No.307

THE MAGAZINE FOR HOBBY ENGINEERS, MAKERS AND MODELLERS

MODEL ENGINEERS' WORKSHOP

Join the conversation at: www.model-engineer.co.uk

SEPTEMBER 2021

INSIDE

- The Chemistry of Pickling
- Repurposing a Digital Caliper
- Reproducing a Helical Tufnol Gear
- Rotary Table - Project Concludes
- Data Tables
- Making a Rear Toolpost

And much more!

A Quick Change Toolpost

A Winch for Changing Heavy Chucks

COVER STORY

HEAVY METAL - A Metric Gear for a 3-Ton Holbrook Lathe

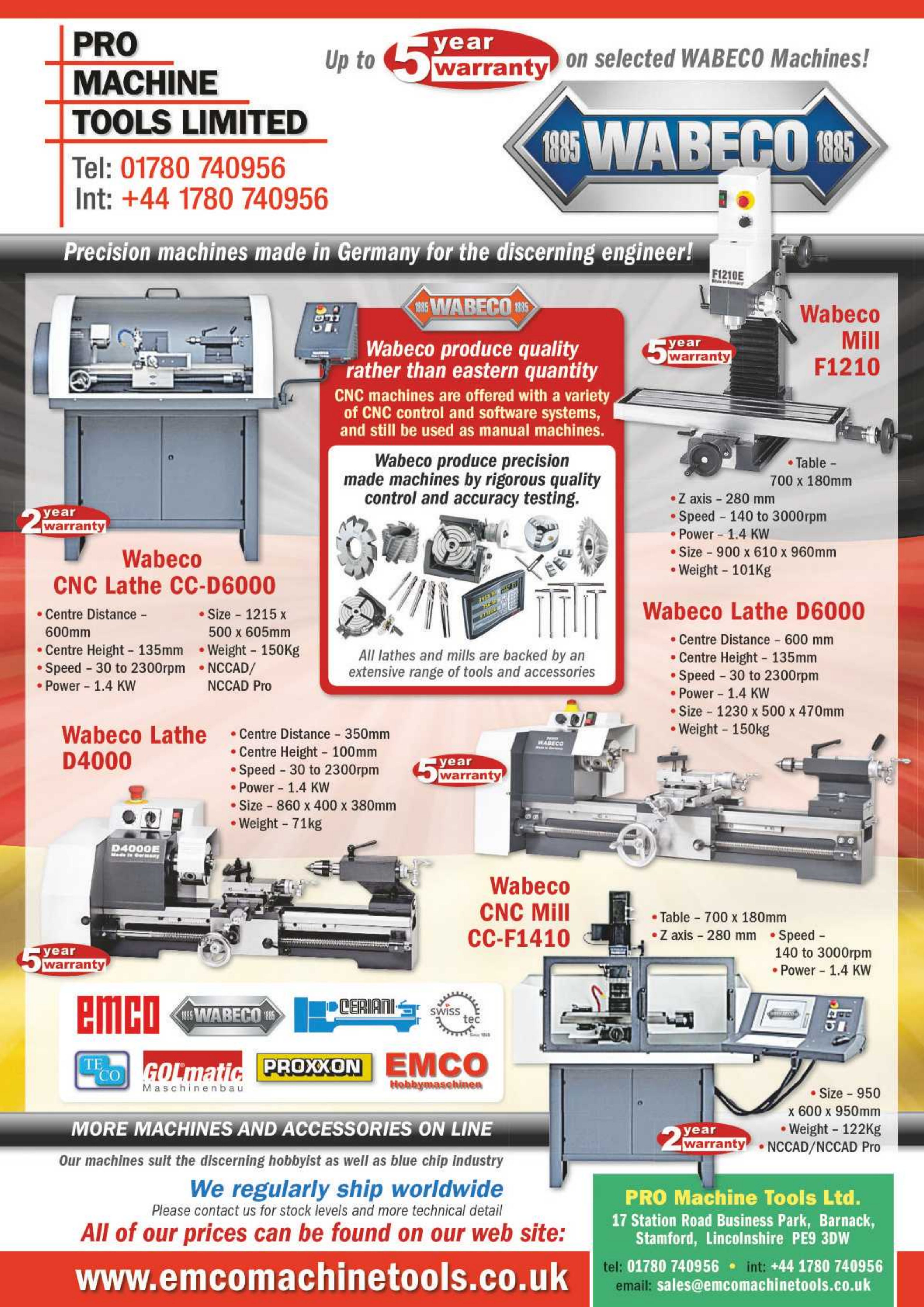
£5.25

mytimemedia ENGINEERING GROUP

07

9 770959 690140

GET YOUR WORKSHOP WORKING WITH MEW


PRO MACHINE TOOLS LIMITED
Tel: 01780 740956
Int: +44 1780 740956
Up to 5 year warranty on selected WABECO Machines!
1885 WABECO 1885
Precision machines made in Germany for the discerning engineer!
1885 WABECO 1885
Wabeco produce quality rather than eastern quantity
CNC machines are offered with a variety of CNC control and software systems, and still be used as manual machines.
Wabeco produce precision made machines by rigorous quality control and accuracy testing.
All lathes and mills are backed by an extensive range of tools and accessories
F1210E
Wabeco Mill F1210
5 year warranty
• Table – 700 x 180mm
• Z axis – 280 mm
• Speed – 140 to 3000rpm
• Power – 1.4 KW
• Size – 900 x 610 x 960mm
• Weight – 101Kg
2 year warranty
Wabeco CNC Lathe CC-D6000
• Centre Distance – 600mm
• Centre Height – 135mm
• Speed – 30 to 2300rpm
• Power – 1.4 KW
• Size – 1215 x 500 x 605mm
• Weight – 150Kg
• NCCAD/ NCCAD Pro
Wabeco Lathe D6000
• Centre Distance – 600 mm
• Centre Height – 135mm
• Speed – 30 to 2300rpm
• Power – 1.4 KW
• Size – 1230 x 500 x 470mm
• Weight – 150kg
5 year warranty
Wabeco Lathe D4000
• Centre Distance – 350mm
• Centre Height – 100mm
• Speed – 30 to 2300rpm
• Power – 1.4 KW
• Size – 860 x 400 x 380mm
• Weight – 71kg
D4000E Made in Germany
5 year warranty
Wabeco CNC Mill CC-F1410
• Table – 700 x 180mm
• Z axis – 280 mm
• Speed – 140 to 3000rpm
• Power – 1.4 KW
• Size – 950 x 600 x 950mm
• Weight – 122Kg
• NCCAD/NCCAD Pro
2 year warranty
EMCO
1885 WABECO 1885
CERIANI
swiss tec
TECO
GOLmatic Maschinenbau
PROXXON
EMCO Hobbymaschinen
MORE MACHINES AND ACCESSORIES ON LINE
Our machines suit the discerning hobbyist as well as blue chip industry
We regularly ship worldwide
Please contact us for stock levels and more technical detail
All of our prices can be found on our web site:
www.emcomachinetools.co.uk
PRO Machine Tools Ltd.
17 Station Road Business Park, Barnack, Stamford, Lincolnshire PE9 3DW
tel: 01780 740956 • int: +44 1780 740956
email: sales@emcomachinetools.co.uk

MODEL ENGINEERS' WORKSHOP

Published by MyTimeMedia Ltd.
Suite 25, Eden House, Enterprise Way,
Edenbridge, Kent TN8 6HF
+44 (0) 203 855 6105
www.model-engineer.co.uk

SUBSCRIPTIONS
UK - New, Renewals & Enquiries
Tel: 0344 243 9023
Email: help@me.secureorder.co.uk
USA & CANADA - New, Renewals & Enquiries
Tel: (001)-866-647-9191
REST OF WORLD - New, Renewals & Enquiries
Tel: +44 1604 828 748
Email: help@me.secureorder.co.uk

CURRENT AND BACK ISSUES
Tel: 01795 662976
Website: www.mags-uk.com

MODEL ENGINEERING PLANS
Contact: www.myhobbystore.co.uk/contact
Website: www.myhobbystore.co.uk/me-plans

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

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

ADVERTISING
Business Development Manager: Angela Price
Email: angela.price@mytimemedia.com

MARKETING & SUBSCRIPTIONS
Subscriptions Executive: Beth Ashby-Njiiri
Email: beth.ashby@mytimemedia.com

MANAGEMENT
Group Advertising Manager: Rhona Bolger
Email: rhona.bolger@mytimemedia.com
Tel: 0204 522 8221
Chief Executive: Owen Davies

mytimemedia
print & digital media publishers

Model Engineers' Workshop, ISSN 0959-6909, is published monthly with an additional issue in August by MYTIMEMEDIA Ltd, Enterprise House, Enterprise Way, Edenbridge, Kent TN8 6HF, UK. The US annual subscription price is 52.95GBP (equivalent to approximately 88USD). Airfreight and mailing in the USA by agent named WN Shipping USA, 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA. Periodicals postage paid at Brooklyn, NY 11256.
US Postmaster: Send address changes to Model Engineers' Workshop, WN Shipping USA, 156-15, 146th Avenus, 2nd Floor, Jamaica, NY11434, USA. Subscription records are maintained at DSB.net Ltd, 3 Queensbridge, The Lakes, Northampton, NN4 5DT. Air Business Ltd is acting as our mailing agent.

On the Editor's Bench

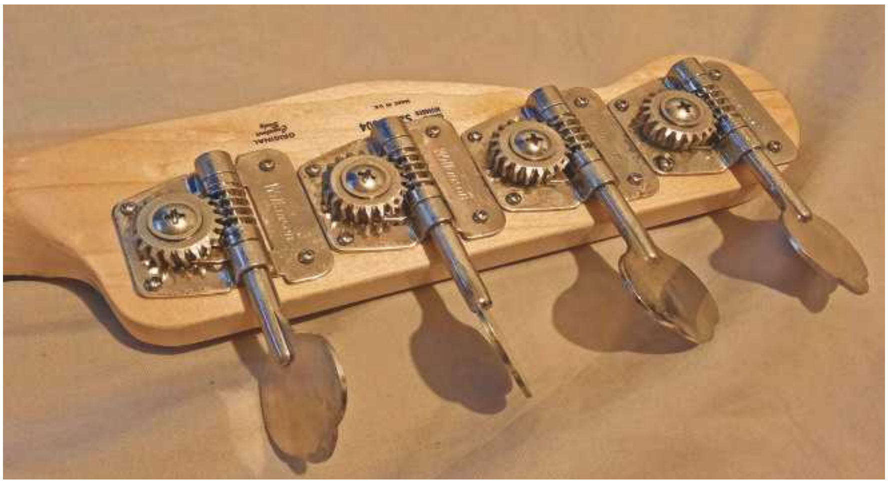
Ageing Nickel

I wanted to replace the cheap, but functional, tuning heads on a bass guitar I made from a kit last year. I thought something more in keeping with the 'vintage style' of the instrument I chose a set of nickel, rather than chrome, plated ones and ordered a nickel-plated vintage style bridge to match. I'd already manged to source a pair of slightly battered second-hand control knobs.

Nickel isn't as bright as chrome, but it still looks very shiny when new, so I wanted to take the 'edge' off it to replicate a degree of ageing, although I wasn't looking for a 'heavy relic' effect. As you might expect the internet offered a wide range of recipes. A few seconds immersed in ferric chloride (a etchant for brass and copper) appeared too strong for my needs, rapidly turning the plating a dull grey. 'Muriatic acid' or hydrochloric acid fumes work well but have the side effect of promoting rust on the underlying iron – as well as being an unpleasant and potentially risky chemical to use. A gentler suggestion was simply covering the components in tomato ketchup. My brother suggested placing in a salt solution combined with dropping in a flat 9V battery – which would generate a small amount of hydrochloric acid by electrolysis.

The method I chose was to place the objects inside a large lunchbox, together with an open container of white vinegar. In the present warm weather, the air inside rapidly become saturated with acetic acid.

The result was a very gentle tarnish which looks fairly natural, and hopefully starting this process will accelerate further gentle tarnishing. Such artificial ageing isn't to everyone's taste, but these ideas may be useful to anyone wanting to make plated fittings where a bright nickel finish would be out of place.



Universal Vice

My apologies for a production error in the last issue which saw the final page of Jacques Maurel's article overwritten by a repeat of the first page. The final page appears in this issue.


CLOCK CONSTRUCTION & REPAIR
Books by:
John Wilding MBE FBHI, E. J. Tyler, John G. Wright, Eric Woof, John Tyler and others.
SPRINGS
BEARINGS
FRAMES
DIALS etc.
FREE Catalogue
Telephone: +44 (0) 1420 487747
www.ritetimepublishing.com


POLLY MODEL ENGINEERING LIMITED
Expanding range of In-house manufactured components
NEW! Axle pumps
Available in ¼", 3/8" & ½" ram. Prices start from £45.00
NEW!
Brake Valve
For steam or vacuum
£83.00
NEW! Blowdown spanner – suitable for 5/16" & 3/8"
£6.50
BR/LMS safety valves
Safety valves
Box Spanners
BA & Metric. Available individually or in sets
Only £3 each
Tender water valves
GWR injector steam valve
GWR dummy whistles
Catalogue available £2.50 UK posted £8 international and enquire for further details or visit our website where you will find Polly Locos Kits, drawings and castings for scale models and comprehensive ME Supplies.
Polly Model Engineering Limited
Atlas Mills, Birchwood Avenue,
Long Eaton, Nottingham, NG10 3ND
www.pollymodelengineering.co.uk
Tel: 0115 9736700
email:sales@pollymodelengineering.co.uk


Tracy Tools Ltd
Tracy Tools Ltd.
Unit 1, Parkfield Units,
Barton Hill Way,
Torquay TQ2 8JG
Visit our brand new website
We ship anywhere in the world
www.tracytools.com
PRODUCTS
• Taps and Dies
• Centre Drills
• Clearance Bargains
• Diestocks
• Drill sets (HSS) boxed
• Drills
• Drill set (loose) HS
• Endmills
• Lathe Tooling
• Reamers
• Slot Drills
• Specials
• Tailstock Die Holder
• Tap Wrenches
• Thread Chasers
Acme Taps
Taper Shank Drill HSS
Reamer
Taps & Dies
Tracy Tools Ltd
Tap & Die Specialist, Engineer Tool Supplies
Tel: 01803 328 603
Fax: 01803 328 157
Email: info@tracytools.com
www.tracytools.com

Contents

Coming up...

in our next issue

In our next issue Stuart Hart describes the making of a high-speed drilling attachment.

Regulars

ON THE COVER

Ian Robinson's massive Holbrook Lathe is capable of big and heavy work, while still achieving a high standard of precision. See page 17 for details of a project to make a metric gear for this lathe.

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

Visit our website to access extra downloads, tutorials, examples and links.
www.model-engineer.co.uk/extracontent

Lionel Pullum's Minilathe Tailstock Seals
Download an STL file to print seals on your 3D printer, or the Alibre Atom3D files to modify the design to suit another machine:
Plus:
Centec 2B - New arrival and Q&A
Experiences in getting a second-hand mill up and running.

More skeleton tomfoolery
A follow up to Tony Jeffree's skeleton bike!

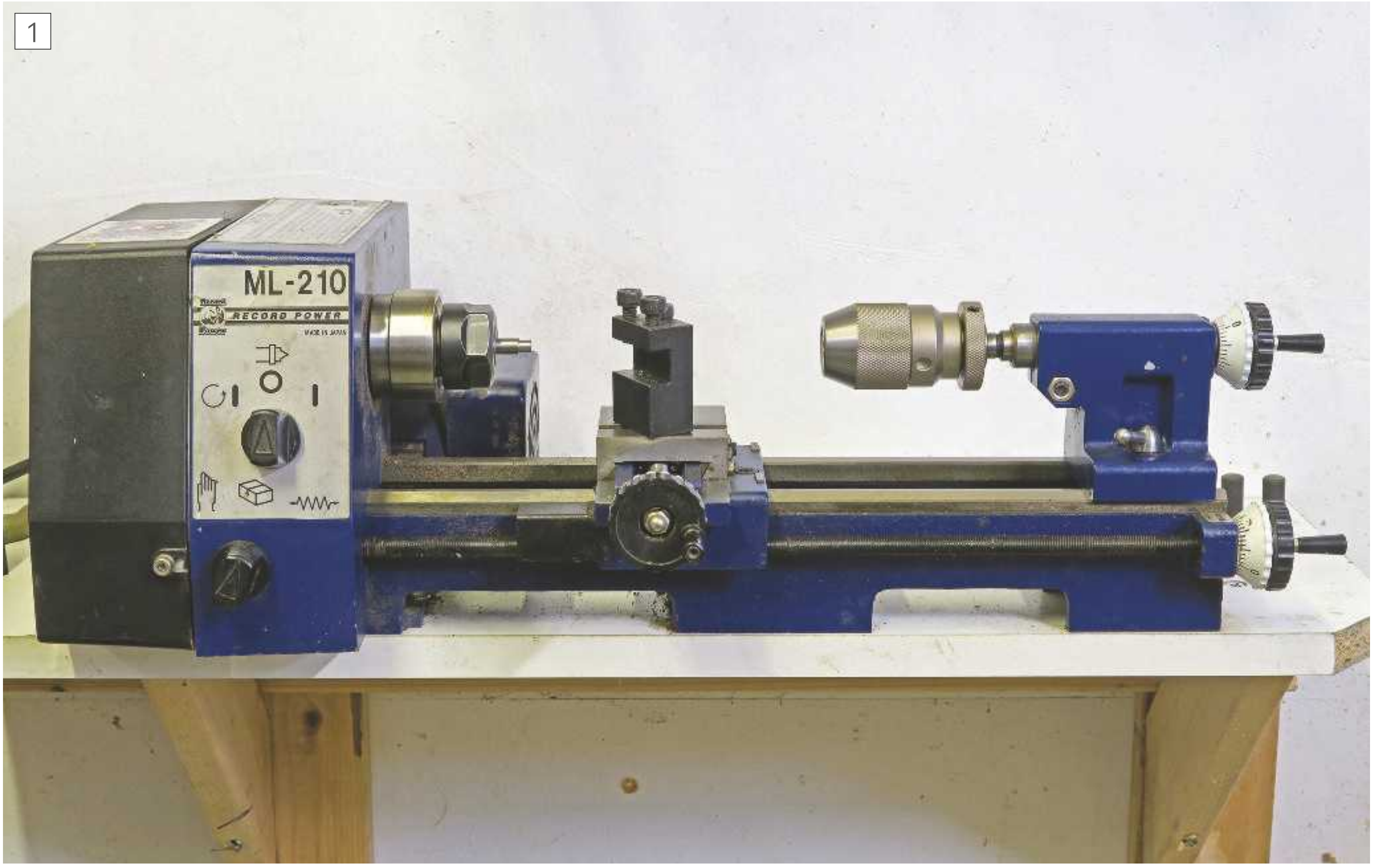
Stuart Twin Victoria (Princess Royal) Mill Engine
An interesting build log with spiced up with some useful tips and advice from forum members.

Come and have a Chat!
As well as plenty of engineering and hobby related discussion, we are happy for forum members to use it to share advice and support. If you feel isolated by the lockdown do join us and be assured of a warm welcome.

CLASSIFIEDS EXTRA SUBSCRIBE ARCHIVE SUPPLIERS

A Quick Change Toolpost

Mike Holmes makes an accessory for his ML-210 Lathe



ML210 with original toolpost.

I have a S&B Sabel, which I use most of the time, which has a quick-change. toolpost (I'm up to 18 toolholders !), but on a few recent projects have used my ML-210 quite a lot for small parts **photo 1**. It came with a single toolpost that needs shims for the lathe tools.

As a little project, I decided to design and make a quick change toolpost and holders for it. I decided the following would be good :

- A single handle for both loosening/ tightening and swapping the holders.
- Not too big.
- Reasonably easy and quick to make.
- Using as much stock sizes as possible.
- I wanted to standardise on ¼" HSS and Silver Steel tools.
- Using all my existing workshop tools.

After a few sketches I decided to use a

Toolpost with slits.

central post with an internal taper which after slitting, could be expanded to grip the holders, **photo 2**. I'm pretty sure I've seen this idea in MEW before? All parts except the handle socket (brass) are made of free cutting mild steel.

Toolpost

The toolpost is made from 1½" diameter stock. It was drilled and tapped M12 in the lathe before turning to size. I settled on ¾" diameter for the post with an internal thread of M12 at the bottom of the taper. I have a ¾" drill which I could use for the holders, to make life simple.

An M6 cap head screw just passes through the M12 thread for fixing to the cross slide t-nut, **photo 3**.

I set the top slide at an angle of 4 degrees, which looked about right, for the internal taper and polished the taper after internal boring. I made a mental note not to alter the angle of the

I wasn't too sure if the toolpost would grip the the holder with sufficient force tp prevent it moving when taking cuts.

topslide as the same angle was to be used on the tapered stud.

I then set the toolpost up on an angle plate on my milling machine and using my slitting saw created the slits.

This just left drilling and tapping two blind holes on the underside for the t-slot locating pan heads. The heads of these were turned down for a nice fit in the t-slot.

Stud

I used ¾" diameter for the stud. I first turned down and threaded the M12 thread, then reversed the stud and gripped it in a collet to ensure it was concentric. I carefully drilled a centre and used a rotating centre to add extra support for the next operations.

I turned the taper using the pre-set topslide angle, taking it out and checking for fit, at regular intervals. The tapered stud was also polished. I use Solvol Autosol which works well. Next I milled a ⅜" square on the end of the stud, **photo 4**. In hindsight, I could have made the thread longer, both on the stud and inside the toolpost.


3

Fixing screw.


4

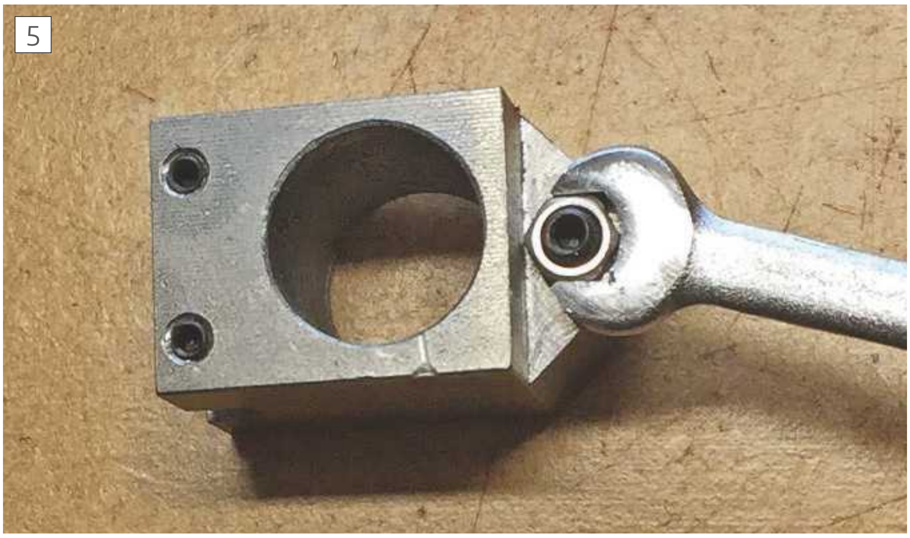
Toolpost taper stud.

I wasn't too sure if the toolpost would grip the holder with sufficient force to prevent it moving when taking cuts. So before I went mad hack-sawing all the holders, I drilled a ¾" hole in a test piece. I was quite surprised how well it held and given the forces on this tiny lathe are quite low, I was happy to carry on with the holders.

Tool Holders

I decided that 1" square bar was about right for the holders. After sawing, the holders were fly cut to size and a ¼" end mill used to cut the tool holder slot. The depth of this slot is just under ¼". The height about 0.040" over. The tool post holes were then marked out and drilled. I found this a bit hard going until I re-sharpened the ¾" drill – tons of swarf!

As a bit of an afterthought, I decided to mill a ledge where the height setting screw and locknut go and to chamfer


5

Example toolholder.


6

Initial slot in socket.

this end at 45 degrees. After de-burring, all that was left to do was to drill and tap the tool fixing holes M4 and the height setting holes M5. I rounded off and polished the bottom of the M5 height setting grub screws so they don't mark the toolpost. The spanner just fits, **photo 5**.

Handle

Brass looks nice, so I used this for the socket. But a square hole was needed. I used ¾" brass and milled a ⅜" slot centrally. Then milled a flat to leave a 3/8" U-section, **photo 6**. I then silver soldered a piece of rectangular brass to the top to form the square hole, **photo 7**.

This was completed by turning down to 0.70" diameter, polishing and parting off to length. Tapped at an angle to accept the handle, **photo 8**. After turning a ball on a length of ⅜" rod, turning down and threading the end, it was screwed into the socket, **photo 9**.

I had to go back and mill a tad off the ⅜" square on the stud to get it to fit. Here's the finished set, **photo 10**, and the toolpost in situ, **photo 11**. I've used it for a few months now and all seems to be ok. Setting the tool height is now a breeze. ■

I rounded off and polished the bottom of the M5 height setting grub screws so they don't mark the toolpost.

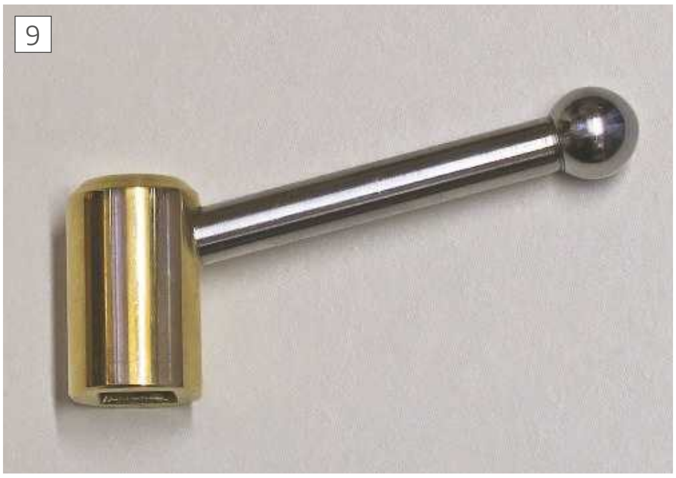
7

Silver soldered fourth side.

8

Turning to size.

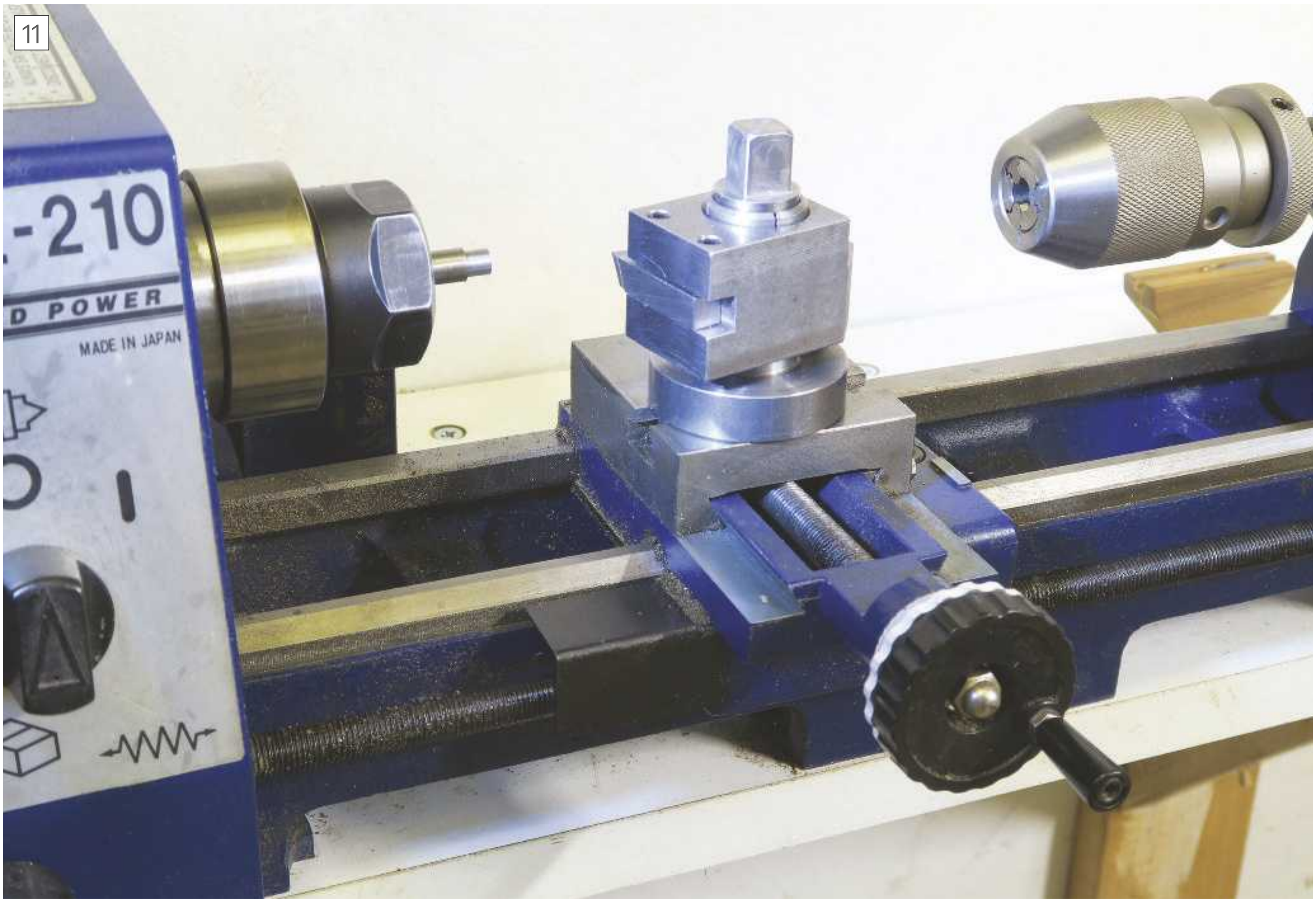
9



Finished handle.

10

Finished toolpost and holders.



Toolpost on the lathe

In our
Next Issue

Coming up in issue 308
On Sale 17th September 2021

Content may be subject to change

Look out for MEW 308, the October issue, helping you get even more out of your workshop:

Stewart Hart presents a high speed drilling attachment.

Mike Cox details a spindle back stop.

Stuart McPherson explores his scrap box.

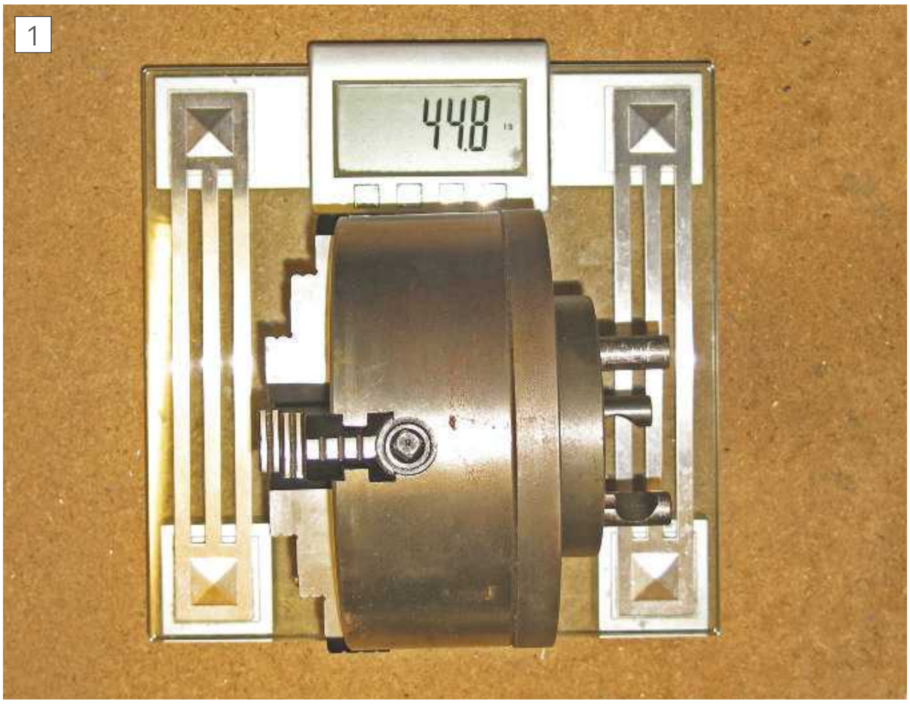
DON'T MISS THIS GREAT ISSUE - SEE PAGE 46 FOR OUR LATEST SUBSCRIPTION OFFER

Saddle up and take it easy

Richard T. Smith shares his approach to handling heavyweight chucks

The chucks on my lathe, particularly the 4 Jaw, seem to get heavier and heavier, **photo 1**. I have been thinking about a winch for a while and finally bought one for £56. This is mains powered and has a pendant with up and down buttons. The speed is fixed and a little on the fast side. The safe working load is way over what is needed.

I looked on YouTube and elsewhere for what other people had done. My workshop is divided off from the end of my garage and space is limited. The lathe lies along one end with a small gap between the headstock and the wall which is needed to remove the guard to get at the gears. As there is a built-in gear box, I don't have to get at this very often, so I decided to store the chucks in this space as I could always use the winch to move them out of the way. This gave a straight run from storage over the headstock to above the lathe bed. The next problem was that one of the roof timbers runs above the headstock at roughly 90 degrees which limits the headroom over the headstock. Consequently, the support track had to be as small and close to this timber as possible with the winch held close to the track. I could support the track at the wall end off the wall and the other support would have to be off the roof timber with the track continuing on past the support. **Photograph 2** shows the final installation.


1

Four jaw chuck on bathroom scale.

I bought a length of 40 x 40 x 6 Tee section for the track and a piece of 40 x 40 x 5 Angle to make the supports. **Photograph 3** shows the wall end support. There are two slotted holes in the Tee section which bolts to a piece of angle screwed to the wall. The wall divides the workshop from the garage and is constructed from 3 x 2 ins timber covered both sides with 6mm MDF and with the cavity filled with polystyrene. The screws go into the timber structure. Incidentally the whole workshop including walls, ceiling, and suspended floor is insulated with polystyrene and warms up very quickly with a fan heater. The support off the beam is shown in **photo 4** and was easily cut from the angle using the guided power feed on my bandsaw, **photo 5** shows the end notches being cut together. The beam proved to be not quite square with the lathe but a bit of packing on one side together with the slotted mounting holes at the wall end solved that.


2

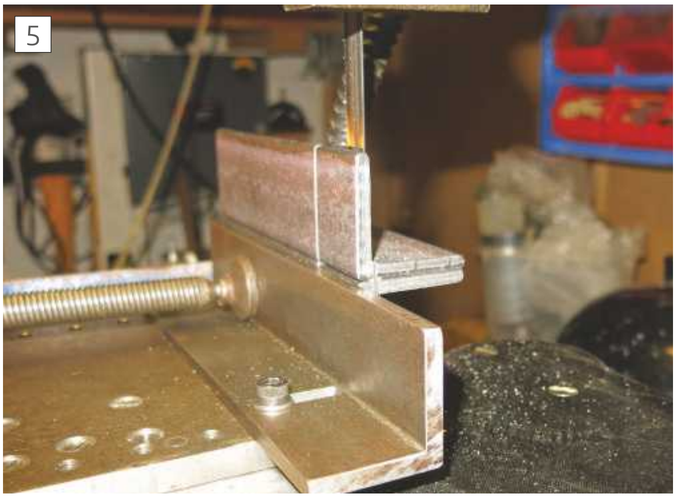
Winch installed above lathe.


3

Wall end support.

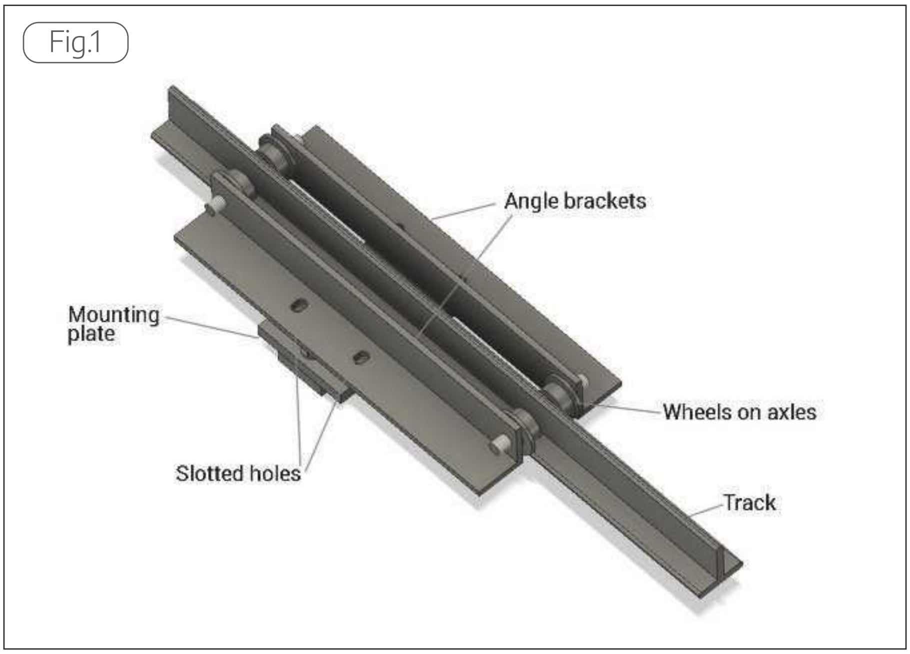
To carry the winch on the track I decided to replace the existing mounting plate which attached to the winch gearbox with two M8 screws. I drew the new mounting arrangement up, **fig 1**. At first, I thought the existing arrangement provided an extra bearing at the far end of the drum but when I examined it this was not so. Unloaded the weight of the winch is on the centre line but when loaded the wire carrying the chuck is off centre and the combined load will be off centre towards the wire.

Hanger from beam.



Cutting end notches.

The winch weighs 14.8 lbs and the centre of gravity lies on the centre line. The heaviest chuck is the four-jaw independent which weighs in at 45 lbs. I allowed another 2 lbs for a carrier to fit in the jaws so called it 47 lbs. The track is 40 x 40 x 6mm tee with wheels running along. The edges are rounded so the actual wheel contact spacing is more like 30mm. The wire on the winch drum is 33mm off centre., which is greater than the wheel contact spacing. However, the chuck weight is partly balanced by the winch weight. I calculated an offset from centre of 12.5mm would keep both loaded and unloaded forces between the contact points, and this has proved to be so in practice. **Photograph 6** shows the mounting plate being drilled and **photo 7** shows it attached to the winch.



The angle brackets for the wheels were simply cut and drilled, although two holes in one piece for attaching to the mounting plate were slotted to allow adjustment of the wheel spacing. The wheels and their axles were straightforward turnings and **photo 8** shows two finished assemblies with two part made axles. The wheels are not retained on the axles but cannot come off when installed on the track. **Photograph 9** shows the winch mounted on the track, which has an end stop for obvious reasons!

Originally, I was planning to make carriers for the chucks to clamp on with lifting eyes to attach to the winch hook similar to what I had seen online. Two things changed my mind. Firstly, the headroom problem between the beam

Drilling mounting plate.

Mounting plate on winch.

8

Wheel assemblies.

9

Winch on track.

and the headstock, and secondly the lifting speed of the winch. The clamped carrier approach meant positioning a lifting eye over the chucks balance point requiring height for both the lifting eye and for the carrier. The more I thought about attaching the winch to a carrier clamped in the chuck with the chuck still attached to the lathe the less I liked it. Any operational error could be disastrous. Instead, I made up a wooden saddle for each chuck that sits on the lathe bed and just slides very closely under the chuck. When the third camlock is released, the chuck naturally droops slightly onto the saddle which I can then slide down the lathe bed to remove it. To replace the chuck, slide the saddle towards the headstock and the pins will slide into the spindle. Tightening the first camlock lifts the chuck off the carrier which can then be pulled out leaving the chuck free to rotate to tighten the other camlocks in the usual way. When not in use the chucks sit in their saddles behind the headstock. The winch is only attached to the chucks while they are not attached to the lathe. To attach the chucks to the winch I first looked at lifting straps which are quite cheap but to save headroom I needed non-standard lengths. I had some polypropylene rope so I thought that I could make custom slings by splicing two eyes onto a short piece. I found splicing videos online, and I was able to make up two slings very easily. I tested them by hanging the four-jaw just above its saddle overnight to check for any movement. It may be heavy to me, but it is trivial to the rope.

10

Four-jaw suspended above sassle.

11

Chuck storage.

Incidentally I tested the rail by hanging on it, a good margin of safety! The slings pass through a shackle which hooks onto the winch. **Photograph 10** shows the four jaw being suspended with the sling above its saddle on the lathe bed and **photo 11** shows the chuck storage.

I can now change the chucks without having to physically lift them. I can reach the winch to push it along the track which is easy. The winch has a shortened cable going to a single switched socket on the timber beam. I added a support under the chuck storage for the faceplate which I can lift OK and this has freed space on my bench where everything used to go. The mating faces of the chuck and spindle are easy to clean with the chuck sitting on its saddle on the lathe bed. ■

A metric conversion gear

Ian Robinson made a large gear for his Holbrook lathe so he could thread a drive shaft for a veteran Talbot car.

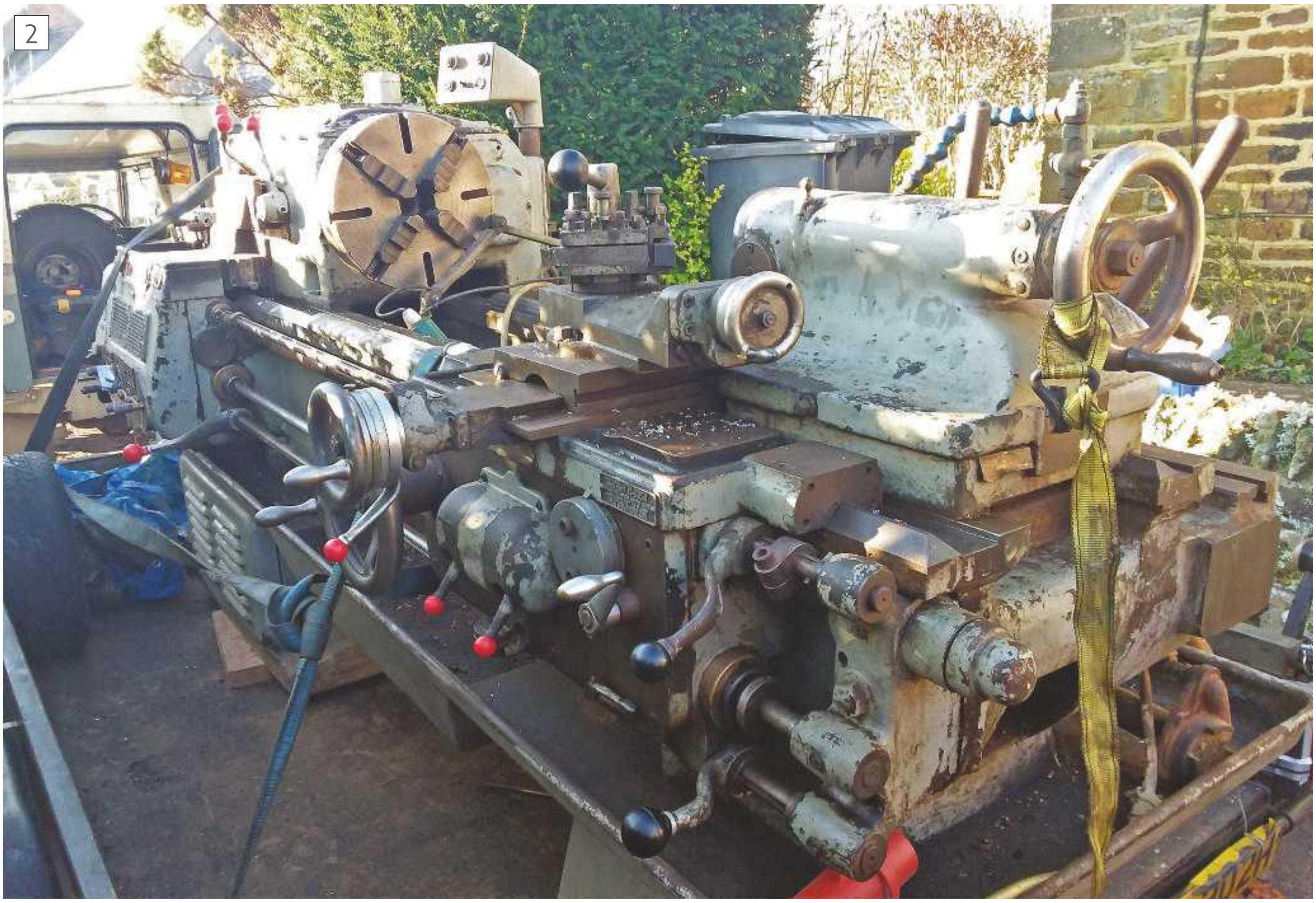
1

The near completed 127 gear mating with an original.

Introduction

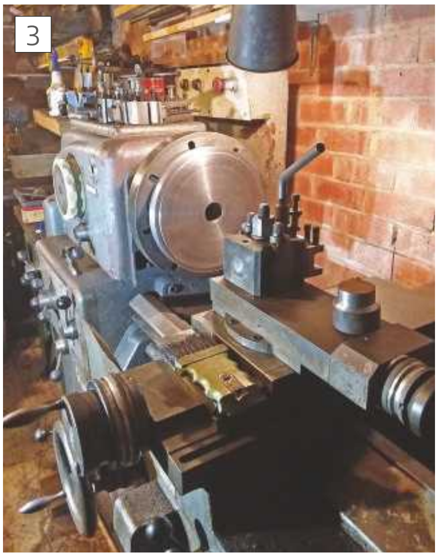
I recently had the good fortune to acquire a Holbrook D18 toolroom lathe complete with many accessories, **photo 2**. The only issue was towing it home: as it can be seen, it's not small!

Holbrook made outstanding quality lathes and the D18 has many handy features, including a screwcutting range of 60 imperial pitches and 90 metric, using just a single 127 tooth gear for conversion. It achieves this feat by reversing the direction of feed through the screwcutting gearbox when cutting metric pitches. A 127 gear would have been supplied with the machine when



2

Three tons of Holbrook D18 the day it arrived.


The gear blank on the Graziano faceplate: Note the plug gauge on the topslide.


Finish turning the bore of the gear.


The differential indexing setup for drilling the 127 hole dividing plate.

new, but, after 70 years of use and many owners, was sadly gone. This article describes the processes I used to make the gear.

Making the gear boiled down to 4 different jobs: Turn the iron blank, make a suitable dividing plate, cut the gearteeth and shape the keyway. Each had its challenges.

Turning the iron blank

Being a large machine, the gear required was also large: 10.75 inches in diameter and 1.25inches thick, with a 1.75inch centre hole. I thus bought a 16.5kg chunk of continuously cast iron bar that turned out to be good quality and easily machined, ref 1. The teeth themselves were "only" 1.125 inches wide, so the blank needed facing parallel on both sides and narrowing by approximately 60 thou for a little over the depth of the teeth. The iron was first put in the 4 jaw and approximately centred to run true. The outside diameter had its outer layer skimmed off and the embryo gear was faced off until clean of all sawmarks. By now I was practically knee deep in cast iron dust and I'd only just started! The width of the faced side was then reduced by 60 thou as previously mentioned.

The essential features of any gear blank are that the outside diameter and inside diameter are concentric and turned closely to size. As I never trust internal dimension measurements, I first turned a 1.750 inch plug gauge to make sure the inside diameter was accurate. A plug gauge is simply a piece of bar turned with a good surface finish to an accurate diameter. I turned mine to exactly 1.750 inches. Prior to this I


An original dividing plate to copy.

checked my micrometer's accuracy, so I knew the dimension was correct. I usually turn the bar 5 thousandths undersize for a short distance so I can tell when I'm getting close: you can't put the metal back on as easily as you can remove it!

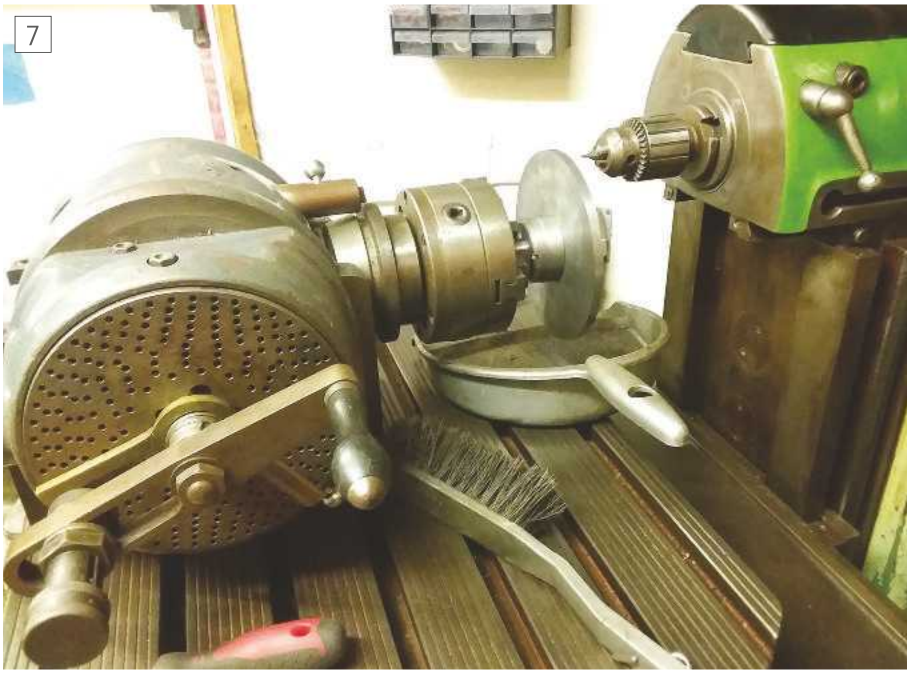
The machined side of my gear-to-be was now carefully marked out with a centre for four holes to match the faceplate of my Graziano SAG14 lathe. These were drilled and tapped M8 to about half the depth of the gear. The gear blank was then fastened to the faceplate with M8 studs and nuts, **photo 3**. The studs passed through some drilled ¼ inch flat bar between the faceplate and the gear blank. This made the blank sit proud of the faceplate. The plan here was to drill out the centre hole of the gear, finish the outer diameter and then face the remaining surface of the blank to the required width. The two opposing sides of the gear would then be parallel, provided the faceplate ran true and the ¼ inch flat bar was all the same thickness. Checking the faceplate and the bar proved this was the case within under a thou. About 20 minutes was then spent indicating the blank and hitting it with a rubber mallet until the previously skimmed outside diameter was running true. The centre hole was then drilled, and the outside diameter was then finish machined to size. I am lucky enough to have a Moore and Wright 12-inch digital vernier calliper and this proved easily up to the job of measuring something so big. I'm proud to say that, either by luck or divine intervention, the diameter came good to within less than half a thou. The centre hole was then carefully bored using the plug gauge as a reference, **photo 4**. All this machining on the faceplate ensured that the bore and outside diameter were perfectly concentric as they had been machined in one setting, something not possible in a chuck. The jobs most likely to move the part were done first for the same reasons.

Making the dividing plate

As you will almost certainly know, there are exactly 25.4mm to 1 inch. For reasons outside the scope of this article, this means that for truly accurate metric screwcutting on an imperial lathe a 127-tooth gear is required. To make such a gear, you must cut 127 spaces between 127 teeth and the distance between one space and the next must be exactly equal. 127 is unfortunately a prime number and so dividing a circular gear blank into this many spaces requires a dividing plate with 127 teeth. Making a 127-hole dividing plate also requires a 127 plate: A metalworking chicken and egg situation ensues and unless you have a friendly cnc operator to make the plate, you become stuck! There is another solution, however: go old school and learn about differential dividing. Whole books are written on the subject of dividing and with the advent of cnc are now obsolete, ref. 2. I was not going to bow to the miracles of technology, however, being firmly in the luddite camp and so read the old books and sourced secondhand gears to fit my old but sturdy Elliott dividing head. I used some thick steel plate I had lying around to make a suitable quadrant and the result was the setup shown, **photo 5**.

A 6.5 inch diameter thin iron disc was chosen to make the 127 hole dividing plate. Its key features were 127 equally spaced holes on a 6.250 inch diameter plate with a 1.000 inch centre hole. It also required three countersunk holes for securing screws and a hole on the rear for a locating peg to prevent it spinning. All needed to be concentric to within a thou. An original plate is shown in **photo 6**. The disc was firstly held in the 3-jaw chuck, faced, drilled and bored to size. A stepped mandrel was then turned, being held in a large collet. The mandrel was then used to centre the new plate on an original, allowing the 3 countersunk holes to be transferred over to the new plate. The mandrel was then drilled and tapped to match the dividing plate and the plate secured to it, machined side to the mandrel. The outside diameter was finish turned and the remaining side faced to size. This was remarkably rigid and chatter free. The method ensured everything was concentric, with only the holes left to drill.

7



Centre drilling the dividing plate.

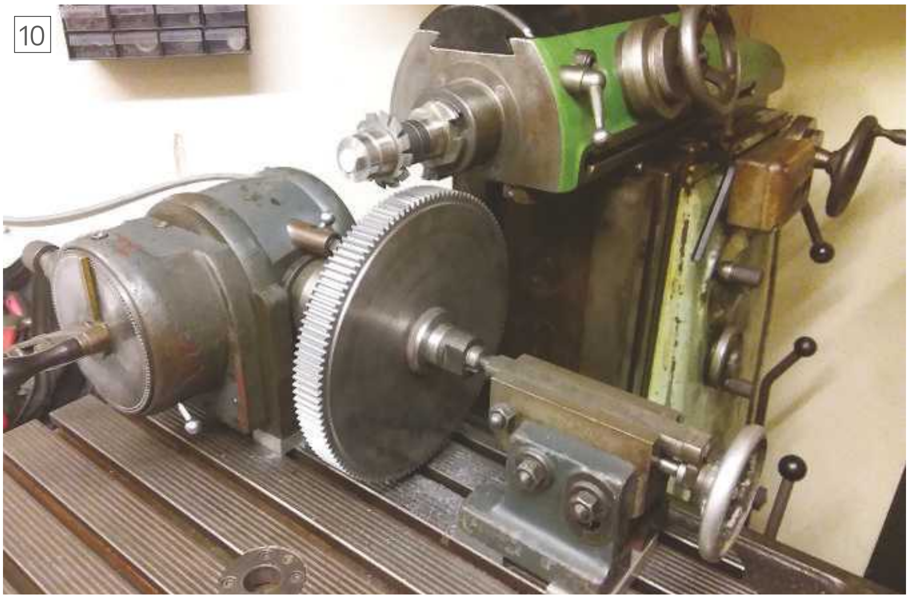
8

The completed 127 hole plate, also showing my error.

9

Finally cutting the 12 DP 127 gear.

10



The final space is cut and the sector on the dividing head lines up. Phew!

Returning to the mill with the machined plate, **photo 7**, showed that the differential dividing set up worked, but my reading skills weren't as good as my maths! I accidentally made the wrong number of centre drill holes on my first go as I'd stupidly manage to misread the markings on my dividing head. Second time round with my brain engaged and glasses on and 127 hole centre drilled dimples was the result. Transferring to the old Progress pillar drill the dimples were quickly turned into 1/8 inch holes half the depth of the plate. The rear hole was carefully marked out and drilled, completing the plate, **photo 8**. Note the dimples showing my schoolboy error!

Cutting the 127 gear

Mounting the gear on the dividing head

Accurately marking out the keyway.

Shaping the keyway.

posed two issues: Its diameter was too large for the centre height of the head, and I wanted to locate the gear on its bore, ensuring concentric teeth. The first issue was easy to overcome: the dividing head and tailstock were raised on some inch thick aluminium bar I had from a previous project. Locating the gear on its bore took longer. My dividing head happens to have an international 40 (INT40) taper and so does my Deckel milling machine. I have plenty of INT40 arbours, but all were 1 inch diameter. I thus made a custom spacer, machining an accurate 1.000 inch bore and 1.750 inch outside diameter, then parting off without removing from the chuck to ensure concentricity. This allowed the gear to be mounted on a short arbour and then to the dividing head. The arbour was first checked with a test indicator to ensure it ran true in the dividing head and was both parallel to the milling table and perpendicular to the milling spindle.

At last the gear blank was mounted on its arbour, the new dividing plate fitted to the head and the correct gear cutter mounted on the Deckel's horizontal spindle, **photo 9**.

Cutting the spaces between the teeth was now commenced with some trepidation, as the blank represented quite a lot of money and time investment. The job progressed well, indexing each space in turn, taking them out in one pass, then returning using rapid traverse, **photo 10**. With each space taking approximately two minutes to index and cut, it took nearly 3 hours to form all the teeth. It was with some relief that, when cutting the penultimate space, the sectors on the dividing head returned to where they started 126 teeth earlier. Success!

Shaping the keyway: the home straight

I bought a very cheap Elliott 10M shaper a number of years back that turned out to be in lovely condition but missing a clapper box. I made it a new clapper box shortly after it arrived and although it is rarely used, for keyways it is excellent. Marking out the keyway was the first challenge in this job. The 127 gear was blued then carefully mounted onto a large angle plate in such a way that the plate could be placed on its base or side, **photo 11**. The previously tapped holes proved useful for fastening it down. The assembly was placed on its side and a height gauge was then used to measure the height to the top of the central hole. The diameter of the hole was then subtracted, bringing the height gauge to centre height in order to scribe a centre line on the gear. The height gauge was then raised 0.125 and another line scribed parallel to the first for one side of the keyway. This was repeated, but with the height gauge lowered 0.125 beneath centre. The whole angle plate was then turned through 90 degrees onto its base and the height gauge raised to 0.125 above the bore, scribing the top of the keyway. This method ensured the sides of the keyway were parallel and the right width apart, plus centred correctly on the bore. The procedure adopted meant I could confidently shape the keyway to the markings.

The whole assembly was then transferred to the shaper and the keyway cut without issue, **photo 12**. The final width was checked using a 0.250 slip gauge and the gear mounted on the machine, **photo 13**.

Conclusion

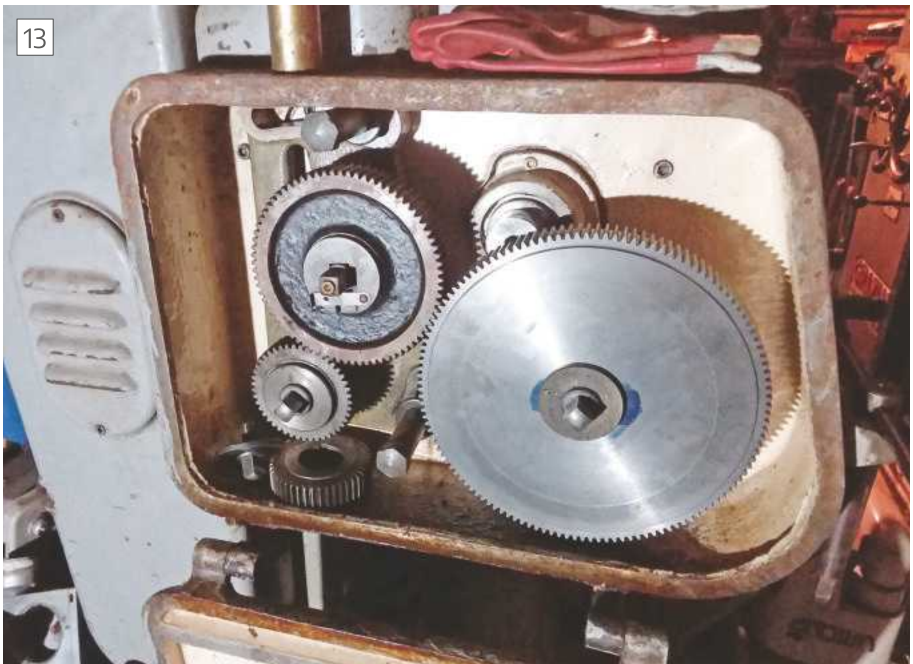
As you may imagine, this process was completed over a significant period, although the gear itself only took a week of workshop time. As with anything like this, the learning process and satisfaction gained easily pay for the time spent. The driving force for this project was the need to cut a metric thread on a driveshaft I am making for my father's 1908 Talbot. Although I have more than one lathe, the Holbrook is the only machine that can accommodate its 40-inch length and easily turn the taper onto which a bevel gear is mounted. Luckily my father was in no rush! The lathe cut the metric thread perfectly, running quietly and smoothly with no vibration. Job done.

Happy machining. ■

References

Ref 1 Abbey Spun Cast ltd (No connection other than a satisfied customer).

Ref 2 *"A Practical Treatise on Milling and Milling Machines"* Brown and Sharpe.



The finished gear fitted to the lathe. ▶

What to do with a slightly damaged calliper!

Bob Trethewey saves a digital calliper from the bin

Having decided not to put a TTL digital scale onto the compound slide of my recently upgraded Myford 254v plus due to the infrequency of its use, I pondered about what I should do with a slightly damaged digital vernier* I had put away at the back of my tool cupboard. Well, the answer lay before my eyes – put it onto the compound slide of the 254v plus.

1

Photograph1: The compound slide needed something as being a metric lathe when machining items to imperial measurements, I'd have to convert from the imperial measurement into its metric equivalent then ensure that I'd taken out the entire backlash in the compound slide's screw. The important thing I had to remember was the overall swing clearance of the top mounted rotating tool post and its attached tools so this meant that any item mounted as a fixed block must have its total height below the compound slides top surface.

2

Photograph2: The compound slide screw and its metric nut – these were removed and checked for wear, nothing excessive found certainly not enough to warrant a replacement of either item.

3

Photograph 3: This image shows the machined compound slide assembly reassembled identifying the positions of the M5 threaded mounting holes for

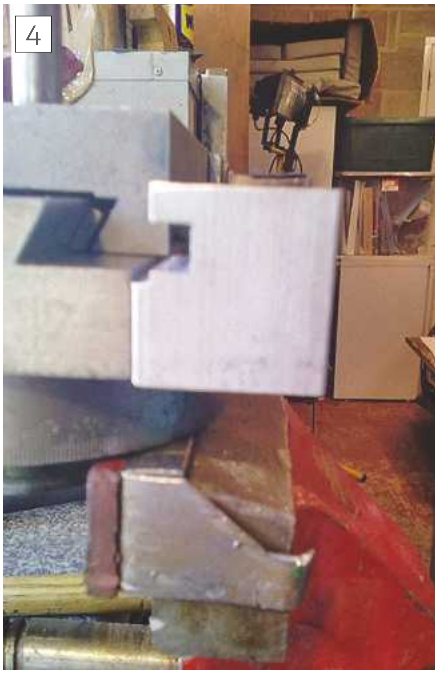
** In the days before digital, precision callipers were universally referred to as 'verniers' to distinguish them from the non-graduated kind. Many people refer to digital callipers as 'verniers' although they don't have a vernier scale. While not strictly correct, this does still distinguish them from simple callipers.*

the lower fixed block and the upper moving bracket.

Photograph 4: Where to position the fixed and the moving mountings? The compound's top slide overhung the lower half by 2.31mm (0.091in) due to the position of the internal gib strip on that side as well as this there are a set of five adjusting screws for the gib strip. These adjustment screws numbers 1, 3 and 5 are longer and protrude further out than numbers 2 and 4 as these are the ones which have machined locations in the gib strip's outward facing side.

Photograph 5: The block that was going to be machined to become the fixed terminal would need to be machined so that it allowed clearance for the gib strip adjusting set screws and the difference in the offset of the top moving slide compared with the fixed bottom portion of the compound unit. This mounting block would be held onto the side of the fixed compound using two M5 x 25 socket headed set screws countersunk into the block's side by a depth of 14mm.

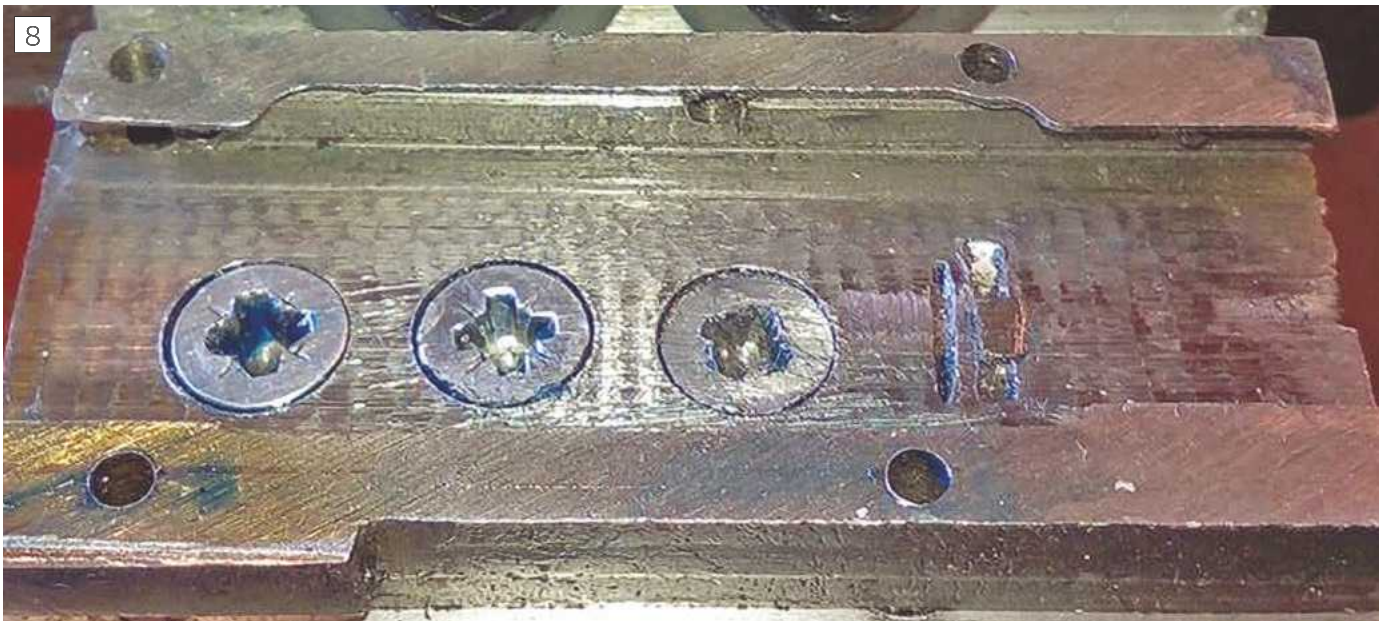
Photograph 6: The height of this fixed mounting block would be determined by the full swing of the rotating tool post and its attached tools. When the vernier clamp head is removed the height of the fixed block should be gauged by placing the base of the vernier onto the moving compound slide bracket and allowing the underside of the vernier slide to be used to scribe the machining level of the fixed block.


4


5


6


7


8

Photograph 7: The fixed block needs to hold on tightly to the end of the vernier scale and would need to have a cap produced so that the verniers slide would be retained and trapped as well as being bolted onto the fixed block. The fixing would be a button headed M5 x 25 set screw.

Photograph 8: The image shows the metal base of the vernier machined to produce a secure location when bolted to its moving bracket on the top slide of the compound slide. Three M4 tapered screws were used to locate this steel vernier base.

Photograph 9: This images shows the location of the steel vernier base located on the moving slide which is held in place using two M5 x 20 button headed cap screws. An elongated slot is machined into the short side of the moving bracket so that fine adjustment can be done when in final assembly.

Photograph 10: Holes were drilled into the large face of this bracket so as to screw the electronic head back onto the steel base. As the moving slides two M5 mounting bolts need to be tightly secured before the electronic head is located. Then all that was left to do before assembly was to drill the machined vernier end to cap it with its scale retaining top and under caps.

Photograph 11: Having assembled the vernier slide and locked it to the fixed lower block, the moving upper bracket was assembled with its electronic head which was screwed through the moving upper bracket and vernier base through the machined holes in the bracket.

Photograph 12: Only one thing to do would be to check the actual backlash I was getting from the compound slides lead screw – winding the screw backwards one revolution and zeroing the vernier's scale the screw was advanced one centimetre the vernier showed a loss of one percent. Not completely accurate, however this modification would prove invaluable in future builds as I'd never again have to convert from imperial time after time.

More images of this conversion can be seen by visiting **www.ritasears.blogspot.com** and looking at tab "R". ■

Amazing Savings!

6 issues for £10

On a quarterly DD stepping up to £15.25 thereafter

3 issues for £10

On a quarterly DD stepping up to £11.25 thereafter

SUBSCRIBE SECURELY ONLINE:

WWW.MYTIMEMEDIA.CO.UK/KELSEY21

CALL 0344 243 9023** AND QUOTE KELSEY21

TERMS & CONDITIONS: Offer ends 30/05/2021. *UK print subscriptions offer only. Subscriptions will begin with the next available issue. MyTime Media collects your data so that we can fulfil your subscription. We may also, from time to time, send you details of MyTime Media offers, events and competitions but you always have a choice and can opt out by emailing us at unsubscribe@mytimemedia.comWe do not share or sell your data with/to third parties. Details you share with us will be managed as outlined in our Privacy Policy here http://www.mytimemedia.co.uk/privacy-policy. Please visit www.mytimemedia.co.uk/terms for full terms & conditions.

A Four Way Rear Tool Post for the Engineers Tool Room BL12-24 Lathe

Howard Lewis details a multi-tool rear toolpost for larger lathes. Part 2

Tool Post Clamp Lever Washer (Item 4)

This is merely a large thick washer with a chamfer on the top, and relieved on the underside. It is finished, after final assembly, by facing off just sufficient to material to ensure that the lever points away from the workpiece when the toolpost is clamped.

Tool Post Clamp Stud (Item 5)

Ideally, this is high tensile steel, machined to length, chamfered, and a M10 thread cut on each end. Again, the die was adjusted to match a commercial M10 high tensile bolt.

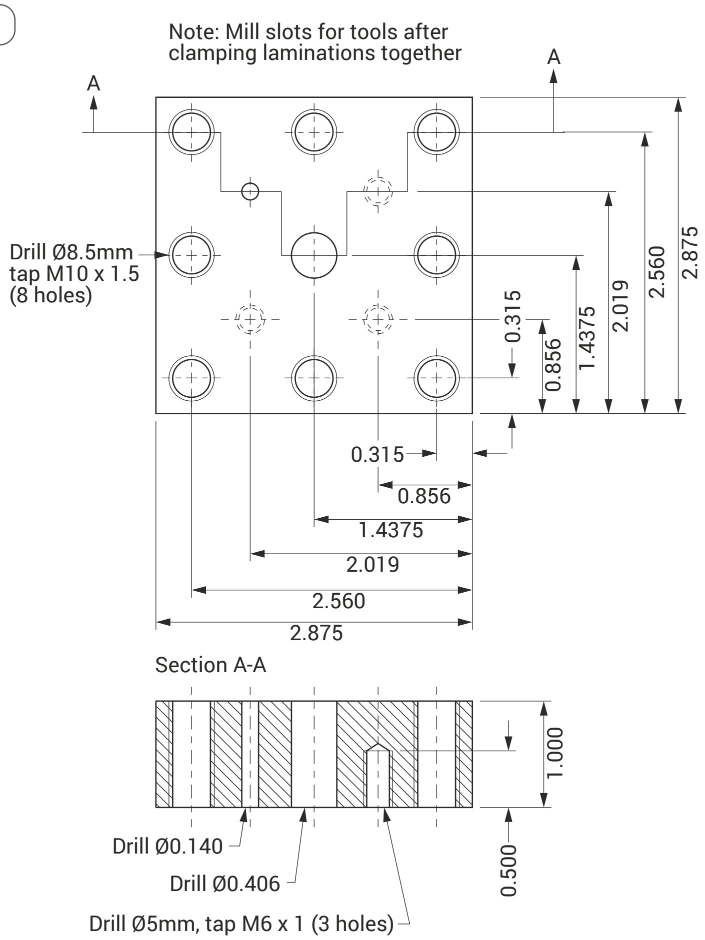
Tool Clamp Screws (Item 7)

Making the eight clamp screws was the only repetitive part of the job. The method used here was to clamp the bar in the three-jaw chuck, turn a suitable length to 10mm diameter, face and chamfer the end, and, using a tailstock dieholder, cut the M10 thread over the full length of the 10mm section. To ensure correct size, the dieholder had been set by using a commercial high tensile bolt as a master.

Having cut off slightly over length, eight threaded blanks, each one was screwed into a piece of bar with a M10 tapping, locked with a nut, and reversed in the chuck, to be faced to length, and chamfered, ready for milling the flats.

Once turning operations on all eight embryo clamp screws had been completed, each one was taken to the milling machine. Using the M10 tapped piece of bar, again, set vertical, in the milling vice, each clamp screw was again locked in place with a nut. An end mill was then run along each side, at the correct depth to leave the shoulder between flats and thread, producing a square head matching the front tool post screws, and able to utilize the same toolpost key. It may be necessary to round the corners lightly with a file to accept the tool post key.

Fig.6



15. Lamination 4
Mat'l: BMS, 1 off

Dowel Assembly

This consists of straightforward turned items, the knob (item 8), the rod (item 9) and the dowel (item 10). To minimize the risk of the three parts separating, it may be worth, on final assembly, to apply an anaerobic sealant to the threads on each end of the rod.

Clearance between the O.D. of the clamping washer (item4). And the knurled knob (item 8) is tight. Before final locking in place, it may be found necessary to reduce the plain shank of the knob a little to ensure clearance.

Toolpost Body

The toolpost body was assembled by clamping together (using the internal Allen capscrews) laminations of the ground steel to accommodate the different machining requirement for each layer. When all the layers had been clamped together, and the tool post fitted to the cross slide, a large (4-inch diameter) milling cutter was used to just clean up the side faces of the tool post. Because of the size of the cutter, minimum speed was used for this operation. This ensured that each of the sides were square to the lathe axis, before using the milling machine to cut the tool slots. Alternatively, a flycutter could be for this operation.

The slots for the tools were produced using an end mill. Because the tools are mounted inverted, the slots were positioned relative to the base so as to need some packing to accommodate slight variations in tool shank size, for setting the tip on the centre line of the work.

Assembly

The General Arrangement, plan view, and Section AA' (fig.1) show the assembly of the major components. Assembly is just a matter of feeding every thing together, in the right order onto the three cap screws, lamination 1 (item 2), lamination 2 (item13), lamination 3 (item14), lamination 4 (item15), followed by tightening up the screws to clamp the layers together, **photo 6**.

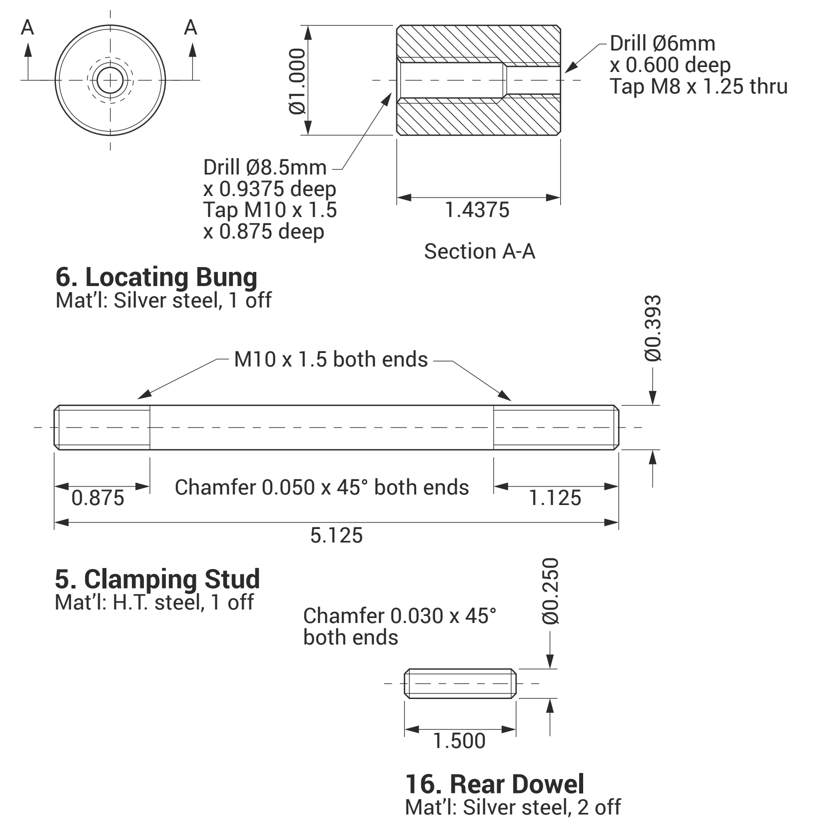
It may be a good idea to use an anaerobic sealant on the threads of the three internal clamping Allen cap screws, and allowing it cure, prior to milling to clean up the sides and then to mill the tool slot on each of the sides. After milling, any burrs should be removed.

Once these milling operations have been completed, the dowel, consisting of knurled knob (item 8), rod (item 9), spring (if used), and dowel (item 10), may be assembled, and the tool clamp screws (item 7) fitted. Anaerobic sealant can also be used to lock the countersunk allen screw that clamps the locating bung (item 6) to the base, photo 2.

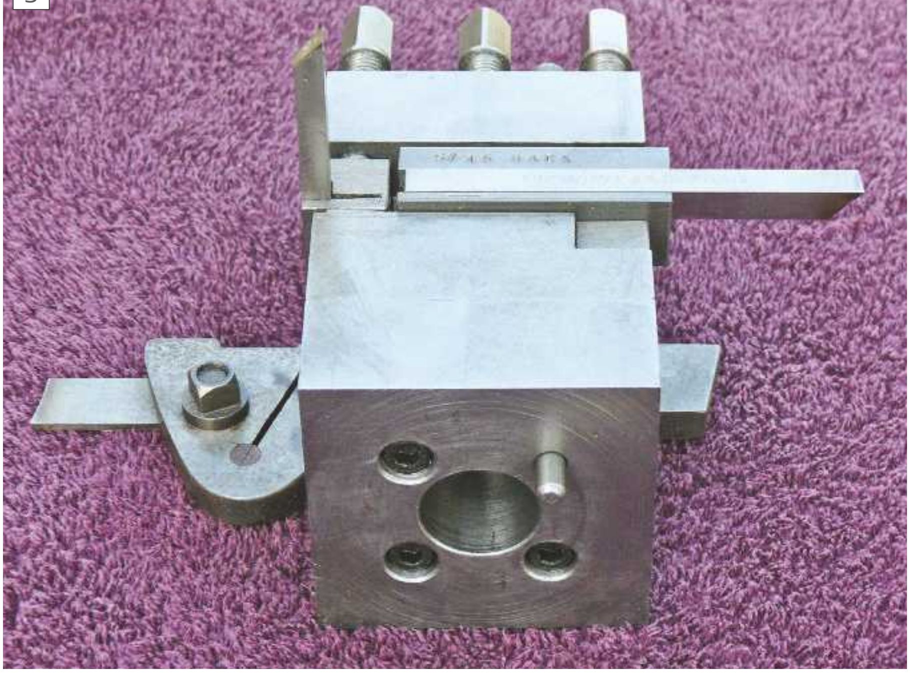
Setting the studs into place in the long tee nut is made easier by the use of a stud box. This is only a short piece of hexagon bar tapped with the particular thread, and with a setscrew as long as the hexagon screwed into it. The hexagon bar should be at least four diameters long, (in this case 32mm minimum). With the setscrew engaged halfway, the stud box is screwed onto the stud, and driven home by using a spanner on the head of the setscrew. When the stud is fully home, slackening the setscrew will allow the stud box to be removed.

The toolpost base is clamped to the cross slide by two nuts on studs set into a long tee nut. The tee nut and studs should be made to suit the rear slot on the particular machine to which the toolpost is going to be fitted, and the thickness of the base. The two short studs were locked into the long tee nut with anaerobic sealant; as were the two Dowels (Item16), into the underside of the Base (Item 11). **Photograph 5** shows the M8 hardware used for this purpose on the prototype. Photograph 2 shows the underside of the base

Fig.7

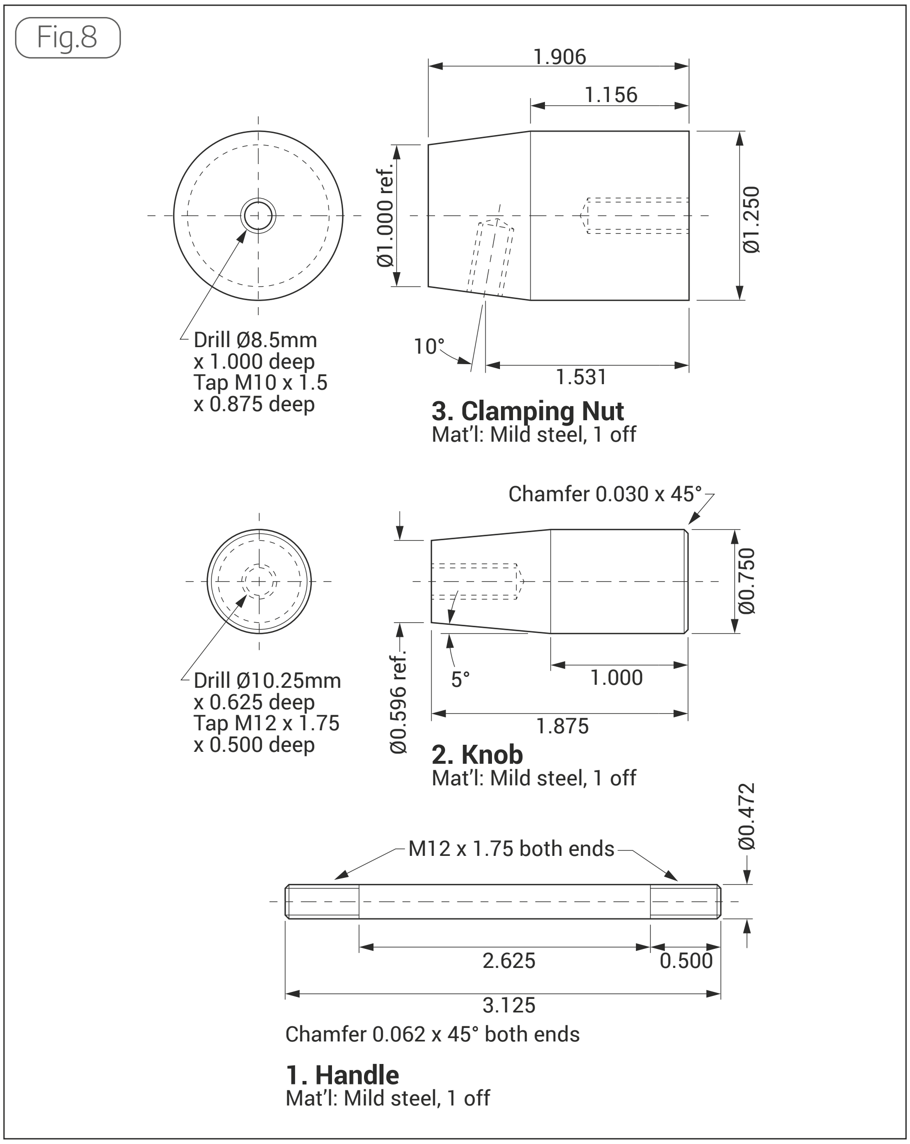


5



Toolpost, with tools ready for use.

Fig.8



assembly with the two dowels in place.

Once the anaerobic has cured, the base can be fitted to the cross slide of the lathe, ensuring that the dowels are hard against the rear face, and secured with the tee nut assembly. The M10 central stud can be secured in place, using anaerobic sealant on the lower (0.875 long) end, if desired.

The clamp lever is assembled by screwing the M12 stud (item1), into the clamping nut (item 3), and the tapered knob (item 2) onto the m12 stud handle (item1), using an anaerobic sealant to ensure that the parts do not separate.

The tool post assembly is then lowered over the clamping stud (item 5), onto the base (item 11), so as to locate on the central dowel (item 10), and the clamp washer (item 4) and clamp lever assembly fitted to the top of the clamping stud (item 5).

Photograph 6 shows the completed toolpost in position on the Lathe. When clamped, the clamp lever should not overhang the workpiece. If it does, the clamp washer needs to be removed and material faced off the underside to ensure that in the clamped position, the lever points away from the workpiece. This is to minimize any risk of contact and injury, whilst the workpiece is rotating.

Estimating the angular change required, and knowing the thread pitch, (1.5mm) it is possible to make a fair approximation of the amount of metal to be removed.

The washer is lightly clamped in the chuck, and using a drill chuck, or centre, the tailstock is used to align the washer in the chuck by applying slight pressure, before clamping more tightly ready for the facing operation.

Finale

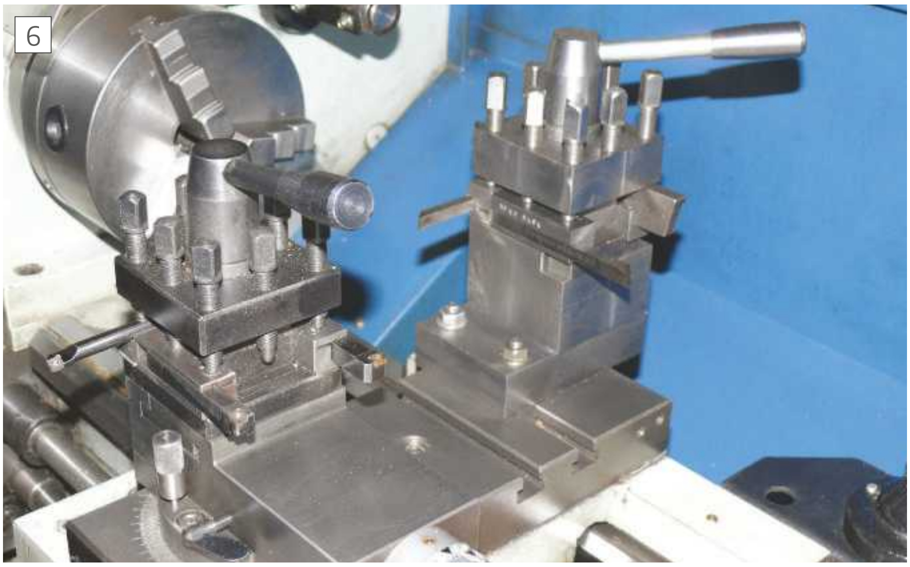
Although not affecting its function, apart from being natural finish as opposed to the black of the front tool post, it looks part of the lathe. If preferred, the parts can be blackened, using one of the available commercial processes.

Disengaging the dowel, ready to index, is easier if the tool post is unclamped.

The only other work required will be to make up suitable packing to set each tool on the centerline of the work. My preference is to use a piece of ¾ inch square steel milled to accommodate the size of tool shank in use, to take up the major clearance, using shim stock, or old feeler gauge blades for fine adjustment. This technique is visible in photo 5.

This has proved to be a most useful accessory, well worth the time and effort of construction, allowing a rear, as well as a front chamfering tool, and a parting tool to be brought into use in seconds, whilst leaving the front tool post to carry turning, facing and boring tools.

I hope that anyone making one will be equally pleased with their handiwork, and its effectiveness. ■



Toolpost fitted to the cross slide.

On the Wire

NEWS from the World of Hobby Engineering

Cancellation of 2021 Midlands Model Engineering Exhibition

It is with deep regret that due to the ongoing uncertainties of Covid-19 pandemic; we have to announce the cancellation of the 2021 Midlands Model Engineering Exhibition which was due to be held at the Warwickshire Event Centre on the 14th-17th October.

This difficult decision is taken despite a real determination by the Meridienne Exhibitions team, trade, clubs, societies, exhibitors and other supporters, all striving to continue to deliver the usual high quality and successful event during this very difficult time.

Over the past few weeks, we have been in the excruciating position of considering every possible scenario to see how we might be able to proceed, but sadly the risks of holding the event now far outweigh the reasons for going ahead. The core decision is based on the escalating cases of COVID-19, and the risks that widespread illness and self-isolation could have on everyone involved. We have navigated our way over the past 16 months through obstacles, but now feel that the odds are stacked against us, and we are no longer able to proceed safely with the unknown government Covid-19 requirements for Autumn and Winter ahead.

It follows that with our decision to cancel the Midlands Exhibition we have also, again regretfully, decided that it is not practical nor financially viable to proceed with the London Model Engineering Exhibition at Alexandra Palace in January 2022.

Having presented model engineering and other exhibitions for well over 40 years these decisions represent a tremendous disappointment for all but hopefully the situation will be different in later 2022 and we may again present a model engineering exhibition.

We look forward to seeing you all again soon.

Avril Spence, Exhibition Manager

News from Transport Museum Wythall

Miniature Railway Wythall Standard Gauge Running Day

The Wythall Miniature Railway, which operates within the grounds of the Transport Museum Wythall, is holding a Standard Gauge Running Day on Saturday August 21st. On this day the railway will operate miniature versions of well-known full size British Railways steam locomotives owned by members and friends of the Elmdon Miniature Engineering Society (EMES) who operate the railway.

Locomotives present will include an LMS Black 5, GWR King, GWR ‘dock tank’, GWR Prairie tank and a Southern Railway Q class. Other visiting locomotives are expected. This is the first ‘standard gauge’ event run by the railway, which normally operates replica and freelance designed narrow gauge steam and diesel locomotives on its public days. The locomotives present today are steam-powered masterpieces of miniature engineering and operate just like the real thing – and they haul a mixture of freight and passengers!

Reece Greenstreet, EMES Chairman, said: ‘Here at Wythall we pride ourselves in delivering a great miniature railway experience for children of all ages but our members always look forward to running their own works of engineering art ‘after hours’. At this event we have decided to go public with our fleet – you won’t be disappointed’.

The ride-on railway operates miniature locomotives and trains at 7¼”, 5” and 3½” gauges on its scenic line around the grounds of the museum. Established in the 1980’s, the Society has continued to develop the railway at Wythall which is fully signalled, has two stations, an engine shed, a viaduct and tunnel and two level crossings shared with the bus museum roadways. The infrastructure has grown and developed over the years and now boasts a circuit with passing loops that covers just over a fifth of a mile. There are plenty of viewing areas and children can wave to the trains as they pass the picnic area.

Standard TMW admission charges will apply on the day with a supplement for train rides. Full details of TMW opening times and admission prices can be found at www.wythall.org.uk and information on the railway at **www.wythallsteamrail.com**.


PNP Railways
Vacuum Brake Parts
For 10¼", 7¼" & 5" Narrow Gauge
Acutators | Reservoirs | Limit Valves | Ejectors | Brake Valves
Vacuum Brake Actuators
Vacuum Brake Refurb Kit
Reservoir Kit
Special Offer - 10% off Actuators, Refurb Kits & Reservoir Kits
Code VBMEA21 - Valid until 30th September 21
Tel: 01453 83 33 88 | www.pnp-railways.co.uk

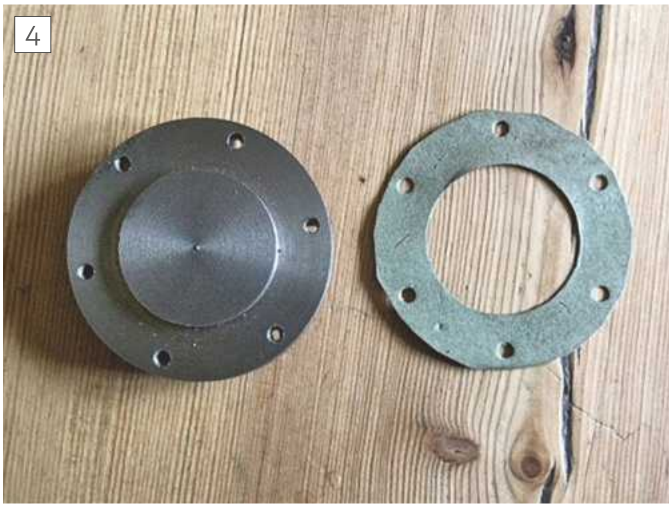

metalcraft™
Hand powered metalforming tools
Handy for so many jobs
Punching
Cutting
Riveting
Bending
Rolling
Scrolling
Twisting
Also suppliers of a wide range of steel, fixings, clock components & much more.
Call today for your free catalogue and if you quote our promo code* MMENGW21, we will send you our demonstration DVD free of charge.
J & C R Wood Ltd, Dept MMENGW21, 66 Clough Road, HULL HU5 1SR
Tel: 01482 345067 Email: info@jandcrwood.co.uk
OR Visit our on-line store at
www.metal-craft.co.uk


Engineers' Cabinets
Tel 07534 458664 or email mark@cassey.co.uk
* Brand new and Hand made in the UK (Lincolnshire)
* Solid English Oak locally sourced (no veneers)
* Grain of oak "wraps" around the cabinet (i.e. a single board is used for the carcass, where the start of the new side has a continuation of grain pattern from that of the previous side).
* Drawer fronts are all from a single board, so the grain pattern "flows" across the front of all drawers
* Made to exacting standards
* Fashioned on the iconic Moore & Wright cabinet
* Size 17" x 8.25" x 11.375" (430x210x290mm) approx
* Bespoke commission undertaken to your dimensions
I currently make two styles, a 5 full width drawer cabinet for £550.00 and a 7 drawer cabinet at £600. Delivery at cost or collection welcomed. Cost of bespoke cabinets depending on size and details.

Readers' Tips

TIP OF THE MONTH WINNER!

Punching bolt holes in paper gaskets



This month's winner is Peter Brown from Hampshire with a tip for making paper gaskets.

When making gaskets for my engines I use to find it difficult to make a neat job with perfect holes. Usually, I cut out gaskets using scissors and for large holes I use leather punches of which I have a selection of sizes however the small bolt holes are a different matter, you can poke a scriber through or even a drill, but this usually leaves a ragged edge. What is needed is a punch of exactly the correct size positioned accurately, after experimenting I have come up with the following method which I have never seen but works for me.

Photograph 1 shows a cylinder end cover with paper gasket cut out. With the gasket in position, I carefully locate the hole using an automatic centre punch, **photo 2**. Once located operate the punch and a perfect hole will be cut in the paper, a tiny paper disk may be left in the hole in the cylinder cover which is easily removed, **photo 3**. Finally, once assembled the outside edge is trimmed using a craft knife, **photo 4**.

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.

Scribe a line

YOUR CHANCE TO TALK TO US!

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

Chassis Punch

Dear Neil, I enjoyed Chris Gabel's article and take the point that this is a short term use tool made from what is to hand rather than a replacement for a commercial tool using rare materials.

Here are a few points that could make the home made punch a little better in use.

1 Cut or mill two parallel flats on the blunt end of the punch so that it can be held in a vice - makes the cutter much easier to use.
2 Drill two 5-6mm holes in the die parallel to the bolt hole so that the slug can be easily pushed out of the die with a rod.
3 Lubricate the bolt and washer preferably a high pressure style grease – the tension in the bolt is very high and the friction with the washer is massive too. A touch of grease on the punch cutting edges can help too. Commercial chassis cutters often used a thrust bearing in place of a washer, that worked very well until it fractured!
4 A high tension bolt would be a refinement, traditional chassis punch use often stretched regular bolts.
5 Reducing the punch outer diameter by cutting a 0.5mm deep relief after the cutting edge leads to much easier "ejection" of the job from the punch.
6 Punches do cut without deforming the surrounding material and make a very smooth hole however the die side is lightly marked around the hole by the die. Punch makers often use a shallow Vee instead of a semi-circular punch face relief.
7 Case hardening of the punch is very desirable, ground charcoal and a pinch of sodium carbonate (washing soda) works well. Something that I have used very many times thanks to Workshop Practice #1 "Hardening, Tempering and Heat Treatment " by Tubal Cain.

I must have punched a heap of holes years back but now I use step drills or hole saws or CNC milling. But a good project from Chris.

Alan Gray, G8LCO.

Lantern Chuck

Dear Neil, in issue 303 you asked for "photos of readers' completed chucks". I attach my version for your consideration.

Neil Warren, by email.

GHT Sensitive Drilling Machine

Dear Neil, I am a long time subscriber to MEW. In my workshop I have a set of castings for a small sensitive drilling machine, very similar to Thomas's pillar drill. Can you advise me if there is any drawings or construction details that have been published in any copies of MEW? I have had these castings now for about 30 odd years, and was going to make it when I retired, Ha! Ha! I have been making brass skeleton clocks (designed by W R Smith.) I have just finished my last one. No 12. There will be no more. There was a picture of my Lyre Clock on the cover of MEW a few years ago.

I look forward to my copy of MEW each month, and I would be very grateful for any information you may have.

Brian Wiffin, New Zealand.

My recollection is that GHT's Universal Pillar Tool included the sensitive drilling machine, and the details are in his book Workshop Techniques. Castings are available from Hemingway Kits should any other readers want to make this device.

Model Engineers' Workshop Data Book

ELECTRONIC COMPONENT MARKING

RESISTORS

Small resistors, intended for electronic circuits, have their values indicated by a series of coloured bands. If four bands, the first two indicate the first two digits with the third being the multiplier. Typically, Yellow Violet Orange would be 47000 ohms. The fourth band is the tolerance + and -.

Standard values
Resistors values are made to a number of standard series. Four band resistors are likely to conform to either series E6, E12 or E24. 6, 12, and 24 being the number of values between 1 and 9.9, 10 and 99, 100 and 990 and so on.

The standard values are.

E24	10	11	12	13	15	16	18	20	22	24	27	30
E12	10		12		15		18		22		27	
E6	10				15				22			

E24	33	36	39	43	47	51	56	62	68	75	82	91
E12	33		39		47		56		68		82	
E6	33				47				68			

Typically the E6 series has values of 1.0, 1.5, 2.2-- 10, 15, 22-- 100, 150, 220 and so on.

E48 and E96 series have smaller divisions, the E96 series starting 100, 102, 105, 107 and 110. Having three digits an extra band is required, the first three indicating the three digits, the fourth the multiplier, and the fifth the tolerance. In some cases a sixth band indicates the temperature coefficient.

MODEL ENGINEERS'WORKSHOP DATA BOOK

ELECTRONIC COMPONENT MARKING

Resistors marked with the value.
In some cases resistors are marked directly with their value but, to avoid the necessity for a large number of noughts for the higher values, they are quoted in either Ohms, Kilohms and Megohms. These use R to indicate Ohms, K to indicate Kilohms and M to indicate Megohms. Also, due to their small size, a decimal point could easily be overlooked, and for this reason the following approach is adopted. The multipliers R, K and M are positioned in place of the decimal point. The following examples should make this method clear.

```
 R33 = 0.33 ohms
 1R5 = 1.5 ohms
33R  = 33 ohms
 2K2 = 2.2 Kilohms = 2200 ohms
68K  = 68 Kilohms  = 68000 ohms
 4M7 = 4.7 Megohms = 4700000 ohms
```

This method is also used on drawings, as again it avoids problems due to errors in reading the decimal point.

CAPACITORS

Capacitor marking is much more varied and, as a result, cannot be covered fully in this data book. The following information may though be of some help in some situations, but needs to be treated with some caution. For the physically larger capacitors, the value, voltage rating and possibly the tolerance, will be printed on fully, but for smaller sizes this is not possible.

ELECTRONIC COMPONENT MARKING

Standard values
Capacitor values also conform to the standard E series quoted for resistors. However, the need for very specific values is rare, as a result, fewer values are available, conforming only to E3, E6 or E12. Typically, for E3, 100pf 220pf 470pf 1000pf 2200pf 4700pf, and so on.

Marking methods
In addition to having the values printed on, it can also be conveyed by means of a colour, or alpha/numeric, code. The alpha numeric code is quite common, consisting of three numbers and a letter. The numbers are a code for the value and the letter for the tolerance. For the value the first two numbers are the first two digits of the value, with the third, the number of added noughts. This gives the value in picofarads. For example 473J gives 47000pf, being 0.047uf, J indicates 5% tolerance.

Tolerance letter

F = 1%	G = 2%	H = 2.5%
J = 5%	K = 10%	M = 20%

Tolerances are plus and minus.

Additional characters will be added to indicate the manufacturers type code, no explanation of these can be given.

Colour coded capacitors, though rare, follow a similar approach with the first two colours being the first two digits and the third the number of added noughts, again the value is in picofarads. Additional colours indicate the tolerance and voltage rating. The colour code for the value conform to that quoted for resistors, but the colour code for the tolerance may differ.

MODEL ENGINEERS'WORKSHOP DATA BOOK

ELECTRONIC COMPONENT MARKING

COLOUR CODE

Digits

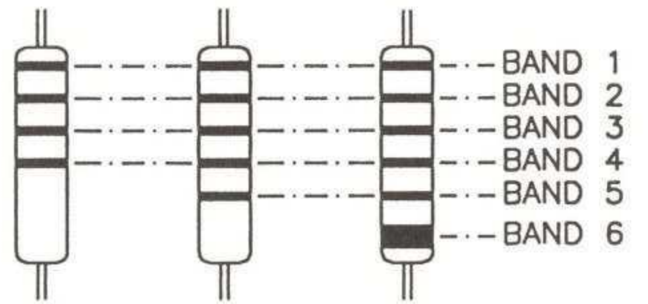
Black	=	0
Brown	=	1
Red	=	2
Orange	=	3
Yellow	=	4
Green	=	5
Blue	=	6
Violet	=	7
Grey	=	8
White	=	9

Tolerances

Brown	=	1%
Red	=	2%
Gold	=	5%
Silver	=	10%

Multiplier

Black	=	multiply x 1 (add no noughts)
Brown	=	multiply x 10 (add 1 nought)
Red	=	multiply x 100 (add 2 noughts)
Orange	=	multiply x 1000 (add 3 noughts)
Yellow	=	multiply x 10000 (add 4 noughts)
Green	=	multiply x 100000 (add 5 noughts)
Blue	=	multiply x 1000000 (add 6 noughts)
Violet	=	multiply x 10000000 (add 7 noughts)



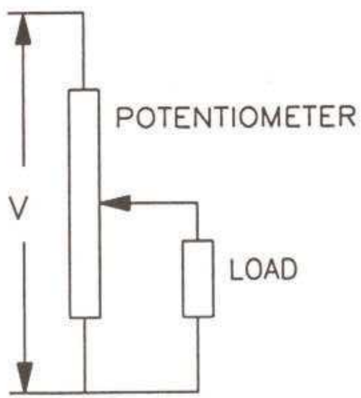
USEFUL ELECTRICAL FORMULAE

Whilst all the examples given relate to three Resistors, Capacitors, Voltages etc, the formulas suit any number from two or more.

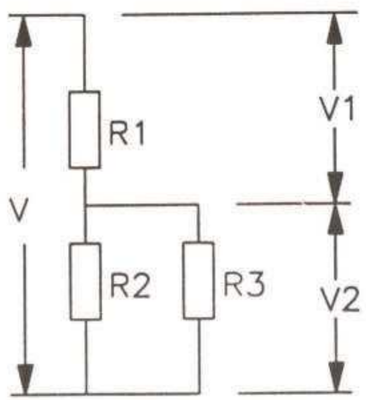
A Series/Parallel circuit

More complex circuits, than purely series, or purely parallel, exist, and voltages and currents in these can also be calculated using the above formulas. A typical example of this would be the use of a potentiometer to supply a load. This consists of a series/parallel circuit and whilst only made up of two components it can for calculation purposes be considered to be made up of three resistors.

Practical circuit



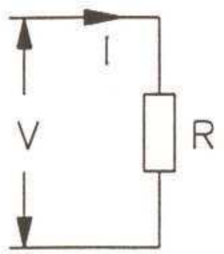
Theoretical circuit



To calculate voltages V1 and V2 in the above it will be necessary to work out the effective value of R2 and R3, using the two resistors in parallel formula. Then, with this value, calculate V1 and V2 as though there were just two resistors in series.

USEFUL ELECTRICAL FORMULAE

Relation between voltage, resistance and current. (Ohm's Law)



$$I = \frac{V}{R}$$

$$V = I \times R$$

$$R = \frac{V}{I}$$

R = Resistance in ohms
V = Voltage in volts
I = Current in amps

Relation between current, voltage and power.

$$P = V \times I$$

Also in terms of resistance.

$$P = \frac{V^2}{R}$$

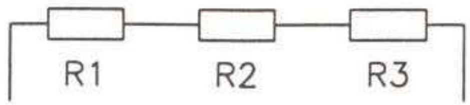
$$P = I^2 \times R$$

P = Power in Watts

The above are applicable to DC circuits, but can also be applied to AC circuits providing the load is pure resistance, that is, no inductive or capacitive content.
Heater elements, even if wound, will normally have a high resistive to inductive ratio and can use the above with negligible error. The formulae do not apply to AC circuits with inductive loads such as motors, solenoids, transformer windings etc.

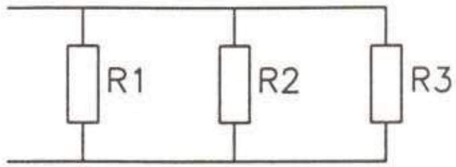
USEFUL ELECTRICAL FORMULAE

Resistors in series



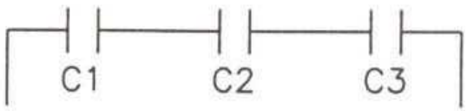
$$R = R1 + R2 + R3$$

Resistors in paral;el



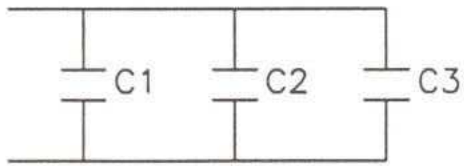
$$R = \frac{1}{\frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}}$$

Capacitors in series



$$C = \frac{1}{\frac{1}{C1} + \frac{1}{C2} + \frac{1}{C3}}$$

Capacitors in parallel



$$C = C1 + C2 + C3$$

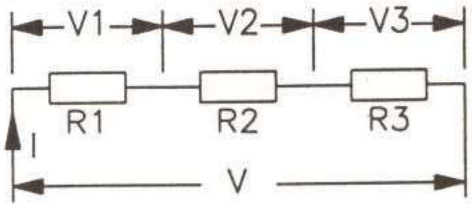
R and C are the effective value of the series or parallel configuration.
Inductors follow the same principle as resistors.

MODEL ENGINEERS'WORKSHOP DATA BOOK

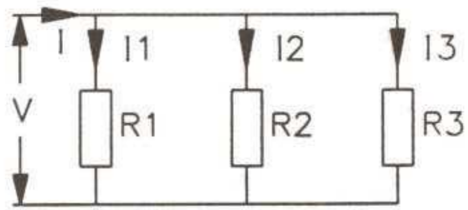
USEFUL ELECTRICAL FORMULAE

Ohm's law is not only applicable to a single resistor applied to a single power source, but also to individual elements of a complex circuit. The following limited examples give some indication of its use in these situations. The first two examples indicate the principles of the addition of voltages and currents in multi element circuits.

Voltages and Currents in complex circuits.



$$V = V1 + V2 + V3$$



$$I = I1 + I2 + I3$$

Applying Ohm's Law (V = R x I) to individual elements of the series circuit.

$V1 = R1 \times I$ $\quad V2 = R2 \times I$ $\quad V3 = R3 \times I$

Applying Ohm's Law ($I = \frac{V}{R}$) to individual elements of the parallel circuit.

$I1 = \frac{V}{R1}$ $\quad I2 = \frac{V}{R2}$ $\quad I3 = \frac{V}{R3}$

The Chemistry of Brazing Fluxes and Acid Pickling

Norman Billingham. ***'I have been in such a pickle since I saw you last' (The Tempest; Act V Scene I)***

Silver brazing is often discussed at various meetings at the Society of Model and Experimental Engineers (SMEE). I give a talk on adhesives, soldering, and brazing to students on our basic training course, and we show Johnson Matthey's video of good brazing practice. We demonstrate brazing the boiler for Tubal Cain's 'Polly' engine to students on our beginners' course, and Keith Hale of CuP alloys gave a nice talk on brazing at a Society meeting. Each time brazing is described, pickling comes up for discussion, often with reference to using sulfuric acid to remove flux residues and oxides. Our recommendation to students on our training courses at SMEE has long been to use nothing more active than dilute citric acid solution, and we disposed of the sulfuric acid in our workshop some years ago, but the subject came up again this year and seems to come up so often that I began to wonder what the authorities on the subject say and why.

Johnson Matthey recommend only hot water to remove residues of their Easyflo fluxes. Tubal Cain's book, **ref. 1**, the oldest modern book in my collection, first published in 1985, recommends hot water, with 10% sulfuric acid for difficult cases. Richard Lofting in his (2014) book, **ref. 2**, also recommends hot water alone, but suggests that 10% nitric acid can be used to remove oxides, and flux residues, and that hydrochloric acid will work well. Keith Hale, in the most recent (2017) book, **ref. 3**, recommends hot water alone, or dilute citric acid, but also discusses using 10% sulfuric acid and suggests it will work better if 5-10% potassium dichromate is added. So, it seems the basic recommendation is clear – stay away from the strong inorganic acids and use either water alone or dilute (about 25 g/l) citric acid, but what is the truth about all the other acids? And, indeed why use flux at all? Since most model brazing is done with copper and its alloys, I'll stay with copper in this discussion for simplicity, though steel will do mostly similar things.

How Does Flux Work?

The terminology around silver brazing is confusing and can produce heated arguments, as witnessed by discussions on the MEW forum. The issue is confusing partly because there are now many soft (low melting point) solders which contain silver, so the term 'silver soldering' is ambiguous. There is an international standard, **ref. 4**, for terminology around soldering and brazing. It defines brazing as any fluid jointing process for metals using a jointing alloy starting to melt at above 450 C but below the lowest melting temperature of the metals being joined, so I'll take that as my definition here. In model engineering, we typically braze using alloys that melt well above 450 C. The original brazing process uses brass as the jointing material and needs a temperature around 900 °C to melt the brass alloy. Our commonly used 55% silver alloy melts at around 650 °C.

Metals (except gold) react with oxygen, with varying ease, to form one or more oxides. Copper for example reacts slowly with oxygen at room temperature, initially to form copper(I) oxide, Cu2O (historically called cuprous oxide). Cu(I) oxide is red, so its formation appears mainly as dulling of the bright copper surface. This oxide layer is easily removed by gentle abrasion and re-forms only slowly. However, at brazing temperatures, most metals will react rapidly with oxygen to form an oxide coating. In the case of copper, the reaction is:

$$2Cu + O_2 \rightarrow 2CuO$$

The product is copper(II) oxide (historically called cupric oxide), and is black. Any oxide layer is a problem because brazing alloy will neither flow on it nor adhere to it, so we need some way to get rid of it. In principle, the simplest thing is to remove oxygen by brazing freshly cleaned metal in a vacuum or an inert (oxygen-free) atmosphere. This is common in industry, but not really practical in an amateur workshop, so we use a flux.

An ideal flux does three things; it acts as a barrier to reduce or prevent oxygen access, it removes oxides, either chemically or by dissolving them, and it is fluid enough to be displaced easily by the (denser) molten metal. Historically, the brazing flux for brass filler alloy was plain borax, a naturally occurring material which is chemically sodium tetraborate decahydrate. Its formula is $\mathbf{Na_2B_4O_7{\cdot}10H_2O}$, though it's better written as $\mathbf{Na_2[B_4O_5(OH)_4]{\cdot}8H_2O}$, since borax contains the tetraborate $\mathbf{([B_4O_5(OH)_4]^{2-})}$ ion. Borax alone is still used by jewellers and silversmiths, who work with high silver-content alloys melting above 700 °C.

When borax is heated complicated reactions happen. The first thing is that the water we use to make the flux a paste, and easy to spread, is driven off, followed by the water of crystallisation. We see the familiar 'foaming' to give a white fluffy powder which is anhydrous sodium tetraborate $\mathbf{(Na_2[B_4O_5(OH)_4])}$. As we continue heating, the chemically bound water is eventually driven off, and the borax melts and reacts, finally forming a clear liquid at around 740 °C. Although the chemistry happens in several steps, it can be represented overall as:

$$\mathbf{Na_2B_4O_7{\cdot}10H_2O \rightarrow Na_2B_4O_7 \rightarrow 2NaBO_2 + B_2O_3 + 10H_2O}$$

The water all evaporates, so the final molten layer is a mixture of sodium metaborate (NaBO2) and boron oxide (B2O3). This mixture acts as an oxygen barrier, but it is the boron oxide which is the actual chemical flux. In the case of copper, its oxide is removed by forming copper(II) metaborate in the reaction:

$$\mathbf{CuO + B_2O_3 \rightarrow Cu(BO_2)_2}$$

Forming metaborates makes molten borax a good reactive 'solvent' for many metal oxides. The colours formed are quite distinctive and are the basis of the 'borax bead' test to identify metals, which was used quite regularly in analytical chemistry until modern physical methods were developed.

Copper and sodium metaborates form a very fluid mixture at brazing temperature so that the copper borate is carried away into the flux layer, allowing more of the active boron oxide into the brazing region. This fluidity also allows the flux layer to be pushed out easily by molten metal. However, it should be obvious that the ability of the flux layer to dissolve oxide is limited by the amount of boron oxide which is available, so the flux can become exhausted if it is heated for too long. In that case oxidation of the copper starts again and the flux becomes black and ceases to work.

A close relative of borax is boric acid. It has the formula, H_3BO_3 (sometimes written $B(OH)_3$). Like borax it dehydrates on heating. The reaction goes through a series of steps but by about 300 °C it loses water, and forms tetraboric acid, $H_2B_4O_7$ (borax is the sodium salt of tetraboric acid):

$$4H_3BO_3 \rightarrow H_2B_4O_7 + 5H_2O$$

Further heating again produces boron oxide:

$$H_2B_4O_7 \rightarrow 2B_2O_3 + H_2O$$

Boric acid alone is not as good a flux as borax because the boron oxide layer is greasy and viscous below about 900 °C. It still reacts with surface oxide to form metaborates, but they are not easily carried away from the surface. Silversmiths use boric acid to reduce 'firescale' the red or purple stain which forms on copper-containing alloys of gold or silver due to oxidation of the copper during annealing.

Because molten borax dissolves oxides, and the liquid layer also acts as an oxygen barrier it is a good flux. However, the high melting/decomposition point of anhydrous sodium tetraborate means it is still solid at the sorts of temperatures we use in model work. Easyflo 2 (AG303) melts at 610 - 620 °C. It contains cadmium so is no longer legally traded in Europe, but there must be a lot of it still around in amateur workshops. Its common replacement is the 55% silver alloy (AG103), sold as Silverflo 55 or 455 alloy, which melts at 630 - 660 °C °C. We need our flux to be a liquid with a low viscosity at these temperatures. It can then act as a good barrier and the molten alloy can easily push it away as it forms the joint. Getting the right melting point also allows the flux to act as an indicator of correct brazing conditions; when the flux turns clear we know that the metal is hot enough to melt the brazing alloy.

Modern commercial fluxes are complex mixtures, made by adding other compounds like potassium or sodium chlorides, fluorides, fluorosilicates or fluoroborates to borax or boric acid. This reduces both the melting temperature and the temperature at which the fluxing action takes place. Borax is often replaced by potassium tetraborate because sodium salts produce an intense yellow flame when heated, making it difficult to see what is happening at the joint area. The inclusion of fluorine compounds like potassium difluorodihydroxyborate **[KBF2(OH)2]** or potassium bifluoride **(KHF2)** increases and prolongs the flux activity. The fluoride acts by reacting with oxides to make soluble, complex fluorides and oxyfluorides, and helps to remove more difficult oxides (like the chromium oxide on stainless steels).

Why Acid?

After doing its job, molten flux is a complex mixture of metal borates. On cooling it forms a glassy solid. If the hot work is cooled rapidly, differential contraction tends to cause the flux residue to crack and lose adhesion and much of it will fall off. The borate mixture formed when borax alone is used as flux can be difficult to dissolve in water, which is why acid pickling solutions were used. However, provided that the flux has not been 'overcooked' the mixture formed by a modern complex flux is water soluble and any adhering residues should be removable by soaking in plain water, perhaps with a bit of brushing. Hot water is recommended for faster clean up. At least some of the oxide formed on non-fluxed surfaces will also tend to fall off in quenching, again due to differential contraction. So why use acid pickling at all? The main reason is that a typical brazed copper job is black with copper oxide formed at braze temperature. This oxide formation can be avoided by fluxing all the areas to be heated but there are two reasons why we tend not to do this. Firstly, it's expensive in flux, but, more importantly, silver brazing alloys are very fluid at brazing temperatures and flow very easily over fluxed metal, so it can be hard to keep alloy spread under control if you are not skilled. Indeed, it is often suggested to use some form of 'dirt', such as typewriter correction fluid, to limit the flow of alloy. Oxide on copper surfaces can be removed easily by gentle abrasion, but it can also be removed with less effort by using an acid pickle.

So, which acid?

Let's look at hydrochloric acid first, since it's the easiest to consider. Suppose we immerse a copper object in hydrochloric acid; what might happen? Well, the obvious reaction to consider is that the copper might dissolve in the acid, according to the reaction:

$$Cu + 2HCl \rightarrow CuCl_2 + H_2$$

Hydrochloric acid is a strong acid, which in chemical terms means that it breaks up (dissociates) completely in water to form (positive) hydrogen ions and (negative) chloride ions. Similarly, copper(II) chloride is a salt so it also dissociates completely in water. If we want to understand what happens, we might better write our reaction as:

$$Cu + 2H^+ + 2Cl- \rightarrow Cu^{2+} + 2Cl^- + H_2$$

Now the chloride ion appears unchanged on both sides of the equation; it is just a 'spectator', so we could equally write our reaction as:

$$Cu + 2H^+ \rightarrow Cu^{2}+ + H_2$$

This is a type of reaction which chemists call an oxidation-reduction or redox reaction. Copper is oxidised (it loses electrons) to make copper ions, and hydrogen ions are reduced (by gaining electrons) to make hydrogen:

$$Cu \rightarrow Cu^{2+} + 2e^-$$
$$2H^+ + 2e^- \rightarrow H_2$$

What this means is that copper can only be oxidised to the soluble copper(II) chloride by a simultaneous reduction of hydrogen ions to hydrogen gas. Now hydrogen ions are stable species in water and the reality is that their reduction to hydrogen doesn't provide anything like enough energy to oxidise copper, so copper does not dissolve in hydrochloric acid (for those familiar with the electrochemical series, copper lies below hydrogen). The situation is different for other metals. Iron, zinc, tin and aluminium all oxidise more easily than does copper and will dissolve in hydrochloric acid (and indeed in any acid).

The situation is also quite different for copper oxides. Copper(II) oxide is an ionic compound whose structure can be represented as Cu2+O2-; in other words, the copper is already oxidised and the oxide reacts easily with hydrochloric acid:

$$Cu^{2+}O^{2-} + 2H^+ + 2Cl^- \rightarrow Cu^{2+} + 2Cl^- + H_2O$$

Or more conventionally:

$CuO + 2HCl \rightarrow CuCl_2 + H_2O$

Hydrochloric acid might then seem to be the ideal pickling acid for copper; it will dissolve oxide and leave the underlying metal untouched. So why don't we use it? Actually, it is often used in industry as an alternative to sulfuric acid for cleaning metal surfaces before painting, but it is more expensive than sulfuric acid. Hydrochloric acid is a simple solution of hydrogen chloride gas in water and the concentrated acid has a significant concentration of gas above it, which can cause corrosion even at a distance; if you have used Bakers fluid (acidified zinc chloride) as a soft-solder flux, you will know to keep it well way from iron objects and to wash the job thoroughly after soldering. Equally, if you've ever used hydrochloric acid to remove rust from corroded iron, you'll know that you can watch the metal re-rust before your eyes.

What about sulfuric acid? Like hydrochloric, sulfuric acid is a solution, this time of sulfur trioxide, in water. However, in this case there is a chemical reaction as well:

$SO_3 + H_2O \rightarrow H_2SO_4$

So, at least at the concentrations we are likely to use, the gas has all reacted and there is none above the solution to cause corrosion or irritation problems.

Sulfuric acid is an oxidising agent so it can dissolve copper, the reaction being:

$Cu + 2H2SO4 \rightarrow CuSO4 + SO2 + 2H2O$

Or, more correctly:

$Cu + 4H+ + SO42- \rightarrow Cu2+ + SO2 + 2H2O$

Copper is oxidised to copper(II), hydrogen ions are reduced, and the sulfate ion is converted to sulfur dioxide. This reaction is used industrially to make copper sulfate. However sulfuric acid is a poor oxidising agent and the reaction only happens at high temperatures, in concentrated acid, not under pickling conditions; copper will not dissolve in dilute sulfuric acid.

As with hydrochloric acid, copper(II) oxide dissolves easily in sulfuric acid. Thus, sulfuric acid at moderate concentrations will effectively dissolve surface oxides but not copper metal and the solution has no nasty vapours above it. The corrosion problem from chloride ions is also not there with sulfate. Historically this made sulfuric the acid of choice for pickling. There is however a problem. The acid is used in some drug and explosive syntheses and has also been an agent of choice in acid attacks. Because of this, in July 2018 it was added to the government's list of explosive precursors. From that date, anyone who wants to hold sulfuric acid above 15% weight by weight concentration needs an explosives precursors and poisons (EPP) licence. Although the usual pickling acid is specified as 10% by volume, the specific gravity of the concentrated acid is over 1.8, so a 10% solution by volume is over the 15% by weight legal limit. If you are using sulfuric pickle of this concentration, without a license you are breaking the law. It may well be possible for an amateur engineer to get an EPP licence but there are quite a few hoops to jump through and I've not tried it so I can't comment.

A safer alternative to sulfuric acid, popular with silversmiths, is sodium bisulfate, NaHSO4, sometimes sold as 'dry acid' or 'pH reducer'. Sodium bisulfate is the product of half-neutralisation of sulfuric acid by sodium hydroxide. It is readily available and commonly used in cleaning solutions for metal, and for lowering pH in swimming pools. Used hot (50^{0}C) a solution of sodium bisulfate is a very effective pickle, but not without its hazards.

Much the same is true of nitric acid. Like hydrochloric and sulfuric acids, nitric acid is a solution, this time of nitrogen dioxide, in water, again with a chemical reaction:

$3NO_2 + H_2O \rightarrow 2HNO_3 + NO$

So, at least at any concentrations we might use in pickling, there is no concentration of gas above the solution to cause corrosion or irritation problems (in industrial manufacture of nitric acid the nitric oxide (NO) produced is collected and reacted with oxygen to make more NO2).

Nitric acid is a much better oxidising agent than is sulfuric acid, so it can dissolve copper. In dilute acid the reaction is

$3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)2 + 2NO + 4H_2O$

The nitric oxide (NO) produced reacts with oxygen in the air to produce brown fumes which are noxious and potentially toxic at high levels.

The reaction happens quite easily even at room temperature in quite dilute acid. For this reason, it is better not to use nitric acid as a pickle; leave your work in the pickle for too long and you may well find the copper dissolving. Nitric acid is also on the list of regulated explosive precursors and the concentration limit for legal ownership without an EPP licence is only 3% by weight.

What about adding potassium dichromate to a sulfuric pickle? This is an old trick of silversmiths working with silver-copper alloys, like sterling silver. Potassium dichromate is a very strong oxidising agent and helps the sulfuric pickle to dissolve copper staining on the silver surface. However, I would very strongly advise against this approach in a home workshop. Cr(VI) salts, like potassium dichromate, are highly carcinogenic and mutagenic with no known safe level of exposure. Like many substances, potassium dichromate used to be quite common, but increased awareness of toxic hazards means that it is now used in laboratories and industry only under very tightly controlled conditions. There is also no easy and safe way to dispose of Cr(VI) salts legally – flushing chromium solutions into the sewage system is a serious no-no these days. Of course, as with so many of these things, the risk from occasional small-scale use in an amateur workshop is small but there is no gain to be had from using dichromate in model engineering practice and lots of good reasons why we should behave responsibly.

What about the weak acids? In chemical terms a weak acid is a substance which is only partly dissociated into hydrogen ions in solution. There are many weak acids, but a good example is acetic acid, CH3COOH (more properly called ethanoic acid these days but I'll stay with the more familiar acetic). Acetic acid is the active ingredient in vinegar. When dissolved in water it dissociates to give hydrogen and acetate ions:

$CH_3COOH \; CH_3COO- \rightleftharpoons + \; H^+$

The odd-looking double arrow is used to show that the reaction is not complete. In water, only a small part of the acid dissociates into the reactive hydrogen ions. It's important not to confuse weakness in the chemical sense with reactivity; hydrofluoric acid for example is a very weak acid in terms of dissociation in water but it's very reactive, and corrosive. Pure acetic acid is also a reactive and corrosive substance; normal vinegar is a weak solution.

We might think that a weak acid

would have less capacity to dissolve metal oxides, but this is not the case; as the hydrogen ions are removed by reaction with oxide to form water, more acid dissociates to maintain their concentration. This means that, molecule for molecule, the weak acid has just the same capacity as a strong acid to dissolve oxide. However, the lower concentration of the hydrogen ions does mean that the reaction is slower. Using weak acids needs a bit more patience but in a model engineer's workshop we can afford to wait a bit.

Acetic acid makes a perfectly good pickle, but it does have some disadvantages. The pure acid is a volatile liquid (commercial vinegars contain about 4 - 8% acetic acid by weight), so the solution smells quite strongly. It can also be quite irritating to skin and eyes, and there are safer alternatives.

Appliance de-scalers are weak organic acids, often citric and sometime other acids. They are effective but a very expensive way of buying acid. The usual recommendation for weak acid pickle is citric acid. This is a more complex molecule than acetic, having three -COOH groups in its structure, but it is widespread in nature and manufactured on a very large scale (currently about 2 million tons per year worldwide). It is solid, water soluble, cheap, and safe in use and disposal, so it's a good recommendation for our work. As with other acids, citric acid solution will not dissolve copper, but it can attack iron so using it to pickle (or de-rust) steel needs a bit more care than with copper. Some people have reported difficulty in buying it over the counter as it's used to cut street drugs and prepare heroin injections, but it's readily available from internet suppliers at about £6-7 per kilo delivered, as it's used in home brewing, some cooking, and making 'bath bombs', as well as in de-scalers. Buy it in a tub rather than a plastic bag and you have a convenient way of storing the solid acid.

To conclude, I'd suggest that in a modern workshop, using current techniques, and fluxes, there is really no need to think of the strong inorganic acids for pickle and every reason to avoid them. The weak organic acids do the job perfectly well, if a bit more slowly, and very much more safely.

If you want to know more about the chemistry and metallurgy of metals and their alloys, the 'bible' for craft metalworkers is Brepohl's book, ref. 5, but it's expensive.

References

1) Soldering and Brazing (Workshop Practice Series), Tubal Cain, Special Interest Model Books, 1998, ISBN-13: 978-0852428450.
2) Brazing and Soldering (Crowood Metalworking Guides), Richard Lofting, Crowood Press, 2014, ISBN-13: 978-1847978363.
3) A Guide to Brazing and Soldering, Keith Hale, CuP Alloys 2017, privately published and available from CuP.
4) ISO 857-2:2005; Welding and allied processes – Vocabulary - Part 2: Soldering and brazing processes and related terms.
5) The Theory and Practice of Goldsmithing, Erhard Brepohl, trans. Charles Lewton-Brain, ed. Tim McCreight, Brynmorgen Press, 2001, ISBN-13: 978-0961598495.

MODEL ENGINEER NEXT ISSUE NEXT ISSUE NEXT ISSUE NEXT ISSUE
NEXT ISSUE NEXT ISSUE NEXT ISSUE NEXT ISSUE
NEXT ISSUE NEXT ISSUE NEXT ISSUE NEXT ISSUE

NEXT ISSUE

We Visit Brighouse
John Arrowsmith's tour of Yorkshire clubs finds him at Ravensprings Park, home of the Brighouse and Halifax model engineers.

Flying Scotsman
Peter Seymour-Howell starts to hang various odds and ends onto his basic chassis, starting with spring hangers and the brake shaft trunnions.

Turbomotive
Mike Tilby, having explored the turbines of *Turbomotive*, now takes a look at the power transmission.

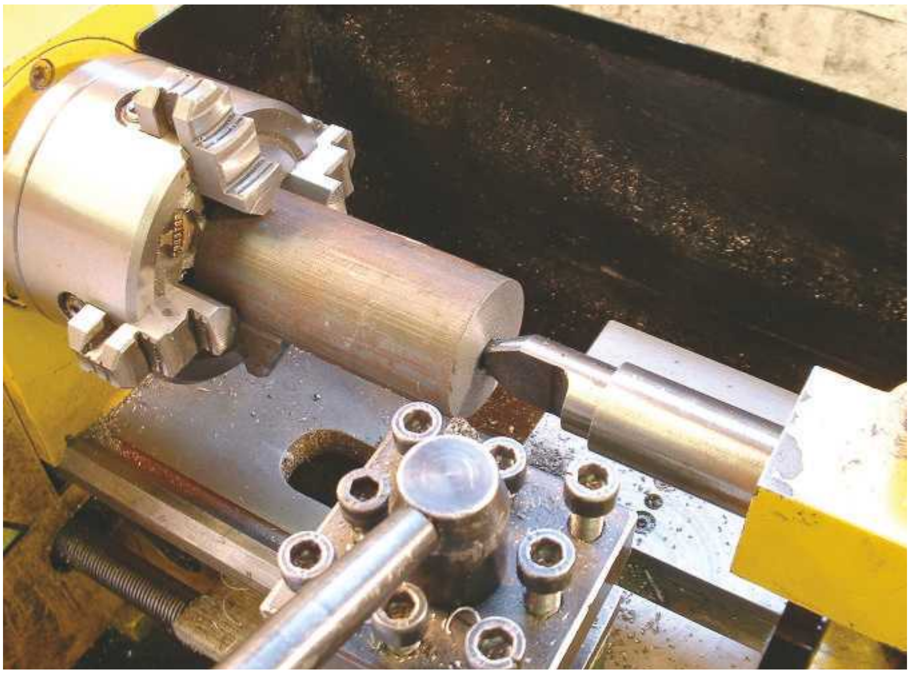
Using a Linisher
Tim Coles shares his experiences with a new linisher and finds it a very useful addition to his workshop.

Content may be subject to change.

ON SALE 27 AUGUST 2021

Materials in the Workshop

The majority of the materials used in hobby engineering are metals, although plastics, composites (like carbon fibre or fibreglass reinforced plastics) rubber, graphite glass and many others may be needed from time to time. Metals can be divided into two main groups: the ferrous (iron containing) metals such as cast iron and steels, and the non-ferrous metals such as brass and aluminium. Here's a quick guide to the most commonly encountered metals.



A cast iron bar set up for machining in a lathe

Cast Iron

When molten cast iron is remarkably fluid, almost as runny as water. This means it can be cast into complex shapes (think about a Victorian cast iron bath, nearly two metres long yet only a few millimetres thick! Cast iron also has the properties of deadening vibrations, wear resistance and being able to be machined to a very fine finish, these make it an ideal material for structural purposes and making machine tools.

If you decide to make a model or tool from a 'kit' you may well find that some or all of the parts are supplied as castings, usually in cast iron, see the separate section on machining castings for some tips on how to deal with them.

Cast iron has a high carbon content, typically in the form of small flakes of graphite, it is this that makes it easy to machine but also rather messy – it's a good idea to use barrier cream and even wear a facemask as it can produce a lot of fine black dust. Always clean your machine's slideways down after machining cast iron as otherwise that dust can cause excessive wear.

All cast irons are relatively weak in tension although types often referred to as 'meehanite' or 'spheroidal graphite' cast iron are better and very free machining. Such material can be bought as lengths of bar which can be shaped easily as an alternative to castings, ideal for one offs or prototypes.

Surprisingly delicate shapes can be machined from meehanite

Mild Steel

Cheap, fairly strong and tough and yet reasonably easy to machine mild steels are essential materials for structural components where corrosion isn't a big risk. Mild steel is available in a bewildering array of sizes, metric and imperial, from thin rod to thick bars in round, square, rectangular ('flat') sections. Bright drawn mild steel has a shiny finish and is fairly accurately sized (precision ground bars are available), but because it is shaped 'cold' it has locked up stresses. If you turn a round bar down these balance and are unlikely to be a problem, but if, for example, you mill away one side of a bright drawn bar it is likely to adopt an unwanted curve! There are two solutions, one is to machine parts oversize, leave them for a day or two, then machine to size. The other is to heat the metal to a dull red heat and let it cool very slowly, for example by leaving it in the ashes of a domestic firegrate (if you have one!) This process is called stress relieving.

Some bright mild steels are 'free machining' and give an excellent finish, but take care as many contain lead that makes them unsuitable for welding – the joints can be brittle. Medium carbon steels are tougher than mild steel, but do not machine as easily.

If you don't want to go to this bother, and are happy to machine your parts all over, the alternative is to use black bar – this is shaped when hot and doesn't have the residual stresses that cause problems, but it is usually covered in dirty mill scale.

Carbon Steels

While mild steel is tough enough for many uses, sometimes you need something a bit more resistant to wear or able to take greater loads without distorting. Carbon steels become increasingly tougher as their carbon content increases and are ideal for parts such as gears or load bearing axles for example. Once the carbon content reaches 4%, the steel can be hardened, this is useful for making tools, springs and parts that might otherwise suffer rapid wear such as cams or ratchets.

Such steels can be machined with normal tools, then hardened done by heating to a bright red-heat (the colour of a boiled carrot), holding it there until it is hot right through, then quenching it. The two commonest types of such hardenable steels are silver steel (quenched in water or brine and usually available as precision ground round bars) and gauge plate (quenched in oil, with due care to avoid any risk of fire sold as flat sheets of exact thickness).

Freshly hardened steel is as hard as glass and very brittle – it can shatter if dropped - so it is usually 'tempered' by re-heating it to a lower temperature and re-quenching. The temperature is critical, but fortunately steel has the property of forming a colourful oxide film at these sorts of temperatures so you can judge the temper by watching the colours. A blue colour is ideal for springs, while cutting tools need to be a pale brown 'straw' colour.

Various sections of mild and medium-carbon steels.

Stainless Steels

When corrosion is an issue and you need high strength then stainless steel is an obvious choice, but take care with your choice. Most stainless steels work harden rapidly, so they need to be cut or drilled with a constant feed – light cuts or a pause when drilling will produce a hard spot that may then blunt a drill or cutter in moments. Fortunately, there are free-cutting stainless steels available that behave better, but don't expect these to be as easy to machine as mild steels.

Copper and its Alloys

Copper and its alloys are generally resistant to corrosion making them useful for parts that are exposed to water or steam. Copper itself is a relatively soft metal, it is rather 'sticky' which makes it difficult to machine neatly. When annealed by heating to a red heat and cooling it is easy to shape into complex forms, for example by hammering sheet to shape over a wooden former. Repeated annealing is essential for more complex shapes or large bends. Copper and its alloys are also reasonably easy to join by silver soldering. It is the material of choice for boilers up to about 5" gauge, and sometimes larger (although it becomes

Bars of silver steel and some shop-made cutting tools made from silver steel.

›

A selection of small gunmetal castings.

very expensive in large sizes). Copper pipes can be easily shaped into complex curves making them an obvious choice for piping on models.

When copper is alloyed with zinc (and smaller proportions of other metals) it forms 'brasses', much harder materials that machine to a bright, corrosion resistant finish. Brass is vulnerable to 'de-zincification' in contact with hot water which can leave it weak, spongy and crumbly (so it shouldn't be used for parts such as boiler bushes) but finds a multitude of applications for small or complex parts, especially as it can easily be shaped by hand using files. Brass is often used for clock making. There are various grades of brass, of varying hardness and machinability. The type known as 'engraving' brass is particularly free-cutting and is a pleasure to machine.

Other copper alloys are generally known as bronzes, typically with tin but you may also encounter aluminium bronzes or the particularly useful copper-tin-zinc alloy known as 'gunmetal'. Gunmetal is an ideal material for parts such as boiler bushes and also machines and casts well and is often used for relatively small-sized castings such as steam cylinders.

Aluminium and its Alloys

Pure aluminium is a very soft metal, with few applications but it is available in a very large range of alloys, some of which are almost as strong as steel and all of which are much lighter. Aluminium alloys have varying degrees of corrosion resistance and this can be maximised by anodising. Which also allows the metal to be coloured. In the UK at least, most hobbyists seem to prefer steel or cast iron for structural components although tougher aluminium alloys can be quite suitable for making such parts.

Many aluminium alloys can be annealed, just like copper, but instead of work hardening, they age-harden so if they are to be bent to shape this should be done as soon as possible after annealing.

Aluminium alloy castings are often used for internal combustion engines, for example. Aluminium castings can be made in quite complex shapes, but the process is more involved that casting iron due to the need to 'de-gas' the melt and remove relatively large quantities of 'dross'. Even so, because of the lower melting point, it is possible to melt and cast aluminium in the home workshop.

Aluminium alloy castings for an internal combustion engine.

Telescope supporting rings machine from plastic sheet.

Less Common Metals
Magnesium alloys are much like aluminium ones, but lighter, though care must be taken as magnesium swarf can catch fire and burns with an intense white heat. Titanium is a very strong metal that is harder to machine than steel but useful if a combination of strength and lightness is essential.

Monel metal is a special alloy smelted directly from a natural ore. It has a bright silver colour (it was known as 'German silver' and is very resistant to corrosion and finds uses for steam fittings and small parts for models that need to resemble bright steel. Nickel is another bright metals, but as a pure metal it has generally been superseded by stainless steel most often encountered as a component in alloys and as a bright plating on brass parts.

Plastics
Many plastics are available as sheet or rod that can be machined to shape and these can be very useful for applications where a metal part just isn't suitable including making simple seals and bearings. Nylon and acetal are commonly encountered engineering plastics, they need to be machined with sharp tools and the speed needs to be carefully adjusted to avoid melting. Nylon, in particular, can absorb water from the atmosphere and expand, so care has to be taken with the sizing for holes, for example.

Acrylic (commonly known as Perspex) is useful when you want to make transparent items and even lenses, it is water clear and can take a high polish. Clear and coloured acrylic sheet is available, but can be fragile and polycarbonate is to be preferred for uses such as safety screens.

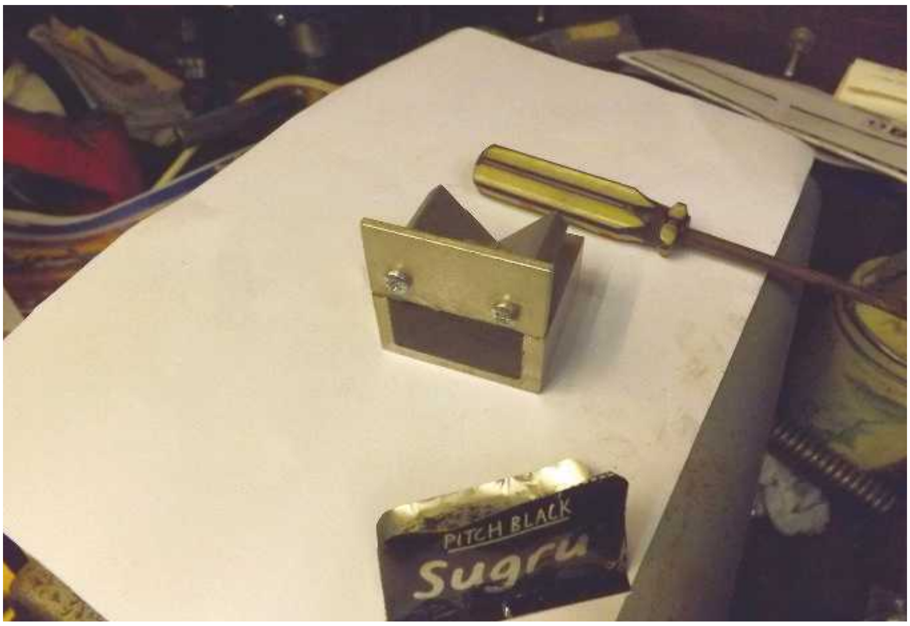
PTFE the 'non-stick' plastic can be used for making piston rings and seals, valves and light-duty bearings. It has a tendency to swell after being machined. For applications like slide valves, where the material is not well supported, it pays to use material that combines PTFE with a filler material that give it greater rigidity.

It's worth mentioning ABS and PLA as the most commonly used plastics in 3D printing, although some more recent machines can also print in nylon.

All the above are 'thermoplastics' that can be reshaped using heat. Resins like epoxy and polyester can be used with fibreglass and carbon fibre to make tough, light impact-resistant structures. An early example of such technology is Tufnol – a polymerised phenol-formaldehyde resin reinforced with paper. Although this sounds primitive, Tufnol is available as sheets and rods which have many engineering applications being highly resistant to most oils and solvents. Tufnol gears run very quietly and are often used for moderate loads when steel gears would be too noisy. Bakelite is a similar product, reinforced with wood flour as a filler, that still has applications when good electrical insulation and temperature stability are needed.

Rubber
Natural rubbers vary from the very soft to almost rock hard, depending on the extent to which they are 'vulcanised'. Softer rubbers are normally available as sheet while harder grades are available as sheet or rod, which can be machined with very sharp tools – although they will blunt rapidly.

As well as natural rubber, there are many synthetic rubbers, some of which can be obtained in a form suitable for 'room temperature vulcanising' a process that allows the manufacture of items such as scale model tyres. A new synthetic silicone rubber that has recently become available is 'Sugru', supplied as small sachets of coloured, mouldable putty which is ideal for making small cable reliefs, making soft grips and making small seals and wipers. It can be shaped by hand or pressed into small metal moulds. ■



Moulding a lathe bed wiper using Sugru (John Stevenson).

MODEL ENGINEERS' WORKSHOP **SUBSCRIPTION ORDER FORM**

DIRECT DEBIT SUBSCRIPTIONS (UK ONLY)

Yes, I would like to subscribe to *Model Engineers' Workshop*

☐ Print + Digital: £13.50 every 3 months

☐ Print Subscription: £11.25 every 3 months

YOUR DETAILS MUST BE COMPLETED

Mr/Mrs/Miss/Ms.................Initial ....Surname ....

Address ....

....

Postcode .... Country ....

Tel .... Mobile..................................

Email .... D.O.B ....

I WOULD LIKE TO SEND A GIFT TO:

Mr/Mrs/Miss/Ms.................Initial ....Surname ....

Address ....

....

Postcode .... Country ....

INSTRUCTIONS TO YOUR BANK/BUILDING SOCIETY

Originator's reference 422562 DIRECT Debit

Name of bank...

Address of bank ....

....

....Postcode ....

Account holder ....

Signature... Date ....

Sort code ☐☐ ☐☐ ☐☐ Account number ☐☐☐☐☐☐☐☐

Instructions to your bank or building society: Please pay MyTimeMedia Ltd. Direct Debits from the account detailed in this instruction subject to the safeguards assured by the Direct Debit Guarantee. I understand that this instruction may remain with MyTimeMedia Ltd and if so, details will be passed electronically to my bank/building society.

Reference Number (official use only) ☐☐☐☐☐☐☐☐☐

Please note that banks and building societies may not accept Direct Debit instructions from some types of account.

CARD PAYMENTS & OVERSEAS

Yes, I would like to subscribe to *Model Engineers' Workshop*, *for 1 year* with a one-off payment

UK ONLY:

☐ Print + Digital: £56.99

☐ Print: £47.99

EUROPE & ROW:

☐ EU Print + Digital: £64.95

☐ EU Print: £55.95

☐ ROW Print + Digital: £71.95 CC

☐ ROW Print: £62.95 CC

PAYMENT DETAILS

☐ Postal Order/Cheque ☐ Visa/MasterCard ☐ Maestro

Please make cheques payable to MyTimeMedia Ltd and write code MEW2021 on the back

Cardholder's name..

Card no: (Maestro)

Valid from.............................. Expiry date.................. Maestro issue no..................

Signature.. Date..........................

POST THIS FORM TO: MODEL ENGINEERS' WORKSHOP SUBSCRIPTIONS, MYTIMEMEDIA LTD, 3 QUEENSBRIDGE, THE LAKES, NORTHAMPTON NN4 7BF

Please visit **www.mytimemedia.co.uk/terms** for full terms & conditions

CODE MEW2021

HURRY OFFER CLOSES 31st December 2021

PRINT + DIGITAL SUBSCRIPTION

- 1 year's worth ***delivered to your door***
- ***Great Savings*** on the shop price
- ***Download*** each new issue to your device
- A ***75% discount*** on your Digital Subscription
- Access your subscription on ***multiple devices***
- Access to the ***Online Archive*** dating back to Summer 1990

PRINT SUBSCRIPTION

- 1 year's worth ***delivered to your door***
- ***Great Savings*** on the shop price
- Save up ***to 23% off the shop price***

SUBSCRIBE TODAY

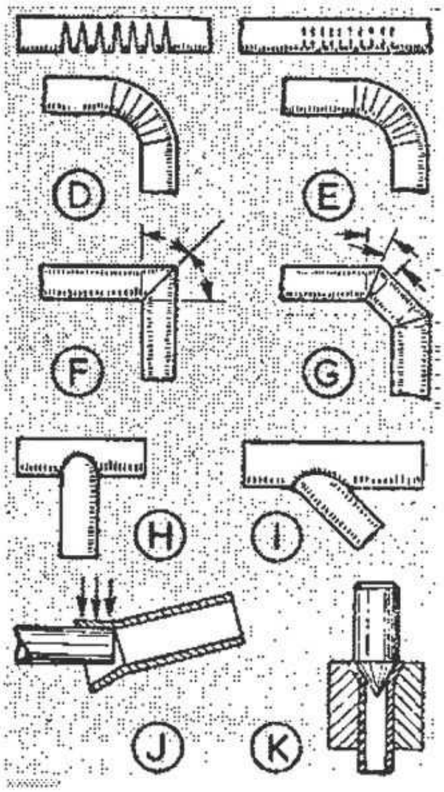
BEGINNERS WORKSHOP
These articles by Geometer (Ian Bradley) were written about half a century ago. While they contain much good advice, they also contain references to things that are out of date or describe practices or materials that we would not use today either because much better ways are available or for safety reasons. These articles are offered for their historic interest and because they may inspire more modern approaches as well as reminding us how our hobby was practiced in the past.

Working pipes and tubes

A workshop practice often encountered on full-size work, the principles of which are helpful in small scale tasks. Geometer shows the novices how to avoid pitfalls

THE IMPORTANT THING to remember when working pipes and tubes is to avoid collapse and splitting. The various methods employed are governed by material, diameters, wall thickness, radii and angles of bends.

When sawing thin-walled tubing, fine-pitch hacksaw blades are essential; by holding the tube in the vice, inserting a close-fitting mandrel or rod and placing packing round the outside distortion can be prevented, as at *A*. Alternatively, soft clamps can be made from pieces of board, gripped together and a piece of thin cardboard placed between them, these are drilled centrally to the size of the tubing. Large size clamps can be bored in a four-jaw chuck.



Copper and brass pipes of small diameter butrelatively thick-walledcan be bent easily unless the radius of the bend is very small. For a bend of minimum radius, the material should be annealed, i.e., heated to red and quenched in water. Small steel pipes should be bent at red heat unless the curve is very gradual, when cold bending is possible.

Bending small pipes

A bend of particular radius can be obtained by turning the pipe round a piece of suitable rod and a coil can be made by carrying the pipe the required number of times round the rod. Where there is surplus pipe, it is often best to bend first .and cut afterwards.

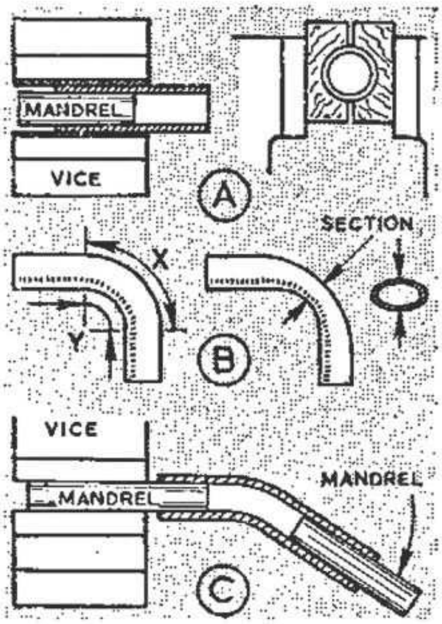
In bending larger pipes or tubing of thinner section, recognition must be made of the fact that, as at *B*, the material round the outside of the bend X must stretch and that on the inside Y must compress. If bent unsupported or without means of effecting the stretching and compressing, the tubing will either acquire an oval section or collapse and split at the bend.

Bending larger pipes

To prevent this splitting and collapsing with pipes that are not too large, fill them with lead or white-metal, bend them when cold and then heat to clear them. Larger pipes can be plugged at one end, filled with sand which is rammed tight, then plugged and bent as required; steel pipes should be heated. The sand must be quite dry to avoid generating steam and the risk of a consequent explosion,

Bending can be performed, as at C, by using two mandrels or rods; one is held in the vice and the other is pulled by hand or by slipping it over another piece of tubing.

Very close smooth bends can be obtained on large pipes by sawing out V-sections almost through the pipe,



as at *D*, then pulling it round to the curvature. The join is then soldered, brazed or welded, according to material and equipment. On this principle, neat bends with wrinkles instead of cuts can be made with pipes that are not too large and a welding torch is available. The set-up can be as at C; the torch flame is swung round and concentrated at various points, as at *E*, to form each wrinkle, and the bend gradually made.

Obtaining angles

Right-angle and other bends can be fabricated, as at *F* and G, provided the pipes are one size and each is cut at the same angle-half the angle between them. At *F*, each pipe is cut at 45 deg.

On a bend incorporating three or more pipes, angles are considered individually. At G, the angle between two pieces is 45 deg. and cuts are made at 22-1/2 deg. T-pieces and branch pipes, as at Hand I, can be fabricated by filing out the curvature on the joining piece, applying this to the main pipe, scribing round it, then chain-drilling and filing the hole, finally brazing or welding.

Pipes can be enlarged slightly by tapping with a hammer when on a mandrel, on this principle they can be flared, as at J. The mandrel is held in the vice and the pipe fitted on and rotated while being tapped. When flaring, the mandrel is applied at an angle.

An accurate flare or cone can be produced on a small pipe, as at *K*. A die is produced from two pieces of steel (as for the soft clamps *A)* by drilling, then running in a centre drill. The pipe is then gripped and opened with a conical punch.

3 in 1 Rotary table

John Gittins details this flexible device inspired by earlier designs in MEW - Part 2

Hold down clamps (fig. 5)

I made five hold down clamps in total. Four to secure the finished table to either my mill or lathe cross slide and the 5th was to act as a table lock. Again, I used off cuts from the base plate to manufacture these parts. I machined the parts to size on the mill, then cut the relief on the underside and the tongue detail on one end. Finally, I drilled through diameter 6.5mm and counter bored for M6 cap head screws, **photo 17**.

I filed a radius in the clamp that would be used to lock the rotation of the table, **photo 18**. This was so that more of the tongue would contact the base of the slot around the table.

Indexing pin and handle (fig. 6)

I used a length of 12mm bar stock for both these parts. For the indexing pin I centre drilled one end, turned a short section down to 6mm, but making an allowance so that I could remove the centre drilling and still have enough thread. I then threaded the end using a tailstock mounted die holder.

I knurled a section near the chuck then turned the body down to 8mm in diameter. I chamfered the knurled end for cosmetic reasons then parted off, **photo 19**, before facing both ends.

The handle used much the same method as the indexing pin. I included a turned 9mm diameter shoulder at the threaded end to locate onto the counterbores I had added to the indexing holes in the table. After threading and knurling I cut a decent chamfer on the knurled end to make it more comfortable in my hand, **photo 20**.

Once I had made the indexing pin, I put the table to its first use and indexed the 6, 8 and 12 M6 holes on the table, which would be used to clamp parts down in the future, **photos 21** and **22**. I found putting a centre dot at the periphery of the table to help mark the position of the indexing holes was really useful and sped up indexing. At the same time, I marked the most popular holes with a set of number stamps 8, 16, 24 and so on.

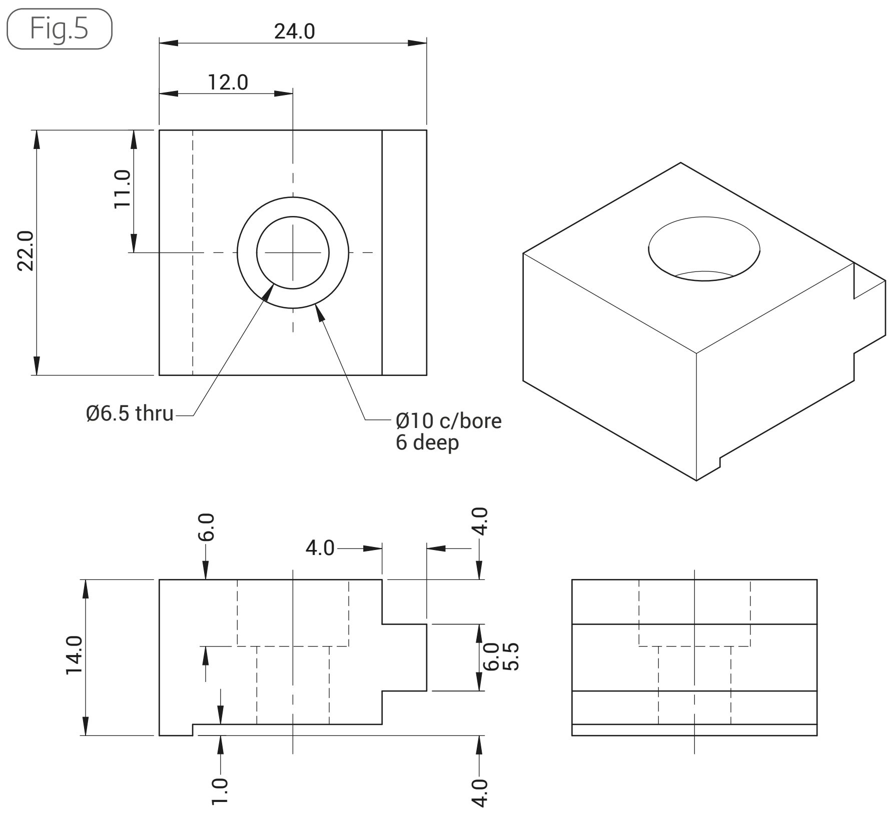


Fig 5. Hold Down Clamp
5 off

17

Five clamps

18

Filed radius on clamp

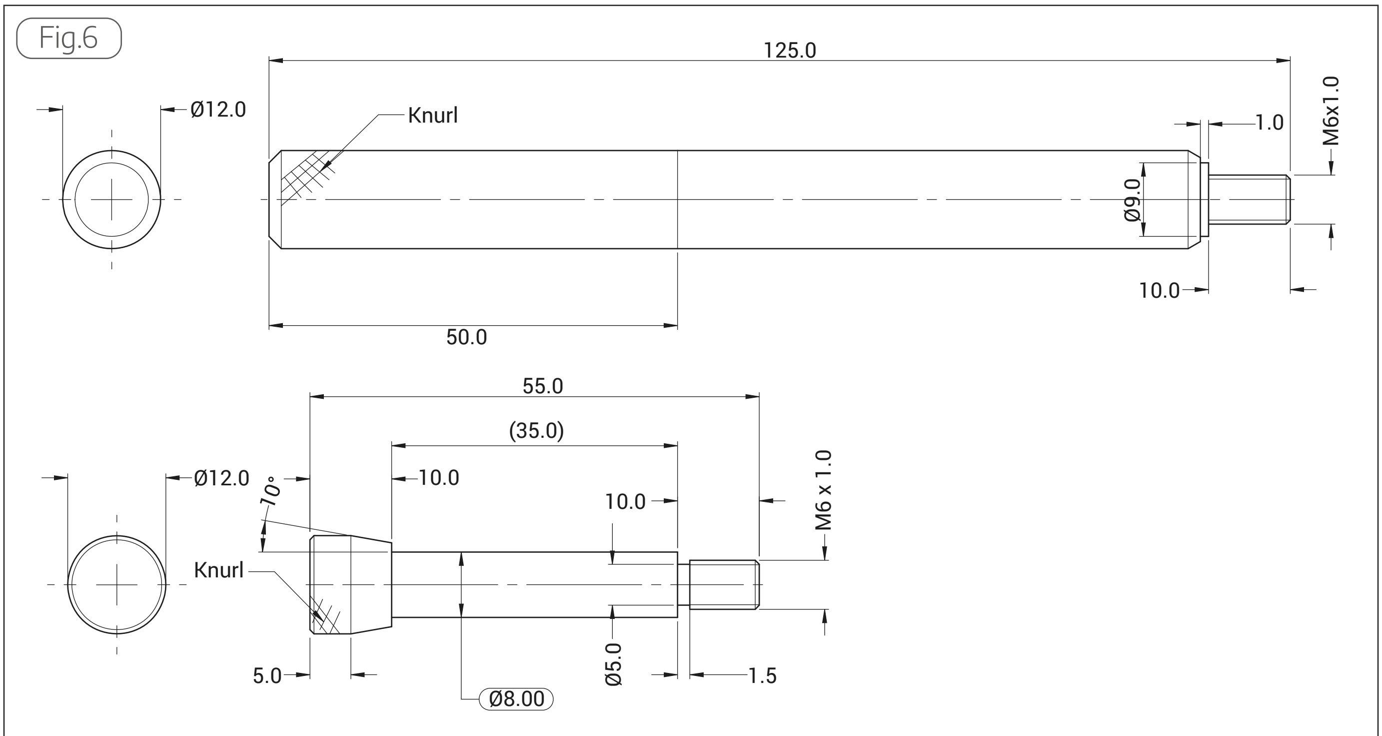


Fig 6. Indexing Pin And Handle

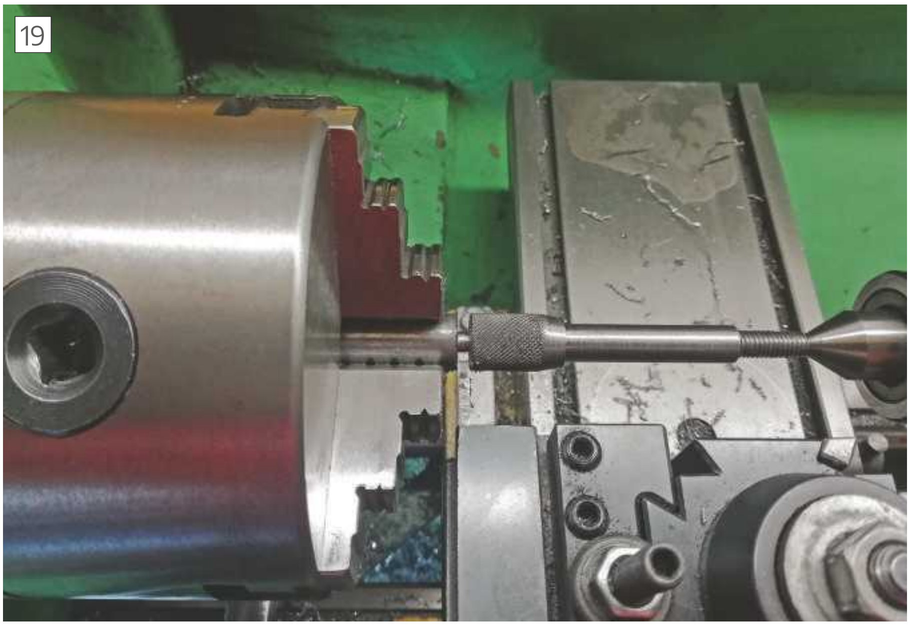
Radius attachment (fig. 7)

I firstly drilled the two holes through the 15mm steel plate that would form the radii at the base of the tower that holds the replaceable tool insert. I roughed the shape out, leaving a few mm for the mill to clean up, **photo 23**. Importantly, I left the tower a good 6mm over size. I milled the base flat first then used this as a datum for milling the base to height and the sides of the tower perpendicular.

With the part held upside down in the milling vice, I drilled 4 x 6mm holes then joined the pairs together with a slot drill, **photo 24**.

Next, I secured the radius attachment on the rotary table and sat it on the cross slide of my lathe. Using a centre in the tail stock I scribed a line on the radius attachment to indicate dead centre on the lathe, **photo 25**. The top face of the tool insert needs to be set exactly to this height, **photo 26**. Now back to the mill to remove the material and form a step to accommodate the tool insert. To further improve the seating of the tip I drew a file across the step to match the angled side profile of the insert, **photo 27**.

With the insert in place and pushed firmly back to the step I spotted through the central screw hole and drilled and tapped for M2.5. To remove the spare material each side of the insert I set my protractor to 60 degrees to line it up on the mill, **photo 28**. I added some hacksaw graduations on the side of the radius tool to act as a rough guide for the size of radius being machined, **photo 29**.



Indexing pin

Indexing pin and handle

Radial stops (fig. 8)

Two of these are required. They have; a tongue to locate into the groove

Table tapping clamp holes

Table complete underside

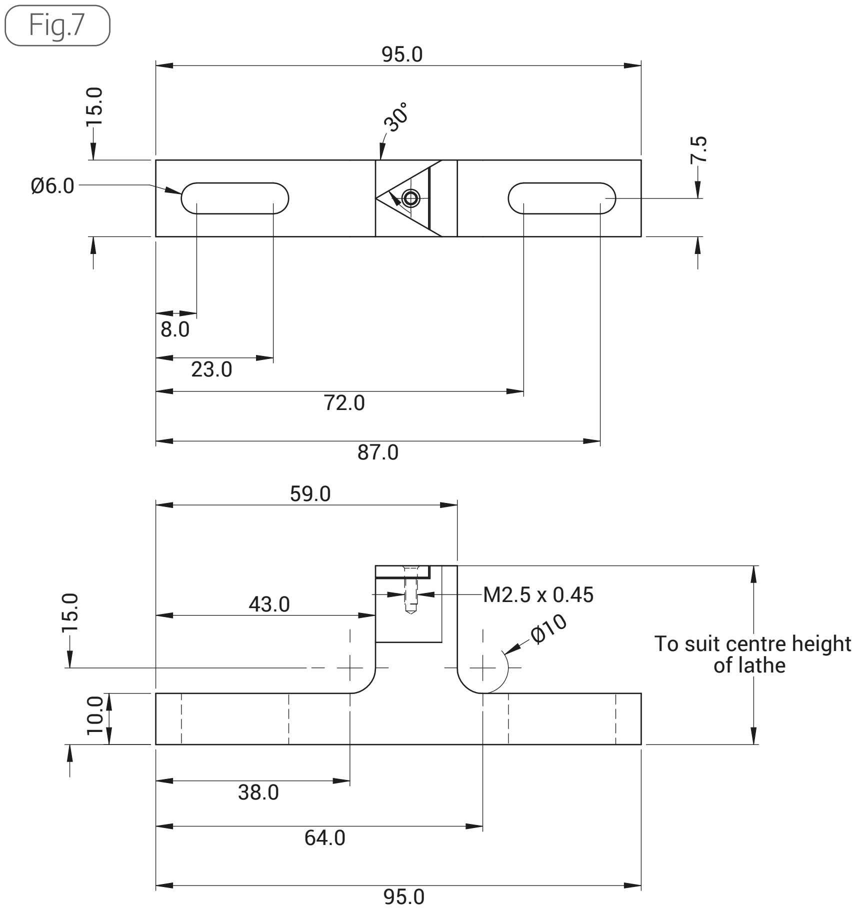


Fig 7. Radius Attachment

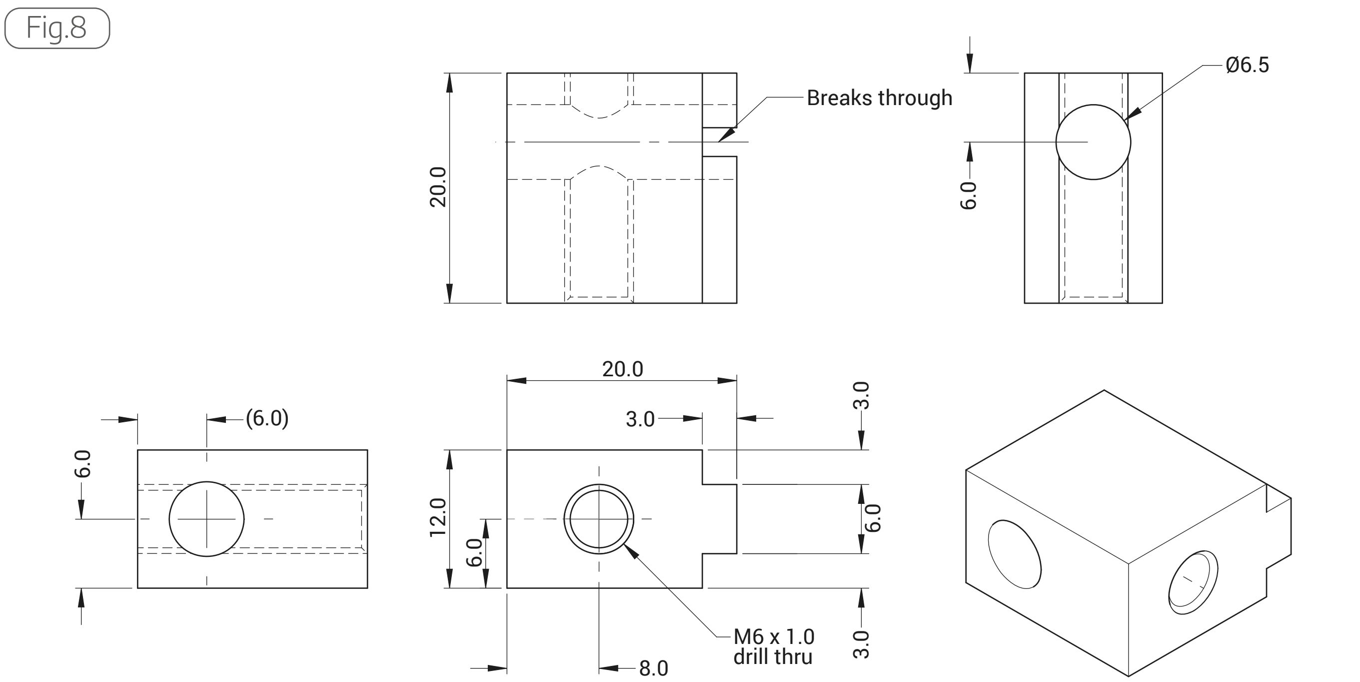


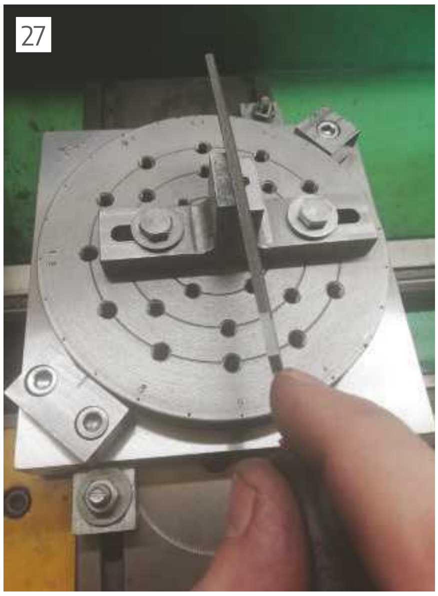
Fig 8. Radial Stop
2 off

Radius tool rough cut

Radius tool slots

Radius tool centre height

Radius tool check height



Radius tool file chamfer

Radius tool mill 60deg

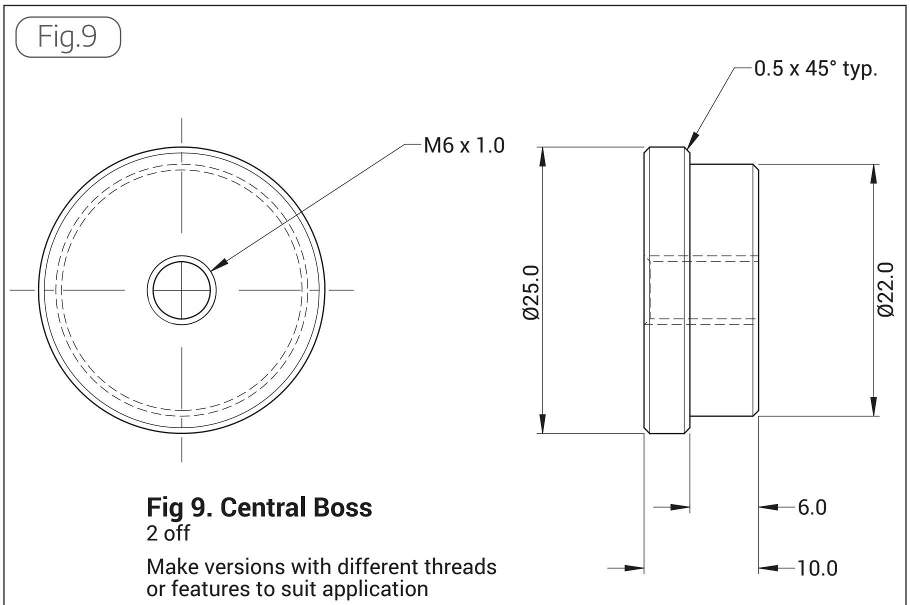


Fig 9. Central Boss
2 off
Make versions with different threads
or features to suit application

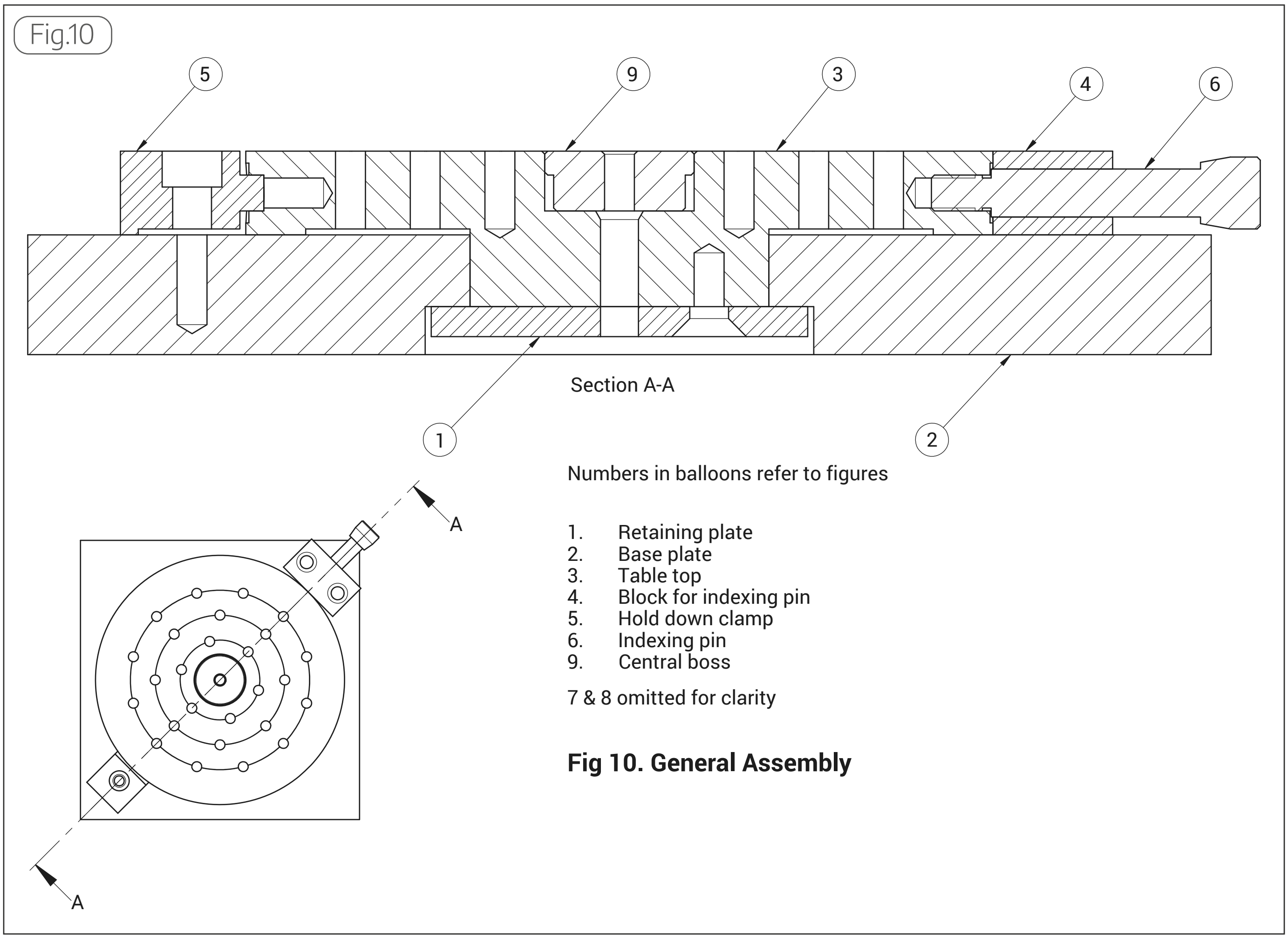


Fig 10. General Assembly

Radius tool graduations

Radial stops

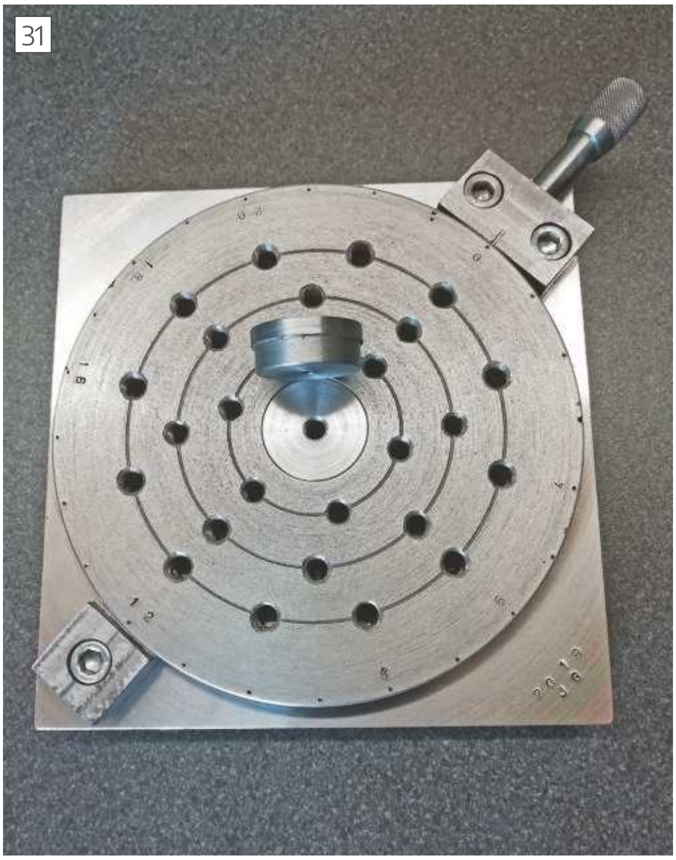
around the circumference of the table, a through hole for the clamping screw and a threaded hole for the stop screw so it can be adjusted. Similarly, to the clamp down block these were made from the 20mm plate offcuts and machined down to size and squared up on the mill. I added a decent chamfer to the stop screws hexagon heads so that they would sit nicely against the indexing pin block when in operation, **photo 30**.

Central boss (fig. 9)

This is an easy turning operation. I made two of these parts to begin with, one tapped M6 the same as the table holes and a second tapped 5BA for the links I intend to radially mill. More bosses can be added as projects demand. I added a reduced diameter, **photo 31** in case the grub screw that locks the boss into the table threw up a burr and prevented its extraction one day.

Assembly (fig. 10)

I lubricated the table pivot with grease, and this resulted in a very satisfying feel to the movement, easy enough to move by hand but with just enough resistance to feel snug. I used 3 counter



Central boss

Assembly retaining plate

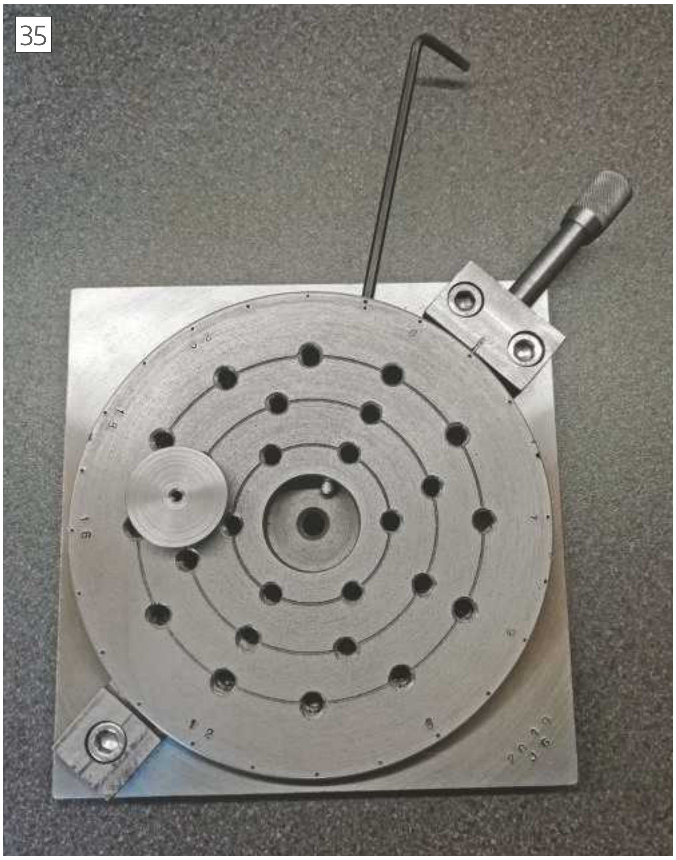
Retaining plate adjustment

sunk screws to fit the retaining plate, this holds the table to the base, **photo 32**. Initially there was a little more float in the table than I would like. With feeler gauges I was able to work out that 0.15mm needed to be removed, holding the retaining plate in the 3-jaw chuck I took a skim from the centre to correct this, **photo 33**.

Use and Improvements

The screw feature of the indexing pin is very positive, with no free play obvious. The table clamp holds everything secure

Indexing ▶



Central boss grub screw

Ball turning

when indexing parts too, **photo 34**. I had my doubts about the central boss locking mechanism, relying on a grub screw to lock it in place, **photo 35**. I did consider holding it in place with a fastener accessed from underneath the table, but it has proven to be quite adequate and up to the job so far.

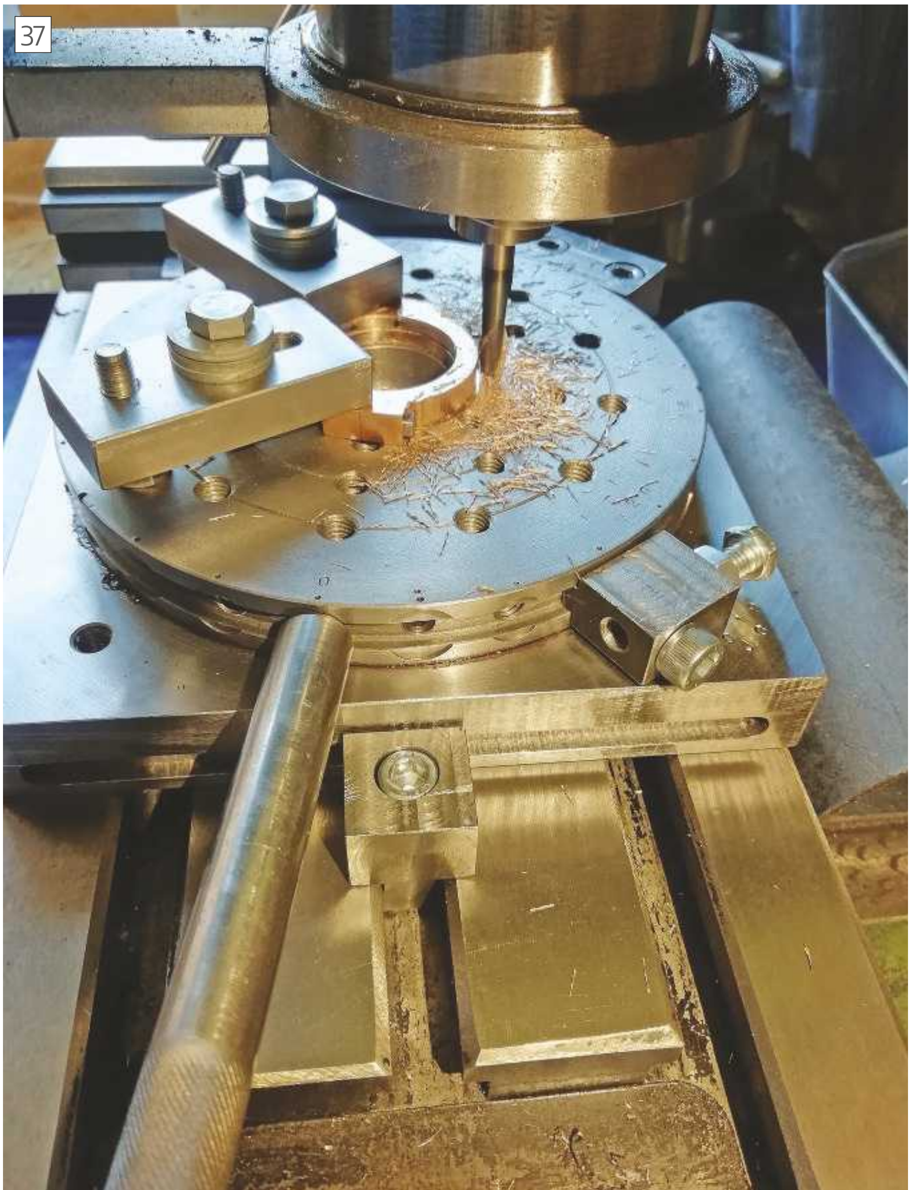
I was surprised with the rigidity of the ball turning attachment in use, **photo 36**, this produced an enviable finish on turned parts.

One thing I overlooked in the design process was that swarf does find its way down the tapped holes in the table, especially when radial milling, **photo 37**. I have since added grub screws to each of the holes to stop the swarf finding its way into the mechanism. Overall, I am very pleased with the project. ∎

References:

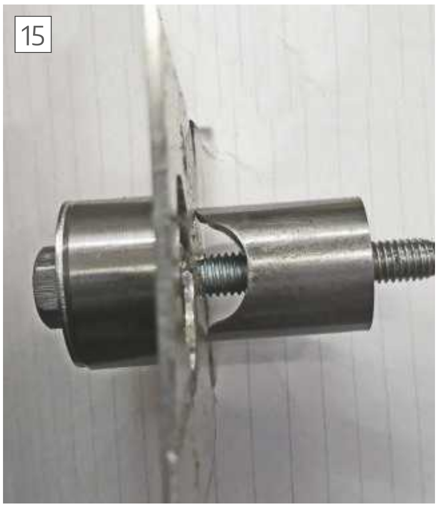
Harold Hall's Rotary table, direct fed - **http://www.homews.co.uk/page462.html**

Chuck Fellows Rotary mill table **- https://www.youtube.com/watch?v=am5774rnjtU**

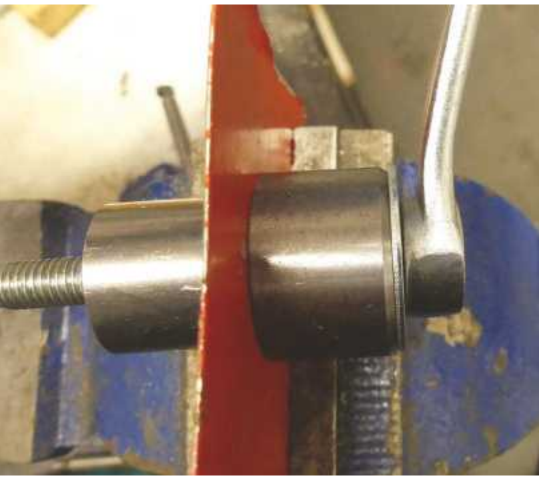


Radial milling eccentric strap ▶

A Chassis Punch by Chris Gabel *continued from previous issue.*



Punching 1.5mm aluminium.



Punching .5mm steel.

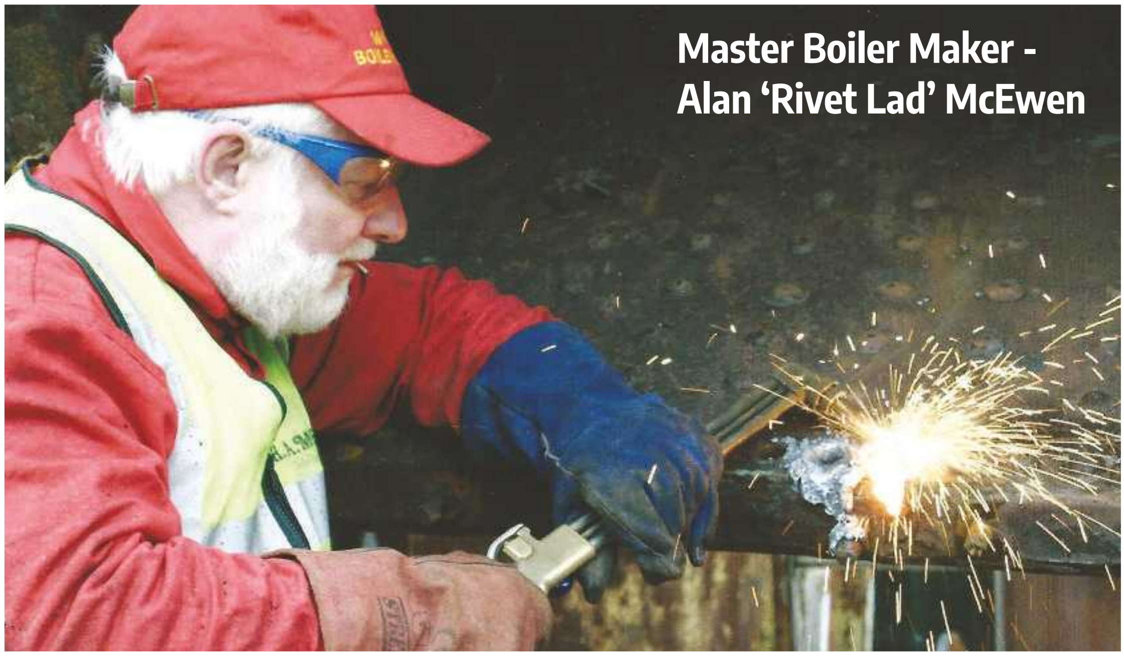
Pilot holes drilled with clamping.

Re-heat to a bright red, **photo 18**, and plunge in clean, cold water. This can be repeated to increase the depth of the case hardening. This is an easy process to carry out, but for low volume work it is probably unnecessary. I found the punch cut well with just a spanner on the bolt. For larger size punches a thrust washer/bearing under the bolt head and washer could make tightening easier.

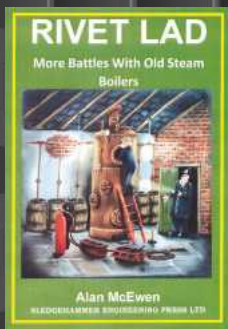
I am not a believer in all jobs being quick and immediate, but this is a simple tool. It could be built from common materials in less time than if it were to be purchased online and delivered. After little more than an hour's work I was able to return to my main project with a set of precisely formed 24.5mm holes neatly made. ■

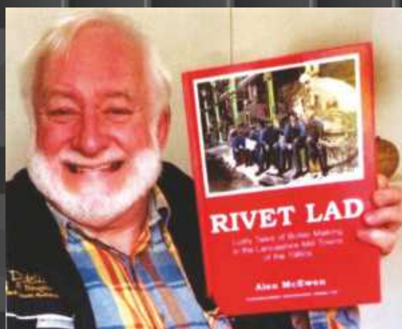
Case hardening. ▶

Bringing British industrial history to life



Master Boiler Maker -
Alan 'Rivet Lad' McEwen





When Master Boiler Maker and author, Alan McEwen was a young sprog, he loved banging and hammering on rusty old boilers; now that he is an old hog, he just prefers others to bang and hammer!
Alan McEwen's Boiler Making adventures and also 'potted histories' of several Lancashire and Yorkshire Boiler Making firms, can be read in RIVET LAD - *Lusty Tales of Boiler Making in the Lancashire Mill Towns of the 1960s.* The book is crammed with 'hands on' technical information of how Lancashire, Locomotive, Economic, and Cochran Vertical boilers were repaired over 50 years ago. The book's larger-than-life characters, the hard as nails, ale-supping, chain-smoking Boiler Makers: Carrot Crampthorn, Reuben 'Iron Man' Ramsbottom, Teddy Tulip, genial Irishman Paddy O'Boyle, and not least Alan himself, are, to a man, throw-backs to times gone by when British industry was the envy of the world.

Alan McEwen's first RIVET LAD book: *RIVET LAD – Lusty Tales of Boiler Making in the Lancashire Mill Towns of the Sixties* published September 2017 is now priced at £25 plus £3.00 postage and packing to UK addresses.

Alan's second RIVET LAD book: *RIVET LAD – More Battles With Old Steam Boilers* was published in September 2018. **Now priced** at £25 including postage and packing to UK addresses.

BOOK BUNDLE SPECIAL OFFER

Both RIVET LAD books can be purchased together for £40 plus £5 postage and packing to UK addresses.
To place an order please telephone 01535 637153 / 07971 906105. All our books can be ordered on our website www.sledgehammerengineeringpress.co.uk or email: lankyboilermaker@btconnect.com.
Overseas customers contact Sledgehammer by email for postage costs.
We accept payment by debit/credit card, cheques, cash and postal orders made out to SLEDGEHAMMER ENGINEERING PRESS LTD.
World From Rough Stones House, Farling Top, Cowling, North Yorkshire, BD22 0NW.

Tufnol Input Gear

Graham Meek makes a replacement gear for an EMCO FB2

The first Emco FB2 was bought in the mid 1980's and early on was aware that the No. 47 Input Gear was a Tufnol and steel composite. Rumours were that this gear was known to fail and with this in mind the design for the Spindle Lock **photo 1**, ref. 1, was formulated. In the meanwhile, two more FB2's have come into the workshop. The last remaining one was an ex-demo model in 1996, but luckily have avoided any breakages of the above gear. Checking availability of a spare recently it was found they were on a back order. Not a nice place to be if you need one urgently and why this spare was made in-house.

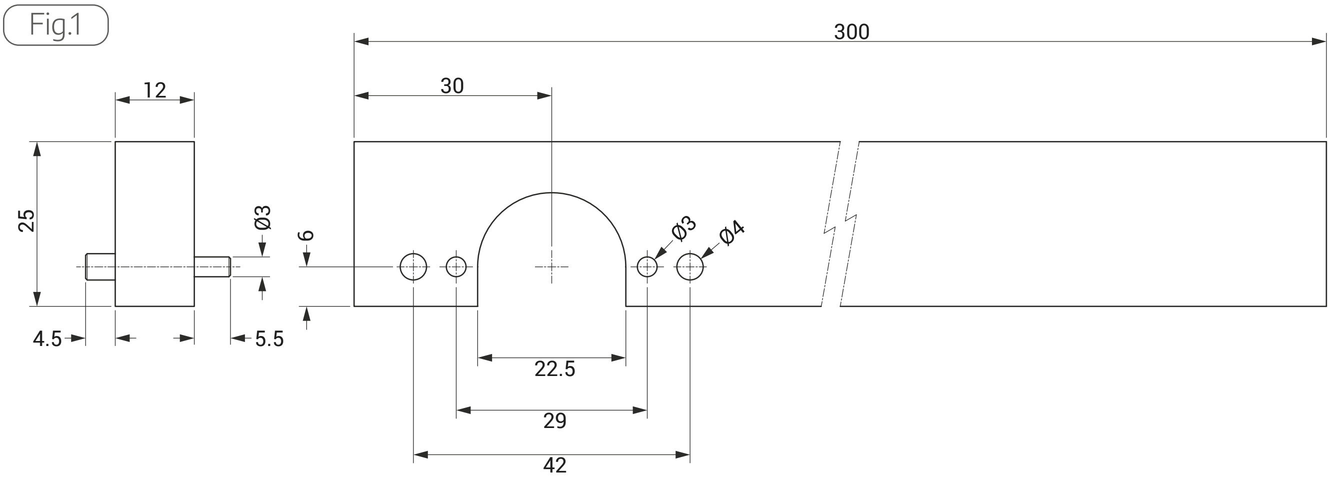
It has long been suspected the use of the bottom speed on the milling machine as a means to lock the spindle by unsuspecting operators, may have been the root cause of these breakages. The spindle turns quite easily by hand in the normal direction of rotation at the lowest speed, but does not want to be turned in the opposite direction. It is as if something is crowding one of the gears, possibly the helical Tufnol gear.

The question of why this gear is called Gear 47 has been a source of intrigue for a while, as those FB2's owned by me have always come with gears having 45 teeth. A recent query on the Forum shows some machines have 47 tooth gears fitted and these are available from some non-Emco internet sources. Some of these sources have also moved away from the Tufnol used originally by Emco and substituted some form of plastic. There are also sources of 3D printed gears, quite how well this material stands up to the usage in the FB2 is hard to say. The methods of construction of these gears also differ from the Emco pattern. Where Emco use a press fit for the Tufnol gear over a coarse knurl on the hub, and to resist the downward thrust of the helical gear in use, the two parts are bonded with some form of epoxy resin glue. The gear profile in this instance would probably be machined after assembly to maintain absolute

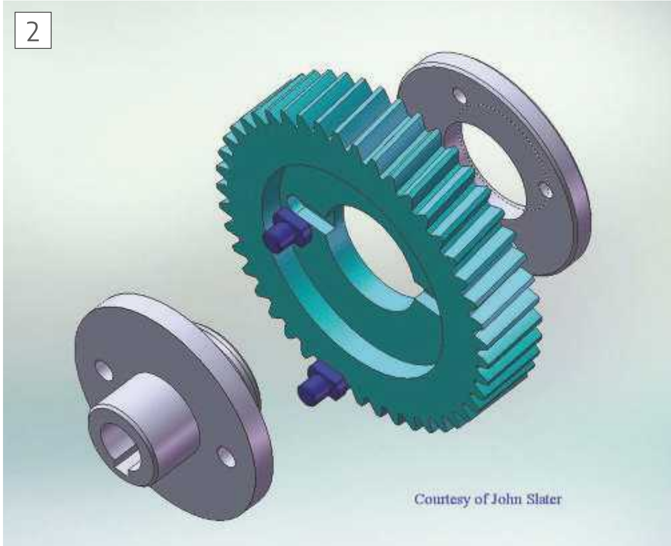
1

Position of ball handle when un-locked.

Fig.1

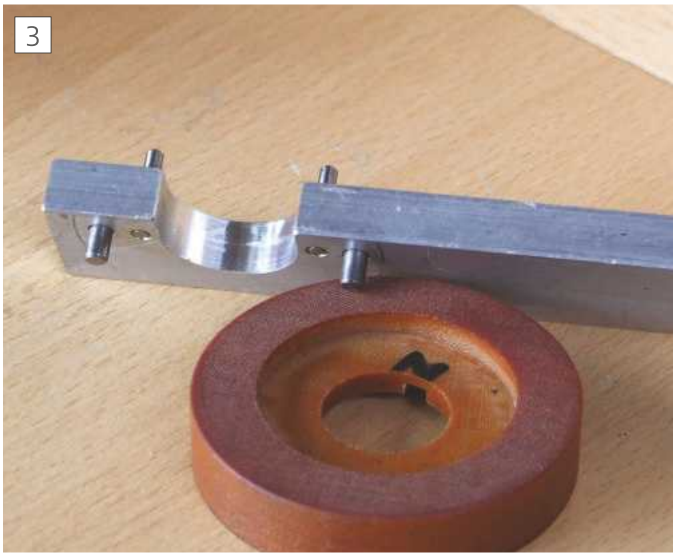


Double Sided FB2 Quill Peg Spanner
Mat'l: Handle - aluminium
Pegs - silver steel



2

FB2 gear complete.



3

Double Sided Peg Spanner made for FB2 Quill.

concentricity.

Some internet designs use countersunk screws to hold the gear onto the steel Hub. This was not considered to be a good idea. Should one of these screws work loose then there is a risk that it can drop down into the workings of the primary gearbox of the mill and chew up the bearing holder beneath it, or worse. This is why in the design put forward here the gear is retained by a ring nut on the top of the hub, **photo 2**. In this design, **fig. 1**, the drive to the hub could have been by a coarse knurl as in the Emco design. However, pressing a fully machined gear onto a coarse knurl did not inspire any confidence when it came to maintaining concentricity. Talking this over with John Slater during an exchange of emails it was decided to drive the gear with some form of circular key or dowel in the lower flange. This key or dowel being sandwiched such that it could not work loose and fall into the works.

Maintaining a location on one part using a dowel offset to the main bore is fine when the hole in one part can be spotted through into the other. If two parts are being made with the view to have interchangeability for replacement of a broken gear at a later date. Then the hole spacings need to be closely controlled to maintain alignment. If the mill is out of order one can hardly spot through into the new gear or vice-versa if this is the only accurate drilling facility available.

Thus, the compromise of a rectangular face keyway was chosen. To make things easier, and to combine both ideas, a spigoted key was used requiring only a reamed hole in the Hub flange. Myford and Emco use this type of key to stop the tailstock barrels rotating. It is highly likely that one keyway and key would be sufficient, but my mentor I. K. Brunel, required that there had to be two, if only for symmetry.

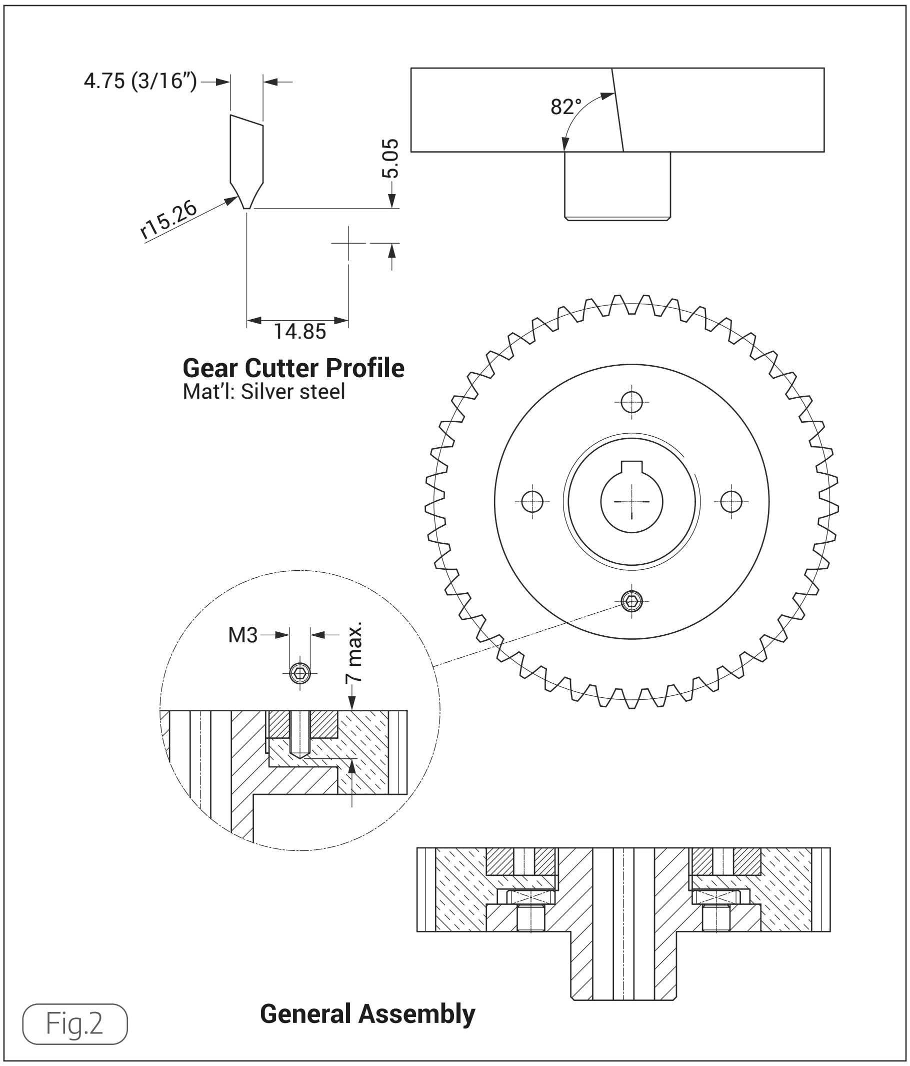
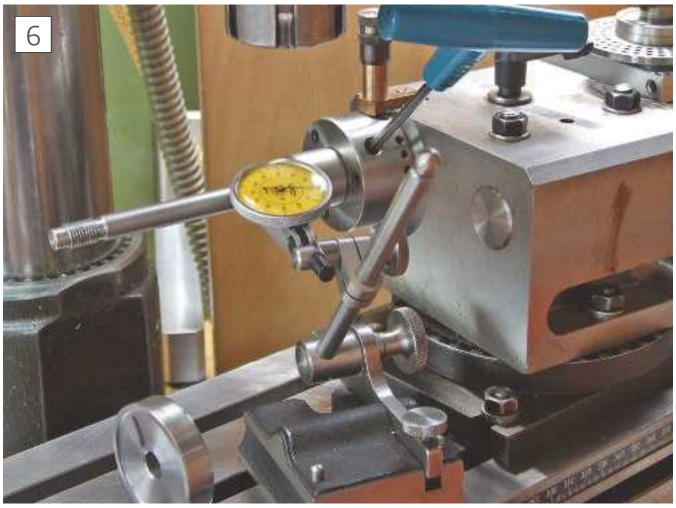


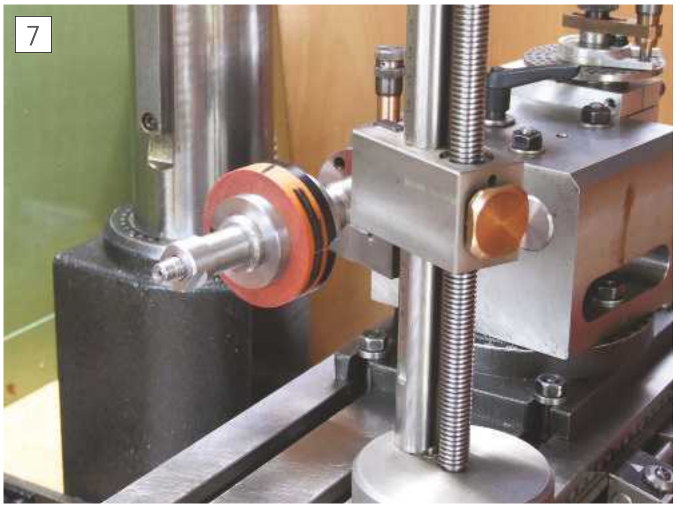
Fig.2

The ring nut is locked on final assembly by an M3 by 6mm long Allen grubscrew into a tapped hole through one of the peg spanner holes. Four holes were used in the ring nut so this would reduce the chances of the M3 tapping occurring over the drive key position. Incidentally the centres of these holes match one set of holes on the quill


FB2 Skew-Helical Gear parts


Checking the 8-degree angle setting over 30mm.


Setting Concentricity of Arbor, the GHT way.


Scribing lines 0.4 mm above and below centreline.

assembly on the FB2. The drawing of the Peg Spanner, **fig 2**, that is used for both assemblies is included; for the reader's future reference, **photo 3**.

Technically the gear produced here is what I would call a skew gear, it is not a true helical gear. There are no resources for cutting helical gears in the Meek workshop, yet! With the helix angle on the original gear of only 8 degrees it was reasoned that the slight loss of helix would not matter if the teeth were cut straight. Especially as a form cutter was being used instead of a hob.

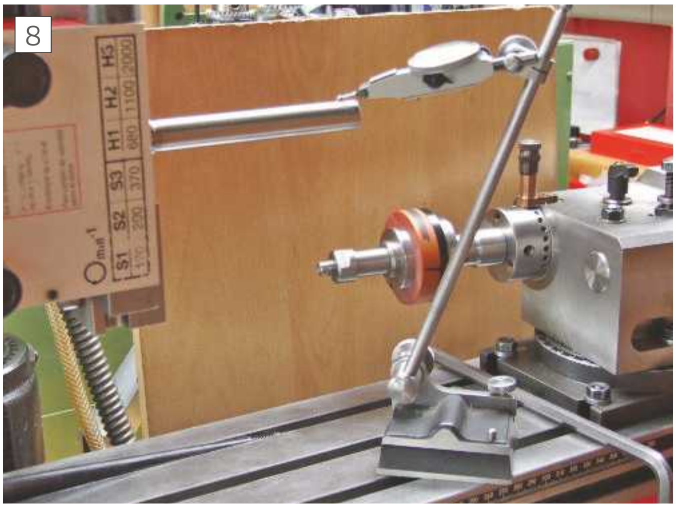
Getting the gear tooth form right did take some working out. The outside diameter of the gear at 60.2mm is far too big for a standard 45 tooth 1.25 Mod gear, which should be at least 58.75mm. Technically the gear should be bigger, as the effects of the 8-degree helix need to be added to a standard gear pitch circle diameter (PCD). A standard 47 tooth gear would give a diameter of 61.25mm, but a 46-tooth gear has an outside diameter of 60mm. Thus, somewhere along the way Emco appear to have been doing some gear cutting magic, in that they have produced a 45 tooth gear on a larger blank, perhaps in an attempt to strengthen the gear. This is easily done on a gear hobbing machine, not so easy with a form cutter.

It was not until doing some reading to refresh the memory. On the effects of a helix angle on a standard gears PCD. In GHT's book "The Model Engineers Workshop Manual", that several pennies dropped. The first was the increase in diameter on his VDH Worm gear, at about five eighths, the helix angle that what was needed for the Emco gear, George had almost the increase in diameter that was needed. That is if one took the 46T gear blank as a base point. The second penny was that he mentioned 20 DP; 1.25 Mod has always been considered a substitute when a 20 DP cutter was not available. Checking in Machinery's Handbook, a 20 DP 45 tooth gear would have an outside diameter of 59.69mm or 2.350". Applying the 8-degree helix angle effects gives an outside diameter of 60.27mm or 0.07mm larger than the measured diameter on the Emco gear. Now it appeared as if we were starting to get somewhere.

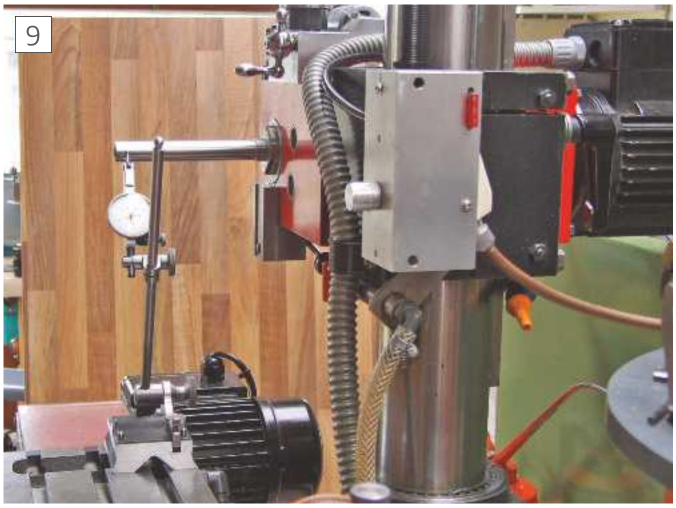
The gear tooth profile was drawn out for this increased gear PCD using the 20 DP, 20-degree pressure angle (PA) geometry. When the 3 by 2.38mm (3/32") rollers were laid onto this gear it produced exactly the right dimension of 61.20mm, which had been measured on the Emco gear. A start was made on a single point cutter to this form.

The reader at this point will probably be thinking problem solved, unfortunately this was not the case. The soft embryo gear cutter was offered up to the Emco gear only to show that it was too wide at the tip of the cutter and the flank radius was way out.

Time for a re-think and a new approach. Using drill shanks the width of the flat at the bottom of the Emco tooth space was measured. As well as the width of the gap at the top of the tooth space. These dimensions combined with the across the rollers dimension, gave 3 points which would



Clocking Test Mandrel Parallel with Table.

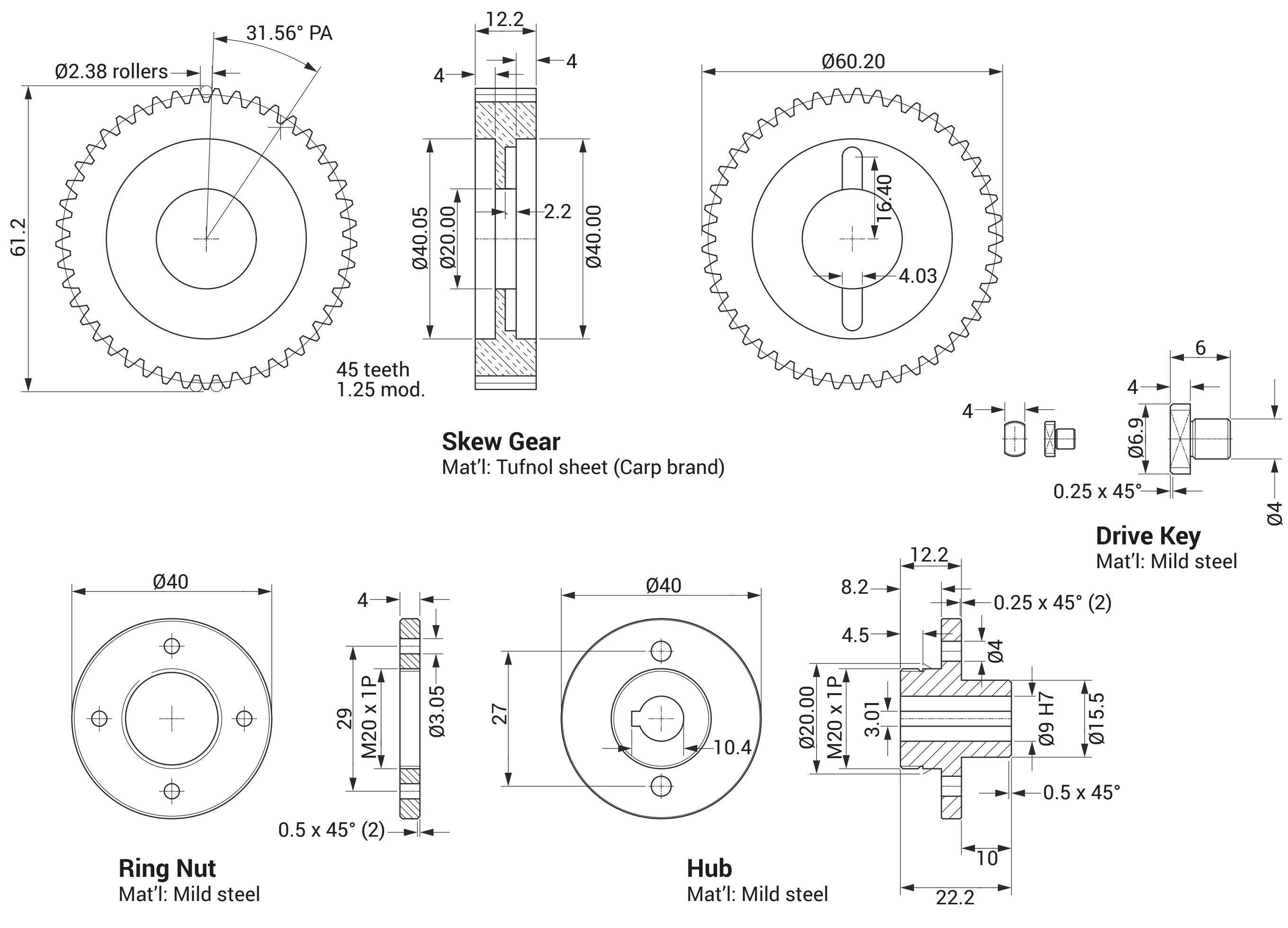


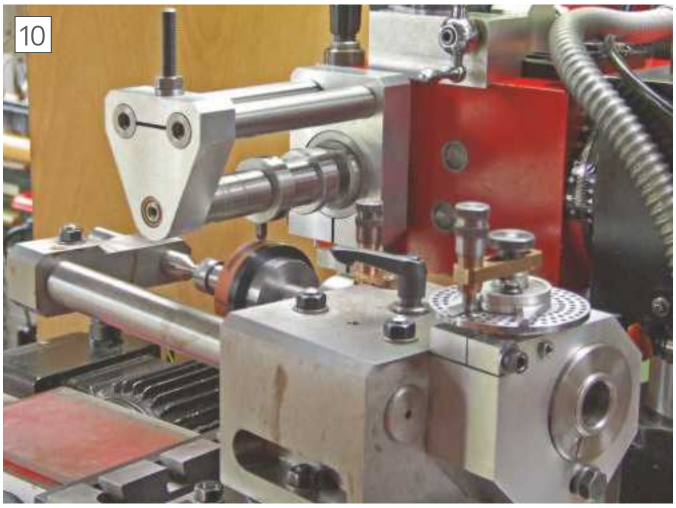
Clocking Test Mandrel Parallel with Cross-slide or Y-Axis.

allow AutoCad to approximate the flank radius. A new cutter form was duly made and again offered up to the gear. This was definitely closer, but it was still possible to detect a slight gap at, or around the Pitch Line of about 0.03mm, (approx 0.001"). Another quick session with AutoCad using the offset mode and the three points to produce an arc, and a new radius was produced. Which was duly tried and fitted the gap perfectly. The cutter was hardened and tempered, after which the top was sharpened on a ⅔ full size Quorn. It is interesting to note that the measured PA for this gear is approximately 31.5 degrees. The original may well be 30 degrees PA. In the beginning it had been assumed this was 20 degrees PA, it just goes to show you cannot take anything for granted in engineering.

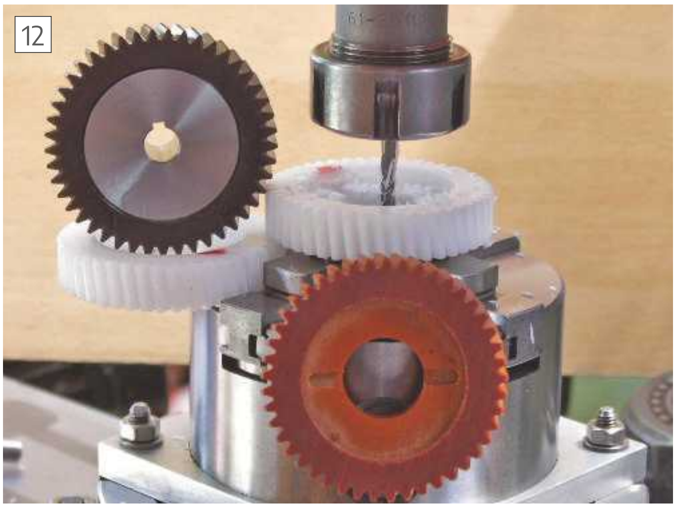
Cutting the gears was fairly easy compared to the designing of the cutter and each gear was completed in fifteen minutes. Using a height gauge and some felt marker ink. Two lines are scribed 0.4mm above and below the dividing

Fig.3




Cutter Set on Gear Blank centrelines after rotating through 90º.


Close-up of Cutter setting.


Machining the Keyways in the Delrin Gears.


Finished Input Gear with spares, note M3 Grubscrew at 12 o'clock.

head (DH) centre-line. The head is then rotated through 90 degrees to get the lines under the cutter in horizontal mode. These lines are used to centralise the cutter both on the DH centre-line and in the centre of the gears thickness, **photos 7** and **11**. While searching for some material for another project, some Delrin of a suitable diameter was found. Two blanks of this material were prepared, and these were machined while the machine was set-up. Photographs are included of how one goes about setting up the FB2, **photos 5** to **10**. The photographs save hundreds of words. The true versatility of this machine is seldom exploited. This may be due to owners not knowing how to go about setting up the machine, so maybe this article alone will inspire others to have a go at getting the most from their FB2. The new Tufnol gear was duly assembled and locked with the M3 grub screw, **photos 13** and **14**. When tried in the machine there was just a little less backlash between the new gear and the motor pinion. The FB2 clearly did not notice any difference with the straight cut Skew gear as opposed to a true Helical gear. The gamble to make the gear this way has paid off. In due course it is hoped to try the Delrin gears, but after several days now of some very heavy milling the Tufnol gear has held up without complaint. ■


The New Spare and the Original.

Ref 1, Engineering in Miniature, Oct 2012, pages 125-128.

Ref. 2, Projects for Your Workshop, Vol 1, page 47.

A Universal Vice by Jacques Maurel *continued from previous issue.*

Index holders 6

These are necessary because part 2 thickness is only 40mm, but not if you can use a 55mm length minimum for part 2.

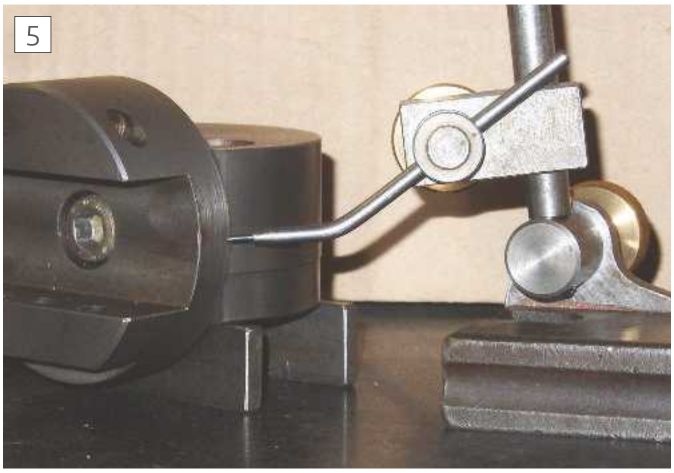
Graduations

Made every 2° as there is not enough room for 1° ones, but this is sufficient for our needs. The dividing can be made with a strip of paper, usually printed from CAD drawing, and wrapped around the chuck, a surface gauge being used as fixed index. The machining is done by hand from the carriage with a threading tool, two stops must be used for the two different graduation lengths.

Marking the graduation start for part 2. Use a scribing block, a machine level and part 2 set in the milling machine vice. Adjust the scriber to the center height of the cylinder, set the upper plane horizontal with the level, and scribe a line on the recess cylinder, this will be the "0". Mark (on the lathe) graduations 20° up and 90° down.

Graduation start for part 3: Set and lock part 3 on part 2 assuming that surface A of part 2 is well parallel with the groove in part 3 (use an angle gauge or a DTI). Set surface A on parallels. Adjust a scribing block to center height (of cylinder 3) and mark a line, **photo 5**. Set part 3 on the lathe in a 3 jaw chuck and graduate up to 0° and down to 90°. Set part 3 back on part 2, align the groove parallel with plane A (use a DTI), and mark the indexes on the index holders.

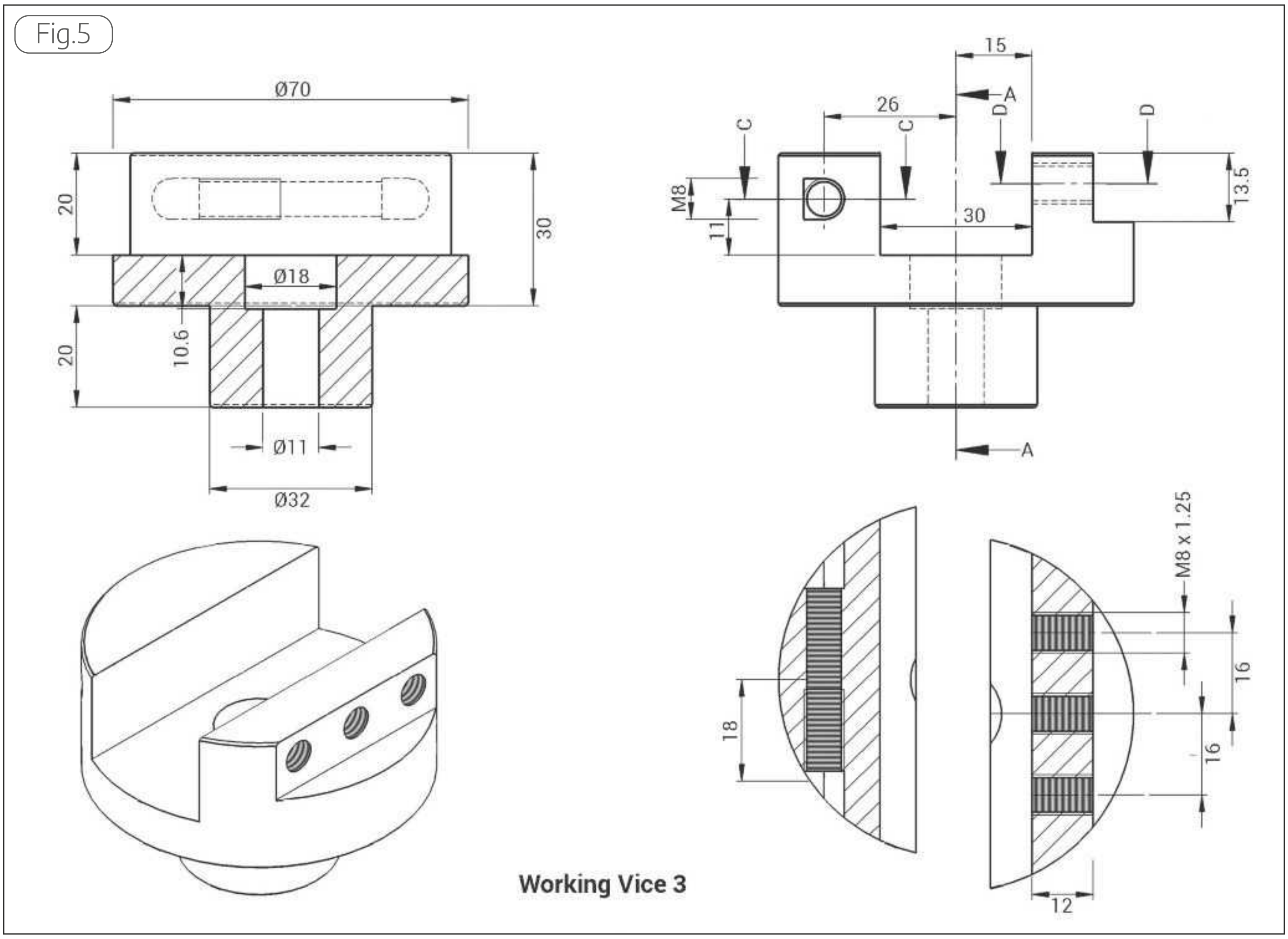
The use of the universal vice will be detailed in a future article for on turning tip holders. ■



Scribing a graduation at centre height.

Parts list:

Part N°	Nbr	Name	Material
1	1	Machine vice	
2	1	Base	Grey iron
3	1	Working vice	Grey iron
4	1	Cotter	FCMS
5	1	Lock screw cap head M8-30	8-8 min.
6	2	Index holder	FCMS
7	3	Vice screw cap head M8-40	8-8 min.
8	1	Screw cap head M10-40	8-8 min.



FREE PRIVATE ADVERTS

MODEL ENGINEER · MODEL ENGINEERS' WORKSHOP

Did You Know? You can now place your classified ads by email. Just send the text of your ad, maximum 35 words, to **neil.wyatt@mytimemedia.com**, together with your full name and address, a telephone number, whether it's a for sale or wanted and stating that you accept the terms and conditions for placing classified ads – see below. Please note, we do not publish full addresses to protect your security.

Coronavirus advice is changing! Please follow local government advice in Wales, Ireland, Scotland or England as appropriate, especially if you are considering buying or selling items for collection.

Machines and Tools Offered

■ Transwave static converter. Input 230v 1ph. Output 400v 3ph. Max 3.7kW. Good condition. £395. Can be seen working. Heavy, so buyer collects.
T. 01257 401258. Redditch, Worcs.

■ Smart and Brown Model A Mark 2 toolroom lathes. 4 ½ x 18. Four chucks. Dickson QC tooling, collets, faceplate, steady, £1,400. Steinel quality German vertical mill, quill head, vice. £1,400. Single to three phase inverter, suit either/ both. Executor sale. Viewing possible.
T. 01425 476837.

■ Empire Mk II lathe. 4 ½". 9" Bernard 4-jaw, 10" 3-jaw. 6" Tudor Pratt soft jaw. 1 ¼" hollow spindle. 22" gap. Norton gear box. Power feed. Drills up to 1". Some reamers up to 1". Lots of tooling extras.
T. 01566 86683. Launceston.

Models

■ 5 inch gauge 0 6 0 Simplex with riding trolly, ground level and raised track. Transport box for loco included. Boiler - Western Steam. Hydraulic 10th April 2025. Steam 10th June 2022. Photos available. £3250. **T. 01638 515363. Near Newmarket**.

■ About 90-100 feet of 3 ½" aluminium track on sleepers, free if anyone would like to collect it.
T. 01438 712585. Welwyn, Herts.

Parts and Materials

■ Four unmachined cast iron Sweet Pea tender wheels and a block of un machined cast iron (5"x2"x1") to make Sweet Pea tender axle boxes. £80. **T. 07920 8335446. Didcot, Oxfordshire**.

■ Two probably ancient and rare model spark plugs ¼" just marked 'T' on the ceramic part. £15 each.
T. 01803 851230, Brixham.

Magazines, Books and Plans

■ Four-hundred and fifty-six Model Engineer magazines. Volumes 186-189 = 43, 190-193= 52, 194-197 = 51, 198-201 = 51, 202-205 = 52, 206-299 = 52, 210-213 = 50, 214-217 = 52, 218-221 = 52. As new. Collect only. Covid safe collection. Weight 68kg, two boxes. £40 ONO.
T. 01282 435843. Burnley, Lancashire.

Wanted

■ Cowells ME90 Lathe must be in perfect condition. I am too old to buy new, distance no object.
T. 01986 835 776. Ipswich/Norwich.

■ Cowells Model CW90 lathe. Must be in first class condition with accessories.
T. 01522 722374. Lincoln.

■ Manual for Myford Super 7 serial number SK9435 (mid 50s, I think). New to model engineering. Photocopy would suffice. All expenses paid.
T. 087 2275266. Portlaoise, Ireland.

■ Instruction booklet for Sussex Steam Co's James Watt model beam engine. I can return it.
T. 0161 368 2840. Manchester.

YOUR FREE ADVERTISEMENT (Max 36 words plus phone & town - please write clearly)

❑ WANTED ❑ FOR SALE

Phone:		Date:		Town:	

Please use nearest well known town

Adverts will be published in Model Engineer and Model Engineers' Workshop.

The information below will not appear in the advert.

Name ....

Address ....

....

....

.... Postcode..........................

Mobile .... D.O.B..........................

Email address. ....

Do you subscribe to Model Engineer ❑ Model Engineers' Workshop ❑

Please post to:
ME/MEW FREE ADS, c/o Neil Wyatt, MyTimeMedia Ltd, Enterprise House, Enterprise Way, Edenbridge, Kent TN8 6HF
Or email to: neil.wyatt@mytimemedia.com

Photocopies of this form are acceptable.

Adverts will be placed as soon as space is available.

Terms and Conditions:

PLEASE NOTE: this page is for private advertisers only. Do not submit this form if you are a trade advertiser. If you wish to place a trade advert please contact David Holden on 07718 64 86 89 or email david.holden@mytimemedia.com

By supplying your email/ address/ telephone/ mobile number you agree to receive communications via email/ telephone/ post from MyTimeMedia Ltd. and other relevant 3rd parties. Please tick here if you DO NOT wish to receive communications from
MyTimeMedia Ltd: Email ❑ Phone ❑ Post ❑
or other relevant 3rd parties: Email ❑ Phone ❑ Post ❑

All advertisements will be inserted in the first available issue.
There are no reimbursement for cancellations.
All advertisement must be pre-paid.
The Business Advertisements (Disclosure) Order 1977 - Requires all advertisements by people who sell goods in the course of business to make that fact clear.
Consequently all trade ads in *Model Engineers' Workshop* carry this 'T' symbol

MODEL ENGINEERS' WORKSHOP CLASSIFIED