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JULY 2020



Making ACME nuts for a Tom Senior Mill



Lockdown Project - a Scratch Gauge

COVER STORY

MEWsonic - make Mark Noel's Ultrasonic Cleaning Tank

INSIDE

- Cherry Hill interview
- Make an Optical Centre Punch
- An Intelligent Dividing Head
- Readers' Workshop - Andrew Johnston
- How to Dismantle a Chuck



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On the Editor's Bench



I think most readers will know I'm an advocate of 3D printing, but I have to admit I'm absolutely astonished by some of the parts my own, rather humble, kit-built printer has produced over the lockdown. A part-packed workshop means I have been relying on 3D printing rather more heavily over the lockdown than usual, including for parts I would never have considered 3D printing.

For example, I'm making an 'equatorial platform' to mount my 10" Dobsonian telescope on, so it can track objects more easily. The scope weighs about 30kg, and most platforms are made of metal and plywood. While my version does have a few turned parts and a plywood base and scope platform, the rest is 3D printed, including the curved sectors that guide its movement. Indeed, 3D printing allowed me to make the sectors true slices of a cone rather than the more usual choice of approximating them with a narrow slice of a cylinder. The part illustrated holds the driven roller and includes press-in ball races and a stepper motor, as well as two printed timing pulleys for a 1.5mm pitch belt. Strength-wise, it's more than capable of taking my weight.

Another project came out of discussion with my brother, and it's going to be a radio-controlled model of a WWII Beaverette armoured car in 1:12 scale. I started by printing the tyres, a logical place to start? I used TPU a flexible, filament that gives very tough parts. I searched for 'differential' on the Thingiverse website and discovered various 'remixes' of working differentials for 1:10 scale racing cars and buggies. These are typically arranged with universal joints for independent suspension, but I made a few changes and designed a split casing to suit a live axle arrangement. My finished item is overscale but fits the track of the model and works perfectly. The little bevel gears inside the 'diff' are just 15mm in diameter and the only metal parts are bearings, M3 screws and a 20mm length of 1/8" rod. I have to admire the ingenuity of the makers who devised the original OpenRC cars (which appear to perform comparably to kit-built ones!)

Previously it hadn't occurred to me just how great the potential is for using 3D printing to prototype smaller working mechanisms that are later remade to be more durable or accurate. That differential could be scaled down further, and copied in metal while keeping the printed tyres and perhaps using 3D printed parts as patterns for axle castings.

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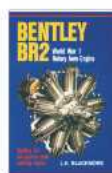
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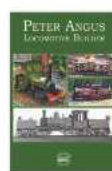
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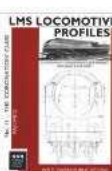
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Building the Maltese Falcon

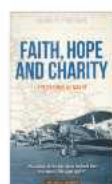
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Coming up...

in our next issue

Coming up in our June issue, number 296, another great read



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

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.

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 or lonely do join us and be assured of a warm welcome.

My new lathe a Warco918

An interesting thread moving from first impressions to making some practical modifications.

How does one scale a worm gear?

Looking at the main challenge of modelling a BCA Jig Borer in 1:3 scale.

Pulley Sizes for an X2 Clone Conversion

This thread shows a wide range of approaches to this popular conversion of a popular mill

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Constructing the MEWsonic: a homemade ultrasonic cleaner



Mark Noel shows how you can build your own sonic cleaning tank from readily available parts



The completed MEWsonic Professional. The blue flexi-tube on the right is for sucking cleaning fluid from the tank, while the one on the left is used to suspend parts for cleaning.

Recently I was given two model glow engines that had been unused for many years and which were gummed solid with dried up fuel and castor oil. By sheer coincidence the Mikuni carburettor on my motorcycle had developed blocked jets, causing problems with uneven tickover. My local bike dealer offered to send the Mikuni and the glow engines away for ultrasonic cleaning, pointing out that these carbs' need repeated attention "owing to the bioethanol toffee they put in modern petrol". The pair of refurbished glow engines were to

be the basis of a renewed interest in aeromodelling, but the cost of having these and the Mikuni cleaned professionally would make a dent in my workshop budget. Surely the solution was to buy, or why not build, my own ultrasonic cleaner? With such a machine in the workshop it might then be possible to revive other items such as clogged taps and dies, old files and drill chucks, by ridding them of stubborn grime. The result of this endeavour is the MEWsonic Professional Ultrasonic Cleaner shown in **photo 1**.

A scan of the Internet showed that

all the electronic components for such a project were commercially available, while deep in the Womble burrow were other bits that could be pressed to the task. After reviewing features seen in a range of hobby grade cleaners, I decided to attempt a design with similar or perhaps even better capabilities. The design brief that emerged was as follows:

- Dual piezo transducers delivering 100W of 40kHz sonic power.
- A 60 minute timer with bell sounder to signal completion of the cleaning process.
- Stainless steel, heated tank

- incorporating thermal safety switches.
- Digital display of tank temperature.
- Parts to be suspended either in a basket or via articulated 'cranes'.
- An electric pump to empty the tank automatically, minimising mess.
- A retractable hose to discharge the waste cleaning fluid.

The concept of cleaning objects with powerful, high frequency sound has been around since the 1950s and is today widely used in industry, in jewellery, dental and medical laboratories and in the final stage of circuit board assembly where flux residues need to be removed from solder joints. In recent years affordable, compact sonic cleaners have become more widely available, finding their way into homes and hobby workshops, with one of the main UK suppliers being Allendale Ultrasonics in Hoddesdon, Hertfordshire.

In most machines the ultrasound is produced using stacked piezoelectric wafers bolted to a solid metal horn which directs the vibrations into the attached cleaning vessel. The wafer material is an exotic ceramic such as lead zirconate titanate which dilates and contracts when an alternating voltage is applied between opposing faces. By stacking these wafers, and using high voltages, the alternating expansion-contraction becomes appreciable and sufficient to send violent vibrations into the vessel's fluid. These sonic waves tear the liquid apart, creating tiny cavitation bubbles which appear and collapse in tune with the sound, creating pulsating high pressures and temperatures which dislodge unwanted material. These bubbles are so small that

they can penetrate and exert a cleaning action inside narrow cavities and drill holes, such as within a carburettor or dental turbine. The process is usually accelerated by using special liquids tailored to the cleaning task at hand, and by warming the tank to further increase their effectiveness. A key feature of ultrasonic cleaning is that it generally causes no damage to the host material, provided that it is sufficiently robust, such as a metal, ceramic or glass. Nevertheless, the process is hazardous in that it can cause nerve damage or burns to fingers placed in the tank while cleaning is underway.

I began the project by purchasing a pair of 40 kHz transducers and a supposedly matched driver board from



Major components for constructing the ultrasonic cleaner, including the lower pan of a steamer set and an ABS box by CamdenBoss. The pair of 40kHz transducers and driver board are seen at lower right.

- High quality stainless steel
- Set contains 2 x 22cm steamers, 22cm casserole with lid
- Suitable for gas, electric and solid hotplates
- 0.4mm body thickness
- 1.0mm aluminium capsulated bottom
- Belly shape
- Wide roll edge
- Mirror polishing inside & outside
- S/S hollow handle and knob
- G type clear glass lid



Panel on the steamer set packaging describing the layer structure of the encapsulated water pan.

one of several sellers advertising on eBay, the aim being to perform an initial 'proof of concept'. The circuit board was happy to drive one of the supplied transducers, which responded with the high pitched squeal typical of such devices. However, this board failed when connected to both transducers, denting my confidence in the anonymous manufacturer of these components. A pair 40kHz transducers and a certified 100W driver board were therefore purchased from Allendale, and were clearly of better quality than the ebay parts. Although these arrived without instructions, their technical guru Kassim Chohan advised how to electrically connect the transducers: the terminal in the centre of the wafer stack is positive.



Close up of the water pan base showing the edge of the encapsulated outer skin.



Using a carborundum disc in a rotary tool in an attempt to remove the encapsulated outer layer. The outcome was to puncture the bowl.



Choice of drills for safely boring holes in thin sheet material. Sometimes the combination of a plain twist drill and a fabric wad can be effective.

This is important since reversing the polarity can damage the units. A quick bench test proved that the Allendale board was capable of driving both transducers in parallel, the result being quite a racket. It was noted that the heat sinks on the power transistors became fairly warm after less than a minute, suggesting that it would be a good idea to incorporate fan-cooling of the board once installed.

Originally my plan was to design an enclosure that was a good fit to all the components, have the sides laser cut from 3mm acrylic, and then bond these together with solvent adhesive. Since each of the six sides and internal brackets would be one-offs, this solution would have been quite expensive, although it does provide total freedom in the design and choice of colours. The box could even have been transparent with all the workings visible, rather like the early Apple iMac G3. Readers wishing to repeat this project might want to consider this trendy option! Eventually, I discovered that Rapid Electronics stock a CamdenBoss ABS box (**photo 2**), with hinged lid that was a perfect match to the required size, and so this shape determined how all the major components were to be arranged inside.

A major problem was sourcing a suitable thin-walled stainless steel tank with a capacity of about 2 litres, i.e. about the right size for the parts I wanted to clean. My search ranged over stock pots, saucepans, storage boxes, biscuit tins, billy cans and even dog bowls, the inspection of which greatly alarmed our dog! Eventually, the best match was found in the kitchen cupboard - namely the bottom water pan of a steamer set (**photos 2 & 3**).

These are made of thin gauge stainless steel usually 'encapsulated' with a thin layer of aluminium between the inner and outer stainless skins to improve heat conduction. **Photo 4** provides a close up of the encapsulated outer layer which appears to be seamlessly united to the inner skin, presumably by electrical resistance seam welding.

Faced with this choice of vessel I was concerned that the 3-layer sandwich might impede coupling of ultrasound between the transducers and the tank fluid because of air gaps in the encapsulation. Therefore it seemed prudent to cut away the outer base layer and remove the inner aluminium disc in order to enhance the ultrasound transmission. I set about this task with a thin carborundum disc in a rotary tool guided by hand with nanometre precision (**photo 5**). As I slowly abraded the stainless steel, atom by atom,

it proved impossible to distinguish between the (shiny) stainless steel and the (equally shiny) aluminium inner layer, which seemed to be tightly bonded together and unseparable. As a result, I accidentally removed too many nuclei and the cutter made a hole in the pan. Ouch! Nevertheless, this experience did indicate that the three-layer base was so firmly encapsulated that it was unlikely to attenuate the ultrasound. Another steamer set was purchased from the workshop overdraft, its handles ground away, and consideration then given as to how to bore 10mm holes for bolting on the transducers.

Drilling thin sheet metal is probably one of the most hazardous jobs in the workshop. Without secure clamps there is always the risk that the part can grab and ride up the drill, becoming an effective finger slicer. Stainless steel is the worst candidate for this



The alternative method of drilling thin sheet metal by plunging a twist drill through a wad of fabric into the metal. However, this technique is not always effective.



Additional small parts used to complete the build, including 4 brass components made from $\frac{1}{2}$ " to $\frac{1}{4}$ " BSP brass couplings. The centre pair are for fixing transducers, the other two are for plumbing the pump to the PVC tubing and for mounting the crane.

task since it quickly work hardens and is therefore best tackled with HSS or carbide tools, proper lubrication and a firm feed to prevent scuffing and consequent hardening. A diamond core drill might seem the best tool in this instance but reports suggest that the cutting edge can quickly clog, reducing its effectiveness. The safest approach to drilling thin sheet material is to use the cone or stepped drills shown on the left in **photo 6**. This image shows a third option comprising a normal twist drill and a wad of old rag – a novel approach that sometimes works. Gentlemen, there is no need to sacrifice your Y-fronts for this operation, since tests show that knickers perform just as well. The idea is to centre the drill over the part and then drill smartly through the wad and into the metal as shown in **photo 7**. Somehow the fabric pad guides the drill tip preventing it from making a polygonal hole and from grabbing the part as mentioned earlier. As a postgraduate at Newcastle University I was shown this tip by the long-suffering technician in charge of our student workshop – a magical place that provided my initiation into the world of hands-on engineering. However, my entry into Bert's domain was not without impediments. My project called for a coil former to be turned on something they said was called a 'lathe', but Bert deflected me, stating firmly that the Myford was occupied by Dr. Jessop who is "busy with Government work". A week later I tried to book time on another contraption they said was called a 'milling machine' but once again I was barred by the fact that "Dr. Jessop is using the Bridgeport for Government

work". It was only after several months of frustration that I learned that 'Government work' or 'Guvvy jobs' were actually private work and that the secretive Dr Jessop was making parts for his yacht! Happily, I now have my own workshop where the entire enterprise is directed towards Government work.

Anyway, back to the task in hand. The base of the pan was centre punched and a pair of 10mm diameter holes bored though using a HSS cone drill in pools of Rocol cutting fluid. By supporting the base on a block of aluminium, the burrs rising from the cuts were reduced but the rotary grinding tool seen in photo 5 was still needed to trim the edges and provide flush seats for the transducers. The same tool was used to cut away the pair of handles spot welded to the rim of the pan.

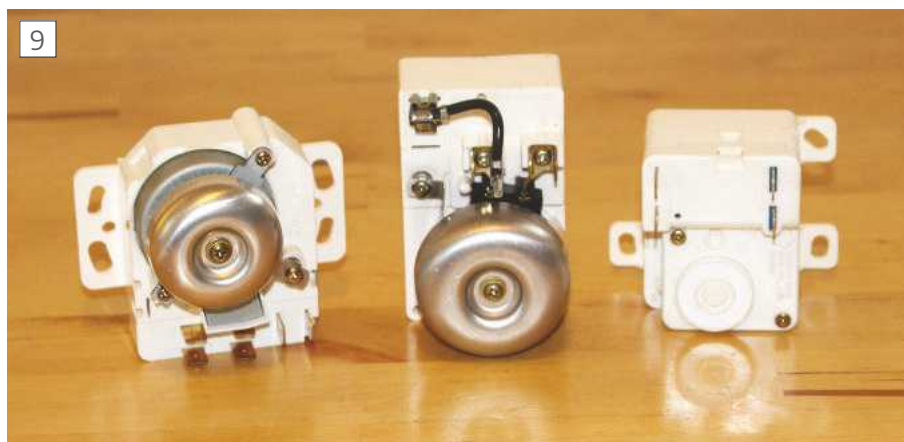
After sourcing the pan and the ultrasonic components the remaining parts were either purchased or unearthed from my box of Womble (**photos 2 & 8**):

- A 600W ATX computer power supply from Amazon.
- A small CPU cooling fan and a larger main board fan from a dead PC.
- A Bakelite knob from an old valve radio.
- Two rocker switches purchased from Rapid Electronics.
- Four 20W, 12V heater foils from ebay.
- Two 45°C, normally closed, thermal limit switches from ebay.
- A pair of plastic carriers for 22 calibre rifle cartridges, without the bullets!
- The ventilation grille from an old tumble drier.
- 12V fuel pump and two flexible spouts from ebay.
- Various washers, spacers and cable clips.

The Allendale ultrasonic board is powered from the 240V mains, while a reliable ATX power supply was needed to provide 12V and 5V for the pan heaters, the temperature sensor and display. Having had problems with cheap salvaged units in the past (no short circuit protection) I opted for a quality unit from EVGA which had been highly rated in Web reviews. My article in MEW226 (March 2015) explained how these units can be adapted to provide a versatile workshop power supply.

Out of my Womble box came three timer units salvaged from deceased microwave ovens (**photo 9**). These appliances, by the way, are a wondrous source of components, including a megamagnet that can pull iron meteorites from the sky. Most timers are made by Sankyo with 30 or 60 minute intervals that terminate with a pleasing 'ding' to say that dinner is ready. The 60 minute Model from a Philips microwave (centre photo 9) is particularly interesting since it has a non-linear graduation, moving faster for the first 10 minutes than it does for the remainder.

●To be continued



Three salvaged Sankyo microwave oven timers. The leftmost one was used in this project.

A Simple Scratch Gauge

This neat little marking out tool from Jim Binnie offers greater precision than traditional calipers



This neat scratch gauge offers greater precision than odd-legg or 'jenny' calipers.

I became disenchanted with odd leg calipers when marking out a job and decided a scratch gauge based on a woodworkers gauge might be a better option. It is made from left over materials and my design can be altered to suit what the builder wants. The gauge is in three parts the main body, the sliding spindle and the locking screw.

1 Main Body.

The main body is made from 20mm square mild steel bar 60mm long, the ends are faced square in the lathe and one end is drilled and tapped 6mm x1mm pitch thread 12mm deep, the ends are chamfered for a neat appearance, I have cleaned up th sides of the main body on my linisher, (if a linisher is not available then how about a sheet of 120 grit emery cloth tacked to a wooden board so the job can be rubbed on the emery?) The next task is to mark out a hole in the main body 15 mm from the end, drill 8mm diameter and ream.



This picture offers a better view of the clamp screw.



3
This rod across the front of the Boxford BUD is arranged to provide a reliable leg-operated emergency stop.

2 Sliding Spindle.

The sliding spindle is a piece of 8mm round mild steel bar, the ends are faced square in the lathe and both ends are drilled and tapped 4mm. I have used a tungsten carbide lathe tool triangular insert to cut the scribed lines because of its hardness but a High Speed Steel scriber point would also work quite well with an extra cross drilled hole to hold it. A 4mm cap head screw holds the carbide bit in place. The spindle has a 3mm wide

flat filed along its length for the locking screw to grip it and hold it in place.

3 Locking Screw.

The locking screw is made from a small piece of material (I used brass) 20 mm diameter knurled chamfered then drilled and tapped 6mm then countersunk and finally parted off to give a length of about 8mm, fit a countersunk headed screw 20mm long use a thread locking compound.



4
A simple tip for a magnetic tool tray that will suit many lathes with a large leadscrew gearbox.

When setting the gauge place a rule against the main body and move the sliding spindle to the required setting and lock with the screw.

Boxford Tips

The last two photos show some modifications I have done to my Boxford BUD lathe. **Photograph 3** is a leg operated safety stop switch, while **photo 4** shows a storage tray attached to the headstock via a magnet. ■

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● Club News

Geoff Theasby celebrates a decade at the helm of *HMS Club News*.

● ME Beam Engine

David Haythornthwaite completes his one inch scale *Model Engineer* beam engine by adding the water pump.

● Tractive Effort

Duncan Webster studies the cyclic variation of locomotive tractive effort.

● Tempering

Martin Gearing applies the tempering process described in his first instalment to the making of involute gear cutters.

● Wenford

Hotspur connects the crosshead pump to the water tanks in his 5 inch gauge Beattie well tank.

● Smoke Signals

Noel Shelley looks at some of the subtle ways electrical equipment lets you know all is not well.

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From the Archives:

Grinding Rest

Harold Hall, MEW Issue
89, April 2003 - Part 2

Grinding Rest Accessories

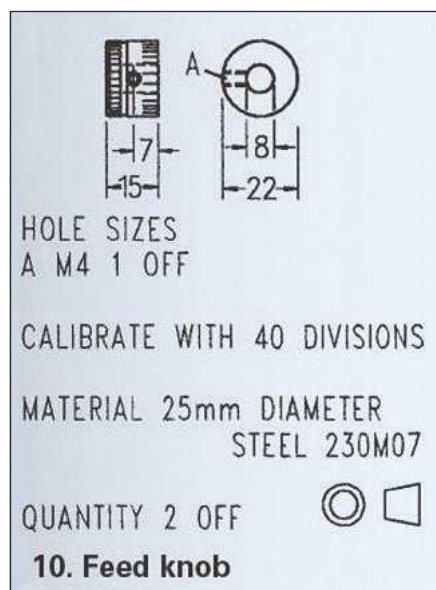
The full extent of the adjustable off hand grinding rest's capabilities will only be realised by the addition of various accessories. First however, please make sure you follow the very important safety considerations in **Box 1**.

The accessories

Fence and stop assembly (11)

This is an essential part of the system being used to accurately guide the part being ground, either across the face of the wheel or down its side. A stop screw can be fitted when required to ensure that the part being ground cannot pass beyond a certain point.

Much milling work can be carried out without using a vice as the work holding device. Where a vice does come into its own, is with the smaller items which are much more difficult to hold by other means. The adjustable fence (11) is a typical instance. Machine lower web, **photo 20**. Turn over, hold on web just made, and machine top surface to reduce thickness to 6mm. Drill and tap holes. Radius web ends using a file. Note that the two M4 tapped holes are shown blind. If drilled through, then grinding



Ask a group of Model Engineers' Workshop readers what they think are the best tool builds to appear in the magazine over the years, and you will get many different answers, but you can be sure that one particular article will be mentioned over and again: Harold Hall's grinding rest.

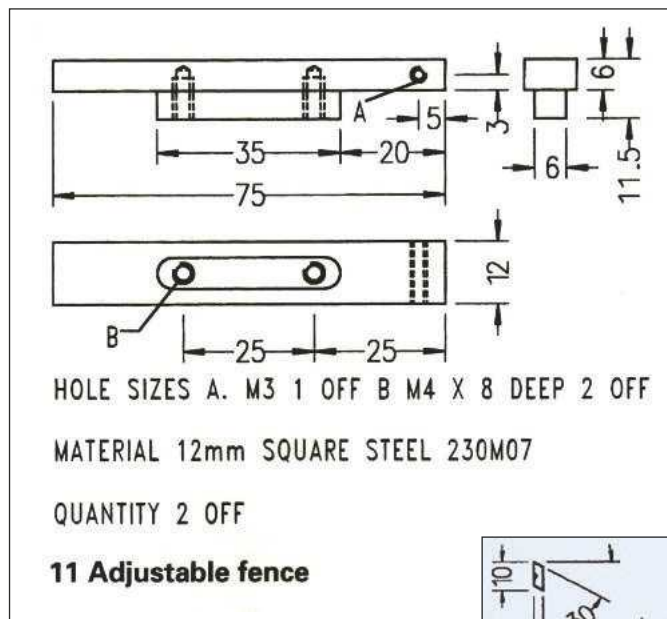
IMPORTANT SAFETY REQUIREMENTS

- Do wear safety glasses or a face mask, and ensure wheel guard is fitted.
- Due to the item being ground often being unsupported close to the wheel when using the accessories, only take very light Cuts. The depth of cut should be controlled by the fine feed and the fence rather than manually.
- Make multiple passes rather than try to remove a great depth at a single pass.
- Keep the overhang of the tool from the accessory holding it to a minimum.
- In view of the overhang do ensure the accessory is held firmly down on the rest's table.
- Keep the table and the sliding surfaces of the accessory as free of grinding dust as possible. This results in easier hand feeding and makes for safer working.
- The rest can be used as a conventional off hand grinding rest in which case ensure that the front edge of the table is no more than 1mm from the grinding wheel and the item being ground supported by the rest's table.
- When the grinder is running do not make adjustments to the rest, other than using the table's fine feeds.
- Make sure that all locking levers are firmly tightened before starting grinder.
- As the grinding rest is not directly mounted off the bench grinder it is essential that both are mounted on a very robust base. If this is not done the rest will be able to move relative to the off-hand grinder when in use. At best this may result in inaccurate results but much worse be the cause of a serious accident.

dust will find its way very easily into the threads. The assembly also requires some turned washers (33). However, I will not comment on them in the text, as the drawings should give all the information required.

Photograph 21 shows the fence fitted. It can of course be in any one of the three slots. The web which fits into the slot is shorter than the slot permitting coarse adjustment of the stop screw position. Final adjustment will be achieved using the fine feed facility of the rest. You may find it easier to fit the fence to the table if you remove the table from the remainder of the rest.

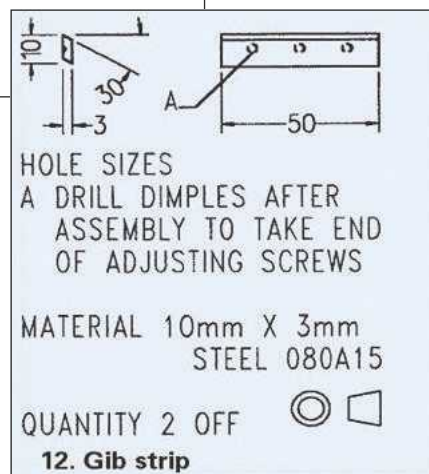
Much milling can be carried out without using a vice as the work holding device.



Square workpiece holder and swivel base, AS3

The main purpose of the holder is to hold square section lathe tools but no doubt other uses will surface. The base (31) is used for setting the angle of the workpiece relative to the feed direction and is also used with many of the remaining accessories. For simplicity it is not shown on their drawings but can be seen in the photographs.

To machine the square workpiece holder (32) mount on an angle plate using a parallel to ensure the part is parallel to the machine table. Commence machining groove with an 8 or 10mm slot drill, working to the 5mm dimension. Open up to 13mm using an end mill. Drill

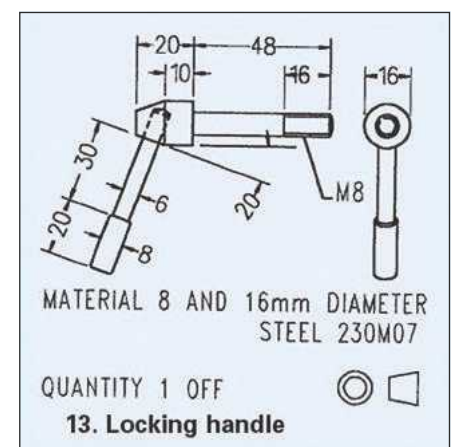


and tap holes. Cut a length of 50 x 6mm for the Swivel Base Machine (31) ends to 75mm, again using the angle plate for mounting. Drill and tap holes.

To sharpen a lathe tool, mount the



Milling the fence.



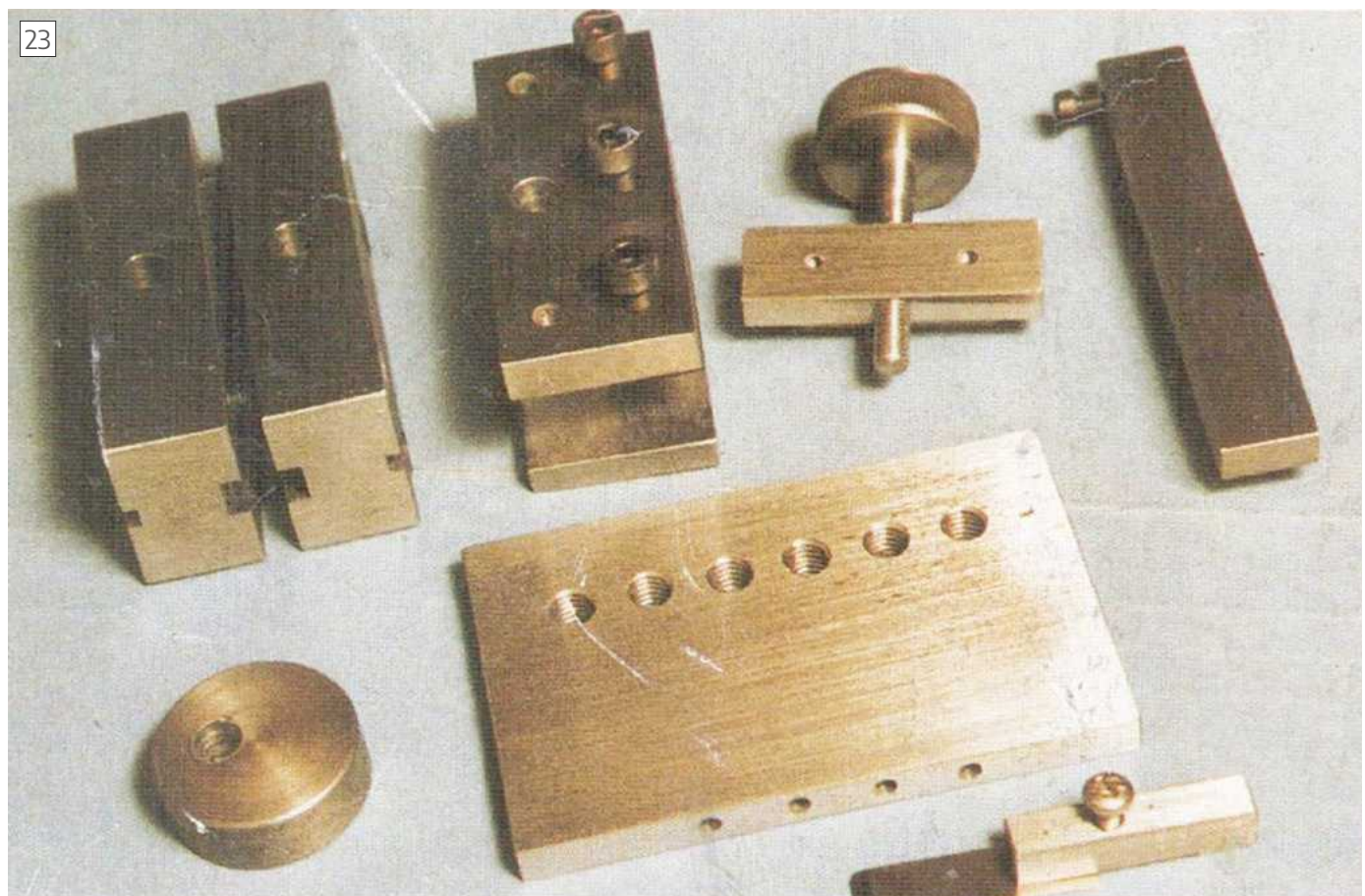
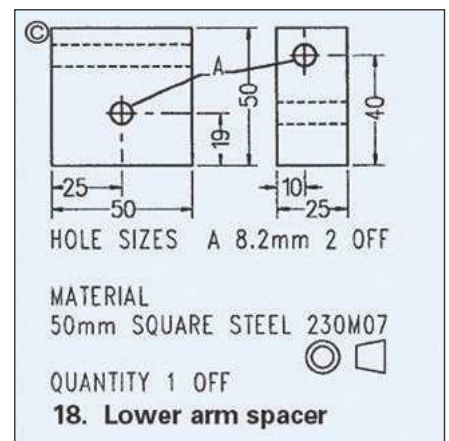
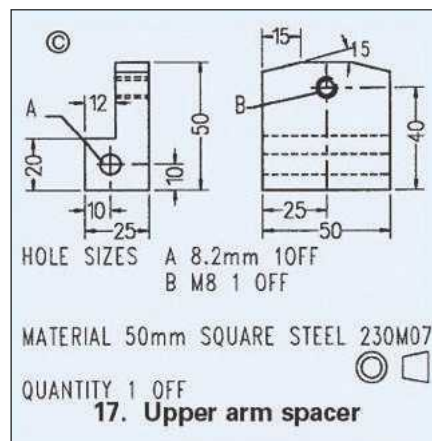
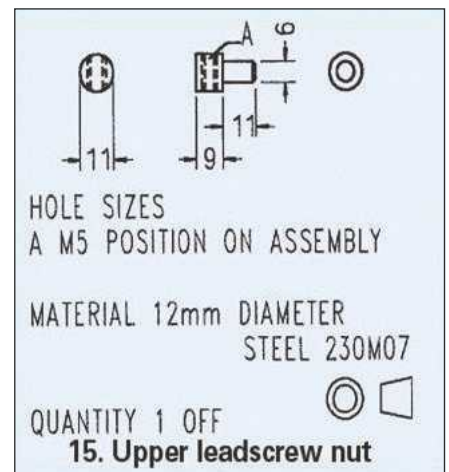
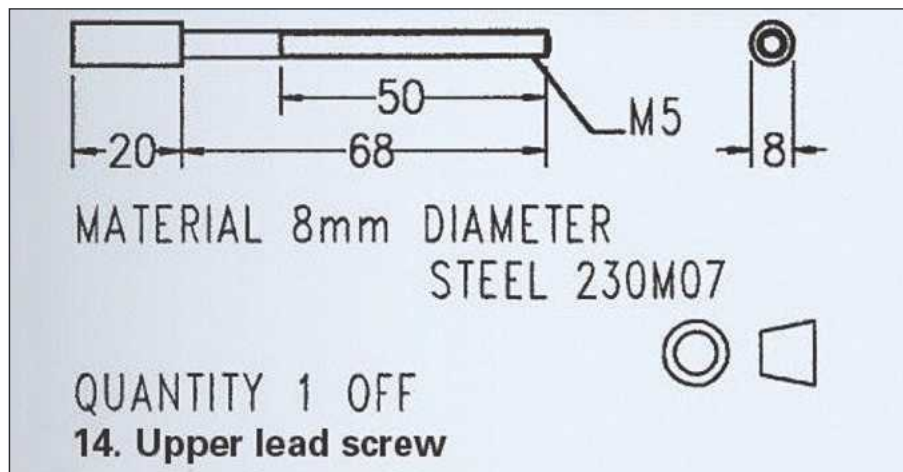
holder on the swivel base at an angle to suit the tool's side relief and with the rest's table angled left to right to suit the tool's side clearance. **Photograph 22** and **fig 34** show this operation.



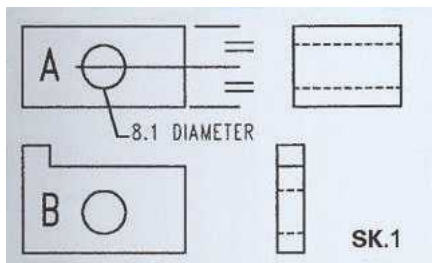
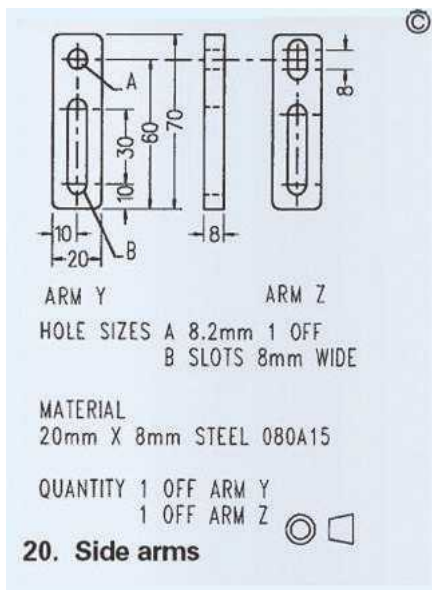
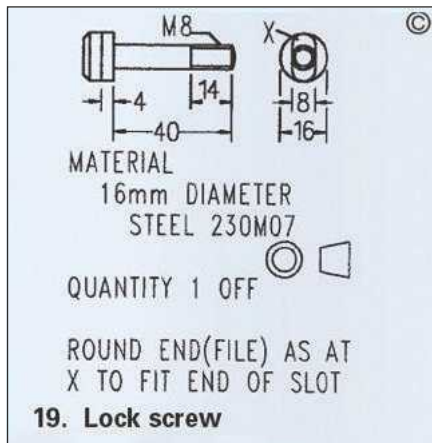
The finished fence in position.



Using the square tool holder on the swivel base to sharpen a lathe tool.

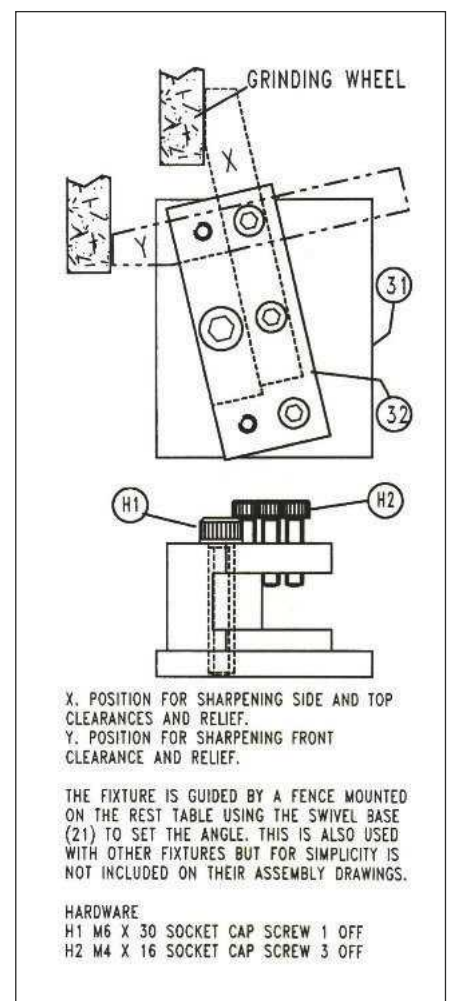
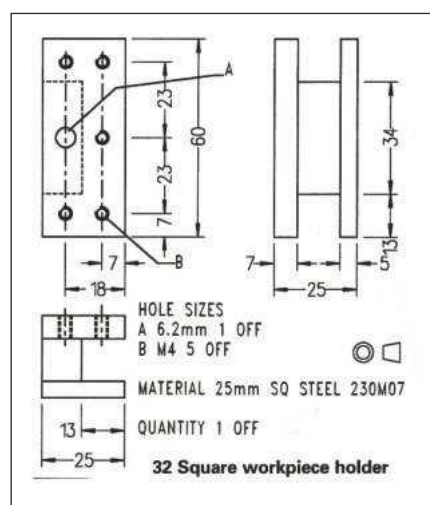
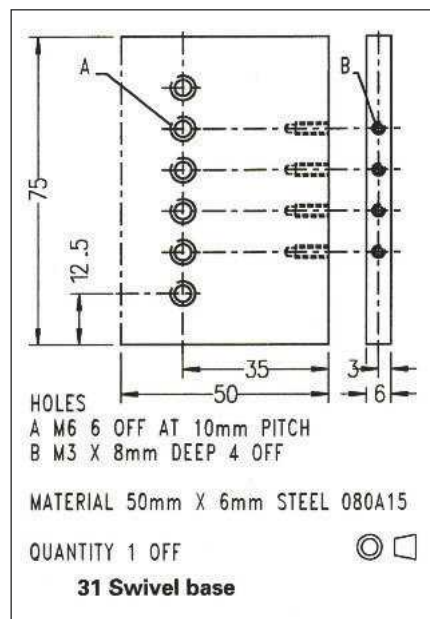
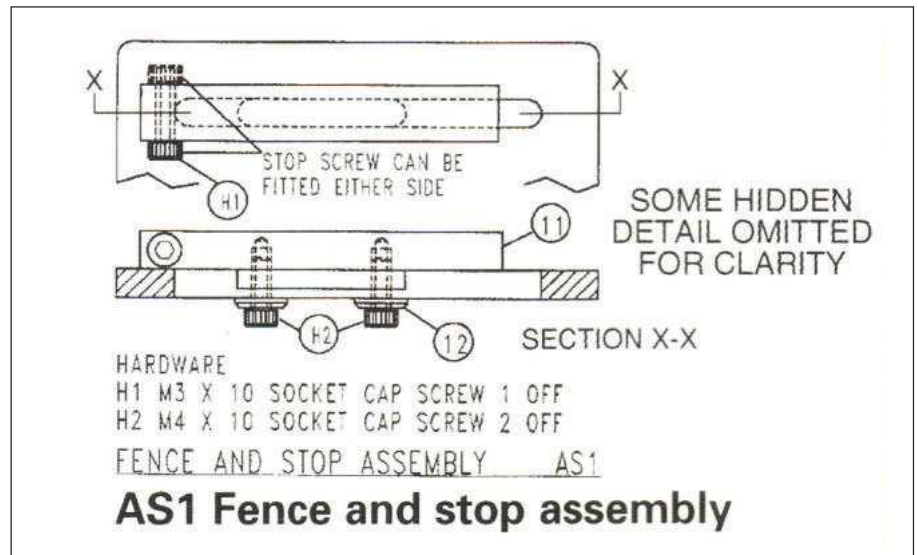


Some of the basic accessories for the grinding rest



If you have studied the grinding rest in detail you may consider that the angle set using the swivel base would actually be achieved using the rest's swivel facility. This is not so, its use, with a few exceptions, is purely to set the approach angle of the face being ground to the wheel.

When grinding a portion from the side of a workpiece it would seem obvious that the feed direction should be parallel to the side of the wheel, see **Sk4(A)**. However, any small error in the approach angle could cause the part to be additionally ground on its side, as in **Sk4(B)**. In view of this, feed direction is deliberately set to an angle to the side of the wheel to avoid this possibility.



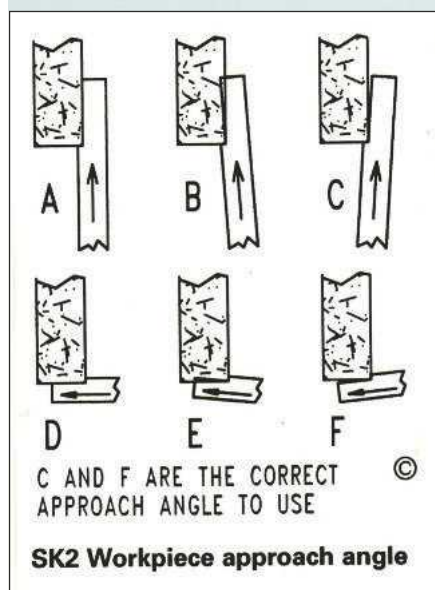
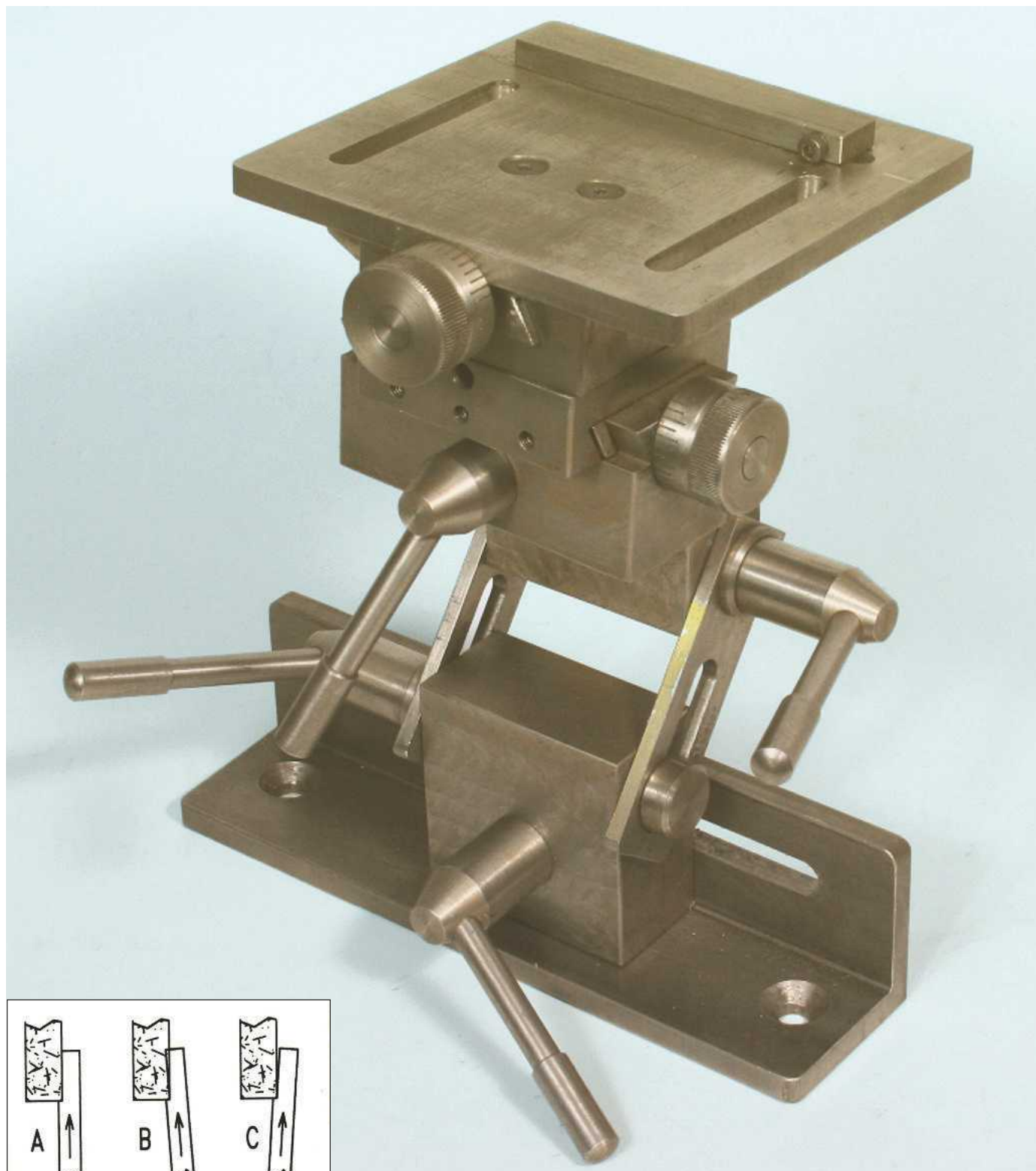
Sk4(C) shows this arrangement.

This may seem like a procedure to overcome the accuracy limitations of the home workshop, it is though frequently adopted practice in industry. **Sk4(D,E)**

X. POSITION FOR SHARPENING SIDE AND TOP CLEARANCES AND RELIEF.
Y. POSITION FOR SHARPENING FRONT CLEARANCE AND RELIEF.

THE FIXTURE IS GUIDED BY A FENCE MOUNTED ON THE REST TABLE USING THE SWIVEL BASE (21) TO SET THE ANGLE. THIS IS ALSO USED WITH OTHER FIXTURES BUT FOR SIMPLICITY IS NOT INCLUDED ON THEIR ASSEMBLY DRAWINGS.

HARDWARE
H1 M6 X 30 SOCKET CAP SCREW 1 OFF
H2 M4 X 16 SOCKET CAP SCREW 3 OFF



and F) show the same situations relative to the front face of the wheel. This angle, set by the rest's swivelling facility, should only be a degree or two maximum.

Postscript

Harold Hall followed up with further articles on various accessories to simplify grinding all sorts of items from screwdrivers and scribes to lathe tools

and milling cutters such as those in **photo 23**.

Details of these various accessories were later published in his book *Tool and Cutter and Sharpening*, Workshop Practice Series number 38, Special Interest Model Books, available from www.myhobbystore.co.uk, search for 'wps 38'. Harold's website give details on using the rest at www.homews.co.uk/page224.html ■

Readers' Tips



Cross-slide lock for Myford 7 lathe

**TIP OF
THE MONTH
WINNER!**



This month our lucky winner of £30 in Chester gift vouchers is Peter Brewer who suggests a simple addition that allows the cross-slide of a Myford 7-series lathe to be locked.

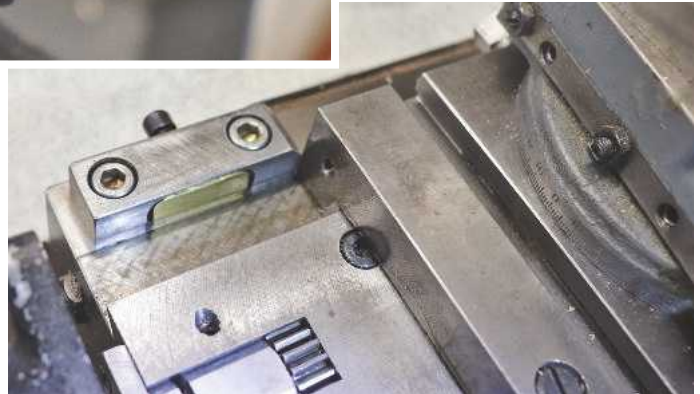
In essence, the two cap screws on the front LHF corner of the saddle are replaced with longer versions that hold a small fitting housing a brass pad which can be pushed against the cross-slide using a socket head machine screw.

The first photo shows the system in place – The height of the block allows free movement of the Top-slide-retaining-screw over the top. The block itself is set within 0.05mm – to stop swarf getting in.

The second photo shows the cross-slide disconnected and slid away to the rear. The brass pad is enclosed in its own pocket and free to move. The black socket head screw is threaded into the block and just pushes the pad against the side of the slide – locking the slide does not deflect it - according to my dial gauge!

Note that I have used grub-screws to lock the top-slide, (two can be seen on the seen on the right).

In use I leave the Allen Key in its socket as the movement from free to locked is only a quarter turn.



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New Motion Nuts for a Tom Senior M1



The old nuts when removed from the mill

Laurie Leonard restores accuracy to a well worn milling machine

I purchased a used, and as I subsequently found, very used, machine and utilised it on many projects but was conscious of having to allow for the backlash in all the motions and the “jolts” as the knee suddenly dropped when trying to lower the table. As often happens the time came when it was decided that enough was enough and that something had to be done. The machine was partially dismantled to remove the motion nuts for examination. These are shown in **photo 1**. From left to right they are knee, table feed and cross feed. The corresponding threads are:

- Knee - 1” 5 threads per inch (TPI) left hand
- Table feed - 3/4” 5 TPI right hand
- Cross feed - 3/4” 5 TPI left hand

Not obvious from the photograph is the state of wear on the thread in the knee nut or the way that the thread

has worked itself out of the bore. Use has stretched the thread which was commensurate with the backlash.

I had trouble removing the table feed nut due to a seized Allen retaining screw

as will be explained later but it would appear that it had been removed before with the screw still bearing on it as evidenced by the massive score mark.

I found the state of the cross feed



The table nut in situ in the cross feed casting



Removing the seized grub screw



The removed grub screw with surrounding metal of the casting



5 & 6 Removing the table feed nut from its housing in the cross feed casting

nut even more interesting as it too had been out before and somebody had attempted to reduce the backlash by slitting the nut and then opening the slit, thus tightening the thread, using grub screws inserted in the extra holes shown adjacent to the main thread hole.

From the photo it can be seen that the shapes of the nuts vary considerably, and thought was given to what phosphor bronze stock should be purchased to make the new ones bearing in mind material cost. Round bar of suitable dimensions would cover the knee and table feed nuts, but the cross feed nut is an odd shape and appeared to be made from a casting.

Turning the shape of the knee nut from solid bar would create a lot of expensive swarf and even by purchasing suitable hollow stock the size of the locating flange would still require a lot of machining with the inherent volume of

swarf. The solution chosen was to use hollow bar of a smaller outside diameter but a size which would still provide an adequate land on the support casting as will be shown later.

Rectangular section stock was priced for the cross feed nut, but it was expensive and the threaded portion was only in a small area of the cross section. It was decided to make the complex shape out of mild steel and the threaded portion out of cylindrical phosphor bronze and fit this into to the mild steel formed piece as an insert.

A length of hollow phosphor bronze round bar was purchased for the knee nut and a length of phosphor round bar of a section that could be used for both the cross feed insert and the table feed nut. As described later a length of mild steel section was purchased to produce a housing for the table feed nut.

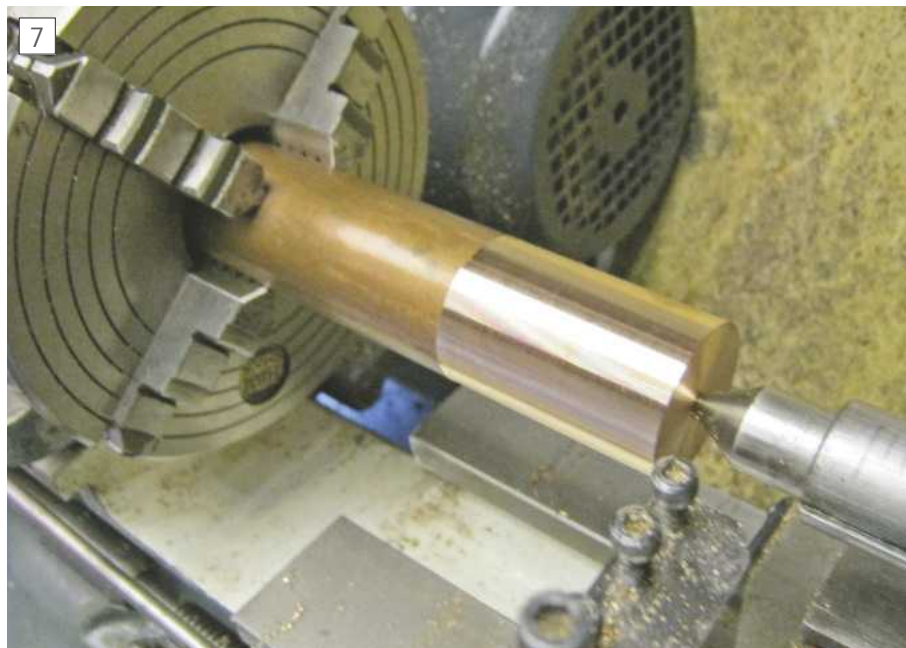


Whilst the nuts were definitely past their sell by dates it was hoped that the feed screws, being made of harder material, would not be that worn but there was a plan to cater for some wear if this proved to be needed.

The Table Feed

With the table removed from the cross feed the table feed nut can be seen located in part of the cross feed casting, **photo 2**. It was concluded that it was a plain bush/insert containing the thread held in place with an Allen screw. All attempts to undo the screw failed. The last attempt with hex key socket ended with the hardened hex key snapping off flush with the surface of the casting. In a vain attempt to remove it a high speed steel drill was tried and as expected it would not touch the broken piece of the hex key. An alternative approach was needed.

The smallest diameter hole saw that I could find was purchased. This was still rather large as my plan was to cut out a cylinder of the casting around the grub screw to remove it completely. Although the hole saw diameter was large, there was plenty of meat on the casting left



Machining the outside diameter of the new table feed nut

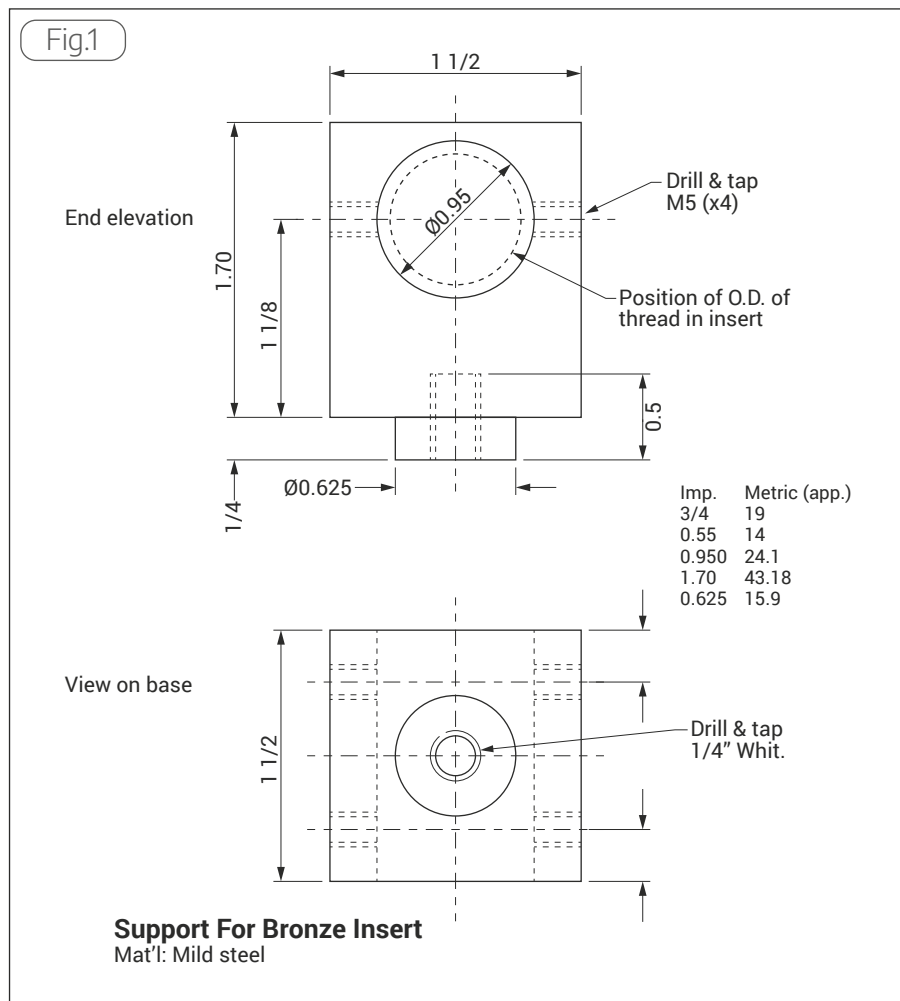
ensuring sufficient strength and space to fit two new grub screws. The reason for two will be covered later.

The mill was reassembled, and the hole saw mounted in the mill chuck

but without the normal pilot drill in the middle, for obvious reasons. The cross feed casting was positioned such that the saw would cut around the seized screw, part cut shown in **photo 3**, and



Tapping the table feed nut



suspected. The majority of this play was eliminated by sawing the new nut in half! The two halves were then replaced in the cross feed casting, the table feed screw introduced and the two half nuts screwed to lock against each other. Freedom of movement of the cross feed screw was tested after which the two half nuts were secured with the newly fitted grub screws, **photo 9**. Note that although the grub screws protrude above the casting it was ensured that they did not foul the underside of the table when it was fitted. (The areas worked on were given a good clean before final assembly).

The Cross Feed

The old cross feed nut was measured and a drawing made of the new arrangement, **fig. 1**.

The mild steel housing was bored as shown at 0.95 inches to take the phosphor bronze insert. The drawing shows the position of the outside of the thread in the insert. This was drawn in to give confidence that it would be strong enough at the minimum material thickness areas. The four M5 grub screws locate the insert in the housing.

Although an interesting shape, machining the housing was relatively straight forward. The as purchased billet was machined to length in the lathe supported in the four jaw chuck. Having marked the centre of the bore for the insert the job was set up in the four jaw chuck, **photo 10**. The tailstock centre was used to set it as near as possible and then the lathe Digital Read Out (DRO) was used to confirm set up/final adjust by advancing the turning tool to just make contact, **photo 11**, and noting the reading. It is accepted that personal "feel" comes into this but on other jobs where the use of a clock gauge can

the knee raised slowly monitoring the swarf from the cut for change in colour indicating that the bronze nut had been reached. At this point the piece being removed was just still attached but was easily removed with narrow nosed pliers, **photo 4**. The old nut was withdrawn using a piece of stud bar and suitable washers, nuts and spanners as shown in **photos 5 & 6**.

Having confirmed the outside

diameter of the nut the piece of phosphor bronze stock was turned to the correct size, **photo 7**, cut off, faced, remounted and then bored to the tapping size for the 3/4" ACME thread. Remounted in the four jaw chuck, the nut was then tapped, **photo 8**.

The new table nut was tried on its screw and as expected there was still play. This could be due to the tap cutting over size or wear on the screw as was



The two halves of the new table feed nut in place fixed with grub screws



Setting up the cross feed nut housing ready for boring



Using the tool to check the position of the housing

easily be utilised this has confirmed the “as felt” setting as near as is required for most jobs.

The spigot that locates the nut in the knee casting was a straightforward piece of machining, **photo 12**. Obviously, this has to be a good press fit into the knee to ensure no backlash is introduced at this point.

The insert, which in the new set up

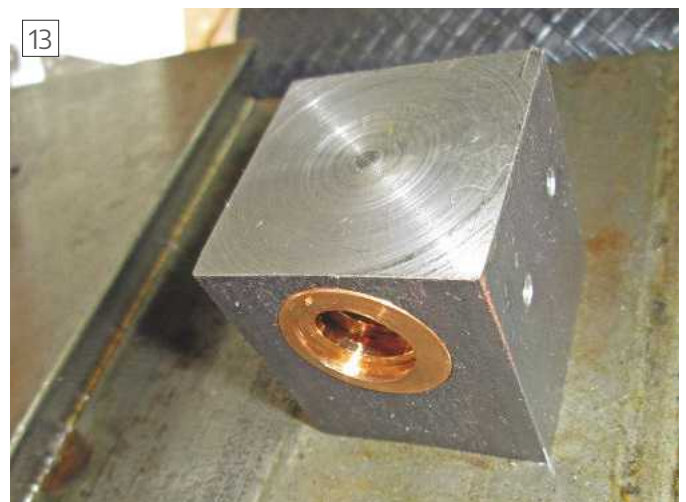
is the actual nut, was machined from a piece of the phosphor bronze stock in a similar way as that for the table feed. The completed housing and nut are shown in situ on the knee casting in **photo 13**. As in the table feed, the nut (insert) was sawn in half and the two halves hardened against each other with the feed screw inserted to reduce the backlash and the grub screws in the

housing tightened but some backlash appeared to be still present possibly due to wear on the screw. The composite nut swivels on the spigot where it mates with the knee casting and alignment takes place when the machine is finally rebuilt. The composite nut is clamped to the knee casting with a screw and washer into the spigot from below.

●To be continued



Machining the cross feed nut housing spigot



Cross feed nut in place in its housing trial mounted on the knee casting

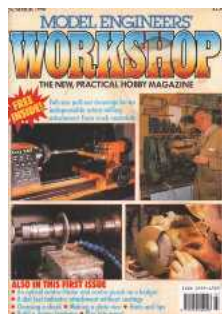
From the Archives: Home Made Precision Optics



'Bluey', from MEW
Issue 1, Summer 1990

When you are setting-up work or marking out, do you sometimes sigh 'oh for a pair of eyes'? In this ingenious feature 'Bluey' comes to the rescue with an easily made pair of aids for your workshop. You'll find this optical centre-punch and centre-finder indispensable and they'll cost a fraction of what you'd pay for commercial items.

Centre punching is a tricky business although in theory there is nothing to it! What should happen is that the centre punch should be used at the junction of two scribed lines and should be drawn along one until the intersection is felt



This article about a couple of handy optical aids appeared in the very first issue of Model Engineers' Workshop. Whilst they will be very useful if made to a reasonable standard of accuracy, the term 'precision' may be a slight exaggeration! The identity of the mysterious 'Bluey' was obscured in a mist of coolant, however, anyone familiar with his inimitable style will recognise that of founding Editor, Stan Bray!

and then at that point tapped with a hammer. I am sure most of us follow this excellent advice only to find that the punch has slipped out of position before being hit and we then have to start laying it an angle and trying to retrieve the position. (It is rather like sawing legs

of a chair to make it shorter - we keep going a bit more and a bit more until the whole thing becomes quite a mess.) The result is often an elongated punch mark more or less on the spot required but because of its shape, a drill, and particularly a small diameter one, is likely to wander some way from where we really want it to be.

The optical centre punch

I had seen advertised an optical centre punch and at an exhibition actually saw one. I must say that I was quite impressed. However, buying things that can be made is not my way and so next day it was into the workshop and a start was made on scheming out an optical punch for myself. Although made from odds and ends which happened to



The completed optical centre-finder in the milling machine; in actual use it would be brought closer to the work than shown in order to line it up accurately.

...buying things that
can be made is not
my way and so next
day it was into the
workshop and a start
was made...

be around my own workshop there is nothing required that is not very easily obtainable.

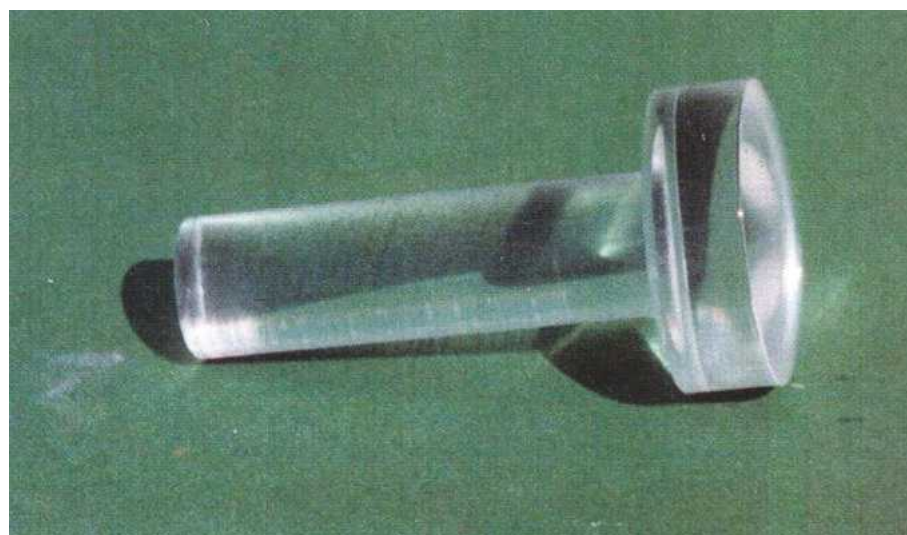
The actual punch is $\frac{3}{8}$ ths in. diameter and, whilst my own was already around in the workshop and was pressed into use, there is nothing difficult about making one from silver steel, hardening and tempering it to a straw colour. The actual sizes shown suited me, but there is no need to comply with them if convenient materials are to hand. The point on the centre punch is shown as an included angle of sixty degrees, which is the angle I prefer. Technically speaking, the angle should really be ninety degrees to allow the drill to seat better in the punch mark, sixty degrees being normally used for initial marking-out and the mark then opened out with a punch at ninety degrees. However, all this is a matter for the individual.

The support body

The support body was machined from



The body of the optical centre punch; this one is from aluminium but almost any material will do.



The magnifying lens for the tool. Made from acrylic, it is a simple turning exercise; shank must be a good sliding fit in the body and the large diameter rounded at the end to provide magnification.

a piece of 1 inch diameter aluminium but could just as easily be mild steel or brass if these are more convenient. The central hole should be bored or reamed to a good fit as there must be no slop on the punch when it is inserted. A groove is machined in the end and this accepts an 'O' ring which stands just proud of the actual body and so prevents the thing from sliding around whilst being lined up.

The insert

The original optical insert was made from Perspex and actually machined from a piece of sheet material, no other being available. Also, originally it was

There must be no slop on either the optical insert or the punch, as this would immediately lead to errors when in use.

parallel; there was no magnification and not as much illumination as one might have wished for, so, whilst visiting the 1990 Model Engineer Exhibition, I purchased a piece of 20mm diameter acrylic rod from College Engineering Supplies. I then made a new insert with a domed top which gave more light at the base and also provided a degree of magnification. Acrylic is not quite so easy to machine as Perspex as there is a tendency for it to string. However, both are quite reasonable to work with.

Polishing

The insert must be highly polished and this was done with Solvol Autosol which can be obtained from most car accessory

Events of Summer 1990

June 13 – Demolition of the Berlin Wall starts

July 1 – Re-unification of East and West Germany

August 2 – Iraq invades Kuwait, triggering the Gulf War.



The centre punch. This, too, should be a sliding fit in the body; the 'O' ring at the top has no effect on the operation of the tool but makes it easier to handle.



The ends of the body and magnifier. The 'O' ring recessed in the body prevents accidental movement when adjustments are made. Black felt-` tip pen ink wiped over the base of the magnifier picks out the cross-hairs.

shops. It is rubbed on with a cotton cloth and then buffed hard to give a good finish. I should point out that it is essential that the original machining must also be to a fine finish to prevent excessive polishing being required. I also polished the support body by the same method. Very fine marks (cross hairs) must be made across the bottom of the insert and these line up at the place where the centre punch mark is to be made. These can be done in the lathe using a sharp pointed tool which is drawn across the face, the lathe then rotated through ninety degrees and the operation repeated.

Of course, such an instrument relies on

accuracy in the first place. There must be no slop on either the optical insert or the punch, as this would immediately lead to errors when in use. Care must therefore be taken to ensure that the point on the punch is made accurately. If the three-jaw chuck of the lathe is not one hundred percent accurate then set the punch up in the four-jaw chuck. Failing this, use a larger diameter piece of metal than required and turn the parallel shank and the point in one setting. Part off the excess larger diameter material and the punch must be right.

Similar precautions must be taken with the insert and, in particular, care must be taken to ensure that the

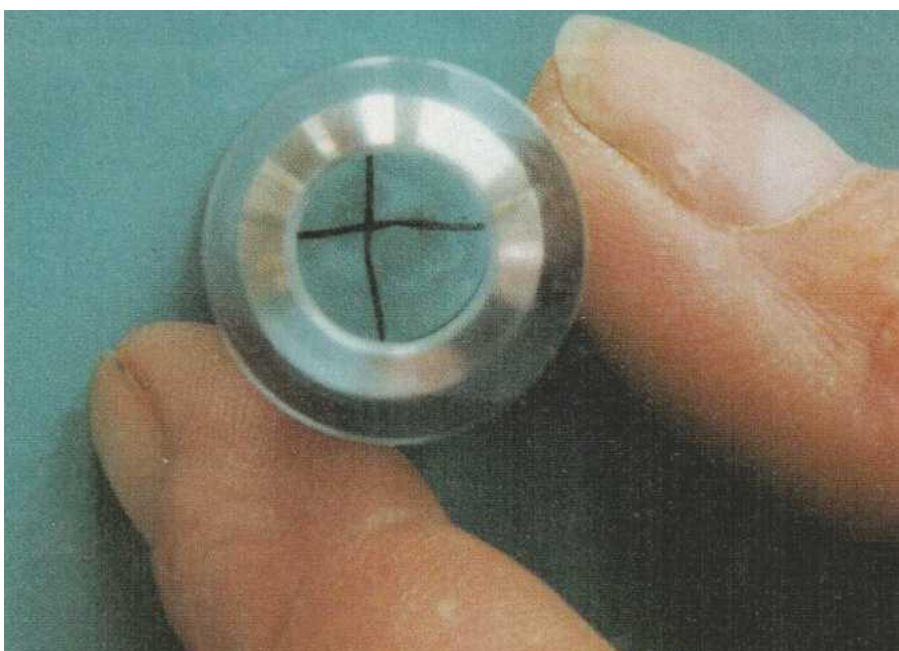


The body with magnifier ready to be positioned over the work.

tool used to scribe the cross hairs is absolutely on centre height.

The centre-finder

The centre punch proved a delight to use, making marking out both extremely quick and very accurate. Fired with enthusiasm, I looked at a very expensive piece of equipment in the form of an optical setting-up guide. We all know the problems; some form of pointer or a wiggler is put in the milling machine and brought to the work. Sometimes the setting can be done quite easily and no real concentrated visual observation is needed. On other occasions it is impossible to get the light exactly as required to see what one is up to, and if the light shines on the point of interest then it casts a shadow that makes it impossible to see exactly



A good view showing the inked cross-hairs.

The centre punch proved a delight to use, making marking out both extremely quick and very accurate.



When the body is in the correct position the magnifier is removed and replaced by the centre punch.

what is happening. Usually in these circumstances we resort to the use of a magnifying glass, which invariably is covered with dirt when needed, or hides itself away in a corner of the workshop (like on the marking-out bench) and cannot be found until other methods of setting up have been resorted to!

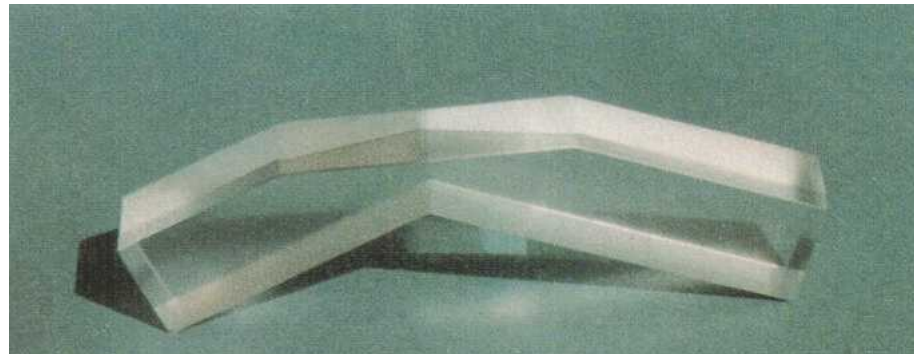
But an optical centre finder sounded quite formidable, and judging by the price they must be made of pure silver. So if I can make an optical centre punch, why not an optical centre finder? I picked up a piece of aluminium of what I thought would be a suitable diameter and started experimenting. Originally I made the

optical insert from two pieces of Perspex which were to be joined. That caused problems as any adhesive would have upset the optics. I then hit on the idea of making it from a single piece of material.

The material I used was thicker than required and was very scratched and so I had to machine all faces. This will not be necessary if the correct thickness of material is available. Perspex is not hard to come by in sheet form, a quick look in the Yellow Pages under plastics will, in most areas, reveal several suppliers and most of

these keep boxes of odds and ends. The betting is that if you pay a visit to one then you will come home with bits of PTFE and all sorts of things.

My thicker diameter material was fly-cut with a very fine feed and this produced an almost polished finish all over, the only parts that really have to be polished up to a mirror finish are the two square ends and the twenty two and a half degrees chamfer. Again Solvol Autosol was used for the final polishing.



The centre-finder lens. In the prototype, this was cut from a sheet of Perspex and polished. The angle enables the operator to look round the corner to the point of setting.



The body of the centre-finder showing how the slot has been milled out to accept the lens.



This frontal view of the body shows the two angles required accurately to position the lens. The angle value of the body itself is not critical, provided, of course, that it is matched precisely by that of the lens.

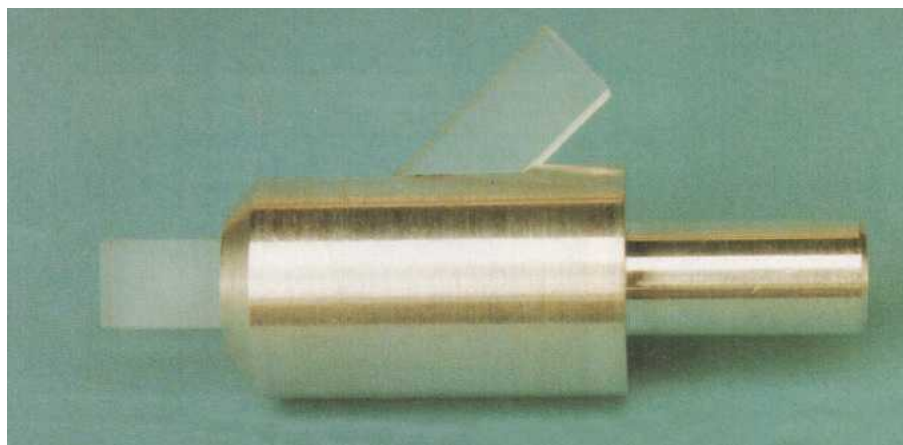
So if I can make an optical centre punch, why not an optical centre finder?

The body

The body was made, in my case, from 1 in. diameter aluminium, but brass or mild steel would do equally well. The bar was first machined as required in the lathe and then the slot was milled out with a 3/8 inch diameter cutter in two separate operations. The first operation was to machine a slot 11/16 inch deep and 3/4 inch long. The work was then carefully re-positioned in the vice and a second slot machined at an angle of forty five degrees so as to intersect the first slot at 3/4 inch from the end.

Assembly

The two components were assembled ensuring that the protruding end was parallel to the body. To do this, temporarily fix it in place, stand the assembly vertically on a surface plate or, if you do not have a surface plate, on the drilling table or some similar object. Check right round the body to ensure that it is upright. When you are quite sure it is right, the assembly can be permanently secured with an epoxy adhesive ensuring that the adhesive does not touch the polished twenty two and a half degrees angled face. When



The assembled optical centre-finder; it is absolutely essential that the lens lines up centrally in the body if accuracy is not to be impaired.

the adhesive has thoroughly set, any excess can be scraped off.

The whole unit is now mounted in the lathe ensuring it is absolutely centralised, and the cross hairs engraved in the same manner as with the centre punch.

Using the centre finder

To use the centre finder, mount it in the spindle over the work. Adjust the table in either direction until the cross hairs

are located exactly at the point required. Lock the table in position and raise the spindle to remove the centre finder which is replaced with the cutter. Do not, of course, alter the table position until cutting has started.

The tool proved remarkably easy to make and is one of the most useful little devices I have ever made. ■

In our Next Issue

Coming up in issue 296
On Sale 14th August 2020

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Look out for our August issue, number 296:



A new major series with full plans for **Ian Strickland's** Rotary Table



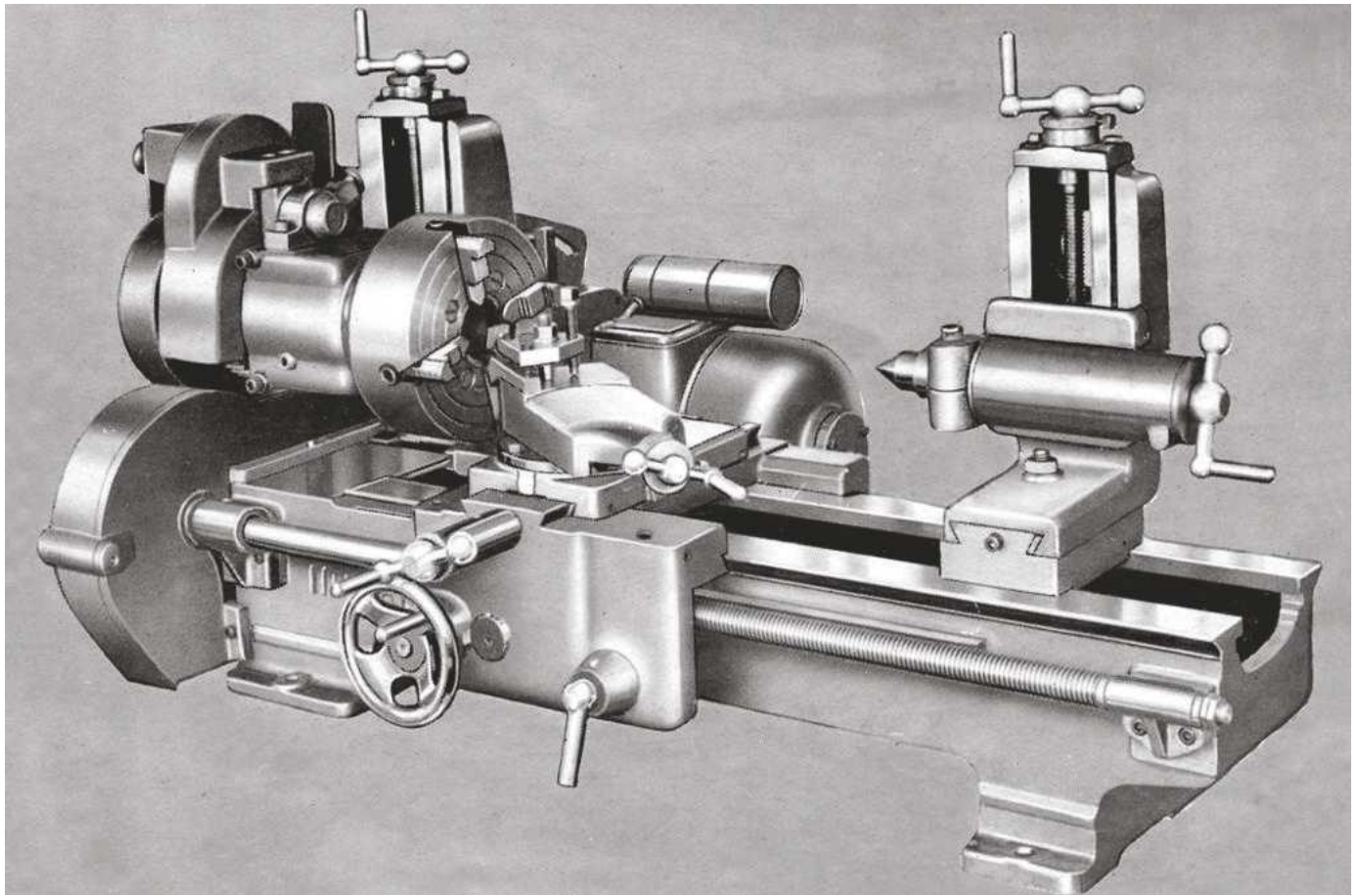
Ray Griffin claims to have the 'perfect' bench drill



Stuart Walker makes a jumbo grit blasting cabinet

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Machine of the future



The Murad Bormilathe

Geoff Harding shares his thoughts on where hobby machines could go next

I was re-reading my November issue of MEW and was especially drawn to Antony Mount's "Lathe of the Future" article. In his letter he mentions the Bormilathe by Murad. In my workshop I am lucky to have one of these machines. It is usually set up as a horizontal milling machine as I have a Mill/Drill machine and a 9 inch Southbend lathe.

Antony's letter got me thinking about what a model engineers machine of the future would look like.

Based on the idea of the Bormilathe I think an update would bring it into the 21st century. A list of my proposals would be as follows.

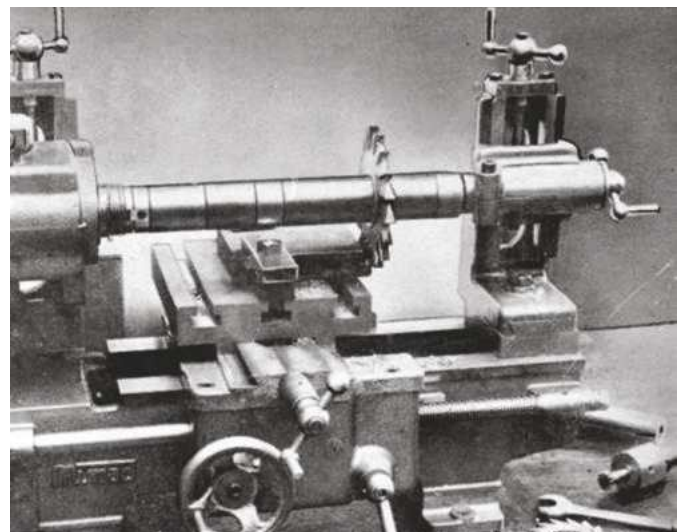
- 1, Variable speed motor plus back gear.
- 2, Norton screw cutting gearbox.
- 3, DRO or full CNC capabilities.
- 4, Vernier engravings on head and tailstock to help centre height adjustment accuracy.
- 5, Longer bed.
- 6, Perhaps a vertical head.

The Chester "Centurion" goes a long way to achieving my ideas but without the rise and fall head and tail-stock it misses out on being able to be used as a horizontal mill or boring machine.

The next question is just how viable such a machine would be? Again, looking at the Chester Machine tool catalogue I see

that a lot of the structure already exists. Looking at some of the lathes I can see that the bed on some of the lathes are a machined through item. The saddle, apron, lead-screw and cross-slide are all in existence. All is required is a rise and fall head and tail-stock and a milling table to replace the tool post. Once more DRO and CNC mechanisms are already available.

Food for thought! ■



The Bormilathe set up as a horizontal milling machine.

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Desktop Gear Hobbing

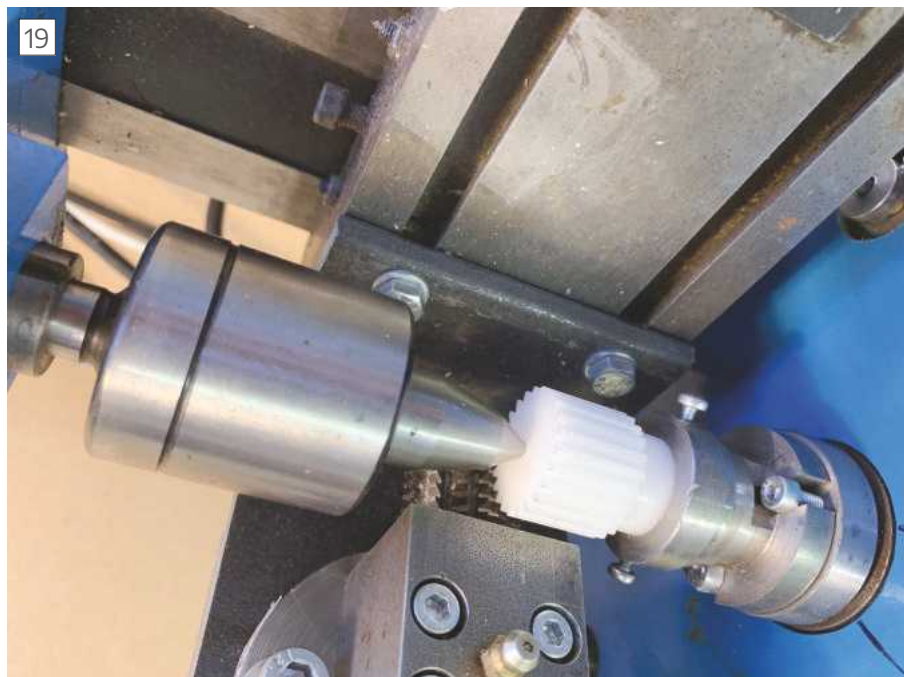
Toby Kinsey has designed this fascinating piece of gearmaking equipment - Part 3

The two M3 screws of the holder are tightened onto to the work, the goal being to keep everything concentric, **photo 19**. This worked but was a bit cumbersome and meant there was a section of the blank that couldn't be used, as it was needed to fit into the holder.

The next solution was to use a woodworking drive dog, **photo 20**. These are used on wood lathes to hold timber lengths between centers for turning timber. They come in different sizes and have a retracting centre that keep the blanks concentric as they are pushed onto the "teeth" of the dog by the tailstock. They bite enough into the plastics I use to allow no slip between the headstock and blank and allow you to cut the entire length as a gear. This is a bit of a bodge in some ways, and would struggle holding metal blanks, but it is a quick method to mount and unmount work.

Electronics

The next phase was the electronics. There is mains voltage involved in the electronic part of the project so if you intend to make your own please be aware of the dangers of mains voltages. I used an Arduino Nano, **photo 21**, as the brains of the project, (**ref. 7**).



The first work holder in use to cut a gear.

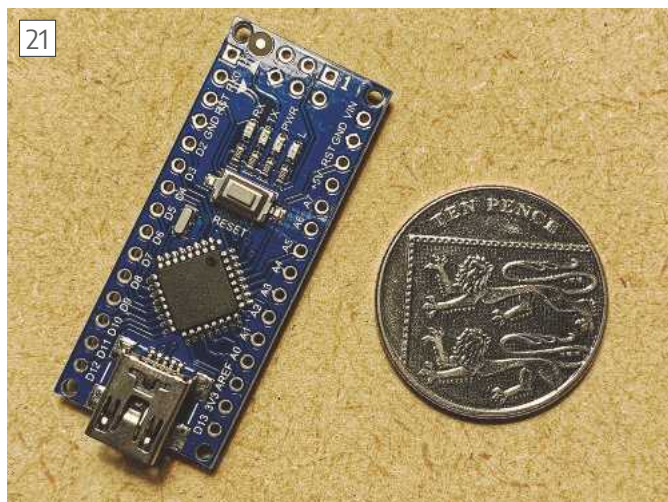
This is one of a range of inexpensive easily programmed microcontrollers. A microcontroller is a basic computer unit where you can control external devices and read sensors with very little other circuitry. See the later sections on Wiring and Software for more information. I have had some experience of working with Arduinos in my job, but I am in no way an expert but have found them relatively easy to use, and there is a large amount of help and advice online to get you through any problems.

In the original iteration of MEGS there was a disk with 100 slots cut into it.

This was fixed to the spindle motor. Fixed at the edge of the disk was a photomicrosensor. This is a small device that sends a beam of light across a small gap to a receiver. As the disk rotates between in the gap of the sensor, the beam of light is constantly being interrupted, **photo 22**. The Arduino can read the signal generated and it can then do some simple calculations and send signals to the stepper motor driving the headstock to drive it at the right speed. The Arduino is also connected to a 16x2 character LCD screen and 4 buttons. Using the buttons you can set the



Woodworking lathe dog.



Arduino Nano.



The setup for measuring the speed of the cutter spindle.



MEGS Set up for cutting 12 teeth.

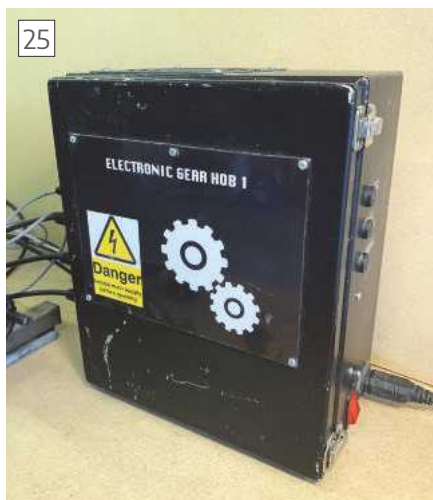
number of teeth of the gear you wish to cut, which is all displayed on the little LCD screen, and set the stepper motor running, **photo 23**.

The original Sieg drive motor electronics, **photo 24**, which allowed you to vary the speed of the motor, was removed from the lathe and placed in a metal electronics cabinet bought off the Internet. I sprayed the cabinet black after I received it. But due to the length of time since then, and the many times it has been pushed under a bench the paint is a bit tatty now, **photo 25**. The Arduino and screen and buttons were placed into the door of the cabinet.

In the cabinet is also a transformer to supply power to the stepper motor. This is a 36 volt power supply with three outputs. Where I purchased this from originally is lost in the mists of time, unfortunately. I have found reference



Original lathe motor and speed control electronics.



The cabinet (could do with a respray!.)

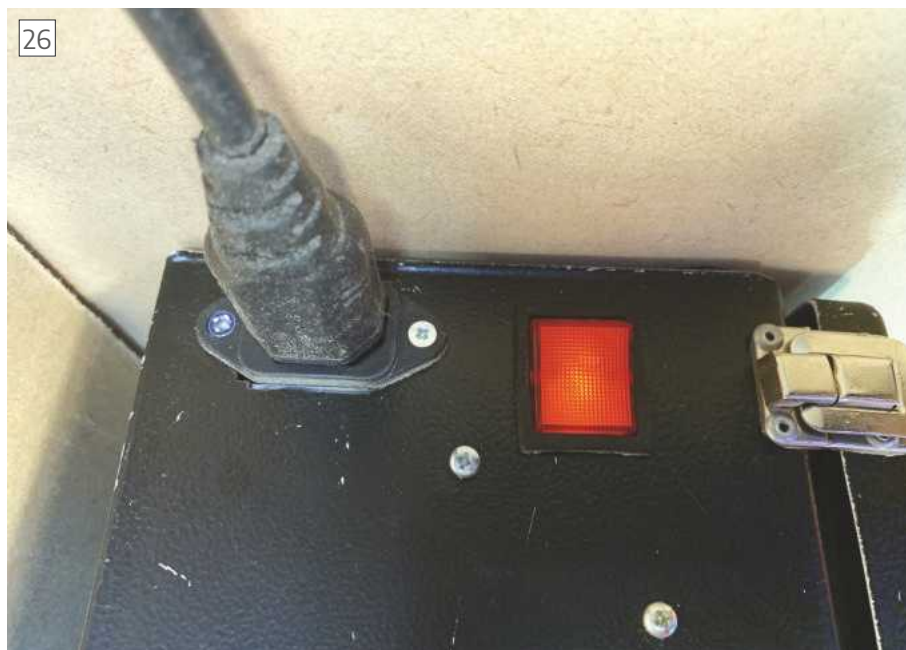
to a similar one but I haven't used this supplier so I cannot vouch for them, (**ref. 7**) and a 240v to 5-volt dc "wall wart" transformer was de-cased and mounted in the cabinet. This supplies the requisite power to the Arduino. A 240v IEC 3 pin socket, commonly used for kettles and the like, and a mains switch were also fitted, **photo 26**. As I wanted to make sure everything was kept nice and cool a second hand PC fan and grill, bought online, was fitted, after cutting a hole in the top of the cabinet. Another hole was cut in the bottom of the cabinet, with mesh covering the

hole. This would allow cold air to be drawn from underneath the cabinet then expelled through the top. These components were all fed mains voltage via appropriately sized fuses, **photo 27**. Joining the other bits in the cabinet were two 4.2 amp stepper motor drivers. One is to drive the headstock, and one is to drive the lead screw, (**ref. 9**). They took the simple low current output pulse from the Arduino and translated it into the correct phasing of the coils to control the stepper motors. The driver also has all sorts of fancy protections against over current, over voltage and even incorrect

wiring of the stepper motor, thus much reducing the chances of something going bang! The drivers have a row of tiny switches, some are set to limit the current supplied to the motor, **photo 28**, **ref. 9**, in this case set to 4.2amps. The switches also set how many steps per revolution the motor did, in MEGS case it was set to 400steps/rev.

I made up some 4way XLR cables, which seem to be commonly used to connect stepper motors to their drivers, but they are normally used in an audio and visual context, **photo 29**) My idea was to use cables with plugs and sockets so that control box and lathe part of MEGS could be separated for ease of moving and storage. The cable was wired to stepper motor and the connections contained in a small potting box cable tied to the body of the motor, **photo 30**, **fig. 7**. I was mildly concerned that the motor electronics might be a little noisy electrically and also not very reliable, judging by the comments I found online. Both proved to be the case. The Arduino worked fine until I started up the lathe motor, at which point it started misbehaving. So, I think it was broadcasting a lot of electromagnetic radiation, which was causing all sorts of issues. The Arduino would lock up or receive all sorts of false signals. I thought about trying to shield it but in the end, I decided to move it to its own enclosure. Another change, another visit to the web, and a small die cast project box was purchased and the Arduino and screen were mounted in that instead, **photo 31**.

A 5-pin DIN cable was made up to carry the control signals from the Arduino back to the cabinet. This allowed the Arduino to be kept some distance from troublesome electronics.



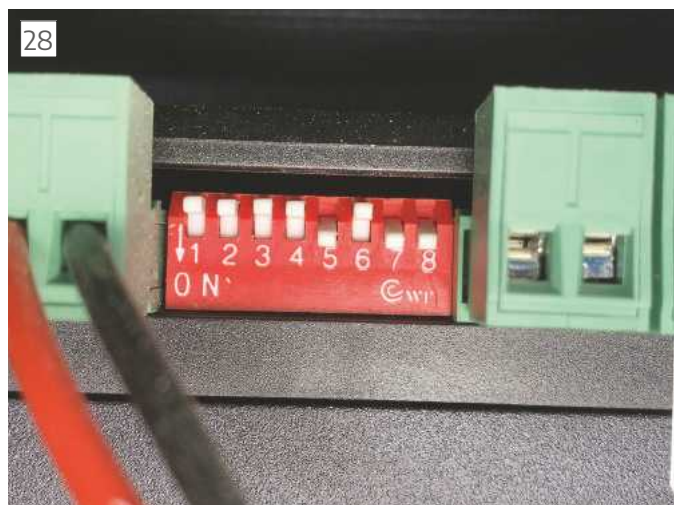
Cabinet mains IEC socket and cable and the illuminated mains switch.



Fuses mounted mounted in the side of the cabinet.

By this time the lathe motor control was behaving in a rather intermittent manner itself and the speed control was very hit and miss. The turning the speed control would result in the motor not starting or suddenly starting up. But ploughing on I fitted the XLR sockets into the cabinet, **photo 32**, **ref. 10**.

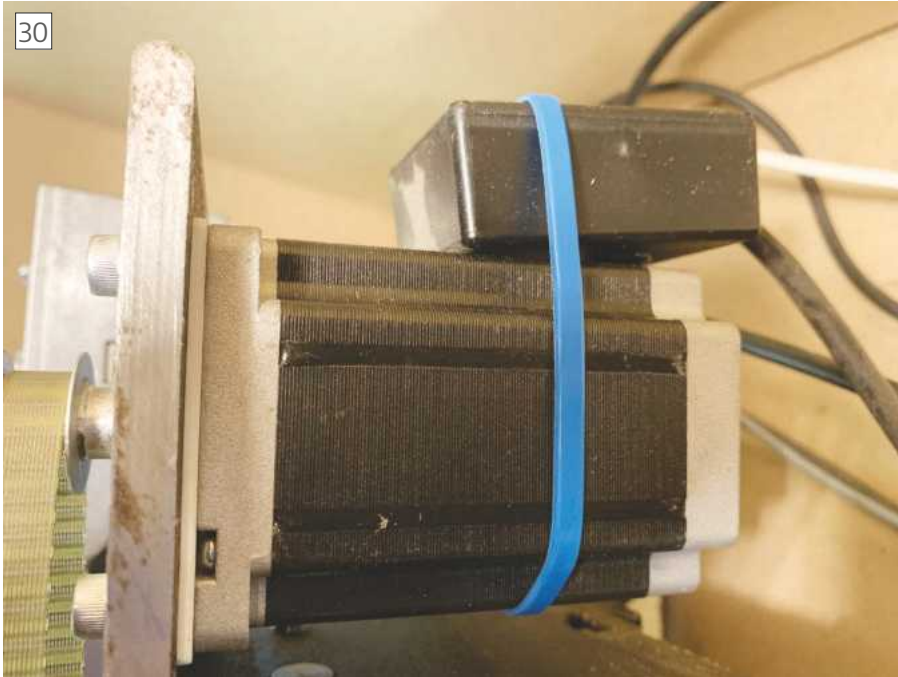
I wired the sockets to the drivers and connected everything together. After writing a tester program and downloading it to the Arduino I was able after some fettling get it functioning, but only if I turned the spindle by hand. As soon as I turned on the old lathe motor, things started to go awry. The idea was that every time the disk on the motor broke the beam on the detector, it would cause an interrupt in the Arduino. An interrupt as its name suggests, would cause the Arduino to halt whatever it



DIP switches to control max motor current and number of steps per revolution on the stepper motor driver.



XLR 4-way stepper motor plug.



30 Potting box to hold the wiring connections on back of stepper motor.



31 Die cast project box to hold Arduino.

is doing and run a small bit of code to deal with or “service” the interrupt. In this case it would add one to the count used to keep track of how many times the beam has been broken and, by extension, how many revolutions or part revolutions the spindle had made.

This method was used because it is obviously important to maintain the correct ratio between the gear being cut and the gear hob cutter. In an industrial machine these ratios are maintained with a gear train, so unless there is mechanical fault the ratio will always be correct. But as I was trying to do the same thing electronically, if the spindle revolutions were not being accurately counted, when the program was calculating the number of steps to send to the stepper motor it would get it wrong, this could lead to slippage and the ratio changing. This would cause the teeth form becoming too thin and sometimes, as I found out, the hob cutting the teeth out of existence. Which goes without saying, wasn’t ideal. Using interrupts was meant to solve this issue by insuring every single one of the 100 slots on the disk was counted. But when the lathe motor was fired up the Arduino started missing counts of the slotted disk. I assumed that there still must be some sort of interference reaching the Arduino’s location. I tried all sorts of ideas to get it working reliably but to no avail. It was all very frustrating and due to other projects I had to work on, MEGS got parked under a bench.



32 Sockets for stepper motor XLR plugs and DIN socket for connection to Arduino.

New Direction

A while later, seeing it sat there covered in dust, I felt I should really try and get it working. Then it occurred to me, if I swapped out the lathe motor for a stepper motor a lot of the problems would disappear. It would also be very simple task for the electronics, for if you were cutting a 10-tooth gear, step the spindle motor 10 steps and then the headstock motor 1 step. No problems trying to measure revolutions, no troublesome motors and unreliable drives.

The only downside was that the

maximum speed you can reliably drive a stepper motor would be somewhat less than the speed the original motor could cope with. There is also a maximum rate you can send pulses to the motor. Exceed this rate and the motor won’t have time to move between each pulse and will stop rotating. Therefore, cutting a gear would possibly take longer than using the original motor. But that was something I thought I could live with.

●To be continued

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Coronavirus Update

This month it's really quite difficult to give a status update on suppliers to the hobby. It does appear that mail order, via the internet or telephone, is working pretty much as normal with only a few local issues around delayed delivery. Some of the suppliers with public facing showrooms and counters are already opening with social distancing in place and from the 4th of July it looks like all such outlets should be able to open if they wish. The best advice for the moment is to check websites, call or email before travelling. Also try to use card or contactless payments instead of cash if you can.

Away from the shops, it's clear that mass gatherings like engineering shows are still unlikely to be happening in the medium term, but with small groups being allowed to meet outside, it may well be that some clubs can organise workparties or outdoor steaming days with strictly limited numbers.

Also, it looks like good news for overseas readers, I'm hoping that this issue will see the resumption of your subscriptions as international distribution is getting back on an even keel, although I'm afraid I can't give a cast iron guarantee just yet.

On Robot Intelligent Screwdriver

I think it's going to be along time, if ever, before we have robots assembling our projects, but readers will be interested in how industry approaches such tasks.

The new OnRobot Screwdriver can be deployed and redeployed for different applications in minutes, with built-in smart features—including precise torque and embedded axis control. Its smart, complete-out-of-the-box Screwdriver that allows manufacturers to automate a wide range of assembly processes quickly, easily, and flexibly. This provides welcome relief for manufacturers who are eager to automate repetitive, unergonomic, and often inconsistent manual screwdriving processes, but who struggle to integrate and program typical piecemeal screwdriving systems.

Programming the OnRobot Screwdriver is as easy as entering the appropriate screw length and torque value into the user interface that is integrated into the teach pendant of any leading robot. With precise torque control and embedded axis, the OnRobot Screwdriver automatically calculates the speed and force required for consistent, accurate screwdriving. The Screwdriver can detect incorrect screw length, which can help improve overall quality and reduce scrap. Screws are retracted inside the tool and driven automatically once the robot arm moves into position, which reduces robot arm movement and additional programming.

The Screwdriver can handle a wide range of screw sizes and lengths, from M1.6 to M6, and up to 50mm long. With its simple programming and easily exchangeable bit system, the Screwdriver can be quickly changed over to a different screw size, length or product line in minutes, which minimizes downtime and improves productivity.



New Paints for Modellers

The Airbrush Company have announced some new additions to the Lifecolour range, to complement their wide range of specialist colours for subjects like railway and military models. The new Lifecolour sets contain popular basic and primary colours in two versatile sets. They allow you to blend limitless colours with ease. Suitable for a wide range of applications. They are water soluble acrylic colours for modelling and hobby uses. LifeColor is excellent for paint brushing or airbrushing on plastic, resin, metal, vinyl, wood, cloth and ceramic.

Find out more at www.airbrushes.com.



Machine Mart Fans and a new Sander

These great value robust drum fans are ideal for fast cooling in large workshops. The range produces an excellent amount of air flow, up to 310m³ per minute, allowing large areas to be cooled quickly and efficiently, with three large fan sizes to choose from: 24", 30" or a massive 36"!

All models include 2 handles and are mounted on large rubber wheels for easy transportation to wherever it is required. Main features of this range include:

- Robust steel frame
- Steel guard for safe operation
- Large rubber wheels for easy movement
- 2 speed control
- Durable painted finish

Models in this range start from £142.80 Inc. VAT.

Machine Mart have also announced a new 'multi-sander' from Clarke. The CMS200 Orbital 3-in-1 multi sander is a versatile sander with 3 interchangeable sanding pads, giving one tool for most sanding requirements. The sanding plates take sheet, delta and disc abrasive sheets. More at www.machinemart.co.uk.



From the Archives:

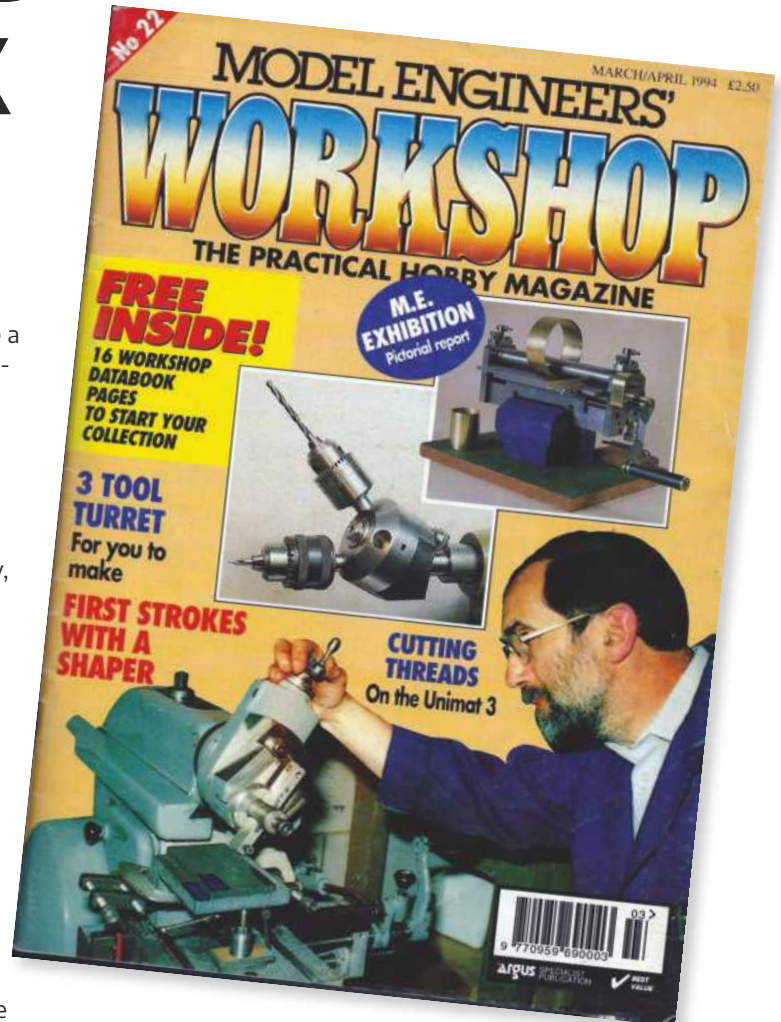
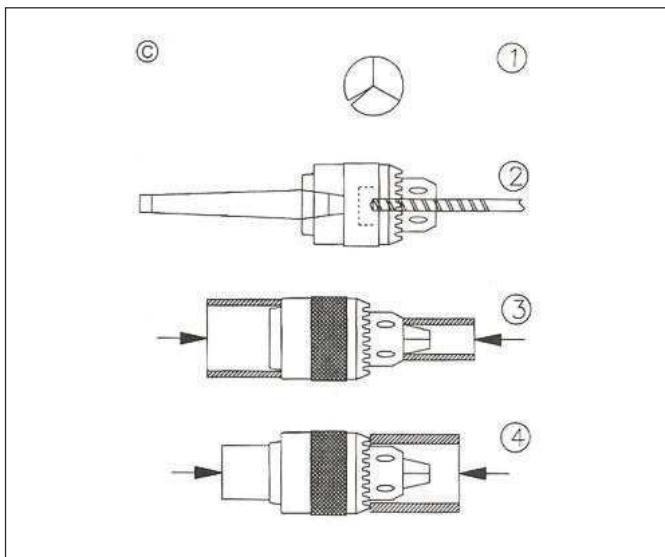
Dismantling a Jacobs Type Chuck

Doug Cooper MEW
Issue 22, March/April 1994

Many inexpensive modern chucks have pressed steel bodies and dismantling them means having to make a new body, but did you know that many older Jacobs-type chucks can be taken apart? The method of assembly is far from obvious making a full strip down for cleaning and maintenance a non-starter. In 1994 Doug Cooper let MEW readers into this little secret, which may help you to breathe new life into some old, but good quality, chucks.

To remove the taper arbor from the chuck body, rotate the open chuck in the lathe and drill through the rear of the body, say 0.25 inch. Pass a punch through the hole, to the head of the arbor and drive it out. New arbors can be obtained from the usual tool merchants, but take the body, chuck tapers do vary in size.

To disassemble the chuck for cleaning, make up a short tube to clear the rear of the chuck body and a similar one just large enough to clear the jaws. With the jaws nearly closed apply opposite pressure to the two tubes. This will force the gear ring off the body. (Some makes of chuck may come apart in the opposite direction.) It may take quite a hefty pressure to shift it! When the gear ring parts company with the body you will find a split ring inside - yes, it is made that way! Remove the split ring and the three jaws can be slid out. Either clean them individually or mark them so that they go back in the same position. Some are numbered but others may not be, so take care.



Clean and check the jaws for burrs on the gripping surfaces - these can be carefully stoned off. Check also for burrs on the nose of the chuck, where it may have contacted the work at some time.

To reassemble, lightly oil and slide the jaws into the body. Replace the split ring, with the jaws in the near closed position, and push the gear ring onto the body. Using the larger tube, press the gear ring back onto the chuck body. Make sure this goes fully home or the key will not fit the gear ring.

Sometimes for light milling operations, it is necessary to retain a Morse taper arbor in the machine mandrel with a drawbolt. Although Jacobs chuck arbors look rather hard they can be drilled and tapped for a drawbolt. First cut off the tang, a 'blue blade' will do this easily and set the arbor up in the lathe to run truly. On my Myford I push the 'chuck' end of the arbor into the Myford mandrel and grip the middle of the arbor in the three jaw; not ideal, but it seems to hold it well enough to drill the tapping hole: 3/8 inch BSW was used for No.2 Morse tapers, but this may have changed since metrication. If being used for milling the chuck must be made captive to the arbor. Perhaps using a screw into the arbor through the hole in chuck as made in 2 above. ■

From the Archives: Cherry Hill interview - Part 2



Photo 21: A simple buffing and polishing spindle is a vital tool when imparting the high finish which Cherry achieves. (JL)



Photo 22: Some items of the rear cultivator drive of the 1863 Blackburn engine, showing how some of the chain components are developed. (JL)

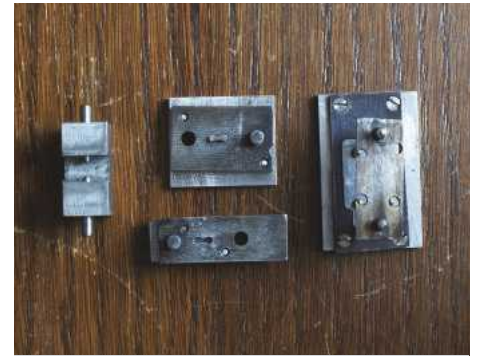


Photo 23: Press tools and riveting tools for the chain components. (JL)



Photo 24: The small size of Cherry's models requires the manufacture of a significant number of special tools, many of them being special spanners such as this, each being hardened. (JL)



Photo 25: The Universal Pillar Tool to the George Thomas design – one of the first made. (CH)



Photo 26: The Pillar Tool is fully equipped with the accessories described by GHT. (CH)

complete with traditional drawing board, **photo 3** on which General Arrangement and component detail drawings are worked up from the often meagre information which can be gleaned about the prototype. Some of the drawings are created at full model size, **photo 4** but Cherry prefers to work at ten times full size for most as, at this scale, she finds that she can assess clearances more accurately.

“All Cherry's models are capable of being operated”

One of the workshop rooms is equipped mainly as a machine shop, **photo 5** while the other is where most of the hand work and fitting takes place, **photos 6 and 7**. As mentioned previously, pride of place in the machine shop is still occupied by the Pittler lathe, **photos 8, 9 and 10** but this is augmented by the latest in a succession of Myfords, this being the Connoisseur version, **photos 11 and 12**. The largest milling machine in the workshop is a Myford VMC, **photo 13** which is capable of dealing with the heaviest work that Cherry is likely to undertake. An addition to the VMC is an inverter drive which allows control of motor speed, a particularly welcome feature, says Cherry, as this obviates the need for frequent changes of drive belt position – not



Photo 27: The UPT set up in 'light' staking mode i.e. with the 'anvil' set in the arm, rather than in the base. (For heavier riveting and staking, a set-up similar to that shown in photo 28 is used.) (CH)

Photo 20: Cherry's other lathe for small work is a Cowells 90 of 1.75 in. centre height, a model which is still in production. (JL)



Photo 28: Cherry has produced a simpler version of the top arm for use with the tools shown in photo 29. (CH)

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the easiest of exercises on this tall machine.

Alongside the VMC is a bench mounted Centec 2A horizontal/vertical miller which Cherry says that she finds particularly useful because, in some circumstances, the horizontal arbor can be used with the vertical head still in place. This proved to be the case recently when cutting the teeth on some lengths of rack for

“The heavier work is now handled by some more modern companions”

the Blackburn 1863 engine. The Centec, though, does have one annoying habit – that of leaking oil from the vertical head when not in use – hence the plastic ‘drip container’ seen in **photo 5**. An addition to the Centec which has proved useful is the fitting of dial gauges to indicate movement on the X and Z axes, **photos 14, 15 and 16**.

Sitting opposite the Centec is another bit of history, a simple sensitive drill, **photo 17** which was a companion of the Pittler lathe in the original workshop. The drilling machine is still in use, but the heavier work is now handled by some more modern companions, a Startrite Mercury Mk II, a Meddings and a small Toyo, the latter two being in the other room, as can be seen in **photos 6 and 7**. The Meddings is best suited to drilling smaller holes due to its high speed.

An additional milling machine has more recently been installed, this being the Wabeco F1210E which can be seen on the extreme right hand edge of **photo 5**. This is equipped with digital scales on all three axes, which have currently still to be set up to Cherry’s satisfaction.

As has been mentioned, the second room of the workshop complex is the focus for bench work, although it does house some smaller machines such as the Toyo and Meddings drills already described and a couple of small lathes. These are a 2in. centre height IME instrument lathe, **photos 18 and 19** and a 1½in. centre



Photo 29: The tools of various diameters are located directly in the adapters which are plugged into the special top arm. (CH)



Photo 30: The Centec ‘A’ milling machine set up for gashing a worm wheel. (CH)



Photo 32: The range of home-made dividing plates available for use on the dividing head. (CH)

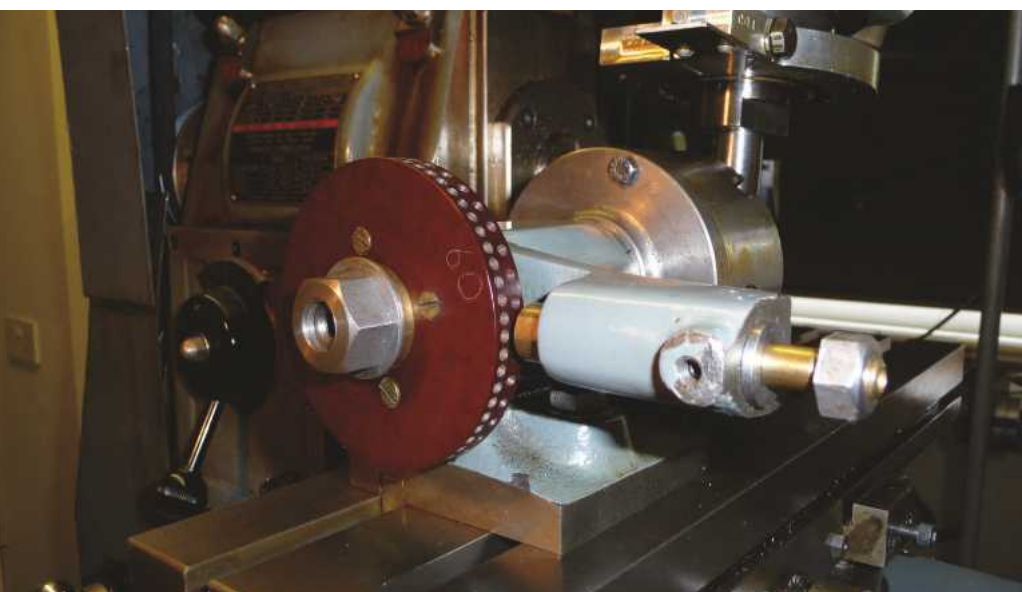


Photo 31: The dividing head on the Centec equipped with one of the dividing plates made by Cherry. (CH)



Photo 33: The gashing of a worm wheel nears completion. (CH)



Photo 34: Machining a worm gear on the IME 100 lathe. (CH)



Photo 35: A slender worm shaft requires carefully sharpened tools and fine cuts! (CH)



Photo 36: The Pittler lathe and overhead drive set up for lapping a worm gear to its worm wheel. (CH)

height Cowells machine, **photo 20** both being used for smaller components. A simple buffing and polishing spindle made by simply mounting a chuck and a hub for the mop to a well-known make of reversible electric motor is one of the tools used to bring components to a high standard of finish, **photo 21**.

With work benches set at a convenient height and plenty of natural light from a large window, this workshop is the ideal setting for the fine fitting work required on Cherry's models. While we were there we had the opportunity to see (and handle!) some of the components of the drive train to the cultivator section of the Blackburn engine. The two-stage sprocket and chain arrangement on each side of the engine

entails the manufacture of a very large number of components, just a selection of which is seen in **photo 22**, while a few of the specially made tools involved are shown in **photo 23**. With the very restricted space available on models of this scale, Cherry has found that purpose-made spanners are essential and now has a large selection of the type seen in **photo 24**, all of which are hardened for durability.

As would be expected of Cherry, any home-built piece of workshop equipment would be to the same high standard as any other piece of her work. Typical is a nice Pillar Tool to the George Thomas design, **photo 25** which is fully equipped for tapping and riveting, **photos 26 and 27** with some additional items



Photo 37: Lapping in progress – always remember to protect the lathe bed! (CH)



Photo 38: The worm and wheel nearing completion. (CH)



Photo 39: Slotting the worm wheel keyway on the Myford. The bore is 9/32in. diameter and the keyway is .024in. wide. (CH)



Photo 40: The comparison with a 20p coin emphasizes the quality of the workmanship. (CH)



Photo 41: More gear cutting, but this time the internal gear which can be seen on the inner periphery of the drum in photo 2. (CH)



Photo 42: The tools used to cut the internal gear seen in photo 41 with the 'tools' used to make the tools. (CH)

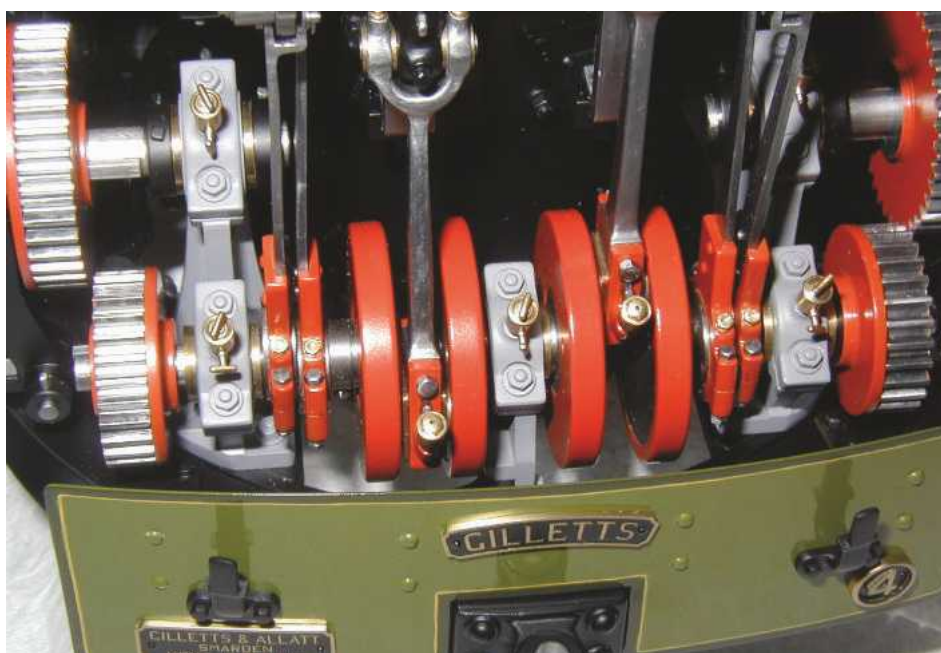


Photo 44: The excellent detail and fine finish on the motion work of the Gilletts and Allat engine, which also won the Duke of Edinburgh Trophy, in 2004, after having won a Gold Medal and the Bradbury Winter Memorial Trophy in 2003. (GS)

of Cherry's own design to increase its versatility, **photos 28 and 29**. George Thomas visited Cherry soon after the completion of the Pillar Tool, commenting that it was the first he had seen following the constructional series published in Model Engineer.

Although there were no major machining operations in progress at the time we visited, Cherry has supplied some photos of her own, taken at the various stages of machining a worm gear and wheel pair for the new model, **photos 30 to 40**. The photos of the internal gear and the associated tooling, **photos 41 and 42** also illustrate the amount of effort which goes into ensuring that each component is not only correct in appearance, but fully functional. On occasions, however, all does not go according to plan and, despite all the careful calculation and detail drawing, finished components do not always come up to the high standard which Cherry sets. She has no hesitation in rejecting a component if she is not satisfied so, despite many hours of work, a cylinder fabrication, **photo 43** was discarded because the bosses for one set of cylinder cover studs appeared to be too long. It did have a use however, because its similarity to the component on the 1857 engine made it useful "supporting evidence" for a competition entry.

It will be a little while yet before the components of the later 1863 Robert Blackburn engine will be ready for painting and final assembly, so I include a photo, **photo 44** of the motion work of the Gilletts and Allat engine which I took on an earlier visit. This clearly illustrates the high standard of finish and detail that Cherry is able to achieve.

It was a great pleasure and privilege to be able to visit this charming and talented lady and to admire her workshop and the work which emanates from it. The lesson to be learned is that it is not necessary to own a facility packed with hugely expensive and complex state-of-the-art machinery to be able to produce top class work. Over the years, descriptions of many award-winning models have made reference to the modestly equipped workshops in which they have been produced. The same still applies today. We look forward to seeing the next masterpiece from Cherry. ■



Photo 43: The rejected cylinder fabrication, of which the lower cylinder cover stud bosses were just too long, was used as 'supporting evidence' when the 1857 Blackburn engine was entered for the 'Duke of Edinburgh Trophy' competition, which it won. (JL)

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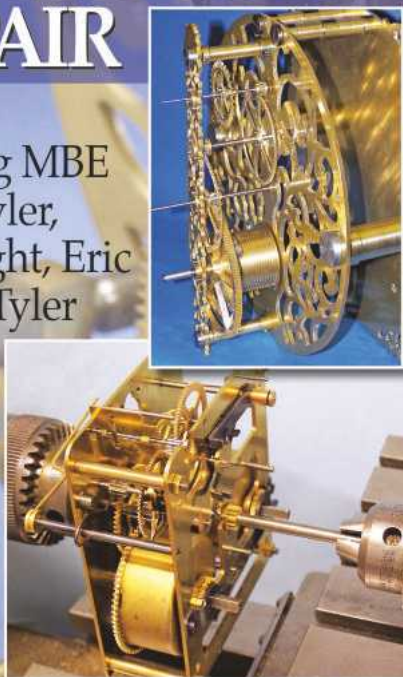
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The Rawson Divider

Adrian Rawson details his 'intelligent' dividing device

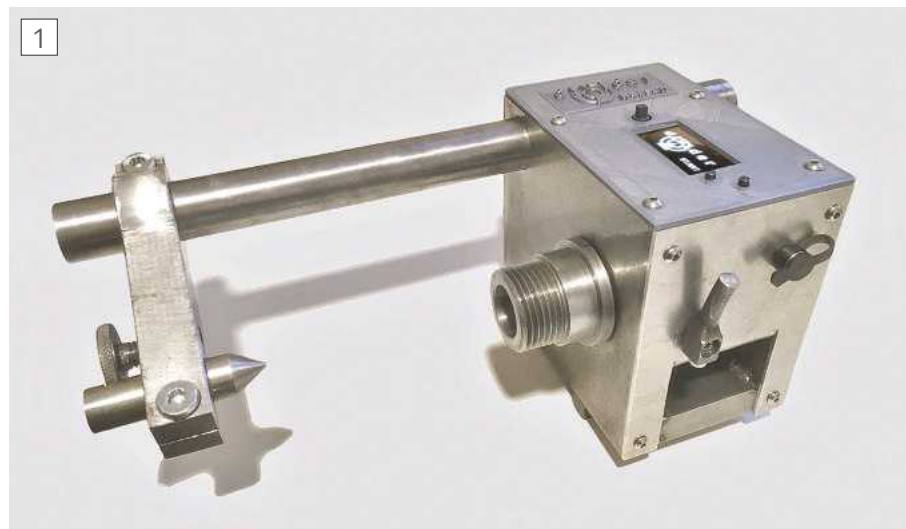
Why did I embark on this project? Well, I had a couple simple questions.

Why does dividing on the lathe involve perforated wheels, worms, detents and sector arms, and why does the equipment required command such a high price?

I read the chapter on dividing in the Myford Series 7 Manual and was overwhelmed by the apparent complexity of setting up a simple circular division, and was left wondering how one might manage to take a break, mid circle, without losing one's place.

I had to attempt a computerised version of the traditional setup, **photo 1**. Let the computer remember where it's up to and do the counting.

I stuck some numbers in a spreadsheet and deduced, that using a 200 steps/revolution stepper motor with a 125:1 reduction, that it would be possible to divide a circle by any number of divisions from 1 to 360 with a maximum error of 25 arc seconds. But that's history, I

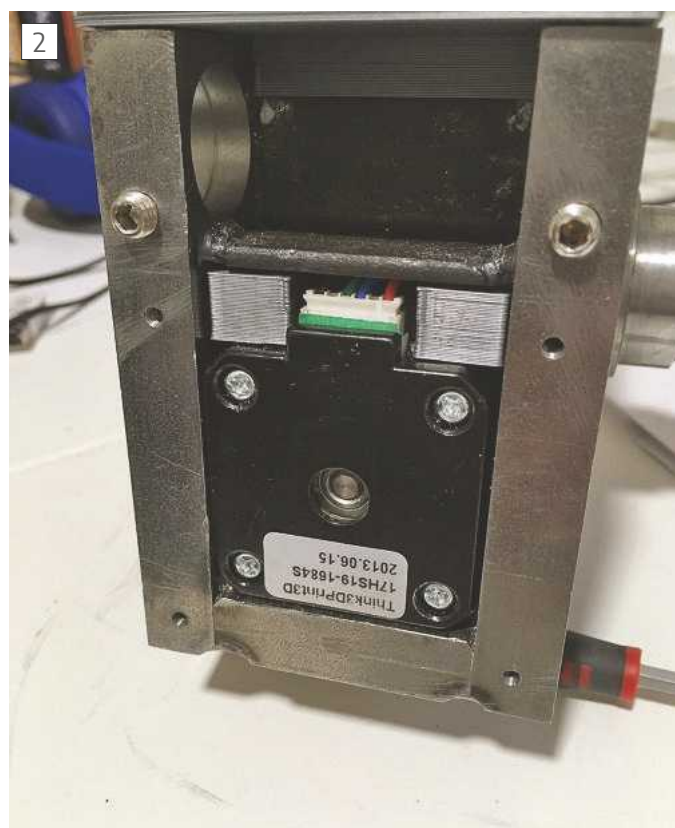


The Rawson Divider

couldn't make it work. The worm drive was too fine for me to engineer, and my lack of workshop experience conspired against me when it came to making things that ran concentrically, and there were other constraints. The device must

be small enough to fit neatly on the cross/vertical slides and the shaft had to be at Myford centre height.

Research showed me that the typical Myford divider has a 60 tooth worm, so I plugged that option into my calculations

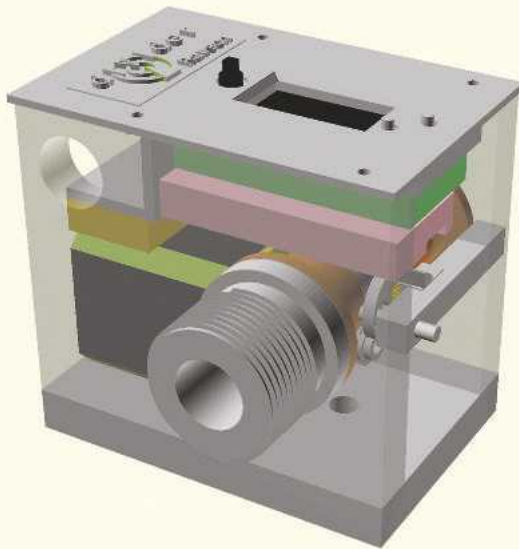


The motor is a neat fit in the case.



Setting the tool to cut the worm gear.

Fig.1



Case design

and got a maximum error of circa 50 arc seconds. This was only half as good as the original plan, but I decided the resulting 0.013 of a degree error would be hard to detect given all the other system tolerances. It's important to say at this point that the software keeps an eye on errors to avoid any accumulation.

The other problem I had encountered with earlier attempts was the power in the motor. I tried two lesser motors before choosing a Nema 17 with 1.6 amp windings. And as luck would have it, its dimensions are such as to allow the worm gear to just fit within centre height with a case made from 1/2 inch steel plate.

The other constraint I set myself was the shaft size. It had to accommodate an MT2 taper. I ended up using a 22mm Oilite bush for the front bearing and a 3/4" Oilite bush for the rear. This left ample metal to accommodate the taper.

Using 1/2 inch steel for the case meant that the external dimensions had to be 100mm wide, 70mm deep (front to back) and 95mm high. The 70mm depth left ~2mm clearance for the 42mm motor with the space above it perfect for an overarm, **photo 2**. A lot of energy was put into CAD drawings making sure that everything would fit before cutting any metal, **fig. 1**.

Having attempted a previous build with 10mm steel sections bolted together I decided on a more robust welded construction for this version.

The welded body was bored, from the front face, right through, at centre height and 28mm in from the right side. The holes were then opened out to accommodate the front and back bushes and counter bored to accept the bush flanges. The front flange was left slightly

proud of the body to act as a bearing surface for the Myford nose. The rear bush was sunk in to allow for a thrust washer to run flush with the outside rear of the case.

The Oilite bushes should have been a press fit but they ended up a nice fit pressed in with super glue.

Having tried hobbing a worm gear out of aluminium with a brass worm drive,



Spindle with finished gear.

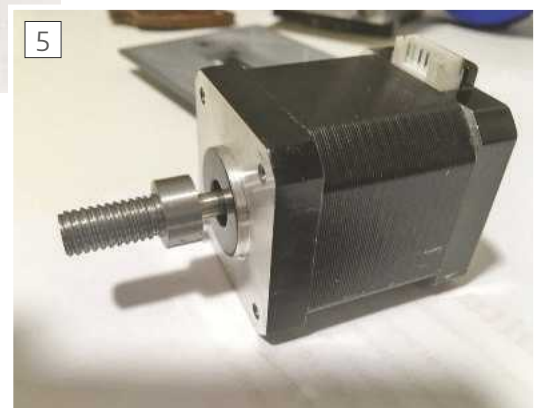
it became obvious that I had to get more serious. I acquired a piece of phosphor-bronze bar for the worm gear and made a tool to cut it. Calculations showed that the blank had to be 1.145 inch diameter to carry 60 teeth at 18 TPI (teeth per inch). I set my right-angled tool in a 4-jaw chuck and turned it by hand,

The device needed some way of locking the shaft and powering off the motor during machining activities.

photo 3. The photo shows an aluminium worm which was hobbled with a tap. Although not useable it came in handy as a spacer and gave guidance for setting a small angle on the worm being cut. The divider I used was a simple affair that stepped around a 60 toothed gearwheel but gave good results, **photo 4**. Then the tool was copied to screw-cut the 18TPI worm from 0.33 inch diameter steel. This was derived from the total space + 0.040 inches to give a working depth for the worm teeth.

Previous worm attempts had failed to run concentrically on the motor shaft. They had a bit of wobble, and considering that the worm gear was so fine, this mattered a lot. I thought maybe this was caused by machining everything in the chuck. The hole drilled through the middle for the 5mm motor shaft wasn't true. This time I took the drilled blank out of the chuck and turned it between centres. This did the trick. The worm shown, **photo 5**, doesn't look that crisp but it meshes well with the gear.

The device needed some way of locking the shaft and powering off the motor during machining activities. The motor windings can get quite warm if



Stepper with worm.



Locking arrangement.

I also found that shimming the rear thrust washer to give the shaft slight end float helped everything run more freely.

left powered while stationary. Also, I was worried that any excessive torque on the shaft might strip the worm, so I welded a bar onto the frame, parallel to the shaft at centre height. This was tapped 5mm and slotted to take a lock detection micro-switch. The front Oilite bush was drilled through in line with the 5mm hole and a 5 x 25mm bolt screwed through the bar to play on the shaft as a brake. I then fashioned a steel 'pecker' with 5mm thread and 3mm grub screw to activate the switch when the shaft was locked, **photo 6**. The bar was also drilled and counterbored to take the 2mm micro-switch bolts.

To hold the shaft in place I made a flanged washer that bolted onto the shaft and ran on the flange of the Oilite bush, **photo 7**.

On assembly the worm only just meshed with the gear so I drilled and tapped a hole through the base of the case and made a screwed brass



Shaft retention washer.

8mm stud that could raise the motor. Unfortunately, it caused the rear of the motor to rise so I made a plastic wedge to hold the rear of the motor down against the steel angle above it. This enabled the gear mesh to be finely adjusted before tightening the motor bracket screws, also tapped into the base.

I also found that shimming the rear thrust washer to give the shaft slight end float helped everything run more freely.

So what else?

Well there are a few plastic components required which require 3D printing, **fig. 2**.

The top plate which holds the computer and screen is the major piece of work. There is a bracket and wedge that holds the motor in place, but these

could be made from steel. I originally made the lock 'pecker' from plastic but it was difficult to mount it rigidly to the locking screw, so I made a copy in steel. The case sides are aluminium sheet screwed to the frame, leaving spanner access for the T-bolt on one side.

The brains of the device is a Raspberry Pi zero computer programmed in Python and achieves the following:

- Calculates steps required for any division from 1 to 999 with step correction for accumulated errors.
- Enables working clockwise or anticlockwise.
- Allows for any division to be reversed to the previous position.
- Configurable backlash correction.
- Motor nudging facility for initial positioning.
- Motor power off when locked in position for machining.

I've totted up the total materials cost, and it's around £150. 'Myford' dividers cost in the region of £500, but they do look the business.

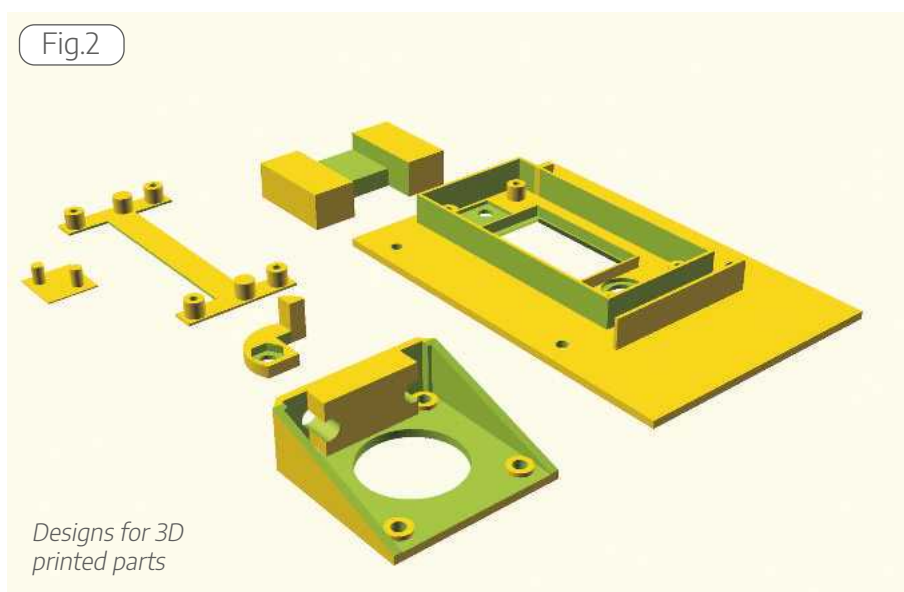
So far, I've made a couple of Youtube videos for those who want additional information and to see the divider under test.

<https://youtu.be/g3SYf010tW8>

https://youtu.be/_Tvj-cLd6S8

I consider this project a success, in that it seems both robust (with overarm attached it weighs just shy of 4 kg) and accurate. To achieve perfection, I would like to improve access to the T-bolt mount and maybe beef-up the locking mechanism. However, I hope that this article encourages someone else to have a go.

I'm looking into putting kits together for the software and electronics if enough interest is shown. ■



Designs for 3D printed parts

From the Archives:

The first steps in tapping internal threads and some of the technical terms used are explained by GEOMETER in ...

BEGINNER'S WORKSHOP

THREADS AND HOW TO MAKE THEM

SCREW THREADS in nuts are, in most instances, produced by taps, though large threads and those which do not come within a recognised rate are produced on machines such as lathes, that is they are screwcut.

Over a wide range of sizes, the production of threaded holes in metal is not in itself a difficult operation, as it demands only suitable drills, taps, wrenches, and some knowledge of threads to be produced—plus the skill which comes with practice.

Standard taps are shown in Fig. 1. The taper tap has a long taper at the end for starting easily in a hole. The second tap is less tapered to follow behind the first one, and the plug, or third tap, is parallel down to the end.

Proportions of a thread

The main proportions of a thread are the pitch, angle, and depth. The pitch is the distance, advanced by the thread in one complete turn. In many instances a pitch is chosen which results in complete numbers of turns in 1 in. Thus, pitch is expressed as the number of turns per inch, or t.p.i.

The angle of thread is chosen according to design requirements, and is standard for different rates; common angles are 60 deg., 55 deg. and 47-1/2 deg. The depth is governed by the angle, and by the radius at the top and at the bottom, though threads can be sharp or flattened at top and bottom. The depth, however, is always the same proportion of the pitch for a particular rate of thread.

Rates of threads

The different rates of threads, are given in text books, but the newcomer to practical work need be concerned with only three. These are the British Standard Whitworth (B.S.W. or Whitworth), the British Standard Fine (B.S.F.), and the British Association (B.A.). In the two first rates, the diameter of the thread is given as a fraction of an inch, and the pitch or

t.p.i. is related to the outside diameter.

B.S.W. is a coarser rate than B.S.F., and has fewer t.p.i. for a given diameter; at present it is used in general and agricultural engineering, while B.S.F. is common on cars and motor cycles, though for special purposes, one or other rate may be used. The angle of both threads is 55 deg.

The B.A. rate is a small millimetre thread, used in electrical, instrument,

drill sizes—obtainable from tables. The angle of this thread is 47-1/2 deg.

The tapping drill size produces the core diameter of the hole, and this must be suitable for the particular rate of thread, so that a full thread is produced, and no more. If the hole is small, too much metal will be left, and it will be difficult or impossible to produce a thread, or in small sizes, the tap may be broken.

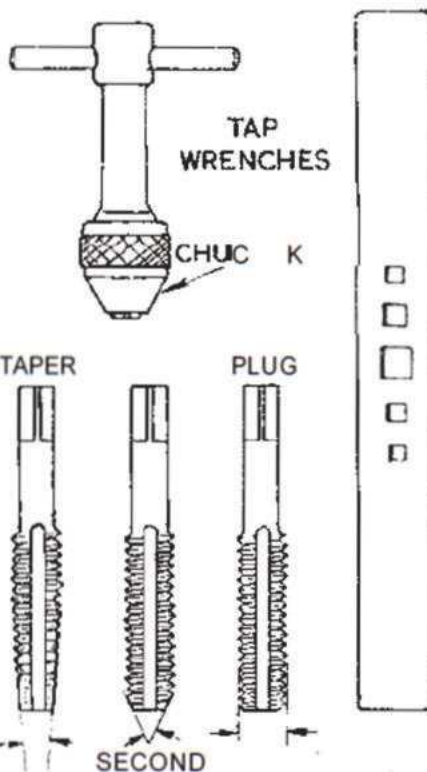


Fig. 1. The standard taps and wrenches used in making threaded holes

and model work. Outside diameters are given in millimetres and fractions of a millimetre, and the pitch similarly. Thus, the pitch does not produce exact t.p.i. These threads are given numbers from 0 to 25, and to deal with them it is only necessary to know the outside diameter, and the tapping and clearing

Truncated threads

Alternatively, if the hole is too large, the thread produced will be truncated or flat at the bottom instead of rounded, and such a thread is weak depending on the extent of truncation. If the metal to be tapped is tough, however, a certain amount of truncation is not undesirable.

Tables show the correct size tapping drill for standard rates of thread as mentioned, and these should be followed; it is then only necessary to centre punch the position of the hole in the metal, and drill the hole squarely.

If the hole goes right through the metal, a taper tap can be used, followed by a second or plug. If the hole is "blind" however, the taper tap will not bite, and a second tap is required for a start, with the plug tap to finish the thread to the bottom of the hole.

How to tap

When tapping, work should be mounted firmly, the tap presented squarely and rotated by means of the wrench. After a turn or two, resistance will increase and it is necessary to ease the tap back carefully, then advance again as far as possible, the process being repeated until the hole is tapped; complete withdrawal and cleaning of the tap is also necessary on occasion. For lubrication, thin oil may be used for steel, and paraffin for duralumin and aluminium. Worn taps, like worn dies, produce threads tight in the core or on the outside diameter, due to loss of radius.

Starrett-Type Clamps for Model Engineers

Stewart Hart recreates an historic tool that's still useful today - Part 2



Skimming off distortion.



Milling ends to size.



Drill and tap m8, note use of end vice stop.



Part off jaw and face to length.

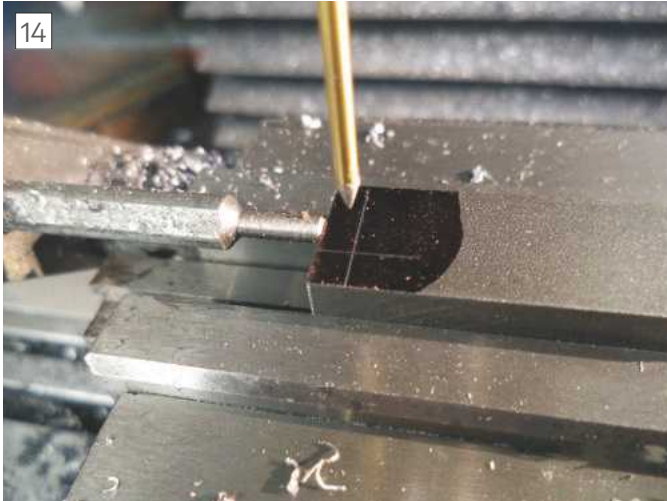
With both bodies clamped together and using a nice sharp end mill take a light skim off the base and the top to get rid of any distortion, **photo 10**, before bringing the cut out to final size. Stand them on end taking care that you have them square bring both ends to size, **photo 11**. Before separating the bodies mark one end so that when you drill and tap M8 from the same end they will match perfectly, **photo 12**.

It is better to drill and tap the M3 hole in the jaws for the keep before you drill

the 6.5mm hole. If you drill the 6.5 hole first when you come to drill for tapping, you will risk the drill breaking as it enters the 6.5mm hole, I found this out the hard way. Hack saw or part the jaws off and face them to length using a self-centring or independent four jaw chuck, **photo 13**, and mark out the position of the M3 hole. As you will be making a number of jaws it is worth setting it up with a vice stop this way you will save on set up time, **photo 14**. With the M3 hole drilled and tapped set back up in the four jaw, and centre drill and drill 6.5mm to an

accurate depth of 9.5, **photo 15**. Getting the 9.5 depth accurate is important as you want the clamp load to be taken on the nose of the bolt.

To simplify manufacture of the bolt I fabricated it using a M8 coach bolt; dies would run out threading a bolt this length and screw cutting is an unnecessary complication. Start by knurling a length of bar, **photo 16**, enough to make both handles, then drill and tap M8 and part each handle off. Grip the bolt on the threads in the lathe chuck:- you will be gripping on a good



Setup using vice stop for drilling and tapping.



Accurately drill to depth.

Hack saw or part the jaws off and face them to length using a self-centring or independant four jaw chuck.

length of threads spreading the load so it's unlikely you will damage them. Turn the head of the bolt down, **photo 17**, and put in the groove using a parting tool, ensuring that you get the length correct so that the load will be taken on the nose of the bolt. Screw the bolt into the handle leaving it 2 or 3 mm short of protruding then simply fill this void up



Knurling handle.



Head of bolt turned down.



Weld handle to bolt.



Making the keep from an M3 cap screw.



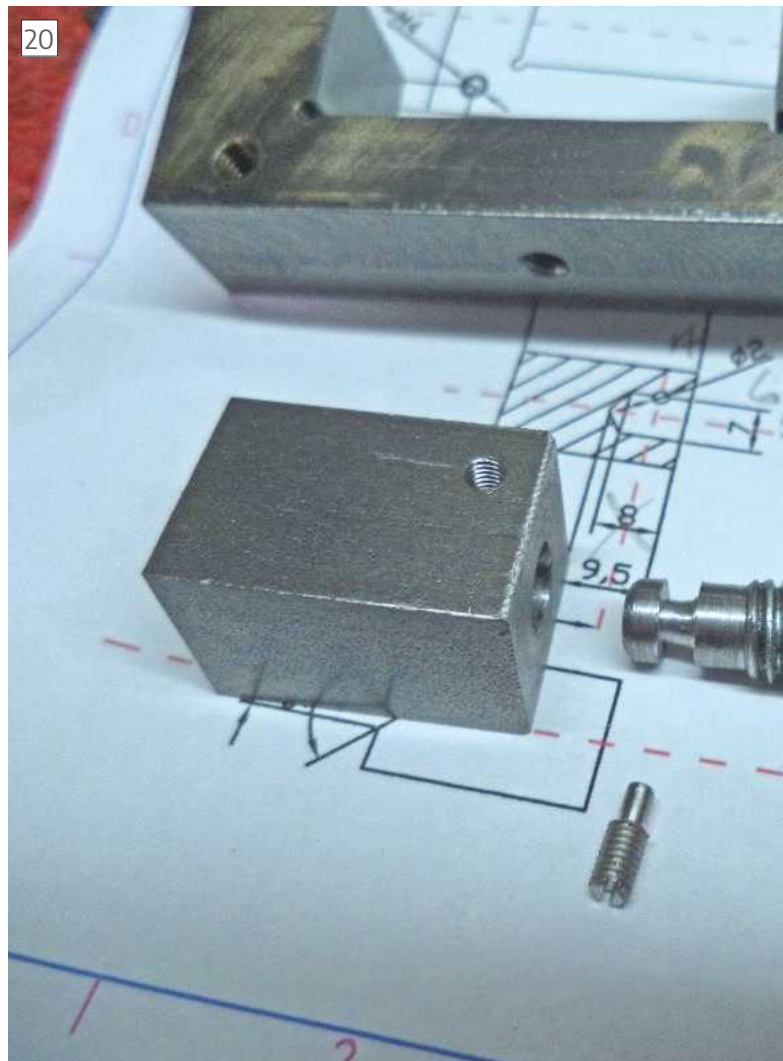
Clamps fixed to an angle plate in different orientations.

with weld, **photo 18**, clean and face up. Alternatively screw the bolt all the way in and silver solder, or just rivet the end of the thread over to secure it in place.

The keep is made from an M3 cap screw, **photo 19**, simply turn down to 2mm diameter and cut a screwdriver slot with a junior hacksaw. **Photograph 20**

shows the finished vice.

From the photographs of the used clamps for sale on the internet you could see that many of them had been adapted for specific uses. One adaptation was to drill and countersink through the base of the clamp this would allow it to be fixed to another



Completed Parts.

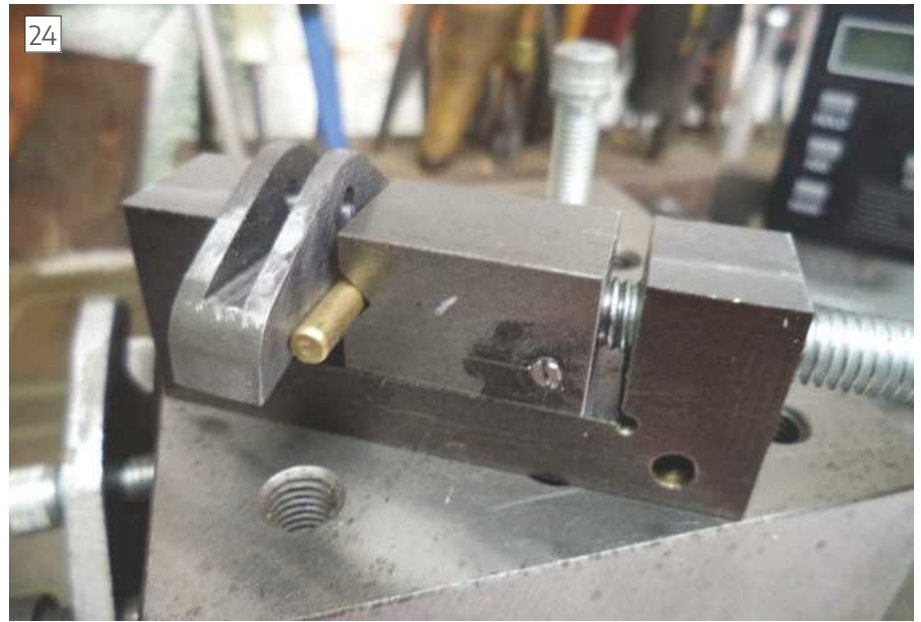
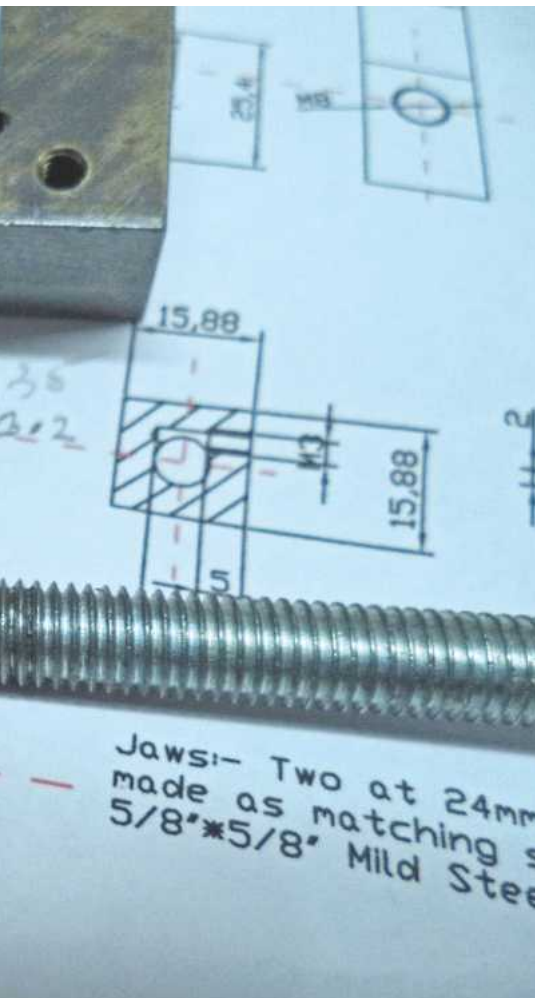
piece of equipment such as an angle plate or a lathe face plate, **photo 21**. Another adaptation is to mill a vee in the jaws for gripping round bars, **photo 22**, this led me to realise that the jaws being square that this vee could be orientated horizontal or vertically, **photo 23**. The easiest way to machine the vee in the



Milling a vee across the jaws with an end mill.



Vee being used vertically and horizontally.



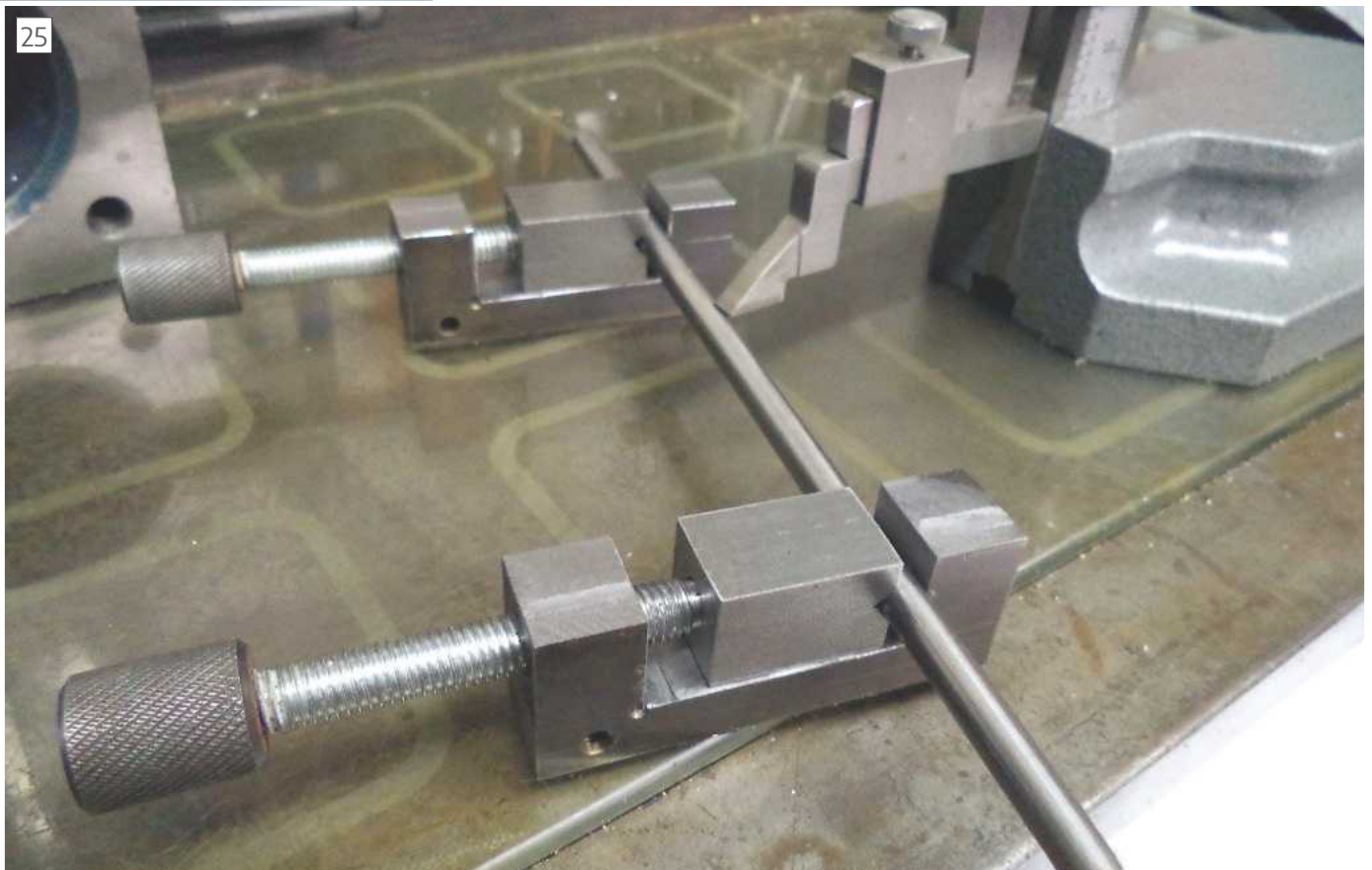
Round bar being used to eliminate jaw tilt.

jaws is to mount them as a pair in a vee block and mill with an end mill. The jaws being easy to make, it would be time well spent making a few spare sets that you could adapt for specific uses.

One of the drawbacks with this type of clamp is that the floating jaw will tend to tip, putting the work out of square. It can alleviate this effect if you insert a piece of round bar in the vee and use

this to clamp down on the work, **photo 24**, the point contact will eliminate this tipping effect. Likewise, if you do the same thing but with the vee vertically you can grip tapered parts.

As you can see from these few examples this type of clamp will have a multitude of different uses, **photo 25**, and will be a valuable addition to any workshop. ■



Clamps being used as a matching pair.

Scribe a line

YOUR CHANCE TO TALK TO US!

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

Rotary Broaching

Dear Neil, I am happy that I was a kind of a trigger for M. Malcolm Leafe (MEW 294), page 48.

My hole of 5 mm is square, because I made the cutter not off-hand, but using the grinding rest of another great man: Harold Hall, in conjunction with a Stevenson's Collet Block ER 25 from Arc Euro Trade (the square one).

Thank you for your magazine, helping me so much in difficult times.

Bernard Zaegel, The Netherlands.



My Free Ad

Dear Neil, you may remember my ad. last September when I asked for unfinished projects that I could complete, (bored 90 year old/traction engines). I thought you might like to know the outcome. I had seven or eight replies from all over, three of which brought results. The ones that didn't were for traction engines beyond my budget. A pair of Stuart models were fun but familiar. The second was much more challenging, Anthony Mount's model of James Booth's Rectilinear engine which a model engineer had completed but given up trying to make run. It was, in 1843, an intriguing concept but impractical in reality. It gave me some three months of frustration and a bit of redesigning before I finally got it to run and is now back with its owner. I have to admit I am pleased with that one. The third is a set of castings, unstarted, of a 2" scale model of a Ransomes traction engine, arriving tomorrow. That should stifle my boredom for a year or two. Thankyou for the ad. entry.

Peter Hamm, Diss

Wide Guides

Dear Neil, a friend of mine here in New Zealand receives the "Model Engineers Workshop" and passes them onto me to read. I noticed in last November's issue (287) a article on converting Myford 7 inch lathes to wide guiding of the saddle.

As my super 7 is a narrow guide this greatly interests me as my lathe had a bit of slack that I could no adjust out.

I went ahead and converted mine to wide guide using a piece of 1/16 x 1/2 gauge plate 7 1/2 ins long and securing it onto the rear strip of the saddle, I had to machine 0.047 of the saddle and secured the gauge plate with two 3/16 dowels slightly under the plate face surface. This was only completed 4 days ago and then same day I received issue 288 and lo and behold another article (In Scribe a line) on the same subject.

As this modification really takes care of any slackness with the bed to saddle fitment and makes a very usable lathe and a breeze to use, I can not see why Myford used the short narrow guide in the first place.

Ally Stephens, New Zealand.

Using Tough PLA

Dear Neil, I was interested to read Stub Mandrel's musings about PLA Plus, the supposedly stronger version of the standard PLA for 3D printing.

I print with an Ultimaker 3, and after making my first parts with conventional PLA have changed to Ultimaker's Tough PLA. This is definitely much stiffer, prints with similar settings and produces parts with an equally good finish on the default settings. Like PLA it can be glued with Plastic Weld liquid (Methyl Chloride) or super glue, the latter having the benefit of more working time and an ability to fill gaps and leave a fillet.

Unfortunately, all Ultimaker filaments are 2.85 mm in diameter which means that their Tough PLA cannot be used on other machines with 1.75 mm feeders. However, it may be possible to use the much cheaper PLA Plus on an Ultimaker, although I have yet to try this.

I use printed parts in the construction of model aircraft – mainly for ribs and fuselage bulkheads, spars and longerons being carbon fibre pultrusions. Whenever my planes crash it is the PLA parts which fracture, even though they appear to be strong enough when tested by hand. This experience suggests that PLA behaves as a 'Plastic Elastic Brittle Solid', similar to Blu Tac in terms of ductile behaviour. When flexed very slowly it eventually creeps to hold a deformed shape. When flexed more quickly it springs back elastically. Finally, when flexed very rapidly to the same angle it snaps, which explains the breakage when the ground moves up to meet my aircraft!

Mark Noel, Isle of Man

Feedback on Issue 293

Dear Neil, Just to say how pleased I am to read the first part of the article on Cherry Hill! I have been fortunate on a couple of occasions to enjoy her company at lunch at the annual Bristol Society of Model and Experimental Engineers exhibition at Thornbury when I was editor of the Society's quarterly journal "Our Cog".

Ever since I first saw some of her amazing work, I have simply been in awe of her ability and accomplishments.

They are so amazing as to make one take tiddlywinks and give up all hope of model engineering in the face of such work. It's not even as though any of her items were popular well known in their day. With few exceptions, all have been rare machines, requiring considerable research before launching into construction, and the results defy anything but utter admiration.

I look forward to the next part of this fascinating article, on the life and work of an amazing and unparalleled "model engineer"!

In earlier years, I have done quite a bit of electronic circuit making and assembling.

That is now long in the past. The article on an Arduino tachometer looks interesting, but would appear to be very incomplete!

There IS no "schematic"! No wiring diagram, no layout. The relationship of the connections diagram to the photo of a mounted board, with no view of the track side is not in the least helpful. Nor is the comment that one can get "code" only from a forum website, with the information that then one has to "paste" it into something, somewhere!

Altogether, far too much is assumed and left out from the article.

As a "practical" project, it lacks almost totally any information in what should be a complete article, and not just a few vague hints on as to go about it all!

Even with my old, and now very out of date knowledge, this project is impossible, so for one with even less, quite out of the question.

For a "practical" magazine, this isn't "on", for leaving so much

unsaid, and dependant on a reader's assumed knowledge and ability.

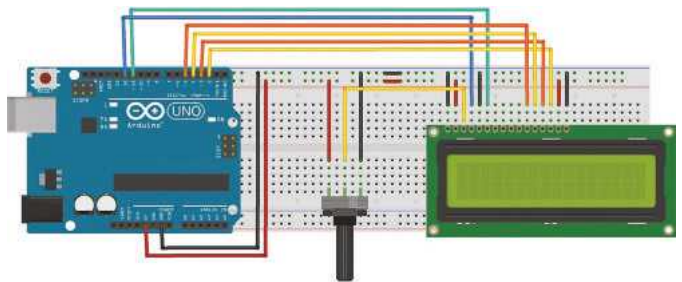
Davina Elaine Hockin, Portishead

I am glad that many readers appreciate the interview with Cherry Hill, which concludes in this issue.

I think it's fair to say (although I have some prior experience of Arduinos) that Duncan's diagram does make sense if you have the modules 'in your hand'. It would help if he had made it clear that Load, CLK and Data In are also connections on the display module and separated the display module connections from the sensor connections..

These days electronics seems to be mostly about wiring up various pins on modules with obscure (and often non-matching) names then adding a power supply.

I personally prefer proper wiring diagrams, but the standard for Arduino projects seems to be so-called 'Fritzing Diagrams' (see the picture, opensourced from the Arduino website). To me these look a bit 'noddy' but they are fairly easy for people with no electronic knowledge to follow. Perhaps I should encourage contributors to create diagrams like this if a proper circuit diagram, is not suitable? Neil.



Mystery Tool from December's MEW

Richard Cains strange old tool shown in Scribe a line for the December edition of MEW, is, as Neil says, a general catch all tool, but not a blasting tool, despite being found with black powder and safety fuse. Here are shown the tools for the job. I have been involved in tunnelling in many places all my life. The crimping pliers are designed for cutting fuse to length and the crimping of detonators and bean-hole connectors. The copper end to one handle is for making a hole in Gelignite cartridges and insertion of a detonator, though I prefer the brass pricker shown. All are standard South African issue on the 1970's, where I was blasting tunnels, shafts, stopes, etc., 11,700 feet down in the gold mines. At that depth, square tunnels over time became round tunnels, and the excavation of the gold seam closed up completely despite massive amounts of timber. Such was the intrinsic pressure in the rock – like at the bottom of the ocean. Rock temperature is 160 degrees F., humidity 100%, and only Africans and Fanakalo are the spoken languages. I came back in 1973 to blast the new tunnel for the Ffestiniog Railway, a breeze in both senses, and have done more tunnelling since with these tools.



Bob Le Marchant, Paignton.

Readers' Workshops - Andrew Johnston

By a combination of lucky finds and a shrewd eye for used equipment Andrew Johnston has a workshop capable of tackling a wide range of jobs

While at secondary school I had a small workshop in the end of my parents' garage with an old Logan lathe and an unknown make of pillar drill. With help from the local model engineering club I started building 'Mona', a 0-6-2 tank locomotive by LBSC. The machines were sold when I left school and went to university.

At school I had started dabbling in electronics and this continued at university and beyond. I also took up gliding and power flying. During this period, I had access to a lathe and milling machine for small jobs at my flying club. Nearly 20 years ago I moved out of a city flat and into a bungalow in a village, one reason being to get the space to set up a



Centre Lathe

proper workshop in a double garage.

In retrospect had I realised how much machinery I would acquire I would have laid the garage out differently, with the machine tools around the outside and benches in the middle. My workshop is untidy; as well as model engineering, I use it for prototyping and production runs to aid my engineering design work.

Starting in the far corner, **photo 1**, is my centre lathe, a Harrison M300. As shown, it is set up with a hydraulic copy unit as my current task is screwcutting



Vertical Mill



CNC Mill and Guillotine



Cylindrical Grinder and Horizontal Mill



Repetition Lathe

tapered threads. Top centre is a 3-phase meter and distribution board and to the right of that is the single-phase domestic consumer unit, recently updated to a metal box and RCDs. I made the decision to install 3-phase when I bought the lathe and vertical mill. Most of my machinery is ex-industrial and hence 3-phase. The cost was justified partly by the fact that the property originally had a 60A supply and an outdated fuse box using fuse wire rather than cartridge fuses.

Moving right, **photo 2**, is the vertical

mill, a varispeed Bridgeport. This, and the Harrison, were the first two machines I bought, secondhand from a dealer. To the left, by the lathe, is a home-made steel trolley with a capstan unit for the lathe and on the lower shelves lathe chucks and a 12" faceplate. The 18" faceplate can be seen on the floor at the end of the lathe. To the right are shelves made from MDF and salvaged wood which hold accessories for the vertical mill as well as oils and greases for the workshop. Underneath the shelves are aluminum offcuts and

scrap used mainly for jigs and fixtures. The sloping shelf above the lathe is also made from offcuts and salvaged wood. It carries drill chucks and centres, and odd size drills bought cheaply on the internet for opening up holes prior to boring.

Moving left **photo 3**, is a 4-axis CNC mill and in the background a 4ft by 1/8" power guillotine. The CNC mill was imported new from the US, but the guillotine was secondhand from the internet. The CNC mill gives me freedom in designing parts and removes the tedium of making multiple parts, such as wheel spokes. I can also design and make parts that cannot be made on manual machines, such as bevel gears. Above the garage door there are some red brackets, fixed to an RSJ, which hold my stock of small sections. To reduce unit cost I often buy material in standard 10-foot lengths. In the background, to the left, is a Brown and Sharpe surface grinder.

Towards the back of the garage, **photo 4**, are a Myford cylindrical grinder bought from a dealer on the internet and an Adcock and Shipley 2E universal horizontal mill bought direct from a dealer for the princely sum of £175. The horizontal mill was an impulse buy, but has proved to be useful, especially for



Bench and Box & Pan Folder



Lathe, Mill, Threading and Drilling Tools



Tooling and Measurement Equipment

to me by a local acoustics and vibration consultancy. Partly visible on the shelves behind the arbor press are dozens of milling cutters and slitting saws for the horizontal mill, all secondhand, mostly from the internet. To the right is a flypress, bought from the internet, sitting on a large metal plate after the bench top broke when I was using the flypress to close $\frac{3}{16}$ " steel rivets. By the door is a first aid kit and below that an eyewash kit, just in case. At the top of the picture are red hooks attached to the rafters that hold my stock of aluminum extrusions. The plastic bins to the right were mostly rescued from skips.

Looking parallel to the centre lathe and vertical mill, but on the left of the garage, **photo 6**, is another home made bench, with a secondhand electric furnace and almost hidden behind that an old US pillar drill acquired from the

Inevitably the workshop has spread into the bungalow. In the dining room are more taps and dies, many sets of Coventry diehead chasers and all my measurement equipment including assorted imperial and metric micrometers and gauge blocks, all secondhand, mostly from the internet, **photo 8**. At the end of the sitting room is a secondhand Pultra lathe, **photo 9**, and a new VFD and motor awaiting assembly and my 3D printer. Spread around the workshop and bungalow, but not pictured, are horizontal and vertical bandsaws, bending rolls and oxy-acetylene and TIG welding sets.

My main model engineering project is a 4" scale Burrell SCC engine, **photo 10**. I'm building two engines, which is why there is a second set of wheels to the right. A lot of other parts for the engines are awaiting assembly, **photo 11**.



Pultra Lathe and 3D Printer



Burrell SCC Traction Engine

gear cutting. It has a 5hp motor and geared spindle and can really shift metal. Behind the cylindrical grinder is a home-made bench that holds a secondhand surface plate and a hardness tester. The shelves behind hold accessories for the grinding machines. Out of sight, behind the horizontal mill, is a Clarkson tool and cutter grinder.

Looking the other way **photo 5** is the door into the hallway with, in the centre, a Britan repetition lathe. This was bought from a local two-man machining company who were retiring. Fortuitously extra accessories came up on the internet soon after purchase. The lathe has proved useful as I am making most of the nuts, bolts and studs for my model engines. The repetition lathe has a two-speed reversing motor, which needs a proper 3-phase supply to be useful. To the left, next to the hardness tester, is an Edwards arbor press given

flying club, almost certainly lend-lease. On the right is a secondhand 50" box and pan folder, from the internet, and by the garage door an 18" shaper, which was free. Underneath the bench, and on the floor, are stocks of larger sizes of metal and hot rolled steel sections cut into 36" lengths.

Both benches have sets of drawers on heavy duty runners. Under the short bench are drawers containing reamers, lathe tools and inserts, milling cutters, hand tools, taps and dies and Coventry die chaser grinding jigs and drills, **photo 7**. The drawers under the long bench contain silver steel, gauge plate and shim, DIY tooling and welding and repetition lathe accessories.

Naturally, there are more machine tools I'd like, but I've pretty much run out of space. However, there is always more tooling that will be needed. ■



Engine Parts

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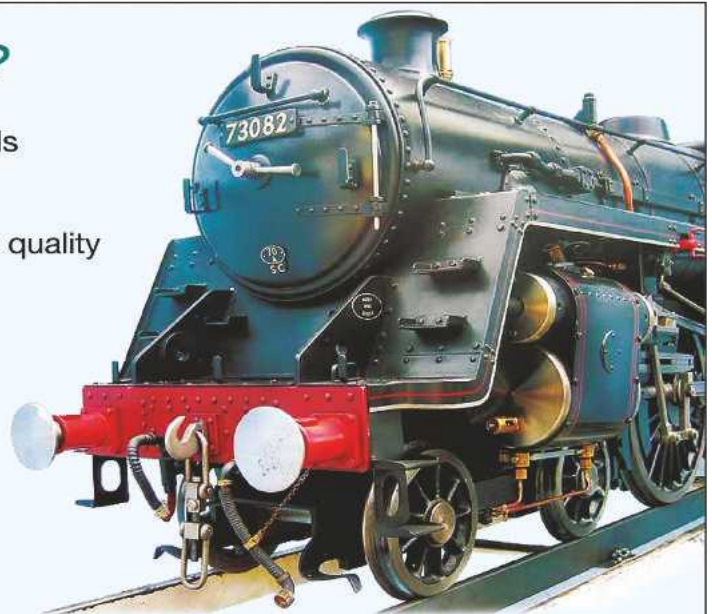
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