This should leave visible a figure of a circle with a stalk at the top but with a little gap between the stalk and the circle. Now create a fillet in the correct direction between the bottom of the arc and the new whole depth circle with a maximum radius equal to the tooth clearance gap, f. In DC17 this gives a fillet to the left from the side of the embryo tooth to the circle, and a gap to the right to where the program has deleted part of the circle to create the fillet (it may be necessary to zoom in to see the gap, but it will be there). Also, in DC17, the fillet and the arc (the remaining part of the circle) are separate entities. Delete the remaining part of the new whole depth circle (ie the large arc) leaving the side of the embryo tooth and the fillet. If your program allows it, you should group these two elements together such that they act as one entity. This will avoid any problems with losing any of the parts of the figure when performing other operations. Restore the hidden lines, delete the lines OA, PB, and any texts, and the result should look like **fig. 5**.

The next step is to draw the other side of the tooth. As this is a mirror image, if your program allows you to produce the mirror image, then this will be the easiest way to do it. If not, then you will have to draw the side in a similar manner to that shown above but with directions reversed. Whichever method is used, it will be necessary to place the mirror image the correct distance away from the original, at the correct angle and at the correct side.

Normally, one would expect to use calculations based on the Pitch Circle, however CAD programs offer graphical methods which in this instance are far easier. From fig. 5 it will be seen that the vertical centre line passes through the intersection of the tooth side and the Pitch Circle. Therefore a similar centre line at the appropriate angle should pass through the same intersection on the opposite side of the tooth.

To find this line all we have to do is to draw a line from the centre of the circles and rotated by an angle equal to half the angle subtended by one complete tooth and space. (Note that some authorities recommend reducing the tooth thickness to tooth space from 50:50 to 48:52 and this will affect the spacing and hence the positioning of this line.) So, start by changing to Layer 9, then, where tooth and space are equal, divide 360 degrees by the number of teeth, divide the result by 2 to account for the space, draw the new line at this angle from the centre on the new layer. Next draw a new PCD circle on Layer 9, hide Layers 2 and 7, followed by cutting the new circle just to the right of the new radial line, and again just to the left of the existing tooth side. Now delete the remainder, if not automatically deleted, of the circle leaving only a short arc. It is now possible to mirror the existing tooth side onto the new radial line. In DC17, this requires selection of the existing tooth side by clicking on the junction of the short arc and the existing tooth side, ensuring that the tooth side is selected and not the arc, then selection of Custom Axis within the Mirror command, whereupon a reversed image of the tooth side will appear and which can be moved to, and set to the junction of the short arc and the new radial line. **Figure 6** refers. (Note that I have restored all Layers for this figure.)

Having drawn the two sides, the tooth top may now be completed. Delete the short arc and radial line on Layer 9, restore Layers 2 and 7, then switch to Layer 1 and draw a new OD circle on top of that existing on Layer 7. Now hide Layer 7 again, cut the new circle on each side of the sides of the tooth leaving a short arc. Finally, trim the short arc to complete the top of the tooth. Now for security, combine the two sides and top into one group. Restore all the hidden lines. **Figure 7** refers.

(For information, I created Figures 5, 6 & 7 side by side on the vdu. I found this enabled › the sequence to be more easily understood.)

All we need to do now is to duplicate the tooth around the circle using Circular Array or equivalent. (In DC17, Circular Array is a means of duplicating an element any number of times around a circle or arc: there is also Array which duplicates elements in a straight line as required in one or more directions.) To do this, hide all layers except Layer 1, then use Circular Array to create the additional teeth, 19 in this figure. Note that in DC17, the original is counted as the first copy, hence it is necessary to set the command to create 20 copies. If you have gaps in the roots, then you will need to fill it by drawing a straight line between the ends of two adjacent fillets followed by using Circular Array to create a further 19 copies. Alternatively, you may have overlapping ends in which case you should reduce the fillet radius to suit. On completion, combine the figure into a single group for security.

Now rotate the completed gear wheel as necessary. This can be done be selecting the centre of the circle which should automatically select all the teeth. Then, by using the Rotate or equivalent command, the teeth may be rotated around the centre by any desired angle. Note that restoring Layer 2 may be required. Now restore all layers to show how the teeth fit between the OD circle and the Whole Depth circle, and how the teeth are now lined up with the vertical and horizontal centre lines. **Figure 8** refers and should be compared with fig. 7.

Finally, delete the circles etc on Layer 7 unless they are to be retained for reference purposes.

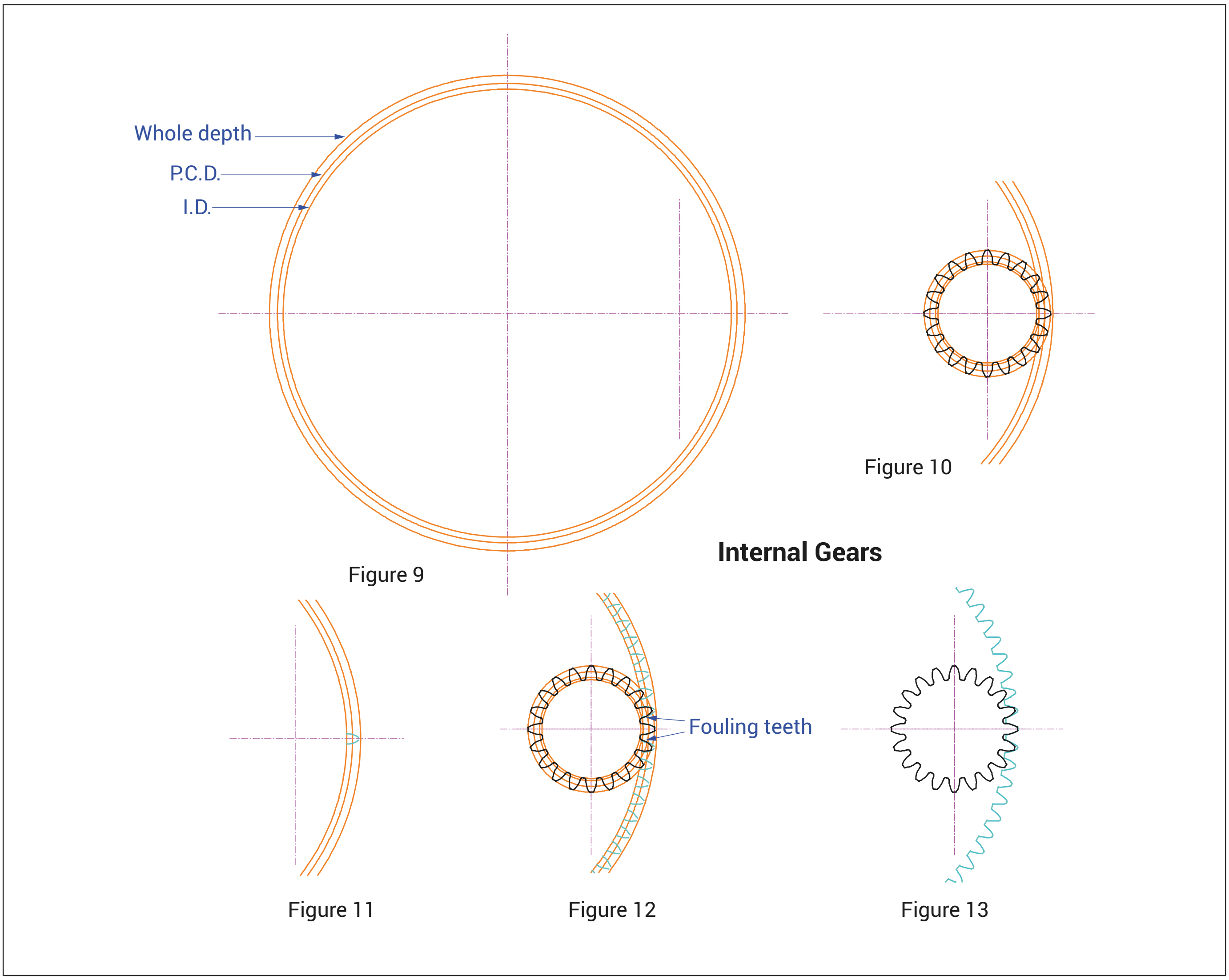
How to draw Internal Gears based on the Dave Lammas scheme.

When I was doing my research for this project, I failed to find a relatively easy way to draw internal gears. What I did find though, was that other people have also had problems, so it seems that there probably is not an easy method of figure internal gears. I therefore decided to use Lammas's method of making internal gears as a guide towards creating a figure. The Lammas method involves making a cutter out of hardenable steel which is identical to a mating spur gear, and uses a single tooth to cut, or gash, an initial slot around the inside of the internal gear, thus producing a series of slots identical to the teeth of the mating spur gear. This can be easily copied in CAD.

Unfortunately, with just the single gash or slot, the pinion cannot engage or disengage as the two gears rotate: it is therefore necessary to shave the internal gear teeth to allow the pinion teeth to move in and out of engagement. Lammas does this by using a 120 degree arc of teeth on the opposite side of the cutter gear to preform this shaving action: in CAD, the same idea can be achieved by noting where the spur gear teeth overlap the internal gear teeth and then adjusting the sides of the teeth to allow sufficient clearance.

The remainder of this section explains how to perform both these actions in CAD. There is, though, a problem in that the size of the internal gear makes for a rather large figure, most of which is empty space. I have therefore shown extracts only wherever possible.

All gears mesh correctly along their pitch circle, hence the calculation for the internal gear pitch circle must be the same as that for the spur gear pitch circle, that is N x MOD. Next consider the tips of both sets of teeth. Both sets of teeth project into the corresponding gaps and there must be clearance between the tooth tip and the bottom of the corresponding gap. Therefore, the Inner Diameter (ID) (or Addendum Circle) of the internal gear (corresponding to the



Internal Gears

Figure 9

Figure 10

Figure 11

Figure 12

Figure 13

spur gear Working Depth Diameter) must be equal to the PCD minus twice the tooth Addendum, i.e.

ID = PCD - (2 x MOD) = (N x MOD) - (2 x MOD) = (N - 2) x MOD.

Similarly, the Whole Depth Circle diameter for the internal gear must be equal to the ID plus twice the whole depth of the tooth, ie ID + Whole Depth x 2. So, for an internal gear with 80 MOD1 teeth:

ID = (N-2) x MOD = 78

PCD = N x MOD = 80

Whole tooth depth = 2.4 x MOD (for gears less than 1.25MOD) = 2.4

Whole tooth depth circle = ID + (Whole Depth x 2) = 82.8.

The three circles can now be drawn on Layer 7 along with the centre lines on Layer 2. **Figure 9** refers.

The Lammas method of cutting internal teeth requires that a cutting tool equivalent in size to the mating spur gear be used and mounted on the same centre as the mating spur gear. Therefore to draw this system, we need to know the position of this centre in relation to the internal gear centre. Assuming the use of the 20T Mod1 gear used earlier, this is:

(PCD Internal – PCD Spur) / 2 = (80 – 20)/2 = 60/2 = 30

This can now be marked as an additional vertical centre line on Layer 2, 30mm to the right of the main vertical centre line, as shown on fig. 9.

Copy fig. 8 including the four circles - OD, PCD, Working Depth & Whole Depth, and the two centre lines. Make into one entity. Move this copy onto the new centre lines as shown in **fig. 10**.

Now use a suitable command to trace and copy both sides of the spur gear tooth located at the 3 o'clock position. Use Layer 9 for this. Start where the side of the spur gear tooth crosses the spur gear's Working Depth Circle and click on every intersection ending where the tooth ends on the spur gear OD circle, five points in all. Note that it will be necessary to zoom in by a considerable amount in order to see these intersections.

In DC17, use the Curve command with the Save as a Line option deselected. Note that although the sides of the tooth are arcs and therefore could be traced by using an arc command, in DC17 it is better to use the Curve command since this will facilitate adjustment later. Note that there may be a slight mismatch on the addendum of the spur gear tooth between the existing curve and the new curve due to the Curve command not following the existing curve exactly. If so, in DC17, there is a mode known as Point Select Mode which enables the user to adjust a part of the curve as required. In this instance, the intention is to superimpose the new curve over the top of the spur gear curve. The Curve command may also be known as Cubic Spline or just Spline. Whatever it is called, the intention is that the command draws a smooth curve between all points selected.

Now move the spur gear figure away from its present position. This is not really necessary, but will allow the figure to appear less cluttered. **Figure 11** shows what it looks like with the spur gear figure removed, leaving the two new tooth sides on their own (it may be necessary to zoom in to see them). Next, select the two new curves, and using Circular Array or equivalent create 80 copies around the internal gear figure. Replace the spur gear figure and closely examine the sides of the new teeth and look for instances where they foul the spur gear teeth. For this drawing, these were the teeth on each side of the 3 o'clock position. **Figure 12** refers.

Switch to Layer 10 and create a new curve to replace the fouling curves. Start where the side of the spur gear tooth crosses the internal gear ID circle, moves through the point where the internal gear PCD circle and the new Layer 9 (tooth) curve coincide, then to the point where the Layer 9 curve coincides with the spur gear OD circle, and finishing on the free end of the original curve. Do this for both of the fouling curves.

Delete the contents of Layer 9, then move the contents of Layer 10 onto Layer 9. The easy way to do this in DC17 is to make Layer 9 current, hide all other layers which protects them from accidental modification, delete the embryo teeth followed by restoring all layers, then as before, move the spur gear figure out of the way, transfer the two new sides from Layer 10 onto Layer 9 changing colour as necessary.

Use Circular Array again to create 80 copies of each curve around the internal gear. Restore the spur gear figure, examine the teeth for fouling and make corrections as described above. I found that after two corrective cycles, I had achieved a situation where the curves seemed satisfactory.

> The circle enclosing everything was drawn to make the figure look "pretty". It serves no useful purpose other than to emphasise that this is an internal gear!

Complete the internal teeth by joining the tops and bottoms. To create a fillet for the root of the teeth I found it easiest to create an arc that joined the two sides with a smooth curve. For the top (ID circle) of the internal tooth, I drew a straight line between the two appropriate curves, followed by using Circular Array to add the two additions to all teeth.

Finally, hide everything except for Layer 9, select everything on Layer 9, e.g. all the teeth, and make into one group. Restore all layers and transfer the contents of Layer 9 onto Layer 1. **Figure 13** shows how the spur gear teeth mesh with the annulus teeth.

Creation of Figure 1.

Readers may be interested in how I created fig. 1. The process is relatively simple despite the large amount of text. Start by figure one 20T gear wheel and use that to create the annulus/internal gear wheel. As part of this process, the centre of the 20T wheel will have been determined, and can be used to determine the centre position of the second 20T wheel, and a vertical centre line drawn. The first 20T wheel may now be copied and the copy inserted in the second position using the vertical and horizontal centre lines for alignment, thus creating the two Planet wheels. A similar process can be used if, say, four Planet wheels are required.

From the two Planet wheels, the Pitch Circle Diameter for the 40T Sun wheel may be determined, and the 40T wheel drawn away from the main figure. The 40T wheel can be drawn in position, but there may well be interference between the teeth of the 20T wheels and the 40T wheel making it very difficult to rotate the larger wheel into alignment. Therefore, by figure it away from the main figure, the larger wheel may be correctly aligned before inserting into the main figure. As before, alignment may be achieved by means of the vertical and horizontal centre lines.

The circle enclosing everything was drawn to make the figure look "pretty". It serves no useful purpose other than to emphasise that this is an internal gear!

Conclusion

Although there is a lot of descriptive text, the actual process is relatively simple, and it should be possible to use this process for any combination of wheels. I have not tried any other combination since for my purposes, i.e. self-education, figure a single Planet wheel and annulus was sufficient.

It is also worth pointing out that the figure of the internal gear is based on Dave Lammas's method of making an internal gear. I understand that in fact, designing an internal/external gear system is much more complex than presented here. Nevertheless, from an amateur point of view, creating a figure in the manner presented here will go some way towards understanding the system. ■

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Special 5 for £20
Myford ML7/ Super 7 Rifle/ Bridge bed felts
£90
Tripus (German) on/off switch
£525
Union 10" pedestal grinder
£845
Tom Senior Mill
Each £2750
Harrison M250 5" x 24" centres six off
Please PHONE 0208 300 9070 to check availability or to obtain our list
DISTANCE NO PROBLEM! • DEFINITELY WORTH A VISIT • ALL PRICES EXCLUSIVE OF VAT
Just a small selection of our current stock photographed!
We are currently seeking late 'Myford Super 7B' & 'Super 7 large bore' model lathes!
SHIPPING WORLDWIDE

CHESTER Hobby Store


H80


H110


HV128


HV128S

	H80	H110
Max. Cutting Capacity @ 90°	**Round** 90mm	**Round** 110mm
	Square 85x85mm	**Square** 100x150mm
Max. Cutting Capacity @ 45°	**Round** 40mm	**Round** 100mm
	Square 38x38mm	**Square** 85x65mm
Blade Speed	20/29/50m/min	20/30/50m/min
Motor Power	0.4kW (0.5hp)	0.55kW (0.75hp)
Power Supply	240v	240v
Blade Size	1300x0.63x12.5mm	1640x0.65x13mm
Dimensions	760x295x465mm	965x410x500mm
Weight	44kg	60kg
Price inc VAT	£187.95	£309.75

	HV128	HV128S
Max. Round Capacity	128mm	128mm
Max. Rectangle Capacity	115x150mm	128x150mm
Blade Speed	65/95/165fpm	20/29/50m/min
Motor Power	0.25kW (0.33hp)	0.25kW (0.33hp)
Power Supply	240v	240v
Blade Size	1/2x64 1/2"	12.7x0.65x1635mm
Dimensions	895x457x985mm	1020x445x560mm
Weight	62kg	78kg
Price inc VAT	£385.00	£628.95

All our bandsaws have swivel arms and come with stand, manual and fitted blade. Spare blades are also available.

HV128 Features: Anti vibration rubber feet • Rugged cast iron construction • Mitre vice ensures positive material clamping between 45° to 90° • Adjustable stop • Sealed and lubricated steel/bronze worm gear drive • Automatic cut-off

HV128S Features: Cast base and arm for rigidity • Fully adjustable hydraulic down feed controls the rate of descent • Full blade cover • 3 belt speeds • Dual swivel cutting angle from -45° to +60°

For more information contact our **Sales Team,** call us on **01244 531631,** email us at **sales@chesterhobbystore.com** or visit **www.chesterhobbystore.com**

Prices may be subject to change without notice