

No.298

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# MODEL ENGINEERS' WORKSHOP

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NOVEMBER 2020



**Special Archive  
Feature:  
Ivan Law Explains  
Gear Hobbing**

## INSIDE

- **Make a Sub-Table for Accurate Drilling**
- **Bandsaw Attachment for awkward work**
- **EMCO Mill Alignment Device**
- **Machining a Watch Bezel**
- **Grit Blasting Cabinet**
- **And much more!**

## COVER STORY

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# On the Editor's Bench



At present with the progress of Covid-19 it looks like we are headed for more restrictions as the winter approaches. I particularly sympathise with readers in those areas affected by local lockdowns, I hope that all readers and their families are able to keep safe and well.

Before the restrictions were further tightened, I was able to pay a visit to family in South Wales at last, and also to visit a place I worked at early in my career. Back then the Glamorgan Wildlife Trust operated out of a set of portacabins and had a small nature area on land formerly part of Parc Slip Colliery, which was coming to the end of its operational life. Today the whole area has been transformed into a nature reserve with many fine walks. The South and West Wales Wildlife Trust operates a visitor centre there and I enjoyed a light meal from their café. On a bright day I must say it was very pleasant to visit, but also very different from how it was well over thirty years ago.

Another change was that across the road is the Bridgend Miniature Railway, operated by the Bridgend and District Model Engineering Society. A club of like-minded individuals they are interested in model engineering in all forms, although the railway is a major focus for their activity. It's likely that when my long-planned move comes to pass I will be located quite close to Bridgend, and if so I hope to join the club.

I'm most grateful to John Owen and members who made me welcome and allowed me to have a look around their site, within the limits required by social distancing. They have a 5" and 7¼" ground level track about a mile long, as well as a raised track for 3½" gauge. The canopy for their station/steaming area is a remarkable structure, all built by members. They have a sophisticated signalling system to control traffic in and out of the site (which has to cross over the tracks) which includes a battery backup system and even a PABX telephone exchange to keep all parts of the site in contact. Naturally, the situation limited how much I could see, but the club has great facilities and I couldn't help thinking it might make a future venue for IMLEC (International Model Locomotive Efficiency Competition) with its long track and a demanding 1 in 80 gradient.

Like many clubs, their operations have been hit hard by Covid-19 restrictions. The main one being that their railway has been unable to operate for the public with an obvious and unwelcome impact on their finances. A similar situation faces many model engineering clubs across the UK, and I see that Kerr's Miniature Railway in Arbroath – the oldest in Scotland, has had to close this year. Hopefully, there will be brighter times ahead.

I would encourage any clubs facing difficulties because of Covid to look at special sources of funding. The Heritage Emergency Fund offers grants to not-for-profit heritage organisations for example. Other avenues worth investigating by any club include Charity Bank and Grants Online which should help identify local sources of help.

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# Contents

## **9 An Aid to Cutting Corners on a Bandsaw**

Richard T. Smith describes how to make and use what he calls an 'attachment for an attachment'.

## **16 Using Standard Masonry Bits with as SDS Hammer Drill**

Jacques Maurel explains and improves adaptors for using ordinary chucks with SDS.

## **18 Making Grit Blasting Cabinets**

Continued from issue 296, Stuart Walker concludes his article on larger capacity grit cabinets.

## **21 A Chucking Problem**

John Pooler makes a fixture to rescue a vintage watch.

## **25 Soft Soldering**

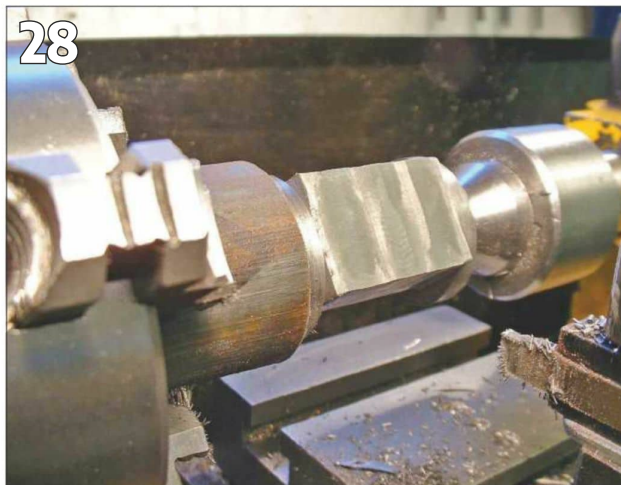
This archive article from Geometer underlines how, unlike many aspects of our hobby, the art of soft soldering has changed in the last sixty or so years.

## **28 Machining a Cylinder from Solid**

Stub Mandrel explains his approach to milling a complex shape.

## **36 A Temporary Coupling**

Des Bromilow uses a wooden jury-rig to test a gearbox.



## **37 A Work-Holding Sub Table**

Rod Renshaw achieves more accurate results with this accessory for this pillar drill.

## **42 A Vertical Alignment Device for the Emco Compact 5**

Graham Meek tells the story behind an essential aid for owners of Emco and Toyo round-column mills.

## **46 A Simple Indexing Device**

John Hinkley completes the build of his flexible indexing device.

## **51 A 5" Diameter Rotary Table**

Ian Strickland continues his build of this accurate and elegant piece of tooling.

## **56 Gear Hobbing in the Workshop**

Ivan Law explains the background to this useful technique for generating gears that needs just one cutter for each pitch.



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# Coming up...

## in our next issue

Coming up in our December issue, number 299 another great read



## Regulars

### 3 On the Editor's Bench

A rare opportunity to visit a model engineering club.

### 14 Readers' Tips

A great tip for improving the flexibility of step blocks.

### 26 On the Wire

This month's news from the world of hobby engineering, including a supplier's perspective on the pandemic.

### 33 Scribe A Line

A bumper collection of reader's feedback this month.

### 50 Readers' Classifieds

This month's chance to grab a bargain with our readers' sale and wanted ads.

### ON THE COVER



This month's cover shows an embryo steam engine cylinder emerging from a cast iron bar, making use of Stub Mandrel's X2 mill and workshop-made rotary table. More details on page 28.



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Any questions? If you have any questions about this issue, or you would like to suggest ideas or topics for future instalments, head over to [www.model-engineer.co.uk](http://www.model-engineer.co.uk).

Visit [www.model-engineer.co.uk/stevenson](http://www.model-engineer.co.uk/stevenson) to vote for your choice in the competition

Our Web forum continues to be exceptionally busy, and we have welcomed many more new members. The forum is a 'safe space' for anyone with an interest in model and hobby engineering to come and join one of the busiest and friendliest model engineering forums on the web at [www.model-engineer.co.uk](http://www.model-engineer.co.uk).



[www.model-engineer.co.uk](http://www.model-engineer.co.uk)?

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.

**How do I disassemble Vickers dual metric/imperial dial?**

Even if you don't have the need to repair one of these, this thread gives a fascinating insight into how dual speed dials work.

**Engineering Sights on Google Streetview**

As a bit of fun join in this 'virtual tour' of engineering sights around the UK – and further afield. Highlights include a portable engine in a front garden and another outside a café in Malta!

**Whitening**

Here's an interesting compound from the old days. What is it and what is it used for? Visit the forum to find out.

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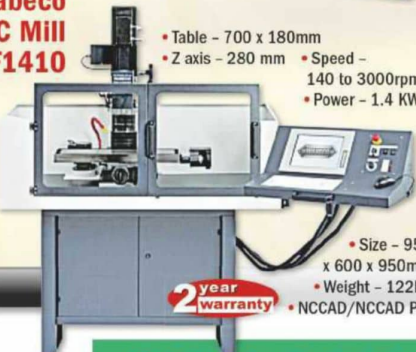


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# An Aid to Cutting Corners on a Bandsaw



Richard T. Smith makes an attachment for an attachment.



I made this attachment to fit on my bandsaw guided and powered feed attachment, so that I could cut blanks ready to turn from flat material such as **photo 1**. In the first version blanks have a central hole which is used both as a pivot for sawing, **photo 2** and for mounting in the lathe for turning, **photo 3**. A second version is for hole free blanks.

The body is made from 50 x 25 BMS which I cut on the bandsaw with the powered feed, **photo 4**. This was interesting because I had 700 mm of flat hanging out to the left unsupported. I was going to revert the saw to horizontal operation but decided to try clamping the flat on the table and realised that because of the stiffness of the guiding it would be fine. The actual clamping is shown in **photo 5**, there is



Twice around the corners.





*Second corner cut.*

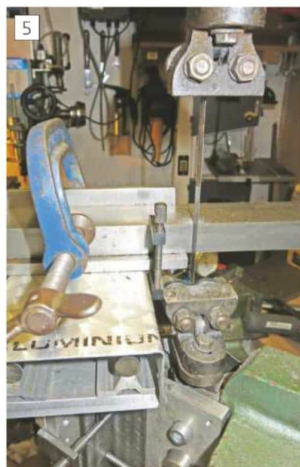


Turned round.

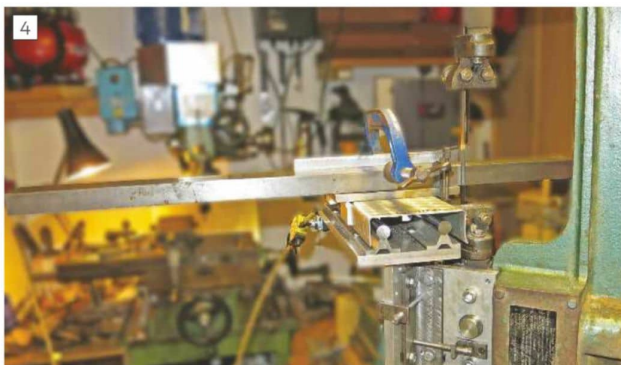
just room to get the small toolmakers  
clamp in!

I first cut a 20 mm wide strip of 10 mm thick BMS and machined the edges. This slides in a slot in the body which was machined in the vice to just over 10 mm deep, **photo 6**. One end of the strip was filed to fit the end of the slot, **photo 7**. Then I turned the body over and milled a 12 mm slot from the middle to close to one end, **photo 8**. To finish the body two counterbored holes for M6 capheads to fasten to the table were added to the top, and an M5 tapped hole for a grub screw to lock the slide was added in the side. I made a small aluminium plug to go between the grub screw and the slide to protect it. The body screws on the table with the slot roughly centred on the travel of the saw blade although other positions are possible.

I positioned the mill spindle over a



*Clamped to the fence.*



Flat bar overhanging 700 mm.

slot in the table. I locked the slide fully inserted and located the assembly under the spindle using the 12 mm cutter held in the drill chuck. I had some scrap under the slide so that it was clamped firmly to the table then drilled and tapped M10,

**photo 9.** This completed the slide.

Now I had to make the pivot. I had decided to make the pivot screw into the slide with the bottom section running in the slot in the body. Initially I planned to make several pivots with different



*Milling the body to take the slide.*



Slide end filed to fit the body.



Milling the slot for the pivot.



Drilling the slide through the body.



Pivot screw with two bushes.



Adjusting the slide to lineup work edge with blade.





*Making a cut.*



*Turning round on a stub.*

diameters for the top part which fits in the hole in the blank and locates it. However, in the end I made the top 6 mm diameter threaded M6 most of its length, and made 8, 10 and 12 mm diameter bushes to slide over it. There is a male M10 thread on the other end that screws into the slide. The basic pivot is shown screwed into the slide with two of the bushes in **photo 10**.

My first trial was to make a 60 mm diameter by 10 mm thick disk starting from some 80 x 10 mm flat. First, I cut a piece 64 mm long and drilled and

reamed a 12 mm diameter central hole. The blank was located on the 12 mm diameter bush with the sawn ends across it and pushed gently up against the blade, **photo 11** and the locking grub screw in the body tightened to lock the slide. The 80 mm original sides were cut down to 64 mm by setting them square with the body then sawing off the surplus. Now the corners could be cut off, **photo 12**. Because the saw blade is approaching the work at 45 degrees the cut has to be started under light hand pressure before using air pressure.

I also finished these cuts under hand pressure.

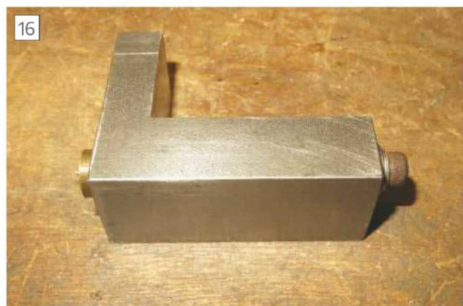
I decided to cut across all the corners which I am not sure was really necessary. The blade now approaches the work at more of an angle and I had to be much more careful starting the cut by hand pressure before applying air pressure. The result is shown in photo 1 above. I doubt these extra cuts were worth the effort and will stick to octagons in the future. The pieces cut off the second time around were quite small. One fell between the blade and



*Sawn L shape stop body.*



*Checking brass fits stop body.*



*Brass secured in the body ready for cross drilling.*



*Cross drilled for stop rod.*





Brass ready for sawing across dimple.



Locking trial with temporary caphead.

the guide bearing producing terrible noises which had me panicking that the bearings were going in the saw gearbox!

To turn the blank round, I bolted it to a stub held in the 3 jaw chuck, **photo 13**. I used a 0.8 radius tip and had no problems with the intermittent cut. The photo shows it just turned round and the scribed line shows the target 60 mm dia.

By this time, I had decided it would be really useful to have an adjustable slot to limit the table movement. This could enable repeated cuts to the same depth and also if set right stop the table running away when sawing right through. First, I used the saw to

cut an L shaped piece, **photo 14**, and machined the cut faces. I had some 10 mm diameter silver steel for the stop rod and I planned to use a brass split clamp at right angles and overlapping it. I drilled and reamed a 10 mm diameter hole for the brass down the long side and turned down a piece of brass rod to slide in it, **photo 15**. The end of the brass was drilled and tapped M5 deep enough to pass where the stop rod hole would be drilled. At the chuck end the brass was left larger than 10 mm diameter and the turned brass section was slightly shorter than the stop body. The parted off brass was then be clamped in place with an M5 screw and washer, **photo**

**16**, to stop it moving when the cross hole for the stop rod was drilled, **photo 17**. The brass piece was removed, **photo 18**, sawn across in the middle of the dimple, the left end turned down to match the rest of that piece and drilled right through 5.5 mm dia. A long M5 cap head screw allowed assembly onto a scrap of silver steel, **photo 19**, and some filing and emery got it working smoothly. The stop rod is offset in the bracket and I drilled two 6.5 mm diameter holes similarly offset in the short part of the bracket.

●To be continued

## In our Next Issue

**Coming up in issue 299**  
On Sale 20th November 2020

Content may be subject to change

### Look out for MEW 299, your December issue:



**John Garnish** offers advice on accurately drilling holes across a diameter.



**Laurie Leonard** fits new bearings to a Tom Senior Milling Machine.



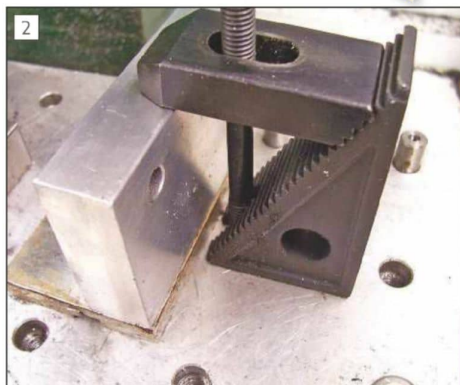
**Stewart Hart** improves a pan folder.

# Readers' Tips



## Improving Step Block Versatility

TIP OF  
THE MONTH  
WINNER!



**This month our lucky winner of £30 in Chester gift vouchers is Alistair Robertson who has come up with an interesting improvement for popular step block sets.**

I have attached some photos of a modification I have made to a recently acquired Step Block Clamp Set.

I have done this to many clamp sets over the years as, by machining a slot in the largest step block it allows it to be used in confined spaces which is especially useful in a small hobby machine such as my Denford Novamill which although I use a Grid Plate I find that at times things are tight on the table.

**Photo 1** shows the problem and the difficulty in getting a securely aligned clamp.

**Photo 2** shows the machined Step Block that fits around the securing stud and the extra space on the table.

**Photo 3** is a general view of the modification which is simply cut with a 9mm Ball-nosed cutter to a 14mm depth to fit around the M8 studs that I use in my Grid Plate.

Any size of Step Block Kit can be modified, and the block still retains all its strength and rigidity.

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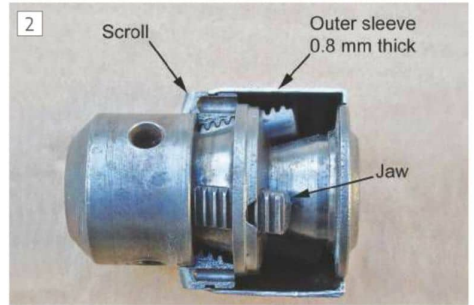
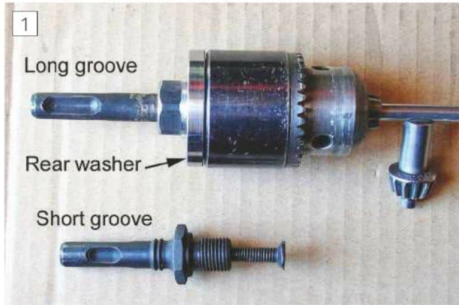




# Using Standard Masonry Bits with an SDS Hammer Drill



Jacques Maurel makes an adaptor to fit an ordinary chuck to an SDS drill



To use ordinary masonry bits with an SDS drill you must use a drill chuck with an SDS adaptor, see **photo 1**, this adaptor was, as usual, machined with a short "cylindrical groove" that can be seen in the photo, note 1. With this short groove its impossible to hammer the drill while turning as it is set up to stop one using a chuck when in hammer mode.

I've made an adaptor by silver soldering a SDS shank (from a sacrificed drill with a long "cylindrical groove" as seen in photo 1 to a machined head carrying the  $\frac{1}{2}$ " 20TPI UNF thread for threading the key chuck on, so hammering was now possible. After a short time in use, the chuck exploded! It was not broken but the outer sleeve, being located in a shallow groove machined on the two-part scroll, **photo 2** and note 2, was pushed back by the strong strokes, and the scroll parts were freed. Hence the solution (see photo 1) of a rear washer to stop the outer sleeve movement if it occurs.

Another improvement is to machine three flats on the bit's shank to avoid slipping and spoiling the cylindrical part. **Photo 3** shows some scratches on the remaining cylindrical part, and a fourth one bought new with a hexagonal shank.

It can be seen on photo 1 that there is a left threaded flat head screw to lock the chuck when it's used for unscrewing. This is not necessary, a plain right-hand screw works as well, because the screw



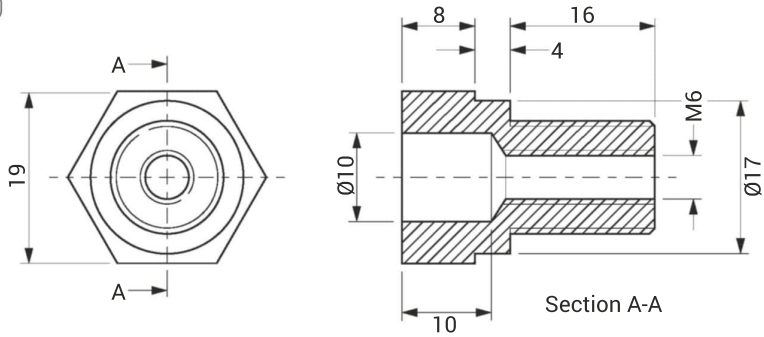
pitch (1mm for M6 screws) is different from the chuck screw pitch (1.27mm for 20TPI). As these pitches are different, they are locking one against the other

and chuck unscrewing is impossible when turning anti-clockwise.

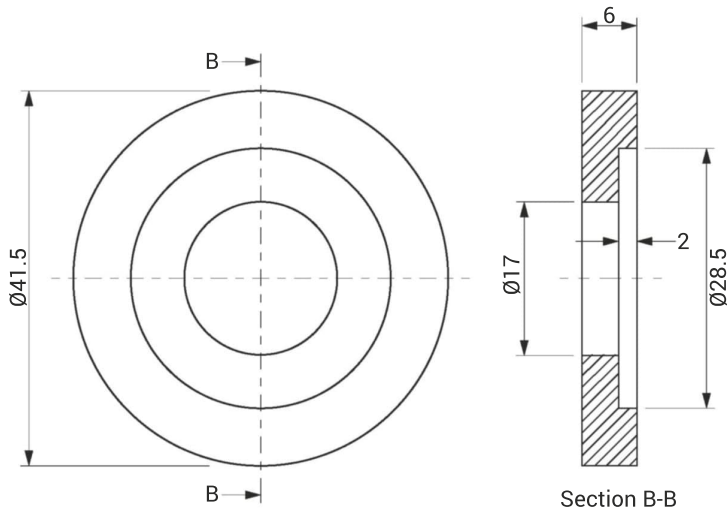
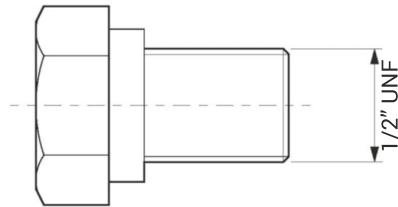
**Figure 1** gives the dimensions for my chuck, but could be slightly different



Fig.1



Chuck Adaptor



Rear Washer

for your own, a little play must remain between the rear washer and the chuck back part. The washer must be a press fit on the adaptor.

#### Notes

- (1) -These adaptors are now sold with the long groove, but without rear washer.
- (2) - See **photo 4** for different views of

the scroll, which is broken into two parts after machining to allow the setting in the chuck body groove. A special steel is used for this purpose. This process is also used for making connecting rods. ■

# Making grit blasting cabinets



**Stuart Walker responds to a request for information on larger grit blasting cabinets - Part 2**

## Doors and seals

Some of the commercially made cabinets are front opening but most home shop designs use end openings because it's easier to make and doesn't require fancy hinges and gas strut supports as shown in **photo 11**. With sheet metal framed cabinets, corner frame stiffening is needed and also the door panels need stiffening to maintain rigidity. Mine is fitted with normal strap hinges which work well and enable the door to fold down vertically, as shown in photo 10. Self-adhesive felt was used to form the seal and two toggle latches used to keep the door closed and leak free. I daresay rubber seals could be used, and it might be worthwhile using screw adjustable toggle latches.

## Guns and gauntlets

Most small workshop grit blasters use hand trigger operated guns which work well and have the advantage that the same gun can additionally be used for outside free blasting. However, the trigger valve makes the gun quite



*Large industrial cabinet with front opening and gas strut supports*

long and somewhat cumbersome to handle in the confines of a cabinet, and if you have a lot of blasting to do it can soon become very uncomfortable to constantly keep your finger on the trigger. Should this cause you difficulties, a foot operated gun is a better choice; most of the more expensive cabinets designed for professional use have this arrangement, but you don't need to fit one straightaway as conversion kits are available at a reasonable price,

shown in **photo 12**. Guns are made to accommodate replaceable nozzles which come with a range of nozzle sizes to control the flow through the gun, and the maximum size you can use very much depends upon the capacity of your compressor - more about that later.

Whilst all gauntlets are fitted into the cabinet, there is a choice to be made. If you intend to use an internal trigger operated gun, I'd recommend the use of Marigold Industrial Emperor ME 104 which are more supple than the standard glove, shown in **photo 13**. They provide the same level of protection with a good service life, but the more robust standard glove might not need replacing quite so often. Note that if you decide to use the Marigold gloves you'll need a 150 diameter top hat flange to fit the gloves because you won't be able to satisfactorily stretch them to fit the 176 diameter flange needed for the larger standard gloves.

## Viewing and lighting

Most of the smaller cabinets seem to be fitted with a single internal lamp which can easily be damaged and is, in my view, inadequate. With advancing years I need more light, so designed a light box to fit on top of my cabinet with a glass window to shed the light directly down in front of the viewing window and onto the work being blasted, see **photos 14 and 15**. The box lid can be easily removed to replace the strip lamps, and on the outside I mounted a light switch and air pressure controller which enables me to keep an eye on that all important air pressure.

The viewing window is also made of glass and both are provided with rubber seals and peel-off plastic scratch protectors to maintain good visibility in the dusty environment.

## Compressors and dust extraction

Compressor size does really matter. Grit blasting is not a fast process at the best of times and a small compressor will soon run out of air, even with a small gun. To make any serious headway you'll need at



*A typical foot pedal conversion kit for grit blasting cabinets*





Internal view of my completed cabinet, showing the Marigold gauntlets



The light box i built on the top of the cabinet with film protected glazing



Light box top cover complete with strip light and inlet pressure gauge



My 5.5 hp compressor along with a useful 2.0 hp support.

least a 5 - 7hp compressor capable of 20 CFM. If it helps, it's worth bearing in mind that two or three smaller compressors can be linked together to keep up with the demand. **Photograph 16** shows my two compressors.

Extractors have two functions; namely, provide a clear view of the blast area and separate the lighter dust from the heavier grit to allow the latter to be effectively re-used with the minimum of contamination. On my cabinet I use a filtered air inlet near the top of back panel close to the door with the extract high up at the back of the end panel. The inlet is fitted with a swivelling y-bend so that the direction can be adjusted - set upwards at approximately 45 degrees, it's connected to a domestic wet and dry vacuum cleaner which adequately deals with the dust and provides good visibility in the cabinet, see **photos 17-19**. I understand that a Cyclone dust separator of the kind shown in **photo 20** is a useful way of reducing the dust going through the vacuum cleaner and is

something I'll be adding soon.

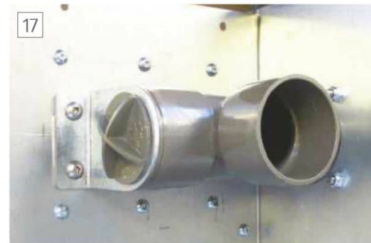
Purpose made, bolt-on extractors can be purchased - as shown in **photo 21**. Probably a better option if you end up doing a lot of blasting with a large setup is to use a fully integrated stand alone cyclone filter system which I understand is quieter and with a larger throughput. Whatever system you use, it's worth checking to see that you're not extracting too much grit with the dust and, if you are, fit a larger baffle inside the cabinet to slow down the extract airflow and allow more of the heavier grit to fall out for reuse.

### Air lines

Whilst it's worthwhile keeping your compressor away from a dusty workshop environment so that it's drawing in clean and dry air, a generous size pipe main is need for long runs to keep pressure loss to a minimum.

Make sure the rigid air lines are provided with falls and drain points to deal with any condensation that might

form. I'd recommend using standard steel or copper water pipes. Whilst purpose made rigid plastic airlines can be used, a friend found that the ones he fitted started leaking for no apparent reason after few years of use. For long runs I used 22mm diameter copper tube with both solder and compression joints which are fine, but the screw connections leaked badly because I used



Internal view of dust extract fitting with vertical adjustment using standard domestic waste pipe fittings



External view of dust extract duct showing the adjustable suction facility

the PTFE tape intended for water pipes rather than the tape specifically designed for sealing gas and air screw fittings. I also found that liquid PTFE works well for water, gas and air, **photo 22**.

Combined air pressure regulators with water traps are useful at both ends of the air lines and I fitted one on top of my cabinet to make sure I can keep an eye on that all important air pressure.

### User tips

Make sure all the parts you intend to blast have been thoroughly degreased as any hint of sticky substance will soon gum up the works of a recirculating system.

Keep the sides of the hopper clean and polished to ensure a good grit flow.

As far as consistency of finish is concerned, it's best not to fill the hopper more than quarter full, run it on the lean side and regularly add more fresh grit.



Light and heavy-duty compressors linked into my air distribution pipework



Numatic Wet and dry vacuum cleaner



Typical cabinet mounted dust extractor

Occasionally, blockages will occur, but these can often be cleared by simply putting your gloved finger over the end of the nozzle and pressing the trigger.

Should this fail, you might need to make a slight adjustment to the air bleed where the grit is picked up at the base of the cone, which requires fine tuning to achieve optimum abrasion. It might be that there is too much grit in the hopper or that it's compacted by dirt or damp - try draining some from the base of the hopper to see if the blockage is in the hopper or in the pipework.

Blast cleaned surfaces are susceptible to rapid corrosion after blasting and any dust should be washed off with soap and water, thoroughly dried and treated with a phosphoric acid based product to ensure all corrosion is removed/converted before applying long term protection. Castings should be similarly washed, dried and treated before machining.

Regularly drain any water from your compressor tank and make sure that it's serviced and the airlines checked for leaks.



Typical small cyclone dust separator

Regularly check your dust extractor and clean/replace dirty filters.

### Update and Conclusion

Since writing this article, I have made the cyclone extractor referred to above, and it works well. It's shown in **photo 23**.

Whether you decide to make your own cabinet or simply go and buy one, I hope these notes will help your assessment of what will work best for your particular needs. ■

### Useful suppliers

Cabinets and fitting kits -

[www.sandblast.co.uk](http://www.sandblast.co.uk)

Cabinets, compressors and fittings -

[www.machinemart.co.uk](http://www.machinemart.co.uk)

Compressors and fittings -

[www.tbs.co.uk](http://www.tbs.co.uk)

Wet and dry vacuums -

[www.numatic.co.uk](http://www.numatic.co.uk)

Low cost cyclone powder dust collectors

- [www.amazon.co.uk](http://www.amazon.co.uk)

Open top steel drums for dust collection

- [www.speedyshelving.com](http://www.speedyshelving.com)



Cyclone dust extractor powered by vacuum cleaner.

# A Chucking Problem

John Pooler tackles an unusual challenge

**A**fter walking 3 miles along a beach, I noticed that the bezel on my 50-year-old Omega watch had come off, **photo 1**. The watch glass clipped onto the watch and it seemed that the bezel clipped onto the watch glass.

I wondered how could such a flimsy part be made on a 3 ½ inch lathe? Looking through my box of bits, I found a piece of mild steel 5.5 x 4 x 6 mm thick. I drilled two holes on a diagonal and tapped both 4 BA. The piece was then bored so that the watch glass could fit loosely inside, **photo 2**.

I found the brass plate of an old lighting switch which was about the right thickness. It was drilled on a diagonal to match the 4 BA screws. The steel backing plate was centred in the 4-jaw independent chuck and the work piece bored to be a tight fit on the watch glass, **photo 3**, and turned a concave shape to match the watch body.

The work piece was removed from the steel backing plate and bolted the other way round. The work was then turned convex to match the watch and the outer edge turned almost through. The final cut was made with a junior hacksaw and trimmed on the grindstone, **photo 4**.

The finished workpiece was gold plated and glued into place on the watch, **photo 5**. ■



The watch after losing its bezel.



Steel backing plate.



Boring the bezel.



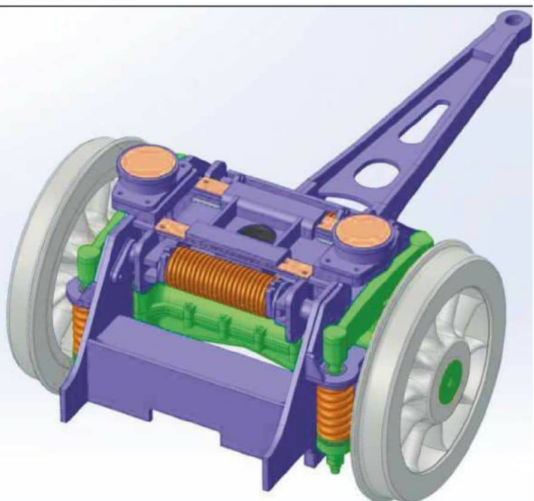


Restored watch after plating of the bezel.

Finished bezel.

# ISSUE NEXT ISSU MODEL NEXT ISSUE NEXT IS E NEXT ISSUE NE ENGINEER SSUE NEXT ISSUE

- Britannia**  
 Norman Lorton explains how he set about improving a Modelworks 'Britannia' locomotive.
- Pannier Tank**  
 Doug Hewson shows how to make the steam turret for his improved 5 inch GWR pannier tank.
- A1 Pony Truck**  
 Graham Langer reviews the design process behind the A1 Locomotive Trust's latest project, *Prince of Wales*.
- Air Brakes**  
 Rhys Owen looks at the equipment needed to provide a railway vehicle with air brakes.
- Name Plates**  
 Luker shows how name plates can be etched using easily obtainable bits and pieces.



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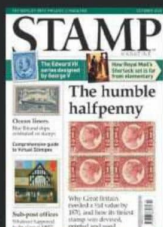


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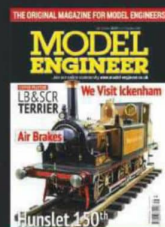
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# From the Archives:

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.

## BEGINNER'S WORKSHOP

# SOFT SOLDERING



**THE SIMPLEST METHOD** Of jointing metals is by soft soldering, which can be performed by a soldering iron or copper bit heated in a flame or the domestic fire. A variety of metals can be soldered in this way, including brass, copper, bronze, iron, steel, pewter and lead, on which the beginner should practise.

A typical soldering iron consists of a copper bit on a steel shank in a wooden handle. A common size for the bit is about 3-4 in. square and 2-1/2 in. long. Larger sizes are used for heavy work requiring much heat, and smaller ones for fine work like soldering wires.

Soldering irons may also be heated electrically or from a gas supply. These avoid the reheating process which is essential when the ordinary iron cools off.

### Using blowpipes

Many classes of soldering and tinning can be performed without a soldering iron, using only a suitable blowpipe. A simple blowpipe may use gas and air from a foot bellows, or small blower, or an oxy-acetylene blowpipe, or torch, can be used with a very small nozzle to keep down the ordinarily fierce heat.

A mouth blowpipe can be used for very small work. This consists of a tapered tube ending in a very small hole, and is held in the mouth to blow a fine jet of flame from the flame of a spirit lamp, the work to be soldered being held in the hands.

### Types of solder and fluxes

Solders consist of a mixture of pure tin and lead, and sometimes antimony to a proportion of not more than six per cent. The tin/lead proportion varies greatly from about 15 per cent. tin and 85 per cent. lead, to almost pure tin. For general purposes

a 50/50 solder of tin/lead is common. Solders may be obtained as sticks, wire, or in strips, cored with flux, or plain.

Fluxes are the medium for causing the molten solder to run and adhere to the metals, and are usually necessary even after surfaces have been well cleaned. Killed spirit or zinc chloride can be used for most of the metals mentioned in the first paragraph and a suitable preparation is Baker's Soldering Fluid, obtainable in tins. Tallow can be used for pewter and lead. Paste fluxes are also obtainable for general use, or for electrical work.

### Cleaning the metal

The surface to be soldered must be perfectly clean, and this is effected by scraping, filing or rubbing with emery cloth. Only surfaces already tinned will solder without preparation. With the surface clean, a quantity of flux is applied with a small brush or strip of wood, and it is then ready for tinning or soldering.

Tinning is performed by heating the metal in a flame and applying solder from a stick, the solder spreading, and being assisted in this by further applications of flux as required.

### Soldering details

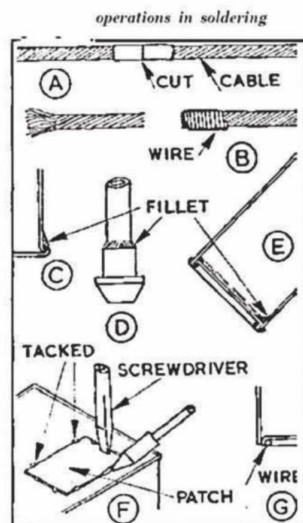
Soldering can be carried out without preliminary tinning, though the latter process renders the work easier. The iron is heated to a point where it gives off a blue-green flame. It is then dipped at the end in a small quantity of flux in a jar, and is ready to work. If only a small quantity of solder is to be applied, the iron is touched on the solder, then on the work. Otherwise, both iron and solder are applied to the work and moved along the joint. It is important for the solder really to flow along and in the joint being made.

If an iron is overheated, the tinning

will be burnt off; its faces should then be filed clean, heated, dipped in flux, and solder applied.

### Typical operations

The drawing illustrates typical operations. Before a cable is cut, it should be soldered. (A) A frayed cable may be bound and soldered (B). Fillets should be formed at the edges of joints and round nipples (C and D). Solder may be placed as lumps in a vessel, and this heated over a flame to produce an internal fillet by revolving (E). A patch should be tacked and held with a screwdriver while soldering (F). A wire may be soldered round the base of a metal jug to absorb the wear (G).



# On the **Wire** **NEWS** from the World of **Hobby Engineering**

## Pandemic 2020 - a distributor's view



Warren Machine Tools, Warco, have tried during the lock down and since to continue to offer good service to our customers. The offices have stayed open continuously since March. While some staff worked remotely, others have carried on working in the offices or warehouses, under severe pressure from busy phone lines and a high volume of orders. While some callers were impatient and did not understand that it is difficult for reduced staff numbers to cope with 6 phone lines and still stay sane, in the majority callers were so kind and sympathetic to the difficulties faced. Managing Director, Roger Warren, said, "The staff have been just marvellous. I am so thankful to them for their dedication and hard work. They have never complained and have taken on tasks which are not strictly speaking theirs just to keep everything running and to keep our customers happy. With staffing levels cut by one third, it has not been easy for them. We have not had to use the

furlough scheme or ask for any Government assistance. In fact, we have now taken on two new staff members with plans for two more."

Following exceptionally high sales during the lockdown and a lack of shipments from suppliers due to factory closures in the Far East, stock levels were at an all time low for some time, but now things are improving, with containers arriving each week.

The launch of the new brochure, planned for March, was impossible, with social distancing regulations taken into account. However, the new publication will soon be finished and can be requested by email, web or phone.

Even at this difficult time, Warco has launched new products: the WM14B belt drive mill, a new drill grinding machine, a belt/disc sander, 2 new educational drills, an entry level mini lathe and the GH1439 gear head lathe. Sadly, Warco's popular Open Days are not possible in the current circumstances, but when we can all get together again, this will be announced on our website. Used and ex demo machines are listed on line and are proving to be very popular.

We thank all customers and associates for their support during this strange time and hope that we can all stay well and safe.

## London Model Engineering Exhibition 2021 Cancelled

The organisers of the London Model Engineering Exhibition have announced that they have taken the difficult decision to cancel the 2021 show due to the ongoing impact of the Covid-19 pandemic.

The organising team has been looking at scenarios to try and deliver the event with the health and welfare of everyone involved at the heart of that decision-making process.

However, it has been concluded that it is not possible to run the event in January 2021 given the commercial implications of the Government social distancing guidelines and mass gatherings restrictions along with the numerous additional COVID-19 safety requirements.

Chris Deith, Exhibition Director, said: "We created this event back in 1996 and since then it has run every year since, becoming the South's major showcase of

modelling and the only London based event of its kind. This was an incredibly hard decision to make and I thank all of our exhibitors and visitors for their support and understanding. Our team has worked tirelessly, exploring every possible option to enable this event to run in January. The current pandemic and the governments restrictions and unclear future plan for mass gatherings have made it impossible to plan and deliver an event of this size at present. We are aware that many thousands of our visitors will be disappointed with this decision but it would not be right to organise an event that does not meet the high standards of previous years".

Organisers said that the event would be returning in January 2022 to Alexandra Palace and they look forward to welcoming all exhibitors and visitors safely back then.



## Powering a Mars Rover

In July, NASA sent its fifth rover to Mars. Its main mission is to collect soil samples that will be analyzed on Earth at a later time. The rover will also carry a helicopter that will perform the first flights on the Red Planet. maxon's precision DC and BLDC motors will be used for numerous mission-critical tasks.

maxon's drive systems are very familiar with Mars. Our drives have been used in virtually every successful robotic mission over the last three decades. There are now more than 100 of them on the Red Planet and there are likely to be more soon. The launch window for NASA's next mission opens on July 30th. An Atlas V rocket will launch the new Perseverance rover on its way to Mars, where it will be searching for signs of previous life on the planet. Its most important job is to take multiple soil samples, seal them in containers and deposit them on the surface of Mars so that a future mission can return them to Earth. Several maxon motors will be used to handle the samples inside the rover. For example, maxon DC motors are installed in the robotic arm, which moves the samples from station to station. Maxon motors will also be used for sealing and depositing the sample containers.

NASA's Jet Propulsion Laboratory (JPL), is carrying out the mission, and have asked maxon to produce 10 drives for the rover. As with almost all previous Mars missions, these drives are based on standard products from maxon's catalog with modifications. For the first time, NASA is using brushless DC motors, including: nine EC 32 flat and one EC 20 flat in combination with a GP 22 UP planetary gearhead. Working closely with JPL specialists, maxon engineers developed the drives over several years and tested them thoroughly to achieve the highest standards of quality. "We've learned a lot from this exciting project," says Robin Phillips, head of the maxon SpaceLab. "We now have very broad expertise in space applications and have established quality assurance processes that meet the expectations of the industry. Customers from other industries such as the medical sector, where requirements are often similar, can also benefit from this know-how." Space missions place the highest demands on drive systems. This includes vibrations during the rocket launch, vacuum during the journey, impacts on landing, and the harsh conditions on the surface of Mars, where temperatures fluctuate between -125 and +20 degrees Celsius and dust penetrates everywhere.

The Perseverance rover is expected to land on Mars on February 18, 2021 – but it won't be alone. A drone helicopter called Ingenuity will be attached to the underside of the rover. It weighs 1.8 kilograms, is solar powered and will perform several short flights, as well as take aerial images. The main goal of this experiment is to test the concept for further drones of this kind. maxon has six brushed DCX motors with a diameter of 10 millimeters controlling the tilt of the rotor blades and the direction of flight. The drives are very light, dynamic and highly energy-efficient. These properties are crucial, because every gram counts on the Mars helicopter. Flying on Mars is not easy. The atmosphere is extremely thin, roughly comparable to the conditions on Earth at an altitude of 30 kilometers. "We hope that everything goes well and that we'll soon see our drives in action on Mars," says maxon CEO Eugen Elmiger. "We're all keeping our fingers crossed."





# Machining a cylinder from the solid

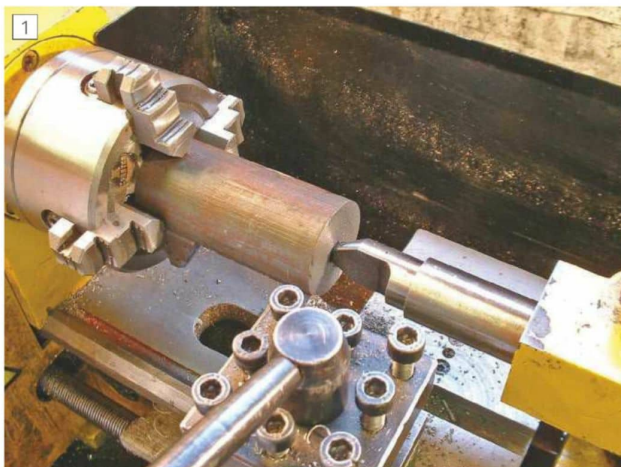


Stub Mandrel describes an approach to milling a complex shape

A few years ago, I unearthed some dimensions and a sketch of an old colliery winding engine. It was an unusual, but straightforward subject, and I decided it would make a great subject for a model. One of the first components I made was the cylinder, which I machined from the solid, that is from a length of cast iron bar instead of a casting. For various reasons, nothing to do with the success of that cylinder, I ended up making a pattern and getting a casting made, but I thought that readers may be interested in how I went about producing that first cylinder.

The cylinder in question has a rather nice shape, being fairly tall and having angled sides that taper into the valve face. This shape lends itself to being machined reasonably easily.

I used Corel Draw, a vector drawing programme, rather than full CAD, to produce my drawings. One of the advantages of using the computer is being able to move things around to see if they fit. In this case I was able to see that there was plenty of room for the cylinder, including the valve face, in a 1½" continuous-cast meehanite bar. This was obtained from College engineering and machined beautifully with no hard spots (unlike square



Cast bar set up in 4-jaw.

section bar which I find may have hard corners) and very little 'skin'.

An eccentricity of roughly  $\frac{1}{64}$ " would leave a machining allowance all around the casting. I set the bar in my 4-jaw chuck using the tip of a tool in the toolpost and a  $\frac{1}{64}$ " drill to gauge the offset. Greater accuracy was not needed.

I then centre drilled the bar and faced the end, supporting it with a half-centre, **photo 1.**

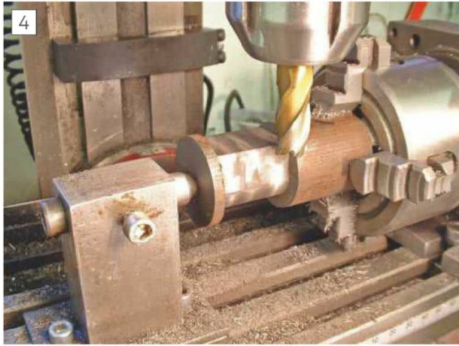
Still in the chuck, I moved the whole caboodle onto a rotary table on the milling machine, supporting the bar with a tailstock in the pre-drilled centre. I had previously adjusted the rotary



Profile milling cylinder 1.



Profile milling cylinder 2.



Profile milling cylinder 3.



Turning cylinder flanges.



Drilling cylinder.



Boring Cylinder.

table to minimise backlash. I then used a 1/2" four flute endmill to shape the outside of the cylinder. For the record, I ran the mill at 900rpm. The milling was carried out in the following stages:

1. Line up the centre line of the cutter with that of the cylinder. Set index to zero and note the reading when approaching from the other direction to allow for backlash. Orient the bar so the 'low point' (which will become the far side of the cylinder from the valve face) is on top. Take two skimming cuts at  $\frac{3}{4}$ " spacing to mark the width of the inner flange faces  $1\frac{1}{4}$ " inches apart. Index reading in one direction set to zero, note that in the other direction (note this is not the expected value of 1.25", due to backlash).
2. Set the cutter over to one end of the cut and on the cylinder centre line. Gently rotate the work through just over 90° (not critical). Set the rotary table index to zero. Move the cutter across to the other flange and turn the table back

183°. Return to the first flange and then retract the cross slide to clear the cutter from the work. One can now see the indication of where the curved surface of the bar has to be machined away, and defined what will be the start of the slightly tapering (to simulate the draft on a casting) flat sides of the valve face, **photo 2**.

3. Measuring across the diameter of the curved surface it was apparent that it needed to be reduced by just over  $\frac{3}{8}$ ". This was done in just two cuts feeding in  $\frac{3}{32}$ " each time. For the first cut the depth was much more than  $\frac{3}{32}$ " once the cylinder had been rotated - about  $\frac{1}{4}$ " in fact, but this did not cause any problems. As well as machining the curve around the back of the cylinder, the cross slide was used to form the sides of the valve faces, **photo 3**. For these final cuts across the sides of the cylinder the rotary table was locked.
4. Finally, the rotary table was locked with what would become the slide

face uppermost. I made the mistake of removing all the material in one go and didn't get a very good finish but didn't realise this immediately, **photo 4**. This meant I had to re-finish the valve face later.

The cylinder shape was now starting to appear. I returned it, still in the chuck, to the lathe and turned down the flanges to size. One of these had to be done using a parting tool, **photo 5**. I was nervous about taking an interrupted cut through the surface of an iron casting with a parting tool. Fortunately, the minimal skin and excellent cutting properties of the bar meant that I had no difficulty. In retrospect it might have been wise to take the 'skin' off the bar before setting it up eccentrically, just in case.

I decide it would be sensible to drill and then bore the cylinder while it was set up accurately centred in the chuck. I went up using several drill sizes in order to avoid any risk of a drill jamming and spoiling the set up, **photo 6**. Final boring was done dead slow with

cutting oil and the tip of the boring tool stoned to a gentle curve, **photo 7**. The reward was the lovely satin grey finish that is ideal for a steam cylinder.

The cylinder bore was given as 9", which scaled to  $\frac{3}{4}$ " at 1:12 scale. This would have left the sides of the cylinder  $\frac{1}{16}$ " thick at most. I felt this did not leave much of a margin for error or strength. The information also stated that this was an estimate, so I decided there was no reason why the bore could just as easily have been 8" on the original engine, and therefore bored the cylinder to 0.667".

I used the half-centre again and reduced the top flange to  $\frac{3}{16}$ " thick, then took away all support and parted off the cylinder leaving the bottom flange the same thickness. It parted away leaving a small ring of metal attached to the end of the bore. This was so thin it broke off neatly under thumb pressure. I gently bevelled the cut edge with emery paper, **photo 8**.

In theory I could have taken advantage of having the cylinder set concentrically to the bore and carried out other operations before parting it off the cast iron 'stick'. I decided not to do this as at this stage I had still not decided on details like the arrangement of cylinder cover studs, and I could only have drilled one end, anyway.

From the sketch it was apparent that external dimensions of the valve chest would be about  $\frac{3}{8}$ " deep and 1" long. The eccentric strap would be about  $\frac{1}{2}$ " diameter. The width of the valve chest

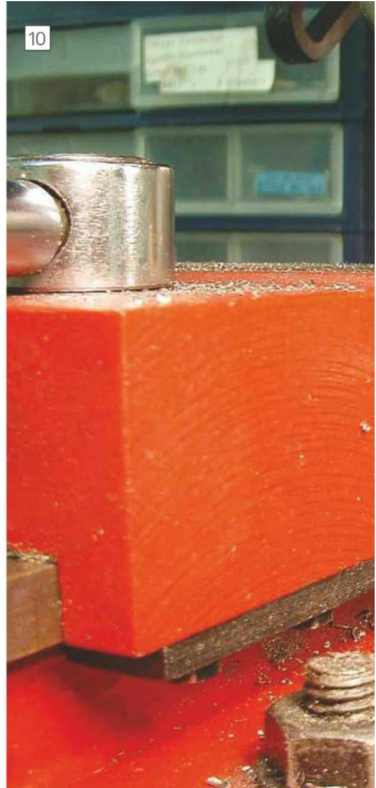


*Cylinder after parting off.*

could not be deduced directly from the information I had, but the technique used for making the cylinder gave a width of just under  $\frac{7}{8}$ ".

I had to decide on my own valve dimensions. I decided on steam port width and spacing of  $\frac{1}{16}$ ", exhaust port width of  $\frac{3}{32}$ " and port length:  $\frac{3}{16}$ ". The ports can be milled out, but for guaranteed accuracy there is nothing to beat a simple ganged cutter as advocated by LBSC.

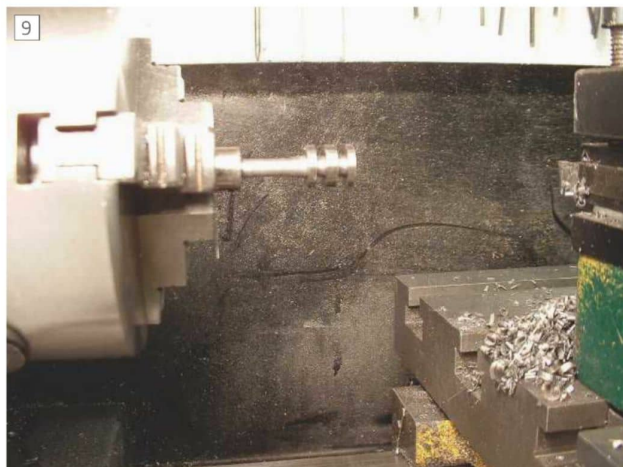
A small diameter cutter is needed, in order to get a reasonable port depth. In this case to get a width of  $\frac{1}{16}$ " a cutter and a depth of approximately  $\frac{1}{16}$ " a cutter



*Machining teeth on gang cutter.*

from  $\frac{3}{8}$ " silver steel was chosen. Using a  $\frac{1}{16}$ " wide parting tool I made a tool blank in the form of three disks on a shank, **photo 9**. The end disks being  $\frac{1}{16}$ " wide and the centre disk  $\frac{3}{32}$ ". The shank had to be long enough to clear the entire slide face and the top flange.

I milled six teeth on the cutter following a sketch by Edgar Westbury in his Model Engineer series "Utility Steam Engines", specifically "Unicorn". This requires milling large 'bites' with the cutter lined up on the centre line of the blank, in order to create pointed teeth with no top rake, and a very small witness at the tip, **photo 10**. With the cutter running fast, but with a slow feed I had no problems with 'grab'. I indexed the blank by eye, as uneven tooth spacing is actually an advantage in this type of cutter, reducing the danger of resonant effects causing chatter. I carefully cleaned up the sides of the teeth with a file. I hardened the whole cutter then tempered it in the oven. I wanted to temper it a bit further than the usual pale straw, as it looked very fragile. I decided to start at gas mark seven (which is supposed to be about



*Gang cutter blank.*





worth being aware of if you are going to the bother of using such an aid to setting up! I advanced the cross slide by half the width of the valve face plus half the width of the ball. I now had to fiddle a bit to get the cutter exactly half way up the valve face, ensuring the chuck would clear the fixing bolt, **photo 11**.

I was very apprehensive that such a delicate looking cutter would bend or break if it dug into the work. With two sets of teeth in the work at once the total cut length would be  $\frac{7}{16}$ ", which is an awful lot for a tool shank about  $\frac{3}{16}$ " in diameter. I ran the cutter at about 500 rpm, and fed the work into it very, very slowly. To my satisfaction, the swarf came out more like fine dust than chips, building into a neat cone beside the cylinder, **photo 12**. The result was absolutely perfect, far better than I could have achieved with an end mill. It seems like the old guard knew a thing or two.

I used a milling vice to hold the cylinder (protected by aluminium slips) and used a  $\frac{1}{8}$ " FC3 cutter to mill the  $\frac{3}{32}$ " deep recesses at each end of the cylinder. I then used a tilting vice to hold it at an angle to drill the steam passages number 53, **photo 13**. I marked the position of the upper valve port on the side of the cylinder in pencil, and repeatedly moved the tip of the drill from in the recess to alongside the cylinder to ensure that it would break out into the port without damaging the face. It is essential that the drill neatly enters the corner of the recess for this to be successful. If you feed too fast or the drill is out of line when it starts, it will wander and could either snap, miss the port or, worst of all, emerge in the port face. I used a depth stop on the mill, and as you can see in the photograph, the drill neatly entered one side of the port. Without

220°/pale straw) knowing the oven thermostat was inaccurate by about one mark. This was just as well, as after a false start (my wife turned off the 'empty' oven), the cutter came out an even pale bronze colour that probably equates to dark straw. I used a diamond slip to clean up the sides of the teeth and to put a shine on the cutting faces.

I clamped the cylinder to the milling

table (you could equally clamp it to a vertical slide on a lathe), with the valve face perpendicular to the long axis of the table. I used an edge finder to locate one side of the valve face. This is a 'ball on a stick' which when spinning over a surface stays still, until they are precisely aligned, when it 'runs' along the surface. My ball is meant to be 0.250", but I miked it at 0.248". A difference well



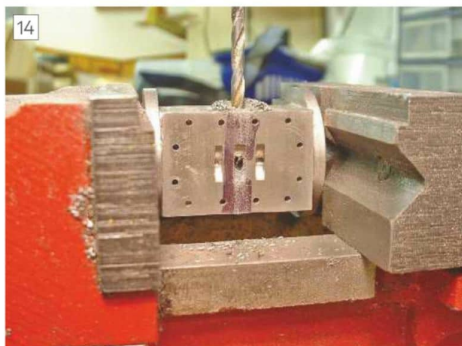
Gang milling set-up.



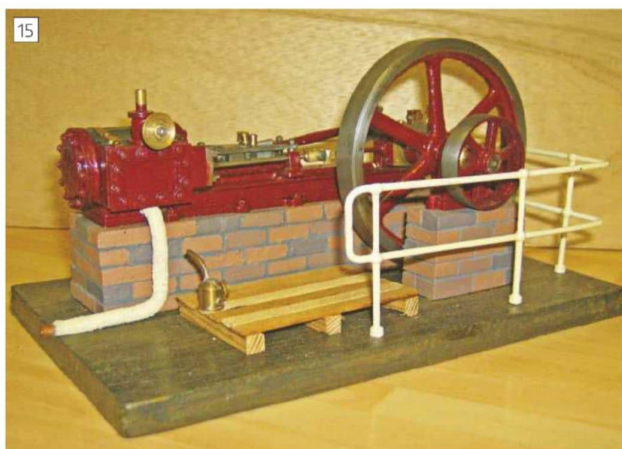
Gang milling ports.



Drilling steam passage.



Drilling exhaust passage.



The cylinder in place on the model Buxton and Thornlea engine.

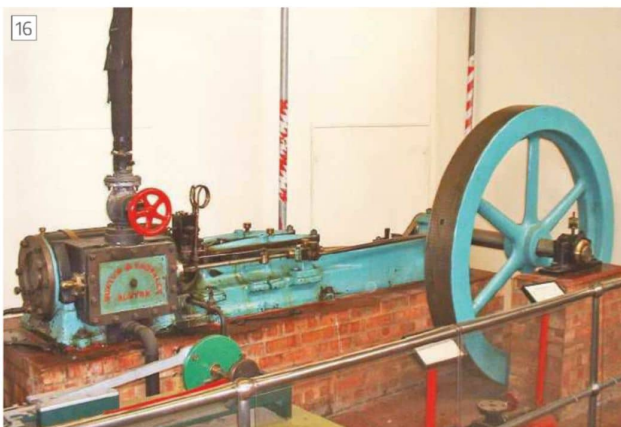
altering the angle of the vice I inverted the cylinder and drilled the other steam passage.

This is a rather nerve-racking procedure. Try to err on the side of drilling at too shallow an angle, as if you miss the port you can 'poke' a  $\frac{1}{16}$ " drill into the bottom of each port to link it to the passage. If you use an end mill to create your ports, you can make them a little deeper and the job becomes less critical - you can make a wooden 'cradle' to hold the cylinder for drilling as you won't need to make small adjustments to the angle.

The final task at this stage was to drill the exhaust port, a less critical operation, as all I had to do is drill parallel to the valve face and avoid breaking into the cylinder bore, **photo 14**. The only danger is breaking the drill as it emerges into the port.

Now there it is, a cylinder complete, aside from drilling and tapping for the steam chest and end covers. While the process was rather more involved than machining a casting, it was far easier than I expected, largely because of the kind nature of the material used. So, if you decide to model a steam engine for which there are no suitable cylinder castings, have a go at milling one from the solid.

So, finally, what happened to the cylinder in the photographs? Along with some other spare parts from the other engine, I used it to make a semi-scale model of a Buxton and Thornlea engine, **photo 15**. The original is in Abbey Pumping Station, in Leicester, **photo 16**, and it has a particularly interesting cast bed, which on the model was milled from a section of aluminium bar – but that's another story. ■



The full size engine at Abbey Pumping Station.

# Scribe a line

## YOUR CHANCE TO TALK TO US!

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

## Model Engineering Books for Beginners

Dear Neil, in MEW 294 Bob Marchant wrote on 'Choosing Steels'. I think he is referring to the book "The Complete Modern Blacksmith" by Alexander G. Weygers. The book runs to 300 pages and I think MEW readers will find much of interest between its covers. Several pages are devoted to rebuilding a South Bend centre lathe which are very interesting.

The author attended a technical school between 1915 and 1923 where he learned to use a lathe, so he uses the methods MEW readers will be used to. Many younger readers of MEW never learned about woodwork and metalwork at school, so the book will go a long way to answer beginners' questions. Michael Portillo on a recent TV travel film visited a farmer who was using a machete made from a recycled Land Rover suspension spring to harvest and trim pineapples. He was highly impressed with the machete, probably made using Weyger's methods.

Before starting the pastime, a book well worth reading is 'Setting Up Your Home Workshop' by Stan Bray, some good tips on workshop location and tools etc. required. Stan Bray was the first editor of MEW.

During the 50, 60 and 70s, the standard of textbook for engineering students on the subject was 'Workshop Technology' in three volumes by W.A. Chapman.

The Engineering Industry Training Board published 'Training Practice for First Year Students', again another excellent book for anyone with little or no engineering knowledge. There are several books in this series covering various engineering subjects.

Before investing in a lathe, beginners will find much information in 'Lathe Design, Construction and Operation' by Oscar E. Perringo. Another excellent book on lathe design up to the year 1916, the book contains much information on what to look for in a lathe before purchase, this information is just as relevant today as it was in 1916.

The book 'General Engineering Practice' by various authors, published by Odhams Press, is a guide to the principles and practice of workshop procedures that appears to be a Second World War publication judging by the paper used, it goes to 550 pages and covers most of the procedures a beginner is likely to come up against.

Before building a work bench, may I suggest the Workbench Book by Scott Landis, aimed mainly at woodworkers, but there are many tips of value to the metalworker between the covers.

The majority of the books mentioned may be found at car boot sales, charity shops secondhand bookshops etc.

Clive Barton, Ilkley

## Cross Slide Lock

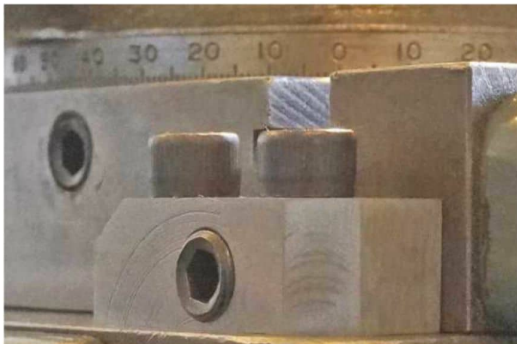
Dear Neil, Inspired by Peter Brewer's design for the Myford 7, I've just made a cross-slide lock for my Super 7.

It works on exactly the same principle – a brass locking pad pressed against the slide. The photo also shows the two, entirely reversible, modifications needed:

- Two of the cap screws joining the apron assembly to the saddle are increased 1"x1/4" BSF to 1.5" long.
- The square-headed screws that lock the top-slide are replaced with 3/8" BSF socket-head grub screws.

As luck would have it, the same Allen key fits the grub screws and the cap screws.

Peter Hastings, Portree





## Rotary Table

Dear Neil,  
The latest issue of MEW has just dropped through the letter box and I was delighted to see my rotary table on the front cover. Thank you very much.

On reading through the article, it seems a gremlin has been at work as photo 9 is actually photo 10. I don't know whether this puts a spanner in the works for you to correct the error.

I just wonder if in the next instalment photo 9 will be where photo 10 should be.

Anyway all in all I am delighted to have this constructional article published, and to say how well the photos have reproduced. Thanks very much.

**Rev. Ian Strickland, by email**

*We were able to repeat photo 10 in its place in issue 297, the correct Photo 9 has been retrieved from the Gremlins and is shown here. Neil.*



## Cutting High Speed Steel

Dear Neil, I need to cut 1/8" diameter high speed steel into 4 x 14mm pieces for insertion into bars for keyway cutting. This is something I have never had to consider ....what do I use? A Dremel fitted with suitable disc cutter? A high speed hacksaw blade doesn't seem to cut it!

**Colin Scott, by email.**

*A Dremel will do it, with a composite cutting disc or a carbide one, but wear goggles. For larger HSS, I cut a notch, hold in a vice with it sticking up and the notch level with the top of the jaws, cover with a cloth and hit with a hammer. Naturally, this then needs to be tidied up on a grinder. It would be interesting to hear other reader's ways of doing this - Neil.*

## Museum Piece?

In MEW 296 I noticed an advert from Home and Workshop Machinery for a Myford ML1 lathe as a 'museum piece'.

In 1962 I found an old Myford A2 lathe in a hedge at the bottom of an old lady's garden. Very rusty but all complete. By complete I mean cast iron gear guard, cast iron tray on original cast iron legs with 'M' cast in both of them.

I rebuilt it and have been using it ever since, making over 60 steam engines and hot air engines.

I wonder if there is a register somewhere or someone who would know of its age?

**Lionel Stout, Penarth**

*For those with access to the internet our forum at [model-engineer.co.uk](http://model-engineer.co.uk) is remarkably good at turning up identifications and information on old machinery. The website [www.lathes.co.uk](http://www.lathes.co.uk) also has information many old machines. The site tells me that A1, A2, B1 and so on were foundry marks used on the beds of ML1, 2, 3 and 4 lathes, but not clearly linked to specific models. This suggests Lionel's lathe is probably one of these models and is most likely to date from the 1930s. I am sure other readers could confirm that many of these 'museum' pieces are still in use! - Neil.*

## DeWalt Extreme

I'd like to thank D. Wilkinson for drawing my attention to 'DeWalt Extreme' HSS bits. These drill bits have 'stepped' tip with a small, more or less conventional tip ahead of a wider cutting diameter with 'wings' not unlike a timber bit. These drills are supposed to be faster than conventional drills offering burr-free holes and grab-free performance on thin and sheet metals. I have yet to try them out, but apparently they offer along cutting life - important as they look rather difficult to sharpen! Mr Wilkinson says he also find them useful as counterbore/spot facers. He adds that he has found ninety degree router bits useful as 'spotting drills'.

## Index Query

Dear Neil, In the centre of the latest MEW (No.297), there is an index where the first column is the Subject. In this column, there is an abbreviation "INST/SERV". I can sort out what all the other abbreviations are but I cannot fathom out what "INST/SERV" means. Can you enlighten me?

**Anon. by email.**

*I have always understood this to be shorthand for 'instructional/service' as is always used for 'how to do this' articles - Neil.*

## Angel Eyes

Dear Neil, having just installed my new Sieg SX3 mill it became obvious that I would need to illuminate the work area. Inspired by various articles on whether to use floods or LED lights I opted to try and use an Angel Eye - those 12v LED rings used in many new cars' headlights as running lights, and which can be sourced very cheaply on the web. I purchased a 120mm unit and went to work with Atom3D. An hour or so later and the 3D printer was printing the housing, and then a transparent lens. Because the LED rings are so small it was fairly easy to make the compact unit shown, which fits snugly on the outside of the quill and, I'm pleased to say, produces a bright, uniform shadow free illumination of the work area. I'm happy to pass on the files to anybody who would like to download them. Now to get onto some serious swarf production.



Lionel Pullum, Australia

## Mystery Object

Dear Neil, I think I can give a likely identification of the item in a photo sent in to MEW 297 by Richard Arwel Jones from North Wales.

It appears to me to be some sort of Dial Indicator, as you are probably aware there are two main types of DTI (Dial Test Indicator) used in engineering, both model and production. One type uses a rack and pinion mechanism with a train of gears, not unlike a mechanical time clock or watch in which a small movement in the rack is magnified on the dial and can typically have a range of 0-1" or 0-25mm, some can even have a range of 0-2" or 0-50mm.

There is also a smaller range movement which uses a scroll as the means of movement, typically giving a range of say 0 - 0.030" movement or 0-1mm range. This one appears to have a lever movement and a range of say 0-0.010".

How it would work is that it appears that the button on the top left-hand is connected to a lever which is unequally pivoted i.e. that the arm that the button bears on is pivoted closer to the button so that a small movement of the button is magnified by the pointer against the scale at the bottom, the button would be spring loaded so that when it is out of contact or you are measuring a small deflection the button would move in and out just like on a full sized DTI.

The long, apparently round, rod that sticks out of the bottom of this device is what you would clamp into a magnetic stand or indeed you could use it in the place of a scriber on a scribing block.

Hopefully this will be an answer to Richard's question, it is amazing what we can find when we buy old engineers' tool boxes and cabinets. I do voluntary work in a local branch of Marie Curie up here in London, and it never stops surprising me what we find in donations brought into the shop. Camera's watches, jewellery etc.

J. E Kirby, Stoke Newington



## Mystery Object 2

Dear Neil. I got one of these from my late father who worked for Rolls Royce Derby in the 1940s I should have asked him about it but never did. I assumed it to be an early type of DTI to check run out on shafts etc. the button in the top left hand of the photo makes the needle on the scale move, the graduations probably a thou but haven't checked.

Ray Ascroft, by email.

*Thank you also to Graham Perry who also offered this identification. My apologies to Richard Arwel Jones for shortening his name in the last issue - Neil.*

# A Temporary Coupling



Des Bromilow uses his ingenuity to test a salvaged gearbox.



*The coupling recessed inside the gearbox.*

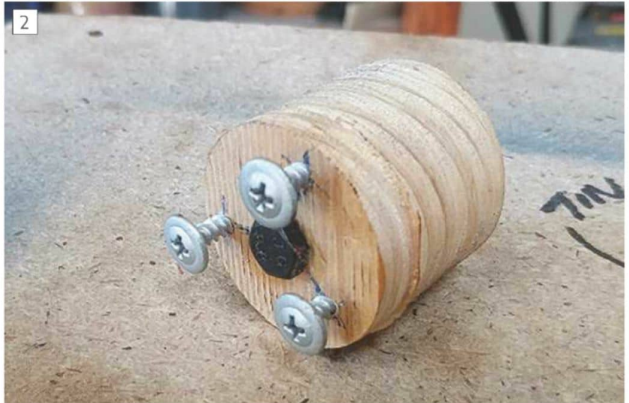
I have been collecting parts to make a small powered hacksaw to take standard 300mm (12") blades. This means I'm always on the hunt for salvageable worm drive gearboxes to mimic the design I am copying.

I stumbled across a 100:1 gearbox with no markings in an industrial skip bin, so I grabbed it with the intent of testing it for my purposes.

Once I got it home, I found that hand turning the recessed input shaft coupling did not produce a detectable movement in the output shaft, so I cobbled up a means to turn the coupling quicker using a power drill, thereby hopefully seeing movement at the output.

The "wheel" from a holesaw job was found to fit easily inside the coupling recess, **photo 1**, so it was simply a case of dividing the face in 3 even divisions (there was enough grease on the coupling face to take an impression of the three teeth) and drill for 3 wood screws. Once the pilot holes for the screws were drilled, they were run in and left protruding about 8mm, **photo 2**.

A long 6mm bolt was then passed through the arbor hole of the holesaw blank and nutted up tightly. Additional nuts were then wound one and tightened up to lock the first nut and



*Face of the adaptor.*

create an extended hex nut shape, **photo 3**.

The nut is then gripped in the drill chuck and ran clockwise so the nut would not loosen up.

Unfortunately, in my case I found that this particular gearbox has a section of about 10 degrees where the

spur gear has been stripped, so the gearbox is only suitable for scrapping if I cannot rebuild it. At least my test has saved me a lot of potential frustration and hopefully this trick might be of use to people providing temporary connection to recessed push-drive couplings. ■

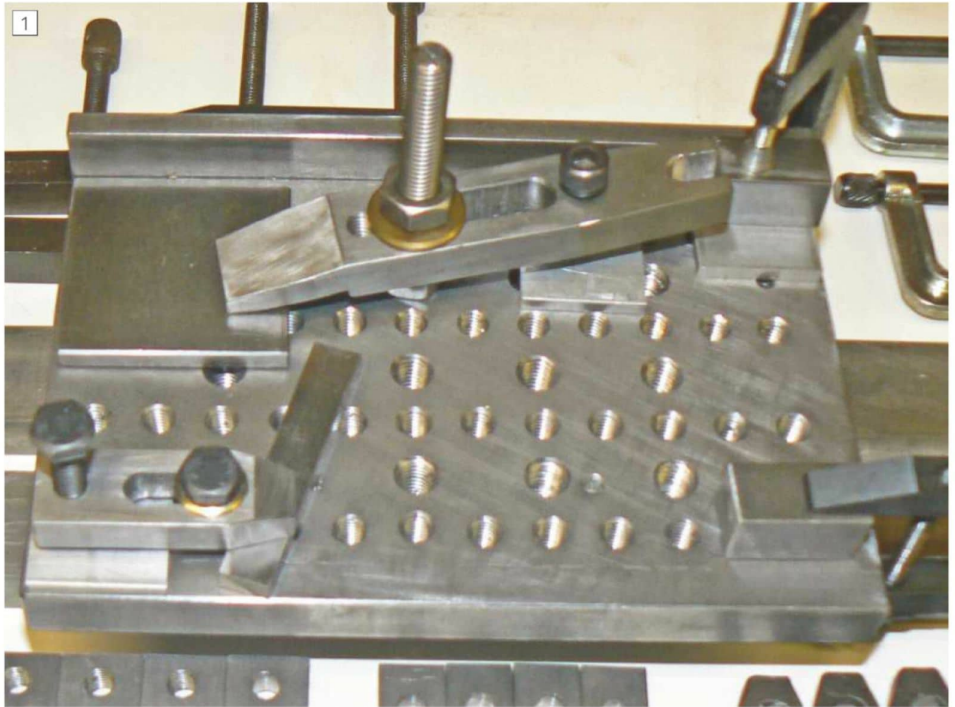


*Side view of the adaptor.*



# A Work-holding Sub-Table

Rod Renshaw makes an accessory to improve accuracy and convenience



The sub table.

**T**hough the drilling machine clamp described in my first article (MEV 276) worked well for work which could be held in the drilling vice, there were some flat, plate-like workpieces that were difficult to hold easily for drilling. For very small workpieces of this flat shape the obvious answer is the toolmakers' flat vice or finger-plate (the same thing, known by two names). This is a classic design much used by clockmakers, especially for drilling brass, and it works well - for small work. But when I tried to scale this design up a little for slightly bigger work, I found

two problems. The larger cutting forces involved when drilling slightly bigger holes in steel tended to cause rotation of the workpiece under the single clamping finger, and the vice itself tended to move on the table of the drilling machine unless clamped down. The issue of clamping the flat vice down brought me back to the issues of clamping down the usual drilling vice. I was told that when using a milling machine I must always use at least two clamps to secure the work. The classic flat vice design breaks this rule and only gets away with it because the work and cutting forces

usually involved are so small.

What I thought I needed was a larger version of a flat vice, with versatile and secure clamping options, and with a capability to be maneuvered and clamped easily on the table of the drilling machine.

After some thought and a few false starts, I decided on a sub-table of a type which is often used on milling machines but rarely, as far as I know, on drilling machines.

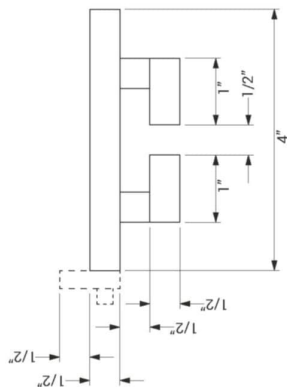
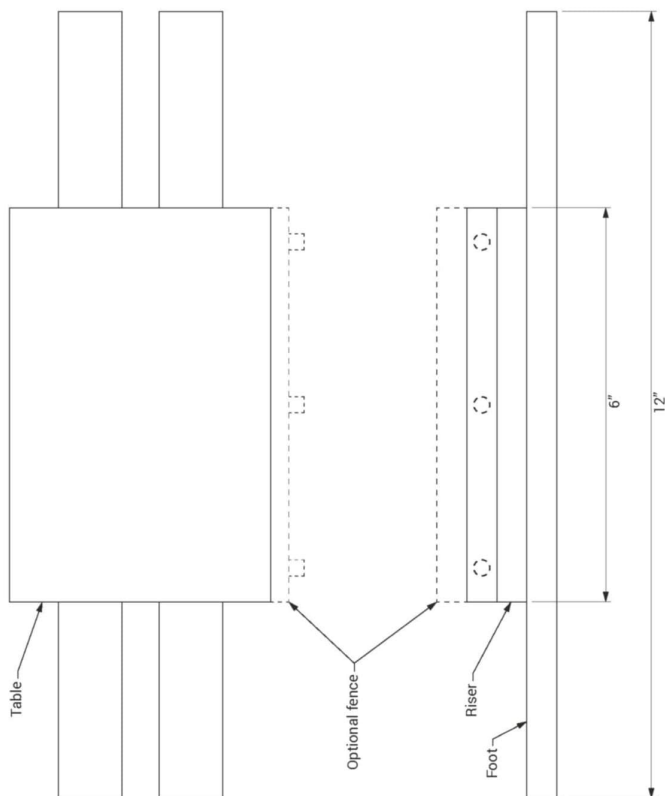
Basically, the sub-table is a flat vice which has fixing lugs to clamp it down. It replaces the normal drilling vice on



Fig.1

# **Sub-Table General Arrangement**

Mat'l: BMS  
 Table =  $4'' \times 1/2''$   
 Risers (2) =  $6'' \times 1/2'' \times 1/2''$   
 Feet (2) =  $12'' \times 1'' \times 1/2''$   
 Fence =  $6'' \times 1'' \times 1/4''$   
 (Optional fence drawn as dotted lines)

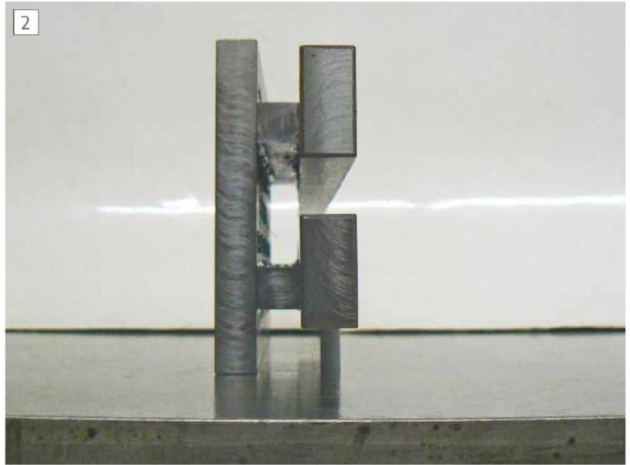


the table of the drilling machine, and it is held secure by the drilling machine clamp I described in my first article.

The sub-table consists of the table proper, which corresponds to the base of a flat vice, and to which the work is fixed, and a pair of 'feet' that facilitate maneuvering and clamping the sub-table down on the drilling machine. The long feet allow for adjustment in the side to side direction and the slots in the drilling machine table allow adjustment in the front to back direction. There are also two risers which lift the table clear of the screws and nuts of the clamp and allow the sub-table to slide from side to side without restriction. If very long work is contemplated there is no theoretical limit to how long the sub-table could be, though considerations of overhang will set a practical limit.

The five parts of the sub-table can be fixed together by any available means, screws, rivets, adhesive or silver soldering. I used epoxy and then inserted hex-socket cap screws from underneath, just in case.

**Figure 1** and **photo 1** show mine as I made it but all sizes can be varied. If your work is small, then consider making a smaller one. I think it could be used to



*Ensuring alignment of feet.*

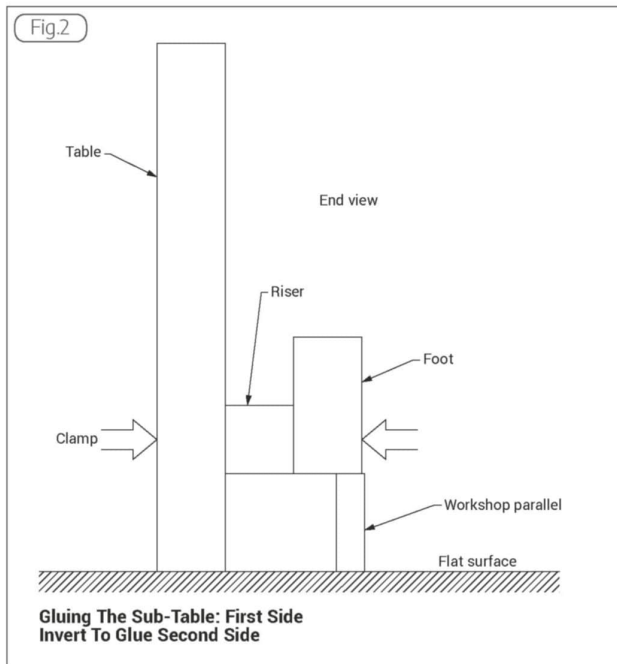
hold and drill clock plates of reasonable size, so perhaps a clockmaker might use a big, but less beefy, one for the plates and a smaller one for the clicks and other bits. None of the sizes of any of the parts are critical. I used lengths of

bright mild steel flat as available. There is no complicated machining; it's just like making a bigger and slightly more elaborate flat vice.

The sub-table and clamp combination is very easy to use. If you once clamp the workpiece to the sub-table, the clamp will allow the drill to reach wherever you need to drill, and it feels very safe because the clamp holds the sub-table securely.

If you are varying your version of the sub-table from the dimensions as drawn, there are some design considerations. The table needs to be stiff enough to not to deflect under the drilling pressures, which can be considerable, and thick enough to give a secure hold for the screwed pillars on which the flat vice fingers articulate. The 6 x 4" size of the table is not intended for work of that size but rather to allow for clamps to surround the work if needed.

The feet need to be flat and straight, and stiff enough to remain so. Their width needs to exceed that of the risers so that they form a ledge under the table which is wide enough to allow the clamp nuts and washers to get a secure hold, it's just like an inverted t slot. The feet need to be long enough to allow the table to be moved from side to side under the drill without disengaging from the nuts of the clamp at either extreme, I found the feet needed to extend a little more than half the distance between the slots on my drilling machine table on each side of the table. So, in my case, slots 5" apart, divide by 2, plus (say) 0.5" equals 3"





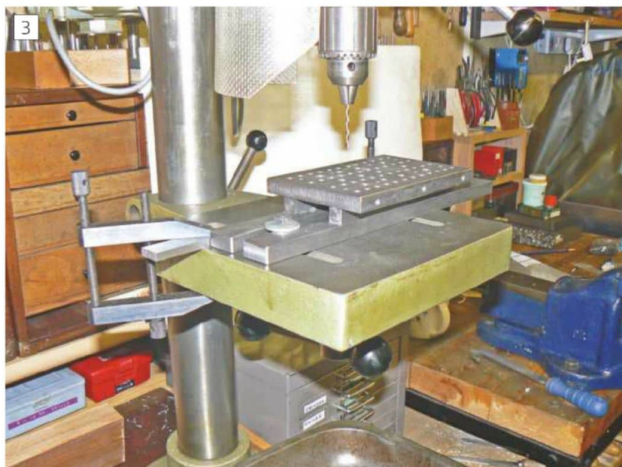
on each side. But check on your own machine.

The risers need to lift the table clear of the feet to allow the screws and nuts of the drilling machine clamp to pass under the table. Their width needs to be enough to accommodate any screws used to hold the whole thing together.

For jig-drilling operations it is very useful if the long edges of the table are parallel with each other. I glued my sub-table together with epoxy, one side at a time, on a flat surface, using a  $\frac{3}{4}$ " workshop parallel under the foot, as in **fig. 2** and **photo 2** when both ends of both table side and foot edge contact the flat surface and the workshop parallel, and the assembly does not rock, then the table edge and the foot will be parallel. If you plan to do this it is worth checking what sizes of workshop parallel you have available when designing your sub-table.

For securing the work the table is drilled with a pattern of small tapped holes to suit small clamps of the type described by George Thomas in his articles on setting up aids and many workers will already have a shop-made set of such clamps. For an awkward job, just drill and tap some additional holes where needed. Additional tapped holes make the table more versatile for future jobs. I used M6 holes as I already had a set of small clamps which used M6 screws.

As a general point here, holes in jigs and fixtures are usually better drilled through rather than being left blind. Through holes are easier to keep clear of swarf, and if they need to be tapped, it is easier to tap a through hole than a blind one. A deep tapped hole for a clamping screw only needs to be tapped about 3



*Sub table on pillar drill.*

diameters deep and the rest of the hole can be opened up to a clearance size for the rest of the depth. Open up the holes from underneath, of course.

The table can also have one or more larger tapped holes to take screwed post(s) to accept clamp fingers as used on toolmakers flat vices or finger plates, and it can also have plain or tapped drilled holes and a "v" groove or any other enhancement the maker thinks useful, just like a flat vice. For larger work, which might rotate if held by only one finger, then two, or even more, posts and fingers can be used. These features can be added to over time as the needs arise. I used  $\frac{5}{16}$ " BSF tapped holes and screwed posts to suit fingers borrowed from my classic flat vice.

The table overlaps the risers at

the sides so that small toolmakers or G-clamps can be used to secure the work.

Finally, smaller work can be secured with adhesive, shellac, soft solder or double-sided tape. Secured either directly on to the table or on to a small piece of plate which is itself clamped down to the table. I find the small piece of (metal) plate idea works well as it is easier to heat just the plate to persuade the adhesive to release rather than heating the whole sub-table.

**Photos 3 and 4** show the sub-table in use and a selection of clamps used with it, you don't need all these types, but if you have them...

The sub-table can be used for just spotting holes, or, if a sacrificial false table (just a piece of alloy sheet, thin plywood, medium density fibreboard (MDF), etc.) is put under the work, then the holes can be drilled right through the work and into the false table. I have found MDF about  $\frac{1}{4}$ ", (6mm) thick convenient for sacrificial tables and despite their name I find that in my amateur shop a piece of MDF lasts for a very long time before I need to turn it over and use the other side. A selection of small squares and rectangles will be found very useful. Why  $\frac{1}{4}$ "? Well, I find I can easily judge setting the depth stop on the drilling machine to within  $\frac{1}{8}$ ", so I get a clean finish to the holes in my workpieces and I don't overdrill into the table, or not very often.



*Table and selection of clamps.*

●To be continued

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# A Vertical Alignment Device for the Emco Compact 5



Graham Meek describes a useful accessory with a long history, with photographs by Jamie Wood.



*Milling machine fitted with the device.*

**D**uring the 1980's I was making many different items for Neil Hemingway for resale. Among these was an alignment device for the Unimat 3 Milling attachment. This device allowed the Vertical milling head to be raised and lowered at will, with no loss of position. It was not long after this attachment was introduced to the marketplace that someone asked Neil,

"Did he do one for the Emco Compact 5".

Of course, Neil was soon on the telephone asking me if I had made one for this machine. Not having owned a Compact 5 at that time there had been no requirement to design one. However never one to pass up a challenge I contacted the MD, Mr Colin Worner at Emco UK with a view to borrowing a Vertical Compact 5 attachment, **photo 1**.

Thanks to past business with Emco an attachment duly arrived by Securicor a few days later.

Not long after the design was formulated, Neil had a further call from someone with a Toyo lathe and vertical attachment. The question then was would the Compact 5 design fit the Toyo. Well with a certain amount of tweaking the design was adapted to





The base clamp plate

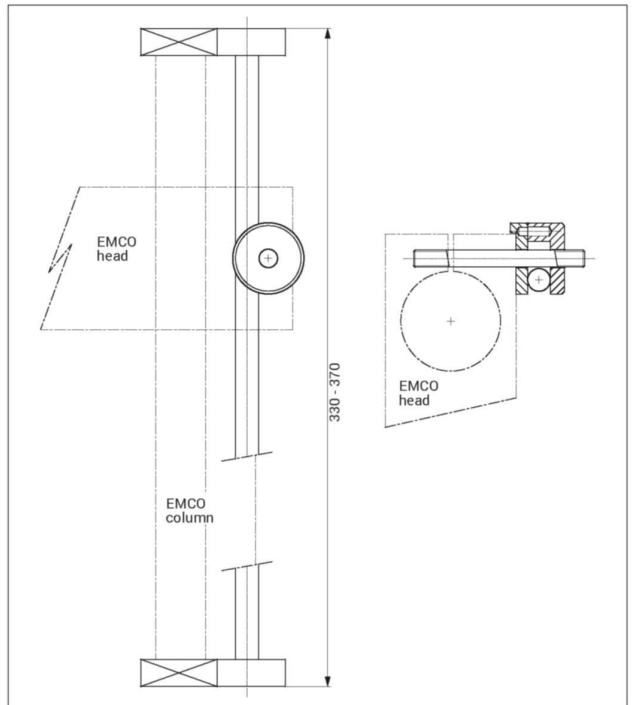


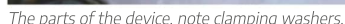
The top clamp plate

accommodate the Toyo as well. It did however mean bespoke parts for each version, luckily the differences were minimal. Thus, the vertical alignment device for the Compact 5 / Toyo was born, or as Neil usually called it, "the VAD". To bring things up to the present day, Toyo was later marketed under the Record brand, so anyone who has one of these machines could have the benefit of the attachment. Manix now manufacture what was the Toyo machine line-up, so again anyone with these machines could benefit from this design. Proxxon machines also have a Toyo heritage so these too should take the attachment. However, given the intervening years it would be a wise move on the readers part to check through the sizes before starting.

Just in passing the drawings for Unimat 3 version have been lost somewhere along the line. Although there is a picture of the device in the Model Engineer, in Around the Trade, something Neil did with the then Editor, unfortunately I cannot tell the reader which issue that was, but I do remember the picture.

The reason this design has surfaced now is down to a comment I made in response to a query on the Forum concerning the Compact 5 Vertical Attachment. This prompted Jamie Wood to contact me and ask for drawings





The secret with manufacturing this attachment is the need for two identical clamp plates, **photos 2 & 3**. these are made out of 2" by  $\frac{3}{8}$ "

8 mm hole was removed with a hand reamer, the column bore was not so easy, so it was purposely made oversize to accommodate the coating. If the reader is not coating, or painting, his or her attachment, then the bore can be made a better fit.

The steps on the clamping washers are best milled away whilst still attached to the parent bar stock, **photo 4**. While I had the benefit of a larger lathe to part off each component, this might present problems on the Compact 5. To finish the faces of each washer after cutting from the parent bar stock I would be inclined to mount the part on a 6.5 mm diameter spigot mandrel. Either by using Loctite, soft solder, or by making the part a press fit on the spigot. It will be found that a more rigid set-up will be had if the spigot is machined on something like ½" diameter bar and with the previously milled face abutting the machined face on the mandrel. It will also ensure the part is running truly. While I have drawn the snug at 3 mm diameter, there is no reason why this cannot be 2 or 2.5 mm if preferred. The only requirement of the snug is to maintain alignment of the parts during use. Notice the hole in the clamp washer to clear the snug is slightly larger to prevent any binding and loss of clamping efficiency.

Assembly is pretty straight forward, but you will need to acquire an M6 adjustable style female lever, **photo 5**, a “Kipp” diecast unit was supplied by Neil in the kit. The column is best removed from the machine and motorised head



removed from the piece that clamps to the column. The two clamping plates are aligned on a flat surface once assembled onto the column. By flat surface I mean surface plate or a piece of plate glass. Two parallels carefully laid across the lathe bed will provide clearance over the cross-slide so that the bedways can double as a

precision flat surface. Of course, the tailstock will need to be removed. This is where the datum edges that were used as the origins for the coordinates come in handy. Once locked in position the 8 mm Silver Steel rod is offered up and it should pass through each hole without difficulty. Unless it is bent, and I have known this, so never take things for

granted. Rolling the Silver Steel in two matching vee blocks with a DTI over the centre of the bar will show up any bend.

Once satisfied with the assembly the column can be reunited with the motorised head and the column reunited with the machine. Don't forget to tram the head to get it truly upright. ■



Close up, showing clamp lever.



# A Simple Indexing Device

John Hinkley makes this interesting indexer which can do all degree steps from 0 to 360 - Part 2.



Drilling index holes.

The rotary table has a worm ratio of 90:1, like so many do, so I used a twenty hole division plate and calculated the number of turns and holes accordingly to obtain the degree spacing called for in the design. The note on fig. 2 explains in more detail and **photo 3** shows the process in progress on the reference plate.

## The indexing plate

The central hole was produced in the same manner as the other plate, although this time to 20mm diameter, the same care being taken to ensure a good fit, this time on the chuck shaft. Obviously, I had the same hardness problem with this plate, but by now I was forewarned so no more lathe tools were harmed during the reduction to 60mm diameter. Next, the 40mm diameter relief was formed on the outer face with my trusty Sandvik boring tool.

After the edges were chamfered, it was mounted on the mandrel in the rotary table and the 6mm tapping size holes were drilled using the same procedure as before, only this time, after each drilling, I replaced the drill with the 6mm tap and tapped the hole before moving onto the next spot-drilled position.

The retaining washer mounting holes were next to be drilled and the extremities of the keyway slot were drilled to ensure correct alignment.

At this point, I glued the Oilite bearing into the reference plate and after the glue had set, reduced its width to 10mm, flush with the outside faces of the plate.

I have recently taken delivery of

a brand new Warco surface grinder, so I decided to try it out on the two plates. When I measured them, I was surprised and delighted to find that they were both about 0.1mm over the 10mm thickness required, so I set about them with the surface grinder and got quite a nice finish on them, for a first attempt. Well, I had to justify the purchase somehow, my wife having kept on asking: "Have you used that new machine, yet?" Now I could reply "Yes, and very I'm very pleased with it."

## The retaining washer

**Figure 5** shows the dimensions of the retaining washer, which incorporates the key to lock together the indexing plate and the collet chuck shaft. It was formed by chucking a piece of mild steel in the four-jaw and reducing it to 40mm diameter then further reducing the outer face to the 26mm diameter to a depth of 3mm. This would eventually form the key. An 8mm clearance hole was drilled in the centre before it was parted off to slightly over the 6mm length. Off to the surface grinder again for more grinding practice and reduce it to 6mm!

Replacing the mandrel with a three-jaw chuck on the rotary table, I used a 6mm carbide cutter to form the keyway as shown in **photo 4**, having ensured the retaining washer was oriented correctly with the holes already drilled. There was just enough room between the jaws and the outside of the 26mm diameter part.

## The detent screws

Both these were made from a length



Cutting keyway.

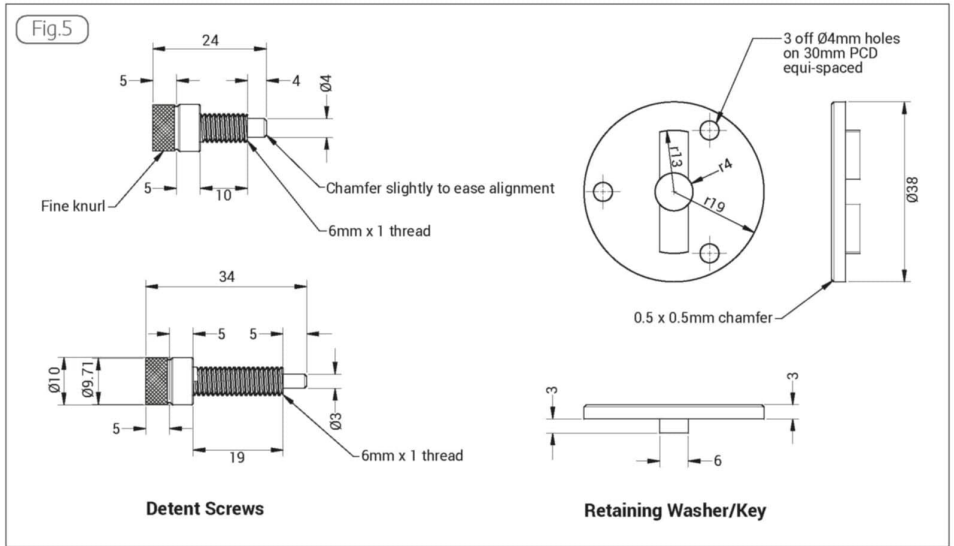
of 10mm diameter silver steel and were a straight forward turning job, although great attention was given to achieving a very good fit of the end pin parts that engage in the reference and indexing plates to avoid any sloppiness in rotational engagement. Two attempts were required for the reference plate screw before I was satisfied with the fit. Figure 5 - the minor parts - contains the dimensions used.

With the benefit of hindsight and in the light of experience with the fixture, it was found to be useful to put a slight chamfer on the end on each detent screw to assist with the initial alignment with the hole in the adjacent plate.

Engraving the division lines and stamping the numbers

I used the previously made machining arbor to mount each of the plates separately for engraving the division lines, starting with the reference plate. I had already decided that, unlike the Alibre design, I would only engrave the 10° divisions half-way across the width of the plate. This would allow me to stamp the numbers equally spaced either side of the line in the unmarked portion. I determined, by playing around with the design in the CAD program and careful measurement of the number stamps available to me, the spacing needed either side of the line.

The indexing plate was similarly engraved halfway for the same reason. For this plate, I tried aligning the numbers with the engraved line by hand by eye. The result was, shall we say, less than ideal. In addition, my smallest number stamps are not of the highest



quality and don't produce as crisp a number stamp as I would have liked. I decided that, in view of the fact that the numbers were going to be much closer together and more numerous on the reference plate that some sort of jig was required. so made one such that the stamp was held on the plate centreline and vertically above the centre. The result was one of which William Heath Robinson would have been proud, no doubt, but it did the job although I was still not happy with the results. In fact, I was so discontented with the number spacing that I machined them off and merely stamped a zero at the appropriate position, while I decide on a different approach for the rest of the numbers.

In the meantime, careful counting of the divisions will be the order of the day. The result is shown in **photo 5**. Oh, for an engraving machine!

### Final assembly

I considered using Loctite to secure the supports to the base and the spacer tube to the supports, but in the end decided against it, in case I needed to dismantle it at some time in the future.

It didn't take long to put everything together and make sure that the theory, already tested in the CAD program, worked in the real-world version. I'm glad to report that it did!

### Further development

I purchased a revolving handle with



*The finished indexer, before engraving.*

a 6mm thread, which screws into the indexing plate. By removing the reference detent screw, the handle can be used to continuously rotate the collet chuck. I intend to try out this feature to cylindrically grind some round stock on the surface grinder.

I have also drawn up a couple of alternative shafts in the Alibre program; one has a 80mm diameter backplate for the mounting of a similarly sized three-jaw chuck, the other has 1½" x 12 Myford-style nose thread. I have a chuck, suitable for the former so I can see a use for that, but I personally don't expect to hang any Myford accessories on the front of mine!

Since writing this article, I have purchased a bench top engraving machine by David Dowling Limited and have experimented a little with it. I have engraved the numbers on the plates

with mixed success. I think I've engraved too deeply for what I consider to be an acceptable finish and have decided to re-make both plates and try again. That should keep me occupied for a couple of weeks

Since constructing this indexer and writing the article, I have acquired an engraving machine but have yet to gain experience in achieving engraving on curved surfaces. I was unhappy with the finish of the reference plate markings, so, as an interim measure, I drew a scale in my CAD program such that it fits exactly the circumference of the reference plate. This was printed onto self-adhesive clear decal sheet. Carefully cutting it out and applying it to the said plate gave a pleasing "graduated" effect which has so far withstood the test of time well. **Photograph 6** demonstrates the result. ■



*And after engraving.*

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# A 5" Diameter Rotary Table

Ian Strickland details the making of a fine piece of workshop tooling based on an original design by G.G. Tardrew - Part 3.



Indexing worm being cut, Part 7.

## Part 5, Pressure pad.

This is a straightforward turning operation, in mild steel, tapped 5/16" BSF. Of course, a similar alternative thread could be used.

## Part 6, Friction material.

I happened to have had in my spare bits department a piece of 1/16" thick Tufnol, but not big enough to cut out the circle in one piece, so it had to be in three pieces carefully cut out on a scroll saw. I can't imagine this will adversely affect performance. So far it has been fine. The Tufnol is visible in photo 22.

## Part 7, Indexing worm.

The next item tackled was the worm to drive the table, in mild steel. It has a single start RH Acme thread to mesh with the worm wheel with a linear pitch of 0.1571" which is 6.3653 TPI. In case you are wondering how to achieve this, by good fortune it is very close to 19 TPI divided by 3, which actually gives 6.33333333 TPI which is 99.5% of the desired thread and is good enough for this project. So if you have a gearbox on your lathe with 19 TPI all that is needed is to drive it three times faster. Otherwise, with change gears, you will need to introduce a



Support for the Q.C. tool holder.



The finished worm and wheel.

gear or gears to speed up the drive three times. My Myford S7 is only supposed to cut a minimum of 8 TPI, so you may need to be kind to your lathe when cutting threads coarser than 8 TPI.

In **photo 25** we see the indexing worm being cut, and in **photo 26** one can see the extra support to the quick change tool holder to stop it deflecting under the cutting forces, as

my long quick change tool holder was deflecting unduly.

**Photograph 27** shows the finished worm and worm wheel/ball bearing housing.

## Part 8, Adjustment / clamping worm

**Photograph 28.** Next, Part 8 was made from bright mild steel, 0.375" in diameter. The procedure follows that



Forming the adjustment/clamping worm.



Milling the worm wheel, at helix angle 7.243°



Part 15, retainer for the eccentric quill being milled out.



Part 15 being fitted to the base casting.

of making the indexing worm. It also has a RH Acme thread of theoretically 8.9 TPI, but 9 TPI is only about 1% different, so is O.K. for this project. The pitch is 0.1111". The depth of cut is 0.077".

### Part 9, Adjustment / worm wheel

This has 20 teeth of 28 DP with an O.D. of 0.888". The helix angle is 7.243°, so the packing for a 5" sine bar is 0.630". This time the dividing head is setup as before with the 5" sine bar but for the different helix angle. The bronze worm wheel was Loctited onto the mild steel hub. **Photograph 29** shows the setup for milling the gear teeth. A special collet was made with a tapered nose to clear the gear cutter.

### Part 10, Lower cover

This mild steel part acts as a retainer for Part 9 when the screw is backed off. Mr Tardrew used an 'O' ring in a groove to seal this item, but I used red gasket sealer instead, which worked perfectly.

### Part 11, Bearing sleeve

Made from an offcut of thick wall mild steel tube, Loctited in place to protect the zinc alloy casting from being abraded by the ball inner race. As I had problems with the base casting, a separate insert casting was made which meant it was a doddle to form the horns on the milling machine. See photos 20 and 21.

### Part 12, Bronze gland

Mr Tardrew shows a groove for fitting an 'O' ring just inside the mouth of this item. I have dispensed with the 'O' ring and made sure the Allen screw (Part 13) was honed and made a very close fit in the bronze gland. So far, I have no problems with oil leakage.

### Part 13, M6 Allen screw for damping control

In the original article Mr Tardrew suggested checking the thread was concentric with the shank, because threads are rolled. If not, use a longer Allen screw with at least 1.5" shank and then screw cut a new thread. The existing threaded portion to be cut off and discarded.

### Part 14, Clamp

This fits around the dividing worm eccentric and is made from a piece of 3/8" mild steel flat stock but reduced to 0.310" thick.

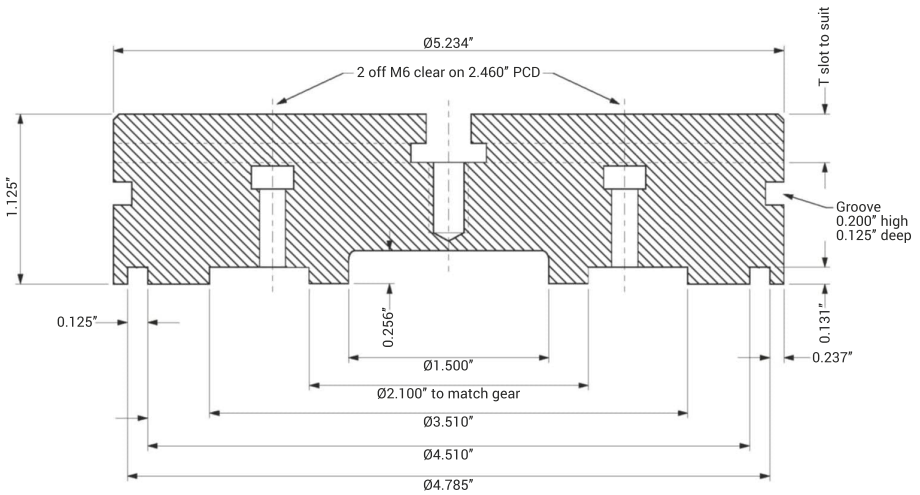
### Part 15, Retainer for the eccentric quill

**Photograph 30.** Here the part is being formed from the end of a slab of mild steel on the milling machine before eventually being parted off from the steel billet. In order to keep dirt, swarf etc., from getting between parts 14, 15 and the base casting, part 14 should be as close a fit thickness wise in the recess in part 15. I have suggested a thousandth of an inch clearance.

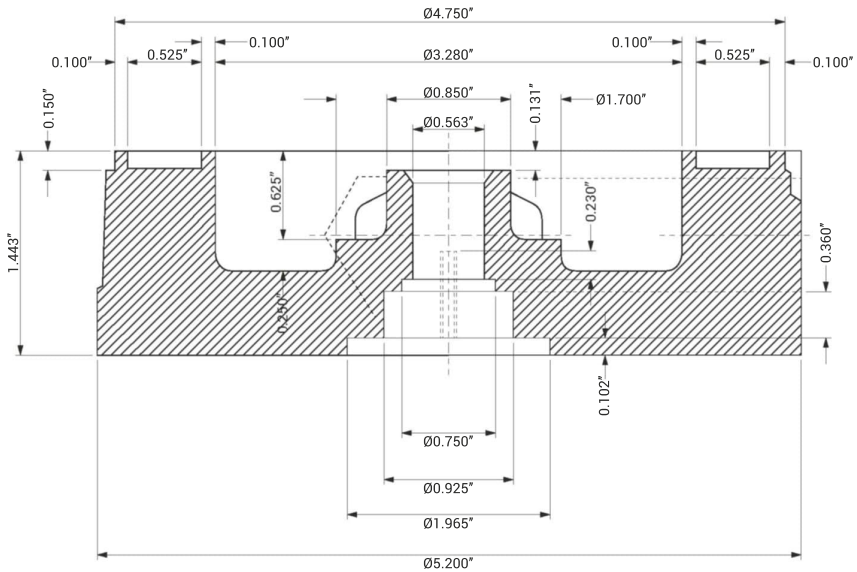
**Photograph 31** On the bench drill we have the base casting



Fig.3

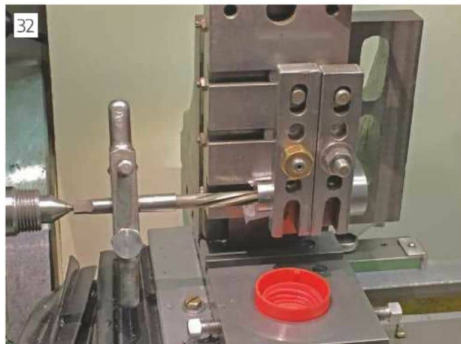


**Table**  
Section on centreline  
Mat'l: BMS or CI



**Base Casting**  
Section on centreline  
Mat'l: Zinc alloy or aluminium





Reaming the eccentric quill for the worm shaft.

clamped to two angle plates back to back, to facilitate drilling and tapping the holes for bolting Part 15 in place. The bottom edge of Part 15 must not project below the base of the main casting, so two blocks of steel were clamped to the base casting to ensure alignment.

### Part 16, Eccentric quill

As the base casting is zinc alloy in my case, or perhaps aluminium in your case, mild steel is fine provided the outside diameter is honed to a good finish to run in the casting without any shake. I found it difficult to determine the distance from the centre of the base casting to the centre of the bore for the mild steel quill. Mine turned out that there was some backlash between the worm and worm wheel, so I suggest you check your dimensions carefully. I have reduced the dimension on Drawing 2 to 1.775" which is 0.050" less than my dimension in an attempt to sort this out.

Mr Tardrew made provision for an 'O' ring to act as an oil seal. I have found that with a good fit between the quill and the base casting, oil leakage has not been a problem. The groove shown on the drawing is for the 'O' ring but a corresponding groove will be needed in the base casting if you decide to fit one.

The 0.375" diameter hole must be offset 0.088" from the centre line. Any more and the worm gear will foul the bored hole in the base casting, any less and it will not engage fully with the worm wheel. Photograph 32 shows the setup for drilling and reaming of the 0.375" hole for Part 16. Notice the padding around the eccentric quill to prevent bruising the honed surface.

The spigot to centre the dividing plate must be concentric with the 0.375" bore for the worm spindle.

The dividing plate shown cross hatched with Part 16 on **fig. 3**, is 2" in diameter which projects below the base of the main casting. I have not found this to be a problem as it sits clear of the edge of my milling machine table. With the benefit of hindsight, I made a larger dividing plate of 3½" in diameter. The twelve holes in the smaller division plate mean there is half a degree between each hole in the rotation of the table. With the larger diameter one can have 24 holes, so that one can move the table a quarter of a degree by moving the plunger from one hole to the next. I also found the radius of the plunger assembly too short for comfort; hence I have shown two dimensions for the arm. I intend to make a small handle to fit the left hand end of the slot which should be kinder to our hands when turning the table against the load of the cutter



Milling the slot in the plunger arm.



Forming the domed head on the knob.

and the friction setting.

You will see in photo 40 of the nearly finished rotary table that I used a knurled brass wheel to clamp the eccentric quill in place. I felt this was more secure than the spring loaded detent ball in the original design. The knurled brass wheel was from my spare bits box.

### Parts 17, the plunger assembly

Mr Tardrew made the arm and body of the plunger out of solid. Having made George Thomas's Versatile Dividing Head, ref. 2. I chose to scale down his plunger assembly to 80% to fit my rotary table. It may be made of BMS, stainless steel and possibly brass. The threads need not be as shown but any suitable close threads would suffice. As my workshop is Imperial, I have used Model Engineer and B.S.F., threads.

**Photograph 33** shows the setup for milling the slot in the arm for the plunger assembly.

**Photograph 34** shows my setup for forming the domed head on the top of the knob. A ball race outer of the desired diameter was clamped to the rear lathe way. A follower was clamped to the cross slide, and the cutting tool was a small diameter cutter. The same cutter was also used to form the grooves in the outside of the knob.

●To be continued

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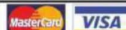
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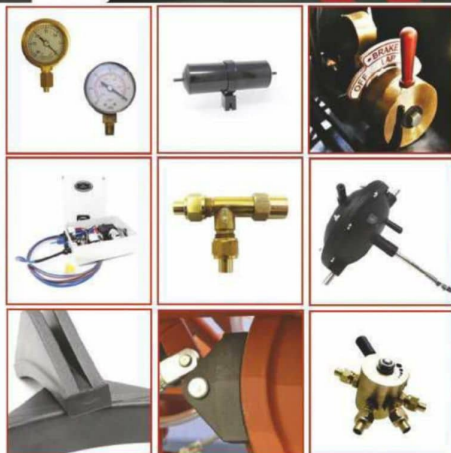
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From the Archives:

# Gear Hobbing in the Home Workshop



Ivan Law explains this way of generating gears, in an article that first appeared in MEW Issue 56, February – March 1999

**T**he hobbing process is one of the most accurate ways available in the production of involute gear teeth. Model engineers, in the main, do not consider the process suitable, or even applicable, to the home workshop believing that it is an industrial process and outside the scope of our – in comparison to industry – sparse and primitive workshops.

There are, I believe, a number of reasons for this attitude; one is the lack of understanding of the fundamental principle governing the functioning of both hobs and the hobbing process. Another is the high cost of suitable commercial hobs. It is true they are expensive, but surprisingly the cost of a hob for any given DP and pressure angle is usually less than a standard set of eight form cutters, **photo 1**. A third reason is the belief that suitable hobs cannot be produced with the equipment we have at our disposal; and, finally, if we do have a suitable hob we do not have a machine on which it can be used.

I have 'volunteered' to introduce the subject by discussing in simple language what a hob is and how it functions.

## Understanding the Requirement

I have said many times, in connection with a variety of subjects, but it is worth repeating because of its relevance, that when faced with a problem it is necessary to first of all understand what the problem is. Once that is fully understood then a great step forward has been made towards finding a solution. We will therefore begin by looking at the shape of a gear tooth and why that shape is needed.



Many hobbyists are reluctant to take on making their own gears, by whatever method. Ivan Law is well known for taking on this huge and complex topic, and breaking it down into clear, understandable language that has helped many, many people to make accurate, efficient gears in their own workshops. On top of this, Ivan is a distinguished model engineer and has long served as the Society of Model and Experimental Engineer's Chief Judge at the Model Engineer Exhibition.



*This hob is 26DP, but has the rather unusual pressure angle of 15 degrees, rather than the more usual 14.5 degrees.*

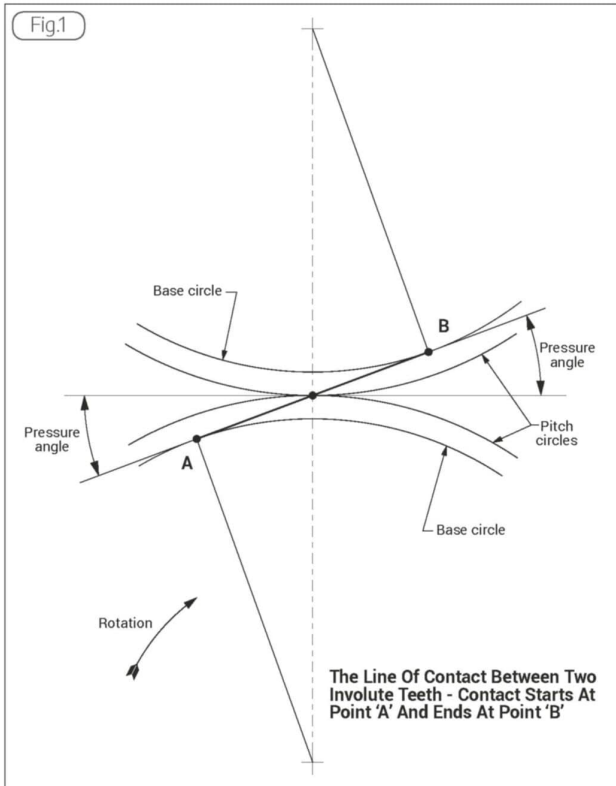
## Gear Tooth Profile

A gear is far more than a disc with slots in its periphery. Gears with incorrectly formed teeth may, for a while, transmit motion and therefore power, but to keep

on working effectively and efficiently the teeth must have a definite and specific profile. There are a number of profiles that can be used, however, these articles will only consider teeth based on the involute curve. The reason for this is that the majority of gears produced to-day are based on the involute curve, as this shape is ideally suited to the generating methods used in modern production engineering.

Although model engineers, in the main, cut their gears one tooth at a time using a suitable form cutter, as opposed to a generating process, the involute profile is almost always used.

Just what performance are we trying to obtain from a gear tooth? First of all, the gear teeth must not rub on each other, as this causes friction, heat and rapid wear. In order to reduce friction to a minimum, this phenomenon being the enemy of engineers, the gear teeth must push on each other but not slide. They should roll on each other along the line of contact until the point of disengagement is reached. As a matter of interest, the line of contact between two involute gears is a straight line



along the pressure angle, as shown in **figure 1**. (Much more about this pressure angle later). Secondly, and often not realised, there must be constant relative velocity between two mating gears. If the drive shaft incorporating the driving gear moves at a constant velocity then it is important that the driven shaft also moves at a constant velocity – though not necessarily at the same velocity, and not in a series of jerks and hesitations. Gear teeth that are based on the involute curve meet the above conditions.

### The involute curve

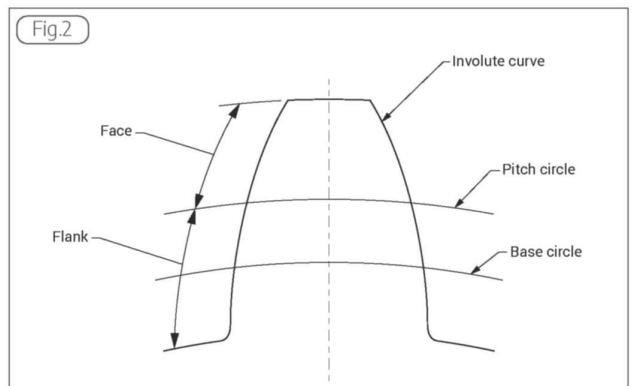
What is an involute curve? and how is it applied to a gear tooth profile? I will not quote the technical definition of an involute curve as it may not help! From our point of view, think of a disc or drum with a string wrapped around it. Now, with the drum stationary, hold the end of the string and, keeping it tight, unwind it from the drum - the

path followed by the end of the string will be an involute curve. The involute curve, in theory, goes on without end, but fortunately we are only interested in the small initial part of the curve, where

the string leaves the drum. It can be seen from the above that the shape of the curve will vary with the size of the drum, a small diameter drum will produce an involute with a pronounced curve, a very large drum will result in an involute with a shallow curve and if the drum is of infinite diameter then the 'curve' will be a straight line. In gear tooth nomenclature, the diameter of the drum is called the base circle and is an important element in gear tooth profiles.

When setting or laying out gears they are thought of as circles or discs and if the resultant gears are to run correctly, these circles, called the pitch circles, must touch each other. The actual tooth consists of two elements, the part above the pitch circle called the addendum and the part below the pitch circle referred to as the dedendum. The surface of the tooth above the pitch circle is called the face whilst the surface below the pitch circle is the flank. Since the involute curve is struck from the base circle then that is where the tooth profile begins, but as clearance in the bottom of the tooth is needed, the actual tooth profile continues for a short distance below the base circle.

**Figure 2** illustrates a gear tooth and the relative elements so far discussed. It will be seen that about half of the tooth, the dedendum, is below the pitch circle and therefore the base circle must always be smaller in diameter than the pitch circle and also be concentric with it. Any pair of mating involute gears must have the same ratio between the radius of the base circle and the radius of the pitch circle. If this ratio alters then the diameter of the base circle for any given gear will alter and so will the



resulting involute curve. It follows that, when considering gears, this ratio is an important element in determining the tooth profile - and so it is.

However, it is not expressed in the form of a ratio but as an angle, the pressure angle, **figure 3**. This pressure angle determines the relative size of the base circle in relation to the pitch circle, a factor which is most important when designing and making hobs.

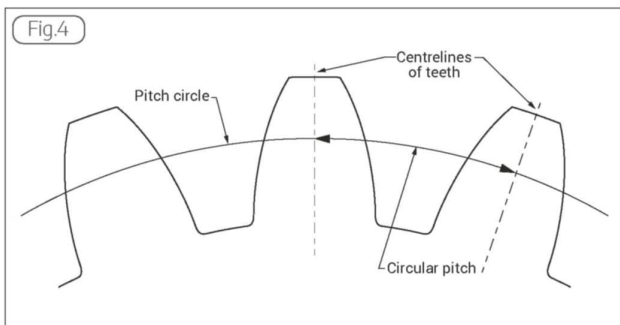
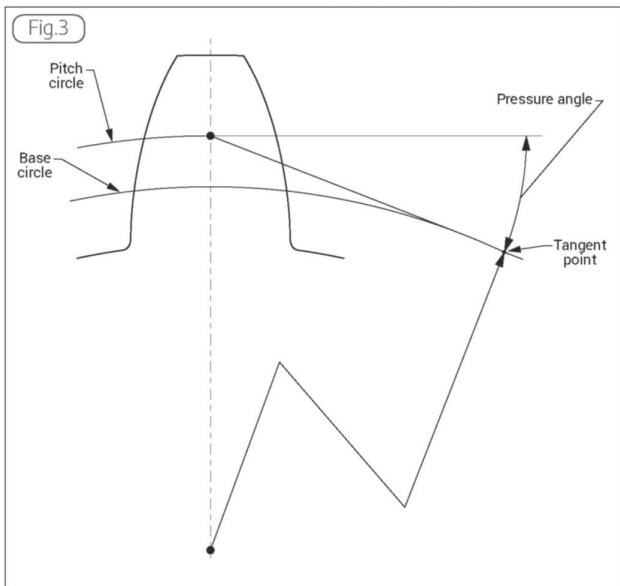
### Gear tooth size

We have now established the shape of a gear tooth, but not its size. A gear of, say, 3 inch diameter could have 30 teeth cut on it - or even 100 teeth. Both sets of teeth could be of perfect involute form, but would not run together as their physical sizes would be considerably different. Some means or standard of determining tooth size is therefore necessary.

As was mentioned earlier, gears in the design stage are considered as rotating pitch circles and this pitch circle forms the basis when determining gear tooth size. There are three methods in use which the model engineer may encounter and the first is circular pitch.

### Circular pitch

The circular pitch of a gear is the distance from a point on one tooth to the corresponding point of the next tooth, measured around the pitch circle, **figure 4**. This circular pitch is usually quoted as some friendly figure such as 0.100 or  $\frac{1}{16}$  or  $\frac{1}{8}$ . In order to obtain the gear's basic datum, i.e. the diameter of the pitch circle, it is necessary first of all to multiply the circular pitch by the number of teeth in the gear. This must be a whole number and it will give us the circumference of the pitch circle. We then have to divide this number by pi to find the pitch circle diameter. As pi is rather an unfortunate number, it follows that the diameter of the pitch circle will be 'awkward' and therefore the centre distance between two mating gears will not be a round figure, but one quoted to at least three decimal places. It can be argued that this matters little as in the workshop an 'awkward' size is just as easy to obtain as a standard one. This may be so, but the problem is largely academic because unless the gear is going to be used in conjunction with a rack to measure linear displacement, such as down-feeds on milling machines, gears encountered by the model engineer will not be based on the circle pitch notation, but on a more popular method known as diametral pitch.



### Diametral pitch

This method, usually referred to as the DP, is the most common of gear size notations, particularly when considering the size of gears likely to be encountered by model engineers. The diametral pitch is simply the number of teeth per inch of pitch circle diameter. For example, if a gear has a pitch circle diameter of 1 inch and has 20 teeth, then that gear is referred to as 20DP. If, on the other hand it has 40 teeth, then the size is quoted as 40DP. A 40 tooth gear of 20DP would have a pitch circle diameter of 2in. and so on. DPs are usually whole numbers and also even numbers, at least in the sizes that model engineers will encounter.

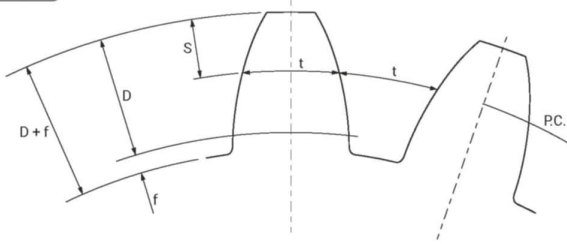
The DP notation simplifies setting out a train of gears. For example, should it be desired to produce a pair of gears to give a speed reduction 3:1 and 20DP was chosen for the gears, then two gears, one with 20 teeth and one with 60 teeth would give us the required ratio. The pitch circle diameter of the 20 tooth gear would be 20/20 or 1 inch whilst the PCD of the other gear would be 60/20 or 3 inches. This would result in gear centres of 2 inches - this being half of the sum of the two PCDs.

### Module

Nowadays, as far as we are concerned, we can regard the module as a 'metric' way of noting gear sizes. The module is

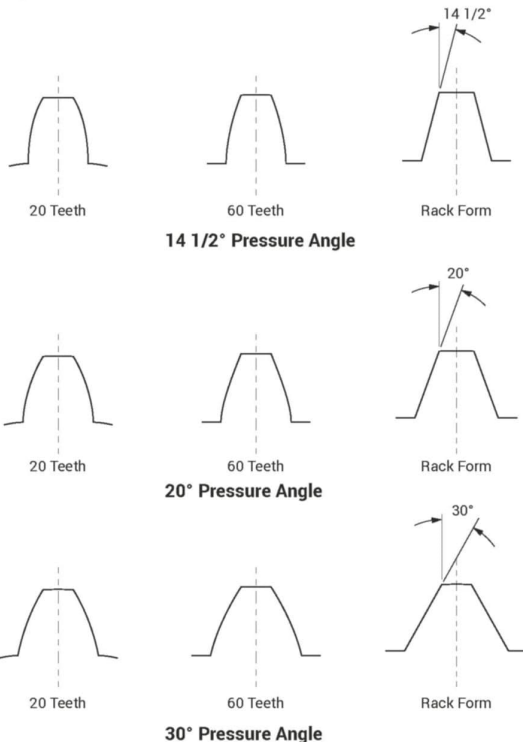


Fig.5



$t = \text{Tooth Thickness On Pitch Line} = 1/2 \text{ C.P.}$   
 $S = \text{Addendum} = 1/DP \text{ Or } .3182 \times \text{C.P.}$   
 $D = \text{Working Depth Of Tooth} = 2/DP$   
 $D + f = \text{Whole Depth Of Tooth} = .6866 \times \text{C.P.}$

Fig.6



**Showing How The Shape Of Gear Teeth Vary  
 With Number Of Teeth On Gear And Also Effect  
 Of Pressure Angle**

the pitch circle diameter in millimetres divided by the number of teeth, or to put it the other way round, the PCD in millimetres is obtained by multiplying the module number by the number of teeth required. There are 25.4 millimetres to one inch so a number 1 module is the same as 25.4DP. A number 2 module would be 12.7DP whilst a 0.5 module would be 50.4DP. I believe that most of the machinery imported from the Continent has gears based on the module system.

It was stated earlier that part of the tooth was above the pitch circle and part below. Before we can determine the specific shape of any teeth, we must look at the proportions of the various elements that combine to give the complete tooth profile. These proportions are shown in **figure 5**. The sizes quoted may be termed 'theoretically' correct and if followed exactly would not allow for clearance between the mating teeth. We know from general practice that size and size do not fit, and some small clearance must be provided. Precision gear manufacturers usually decrease the tooth thickness to about 0.48 of the circular pitch, thus making the tooth space 0.52 of the circular pitch. In practice, by our methods of production, I have found this complication to gear cutter calculation can be ignored! I usually cut my gears to the theoretical proportions shown and they usually assemble without difficulty. Maybe I inadvertently cut the teeth just fractionally deeper than theory suggests!

Some considerable time has now been spent and the word 'hob', the subject of the article, not even mentioned – but it is necessary to understand just what we are trying to achieve. You do not obtain a good tooth profile by chance! If all the above ramblings have been understood, then the rest becomes very easy.

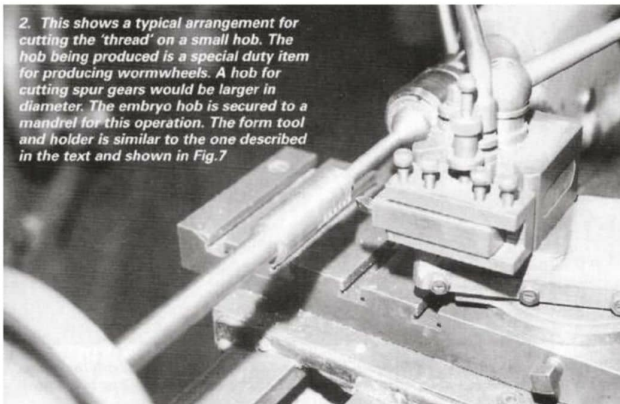
We now know the shape of a gear tooth, but we cannot cut this shape, only the space between the teeth. All cutting tools produce the same thing – swarf! It is the bit that is left behind that we really want. If we cut the teeth one at a time, the usual method employed by model engineers, then we require a form cutter that is the shape of the space between two adjacent teeth but, unfortunately, this space is not constant over a range of gears, even though they may be of the same DP and pressure angle. It follows from what has been said so far that the diameters of both PCD and the base circle from which the

involute is generated will alter with the number of teeth on the gear. **Figure 6A** shows this change in shape although the same DP has been used for each profile and the same pressure angle, viz.  $14\frac{1}{2}$  degrees. The next two drawings **figs. 6B & 6C** show the difference in shape when the pressure angle is increased to the popular 20 degrees and finally to 30 degrees. It is now apparent that cutting gears one tooth at a time by form cutters can only give theoretically correct teeth if a form cutter of the correct pressure angle and specific tooth number is used. This would need a very large number of cutters and would make the process impractical. Fortunately, a small deviation from the theoretical form can be tolerated, and so one cutter may be used for a range of tooth numbers, provided they are of the same pressure angle. In fact, a series of eight cutters covers the entire range from a small pinion to a rack, but – to be pedantic – each cutter can only cut one tooth number to the correct theoretical shape.

## Enter the hob

This is where the hobbing process enters the story. By this means, no matter what number of teeth are required on a gear, the correct involute form for that number will be automatically produced. It may be 20 teeth or 21 teeth or even 87 teeth, it matters not. The teeth will always be the correct shape as the appropriate involute curve is generated by the hobbing action. Only one cutter is needed for each DP and pressure angle, and all the teeth are produced with just one pass of the hob, thus making the cutting of gears much quicker and simpler, as no mis-count of the dividing

**2. This shows a typical arrangement for cutting the 'thread' on a small hob. The hob being produced is a special duty item for producing wormwheels. A hob for cutting spur gears would be larger in diameter. The embryo hob is secured to a mandrel for this operation. The form tool and holder is similar to the one described in the text and shown in Fig. 7**



head can arise because a dividing head is not needed.

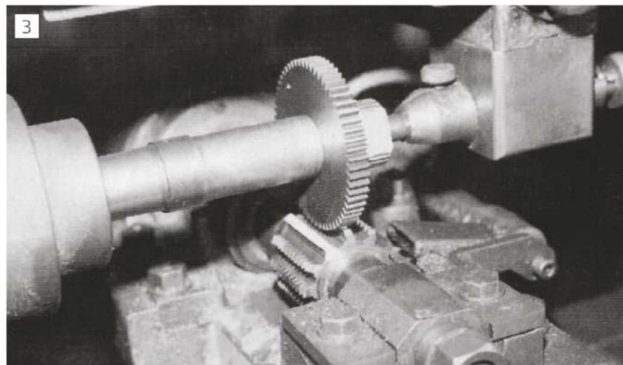
The hob is a cutting tool in the form of a thread or single start worm. The shape of the 'thread' is the rack shape of tooth profile that the hob will eventually produce (figs. 6A/B/C). It should now be apparent why I have kept emphasising the importance of the pressure angle as this is the angle that determines the 'thread' form of the hob.

The hob is provided with a series of gashes or flutes that form the cutting edges of the hob where they meet the thread, **photo 2**. In order for it to cut effectively, the teeth should be 'backed-off'. This process is outside the scope of this article but has been dealt with elsewhere. Unlike general milling cutters, a hob can only be sharpened on its front or radial face, otherwise the tooth profile would be lost and the hob

become useless.

How does it cut a gear? If the hob is secured to a rotating spindle and a workpiece is slowly brought into contact with it, the hob would (neglecting the helix angle) produce slots in the workpiece similar in shape to the teeth on the hob. Now, if that workpiece is replaced by a circular disc, viz. the gear blank, and that blank rotated, then a series of slots or teeth would be produced on the blank. The number of teeth produced on the blank would depend on the speed ratio between the hob and the blank, **photo 3**. If the hob were to make 20 revolutions to one revolution of the blank, then 20 teeth would be formed on the blank. In other words, the number of teeth required on the gear is the same as the speed ratio between blank and hob. Now, and this is the most important function of hobbing, as the blank is rotating, the shape of the teeth produced is not the same as the straight-sided shape of the teeth on the hob. The teeth of the gear being cut gradually come into contact and out of contact with the hob teeth; in other words the gear teeth roll past and through the teeth of the hob and it is this rolling action that produces the correct involute curve that we desire, **photos 4, 5**.

As stated at the beginning of this article, commercial hobs are expensive, but making things is what model engineers like to do, so why not make your own hobs? It is, after all, only a screw-cutting exercise. The hobbing process has one great advantage – it is 'self-correcting'. If the angle of the tooth profile on the hob is not correct to drawing, or if the pitch is not quite what was intended, it does not matter, as all

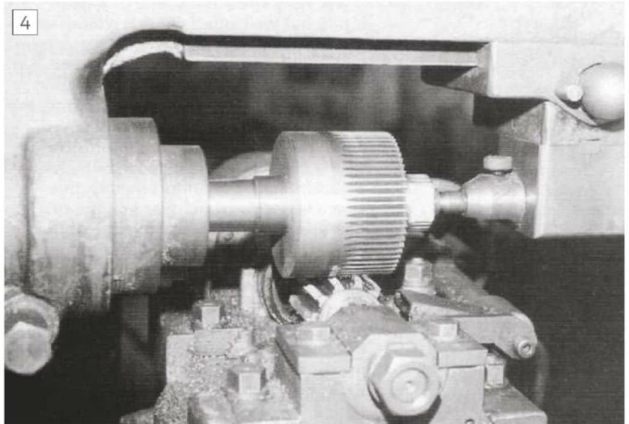


**3** This shows the cutting of a 60-tooth spur gear. The mandrels driving both the gear and the hob are connected together by a gear box. In this case the gear box is arranged to give 60 revolutions of the hob for one of the gear blank.

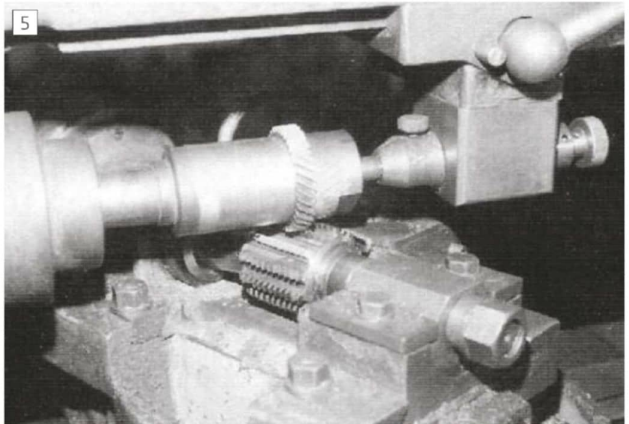
gears, regardless of the number of teeth on them, will mesh and run together perfectly satisfactorily, providing they are produced with the same hob. Another advantage is that we can, if we wish, produce our own standard. We need not keep to standard DPs or pressure angles. This could certainly be useful for anyone having trouble with high speed gear reduction boxes for use with steam or gas turbines. Increasing the pressure angle to about 30 deg. or so will result in a gear more suited to these arduous conditions and so prolong the life of the gears considerably.

### Producing hobs in the lathe

As referred to earlier, making a hob or at least the threaded part is only like producing a single start worm or a coarse thread. A screw-cutting tool will be needed, and this can be similar to a normal screw-cutting tool except that the shape must be similar to the gap between two adjacent teeth of the rack profile. The shape of the tool will, of course, be dependent on the DP and pressure angle required. The tools may be produced by skilful off-hand grinding but it is recommended that a tool and cutter grinder, such as a Quorn, Kennet, Stent or similar machine should be used. This special form tool is the start of the whole hobbing process and so it pays to produce it as accurately as possible. As shown in **figure 7**, the cutting flanks of the tool are ground at the required pressure angle, thus the included angle of the tool is twice the pressure angle. If a cutter grinder is being used, then this angle can be obtained simply by using the protractor scales on the machine. It should also be possible to form the clearance angle at the same setting. The pitch of the hob (the distance from one tooth to a similar position on the next tooth - **figure 8**) is usually very much coarser than that encountered in normal screw-cutting and this affects the side clearance. In order to cut cleanly and without rubbing, the leading cutting face of the tool must have the normal clearance angle of about 4 or 5 degrees plus the helix angle of the 'thread'. The trailing cutting edge will be angled at the normal clearance minus the helix angle. This latter will result in what, with normal turning tools, would be called negative clearances. It is therefore necessary to determine the helix angle of the 'thread' before the form tool can be made, that is if the form tool is being produced from the normal rectangular high speed tool blanks. I find it easier to produce tools of this type from round



*In this case six 60-tooth gear blanks are sandwiched together so that all six gears are produced at one pass. A typical time for this pass is about 15 minutes. The number of teeth produced is 60x6 or 360; this is equal to 2 ½ seconds per tooth.*



*The same hob as shown in the previous photograph is being used to cut a helical gear. Setting up a hobbing machine to cut helical gears is much more complicated than setting for spur gears. The speed ratio between the hob and gear blank is not only determined by the number of teeth required but also the helix angle of the gear and the rate of feed. The rate of feed in relation to the hob and blank speeds determines the helix angles of the gear produced.*

material - in fact this provides a use for broken centre drills! Form tools for DPs as large as No. 10 can be made from ¼ inch diameter material.

It is necessary to have some form of holder when grinding small round tools. In the present case a piece of ½ inch square mild steel about 2 inch long is ideal. Drill a ¼ inch diameter hole in one end for the tool and secure it by means of a pinch screw. The helix angle of the hob can then be ignored and the

tool ground, applying normal clearance and rake angles. The same holder can then be used for mounting the tool in the lathe tool-post for the screwing operation. As the tool is round, the helix angle can be obtained by rotating the tool in its holder.

Using this method there is no need to worry about the true value of the helix angle; set the angle by approximation and start cutting. If the angle is incorrect you will soon find out as the cutter will



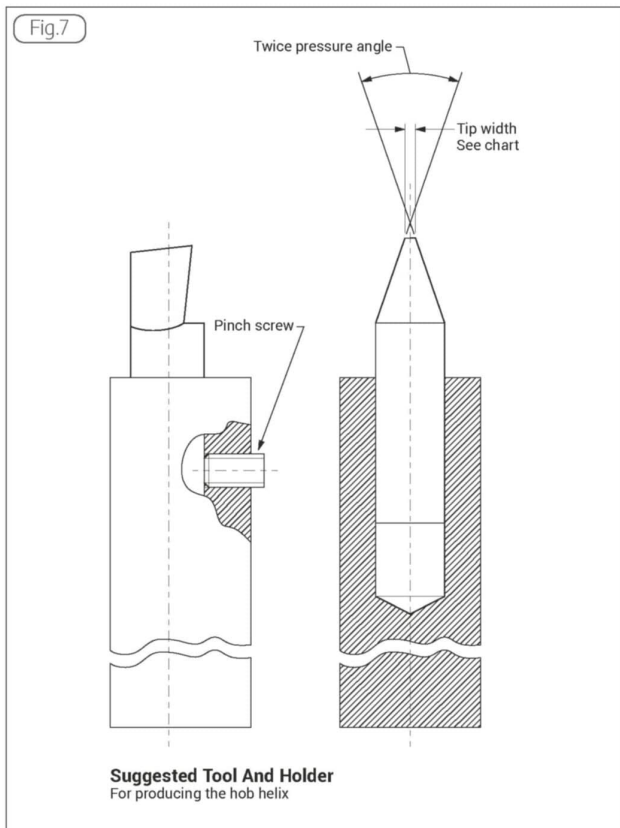
start to rub on one side. Simply slacken the pinch screw, rotate the tool in the desired direction and try again. This round tool method allows the same cutter to be used for different helix angles, situations which would occur should hobs of the same pitch but different diameters be required.

When hobbing gears the only control we have in determining the tooth profile is the depth of cut, the hobbing process and the hob do the rest. It follows that, when cutting the hob, the only control we have on the hob tooth profile is the depth of cut applied to the form tool. From this we can see that the width of the tip on the cutting tool is important. The table, **figure 9**, gives the tip width for a number of DP and pressure angles.

Obtaining this tip width is not easy. There is nothing tangible to get the micrometer on to. If you have access to the equipment of a metrology department then go ahead and use it. I have not, and I am sure almost all my readers will not have either, so we have to do our best with what is available (isn't this the story of model engineering?) The method I use, and one that has proved satisfactory, is to set the micrometer a thou' or so greater than the required tip width and then, using a magnifying glass with a large magnification, grind the tool until it just enters the micrometer anvils – a slight resistance can also be felt to any movement of the cutter through the anvils. The method may not be scientific but it gives results perfectly satisfactory for our needs.

The next problem is to determine the pitch of the 'thread' and then the change wheels needed to produce that pitch. Should the hob be for gears based on the circular pitch notation, then there is no problem. The circular pitch of the gear may be regarded as being similar to the pitch required on the hob. This is not strictly correct as the true theoretical pitch of the hob should be the circular pitch of the gear

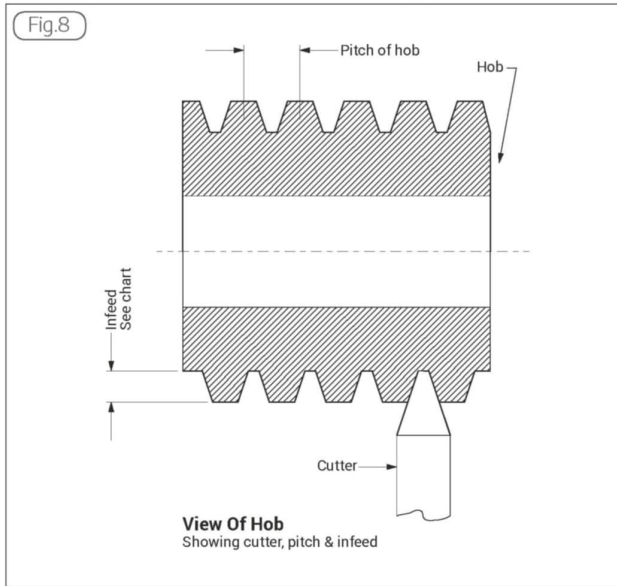
The method may not be scientific but it gives results perfectly satisfactory for our needs.



divided by the cosine of the helix angle of the hob. In practice this makes little, if any, measurable effect and can be safely ignored. So, for example, if the CP is 0.100 then set the lathe to cut a pitch of 0.100 or 10 tpi. However, most gears that we encounter will be DP based and so we will have to convert DP to CP in order to obtain the pitch of the hob. It has been pointed out the advantages of the DP system compared with the CP for general gear calculation but there is a snag. To convert diametral pitch to circular pitch, we simply divide the DP into the function  $\pi$ . Unfortunately,  $\pi$  is not what could be termed a friendly number and so any whole number divided into  $\pi$  will result in an equally unfortunate number for the pitch of the hob. For example, to convert 20DP into CP divide  $\pi$  by 20, which gives 0.1571 for the pitch and this, in terms of threads per inch,

is 6.366. It is pointless looking at the lathe change wheel chart for 6.366, it won't be there. We have, therefore, to work out the change wheels ourselves in order to cut this strange pitch. There is a basic method of doing this termed continuous fractions. I am not going into this somewhat complicated process here, but if any reader wishes to pursue this line, then the method is described at length in 'Gears and Gear Cutting' which is No. 17 in the Workshop Practice series.

A very close approximation of  $\pi$  is 22/7 and we can use this to simplify our change wheels calculation. Paradoxically, using this approximation for  $\pi$  can be used to advantage. It makes it possible to produce a hob that will cut a gear with a theoretically perfect pitch. If the number 35.2560329 is divided by the DP required and the hob then made with a pitch circle



diameter to the number obtained, the gears produced with that hob will have a CP correct to within nine places of decimals; this, however, is of academic interest only. If we multiply both top and bottom of the fraction  $\frac{22}{5}$  by 5 we get  $\frac{110}{25}$ . A 110-tooth wheel is not part of a standard set of change wheels but a 55-tooth wheel is, so the pi factor in our change wheel calculation can be  $\frac{55}{25}$  – multiplied by 2.

The chart, **figure 10**, quotes the change wheels required for most of the standard DPs. These gear trains are based on a leadscrew of 8 tpi, such as the Myford 7 range. In each case the top numbers are the driving wheels whilst the bottom numbers are the driven wheels. I consider the quick-change gearbox fitted to the Super 7 series of lathes to be a tremendous time-saver as a large range of standard threads and self-act feeds are available at the flick of a lever. Unfortunately, it is of little help when cutting DP pitches. A quick-change box does not preclude the use of a normal gear quadrant or banjo. These are available from Myford and can be fitted in a few minutes and so can suitable change wheels. It may be an added expense but it does increase the versatility of the lathe. When using any of the gear trains shown in the chart, set the gearbox to cut 8 tpi. When cutting non-standard

Fig.10

| D.P. | Gear Train                          | D.P. | Gear Train                          |
|------|-------------------------------------|------|-------------------------------------|
| 16   | $\frac{55}{35} \times \text{idler}$ | 30   | $\frac{55 \times 40}{35 \times 75}$ |
| 18   | $\frac{55 \times 40}{35 \times 45}$ | 32   | $\frac{55 \times 30}{35 \times 60}$ |
| 20   | $\frac{55 \times 40}{35 \times 50}$ | 36   | $\frac{55 \times 20}{35 \times 45}$ |
| 24   | $\frac{55 \times 40}{35 \times 60}$ | 40   | $\frac{55 \times 20}{35 \times 50}$ |

#### Changewheel Chart

Upper Wheels Drivers  
Lower Wheels Driven

pitches, it is not possible to disengage the feed screw half nuts at the end of each cut because it would be extremely difficult to pick up the pitch correctly for subsequent passes of the tool. The tool will have to be withdrawn at the end of each pass and the lathe reversed to the starting point before the next cut can be applied.

It is not advisable to use power when cutting pitches or threads greater than that of the lathe's feedscrew, otherwise the stress in the gear train becomes excessive. The 'power' can be easily supplied by fixing a handle on the end of the lathe mandrel and turning the lathe by hand; it will

Fig.9

| D.P. | Depth of cut | Width of tool tip |          |          |
|------|--------------|-------------------|----------|----------|
|      |              | 14 1/2° P.A.      | 20° P.A. | 30° P.A. |
| 16   | .135         | .061              | .045     | .015     |
| 18   | .120         | .054              | .040     | .013     |
| 20   | .108         | .049              | .037     | .012     |
| 24   | .090         | .041              | .030     | .010     |
| 30   | .072         | .033              | .025     | .009     |
| 32   | .067         | .030              | .023     | .008     |
| 36   | .060         | .027              | .021     | .007     |
| 40   | .054         | .025              | .019     | .006     |

#### Chart Showing Depth Of Cut And Tip Width

only require a few turns to cover the length of a hob blank. The handle can be made quite quickly from a few pieces of bar material, alternatively Myford supply such a handle and it can be fixed to the mandrel in a few seconds – an accessory well worth having. It gives ideal control over the cutting process and is a great asset in general screwcutting, particularly when screwing up to a shoulder. For very coarse pitches, where the leadscrew may make several revolutions for each turn of the lathe mandrel, it is advisable to fix a handle on the end of the leadscrew. This will considerably reduce the stress in, not only the gear train, but also the elbow! The depth of cut required for a variety of pitches is shown in the table, figure 9. This depth can be obtained by direct reference to the cross-slide micrometer dial.

The diameter of a hob (other than special hobs such as those used for cutting worm wheels) is in no way related to the diameter of the gear it can produce. For model engineers, the diameter may well be governed by the size of the material available for its manufacture.

When the threading is completed, the hob is ready for the next stage, gashing to form the teeth and for form-relieving to provide the clearance needed to obtain a satisfactory cutting action.

For those seeking further information on this fascinating topic, Ivan Law's book *Gears and Gear Cutting* from the Workshop Practice Series is invaluable. ■

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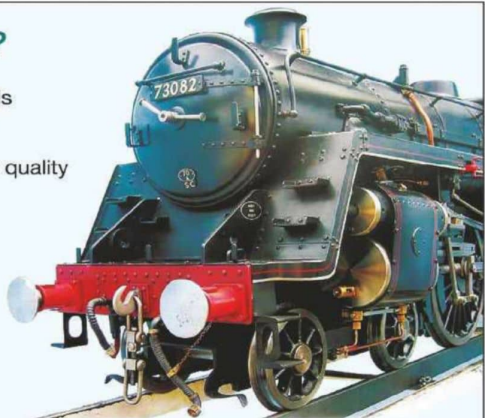
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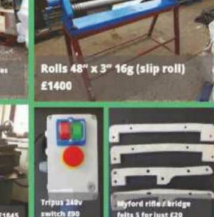
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