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On the Editor's Bench

2018 The Year of Engineering

Did you know 2018 is the Year of Engineering? Neither did I, but if you visit **www.dft.gov.uk/year-of-engineering-2018** you will be able to find out about this initiative.

The Year of Engineering is a year-long government campaign to support the engineering profession in recruiting the next generation of engineers. Throughout 2018 they will showcase the variety and creativity of modern engineering to improve understanding of what engineers do. The organisers want to give young people, their families and teachers an opportunity to take a closer look at engineering.

The organisers are inviting partners to:

- work with us and other partners to create exciting and impactful initiatives and events
- raise the profile of your organisation as an exciting employer by showcasing the forward thinking work your organisation is doing
- join 'open door' and ambassador programmes to share what you do
- use the Year of Engineering brand to identify your own activity or event under our collective banner
- use our communication materials and #YOE to be part of the conversation
- share inspiring stories of engineering careers

While it looks like a bonanza for 'Buzzword Bingo' fans, the aims of YOE to get more youngsters aware of and interested in engineering can only be good thing. I hope to bring you more news of the Year of Engineering, so if you are involved with any 'impactful initiatives and events' or even any fun and inspiring engineering activities for young people, please let me know!

Power Supplies

Following John Firth's article on making a suds pump in MEW 263, both John and our arch-recycler, Mark Noel, have been in touch about re-using ATX power supplies.

Although most supplies, like the one used by John, use a single regulator to provide all the 12-volt supplies, it is possible to encounter ones that use separate regulators for the two 'yellow' 12V supplies. It's not always easy to check if this is the case, but if you common all the yellow wires on such a supply the inevitable mismatch between the two voltages mean it will probably shut down or even go 'pop'. The good news is that supplies with truly independent 12V supplies are relatively uncommon, although Mark has encountered one.

ATX supplies, being mass produced in enormous quantities are an extremely cost-effective way of sourcing high-current, low-power supplies. They are very popular for 3D printers and if you are familiar with these the usual way of wiring them keeps the two-way split of the 12V supply – one being used for the heated bed and the other for the hot end and stepper motors.

A new supply should make it clear which arrangement you have (although many single regulator designs masquerade as dual, simply having two separate current limiters), but obviously if you are repurposing an old, unmarked, supply then do watch for this problem.

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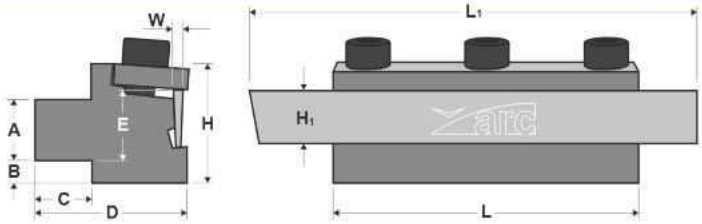

Code	A	B	C	D	E	H	L	W	H1	L1	Included Blade	Price
060-320-01006	6mm	10mm	10mm	27mm	6.5mm	22mm	56mm	1.5mm	10mm	80mm	M42 HSS-Co Blade 1.5x10x80mm	£22.40
060-320-01008	8mm	8.5mm			8.5mm							£22.40
060-320-01010	10mm	6.5mm			10mm							£23.50
060-320-01012	12mm	4.5mm	12mm	29mm	12.5mm							£23.50
060-320-01016	16mm	4mm	16mm	34mm	16.5mm	26mm	76mm	2mm	13mm	110mm	M42 HSS-Co Blade 2x13x110mm	£28.00

Spare M42 HSS-Co8 Parting Off Blades for Parting Off Blocks

Code	Grade	Section	Size	Price
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Code	Size †	Price	Code	Size †	Price
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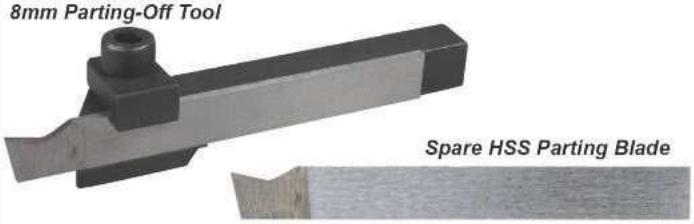
060-320-10008	8mm	£29.60			

† Sizes are nominal and can vary - some may be oversize.

8mm Parting Off Tool

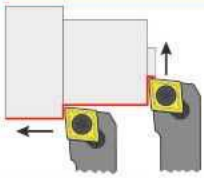
8mm Parting-Off Tool



Spare HSS Parting Blade

Code	Description	Price
060-320-00920	8mm Parting-Off Tool with HSS Parting Blade	£13.33
060-320-00940	Spare HSS Parting Blade 1.5 x 8.3 x 65mm	£5.44

ARC SCLC-R 95° Turning Tool Holders



Right Hand

Torx wrench included

Code	Type	Size	Insert Supplied	Price
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060-325-11010	SCLC R 1010 E06	10x10mm	CCMT060204	£17.14
060-325-11012	SCLC R 1212 F09	12x12mm	CCMT09T304	£18.49
060-325-11016	SCLC R 1616 H09	16x16mm	CCMT09T304	£21.28

ARC SCLC-L 95° Turning Tool Holders

Left Hand

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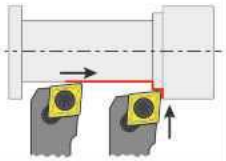
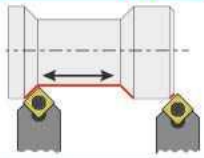


Code	Type	Size	Insert Supplied	Price
060-325-12006	SCLC L 0606 D06	6x6mm	CCMT060204	£14.56
060-325-12008	SCLC L 0808 D06	8x8mm	CCMT060204	£14.56
060-325-12010	SCLC L 1010 E06	10x10mm	CCMT060204	£17.14
060-325-12012	SCLC L 1212 F09	12x12mm	CCMT09T304	£18.49
060-325-12016	SCLC L 1616 H09	16x16mm	CCMT09T304	£21.28

ARC SSDC-N 45° Turning Tool Holders



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060-325-13008	SSDC N 0808 D06	8x8mm	SCMT060204	£14.56
060-325-13010	SSDC N 1010 E06	10x10mm	SCMT060204	£17.14
060-325-13012	SSDC N 1212 F06	12x12mm	SCMT060204	£18.49
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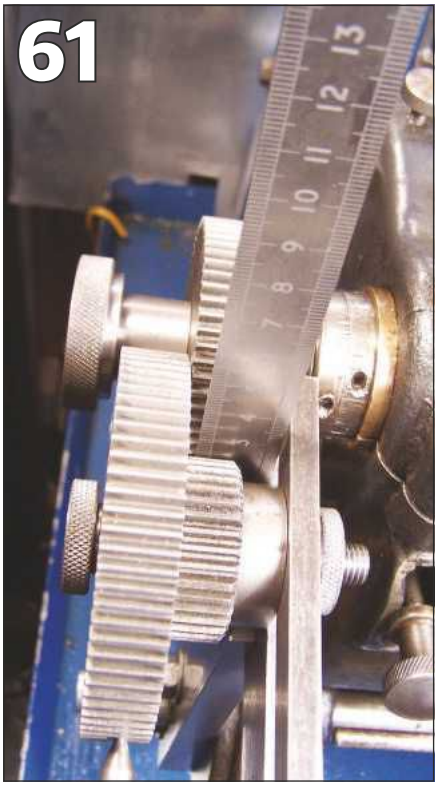

See page 36 for details.

Coming up...

in our next issue

Coming up in our next issue, MEW 265 another rewarding read.

Regulars

ON THE COVER

This month's cover features Stewart Hart's robust clamp drill, his write up includes detailed plans and starts in this issue

HOME FEATURES WORKSHOP EVENTS FORUMS ALBUMS

Visit our Website

www.model-engineer.co.uk

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

THIS MONTH'S BONUS CONTENT

Log on to the website for extra content

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

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

Odd Hole to Correct Size
- Discussions of an old trick to make a twist drill into a cheap reamer

Sine Protractor
- Another, simpler, project from Stewart Hall

What Did You Do Today?
- A New Year and New Thread starts - join in and share your workshop triumphs and tragedies!

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Setrack Curve - Single	ST905x1	£8.00
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MSS

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Potty Clamping Drill

This design for a clamp drill by Stewart Hart generated a lot of interest on the forum

When I visit a fellow model engineers workshop I can't help being extremely nosey; I'm unashamedly looking for ideas that I can use. Whilst visiting my friend Peter's workshop my eyes greedily fell on a windy drill fixture he had clamped to the frame of the 7¼" gauge loco he is building. He was using the fixture to drill the frame to take some of the motion brackets, I could immediately see the advantage of using this fixture as it took out the risk of the drill wandering, break out snatching and drill breakages, you get from a hand-held drill. I started to quiz Peter on the drill and he said, "it's just something I knocked up from bits and pieces I had lying around, it's very handy though", **photo 1**.

Anyone who's worked in Industry, particularly around the shop floor would be familiar with phrases: knocked up, lashed together, cobbled together etc. It usually refers to a bit of kit produced in a hurry to deal with an urgent job or to make a particular job easier. This bit of kit is usually crudely made from any suitable bits of material lying around it may even be an adaptation of an existing bit of kit. The important thing is that it gets the job done. Once the job is complete it is often discarded, lying around to be used for something else or just scrapped off when its original purpose has been forgotten, but occasionally a bit of kit is "knocked up" that proves to be particularly useful and ends up in regular use - I think this will be the case with this Clamping Drill.

I used a Silverline air drill purchased from a well-known on-line auction sites, **photo 2**, my Grandkids thought it was a Jedi Light Sabre. I chose this particular drill because it has a nice parallel section, lending itself very nicely for clamping, other makes of drills had rounded sections that would make clamping difficult. And of course, you don't need to use an air drill if a suitable electric drill could be found that could be used. I've refined Pete's design a little bit in that I've incorporated a toolmaker clamp arrangement into the base, instead of using separate clamps - General Assembly **fig. 1**.

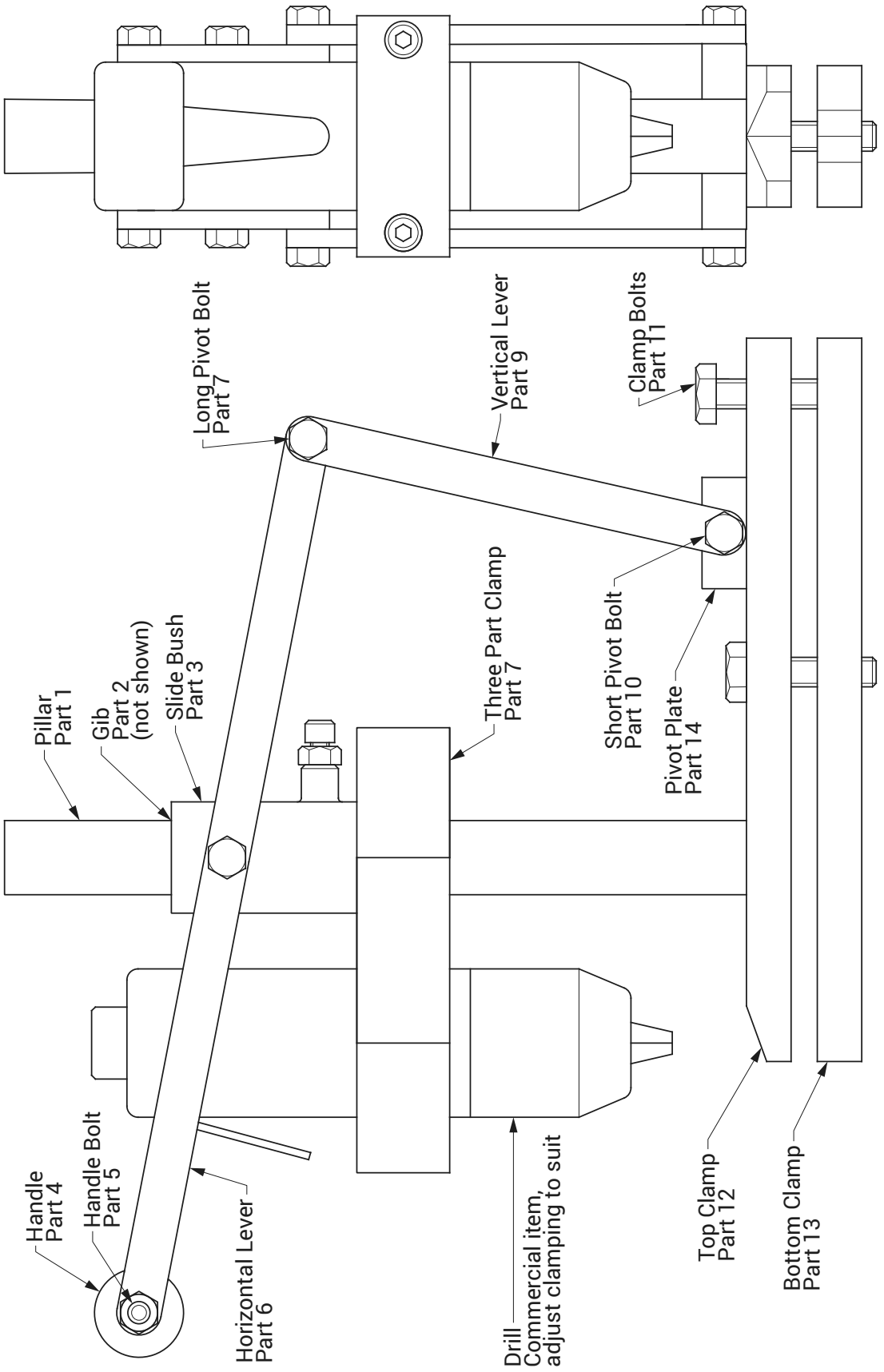
The only material I bought apart from the drill was

Peters 'Knocked up' Drill

Jedi Light Sabre

Material Gathered Together

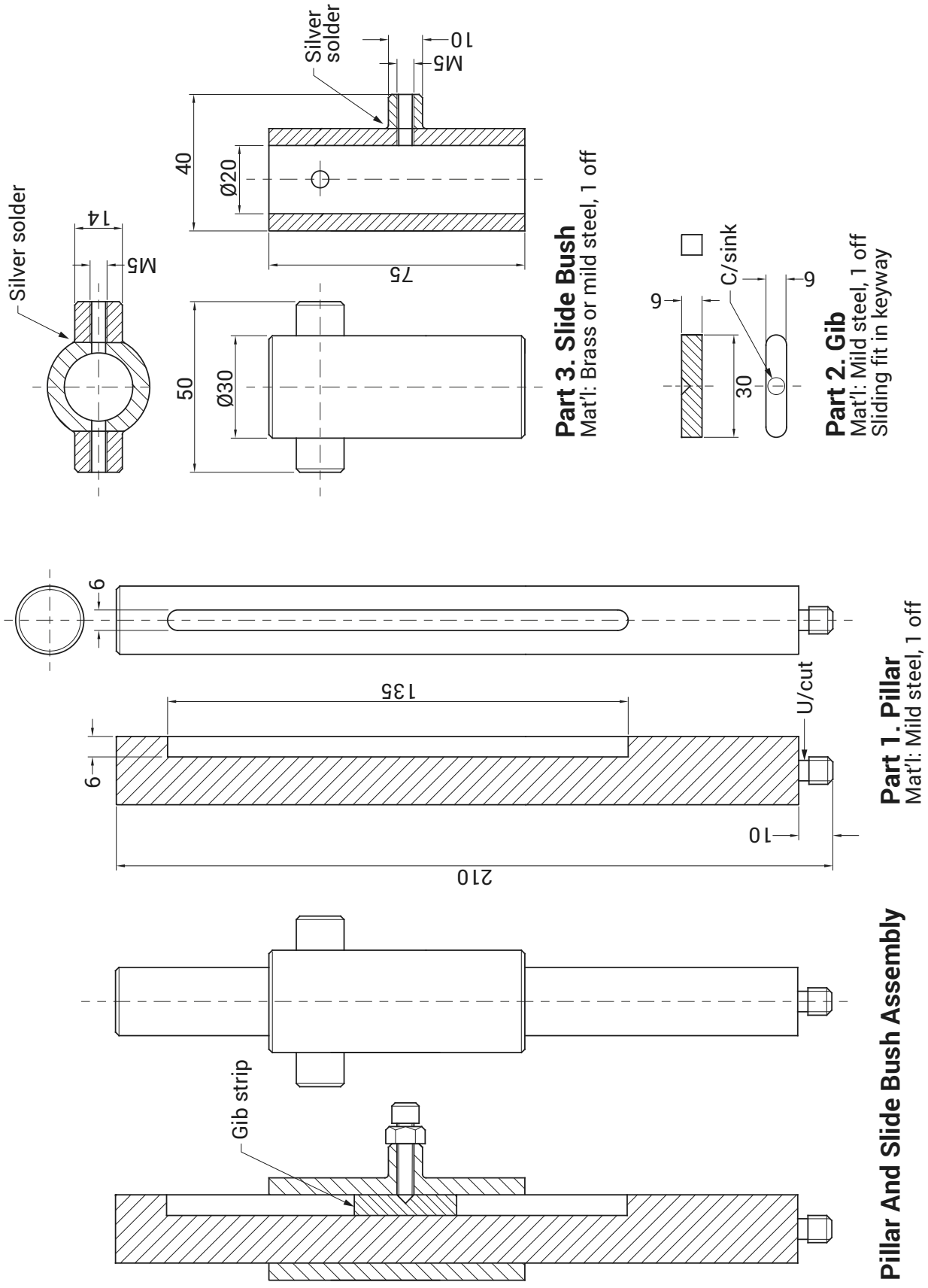
Fig.1



General Assembly

Note: Mat'ls & sizes can be altered to suit local availability

Fig.2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M5
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40
Ø20
75
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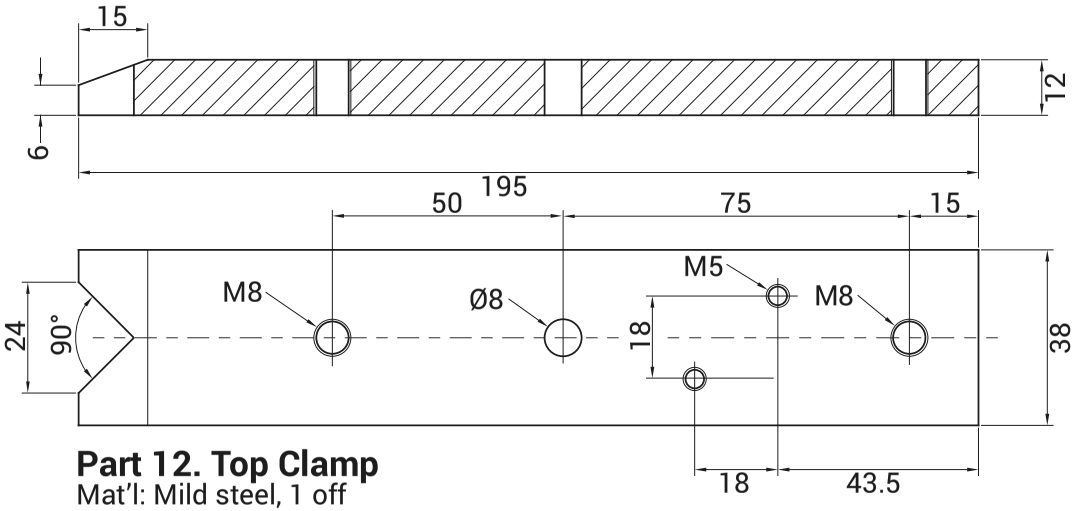
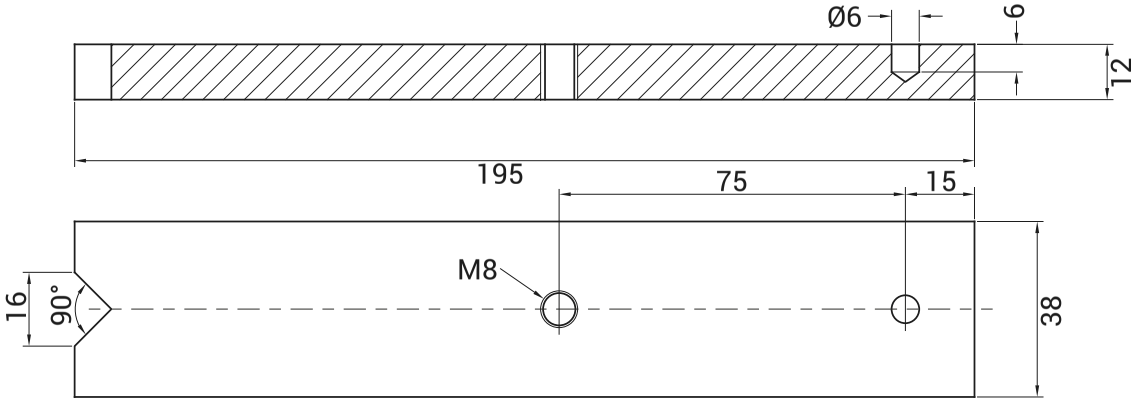
14
M5
50
Ø30
Part 3. Slide Bush
Mat'l: Brass or mild steel, 1 off
C/sink
9
9
30
Part 2. Gib
Mat'l: Mild steel, 1 off
Sliding fit in keyway
6
135
U/cut
6
10
210
Part 1. Pillar
Mat'l: Mild steel, 1 off
Gib strip
Pillar And Slide Bush Assembly

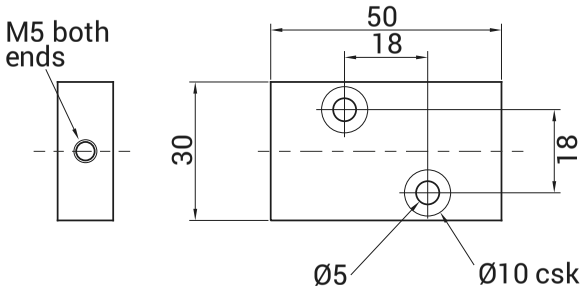
Fig.3



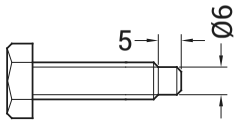
Part 12. Top Clamp
Mat'l: Mild steel, 1 off



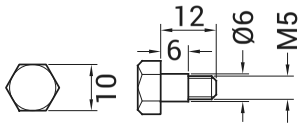
Part 13. Bottom Clamp
Mat'l: Mild steel, 1 off



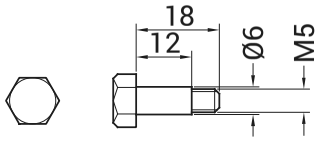
Part 14. Pivot Spacer
Mat'l: Mild steel, 1 off



Part 11. Modification To Std. M8 Bolt
Mat'l: Mild steel hex, 1 off



Part 10. Short Pivot Bolt
Mat'l: Mild steel hex, 4 off



Part 8. Long Pivot Bolt
Mat'l: Mild steel hex, 2 off

Drilling and Tapping Top Clamp

Spotting through to mark hole position

Roughing out the slide bush

Using the spin indexer to drill holes for spigots

Bush fluxed for soldering

Finishing off the bore

Milling out the V

the aluminium plate for part 7 the Three Part Clamp, all the rest of the material in the best tradition of a "knock up", came from my material stash, some of this material in its previous life had been painted, cleaning this off would do nothing to aid its function so it was left in this state, again in the tradition of a "knock up". My design was influenced by the material I had in stock and my drawings reflect what I made, you can of course follow my drawing but better still just adapt my drawings to suit what you have around you, just follow the basic idea, **photo 3**.

Parts 12 and 13 Top and Bottom Clamp were the first parts I made, the material was originally salvaged from some large garage doors. Starting with Part 12 Top Clamp simply mark the centre line and measure and centre pop the hole positions and drill and tap as required, the bottom clamp has fewer holes but the 6mm blind hole needs to be accurately positioned. The best way to do this is to first drill and tap the M8 hole then use this to clamp the top and bottom together then simple spot through to the bottom clamp ensuring everything will line up, **photos 4** and **5**. The two V shape cut outs were first roughed out with a hack saw and finished off with an end mill, **photo 6**. Use two M8 bolts for clamping. Part 11 is one of these bolts modified to engage in the Bottom Clamp.

The Pivot Spacer Part 14- was made from the same material as the clamps and is a straight forward drilling and tapping job, you can choose not to countersink if you don't want to.

Slide Bush Part 3 - I made this from a piece of brass, but mild steel would do just as well, this was first roughed out and using the spin indexer the spigot holes for the threaded bushes were drilled, the bushes were roughed out with a spigot at one end and a nice deep centre in the other, the spigots were well fluxed up inserted in the bush and the whole lot silver soldered together. After soldering the part was returned to the spin indexer and picking up on the centres the holes drilled and tapped, remount the part in the lathe for finishing off the bore for a nice sliding fit on the Pillar the part was then left in the pickle bath for a couple hours, rinsed off in cold water and cleaned up with a bit of emery. **Photos 7, 8, 9, 10.**

● To be continued

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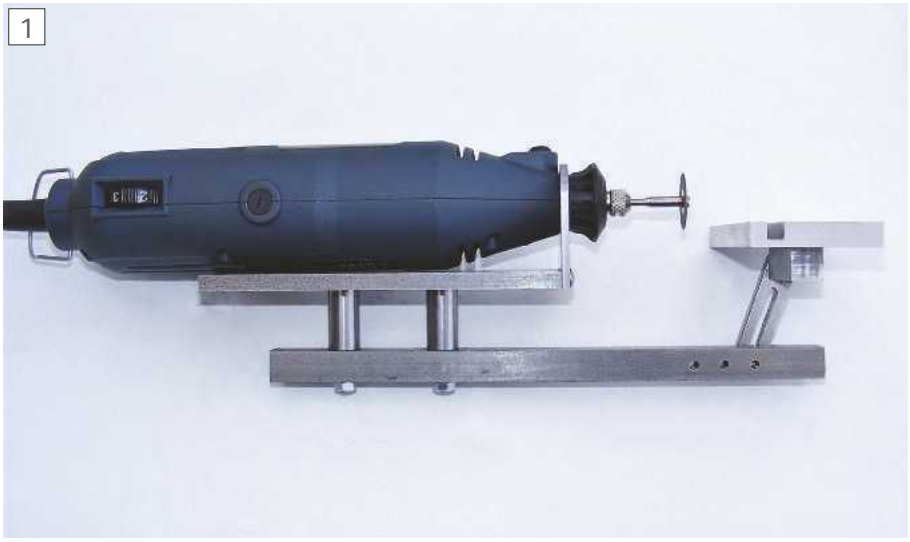
Mike's WORKSHOP

Rotary tool stand

Mike Cox describes a useful accessory for rotary tools

Rotary tools are very useful tools for all manner of cutting, grinding and smoothing operations. They are designed to be used held in the hand or with a flexible shaft. The tool is then brought up to the work to carry out the specific cutting, grinding or sanding operation required. This way of working is fine for many operations but sometimes it would be better if the rotary tool could be firmly fixed in position and the work moved instead. Some means of guiding the work past the tool would also be advantageous to ensure accuracy.

Marvin Klotz posted an article web for a stand to hold a Dremel tool that had a sliding table to facilitate guiding the work past the tool. My rotary tool is not a Dremel but a cheaper version supplied by ALDI and the Marvin Klotz design was not directly applicable to my tool. In this article I describe my implementation of the idea. Many of the non-Dremel rotary tools are very similar to the ALDI Powercraft version that I have so it should be simple to adapt to many other suppliers' products.



The completed accessory

The finished stand is shown in **photo 1**. It consists of a support bar, a bracket carrying the rotary tool on the left-hand side and a small table on the right-hand side. The table height and angle are adjustable.

The rotary tool bracket.

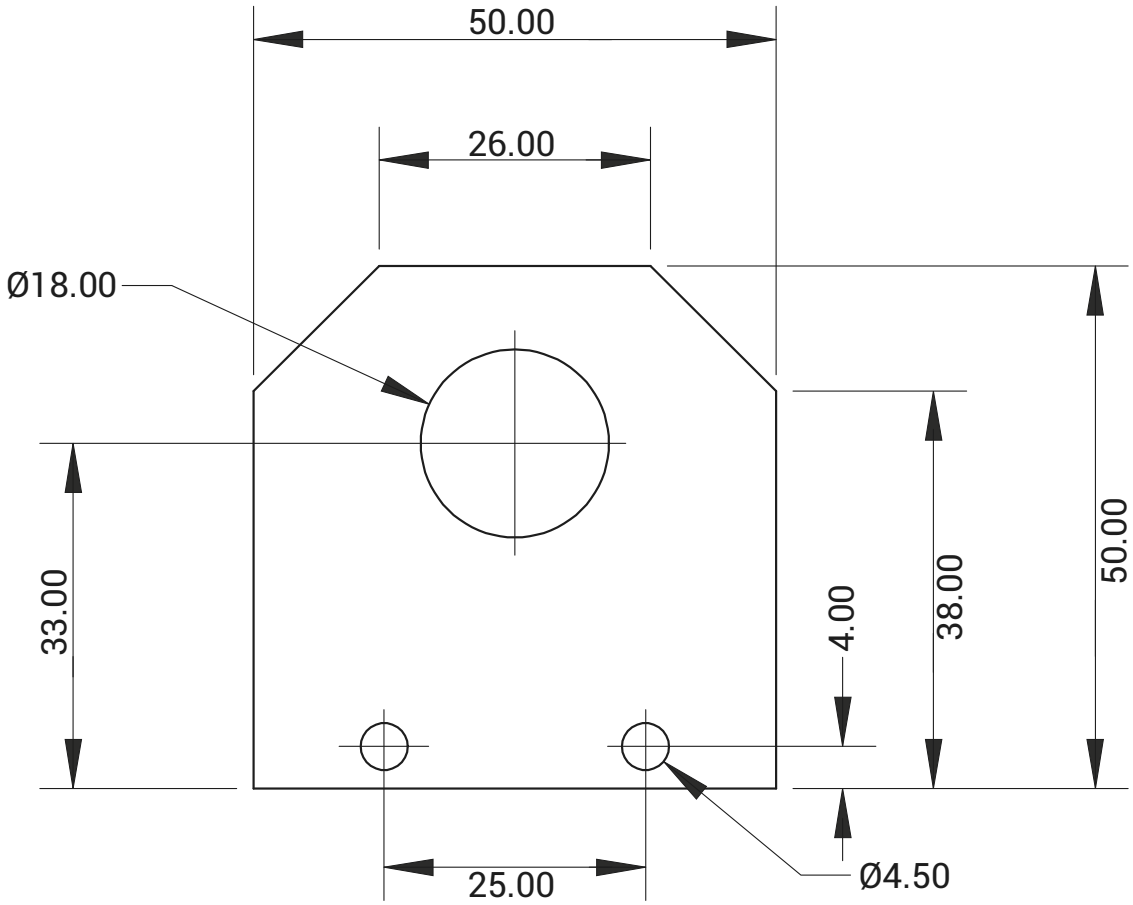
The first step in making this stand was to find a good way of securing and supporting the rotary tool. The rotary tool had a nose piece that unscrews, **photo 2**, and this was used to provide a secure fixing.

> Sometimes it would be better if the rotary tool could be firmly fixed in position and the work moved instead.

The rotary tool was attached to a bracket, **photo 3**. This was made in two pieces and screwed together with M4 button head cap screws. The front piece, **fig. 1**, was made from 3 x 50mm steel flat. This was marked out, cut to size and then drilled out. The large 18mm hole was drilled using a step drill. The base part of the bracket was made from a piece 6 x 50mm steel flat, **fig. 2**. This was cut to length and both ends were milled to make them at right angles to the other faces. The piece was then marked out, drilled and tapped.

Rotary tool with unscrewed nosepiece

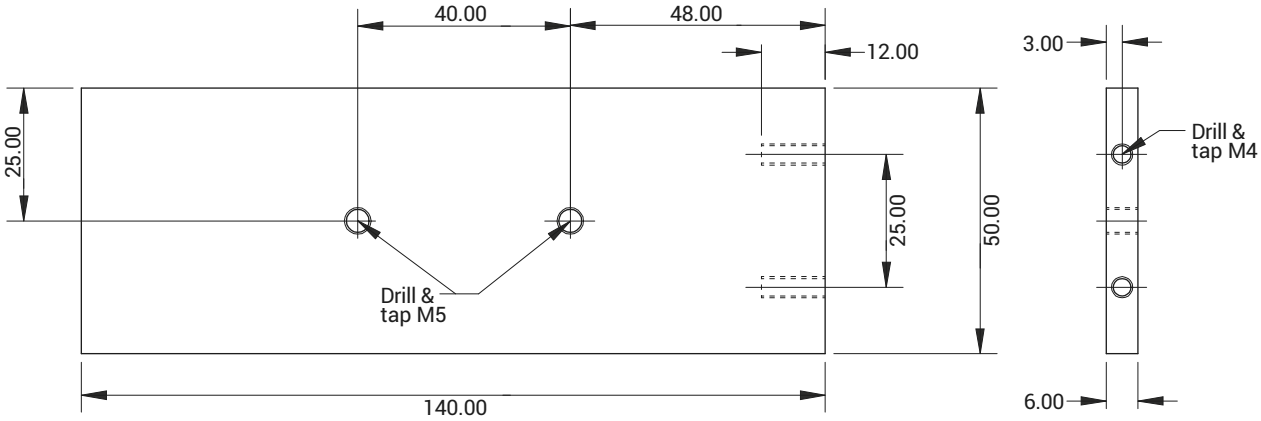
Fig.1



The Bracket Front

Mat'l: 3 x 50 mm steel strip

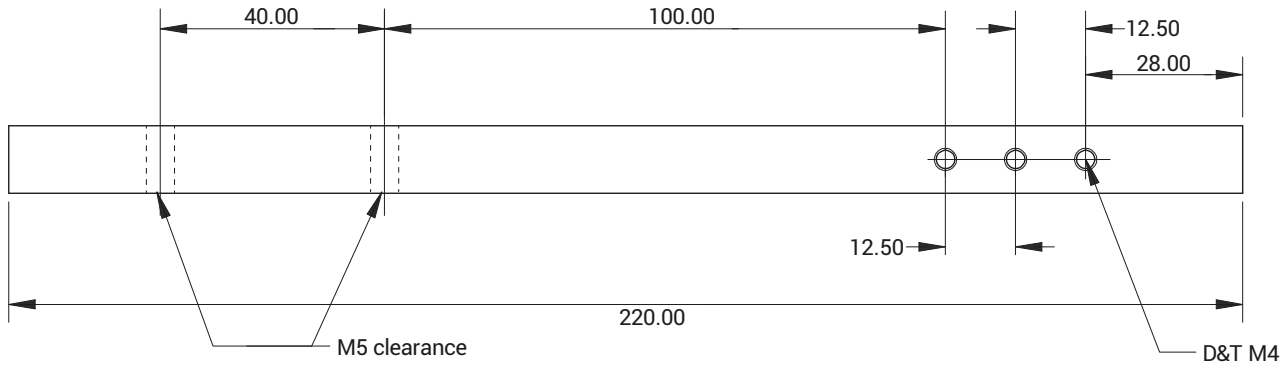
Fig.2



The Bracket Base

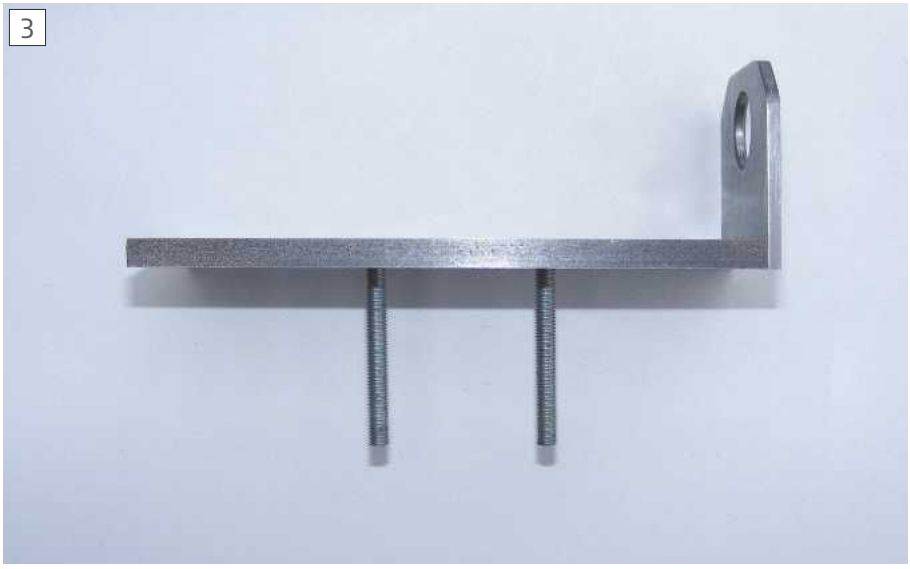
Mat'l: 6 x 50 mm steel strip

Fig.3



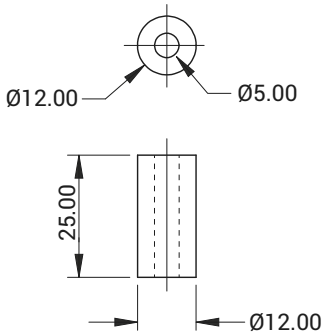
The Support Bar
Mat'l: 12mm square steel

3



The tool bracket

Fig.4



The Stand-off
Mat'l: 12mm round steel, 2 off

The support bar

The support bar is a length of 12mm square bar, **fig. 3**. This was cut to length and drilled out as indicated.

The rotary tool bracket was attached to the support bar using two lengths of M5 studding. These were screwed into the bracket. Two stand offs, **fig. 4**, were made from 12mm round steel. The ends of each stand off were faced and then drilled out 5mm diameter. These hold the bracket at the correct height from the bar. These standoffs were slipped over the studs before passing the studs through the holes in the support bar. The assembly was then bolted up using a couple of M5 nuts, **photo 4**.

The table

The main table, **fig. 5**, made from a piece of 10mm thick aluminium 80 x 50mm. This was set up in the mill vice and a 6mm groove was milled 6mm away from one of the long edges using a 6mm slot drill. This slot is a guide for the sliding sub-table. The two attachment holes in the top were drilled out 4.5mm and then countersunk for M4 countersink screws

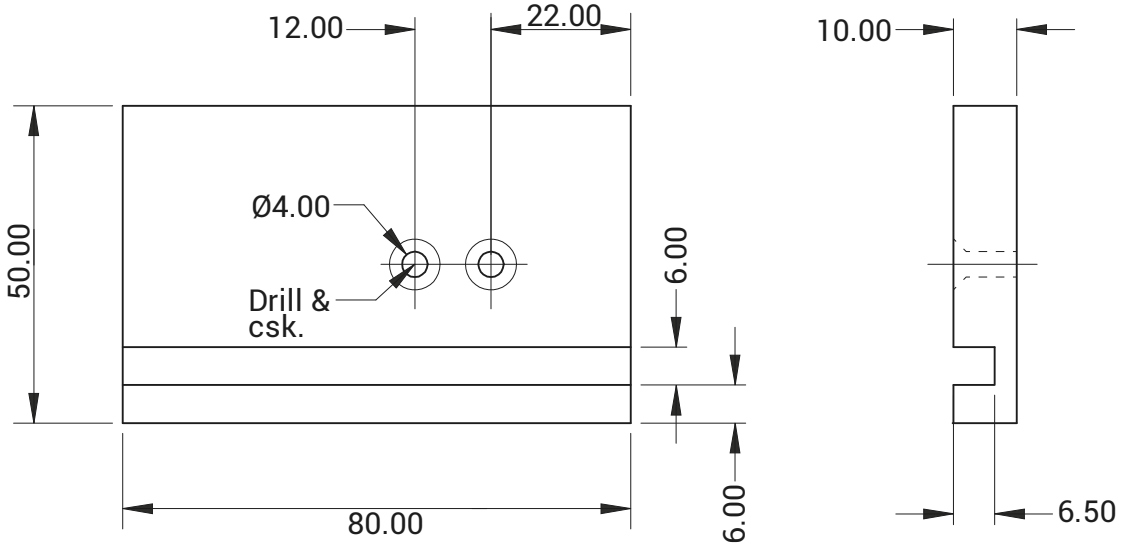
The table is attached to a piece of 12mm square bar, **fig. 6**. The square bar was chucked and centred in the four-jaw chuck and both ends were faced off square. The centre of one end was drilled out 3.3mm and then tapped M4.

The two attachment holes were marked, drilled 3.3mm on one face and tapped M4.

4

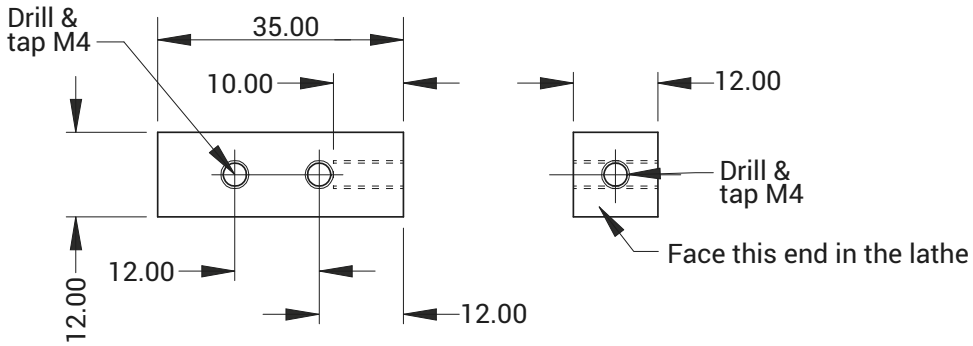
Bracket assembled to support barw

Fig.5



The Table
Mat'l: 10 x 50mm aluminium

Fig.6



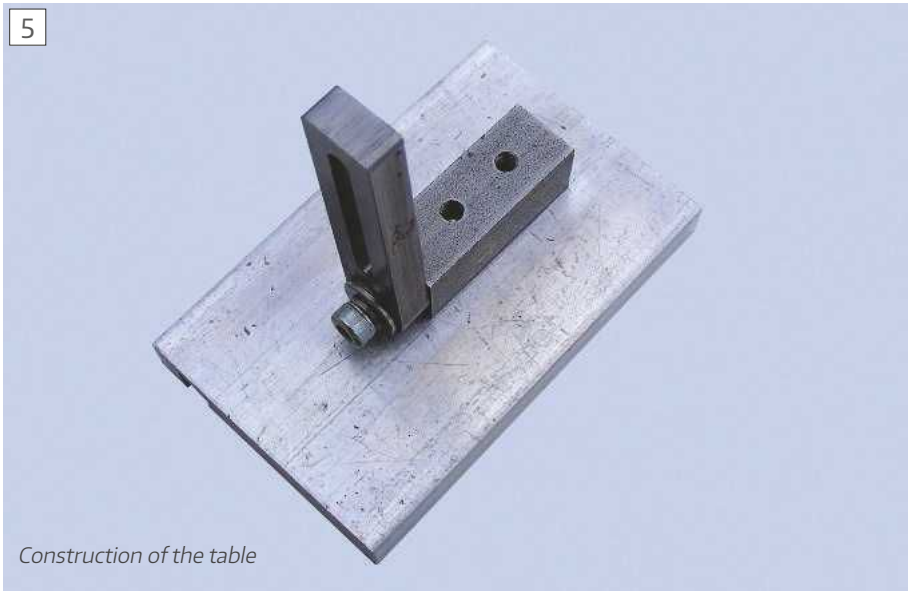
The Table Support Bar
Mat'l: 12mm square steel

The main table was then attached to the square bar using M4 countersink screws.

The slotted adjustable link, is used to attach the table to the support bar. This was made from a piece of 6 x 12mm steel bar. This was cut to length and then the 4mm hole drilled in one end. On the lathe a 12mm diameter washer was made with a 4mm hole through it. This washer was bolted through the hole in the link piece and used as a guide to obtain a nice rounded end on the piece using a hacksaw and file. The link was then mounted in the mill vice and the 4mm slot was made using a 4mm slot drill.

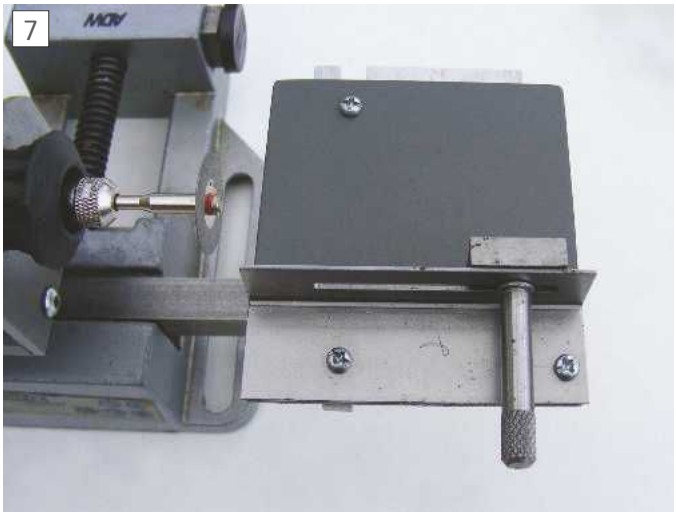
The link was then assembled to the table using an M4 socket head screw, see **photo 5**. The table was attached to the support bar using a M4 screw. There are three possible screw holes in the support bar and the best position is chosen for the required position and angle of the table.

5



Construction of the table

The underside of the sub table with guide bar



The assembled table and sub table

The sliding sub-table

The arrangement of the sliding sub-table depends very much on the type of operation that is being carried out.

The sliding sub-table was designed to for cutting off lengths of HSS tool steel. It was made from 1.5mm sheet steel with a piece of 6mm square bar attached underneath, photo 6. This square bar slides freely in the slot on the main table.

On the top side the sub-table has an adjustable stop, formed from a piece of steel angle and with slot. There is a sliding stop that can be locked in any position in the slot by tightening the knurled knob. When cutting HSS it becomes too hot to handle quite quickly it is convenient then to use a bulldog clip to hold the piece in place.

Other configurations for sub-table are possible. For example an angular guide could be fitted to the table for cutting off HSS at various angles.

Use

The stand is designed to be gripped by the support bar in the bench vice. It then forms a solid platform for carrying out cutting and grinding operation, **photo 7**, on the table. The sliding table allows precise cuts to be made easily. ■

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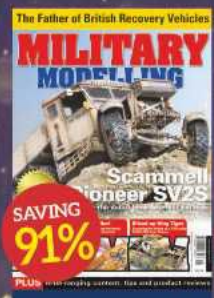

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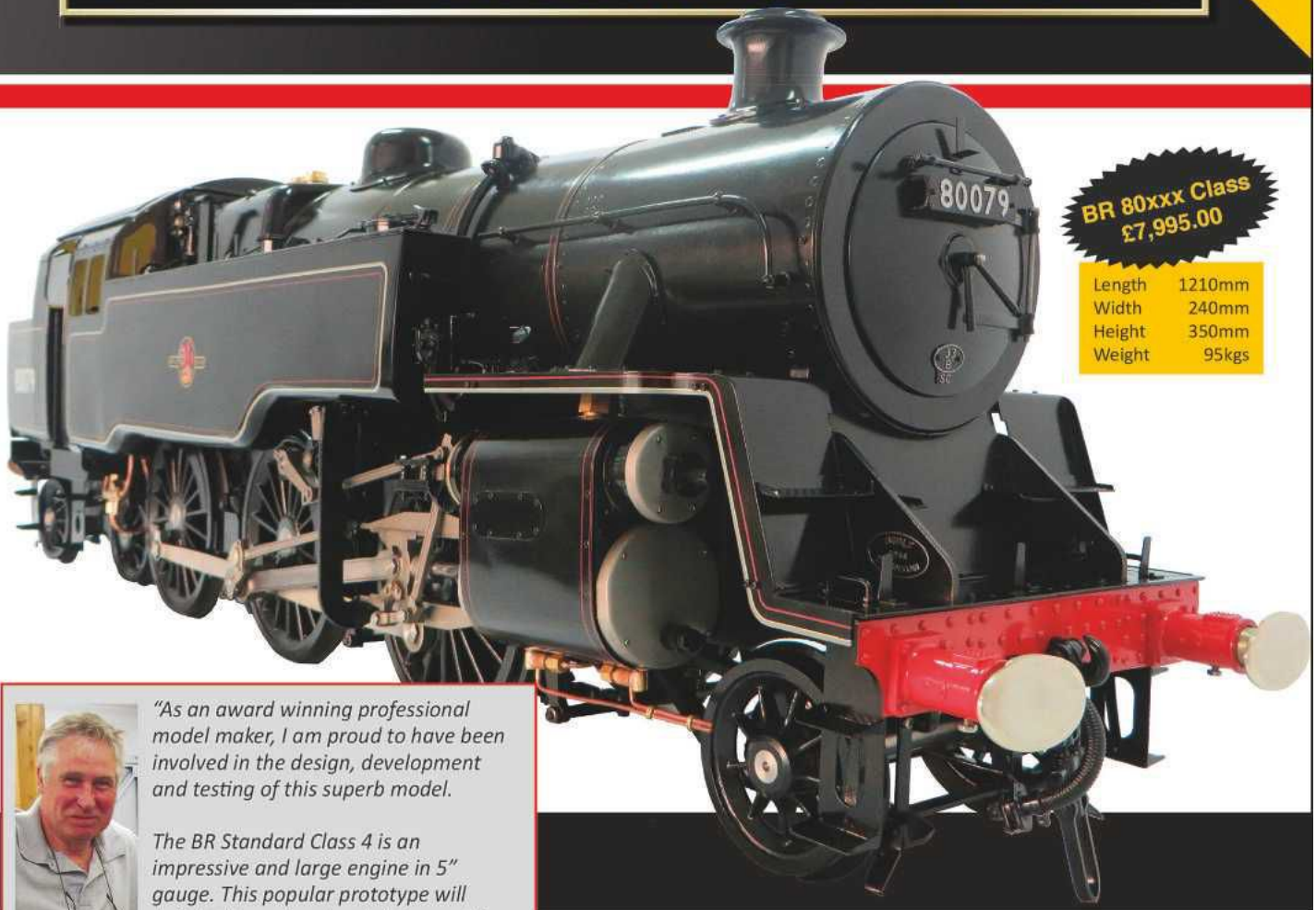

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Setting Up a Gear Train

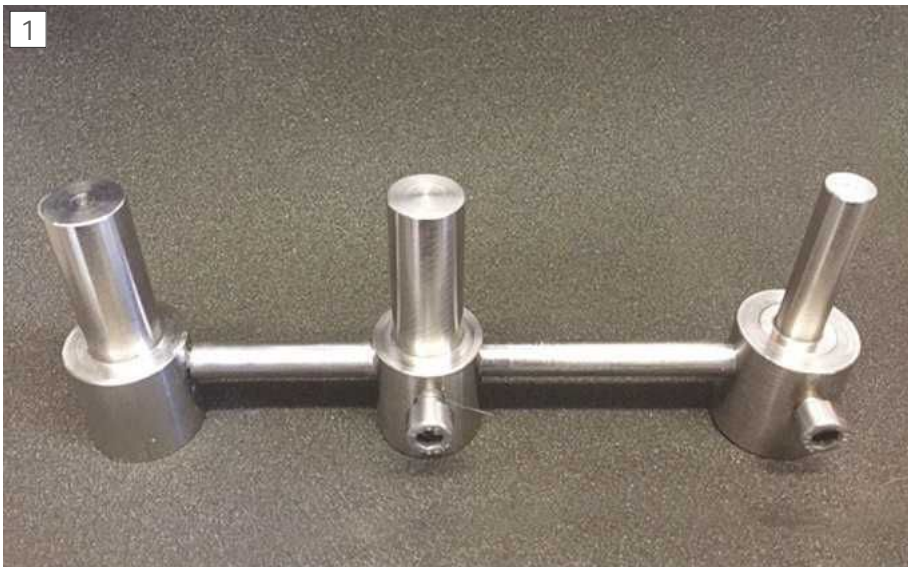
Lyndon Baugh simplifies setting his lathe up for screwcutting.

My lathe is of a type where compromises to save costs have had to be made to keep prices down. It brings hobby lathes within reasonable budget the downside being the compromises. One of these on my machine could be found on the screw cutting set up.

The Problem.

The banjo a common, enough item was secured in place by two bolts either side of the lead-screw shaft. The gear studs were fixed to the banjo via a washer and nut from the rear. With no gears on studs or lead-screw all looked quite reasonable, placing a gear train led to extreme frustration, however. First gear placed on the lead-screw ... easy! Next gear on the stud. Now stud gear and lead-screw gear have to be meshed, which was easy to do by sliding stud along the banjo until meshed correctly, but now the pain!! The stud securing nut is now behind the gear and banjo arm, access is limited even with a small diameter gear with a large diameter access is difficult to say the least. When you can get a spanner on it as you tighten the gears move. A nightmare! When after several failed attempts the gears are set then the next stage is swinging the banjo to mesh the stud gear with the 'driver'.

Remember the two bolts either side of the lead-screw? Now behind the leadscrew gear. Very often I could only tighten one of these not ideal.



The gear setting jig

The solution.

Frustration led me to make the following simple item. Consisting of a non-moving stud on the left and two adjustable and lockable studs to the centre and right, **photo 1**.

The left stud has been made to 'sit' on the lead-screw the reduced top being lead-screw diameter. The centre stud is made to sit on the adjustable gear quadrant stud, the reduced part being that stud's diameter. The right-hand stud is made to fit over the left hand thread idler stud on the quadrant, the reduced part being the diameter of that stud.

In use the lead-screw gear is placed on the lead-screw stud and its driver gear placed on the centre stud, **photo 2**. The

Meshing the lead screw gear and its driver

Using the jig to position the banjo correctly

centre stud is then unlocked and slid to bring both gears to perfect mesh. The centre stud is then locked. The lead-screw gear is then removed.

The gear setter is then placed on the end of the lead-screw while the adjustable gear stud on the quadrant is aligned with the centre stud, **photo 3**. Once aligned the gear setter can be seated fully on both lead-screw and quadrant stud. The quadrant stud is now tightened with nothing in the way!

Now the banjo is rotated to bring driver and driven gears to mesh, the banjo locknuts can then be tightened with nothing in the way!

Once tightened the gear setter is removed and the screw cutting gears put in place, all meshing perfectly. A point of clarification, **photo 4** shows modified boxford banjo which has peripheral clamp, the original banjo clamp bolts are still visible however.

This only took a few hours to make. I hope this ends frustration in the workshop for those with similar lathes! ■

Modified Boxford banjo

In our Next Issue

Coming up in issue 265
On Sale 23rd February 2018
Content may be subject to change

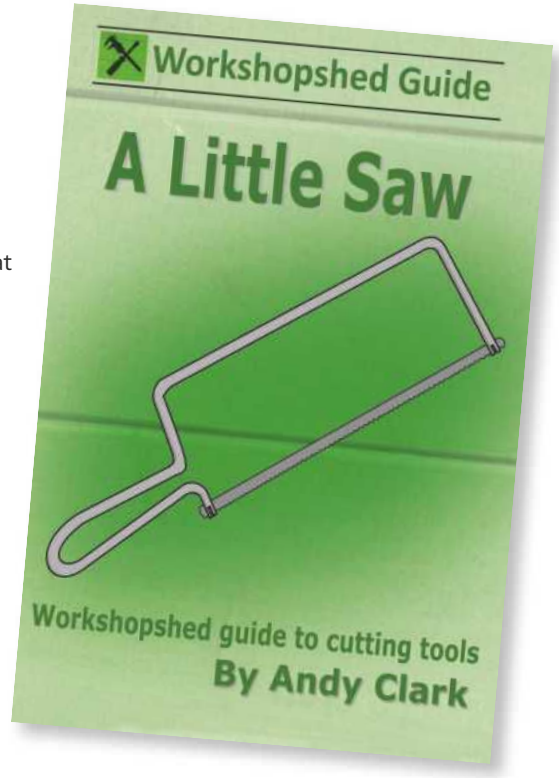
The March issue, number 265, of Model Engineers' Workshop, will showcase two great new designs with fully detailed plans and build guidance

Part One of plans and build guide for **Alex du Pre's** Dividing Head

Jack Maurel's 'Star' parting off system with full plans.

On the Wire NEWS from the World of Hobby Engineering

A Little Saw



Many people like to use the phrase "the right tool for the job". This is great if you know what the right tool is or even what the choices are. There are a bewildering number of different types of saw, so this book by Andy Clarke focuses on some common types that you are likely to find in your workshop, garage, maker space, tool library or shed. With the aid of this book, you should be able to identify and select the right saw for your job. Often it is not critical to get the perfect saw but choosing the best one available to you will help you to quickly make accurate quality cuts.

The book is aimed at the beginners and improvers who want to "chop things up" but are not quite sure which tool to use.

The paperback version is print on demand and is available from Amazon for £3.99, **http://wsshd.com/LittleSaw**. The Kindle edition is just £1.99 **http://wsshd.com/LittleSawEBook.**

3D Printing Demonstration using Alibre for Design, 3D Scan and Reverse Engineering

Rt Hon Matt Hancock MP, the Minister of State for Digital visiting GoPrint3D in November.

My readers will be aware that Alibre Design has been relaunched by the original development team, by Mintronics. They are holding a unique event for 3D printing with Alibre Design plus scan to CAD and reverse engineering technology Geomagic Design X, Geomagic WRAP and Geomagic for SolidWorks in conjunction with GoPrint3D. the event is free and will be held in Ripon, North Yorkshire, on the 8 March.

3D Printers from eleven manufacturers will be on display and during the event the same part will be printed using different 3D Printers illustrating their capabilities. They are dividing the Event into morning and afternoon sessions as requirements vary, but participants are invited to stay for the whole time or just chose a session.

The first session will concentrate on the hobbyist and those starting their 3D Print and Design journey and is likely to be of interest to many readers. Using the latest Alibre they will create an uncomplicated design and 3D print, then design in context of an assembly and 3D print.

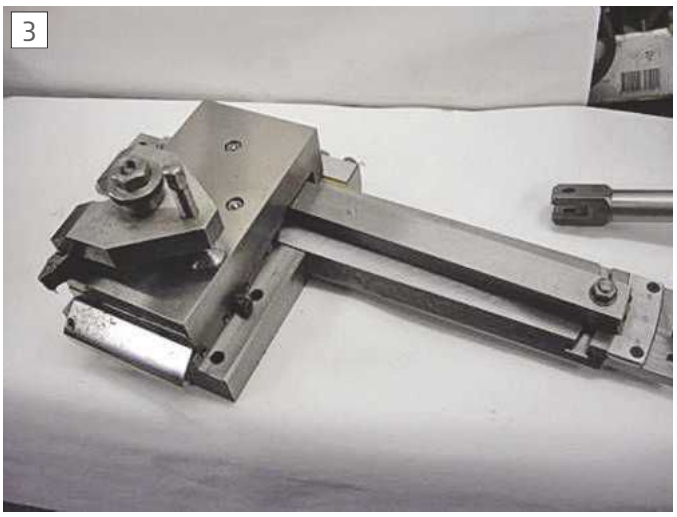
The second session is aimed at industrial users where strength and production volumes are crucial. They will scan a part with the HP scanner and reverse engineer first by scanning directly into SolidWorks, then with Geomagic Design X reverse engineering software technology.

For more information and booking details, visit **https://tinyurl.com/ycn2jcdm**

Finally, we are hearing rumours of the imminent release of a new Alibre Personal Edition, an affordable version of the full Alibre CAD package aimed at meeting the needs of hobbyists.

A Taper Turning Attachment

In MEW 258, Jock Miller tantalised readers with an article featuring a very capable taper turning attachment, but did say that if readers requested them, he would provide more details. The response to the article was overwhelming, with a remarkable number of readers getting in touch. I will let Jock complete the story:



Well, the drawings have been completed and converted to CAD by my friend Peter King in spite of the actions of "Edsel. B. Murphy" (Patron Saint of inanimate objects). Murphy's Law is defined mathematically as: 1 + 1 = R 2, i.e. 'R' hardly ever equals 2.

I made this attachment in 1994 and as a professional Mechanical Engineer NOT a "Draughtsman" – now 81 – made copious rough notes and filed these in a specific manila file which has vanished.

My draughting equipment consists of a state of the art 1957 "T" square with a Perspex blade, an adjustable square + 0.5mm clutch pencil on a wooden drawing board.

When I started to draw up the unit I discovered my eyes had deteriorated a little since the last Drawing Office Work and had to wait for a few weeks for new stronger glasses.

The final straw was when I switched on a "Terry Anglepoise" lamp over the drawing board and the bulb had failed - and my little tester for the wall plug had alas failed also!

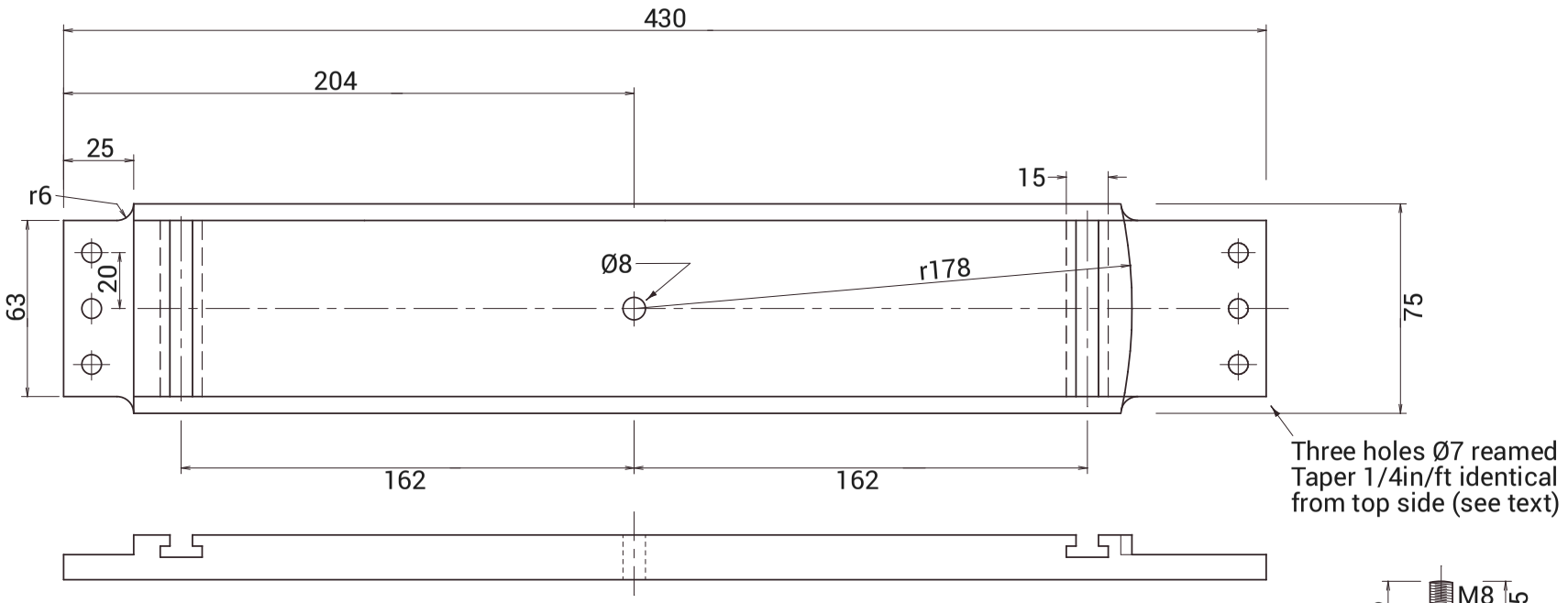
Fortunately, most of the attachment dimensions are in whole numbers of millimetres as metrication was all the rage in 1994.

For photos of the operation and general arrangement refer to **photos 1 – 5**, reprinted from MEW 258.

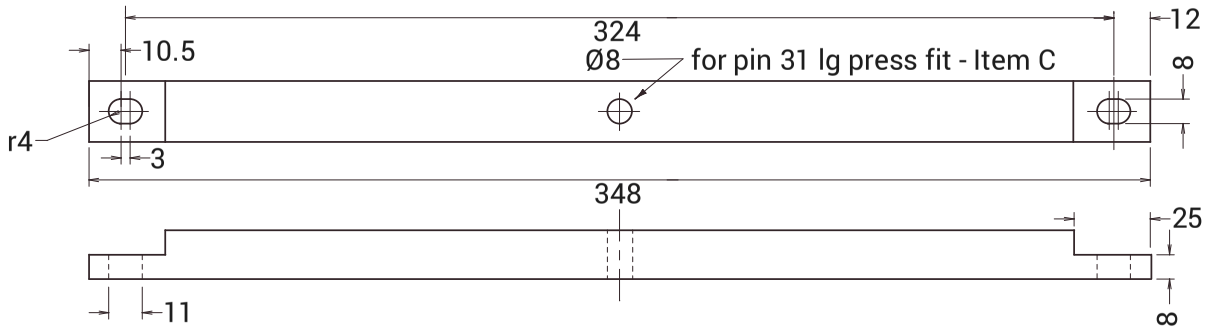
NOTES ON CONSTRUCTION.

1. Ensure the "V" slides, **photos 6, 7**, are smooth with no binding or play. Item A,

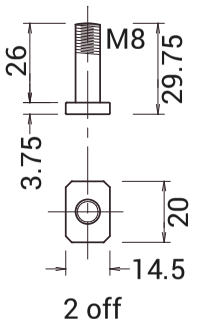
›



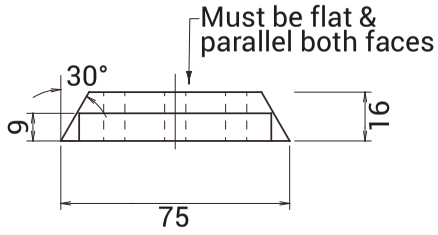
Item A
Mat'l: Cold rolled steel

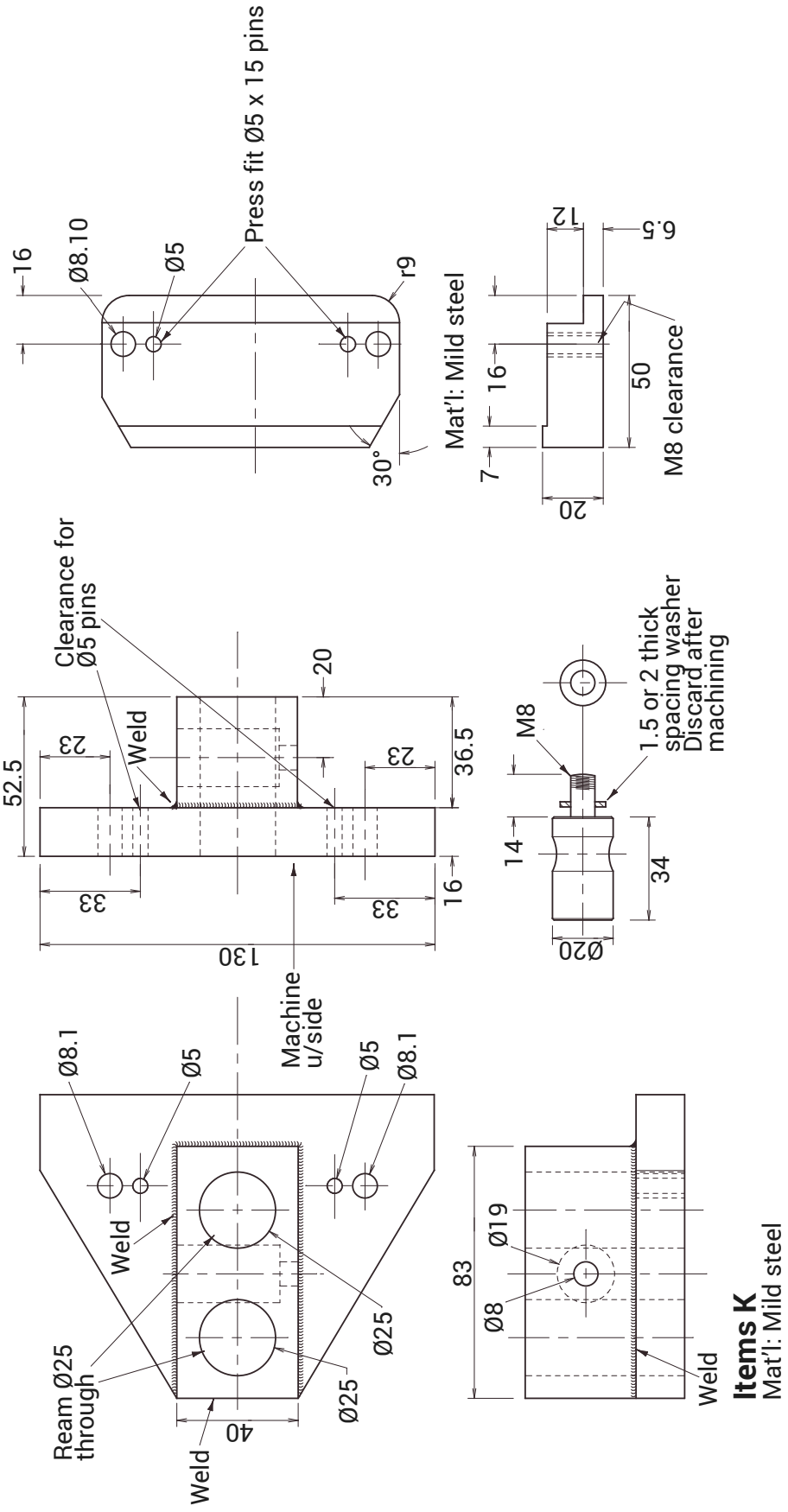


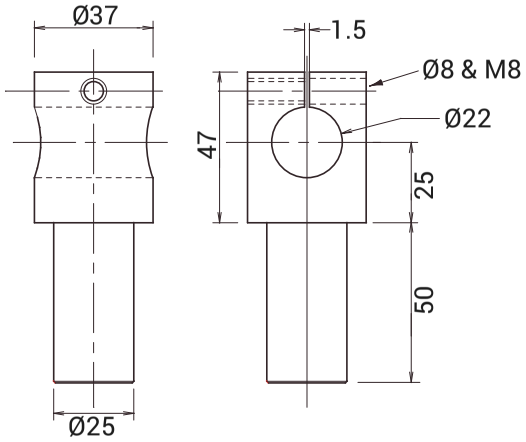
Item B
Mat'l: 1" x 5/8" (25 x 16) gauge plate



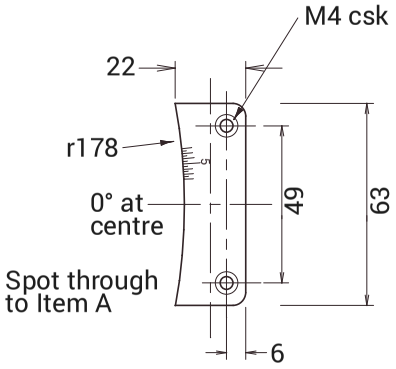
2 off



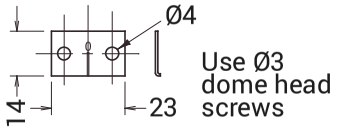

Press fit Ø5 x 15 pins
16
Ø8.10
Ø5
r9
30°
Mat'l: Mild steel
12
6.5
16
50
7
20
M8 clearance
Clearance for Ø5 pins
20
52.5
23
Weld
23
36.5
33
33
16
130
Machine u/side
M8
1.5 or 2 thick spacing washer Discard after machining
14
34
Ø20
Ø8.1
Ø5
Ø5
Ø8.1
Weld
Ø25
Ream Ø25 through
Ø25
40
Weld
83
Ø19
Ø8
Weld
Items K
Mat'l: Mild steel



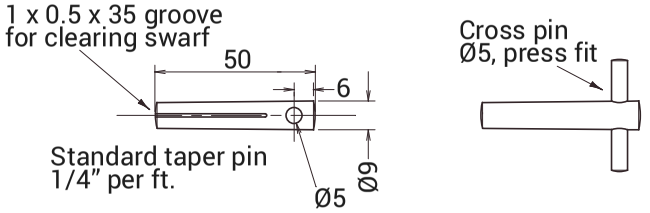
Item M
Mat'l: Mild steel

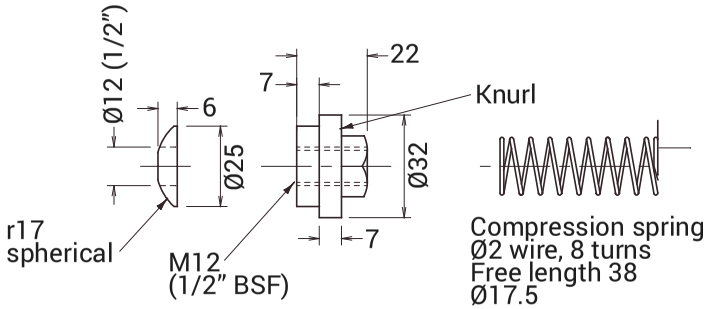


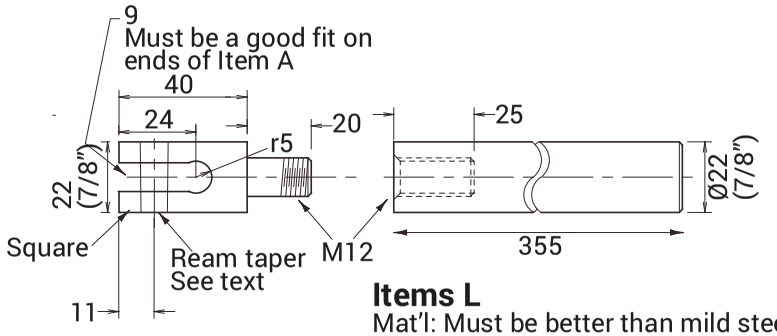
Item A



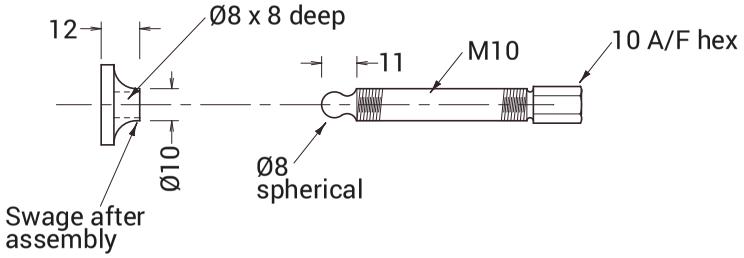
Index Plate
Spot through onto Item B



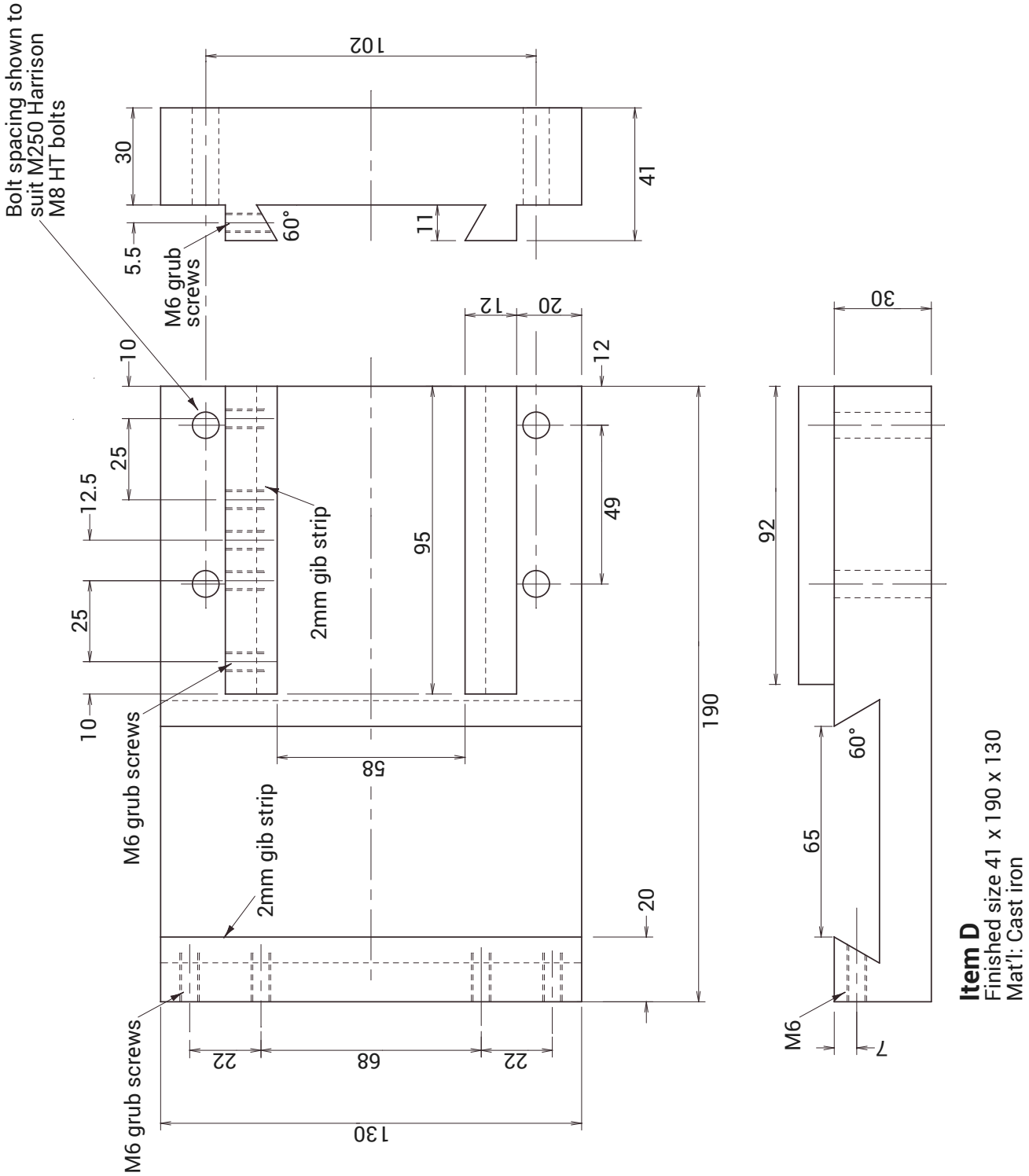




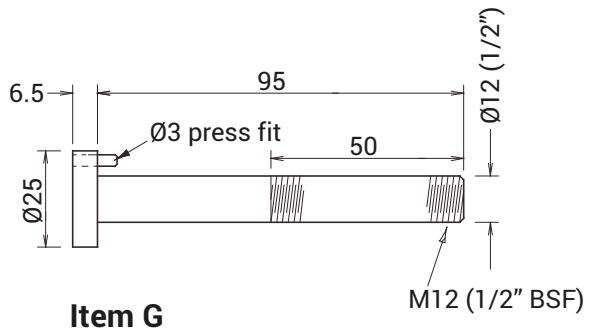
Items L
Mat'l: Must be better than mild steel



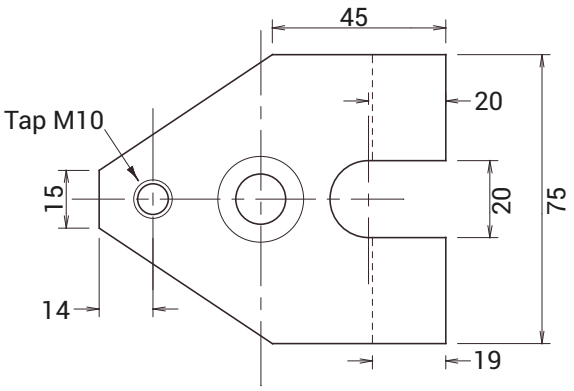
Items J
Mat'l: Better tham mild steel

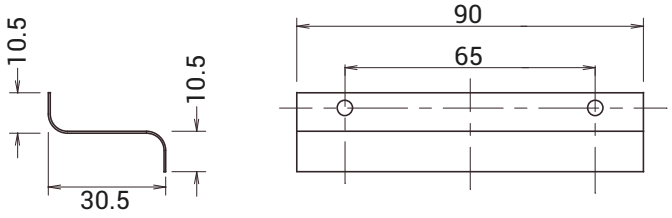


Item D
Finished size 41 x 190 x 130
Mat'l: Cast iron

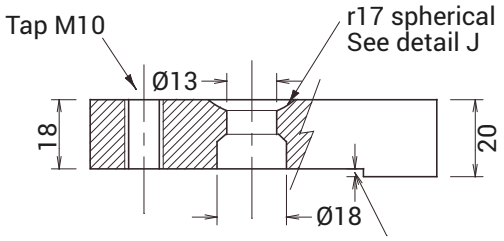


Item G
Mat'l: Med. strength steel

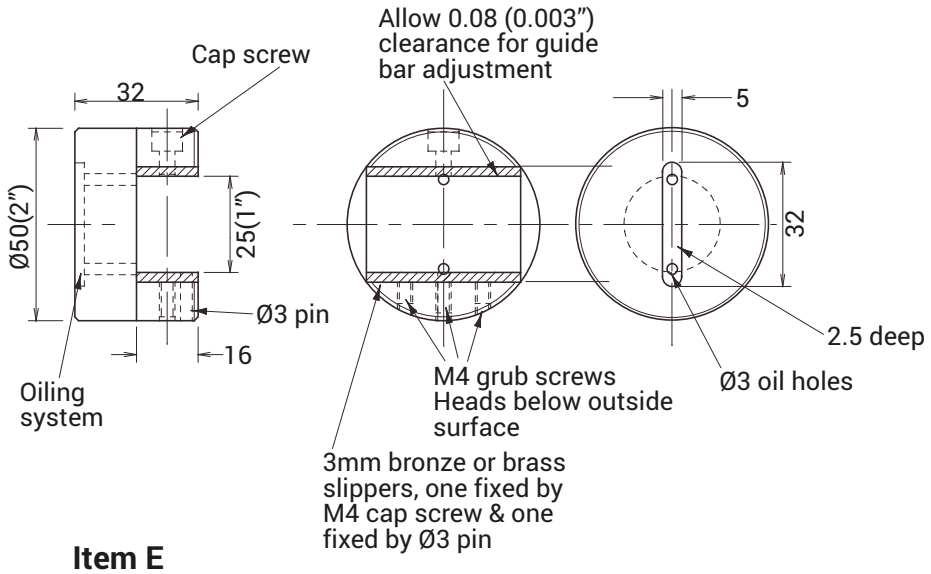




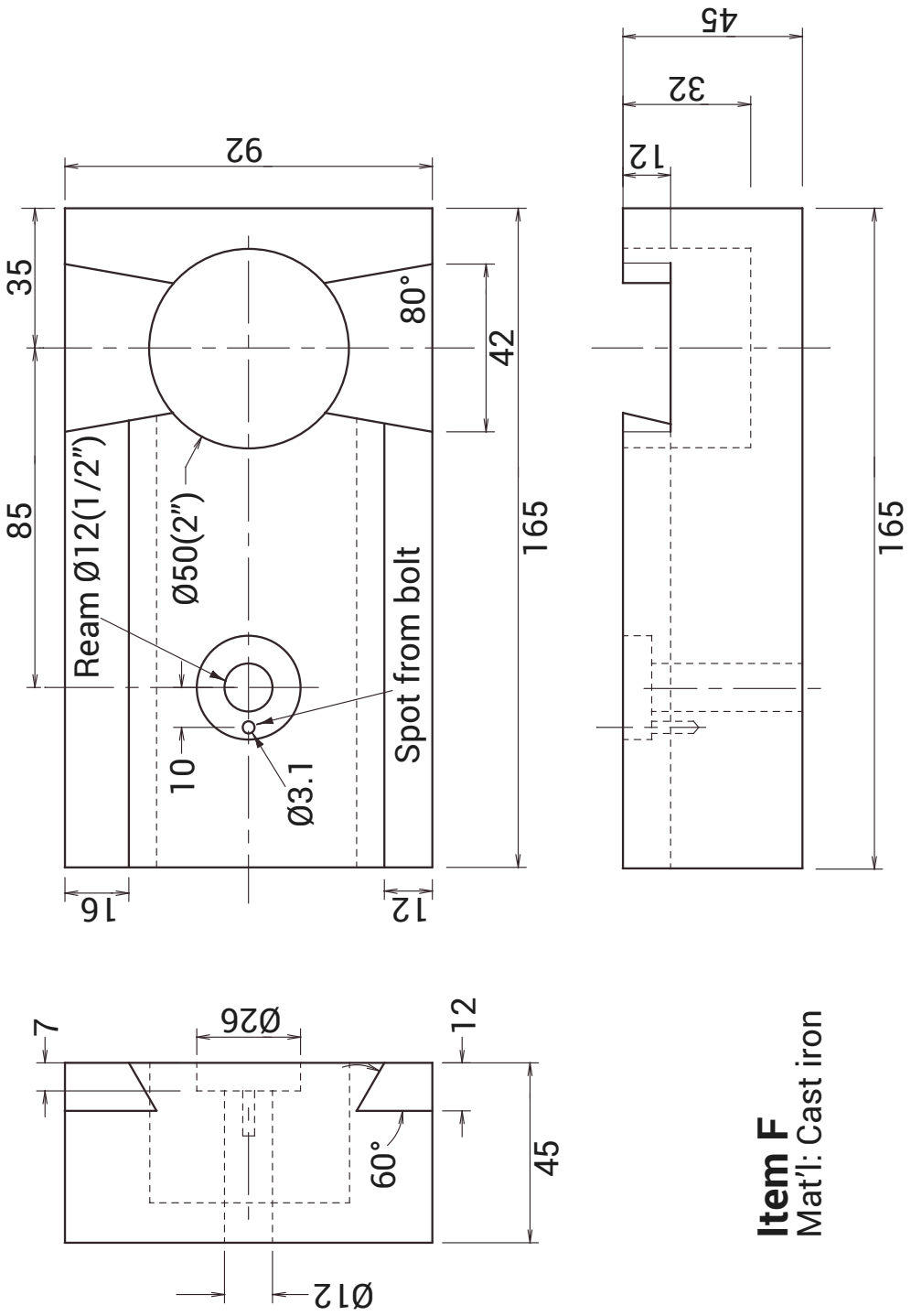
Swarf Guard
Mat'l: 0.5mm stainless steel
Spot holes through & tap M4
Fit to Item F



Item H
Mat'l: Mild steel



Item E
Mat'l: Ground mild steel or better

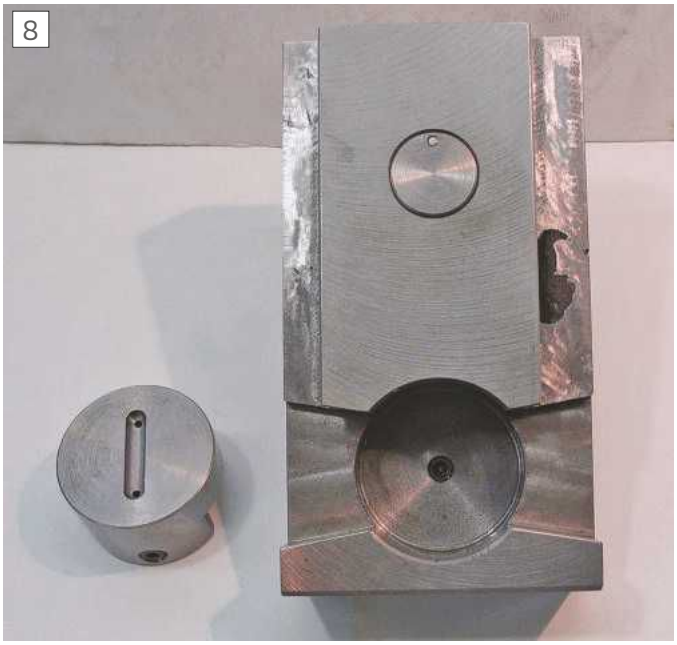


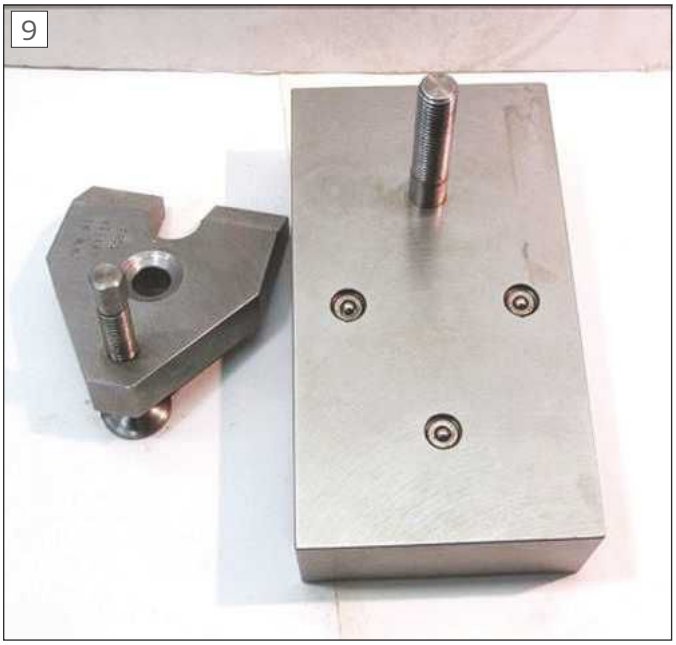
Item F
Mat'l: Cast iron

which was from cold rolled steel, bent when the dovetail edges were milled and needed remediation.

2. The tapered holes in the ends of Item A require care, i.e. ream the anchor fork (Item L) and then ream Item A holes (6 off) so that when the taper pin is solid in the fork there is equal (Item L) clearance in Item A.
3. Sharp eyed observers will notice that I have changed the circular "T" slots at each end of Item A to straight "T" slots and with a slotted 8mm dia in the guide bar Item B, much simpler to manufacture.
4. Make Item M a good fit in the anchor clamp Item K, as any play here and in the "V" slides could produce steps in the job. As noted on the drawings this was made for a 1983 M250 Harrison purchased by my late father. The centre height of the lathe above, to the top of the cross slide is 89.5mm so on a different lathe, packing blocks under Item D or on top of Item F (tool post) may be required (or increase or decrease thickness of these two items)
5. wDegree Scale. Make from 3/16" or 5.00mm aluminium, file 174. oomm radius to fit Item A. With a rotary table using Item A central pivot hole set up for degrees, but put washers under the fixing holes to avoid damaging the engraving tool. The zero plate is made from brass.
6. On Item F fit 3 "disappearing" ball oilers as showing on **photo 9**. The cast iron components were circular slices of 'continuous cast iron'. UK metal merchants may have similar rectangular cast bar.

This project is a good exercise in tool-making and is certainly easy to use without mucking up the cross-slide feed screw. ■



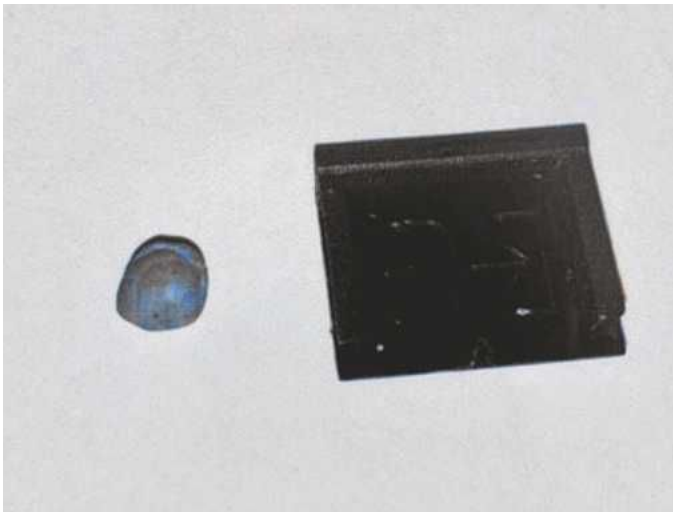


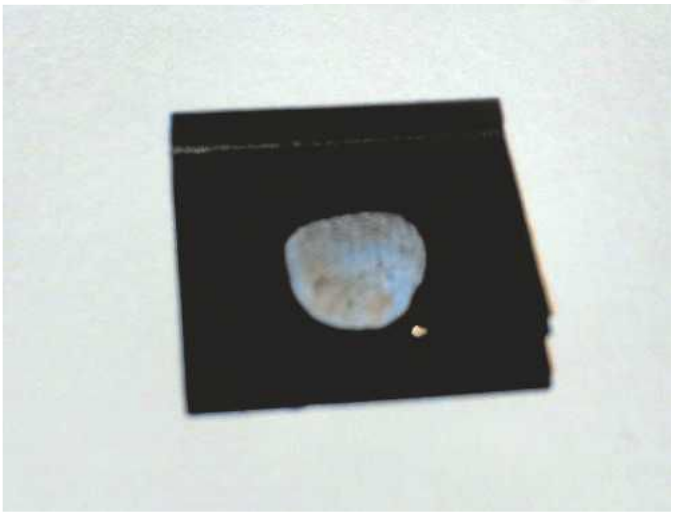
Readers' Tips

CHESTER MACHINE TOOLS

Digital Calipers Battery Cover

TIP OF THE MONTH WINNER!





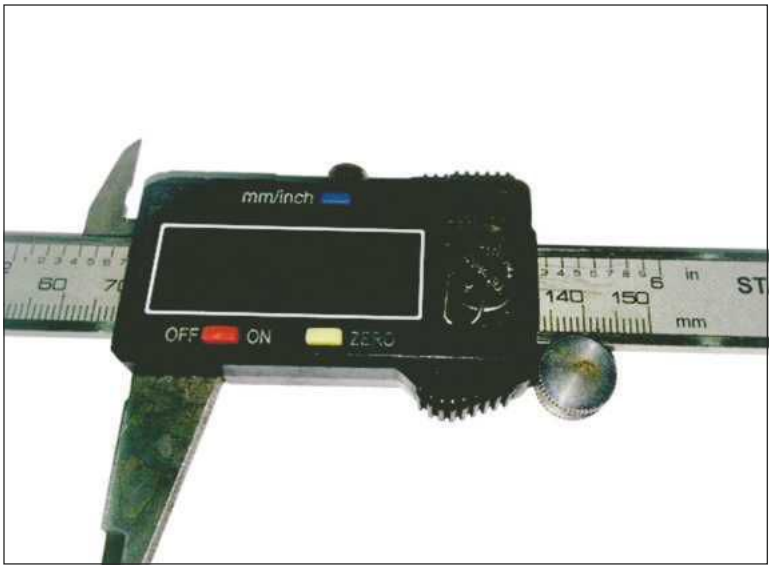
Do you use cheap digital calipers? John Bowers wins this month's Chester Vouchers with a simple upgrade.

Digital calipers are great, and for the abuse I give mine even the cheap ones under £10 do a great job. But, especially on the cheap ones, the battery cover nearly always falls off which leads to problems. I've got a pair of the ones with a metal screw on battery cover, but I'm running out of the small securing screws!

My remedy is to forget the sellotape, insulating tape or a paper clip - a slither of Blu-Tak under the battery cover does the trick! (chewing gum might work too).

I am a self-taught machinist now 72 years old. I used to work for many years as a Sales Engineer for large machine shops and tool makers and was often amazed at the monumental expensive blunders on manual and cnc machines made by the time served machinists and it made me think thank goodness, I am self taught. So, when I see the projects in MEW carried out on small machines by hobbyists - I take my hat off!

John Bowers



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

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

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Chain Hoist Tripod

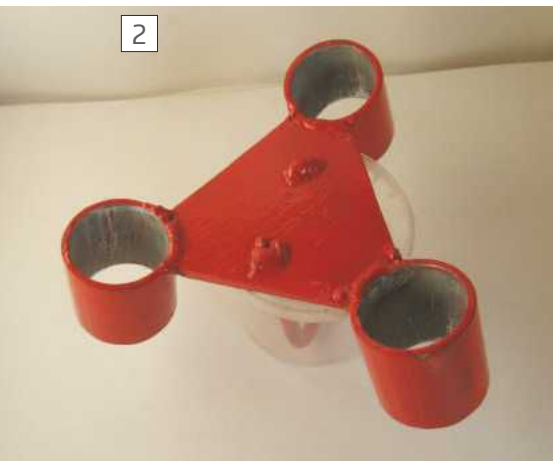
Stan Nesbitt makes a heavy duty tripod for a chain hoist.

I needed to hoist a heavy lawn tractor (a Westwood T1200) onto metal trestles to facilitate dismantling at a comfortable working height, **photo 1**. I decided to use the following method, using "Kwikstage" ten foot scaffolding standards joined by a special adapter plate and a "Powerfix" chain hoist. This portable arrangement could also be transported on a trailer to collect heavy items which cannot be otherwise lifted or wheeled unto a trailer.

Adapter Plate

Draw an equilateral triangle with 140 mm sides on a piece of cardboard. Obtain a piece of mild steel plate, at least ¼ inch thick and lay the cardboard template on the steel plate to mark out the cutting lines. Drill two holes to admit the lifting eye which may be a U bolt or bent mild steel rod, see **figs 1** and **2**.

> This portable arrangement could also be transported on a trailer to collect heavy items...



2

Weld the eye on both side of the plate

1

The hoist lifting the lawn tractor

3

The short tubes should be canted outwards

The lifting eye should project about 3½ inches and the material should be at least 5/16 inch diameter. Weld the lifting eye to the steel plate on both the upper and underside, **photo 2**. The marked plate can now be secured in a vice by clamping on the lifting eye. This construction assumes you are a competent welder, if not, get someone who is to do the welding for you or to oversee your work.

Cutting the plate to shape by hand may be avoided by using an angle grinder fitted with a thin steel cutting disc guided by scrap straight edges clamped to the plate. The three short concave angled cuts can be fashioned using a hacksaw and file to obtain a close fit to the 1 7/8 inch tubes.

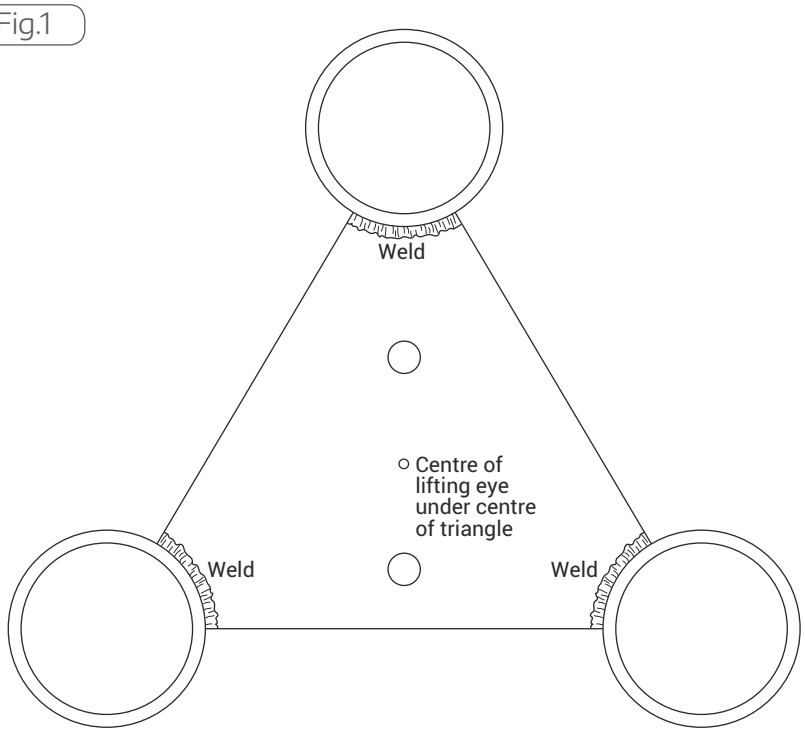
The narrowed top section of the standard is 1 ½ inch diameter so a piece of tubing with an internal diameter (ID) of 1 5/8 inch results in a nice loose fit. Cut three 2 inch pieces of this size of tubing and weld to the adapter plate.

The short tubes need to be canted out at approximately 110 degrees and I found that it was best to lay the plate upside down on a similar thickness of plate to obtain the correct position for welding, **photo 3**.

Welds should be made both to the upper and underside of the adapter plate. Paint should be applied to prevent rust.

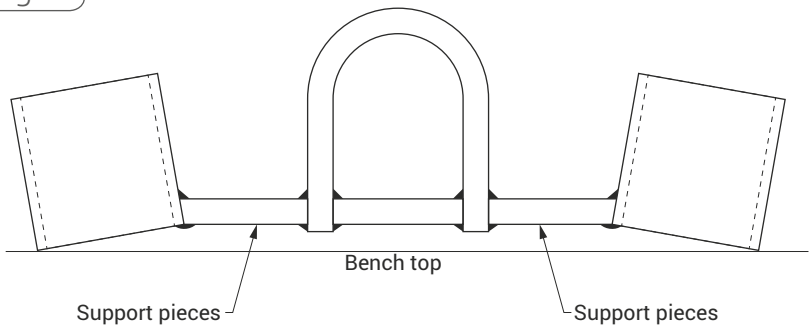
The only work to be done to the scaffolding standards is to drill a 5 mm

Fig.1



Adapter Plate

Fig.2



Welding Set-up

4

Fitting the first two legs to the plate, note the clevis pins

through hole about 2 ½ inches above the shoulders for insertion of the safety pins. This will allow some movement of the structure when re-positioning.

Method of Assembly of The Tripod

Select two of the 10 foot scaffolding standards and lay them over a support with the tops close together and the bottoms splayed apart at roughly 20 degrees. Fit the adapter plate over the top ends and insert the safety pins, **photo 4**. Stand this structure upright and allow it to rest against a building or other support, **photos 5, 6**. You may need to use "strong man" technique walking forward and pressing over head until the two standards are leant against the support. Approach

Lean against a suitable support ready for the third leg

This view clearly shows the eye for the hoist

The completed tripod may be 'walked' to the required position, moving one leg at a time.

with the third standard and insert it upwards into the third tube. Carefully ease the tripod away from the support and using a step ladder insert the third safety pin. Each standard weighs 30 lbs so be careful during this assembly, **photo 7**.

The completed tripod may be "walked" to the required position, moving one leg at a time. Position a step ladder under the tripod and hook the chain hoist unto the lifting eye, **photo 8**. The chain hoist weighs 9.75 kgs (21 lbs) and due the height or poor position of the stepladder, some effort will be required to achieve this connection. Draping the chains over the scaffolding will reduce the effort required.

Dismantling of the tripod is just the reverse of the foregoing assembly.

Using a stepladder makes assembly easier and safer

The chain hoist is hooked to the eye, supporting the chains reduces the weight you need to lift

The chain hoist used was a Powerfix unit with 1000kg swl.

Chain Hoist

The chain hoist is based on the principle of a Chinese windlass which has a large and small diameter reel fixed on a common axle. Its great advantage, with its incorporated brake, is the ability to halt the raising or lowering at any point and the load will stay in that position until the small chain is moved. The one used was obtained from Lidl costing £42.35 manufactured by Powerfix with a 1000kg capacity and with an elevation range of 3 to 3.5 metres.

Safety Pins

Although I had a set of Clevis Pins, none were large enough for this application. As only 3 were required I used a wooden former and 3.5 mm galvanised wire which was quite satisfactory, **photo 10**.

The finished tripod worked well and allowed the work on the lawn tractor to be completed safely, **photos 11, 12**. ■

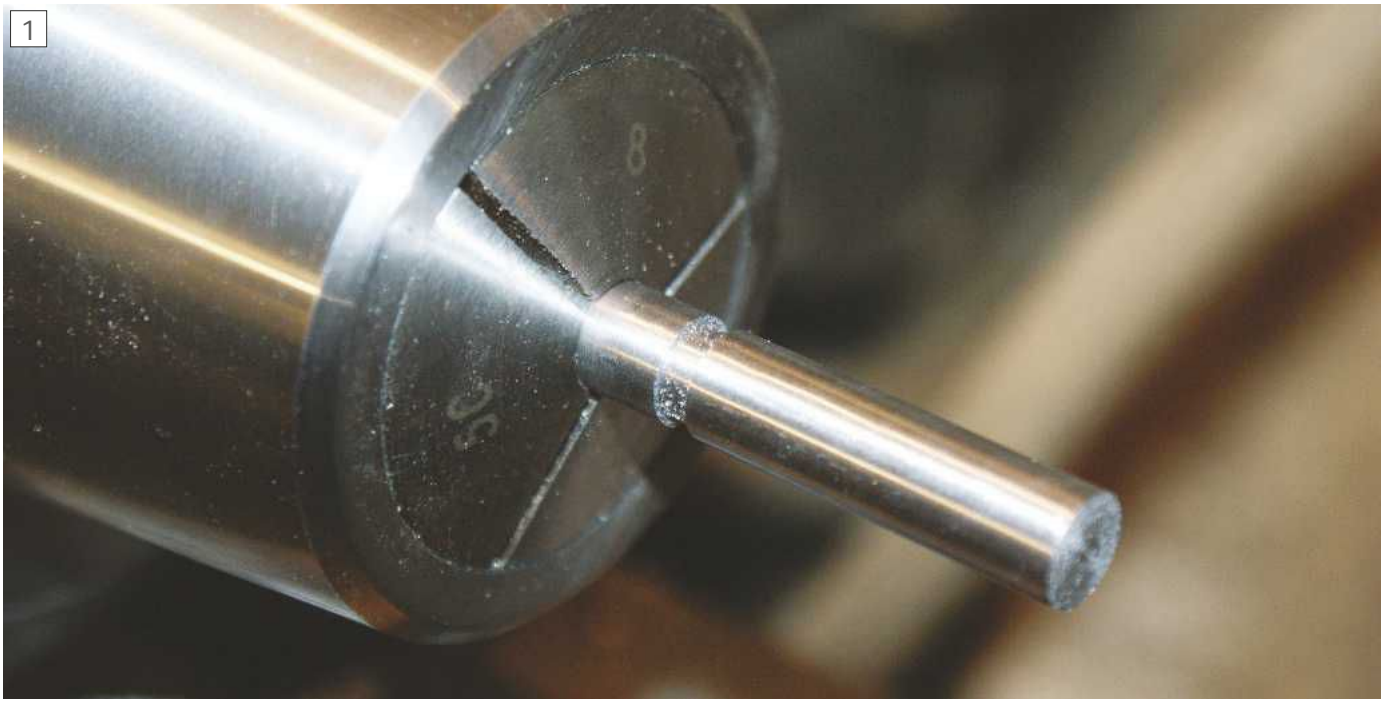
Shop-made clevis pins shaped around a wooden former

The completed tripod.

Another view of the tripod in use.

Clamping

Ian Priest gives some thought to this important topic and its consequences.



The relieved end of a stud before screw cutting.

Some time ago I read with interest a debate on the Model Engineers' Workshop forum regarding the various methods employed to clamp jobs or pieces of equipment to machine tables be they milling, lathe, shaping or any other.

In particular one contributor asked the greater audience to consider how to avoid sections of a 'Tee' slotted machine bed from breaking when clamping down. This is not an uncommon issue, in the past I've seen articles on how model engineers have made good, broken sections of machine tables. Indeed, in industry there are companies whose sole business is the repair of similar disasters. Therefore, as model engineers we are not alone, much better however to avoid the situation in the first place.

I would perhaps suggest the following as a more suitable way of securing our various bits and bobs to our precious machine tables. However, before we do that the requirements of any clamping solution needs to be considered.

Considerations

Be strong and robust enough to perform the required task. This sounds pretty much a given but the clamping solution needs to be 'only just strong enough' and not so big and powerful that any judicious over tightening is injurious to the machine.

Be safe, again a given but although we want our clamping system to be up to the job of securing items to a machine table we don't want it to be so powerful that the inexperienced can easily over do it causing damage to the machine. We need a fail-safe mechanism incorporated into the clamping system.

Be flexible, not in terms of use, in that sense we need it to be as rigid as possible, but insomuch that it easily lends itself to a variety of applications. I find it very frustrating at times not to have at hand just what I need to bolt something down.

Be consistent and interchangeable. Any engineer will have in their mind what equipment is already at hand when planning the next machining operation. It is surprising how often when designing in my head or planning my next machining session how many times a particular feature of a component is influenced in the design stage by the way it is going to be clamped or bolted to a machine to complete a machining operation.

I have from time to time produced patterns for both myself and friends and, for instance, an example of planning how a part is going to be held and subsequently machined may include the provision of a holding lug or lugs incorporated into the pattern/casting. The lug being sacrificial to be machined off, at a later stage.

Be easily replaceable, a clamping system needs I believe to some extent be considered as a consumable piece of equipment. It will wear out, the chosen thread form will deteriorate becoming unsatisfactory for use, the base of nuts will wear, becoming less effective. Here though all is not lost, longer worn out studs can be re-cycled, they could be shortened, the working face of nuts can be faced off giving a new lease of life. All that is required is some thought together with a little planning.

The proposed clamping kit

Many years ago, I settled on a standard bolting down kit consisting of studs, varied in length manufactured from 5/16" diameter steel and carrying a 5/16" BSF thread at both ends.

A suitable metric alternative would be M8 x 1.25. You make your choice and take your pick so to speak. Incidentally the effective core diameter of both thread forms, be it 5/16 BSF or M8, is 0.238" so it really is down to personal choice or to what type of screw cutting kit you have to hand.

The end with the shortest length of thread is the end screwed into the 'Tee Nuts' and should never be longer than the depth of the Tee nut. If it is 'jacking' can occur, the worse case scenario is that the

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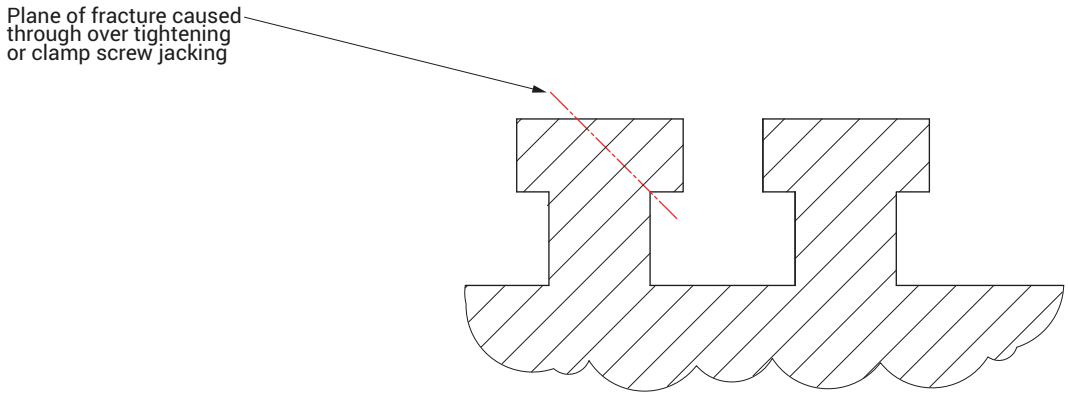
Fig.1



Section Through Typical Machine Bed

jacking force exceeds the strength of the table causing fracture, **fig. 1**.

The other end is threaded for a length of about 2" – 21/4" or whatever length suits an individual's requirements. Both threads are reduced in diameter to the root diameter of the thread where it forms an intersection with the plain portion of the stud, see **fig. 2** for details.

There are three reasons why this section of the stud is reduced in diameter:

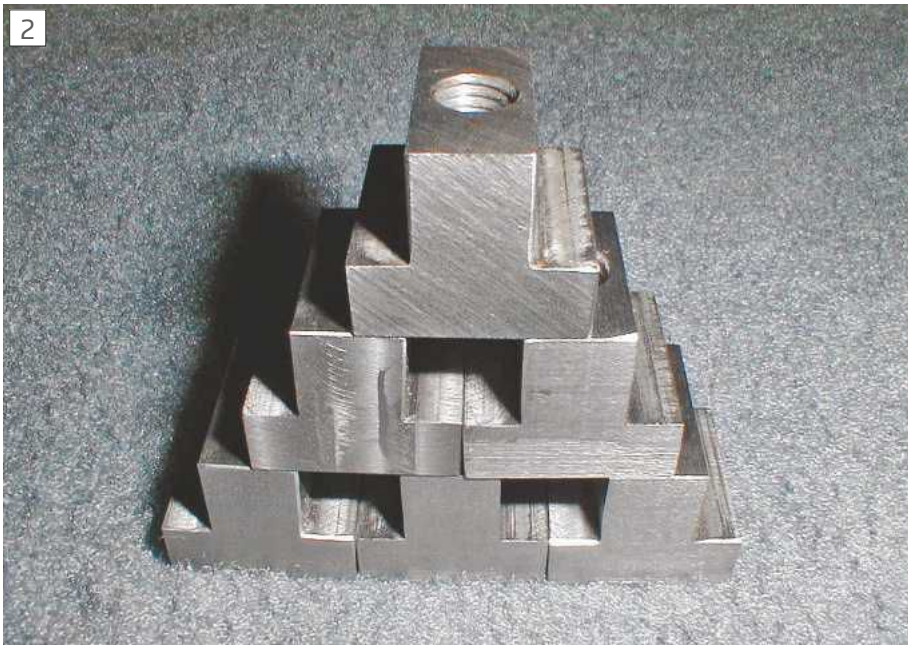
- It provides an area for the cutting tool or die to run out into.
- It provides a square shoulder for the stud when screwing it into the Tee Nut
- It provides the system with an inbuilt safety feature, if the stud is over enthusiastically tightened, then this is the section of the stud that will fail. The strength of the stud is reduced by this necked down section and is far weaker than the Tee slots of the machine table in which it is working thereby protecting the machine and preserving both its accuracy and value. It is also weaker than the remaining stud so if failure occurs the remainder of the stud can be salvaged.

The only downside is that there will in all probability be a section of broken stud stuck in the Tee nut. This could be drilled out however in my experience the action of over tightening may have deformed the thread in either the Tee nut or stud or even both, so we might as well put it down to experience, scrap the Tee nut and make a new one.

The kit is completed with the addition of nuts and to this end I arrived at my own 'standard design' being 9/16" AF with a parallel portion at it's base, again see Fig 2.

Although I'm not entirely sure I believe these are known as 'Penn Nuts', as drawn the parallel portion is dimensioned at 0.125" thick but would be manufacturers could make these a little thicker to allow for subsequent removal of wear and tear which is what I do.

Manufacture is easy, and I usually make them in pairs, I prefer to screwcut my studs so by making a few nuts first they can be used as gauges for the studs. Start with a



A pyramid of finished tee nuts.

bar of mild steel which will clean up to 7/8" diameter about an inch long, mount in the lathe, face off and centre then drill all the way through. with a drill 17/64" diameter (0.265") which can be used as the tapping drill for either 5/16" BSF or M8. Replace the drill with a taper tap of the chosen thread form and cut the thread, follow up with a plug tap.

The tapping operation will have thrown up a small burr so once again lightly face off and chamfer the edge. Remove from chuck turn around and face off the opposite end, repeat the chamfering operation. We should now have a bar with a thread all the way through it.

The next stage is to machine the hexagonal section, my preferred size is 9/16" AF I use a rotary table which can be mounted in either the horizontal or vertical position with a mounted three jaw self centring chuck on it. I prefer the table to be mounted such that the work piece is vertical. Zero the cutter on the top face and raise the table or lower the quill 0.562" . zero off the side of the work and set the rotary table to zero degrees. Now advance the cutter in proportionate steps a total of 0.156" into the work, rotate the rotary table 60 degrees and repeat till a hexagon is formed. The work is now removed from the chuck and swapped end for end where the whole process is repeated.

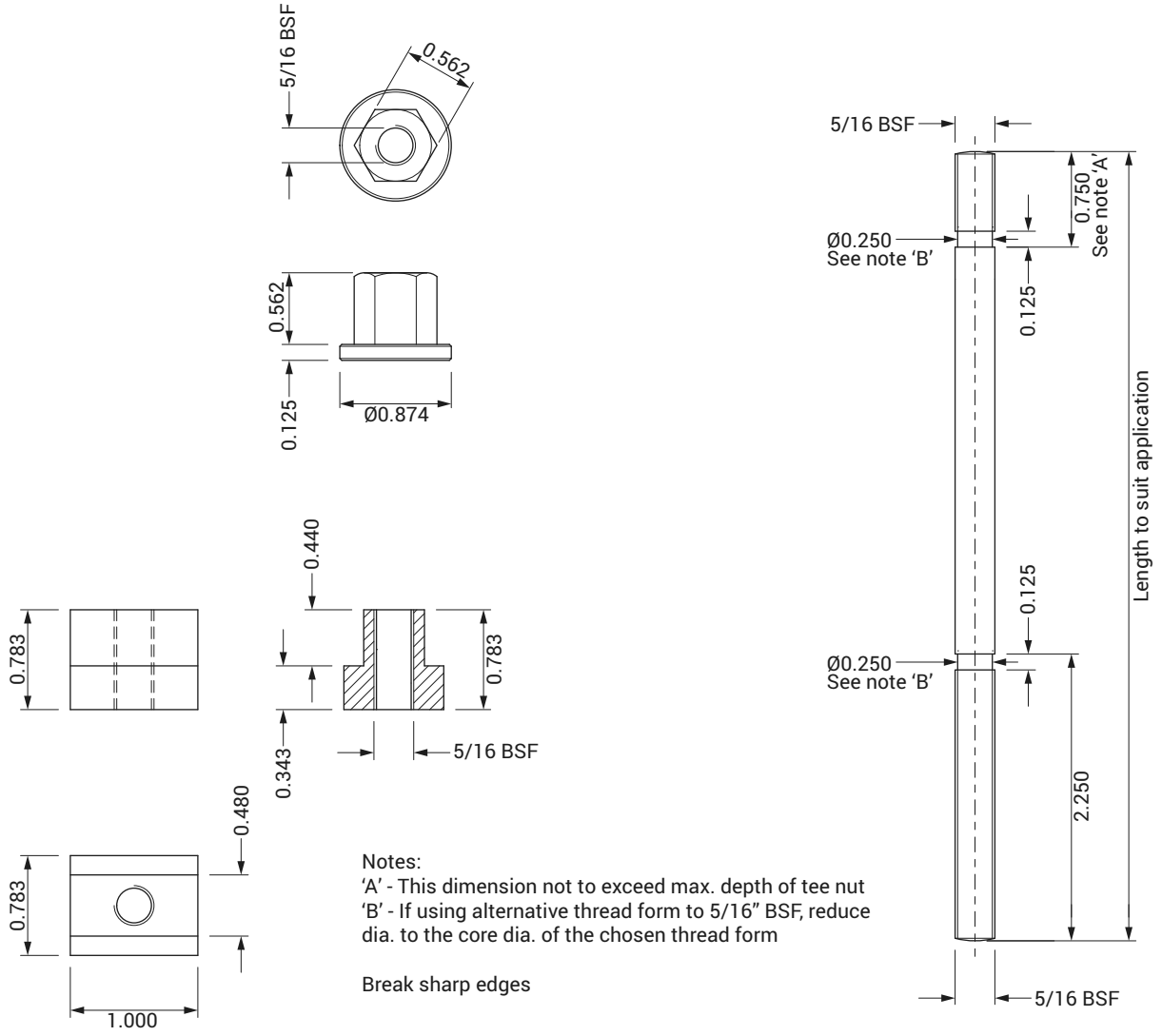
We now have a blank with a threaded hole through it and a hexagon on each end, split the blank with either hacksaw or by parting off; face off in the lathe to desired dimensions which as drawn is 0.125", finally break any sharp edges with the chamfering tool.

My advice is to make as many nuts within reason as you can or until you get bored of the task at least half a dozen is about the minimum but eight is better, might as well go for a dozen!

Studs

Now for the studs and again choices have to be made but the first thing to do is decide what length of studs are needed and whatever choice is made make them in pairs

Fig.2



Notes:
'A' - This dimension not to exceed max. depth of tee nut
'B' - If using alternative thread form to 5/16" BSF, reduce dia. to the core dia. of the chosen thread form

Break sharp edges

as a minimum, I often make studs in quads that is four of each length.

Cut the raw material to the lengths chosen trying to have an overlap in sizes providing greater versatility. Mount in the lathe, face off and chamfer one end, transpose end for end and repeat.

For the Tee Nut fitting ends (for the dimensions given) we need about an inch or so of rod protruding from the face of the chuck then using a parting off tool square to the chuck produce a groove 0.125" wide by 0.031" deep or metric equivalent. See **photo 1** depicting one end of a stud relieved as described.

I like to produce threads such as this by screw cutting which I find quite therapeutic however perfectly satisfactory threads can be produced with a die. Whatever method is used the previously manufactured nuts can be used as a gauge. Swap around and cut a thread on the opposite end by whatever is your preferred means.

Tee Nuts

Again, it almost seems that an engineer can't own too many of these or so at times it seems, however a good compromise which has satisfied my needs is to have about eight. Mine are produced from cast iron, I have never had one fracture or fail. The thread will in time wear out but as mentioned earlier I consider the clamping kit to be a consumable item.

The dimensions given suit my Tom Senior mill, anyone manufacturing for an alternative machine will have to check their own particular sizes before cutting metal.

I tend to make them in a length sufficient for three or four at a time, they are a simple thing to make as such I don't propose to record a blow by blow account as it's my contention that anyone who would need a narrative on how to make a tee nut ought to question whether or not they are safe enough to use a milling machine in the first place anyway! **Photograph 2** is a pyramid of tee nuts waiting to be pressed into service.

Finally

Just an odd couple of personal thoughts. I have heard of and seen machinists both professional and amateur alike, using bolts/studs made from high tensile steel. In my opinion this is a no-no, especially for the home machinist.

High tensile steel lives up to its name, it is my contention that the use of this type of material is probably a significant contributor to the breaking of a machine tee slot. Far, better to use more well-placed clamps to secure a job rather than trying to rely on one or two over tightened ones.

For shorter studs where the whole stud is screwcut it is still necessary to produce the undercut relative to end being employed in the Tee nut.

If the first machining operation of any job requires an 'as cast' surface to be bolted down onto the table of a machine with its attendant bumps and blemishes, then a far better grip will be afforded if a sheet of cartridge paper or thin card is interposed between the machine table and the rough as cast face of the casting. It's also kinder to the machine table as it prevents rough grinding material becoming embedded into the table surface. ■

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Setting Up a Shaper

Bill Morris continues his series on shapers by explaining how the machine is aligned and set up for best performance.

In what follows on setting up the shaping machine, I have learned much from reading Dr Georg Schlesinger's "Testing Machine Tools". This remarkable book went through eight editions between 1932 and 1978 and so has guided nearly two generations of engineers in checking their machine tools. It has only one page on testing shaping machines, but the first section of the book gives 42 pages of guidance on general principles. Second-hand copies are very expensive, but as Dr Schlesinger died in 1949, more than 50 years ago, it is out of copyright in many countries and copies of the seventh edition are available to be downloaded from the internet.

"The manufacturing accuracy of the machine and the accuracy of the finished workpiece are interconnected."(Schlesinger, p.5) The geometrical tests that we begin with have to be supplemented by practical tests, as a poorly designed or constructed machine might meet all the geomerical requirements and yet fail the practical tests. For example, a lathe with an insufficiently rigid bed could pass all the geometrical tests and yet be incapable of putting out good work under load. However, the results of practical tests are influenced by the type and condition of the cutting tool, the cutting speed and chip section, the size, shape and rigidity of the workpiece, the effects of clamping or chucking and operator skill.


1

Selection of levels.


2

Checking level.

Stress produces strain and may lead to deformation of the workpiece and/or the machine tool, while vibrations in one part of the machine may lead to resonances in another part, with the effects being transferred to the finish of the workpiece.

The tests are for the fully assembled machine, though this may sometimes have to be varied to allow access to parts. However, as Schlesinger wrote "No machine is improved by being taken to pieces..."(ibid. p.7) though this does not of course apply to overhauls. In many ways, the tests are tests of manufacturing quality and some of them have negligible influence on machine perfomance unless grossly divergent from the tolerances suggested. For example, it does not much matter in a shaping machine if the vertical ways that guide the saddle lean forwards a little, but it would matter if they leaned to one side or were not straight. A well-used machine cannot be expected to conform to all of Schlesinger's requirements, particularly as the ram and its guides wear, but they give some guidance as to what is achievable.

Equipment

A relatively small amount of test equipment is needed, such as many modern amateurs will already have in their workshops, but it does need to be in ›

good conditon and used thoughtfully.

Most model engineers will now own a dial gauge of sufficient sensitivity with a least division of 0.01 mm (~0.0005 in). As examination of instructional videos on the internet show, these useful devices are often supported on insufficiently rigid parts and overhang should be kept to a minimum. I measured in three indicators a typical spring pressure of the gauge spindle for the needle to make its first full circuit as about 80 grams force and this will cause a deflection of about 0.02 mm at the end of a 200 mm long support of 10 mm diameter. Thus, the indicator with indicate 0.02 mm low, without taking into account any deflection of the column. Ideally, the column should be about 25 mm in diameter and the support rod at least 15 mm. A magnetic base is nice to have, but most of them have rather slender columns for the job. I am fortunate to own one by Mercer's of St Albans which has a column 22 mm in diameter with a 13 mm support arm.

Most model enginers will own a selection of try squares which one hopes have never been used as improvised hammers (I confess to having done so at the age of eight), and if they are made by a reputable manufacturer they will be square enough for most purposes. A most useful item, both for checking squares and for checking right angles when setting up cutters on machines is a bottle square, a heavy cylinder ground to a uniform diameter to within very close limits and ground across the ends at the same setting.

A selection of parallels is very useful, both as spacers and as straight edges. If spot ground off a true surface plate their edges will be as close to being both straight and parallel as is humanly possible.

A precision spirit level is indispensable when setting up machines, but ideas of precision vary, as do the means of expressing it. One method is to express a movement of the bubble of one tenth of an inch when one end is raised a given amount on a base of one foot (305 mm). More commonly, outside the USA, the sensitivity is expressed in millimetres per metre base for a bubble movement of 2.5 mm, but perhaps best of all is to express sensitivity as the angle through which the level rotates for movement of the bubble through one 2.5 mm division, as no mental gymnastics are needed , depending on whether the level base is long or short. Thus, a level with a sensitivity of 0.0005 inches per foot has a sensitivity of tan-1(.0005/12) x 3600 = 8.6 arc seconds, and one of 0.05 mm per metre has a sensitivty of 10 seconds. It is quite useful to have

Table level in Y plane.

Ram guiding surface horizontal.

Face of vertical ways vertical.

Face of cross rail vertical.

levels of moderate sensitivity and of high sensitivity, so that a surface can be levelled approximately to bring it into the range of the more sensitive level. **Photograph 1** shows a selection of levels upon a granite surface table.

The level shown on the left of photo 1 has a lapped base of cast iron with a level vial of 10 seconds.

I made it, including the vial, about twenty years ago. I found the one in the centre in a junk shop. Presumably after the vial had been broken, it seems that it had been used as a soft faced hammer, as both ends of the brass cover plate bears many scars. I was able to refit this relic from the German Kriegsmarine, perhaps one of the spoils of war, with a vial of 60 seconds sensitivity.

On the right is a level called variously a frame level or square block level. All the edges are square to each other and the surfaces are finely ground and scraped to prevent wringing. Two of the surfaces that are at right angles to each other have vees machined in them to use when checking that shafts are vertical or horizontal.

The sensitivity is given as 0.05 mm per metre, i.e. 10 seconds, and this is about as sensitive as is generally useful. I once ground a long vial to 2 seconds sensitivity and the bubble took several minutes to settle to rest, while a ray of sunshine or a warm breath was enough to set it moving again. Even with a 10 second level, precautions need to be taken to keep its temperature uniform and to this end the level shown is fitted with a thick insulating handle. It is easy to find new frame levels costing £400 or more, but since the once-sleeping giant of China has awoken it is now possible to buy one that performs perfectly well for a tenth of the price.

Sensitive levels should be handled with great care as a knock can send them out of adjustment, so they should be periodically checked before use. Any smooth, flat and approximately horizontal surface is needed, together with a straight edge. On that plane surface will be some line that is horizontal and the first step is to rotate the level until the bubble is centred. This position is marked by laying the straight edge alongside the level, **photo 2**. Holding the straight edge in position, the level is reversed end for end and brought into contact with the straight edge again. The bubble should remain centred to within half a division. If it is not, the error is half the difference and can either be adjusted out by whatever means is provided, or if none is provided, allowed for.

For testing machines that have rotating spindles, like lathes, milling machines and drilling machines, a variety of test bars is valuable.

In what follows, the quality and alignment of slide ways and locating surfaces are tested, and in other machines the accuracy of the main spindle and its alignments with other parts of the machine too would also be tested. Finally, practical tests have to be carried out to assure the accuracy of parts produced by the machine.

Levelling the machine.

The usual reason given for levelling the machine is that it was presumed to have

Edge of vertical way vertical.

Top of cross rail horizontal.

Table clamping surfaces mutually square.

Top of table parallel with movements.

been produced on a large machine tool, the work table of which was itself level, and that gravitational stress might cause strains that might distort the product if it were not installed level. For small dislevellment I find this a little hard to swallow and the explanation that I prefer is that levelling is a relatively simple aid to bolting down the machine tool without distorting strains. The aim then is to finish securing the machine to the floor without disturbing levels that it had when free-standing. When setting up workpieces at an angle using a clinometer, it is often also convenient to be able to assume the work table is level.

Levelling can be a frustrating business. Schlesinger shows the shaping machine supported on four wedges. While it is relatively easy to level in, say, the transverse plane (which I will call the X plane) by tapping in the two wedges along one side or the other, levelling in the plane at right angle to this (the Y plane) means that the front or back pair of wedges have to be disturbed equally. I try to do this by listening to the sound of the wedge when it is struck by the hammer but it does not always work and then one finds that another wedge is not carrying any weight. The machine gradually rises off the ground as one switches between the two planes, until a wedge cannot lift any higher and one has to start again.

Once the table is level in both directions the machine is carefully bolted down, ensuring that doing do does not dislevel it and introduce strains. Note that in photo 3, one edge of the level is set against a straight edge held against one side of the central tee slot, while it is set against a square off the side of the table when checking in the X plane.

Schlesinger gives a permissible error for "Table flat and level in both directions as 0.04 mm/metre" or one division on my level. Note that a level of this sensitivity can detect quite small errors in flatness, so I started by scraping the table flat against a small surface plate that I made long ago as one of three scraped flat to each other.

Ram movement parallel with tee slot.

Column and ram square

Schlesinger writes "Guide surface of ram square with guide surfaces of column in plane through centre of column." to 0.02 mm/metre, but this isn't possible exactly, because neither surface is present in the centre of the column. **Photograph 4** shows the underside of the ram being checked for level, incidentally showing that it is parallel to the surface of the table in the X plane and **photo 5** shows the face of the vertical rail is vertical, so that the two surfaces must be square to each other, providing the frame of the level is square (which it is).

Table guide ways

Next comes the "Front bearing surface of table slide flat or level (sic)" where the requirement is 0.03 mm/metre, but the illustration in Schelsinger's book makes it plain that the front surface is being tested for verticality, **photo 6**, not levelment. It does not really matter much whether this surface is truly vertical, provided that the top face of the table is horizontal

The "Upper guide on table ways..." must be "...square with column ways."to within 0.03 mm/metre. This means the edge of the

Side surfaces movements.

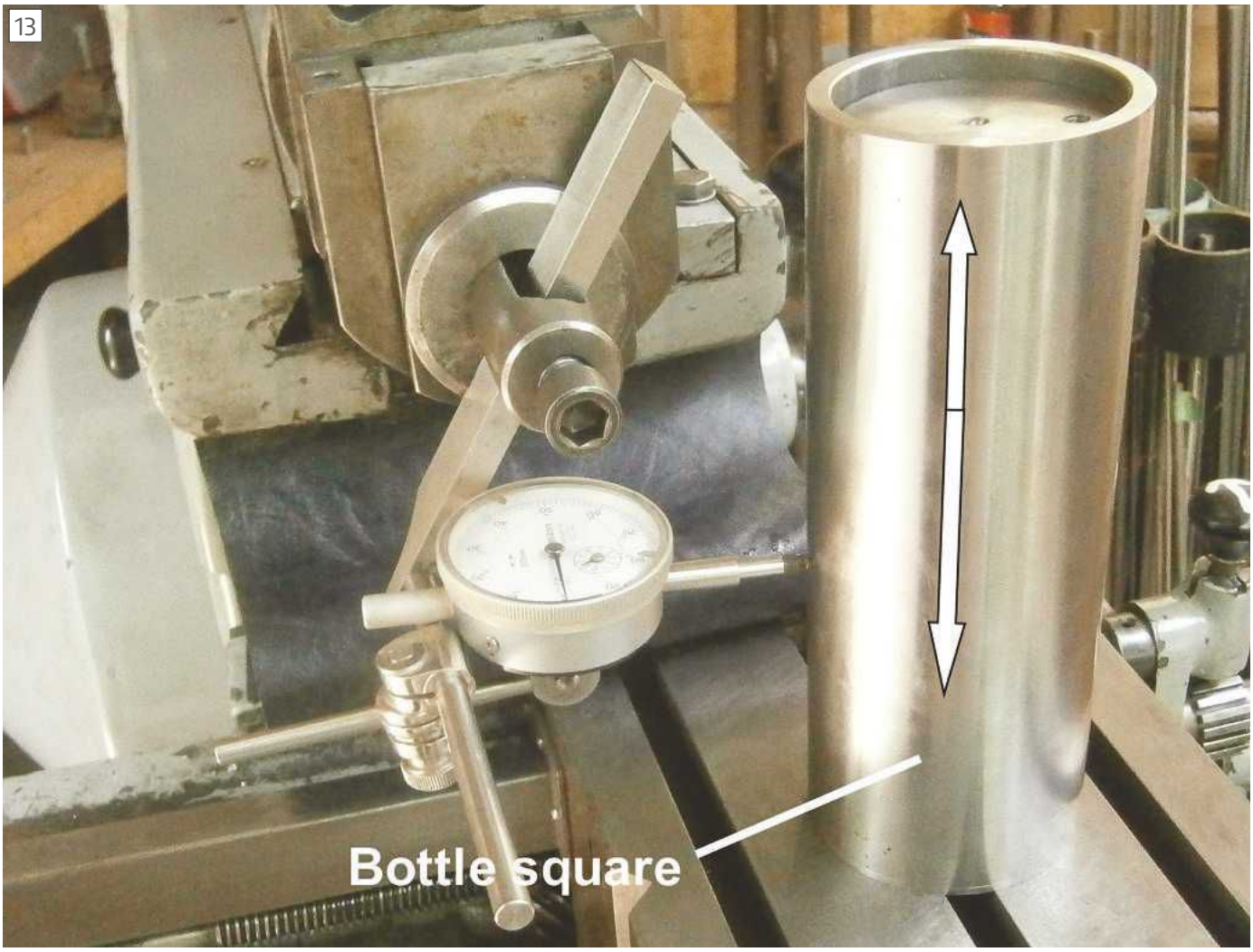
column ways, as shown in **photo 7**, versus the top of the cross rail, **photo 8**.

If the top edge of the cross rail, which guides the table in the X direction is not parallel to the X plane of the table, then work pieces will end up slightly wedge- shaped in this direction. If the machine is badly out of kilter in this respect, there is not much that can be done about it, short of re-machining the guide surfaces of the apron.

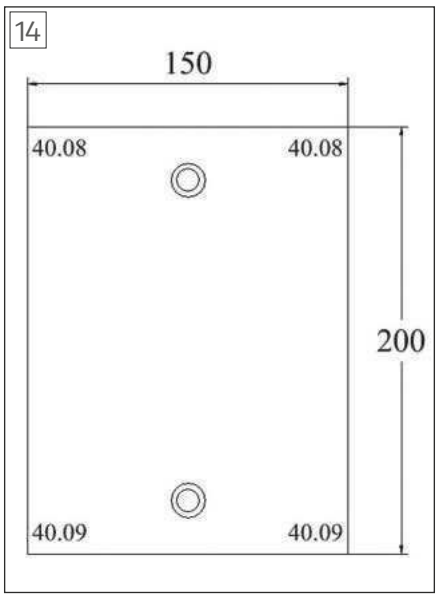
The table

The upper surface of the table must be square with the sides to within 0.02 mm/ metre, **photo 9**. I used a large and very little-used square of good quality to check this, rather than the level, and found that the left side which carries a vee, to be square, but the right side showed a wedge of light. Exploring this with feeler gauges, the error was a relatively enormous 0.3 mm/ 200 mm and I will have to bear this in mind if I ever use the right side of the table for anything critical. Unlike the top of the table, which can be machined in place by the machine itself, there is little I can do about this fault, short of borrowing time on a large milling machine or paying someone to correct it.

The next checks are for "Incline of table in its transverse...and in its vertical



Vertical movement of table square to its top.



Thickness of test piece at corners.

movement", which should not exceed ± 0.015 mm/300mm. This is 0.05 mm/metre and seems to mean that the bubble of my level should not move more than a division when the table is moved from side to side or up and down. Easier to understand is that "The upper surface of the table should be parallel with its transverse movement." to within 0.01 mm/300 mm. Needless to say, if the table is not flat, this test will be deceptive and, although I have scraped my table flat, running the dial gauge across the top of an accurately ground parallel, **photo 10**, will avoid the tip of the spindle falling into local irregularities, the largest of which are the tee slots. Note the very stout bar which holds the gauge in the tool post of the ram.

With the same set up the "Movement of the ram parallel with work table" (Y direction) can be checked to be within 0.15mm/300 mm. Any error should be to rise at the front, as this will compensate for drooping of the front of the table under tool forces in the Y direction.

It is fairly important that the sides of the tee slots should be parallel with the movement of the ram, since, if this is known to be the case, tenons on the undersurface of a machine vice will locate the vice rapidly, without the need to check that its jaws are correctly aligned using a dial gauge off the ram. Mine were out by 0.04 mm in 250 mm, **photo 11**, and I will correct this as an exercise in the next section. While the dial gauge remains rigidly held in the ram, flexing of the various parts of the exploring tip may mean that the error is bigger than indicated. It is also useful to have a scrap of mirror glass for reading the gauge in awkward places.

Ram movement should also be parallel with the side surfaces of the table to within 0.02 mm/300 mm and again the piece of mirror glass is needed to read the dial gauge, **photo 12**. After a little

It is fairly important that the sides should be parallel with the movement of the ram

manipulation of the supports for the dial gauge, one can also check that the "Side surfaces of the table are parallel with its vertical adjustment" to within 0.02 mm/300 mm.

As a further check on the vertical movement of the table the dial gauge can be tested against the side of square as the table is raised and lowered, to assure that the vertical movement of the table is square to its top. A bottle square is shown in **photo 13**, but an ordinary try square of good quality or a frame level could just as well be used. The allowance is 0.02 mm/300 mm.

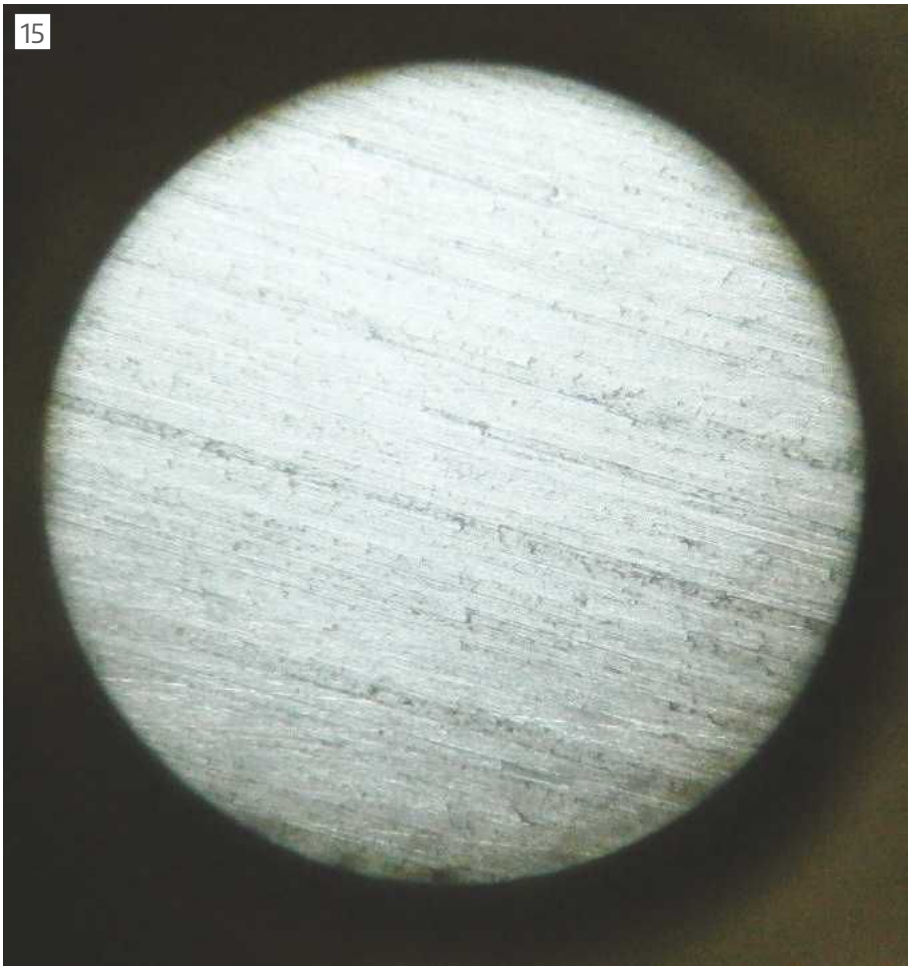
Practical test

Schlesinger described a work piece 100 mm wide and of a length two-thirds of the stroke of the ram, of mild steel or cast iron, and required that after a finishing cut the dimensions at the four corners at opposite ends should be the same within 0.02 per 300 mm, as measured with a micrometer.

This may seem to be a very stringent test for those who have used a shaping machine only as a hack to form bevels on plates prior to welding them, or for bumping off lumps and skin from castings so as not to blunt expensive milling cutters, but it is achievable, as the results in **photo 14** show.

As a test piece I used a chunk of 41 mm (1 5/8 in) "commercial" steel plate 200 x 150 mm which had been flame cut from a larger piece before being given to me and the first task was to clean up the edges. To secure it to the table I drilled two 10.5 mm holes on the long axis and counter-bored them on each face to place the heads of 10 mm Allen screws well below the surface.

After cleaning up each face using a roughing tool, I completed the job with a very fine cut, of about 0.05 mm deep using a round-nosed finishing tool. **Photograph 15** shows the result. The darker striations are 0.15 mm apart, representing the cross feed, while the much finer and lighter ones represent imperfections in the smooth contour of the nose of the tool. ■



Photomicrograph of finish x60

Lathework for Beginners

PART 3 - CUTTING TOOLS

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

Last month we made our first cuts using the lathe, without looking too closely at the tools we were using or the speeds and depth of cut we used. This month we will delve a bit deeper into these issues.

Pre-Ground HSS Tools

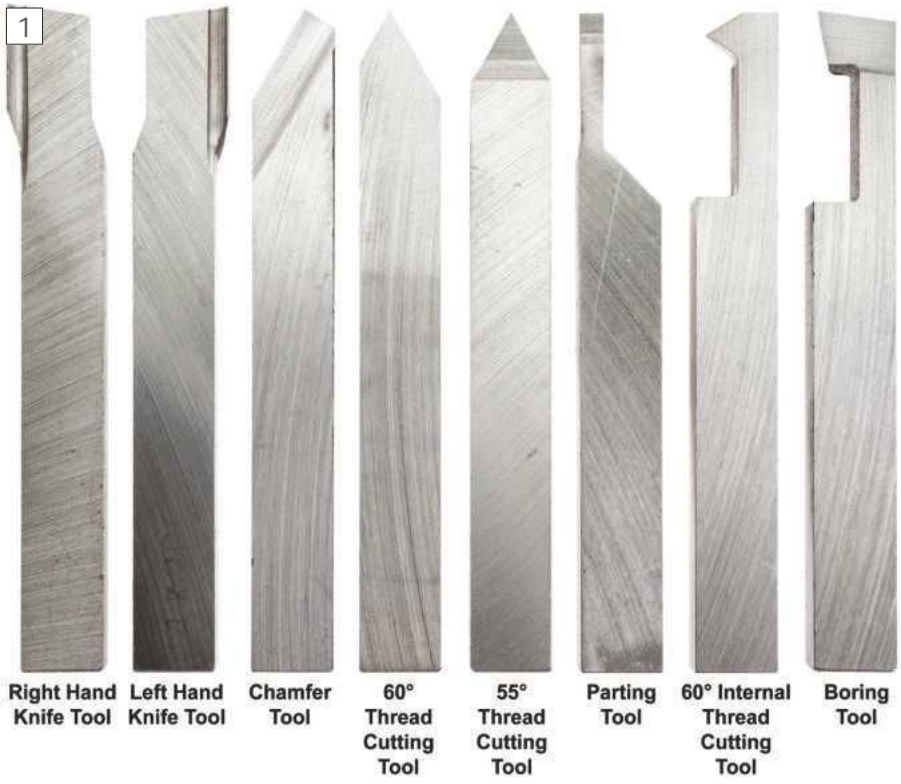
Let's briefly revisit the set of pre-ground High Speed Steel (HSS) tools we saw last time. The advantage of such a set is both that HSS is very forgiving with regard to speeds and feeds and naturally by using them you have one less thing to worry about while developing your skills.

Starting on the left of **photo 1**, we have right and left-hand knife tools (apologies for confusing my left and right last time!) These are typically used for finish turning along the length of a workpiece. While they can be set 'straight' in the toolpost, if you are turning into a corner it is helpful to angle them slightly. Although they seem complex in shape, they can be sharpened simply by grinding away a small amount from the end and so they have a long life. The use of a groove to relieve the upper edge has the benefit of helping break the swarf into shorter chips, rather than forming long ribbons.

The third tool, labelled as a 'chamfer tool', can be used for 'breaking' sharp corners on turned work. Usefully, this shape works very well as a 'roughing tool' as it is capable of taking somewhat heavier cuts than a knife tool (it produces a longer but thinner chip) and the angled edge 'eases' the shock load when taking interrupted cuts. Although the tool can't cut into a corner, it is great for when you need to rapidly reduce the diameter of a bar, **photo 2**.

The thread cutting tools are used for making screw threads. For metric threads the 60-degree tool is used, whilst 55-degrees is used for imperial threads. In brief, thread cutting is done by setting the saddle feed to match the required screw pitch. We will cover various approaches to thread cutting properly in a future article.

The parting tool is 'plunged' into the work to make a groove or separate it from the parent bar, again we will look at parting in more detain again. The two tools on the right are mounted 'lengthwise' along the axis of the lathe and used for taking cuts inside a cylinder. The first is for cutting an internal thread, again we will revisit this tool when we look at thread cutting. The final tool is used for boring out holes more accurately than by drilling, if used with care, it can work up to an internal corner.



A set of pre-ground high speed steel tools

More on Knife Tools

Figures 1 and **2** show three 'knife tools' and how they are set for different types of cut. You can see they are set a slight angle, so they can cut into an inside corner. In practice you can set them 'straight' if you are taking small cuts.

Although the figures show a left-hand tool set crosswise for a facing cut, it is quite possible to take light facing cuts with a left or right-hand knife tool moving it in either direction across the face of the work. It is usually easier and quicker to do this rather than change tool.

While I would advise any beginner to start with a set of pre-ground HSS tools, in time you are likely to want to be able to grind your own. The basic knife tool, as shown in fig. 2, is very easy to grind 'offhand' on an ordinary grinder, as the groove used for the pre-ground tools is replaced by a sloping upper surface. A 'raw' piece of HSS will normally have a suitable angle ground across the end, so creating the knife tool is a case of angling the grinder's support table (it should be set close to the wheel that the bar can't be dragged into the gap) tidying up the end face and then creating slopes on the front and top of the bar. These should meet and create a cutting edge. As well as creating a sharp edge, these angles stop the tool

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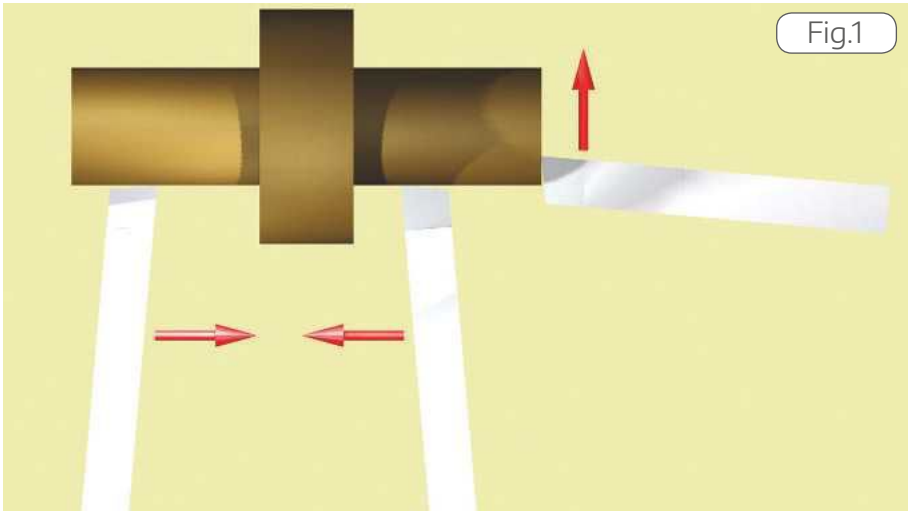


Fig.1

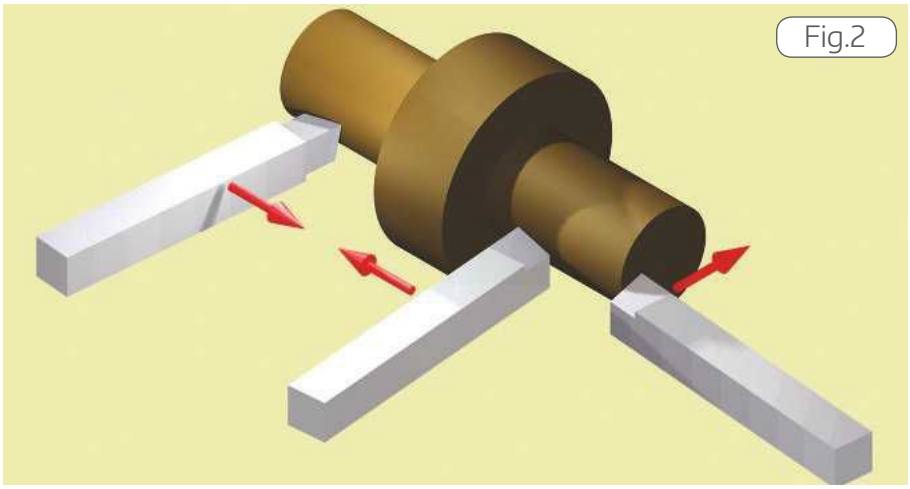


Fig.2

Cutting Speeds

It is easy to find reference tables on line and elsewhere that give very precise cutting speeds for different types of cutting tools and materials. These often give relatively high speeds intended for production work or numbers to great precision. In the real world, many lathes have relatively few speeds (typically six on belt drive lathes with back gear) and even variable speed lathes may only vary speed in 100 rpm steps. Furthermore, the best speed for any individual task will depend on the exact material and tooling used, how sharp the tools are, the shape of the workpiece and the condition of the lathe. If the job is large, or poorly balanced then a lower speed than ideal may be essential for safety. Someone who tends to use light cuts may find they get better results from higher speeds than another machinist who likes to put on a heavy cut. In a home workshop, the ideal speed for any job is best found by experiment and experience.

Even so, it is helpful to have a guide to get you in the right ballpark, so here is the 'rule of thumb' I work to. With experience, you may adjust these rules to suit your equipment and machining style.

- For metric units, divide 10,000 by the diameter of the work in millimetres.

If you prefer Imperial units, divide 400 by the diameter of the work in inches.

- This will give you a reasonable speed for relatively light or finishing cuts with mild steel and a high-speed steel tool.
- For aluminium or brass, multiply this speed by two.
- For stainless steel or other tough steels, divide the mild steel speed by two.
- If you can't get the exact speed, use the next one down.
- For heavier, roughing cuts, reduce the speed by about 30%.
- For carbide tools, increased the speed by 50% or more; you may even wish to double it for more easily machined materials.

Bear in mind these are approximations. If you can't get the speed given just use the next speed down, if your lathe won't go slow enough, use the slowest speed and take a smaller cut. Also, be aware that larger chucks typically have a safe maximum speed which should not be exceeded.

rubbing on the work and encourage free cutting.

The use of a card or metal template makes grinding easier, but the exact angles are not critical, and around ten degrees will work for almost all materials and situations. In time you will learn that for brass the tool can be left flat on top, and that for aluminium and plastic a greater slope and sharper edge work well.

As mentioned before, you can carefully put a small radius on the corner of the tool, or a short 'flat' across the end. This reduces the tendency for a very sharp pointed tool to leave a tiny 'thread pattern' in the work. As your confidence develops you can grind larger radiuses which will leave a nice fillet in internal corners or create angled ends for chamfering corners, etc.

Tangential Tools

In recent years there has been something of a renaissance in 'tangential' tools which hold a near-vertical bar of HSS and other designs which use an angled HSS bar. These are usually ground very easily with a jig and many users find these superior to grinding their own tools.

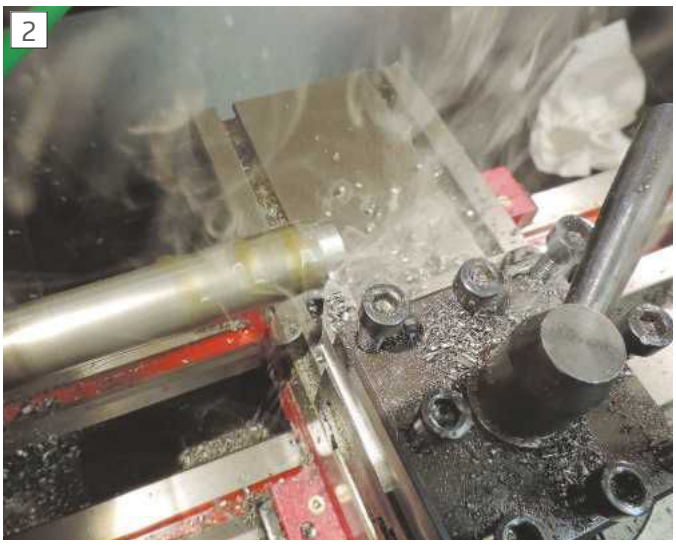
Brazed Carbide Tools

Brazed carbide tools are made by brazing or silver-soldering pieces of tungsten carbide to the end of a steel shank. Tungsten carbide is incredibly hard, somewhat fragile and rather expensive, so this approach allows a well-supported, hard tool tip to be used in an economical way. The method of construction is robust as a well-designed steel shank will fully support the tip.

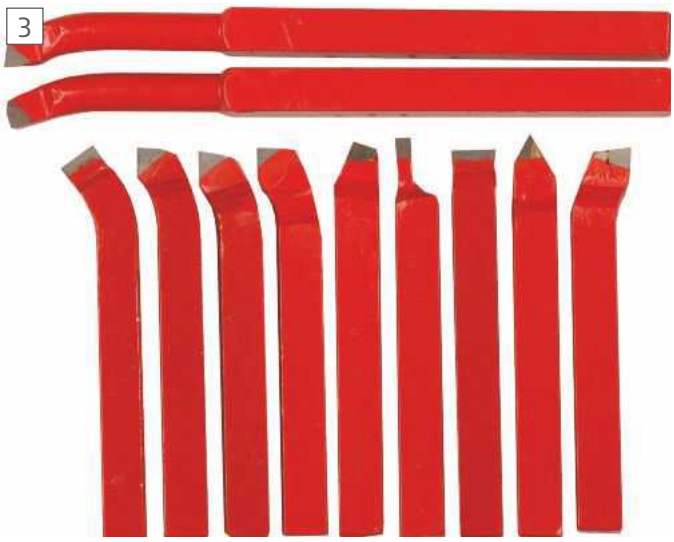
On the whole, I would not recommend these tools for a beginner. They typically need a little attention with a diamond slip to give a good edge and show their best when worked hard. That said, I have had a set for many years and the one task they excel at is removing the tough 'skin' on iron castings or even bullying your way through very hard 'chill spots'. If you do a reasonable amount of work with difficult materials it is worth having a set of these handy.

Photograph 3 shows the selection of tools in a typical 'mid range' brazed carbide set. I won't detail all the shapes, but for example see how the boring bars and left and right cutting tools are in pairs with different angles at the end. One of each pair has an acute tip for finishing and working into a square corner, while the other has a stronger, obtuse tip and is used for roughing cuts. These roughing tools are ideal when you want to tackle something like an iron casting with a really tough skin.

There is great variation in quality between different sets of brazed carbide tooling. The DIN-marked ones supplied by Arc are mid-range tools with machined shanks and superior to my old set with relatively crude forged shanks. These older tools were less accurately shaped and needed more effort to get the best out of them. Even so, machining the chilled main casting for my 'Potts Spindle', some twelve



The 'chamfer' tool works well for roughing cuts, the chip breaker groove promotes short swarf rather than long ribbons.



Brazed carbide tools like these are very tough, but challenging to get the best out of.

years ago, **photo 4**, would have been near-impossible without them. **Photograph 5**, shows the unusual setup I used with the carbide boring bar held offset in a four-jaw chuck (to give the correct internal diameter) and the casting clamped to the topslide. Lathes are truly versatile machines!

Indexable Carbide Tools

'Indexable' tools use small ready-to use inserts that are screwed or clamped on to a reusable holder. Typically, the inserts are made of tungsten carbide but other ceramic and even HSS inserts are available to fit the same toolholders. Carbide is very hard and heat resistant, but more brittle than HSS. The repeatability and wear resistance of carbide inserts means they are used in huge quantities by industry, despite the cost of raw tungsten making them more expensive than HSS.

Photograph 6 shows left and right turning and facing tools with carbide inserts, **photo 7** is a 'neutral' tool used for roughing, chamfering and grooving and **photo 8** shows a boring bar.

Carbide inserts are designed for use at high speeds, often higher than the maximum speeds of most hobby lathes, and usually on industrial lathes which have more rigidity at such high speeds. For this reason, some people feel that indexable carbide tools are not suited to 'hobby' sized lathes. This was probably true once, but there are now a huge range of different styles and geometries of tip available, including types used for fine work on relatively small CNC machines that are no more robust than a good hobby lathe. The problem is not that these tools don't suit small machines, but choosing the right tips to suit your machine and knowing how to get the best from them.

You will probably start by buying matched inserts and toolholders. It is a good idea to make a note of the 'right' inserts for each toolholder. It is also possible to buy different shaped toolholders that use the same inserts, this reduces the number of inserts you need in stock and if you run short you can then swap inserts between toolholders.

Depth of Cut

One of the most frequent worries for a beginner is how deep a cut they should take? This is compounded by the manuals for many hobby lathes advising the use of very shallow depths of cut, typically 0.1mm. Sticking to such small depths of cut will make many straightforward jobs into long ones and wear out your tools faster as all the work will be done by the very tip of the tool. You may want to use modest depths of cut at first, to get used to your machine, but experiment with increasing the depth of cut and see how this affects both surface finish and the accuracy of your work. The lathe will make it obvious if you are trying too deep a cut, usually by leaving 'chatter marks' or making an awful screeching sound. It should be obvious that the lathe is struggling well before you get to the point where the lathe motor stalls.

Photograph 2 showed the 'roughing' tool from the pre-ground HSS set, being used straight out of the box on 19mm mild steel (En1a, but not the leaded 'free cutting' type). The depth of cut is 2mm, or twenty times that recommended by the manual! You can see that this depth of cut generates a fair bit of heat as the HLP 32 cutting oil (applied by brush) is smoking, even so the HSS is not overheating and discolouring, and the surface finish was excellent. The lathe was run at about 400rpm, so slightly slower than the rule of thumb suggests, as this would be classed as a roughing cut. The overhang of the bar is about 125mm, but there is no sign of chatter showing that the SC4-510 is quite a rigid lathe, and it is capable of deeper cuts than this. SC2/SC3 Mini-lathe owners should find that their machines are quite happy with 1mm or more depth of cut in mild steel.

While it is always an option to take very fine cuts to get a part accurately to size or get the best surface finish, unless you have very HSS sharp tools, you are likely to find that the best results come when the tool is working properly, especially with carbide tools. A rule of thumb for carbide tools is to use a depth of cut no less than 2/3 the tip radius. For the 0.4mm insert radius tool we looked at earlier, this would be roughly 0.27mm depth of cut.

This means that, especially with carbide, when you are aiming to cut to an exact diameter, it is best to plan ahead so your finishing cut can be around this minimum depth, rather than being a fine shaving cut.

Insert Codes

There is a standard code for describing inserts, typically four letters followed by a number. The full code is too complex to detail here, so as an example let's look at a typical insert that suits smaller lathes: CCGT 060204, **photo 9**:

Shape – C: 80-degree diamond, this give a well-supported tip that can work into a 90-degree corner. Some other useful shapes are S – square as shown in photo 6; R – round; T – equilateral triangle and V – a long-thin diamond shaped tool intended for CNC profile turning but useful for delicate work.

Clearance – C: 7-degrees; a good compromise between good support for the cutting edge and ample clearance.

Tolerance – G: This is the tolerance of various measurements of the insert. The tolerance letter can be confusing as the tolerance reflects other properties of the insert. The two you are most likely to encounter are G and M. M is a general use moulded insert, while G is ground further into specific shape (e.g. Top rake for

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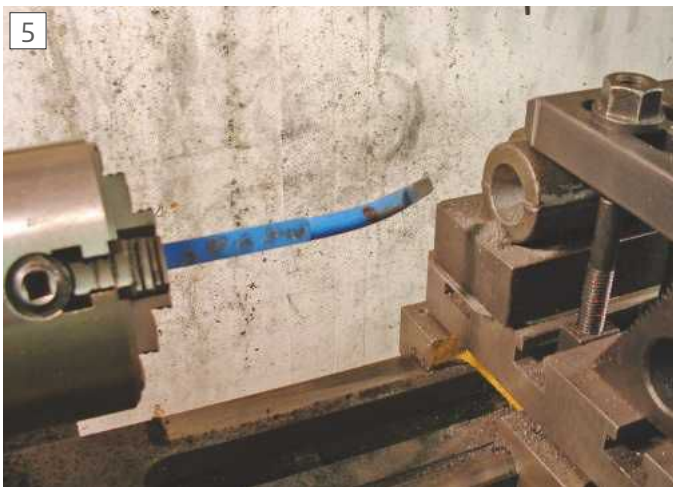
The author's Potts Spindle.



An unusual approach to using a brazed carbide boring bar to bore out a chilled casting.

additional tolerance for specific application, and so will cost more than the M moulded inserts. Both types are available coated for better wearing properties, or un-coated or polished for the G type. In the hobby environment, M type are generally used for machining of steel, stainless steel and cast iron. The polished G type with ground edges, are ideal for cutting aluminium, brass and other non-ferrous metals.

Hole/Chipbreaker – T: A 40-60-degree double countersunk hole (it has to match the screw used by your toolholder) and a single-sided chipbreaker.

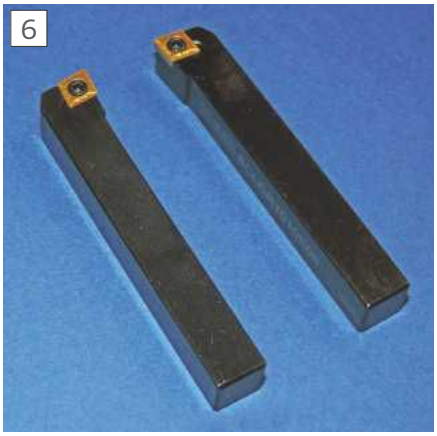
Cutting edge length – 06: 6 millimetres, in this case one side of our diamond.

Thickness – 02: This is 3/32" or 2.38mm.

Corner radius – 04: In this case 0.4mm. For hobby machines corner or nose radius of 04 - 0.4mm (for finishing) or 08 - 0.8mm (for general use) are suggested. Finer radius than this, such as 00 – sharp point, 01 – 0.1mm and 02 – 0.2mm should generally be avoided as they are more suited for use at very high speeds on industrial CNC machines with high rigidity. If used on hobby machines, such inserts are more likely to chip easily.

Toolholder Codes

Some, but not all, the codes used for inserts are used for toolholders, in particular a simpler scheme is used for the clamping method.



These left and right handed indexable carbide tools can be used for both turning and facing at the same setting.

Photograph 10 shows the codes on the SCLC-R1010E06 and SCLC-L 1010E06 toolholders we saw in photo 5. These toolholder codes break down as:

Clamping method – S: A screw fitting, other styles are various types of clamp and pin.

Shape – C: 80-degree diamond, this matches up to the tip code.

Holder style – L: This is the way the toolholder presents its cutting edge to the work. An 'L' toolholder essentially offers the 80-degree insert so it can cut freely into a 90-degree corner. Unlike the knife tool this gives an ideal geometry for both turning and facing with the same tool, which is why this style of toolholder is so popular.

Clearance angle – C: 7 degrees, again this matches the insert.

Handedness – L or R: clearly left or right, there are also N or neutral toolholders, photo x.

Height and width of shank – 1010: the shank of the tool is 10mm by 10mm, this suits the SC4 510, 0808 shank (8mm) toolholders work well with mini-lathes.

Length of holder - E: 70mm, this is rarely critical but shorter holders suit smaller lathes and longer holders can be 'overhung' to extend their reach. A is very short (32mm) and Q is 250mm, so if your chosen size is not available a letter up or down will usually work.

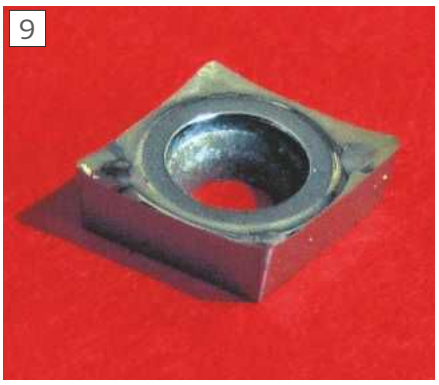
Cutting edge length in mm 06 – 6 millimetres, this must match the insert.

The shape, hole, cutting edge length and clearance are matched to the toolholder, but it is usually possible to use inserts with different tolerances, corner radiuses and even thicknesses in the same toolholder.

Inserts are sometimes sold without the corner radius being specified. It is worth checking as smaller numbers are suitable for machining fine work and sharp internal corners, while a larger corner radius makes it easier to get a good finish and leaves a

This 'neutral' tool is for chamfering and roughing.

Indexable boring bars can be used in surprisingly small holes.



This sharp-edged uncoated CCGT insert is meant for non-ferrous metals, but some people report they work well on steel if used with care.

Helpfully, many toolholders have their codes etched or stamped on them, making it easy to order suitable inserts.

distinct fillet in a corner.

It is also possible to get carbide inserts with a 'wiper tip', this is the equivalent of an HSS tool with the tip stoned to have a small flat on it, and gives an excellent surface finish.

Using Indexable Carbide Tools

Fitting carbide inserts is easy, the tools are usually supplied with a special torx tool, **photo 11**, and hardened screws. These should be done up firmly, it is hard to shatter an insert if you use the supplied tool. Many styles of insert have two or more cutting tips so they can be reversed when they wear or (for inserts with multiple angles) used with a different style holder. You may need to pack the toolholder to get the tip on centre height, **photo 12**, bearing in mind that inserts for a given toolholder may not all be the same thickness. Accurate setting of the tool greatly helps free cutting.

Typically, carbide inserts have a 'blunter' edge than you would use with HSS, this means you need to work the insert hard, so it heats the metal, softening it, in order to achieve a good finish. With the right tools and inserts, success becomes largely a matter of adapting to the increased speeds and feeds required to get the best from them. This can mean that the lathe needs to run considerably faster for a carbide tool as for HSS.

As a rule, toolholders are supplied with a special tool to fit their retaining screw.

10mm shank tools suit the SC4-510 lathe, but as inserts can vary in thickness you may need to use packing with the standard toolpost.

That said, some beginners report that the polished and ground (silver coloured) CCGT 'non-ferrous' inserts work well with almost all materials. They have sharper edges which means they cut more freely, compared to golden or black coated CCMT inserts. This may allow slightly lower speeds to be used. The downside is that the sharper edge wears more rapidly and is more vulnerable to chipping.

The great majority of people who struggle with carbide tooling do so because they are trying to use HSS speeds and feeds, or they have purchased too fine a corner/nose radius insert. A slow, light cut causes the tools to rub, giving a poor finish and sometimes causes the tool to suddenly 'grab', breaking the insert. Gain confidence on your lathe using HSS, then if and when you change to indexable carbide, be prepared to break a few inserts and endure some frustrations before you get the hang of it.

Ultimately there is no 'best' cutting tool, instead as your experience grows you will learn the 'best' tool for any particular job, your machine and your style of working. ■

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Condensation Management – Some Observations

Dear Neil, In response to the article on Condensation Management in issue 263 I would like to comment on some of the points made. In making these comments I am referring to a Psychrometric Chart plotted for a barometric pressure of 101.325 kPa which is normal sea level pressure.

My chart shows that at 20 deg C and 41% saturation the dewpoint is around 6.5 deg C and at 25 deg C and 41% saturation the dewpoint is 11 deg C. Small differences from the article but differences nevertheless. However, the point of writing is that there is the impression given that heating a workshop raises the dewpoint of the air. This is clearly wrong. If the air in the quoted example 20 degrees and 41% is heated to 25 degrees the humidity (saturation) falls to around 30% but the dewpoint remains the same i.e. 6.5 deg C on my chart.

The really important issue in condensation control (preventing machines going rusty) is to keep the temperature of the metal of the machines from falling below the dewpoint of the air in the workshop.

Intermittently heating a workshop is not the answer in my view as the temperature of the machines changes very slowly due to their mass and even if the workshop was heated to 20 deg C when working, the temperature of the metal would not rise very during the period when the workshop was in use.

I have a small microprocessor control system for my workshop and maintain a minimum temperature of 10 deg C all year round only raising the temperature when working in there. This records the temperature and humidity and I can view the previous 24 hours of data.

This is clearly unnecessarily complicated but I did it because I was in the air conditioning industry and I could. A simple thermostatically controlled electric heater would do the job almost as well. My heater is 1 Kw for background heating and I use a larger heater for making the workshop comfortable to work in. I have used this system for over 20 years and have never suffered from rust. I do still get condensation on the single glazing but that is not a concern for me.

Another point regarding condensation is the issue of a well sealed building. When working we release moisture into the atmosphere by breathing and by perspiring with the result that the dewpoint of the air is raised by us but not by heating. So leaving the workshop after a working session and immediately sealing the building is not the best idea. Counter intuitively it would be better to leave the door open for a while to let some of the moist air out before locking up.

Martyn Harrold, by email

On No!

Dear Neil, I have a question, perhaps somewhat strange or well-known to others.

But in the Private Adverts I see sometimes behind prices ONO. What is the meaning of that?

Henk Salij, the Netherlands

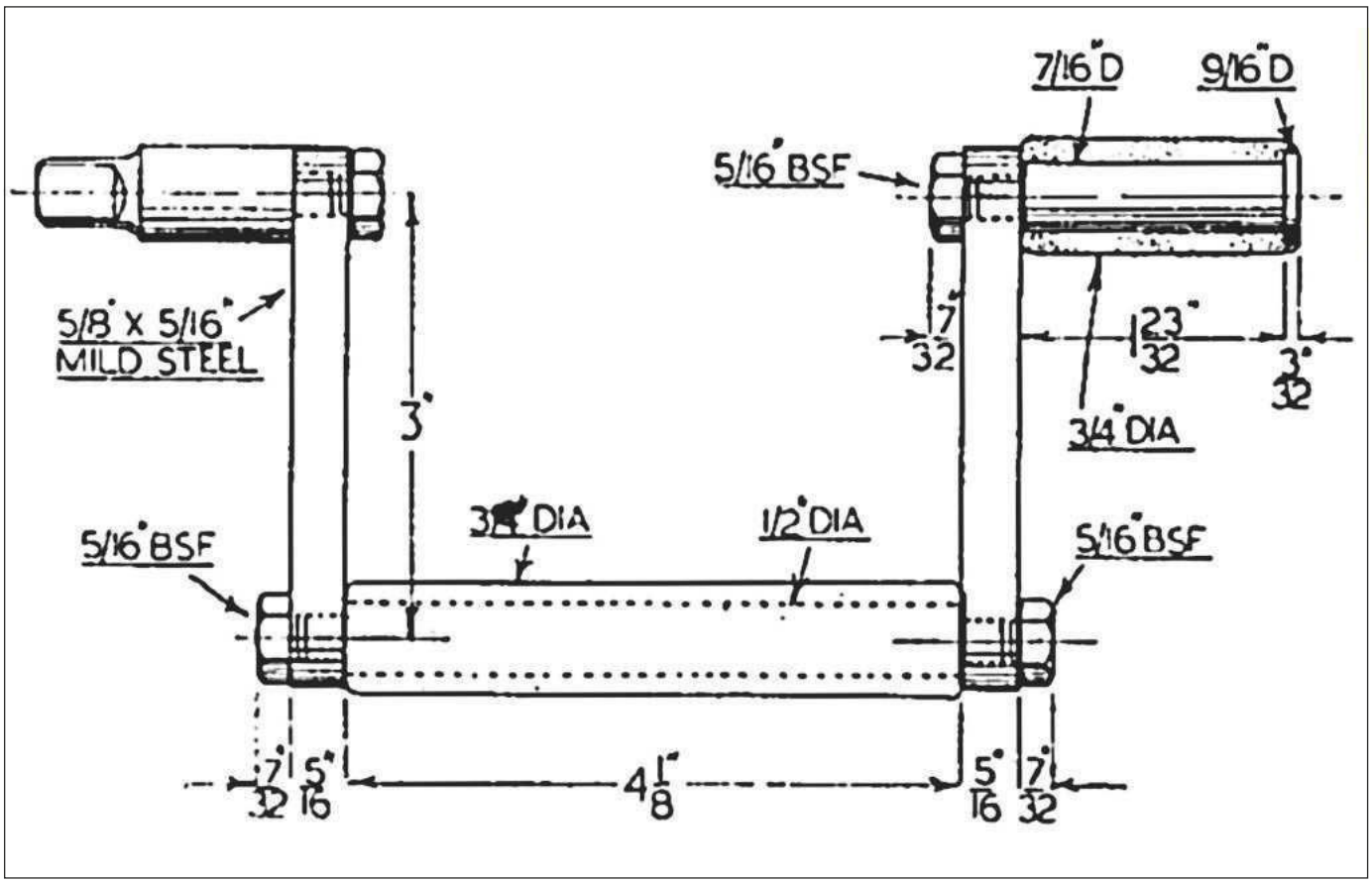
I can understand that such abbreviations can confuse! ONO stands for 'or near(est) offer' and means the buyer is open to some negotiation over the price. OVNO is 'or very near offer'. – TTFN, Neil.

Screwcutting Clutch

Dear Neil, Issue 261 was excellent with a very broad range of articles. The series of articles by Graham Meek is particularly interesting and has prompted me to find and view a couple of clips of threading with a Hardinge HLV lathe on You Tube. I believe the Monarch lathe has a similar facility. The ease with which screwcutting can be carried out without issues over repeat pickup is amazing, particularly so if one is cutting a metric thread on an imperial machine. I wonder if Graham intends to detail such a clutch for a Boxford 4.5/5 inch lathe? I'm sure it would be well received.

Keep up the good work.

David Byways, by email



From the Archives

This hand -brace for rapidly changing the jaws of lathe chucks originally appeared in a brief article by Duplex in Model Engineer number 2876, Volume 115, 5 July 1956. 'Duplex' was the pen-name of a partnership between Norman Hallows and Ian Bradley. We leave it up to individual readers to decide if the effort in constructing this specialised piece of equipment will be repaid by extra convenience in jaw-changing.

BA Threads

Dear Neil, I usually obtain a copy of your magazine from my local newsagent and it arrives in Australia several months behind your time. I read in the no:256 issue the article you wrote about B.A. taps which claims that Lehmann Archer & Co. originated and manufactured the first British Association (B.A.) tap and die. I would like to draw your attention to the following:

• Machinery's Screw Thread book by C Edgar Allen – A.M.I. Mech E AMIEE – editor of "Machinery" Machinery Publishing Co.Ltd, London. Chancery Lane WC2. Second edition 1917

• B.A. B.S.A British Association Screw Thread series can be located on google.

From both sources it appears that the B.A. thread is actually a slightly modified metric Swiss watch thread which became available prior to 1884. The modifications concerned the rounding off of the top and bottom of the thread. The B.A. thread had equal rounding radii for the top and bottom of the thread whereas the Swiss metric thread had unequal top and bottom radii.

I hope this information will be of some interest.

Neil Middleton, Australia

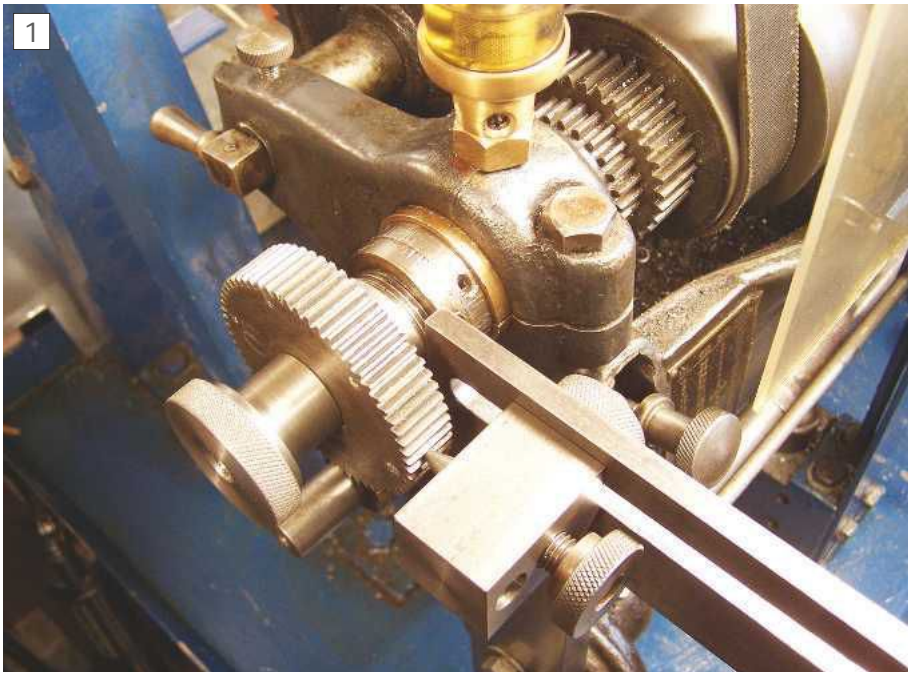
Mandrel Indexing – With Non-Standard Change-wheels

R Finch describes how he indexed a part using change-wheels from his elderly lathe which are not based on a module of 5.

Introduction

I had decided to make a four-facet drill grinding jig and eventually came to the point where I needed to calibrate the feed knob. As the feed screw is 3/8 inch BSF, it has 20 threads per inch, so a calibration of 50 marks would advance the drill being ground by 0.001 inches per division.

Faced with this task, I had a look at the 'prior art' and found out all about direct indexing using the lathe mandrel and change-wheels, by reading the book by the late George H. Thomas (**ref 1**). This book details all the available divisions using the standard set of Myford change-wheels which includes gears from 20 teeth to 75 teeth incrementing every 5 teeth, so includes a 50 tooth gear. However, what do you do if you have not got a Myford with its change-wheels incrementing every 5 teeth? Some other lathes use a different series: The South Bend Lathe uses a set with an increment of 4 teeth, as in 24, 28, 30, 36, 40 etc. as do the Boxford lathes; the Pools Special which I have uses an increment of 3, as in 24, 27, 30, 33 etc. Having a set of wheels with an increment of anything other than five makes it much more difficult to divide easily into 50, 100 divisions or 125 divisions for that matter. I spent quite a time trying to sort out the right gears until it dawned on me that the key is the factors of the gears – not necessarily the total number of teeth. A typical direct indexing arrangement using the 60-tooth gear is shown in **photo 1**. As this uses only one spindle (the lathe mandrel), it can be deemed as 'simplex' indexing, but of course cannot index the 50 divisions which I required.



Simplex' indexing using a single gear

'Duplex' indexing for 50 divisions using 60 teeth and a 30-36 compound gear

The graduated index with 50 divisions

Oops! The gears don't quite mesh...

Finding factors

This can be easily sorted out using simple arithmetic. Now before you think that you need to be a mathemagician to do this, I can assure you that somewhere else within these hallowed pages there will be another article which contains far more maths, so bear with me. It is not difficult, really. Instead of seeing a 50-tooth gear as just a 50 tooth gear, see it as a 5 x 10 tooth gear. Similarly, a 100 tooth gear is 5 x 20 teeth and a 45 tooth gear is a 5 x 9 tooth gear. Now almost all lathe change-wheel sets contain at least one 60 tooth gear (I have two in my set), as this can be used to divide into 2, 3, 4, 5, 6, 10, 12, 15, 20 and 30. If division by 50 is required, then that is 5/6ths of 60, so it is necessary to find a pair of gears with a ratio of 5 to 6.

In my set of gears using an increment of 3, there are 30 and 36 tooth gears, which can be thought of as a 6 x 5 and 6 x 6. Hence, it can be seen that the 30 and 36 tooth gears provide the correct number of 50 divisions, if the mandrel gear is the 60-tooth one, driving the 36 tooth and indexing off the 30 tooth gear which is coupled to the 36 tooth gear making a compound gear. As this set-up uses two spindles, it can be called 'duplex' indexing and is shown in **photo 2**. Note that in this case, the divisions required are fewer than the number of teeth on the mandrel gear (50 vs 60), so the indexing is done on the smaller compound gear, i.e. the 30 tooth gear. The end result of the feed knob graduated with 50 divisions is shown in **photo 3**.

General solution

The previous example was a very simple one to illustrate the method. I would suggest that you make a simple table listing all your gears with their factors, and what I have called the 'Key factor' which is the factor obtained by dividing the number of teeth on each gear by the increment between the numbers of teeth on successive gears (3 in my case). I have given all the ones for the change-wheels on the Pools Special lathe in table 1. If you study the factors in **Table 1**, it can be seen that there is not a factor of 17 present – this is because the change-wheels are intended for screw-cutting and there are not any standard threads with a pitch of 17 threads per inch. You will have to make your own table with the factors and the 'key factor' number for your own change-wheels.

My Pools Special was made in 1935 and came with the set of gears 24, 27, 30, 33, 36, 42, 57, 60, 90 and 96 as standard, but Pools did state that an additional set of gears of 66, 78, 84 and 127 teeth was available as an optional extra, to enable certain imperial threads (notably 26 and 28 tpi) and metric threads to be cut. When I acquired the lathe in the Eighties, it had only the standard gears. Since the Pools Tool Company ceased trading after the Second World War, I had to buy the additional set as 'stock' gears and take 1/32 inch off one face to make them the correct width and bore them out to 5/8 inch.

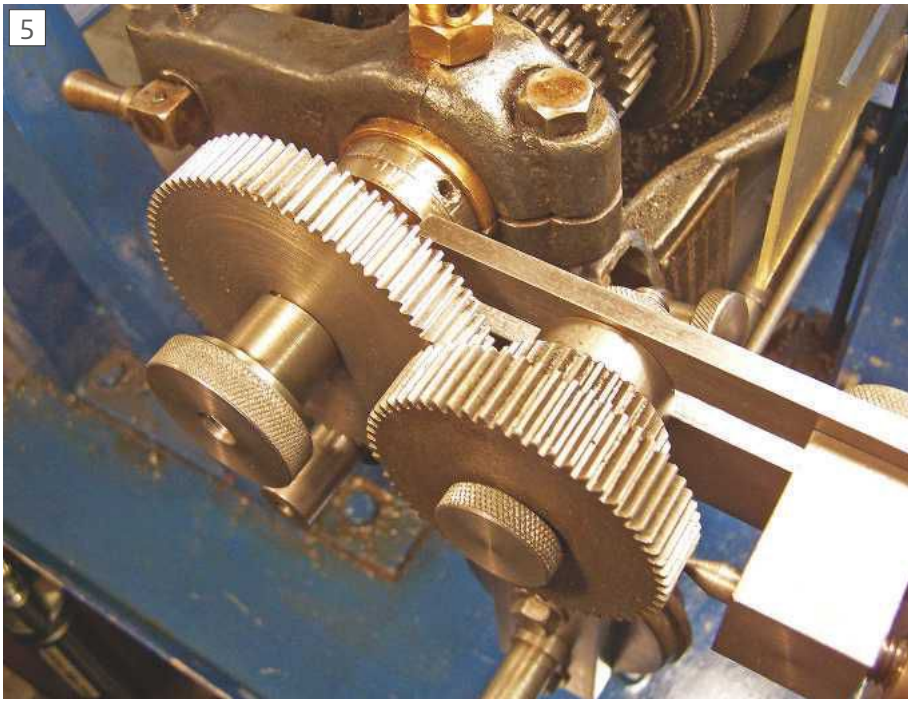
Sometimes, divisions may occur which are not obvious. Taking for an example of, say, 65 divisions, the 'key factors' are required. 65 can be factored down to 5 x 13. If the mandrel gear is taken to be the 60 tooth gear, then this is 5 x 12, so the 'key factors' are 12 and 13. Referring to the table, the 36 tooth gear provides the key factor of 12, and the 78 tooth provides for the key factor of 13. Therefore, these two will be chosen for the compound gear. As the division required is greater than the number of teeth on the mandrel gear, then the indexing takes place on the larger gear, i.e. the 78 tooth gear. However, it can be seen that one of the two gears forming the compound gear is just over twice the size of the other, whereas the required index number is only slightly different from the 60 tooth mandrel gear. To get round this, instead of indexing the larger gear by one tooth, it is incremented by two teeth to give the correct number of divisions.

For those who like a neat mathematical formula, the formula for the division is:

$$Divisions = \left(\frac{Indexgear}{Drivengear}\right) x \left(\frac{Mandrelgear}{Indexedteeth}\right)$$

Substituting in the values for dividing by 65 gives7836 × 602 = 65, so this formula can be used to check that the divisions are correct. As it happens, there is a slight problem in using this set-up in that the 78 tooth gear is too big to allow the 36 tooth and 60 tooth to mesh without the 78 tooth gear touching the mandrel securing nut, **photo 4**. The steel rule shows that the 60 tooth on the mandrel and the 36 tooth on the spindle have a small clearance because of the interference of the 78 tooth gear. However, all is not lost, as there is no reason why the 60 tooth and 78 tooth gears cannot be interchanged – looking at the formula, both the large gears are on the top line, so swapping them round makes no difference to the end result, **photo 5**.

Sometimes, there is more than one way of setting up the gears to carry out dividing. There is nothing particularly sacrosanct about the use of the 60 tooth gear as the mandrel gear. In fact, it could be that a larger gear is used, say the 90 tooth. Since the required number of divisions is 65, the selection of the compound gear is determined by factorising 90 and 65: dividing both by 5 results in 18 and 13 respectively. Therefore the compound gear



Indexing for 65 with the gears changed round

must have factors of 13 and 18. Looking at the table for the key factors, 13 can be found in the 78 tooth gear, but the only gear with 18 as a factor is 90, which is already selected for the mandrel gear. However, 18 can be factored into 2 x 9, and there is a 27 tooth gear with a key factor of 9. Checking to see whether this is acceptable reveals by substituting into the formula:

$$Divisions = \left(\frac{Indexgear}{Drivengear}\right) x \left(\frac{Mandrelgear}{Indexedteeth}\right)$$

which gives:

$$Divisions = \left(\frac{78}{27}\right) x \left(\frac{90}{1}\right) = 260$$

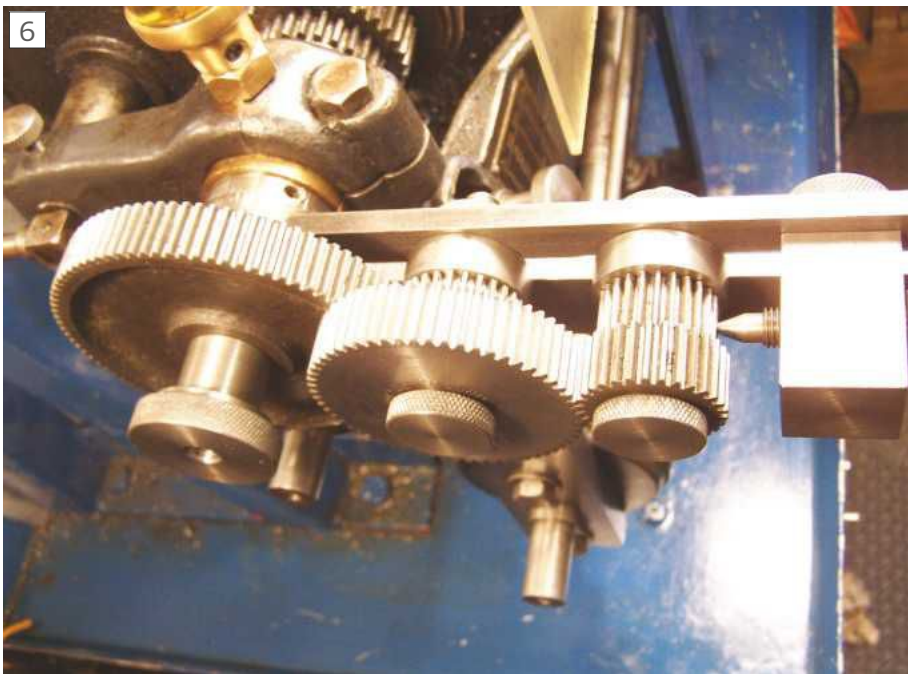
which is four times the required divisions of 65. Therefore, by indexing every 4th tooth, the required 65 divisions are provided. This shows that when dividing, there is sometimes more than one train that can be used.

Divisions not available

Whilst this method outlined above gives a relatively simple way of finding appropriate gear combinations to undertake duplex indexing, there are some numbers that are not available using a duplex train. It is relatively easy to decide whether a number is available or not. As an example, it may be required to put 125 division marks on an 8 tpi leadscrew handwheel to give 0.001 inch divisions. However, 125 divisions are not available with a duplex train with one compound gear because the factors of 125 are 5 x 25, which requires that the mandrel wheel has a key factor of 5, and either the driven gear or the indexing gear has to have a key factor of 25. From the table, the only gears that have key factors of 5 are 30, 60 and 90, and their factors are 30 = 6 x 5, 60 = 12 x 5 and 90 = 18 x 5, none of which is able to be combined to form 125. Therefore 125 divisions cannot be obtained without either a gear with a multiple of 25 teeth or using a 'triplex' compound train.

Triplex indexing

I decided that it was fairly easy to make a new longer plate to accommodate the sliding spindle and add another spindle, making three spindles or a 'triplex' arrangement. This would allow the addition of a second compound gear set to allow for other counts to be determined. Taking the example of 125 divisions, how should this be tackled? Firstly, it is necessary to factorise the division count, so for 125 the factors are 125 = 5 x 25 which is equal to 5 x 5 x 5. Therefore, the mandrel gear, the driver gear and the index gear will all need a factor of 5. Looking at table 1, the only gears that have the factor 5 are 30, 60 and 90 teeth. These will be used as the driving gears. As the mandrel gear is 90 teeth, the factors of this are 5 and 18 which equates to 9 x 2, so a gear with a factor of 9 is needed for one of the driven gears. The only one apart from the 90 tooth one is the 27 tooth one, so this must be one of the driven gears.



'Triplex' dividing for 125 divisions

Since the 60 tooth can be factored to 5 x 12 and the factor 5 is required for the division, the second driven gear must have a factor of 12, which suggests the use of the 24 tooth gear. Therefore the compound train becomes:

$$Divisions = \left(\frac{Indexgear}{Drivengear}\right) x \left(\frac{Mandrelgear}{Indexedteeth}\right) x \left(\frac{Indexgear}{2ndDrivengear}\right)$$

and substituting gives:

$$Divisions = \left(\frac{90}{1}\right) x \left(\frac{60}{27}\right) x \left(\frac{30}{24}\right) = 250$$

As there would be twice as many divisions as required, the indexing is done two teeth at a time, hence there should be a '2' at the bottom of the formula so that it reads:

Divisions = 902 × 6027 x 3024 =125

You may like to read through the logic of that again to make sure you understand it. Even I had to read it twice and I wrote it! Note that had the 36 tooth gear been selected which also has a factor of 12, then the indexing would be incorrect and would work out at 166.66 divisions, which is two thirds of 250 or in gear tooth terms, 250 x 24 / 36 = 166.66. The selection of gears as laid out above is a guide – you should always check that the calculation does give the correct number of divisions rather than assuming that the selection of gears is correct. The set-up for 125 divisions is shown in **photo 6**.

There is an alternative way of deciding how to undertake divisions using large numbers. For a large number of divisions which cannot be done simply, it is best to choose a number which is a fraction or multiple of the desired number. In the case of 125 divisions, a good choice might be 100, as 100 x 5/4 = 125. An alternative might be 200 or 250, which need the divisions to be decreased to 5/8 (200 divisions) or ½ (250 divisions). 100 divisions can be set up as 60 x 5/3 = 100, so the 5 and 3 factors can be obtained with 60 (=5 x 12) and 36 (= 3 x 12) tooth gears, so the mandrel gear would be 60 teeth, driving the 36 tooth gear and indexing off the second 60 tooth gear to give 100 divisions. As the number required is 125, it means that a second set of gears with the ratio 125/100 = 5/4 is needed. Looking at the table for factors of 4 and 5, a suitable pair of gears is 24 and 30, so the required set of gears would be: 6036 × 6024 × 301 = 125 which is easy to set up, but it does rely on having two 60 tooth gears.

Other divisions

Many large numbers other than primes can be indexed using a simple single mandrel wheel, where all division counts given in table 1 in the 'Key factor' column as well as the 'Other factor' column are available by using only one gear on the mandrel. Multiples of these are also available by using one or two compound gears, so for example, 52 divisions (weeks of the year?) is factored to 13 x 4, so the 78 tooth gear (factored to 13 x 6) can be used with a compound train of 24 and 36 teeth, as 2/3rds of 78 is equal to 52. Therefore the division is made using the 78 tooth gear on the mandrel driving the 36 tooth and indexing on the 24 tooth gear. A check can be made using the first formula:

$$Divisions = \left(\frac{Indexgear}{Drivengear}\right) x \left(\frac{Mandrelgear}{Indexedteeth}\right)$$

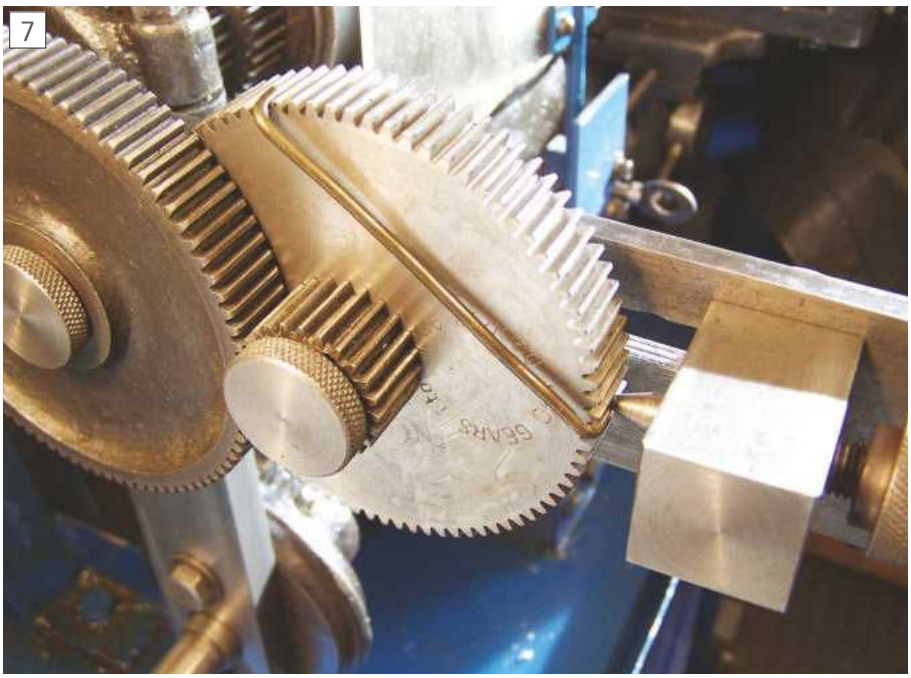
and substituting gives:

$$Divisions = \left(\frac{78}{36}\right) x \left(\frac{24}{1}\right) = 52$$

which is the correct number.

Non-available divisions

Clearly the only prime numbers available are those which are in the key factor column ›



A wire gauge to indicate the next tooth to be indexed

of table 1, so in my case all primes up to 19 except 17 are available but larger prime numbers above 19 cannot be indexed no matter what train is set up. Similarly, multiples of primes cannot be factored in either. For example, 69 divisions cannot be carried out because 69 is three times the prime number 23, and 85 is 5 times the prime number 17 which is not available as discussed before. Virtually all other numbers which do not contain 17 or a prime above 19 can be divided – but be careful when factorising large numbers to make sure that you have done it properly!

Although an *exact* division may be unavailable, it is possible to find a method of dividing with an acceptable error. The method requires the use of the largest number of divisions possible. In my case I used the 96, 90 and 84 gears as driving ones, and the 24 tooth gears as driven gears. This gives a division of:

$$\frac{96}{24} \times \frac{90}{24} \times \frac{84}{1} = 1260$$

Now suppose that the prime number of 17 is required - just as an illustration. Looking at table 1, the factor 17 would fit nicely in the sequence of tooth counts between 42 and 57 teeth. As 3 times 17 is 51, this would be a good start to index for 51 divisions (to cut a gear perhaps?). Now 1260 divided by 51 gives 24.7059 teeth per division. Since it is possible only to index whole teeth, the use of 25 teeth instead of 24.7059 will give an error of

$$\frac{(1 - 0.7059)}{24..7059} \times 100 = +1.19\%$$

for the first division. If the detent is now indexed by another 25 teeth, the error will be compounded, as it should be indexed by 24.7059 teeth. To minimise the error, the required number of teeth in total to be indexed for the second division should be 24.7059 x 2 = 49.4118 teeth, so the second increment should really be 24 teeth rather than 25. This minimises the error so that the cumulative error on the second division is now:

$$\frac{0.4118}{49.4118} \times 100 = -0.83\%$$

Continuing the process, the third division should be over 24.7059 x 3 =74.1177 teeth. As the indexing has already been carried out over 49 teeth, the next increment should therefore be 74.1177 - 49 = 25.1177 teeth. Again, this makes a cumulative error of:

$$\frac{0.1177}{74.1177} \times 100 = -0.16\%$$

but as the errors are minimised at each step, the cumulative error is zero by the time all 51 divisions have been carried out.

Spreadsheet calculations

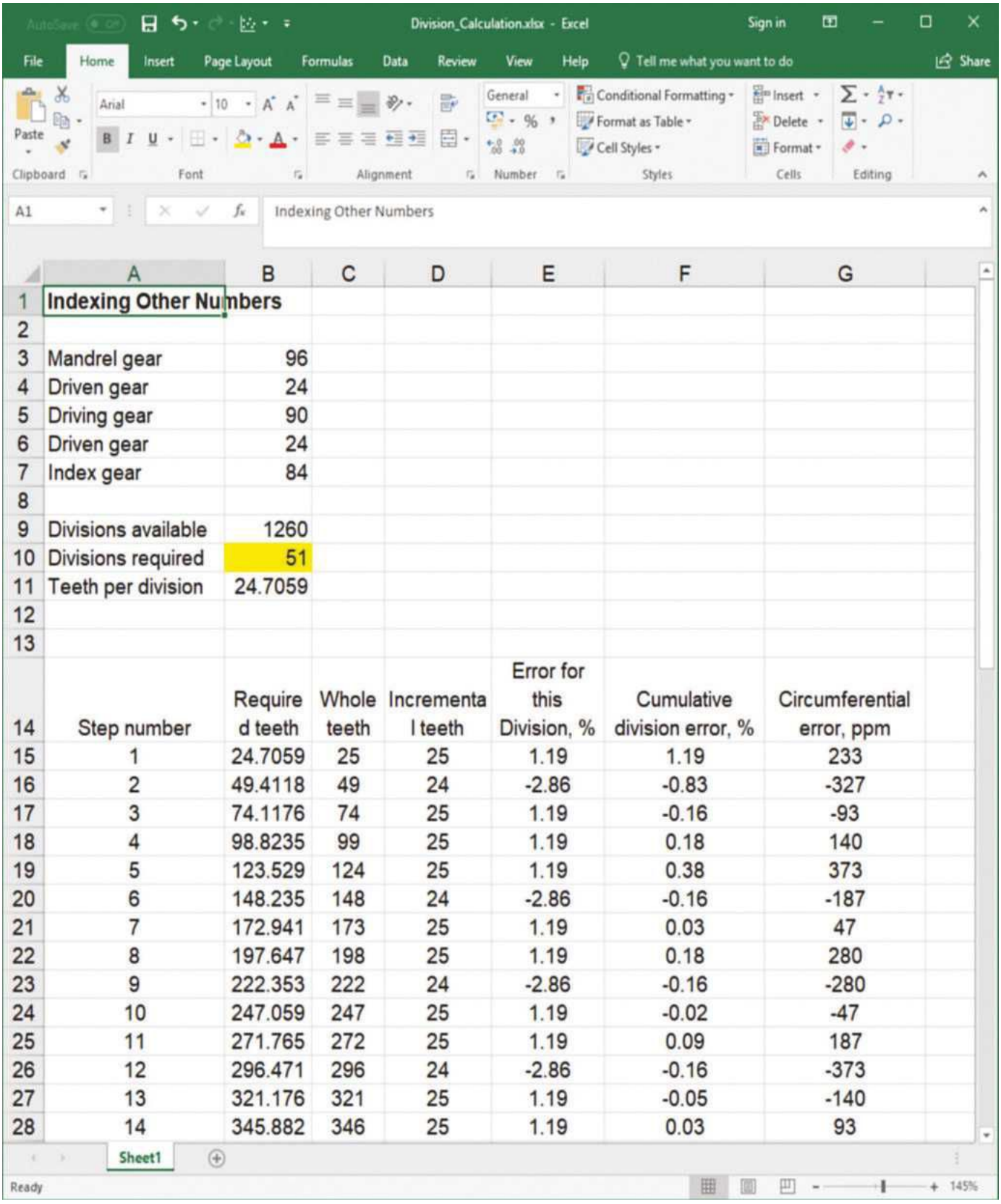
Clearly calculating each step by this method is a bit tedious, so it can be done on a spreadsheet giving each division and the error. The spreadsheet is shown in **table 2**. The calculation is set up with the total number of divisions available by the gears train set up (1260 divisions available) from the gears selected. Each step is set up, and the required teeth per division is obtained in column 2 by multiplying the divisions available by the step number and dividing by the number of divisions required. Column three is the rounded number of teeth from column two. The incremental teeth are obtained by the difference between the whole teeth and the previous whole teeth cells. The error for a division is calculated from the teeth per division subtracted from the incremental teeth divided by the required teeth for the step. In this case, although the error is a maximum of -2.86% this is actually quite small. For an index division of 5 mm, the error is only 0.143 mm which is probably smaller than the width of the tool making the mark. The cumulative error is the number of whole teeth (column three) minus the required teeth (column two) divided by the required teeth.

Finally, the circumferential error is the effective misplacement of the division with respect to where it should be and is calculated from the difference between the required teeth (column two) and the whole teeth (column three) divided by the total number of divisions available (1260 in this case). As can be seen, the actual error is very small being a maximum of 373 ppm. In reality, for graduations marked every 5 mm, the error would be less than 0.002 mm.

Table 1: Pools Special gears and their factors.

Note: gears marked *were optional extra gears

Gear	Factors	Key factor	Other factors
24	2 x 2 x 2 x 3	8	4, 6
27	3 x 3 x 3	9	
30	2 x 3 x 5	10	5
33	3 x 11	11	
36	2 x 2 x 3 x 3	12	4, 6, 9, 18
42	2 x 3 x 7	14	7, 21
57	3 x 19	19	
60	2 x 2 x 3 x 5	20	4, 5, 6, 10, 15, 30
66*	2 x 3 x 11	22	11, 33
78*	2 x 3 x 13	26	13, 39
84*	2 x 2 x 3 x 7	28	7, 14, 21, 42
90	2 x 3 x 3 x 5	30	5, 6, 9, 10, 15, 20, 45
96	2 x 2 x 2 x 2 x 2 x3	32	4, 6, 8, 12, 16, 48
127*	127	127	



	A	B	C	D	E	F	G
1	Indexing Other Numbers						
2							
3	Mandrel gear	96					
4	Driven gear	24					
5	Driving gear	90					
6	Driven gear	24					
7	Index gear	84					
8							
9	Divisions available	1260					
10	Divisions required	51					
11	Teeth per division	24.7059					
12							
13							
14	Step number	Required teeth	Whole teeth	Incremental teeth	Error for this Division, %	Cumulative division error, %	Circumferential error, ppm
15	1	24.7059	25	25	1.19	1.19	233
16	2	49.4118	49	24	-2.86	-0.83	-327
17	3	74.1176	74	25	1.19	-0.16	-93
18	4	98.8235	99	25	1.19	0.18	140
19	5	123.529	124	25	1.19	0.38	373
20	6	148.235	148	24	-2.86	-0.16	-187
21	7	172.941	173	25	1.19	0.03	47
22	8	197.647	198	25	1.19	0.18	280
23	9	222.353	222	24	-2.86	-0.16	-280
24	10	247.059	247	25	1.19	-0.02	-47
25	11	271.765	272	25	1.19	0.09	187
26	12	296.471	296	24	-2.86	-0.16	-373
27	13	321.176	321	25	1.19	-0.05	-140
28	14	345.882	346	25	1.19	0.03	93

Table 2: Spreadsheet output for 51 divisions using the set up described

You can download a copy of this spreadsheet from our forums at **www.model-engineer.co.uk**

An alternative method

If you are not a spreadsheet wizard there is a simpler less-mathematical, but slightly more tedious, way of doing this. It can be seen that as the required increment is 24.7059 teeth, it is obvious that the increment will be either 24 or 25 teeth. As the error is 0.7059 teeth for each step of 24 teeth, it can be seen that the error for 51 divisions using 24 tooth steps will be 0.7059 x 51 = 36 teeth, and for the 25 tooth steps it will be (1 - 0.7059) x 51 = 15 teeth. Since 36 + 15 = 51, the calculation is correct. Therefore, when indexing round the part, the error will be less with 25 tooth steps, but the error will need compensating using 24 tooth steps. The number of times the teeth will be indexed using 25 teeth will be 36 times, and 24 teeth 15 times. These should be interleaved to minimise the cumulative error.

Very approximately, it can be seen that if the steps were 35 and 15, then 35 / 15 = 7 / 3, so you would need to step 7 steps of 25 teeth and 3 steps of 24 teeth for each set of 10 steps, with roughly two 25 steps for each 24 step, but adjusting with an extra 25 put in the middle of the sequence. Therefore, for each 10 steps. they should span 25, 24, 25, 25, 24, 25, 25, 25, 24 and 25 teeth. This is repeated 5 times. As there is one final tooth step (step 51), the last one should be 25 teeth. Compare this with the sequence of steps calculated by the spreadsheet, where the above sequence appears on rows 8 to 17, but is not repeated exactly in the next 10 rows because the exact error is not calculated using this method, but approximated. The overall error using this method can be slightly worse than using a spreadsheet as the decision to use 24 or 25 teeth is based on intuition rather than the actual error. Even so, the error by using the approximate method is still small.

Keeping notes

If you adopt the mandrel method of approximate dividing, there are two things that are necessary: one is to ensure that you index the correct number of teeth and the other is to make sure that you keep count of which division you are making. To make sure that you index the next division correctly, a simple piece of bent wire to form a clip spanning the required number of teeth (either 24 or 25 in this case) can be used for each adjustment as shown in **photo 7**. The wire is put into the gap where the indexing detent is placed, and clipped into the 25th gap. After cutting the division, the gear is rotated until the detent is in the same gap between the teeth as the wire and the detent locked. The wire is then moved towards the next division so that it saves counting the teeth each time. Obviously if the division requires one less tooth, then the detent is put into the gap before the wire. It took me two goes to get the clip the correct length – the first time I made it just a little too short. It then occurred to me to make it slightly too long, so that the effective length can be adjusted by bending the straight part slightly to shorten the effective length.

The best way to make sure that you index each and every division correctly is to take your time and use a paper and pencil to tick off each step as you do it. Also make sure that you take up the backlash in the same direction each time you index (don't ask!), particularly if you have a compound train, as there will inevitably be some slack in the gear train. It is also a good idea to switch your phone off and lock the workshop door to avoid anyone interrupting your work. If all goes well, then you should end up with the last division being one division away from the first division, so incrementing one more time should make them coincide. If all is well, you deserve to go back into the house for a nice cup of tea and a chocolate biscuit as a reward. If, however, the divisions do not coincide, then you should still go back into the house for a nice cup of tea and a chocolate biscuit as a comfort to avoid muttering a few naughty words.

Finally, if you do try this method, I disclaim all responsibility for everything that goes wrong, but I am prepared to accept full credit if it all goes right!

Conclusions

The above method gives a simple way of deciding whether a specific number of divisions can be made with indexing a single wheel on the mandrel; using a compound gear train; or using a double compound gear train.

It gives a simple method of deciding which exact divisions are not possible due to their being prime numbers or multiples of prime numbers or multiples of factors which are not available.

It also gives a method of approximate divisions of prime numbers and their multiples with minimal error. ■

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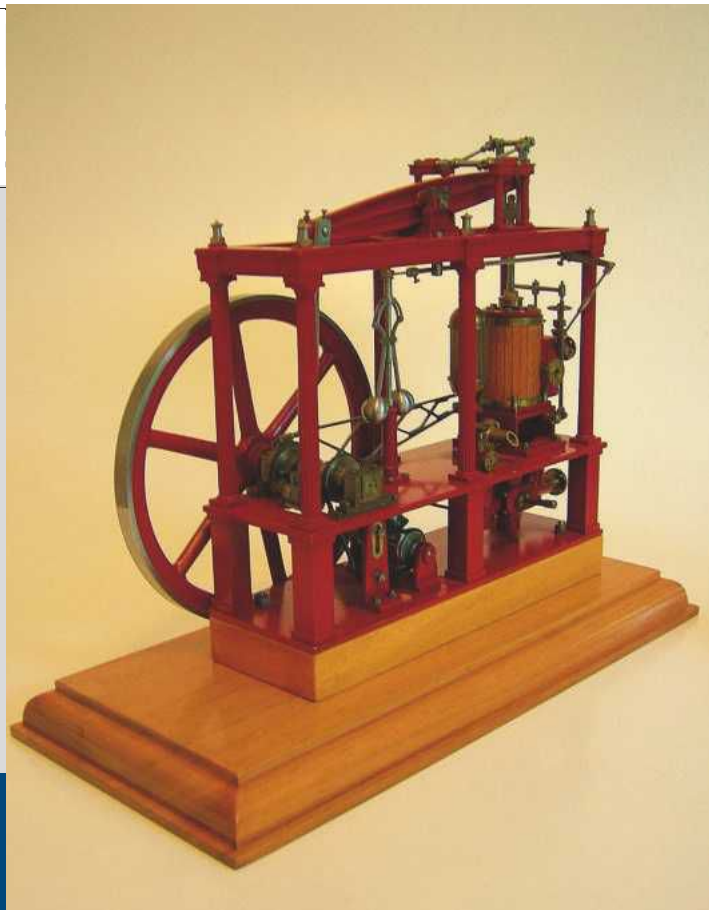
1. Thomas, Geo. H., revised by William Bennett, Workshop Techniques, Tee Publishing, ISBN 1 85761 106 3, (1998)



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T. 01280 850378. Brackley.

■ My late father's 3.5 inch gauge Britannia, it has been in my dining room over 20 years and is in need of restoration. My father built the engine in the 1970s and ran it at Tyttenhanger. £2,500 ONO.
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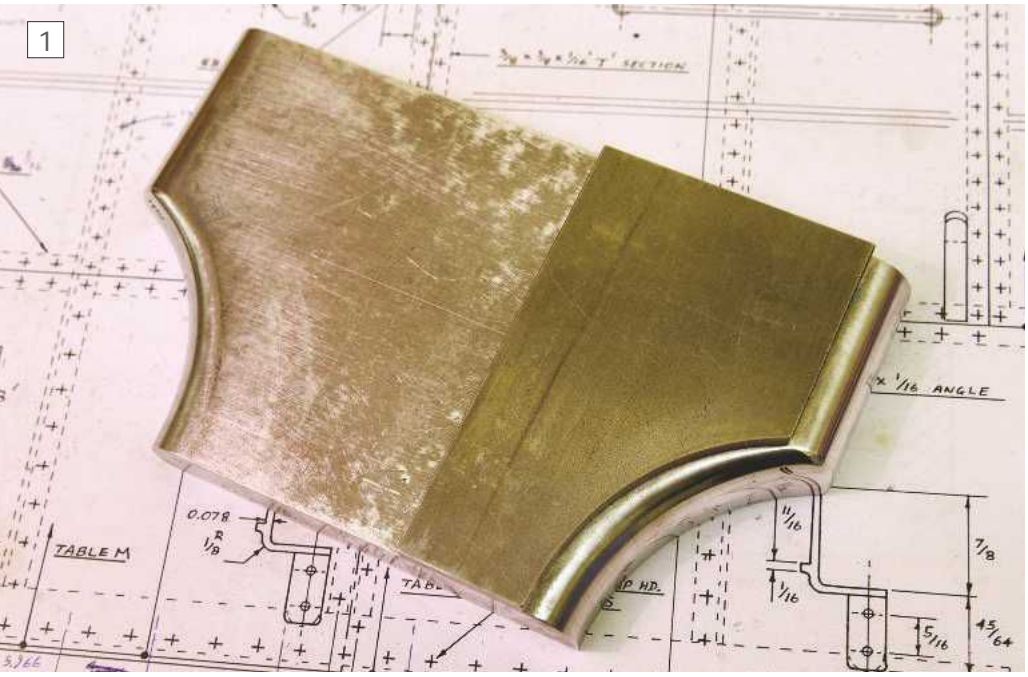
Fight! – Making Bunker Corners

In John Smith's first fight with four pieces of brass in an attempt to make bunker corners for his GWR 1400 class loco, the material won by a good margin, the referee stopping the bout after Round 4 to save John from further punishment. He describes how he prepared for a return match and presents some ideas which enabled him to succeed.



The former for making the bunker corners

There aren't many parts of a model locomotive which, after some time with pencil and paper, I can't figure out how to make – provided a lathe or a mill are involved. With sheet metal it is a very different story. When it came to the bunker corners on the GWR 1400 class, it took me six months to even pluck up the courage to have a go, and that's after Steve Carter, another builder of the 1400 who is ahead of me in the build despite starting 10 years later, kindly lent me the former he had made for the job, **photo 1**. The principle is simple – you clamp the brass sheet blank between the former and the ¼" mild steel plate, hold the assembly in the vice and bash the blank. Steve's model is shown in **photo 2**. His work rate is phenomenal; I'm sure the loco will be in steam before very long.

I am not a sheet metal expert; I am a total novice. The reason for the article is that I would have found it really useful, so others might too!

The First Fight

I had a thousand questions going into my first bout with the 4 pieces of brass:

- How do I anneal it?
- How many times can I hit it before it needs annealing again? 5? 50? 500?
- Where do I hit it? Do I stroke the edges or do I hammer around where it nearly touches the former and gradually work the metal around?
- What type of hammer do I use?

Why four pieces of brass, you ask? Surely only two pieces are required? Well, that's my approach to making any part; I make two so that, if I mess one up, I have a spare. Not so in this case. I messed up all four.

I plied both Steve and Trevor Tremblen (a

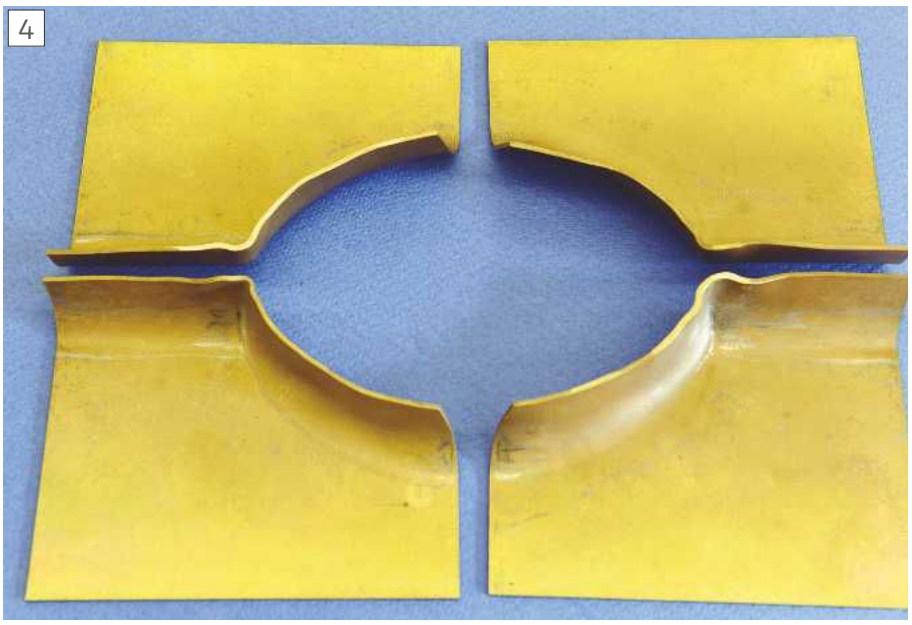
Steve Carter's fine GWR 14XX is progressing well

An arsenal of brass-bashing tools.

master coppersmith) with questions and I made a start. I always like to have the right tool for the job, so I assembled an arsenal of weaponry to attack the brass, **photo 3**. I can tell you that the Thorex 07-410 plastic hammer with a weight of 450 grams and a face diameter of 1¼" worked best for me. This is the smaller of the hammers with orange plastic ends. And you basically do hit the edge of the blank a number of glancing blows to persuade the metal to start its journey around the former – and ten blows between anneals is probably about right. When the metal is approaching the former, you can bash it directly against the former to force it tight to the former.

The first task was to master the annealing of brass sheet. Trevor's tip was to do the annealing after sunset but before the light fades completely. This is because the right temperature for annealing brass is "black heat", that is just before the brass turns dull red. I practised this and after a number of attempts at annealing, bashing the brass and annealing again I became confident that it was working. In fact, I found that annealing in complete darkness worked best for me as it is easier to spot the very dullest of dull reds and remove the heat. I found that just getting the brass up to the right temperature was enough. It was not necessary to "soak" the brass with heat for a minute or more; neither was it necessary to surround the brass with shavings of refractory material to allow it to cool slowly.

After four rounds of annealing and bashing, the material was pulling ahead on points. It was clear that there was just too much material at the corner, which was causing the brass sheet to buckle. More importantly, and what caused the referee to stop the contest, the brass at the bottom of the workpieces had crept up the former so that there was insufficient metal left to mill the corners to the finished size. In other words, I had made the blanks too small. **Photograph 4** shows the problems nicely.



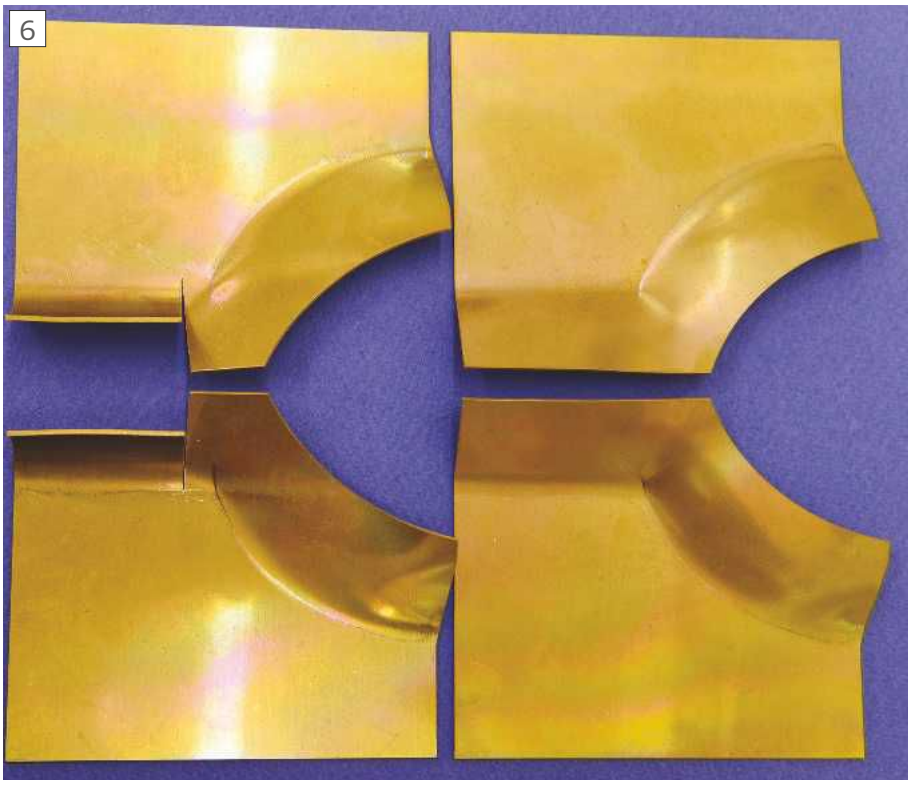
The result of using blanks that were too small

Preparation for the Return Contest

To prepare for the return fight, I investigated the problem of too much material at the corner by folding a piece of suede around the former. Trevor had suggested that I might have to make a saw cut in the brass and silver solder the gap after forming. The suede shows where this cut would be (mid-way between a pair of rivets) and indicates roughly how much metal would eventually need to be removed to form the join, **photo 5**. I also prepared four new blanks, allowing extra material at the bottom to allow for creep up the former.

Suede template to gauge how large a fillet to cut out

I decided to try two different tactics. For one left hand corner and one right hand corner, I would saw the material before I started hitting it; for the others, I would delay sawing until the material had formed a little around the corner. The reason for the latter approach is that I was worried that the material might "tear" at the end of the saw-cuts. I used a "thin saw" made in Japan; it has a blade thickness of just ten thousandths of an inch.



After the initial round of shaping

The Return Match Round 1

Photograph 6 shows the damage suffered by the material after Round 1, which I think

›

Further shaping after making two saw cuts

Initial work was done with the former horizontal

> ...repeating again and again a strategy which fails, while hoping for a different result is a definition of madness...

I can say I won easily. The material had not torn at the end of the saw cuts and all four blanks were taking up the desired shape nicely. I sawed off a tiny sliver of brass where the two sides of what would become the soldered join were touching. It was time to anneal the blanks again.

Round 2

In Round 2, the brass fought back strongly and won the round. It did not want to bend at the corner and I had to use a lot of persuasion. It was time to apply the thin saw to the uncut blanks.

Round 3

After annealing it was easy to bend the brass around the upper curvature (above the awkward corner) on the newly-sawn pieces and I made some progress towards achieving the lower curvature, but the metal in the middle of the lower curvature really did not want to move closer to the former and was getting very tight, **photo 7**. A draw I think. Time to reach for the propane torch again.

Round 4

For the first three rounds, I had clamped the former to an angle plate held in the vice and pushed/hammered the metal away from me around the former, **photo 8**. From this round on, I mounted the former directly in the vice and pushed the metal towards me, **photo 9**. That way I could see how well the metal was approaching its final shape. At the end of this round the metal above the saw-cuts was well-overlapped by the metal below the saw-cuts and I was getting cautiously optimistic that I might actually succeed in making these things. At least I was doing better than in the first fight. I stole this round on points, I think. **Photograph 10** shows the corners at this stage.

Rounds 5-6

Steady progress was made, the metal approaching the former on the lower curvature quite nicely. It was time to saw off the excess material at the join. I also sawed off some of the excess metal along the lower curvature, leaving 1/16" to be milled off. **Photograph 11** shows the corners at the end of Round 6. I was pulling ahead strongly on points. However, the metal was creeping up the former at the bottom; would there be enough? I also worried about whether I would be able to close up the metal at the join sufficiently for it to draw in silver solder. The fight was not over yet!

Round 7

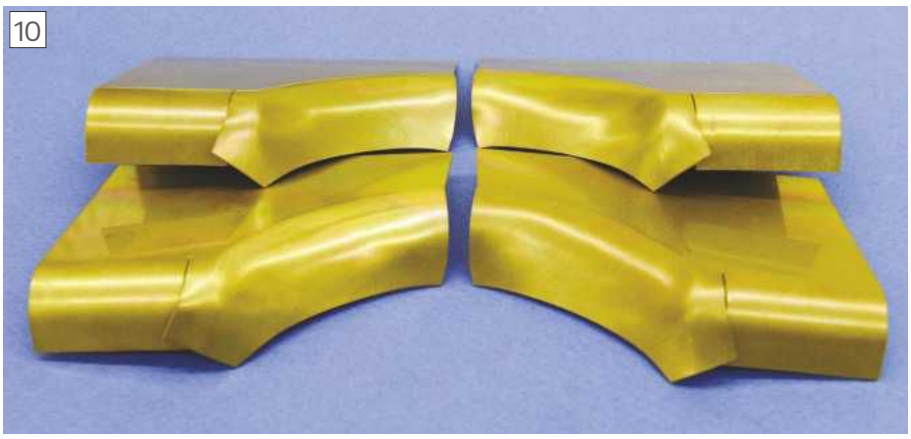
After annealing and bashing, the metal in the lower curvature was almost touching the former. One more round should do it. The gap at the join was alarmingly large. I worked a domed punch along both sides of the join to see how easy it would be to close the gap. The answer? – Not very, without creating an unsightly valley. Points even on this round. However, a cunning plan was forming. Would it be possible to fill the gap with a brass shim and silver solder it in place? Two joins rather than one!

Round 8

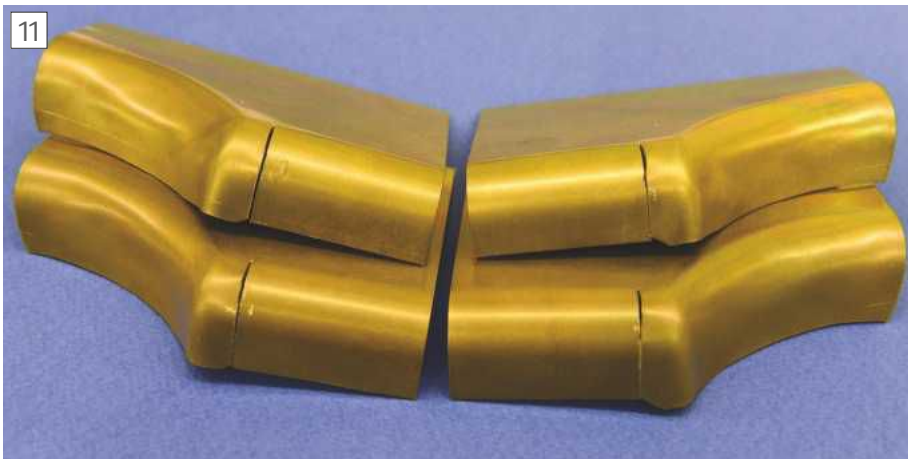
By the end of this round, the metal was tight to the former at the corner and all the way round the upper and lower curvatures. It was time to silver solder the join. Every time I use a toolmaker's clamp to hold pieces of metal together for soldering the

Later rounds took place with the former vertical

same thing happens. Firstly, the clamp acts as a heat sink, drawing heat away from the join. Then, when everything is nice and hot, the clamp becomes perfectly silver soldered to the workpiece and both workpiece and clamp have to be thrown away. As repeating again and again a strategy which fails, while hoping for a different result is a definition of madness, I decided to make some small brass "sacrificial clamps" to hold the two sides of the join in alignment. These were just pieces of 1/8" square brass with a saw cut in the middle of one side. After soldering they can simply be milled off with the rest of the excess metal. **Photograph 12** shows a corner ready for silver soldering.



At this stage the shape is becoming clear



Nearly finished, but the saw cuts look too open

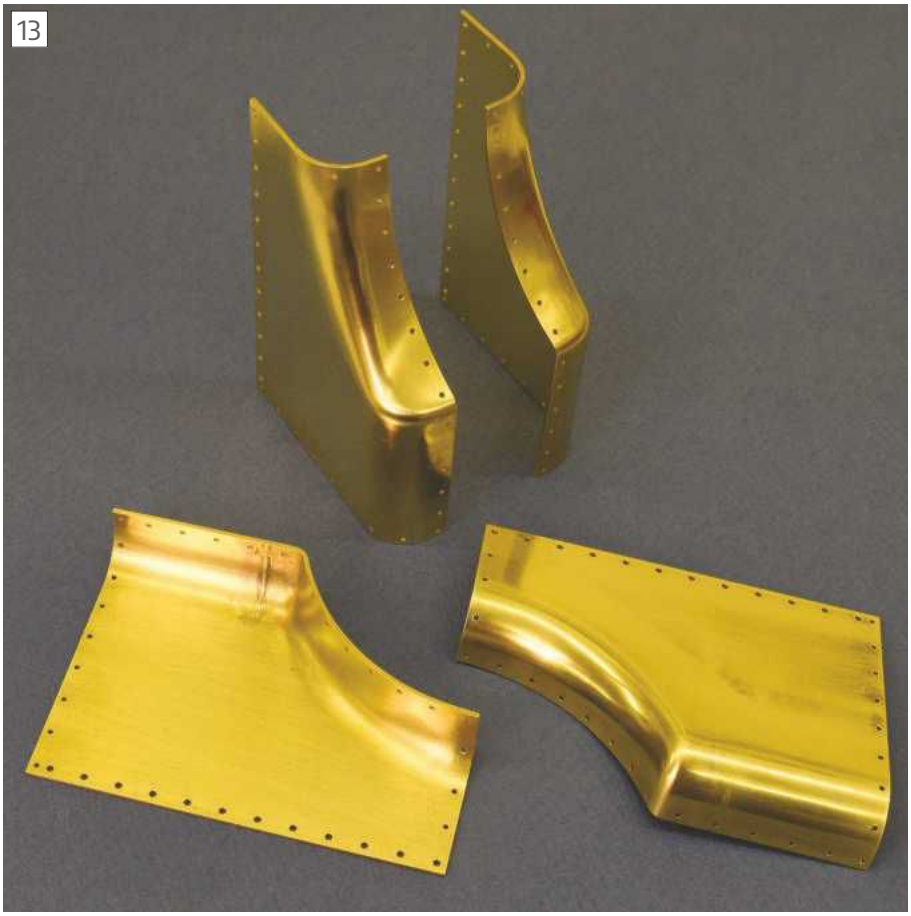
Ready to silver solder the gap

The silver soldering went well and, after cleaning off the flux in hot citric acid, it was clear that all of the joins were perfect. At this stage, knowing that the remaining milling and drilling operations should be within my capability, the referee awarded me the fight by a Knock Out. The excess shim on the outside of the corners was removed by filing; that on the inside was ground off with a Dremel.

What a wonderful hobby we have, and what tremendous satisfaction we obtain when an attempt at acquiring a new skill eventually succeeds!

Photograph 13 shows the finished corners – two for the model and two for the spares box. (That spares box will, one day, give a builder of my 1400 design a wonderful start!)

Could I have won the fight in fewer rounds? I don't think so, as I stopped hitting the brass when it gave me the impression that it was unwilling to move any more. If I had carried on, the brass sheet may have split. "Softly, softly catchee monkey" worked well for me. In fact, I think it would have been a good plan to anneal the brass more often. ■



The finished bunker corners

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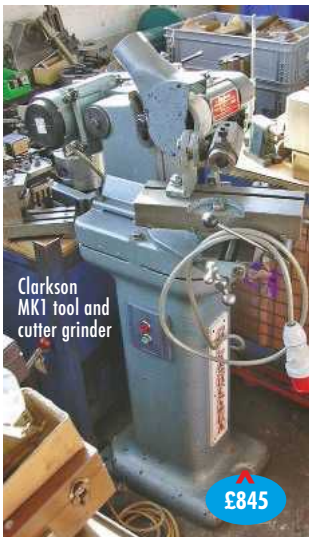

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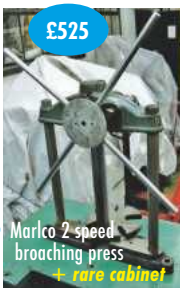

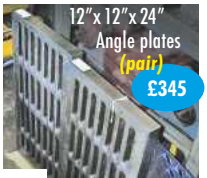

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