

No.291

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MARCH 2020



**Cutting
Edge Model
Engineering**

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The SMEE at Ally Pally

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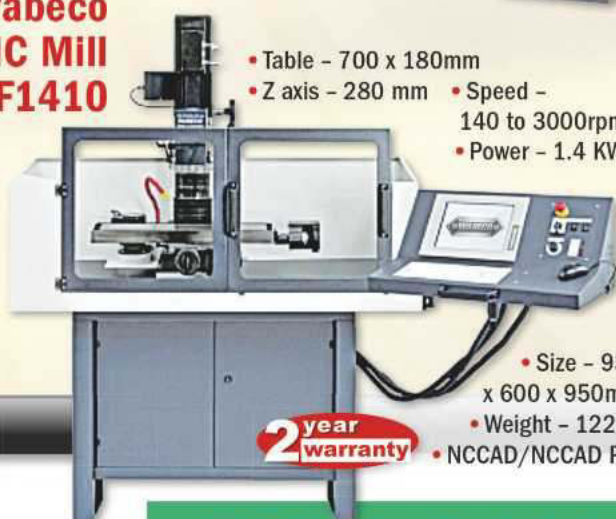
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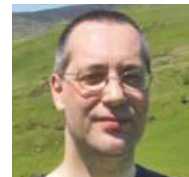
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On the Editor's Bench

Brass, Steel and Fire and James Crebbin

A short while ago I had the pleasure of receiving a call from Ann Hatherill. Ann is one of the longest standing members of the Society of Model and Experimental Engineers (SMEE) and is also the society's archivist. Visitors to the larger model engineering exhibitions will be familiar with the wide ranging work of the society, including promoting the growth of the hobby.

The main subject of our call was the exhibition Brass, Steel and Fire currently on display at the National Railway Museum. The exhibition celebrates early model engineers and was put together with the assistance of the SMEE. In the words of the museum:

See the original Rocket and journey through a great age of innovation when vicars, lace-makers and miners brought their own miniature locomotives to life.

Get up close to the game-changing Stephenson's Rocket, which shaped the future of the railway in 1829.

Meet the ordinary people who, fascinated by innovations like Rocket, turned their kitchens into makeshift workshops and crafted extraordinary hissing, steaming machines entirely from scratch.

Discover their beautifully intricate homemade creations—including some of the oldest of their kind—and learn how their small-scale experiments pushed the boundaries of engineering, influencing the course of the Industrial Revolution.

Brass, Steel and Fire reveals the love invested in models ranging from the precise to the peculiar through 100 years of rapid technological change.

Our conversation turned to a booklet which Anne has researched and compiled on behalf of the SMEE into the life and work of one of these early model engineers – 'James Charles Crebbin an Extraordinary Model Engineer'. A contemporary of Percival Marshall, founder of both Model Engineer magazine and the SMEE, 'Uncle Jim Crebbin' was a pioneer in the construction of small passenger hauling locomotives. His first locomotive 'Cosmo Bonsor', featured in the exhibition, was constructed 'in secret' in a draughty loft workshop, with facilities far more basic than we would expect today.

The exhibition is at the NRM until mid-May, then it moves to the Science Museum in London in April for nine months. I also encourage readers to visit www.sm-ee.co.uk to find out more about the SMEE.

JAMES CHARLES CREBBIN AN EXTRAORDINARY MODEL ENGINEER



Notes compiled by Ann Hatherill
Archivist
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Coming up in our April issue, number 292, another great read



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Cutting Edge Cutting Methods



Mark Noel explores the use of three up-to-date technologies that can be used for cutting a variety of engineering materials

For as long as I can remember I have been intrigued by all things mechanical. This fascination probably started when, as a child of an R.A.F. aviator, my dad would bring home from the Station's Stores a variety of cockpit instruments which included gyros, altimeters and electric motors. These were pulled apart on the kitchen table to reveal the marvels inside but were never re-assembled in a state fit for active duty!

At the age of 8 the Stores yielded my best ever toy - a Gibson Girl box kite, packed and sealed in its original yellow canister, **photo 1**. Thousands of these must have been made and stowed inside Bomber Command dingies, together with a radio and an aerial which could be lofted by the kite to achieve a range of 250 to 500 miles to alert rescue vessels. This kite is beautifully engineered, with a collapsible light alloy frame, kapok buoyancy cells and printed instructions showing which tether point to use for various wind strengths. Dad also requisitioned a mile of 40lb proof nylon line, all of which I paid out one windy day until the kite was but an atom in the sky above our R.A.F. base, triggering an alarm that led to the grounding of all flights that day. My Gibson Girl was also used to lift 100 yards of fine wire that I had unwound from an old coil, and which I connected as a massive aerial to my home made crystal set. With this I picked up faint transmissions from Radio India. On another day I added a 'space capsule' for a bumble bee (with window and escape hatch) made from a toilet roll inner and incorporating a maximum altitude sensor. This used the idea of air escaping out of a bottle through a capillary tube that bubbled into a water tank as the kite rose and the pressure fell. During the descent as the pressure rose, water was drawn back into the bottle by a length along the capillary related to the peak altitude. These gadgets all worked and the 'BumbleBeeNaut' monitored the cockpit instruments, then baled out and returned to Earth safely. At least she was not in the capsule when the kite came back down!

The kite is still with me and so has remained my fascination with widgets and gadgets. A career in geophysical research has often required the invention, design and construction of novel instruments; for studying the magnetisation of rocks, the flow of heat through the deep sea floor and for detecting buried archaeological remains.



WWII Gibson Girl box kite with storage tube and plenty of line. Hours of fun since the age of 8!

Now unburdened by academic duties I am free to return to several themes that remain 'unfinished' - instrument ideas for which there was simply no time nor money to go further, or where the techniques for making these devices were simply not available back then. This article explores the uses of several modern manufacturing methods that have played a part in these revived projects - methods that are versatile and sufficiently affordable to find wider use in our hobby community.

Chemical Machining

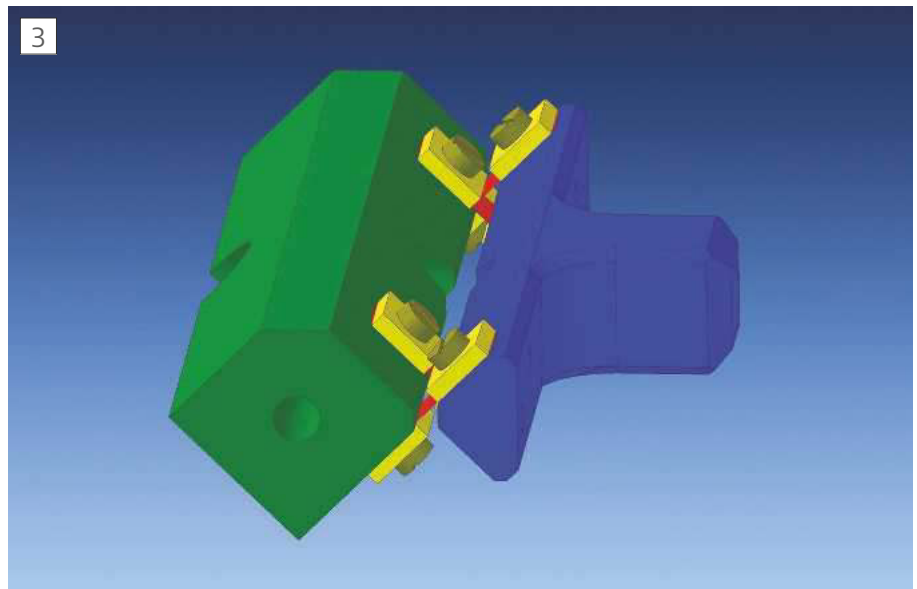
One recent interest has been a return to making **fluxgate magnetic sensors**, this time with digital electronics to drive and decode the device. Such sensors play a key role in archaeological prospection and on inter-planetary probes, since they have the high sensitivity required to map subtle changes in subsoil composition that provide clues to hidden remains, or to pick up the tenuous magnetic fields caused by wafts in the solar wind. The key component in a fluxgate sensor is a core containing a thin foil of a special high-permeability alloy, such as mumetal (the same material, incidentally,



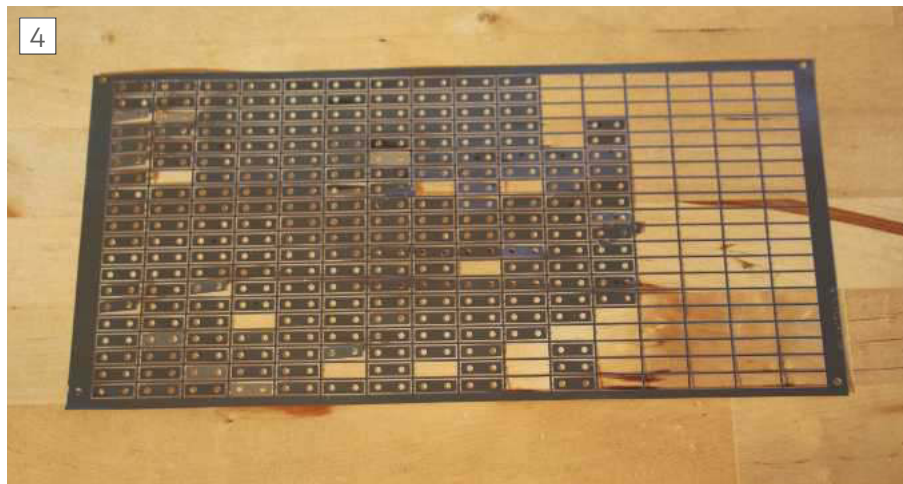
Top: three sizes of mumetal cores for making fluxgates. Middle: two halves of an epoxy former used to house the core and the assembled core with toroidal coil. Bottom: four stainless steel flexures used to make a cross-leaved hinge for a seismometer.

used in theft-proof tags attached to shop clothing). To reduce eddy current effects this foil must be thin, typically less than 0.1mm, and completely unstreined during the process of cutting the part from a sheet that was hydrogen-annealed in the factory. The technical challenge is increased by the fact that the required mumetal part is usually smaller than a penny. Taken together, these constraints rule out the processes of stamping, shearing or milling, even if the foil is sandwiched between sacrificial sheets of rigid material, since micro-burring and micro-heating effects might damage the magnetic properties. For these reasons spark erosion and plasma cutting are also ruled out.

The only practical solution is to gently extract the part by dissolving the profile in chemical reagents. In other applications partial dissolution can be used to inscribe text or logos on metal surfaces or to selectively thin regions to add flexibility on a part where needed. Chemical etching is at the heart of producing complex printed circuit boards



The cross-leaved hinge, with the fixed part shaded green and the moving part blue. Stainless steel flexure elements are coloured red.



The array of stainless flexure springs produced by Precision Micro. Each is loosely attached by tiny tabs.

(PCBs) where a photoresist layer laminated onto the copper is selectively exposed to UV light through a mask that defines the track pattern required. Chemicals then attack and remove unwanted regions, leaving the copper signal tracks behind, bonded to the fibreglass substrate.

Although simple DIY PCBs can be made using schoolroom chemistry from stock copper-clad laminate, this process would have been far more difficult for me to adapt to making mumetal cores at home. Supplied foil is fragile, flexible and not bonded to any substrate, nor is it pre-coated with photopolymer. Special chemicals would be needed to dissolve this metal which is a peculiar alloy of nickel, molybdenum, silicon, manganese, carbon, iron and copper. I therefore sent DXF files of three core designs to Precision Micro in Birmingham, who hold a huge stock of alloys in a range of gauges, including the 0.05mm thick mumetal which was exactly what was needed. Also, their alchemists know from experience what chemical elixir to mix for any alloy being processed. Follow the web link to Precision

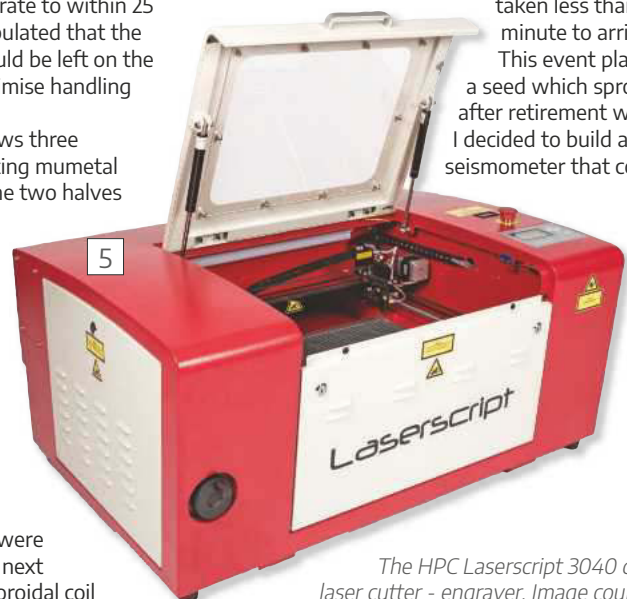
Micro in the Resources section to learn more about the steps they use to produce parts that can be accurate to within 25 microns. My order stipulated that the photo resist layer should be left on the mumetal cores to minimise handling after etching.

Photograph 2 shows three examples of the resulting mumetal cores together with the two halves of a rigid 'doughnut' I made to contain the mid-sized core. Each doughnut half was made by injecting epoxy resin into a brass mould that also created a 0.2mm recess that would allow the core to float in a soft resin matrix without stress when the two halves were bonded together. The next stage was to wind a toroidal coil over the epoxy doughnut using a

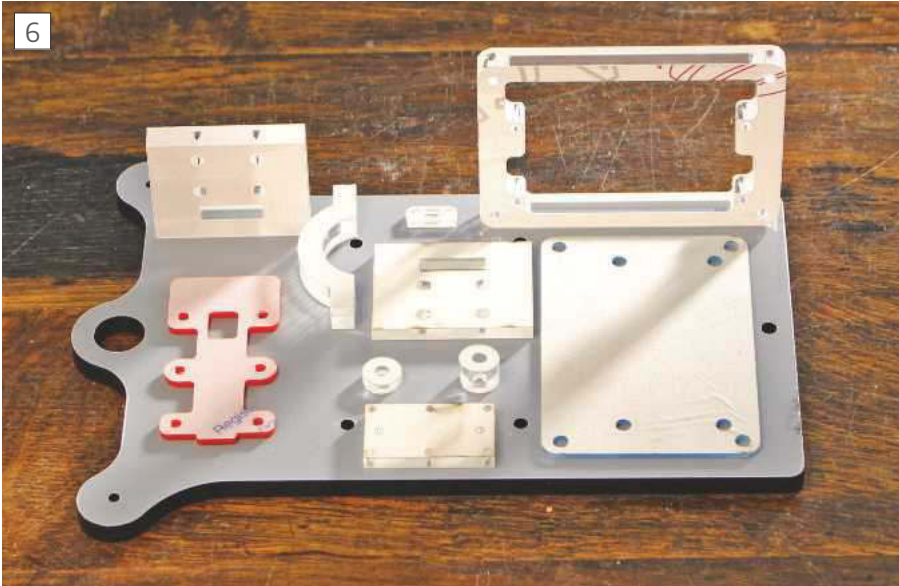
bobbin-pen to dispense fine wire: this coil is eventually driven with an A.C. current to magnetise the mumetal ring. Finally, the sensor was completed by over-winding further coils from which a signal related to the Earth's field is extracted. Thanks to the efforts of Precision Micro and much tedious coil winding, the result was a sensor that could resolve changes of about 0.1 nanoTesla, or about 1/500,000 of the Earth's field strength in Britain - enough to be of use for archaeological survey, and to be part of the sensor array in the Isle of Man's planned mission to Pluto!

Some years ago, I was sitting in my office in Durham University, contemplating the Big Questions as we academics do of course, when my Anglepoise lamp began to sway gently. This lasted for about 20 seconds and turned out to be the response to a weak earthquake 90km away near Carlisle. The lamp was acting as a lazy pendulum swaying in time to the slow seismic waves that had taken less than a minute to arrive.

This event planted a seed which sprouted after retirement when I decided to build a seismometer that could



The HPC Laserscript 3040 desktop laser cutter - engraver. Image courtesy of HPC Laser Ltd.



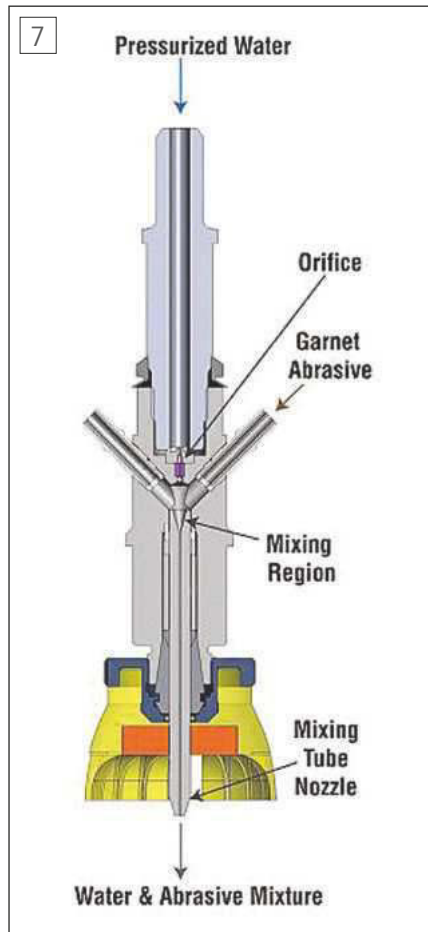
Laser cut parts in 3mm, 8mm and 10mm thick acrylic produced by Cut Laser Cut Ltd.

detect ground waves from more distant 'quakes such as those on the Pacific 'Rim of Fire'. My first effort was a simple horizontal-motion 'Lehman' type of instrument which worked fine but was rather cumbersome. Attention then switched to constructing a vertical-motion sensor, details of which I hope to describe in a future article. Chemical machining was used to make a component which was critical to the success of this instrument, namely the four thin flexures central to the 'cross-leaved hinge' shown in **photo 3** which constrains movement of the sensing beam to only the vertical direction. The part shown green is fixed to the chassis of the instrument and is connected to the blue hinged part by the four thin flexures shown red, arranged at right angles to each other. The sensing beam and 'proof mass' extends from the blue component, supported by a special type of spring (not shown). To minimise elastic forces in the hinge it was important that the flexures should be thin and bendy, measuring 16 x 5mm and only 0.038mm (0.015") thick, with two 2.5mm holes for the 8BA clamp screws. This was another task for chemical machining and a panel of 320 stainless steel flexures was produced by Precision Micro at a cost of only a few pence per part, **photo 4**. It would have been very difficult for me to have made these in the workshop, and certainly not in the quantities later required when eventually this instrument went into small scale production.

To learn more of chemical machining and etching, with particular reference to the making of brass components, please refer to the booklet by King and Watkin listed in the **Resources**. Several companies now offer chemical machining of custom parts to the hobby community and these often advertise in the pages of MEW.

Laser Cutting

This is a well-established technology in the industrial sector, and the cost of small machines has now fallen to the point where some hobbyists can justify the purchase of



Internal construction of a typical abrasive waterjet cutting head, showing the jewel orifice, ports for high pressure water and powdered garnet. Image courtesy of Canadian Metalworking.

their own cutter, **photo 5**. Examples include builders of model boats and aircraft who need to prepare small ply and balsa ribs, bulkheads and spars in large quantities. At the present time however, metal cutting with laser equipment is still out of reach for most of us on a DIY budget, although low power hobby

lasers can engrave on metal after a special ceramic coating has been applied.

In contrast to chemical machining, the principle is to use a finely focussed invisible laser beam to burn (wood) or melt and vaporise (plastics) in order to extract the part for a stock sheet of material. This is a 2D profiling technique in which the part is described in a CAD file, then passed to the laser controller which optimises the cutting path and speed, taking into account material type and thickness, beam width and the laser energy available. In most machines the beam tracks over a fixed workpiece, being guided from the laser via an array of moving mirrors or fibre optic. Alternatively, the laser itself moves, thus eliminating the need for mirrors. It is rarer to encounter laser cutters in which the workpiece instead moves, since more motive power and sturdier mechanics are required in such a configuration.

In nearly all hobby machines the laser is fixed and the beam is moved using a set precision mirrors shifting in X and Y along steel guides, and driven by stepper motors via belts or screws. Careful alignment of these mirrors is needed to achieve the best results and their setting needs to be checked periodically. CO2 laser light is produced from a special low pressure tube, with beam powers usually ranging from 35 - 80W. Although this may seem miniscule, the focus spot is very small and hence the power density and heat produced on the stock's surface is enough to bore through quickly. There are hazards for the operator unless precautions are taken to wear protective glasses and to ensure that safety interlock switches on the cutting machine are functional.

Smoke and fumes are generated during laser cutting, and so these machines usually incorporate an extractor fan and vent hose which can be discharged outside or connected to an absorption chamber which makes it possible to work in a closed environment. A range of materials can be cut with low-power hobby machines: these include wood, ply, MDF, leather, paper, card and plastics but not metals or chlorinated polymers, such as PVC which releases hazardous chlorine gas when heated. Excellent results can be obtained with cast acrylic, whether clear, opaque or tinted, since the process leaves a cut edge that is completely smooth and akin to the result achieved by 'flame polishing'. Extruded acrylic is more difficult to cut since the heat of the laser beam can cause this material to shatter. Certain types of plywood are certified as 'laser ply' and produce more consistent results when cut.

In developing these seismometers, I have used several laser cutting services for all the acrylic parts and also for some cut from 3mm thick 6063 grade aluminium sheet (see **Resources**). As expected, the edge finish on the acrylic components was perfect, **photo 6**. In contrast, the alloy parts were returned with edges that appeared to have been lightly 'filed' by the laser beam, but this texture was easily smoothed out with Scotchbrite cloth before colour anodising. As a precaution, all holes in the DXF part files were scaled

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Slice2 abrasive waterjet cutting head by Diamond Technology Innovations. It incorporates a diamond orifice to minimise wear by the abrasive and is engineered with a slim body to facilitate multi-axis cutting. Image courtesy of DTI.

0.2mm undersize to allow for possible errors or material flow in the cutting process: these were then opened out to the required sizes on the pillar drill. In cases where tight tolerances are essential, I would advise others to follow this suggestion.

Water Jet Cutting

Some new neighbours recently erected an elaborate nameplate outside their house proudly announcing their arrival in the district. This imposing technobling consists of a highly detailed Viking ship riding a stormy sea, complete with warriors' shields, mast and rigging. Discrete enquiries revealed that it had been sliced from 6mm steel plate using waterjet cutting, a process that seemed born of the Space Age.

As a hobby engineer, I had graduated from using hand and power tools through to using laser and chemical machining for parts in my seismometers. This house sign triggered further investigations that finally led to obtaining waterjet-cut parts for my latest 'quake detector'. As a consequence, the design came together more quickly and economically than would have been possible with contract CNC cutting, and with the benefit that the manufacturer already held large stocks of aluminium alloy in the sheet gauges needed.

Waterjet cutting uses the momentum of a narrow, supersonic jet of water to slice through the target material. In **Pure Waterjet Cutting** the stream is simply clean mains water that has enough ferocity under pressure to cut soft materials, such as paper, card, carpet, thin plastics and foodstuffs. In **Abrasive Waterjet Cutting** a finely powdered grit is added to the fluid stream to act as the erosive agent, the liquid acting as the carrier to cool and remove the waste. This more aggressive technology is used to cut a huge range of harder materials that includes most metals, stone, ceramics and tough plastics. Ordinary plate glass can also be cut, but not toughened varieties which tend to shatter as a result of breaching stored stresses. Accurate cuts in metals to depths of 100mm or more are not uncommon.

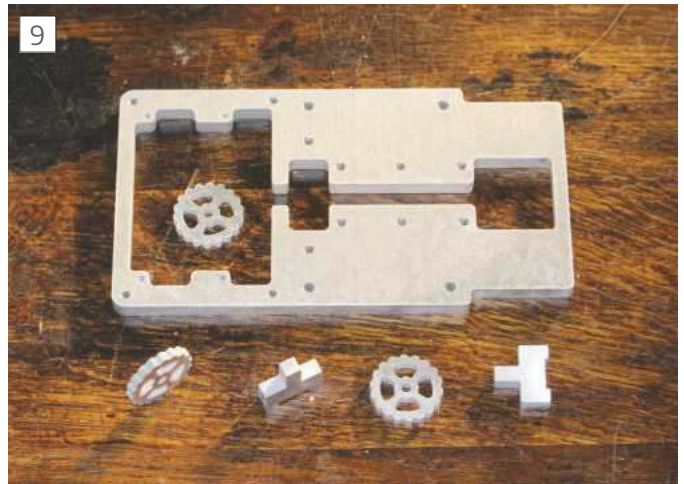
These machines operate with water pressures in the range 60,000 to 90,000 p.s.i., produced either via a **Direct Drive Piston Pump** or by an **Intensifier** which essentially opposes large and small bore hydraulic rams to obtain pressure amplification. To put this in perspective, the pressure at your kitchen tap is only around 50 p.s.i.. High pressure tubing leads to the cutting head where the water is focussed through a hard jewel orifice to create a stream typically 1mm in diameter. Dry, garnet powder is metered into this stream immediately below the jewel, before the jet finally strikes the target material, **photo 7**. An example of an abrasive waterjet cutting head manufactured by Diamond Technology Innovations is shown in **photo 8**. Once again, this process moves the cutting head, rather than the workpiece, and in some advanced machines the head can be tilted about 1 or 2 axes to create tapers and chamfers. After passing through the material, the jet exists through a support grid and into a tank from which the spent garnet can be recovered and re-used, and the water processed for safe discharge to a sewer. This

process is therefore environmentally relatively benign.

The cutting machine is driven by a controller program rather akin to a CNC, but which takes into account the 'floppy' nature of the jet stream. The software imports a DXF design file, then computes a cutting path which must compensate for the jet's diameter, curvature and lag as it pierces the material at varying profiling speeds. In detail: whenever the 'tool' slows, the jet's catenary at the base of the cut catches up, and small errors can therefore arise where there are sharp changes in direction. Hence appropriate corrections must be made to the tool path. With good software and operator experience these effects can be minimal and tolerances can match or even exceed those achieved by CNC milling.

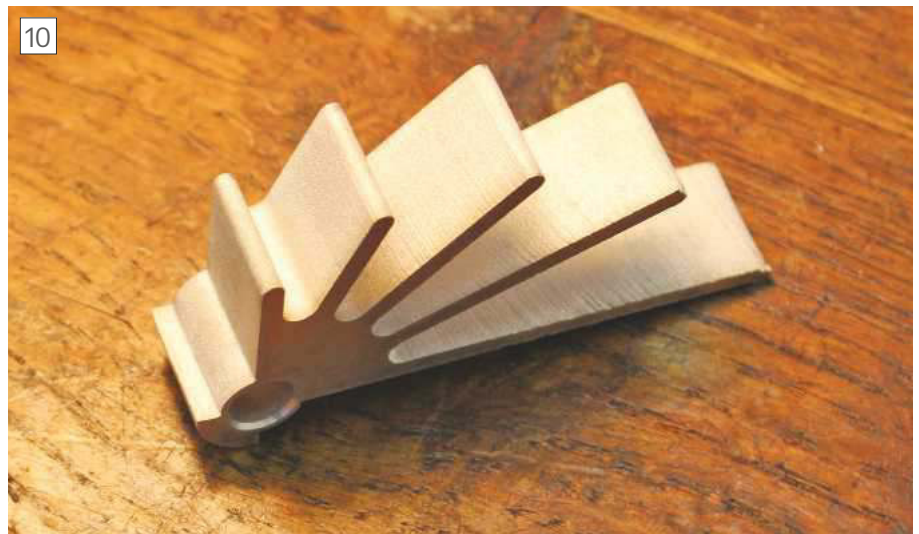
My latest seismometer incorporates three aluminium alloy parts produced by waterjet cutting. In **photo 9** these are seen as a 10mm thick plate 223mm long, an 8mm thick T-shaped piece and a 5mm thick toothed wheel 35mm in diameter. Knowing that the waterjet could cut radii down to 0.5mm

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Aluminium alloy parts for the seismometer as received from Precision Waterjet Ltd.

10

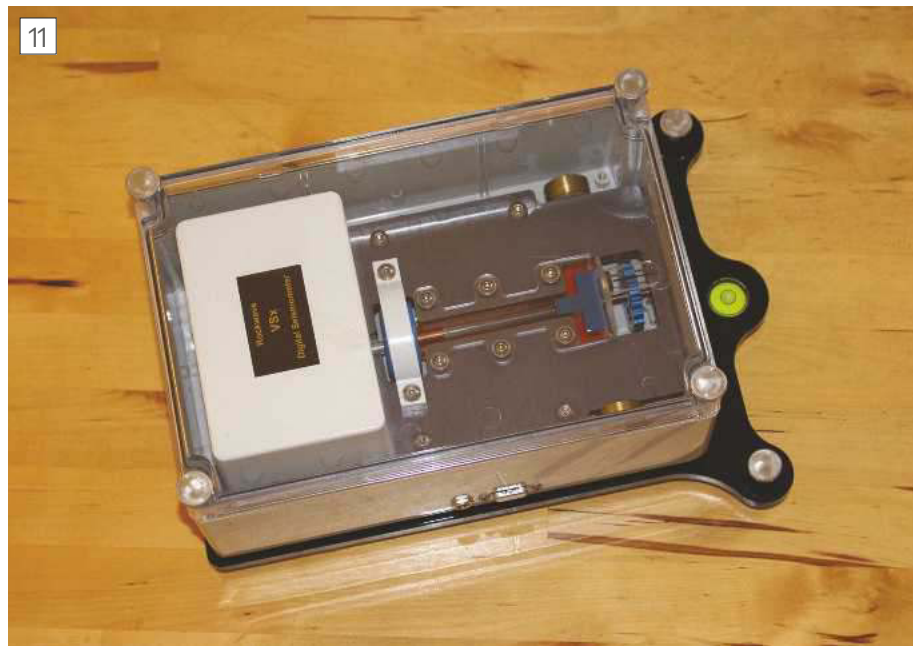


Five finger sample of waterjet cutting showing the quality of finishes on offer from Precision Waterjet Ltd: Quality 1 (coarsest) on the right to Quality 5 (finest) on the left.

liberated the design process, since it was now possible to conceive fine detail and small radii without the tool changes needed in CNC milling. These parts were produced within 10 days by Precision Waterjet in Nantwich, who suggested small changes to the toothed wheel DXF file to optimise the end result. The edge profile was initially designed in FastCAD as a continuous spline which, when exported to DXF, became a chain of tiny discrete lines that would cause the waterjet controller to jerk as each corner was passed. Their 'jetspert' adviser emailed to suggest that I redesign the perimeter as a continuous chain of arcs to avoid microscopic crests where the cutter changed direction. Top service from people who are skilled in the process.

Precision Waterjet offer five grades of quality, each reflected in price as a function of cutting time. **Photograph 10** shows the finger sample they provided, grading 1 to 5 from right to left. I could see no difference between Qualities 4 and 5 and so opted for the less expensive, although others might choose Q2 or Q3 reckoning that the 'filing' texture on edges is attractive or can be polished off with Scotchbrite. Photograph 9 shows the three components direct from Precision Waterjet.

As was the case with laser cut parts, I had configured the DXF files with undersize holes, opening them up to final sizes on the pillar drill. The alloy parts were cleaned and buffed, sent for colour anodising and combined with the laser cut components seen in photo 6 to complete the seismometer seen in **photo 11**. On 20th December 2018 the new instrument had been in operation here on the Isle of Man for only a few days when it detected seismic waves from a Magnitude 7.3 earthquake 7820 km away near Nikol'skoye in Russia, **photo 12**. This 'quake happened a depth of 16.6 km and the first impulse took only 11 minutes to arrive; even quicker than it would take by Aeroflot jet! Surface waves from the event



Completed seismometer which incorporates laser, waterjet, stock enclosures and conventionally machined components.

were still being recorded more than 2 hours later as they continued to ripple around the Earth.

Points of Comparison

Any model engineer considering either of these cutting services will be keen to learn more about their accuracies and limitations. In building my instruments I have used three laser cutting services for metal and acrylic, one specialist for chemical machining and another for waterjet cutting: these are listed in the **Resources** section at the end of this article, and in every case I have been very satisfied with the quality of the parts and their cost.

HPC Laser, based in Elland, West Yorkshire, are the principal supplier of laser cutting

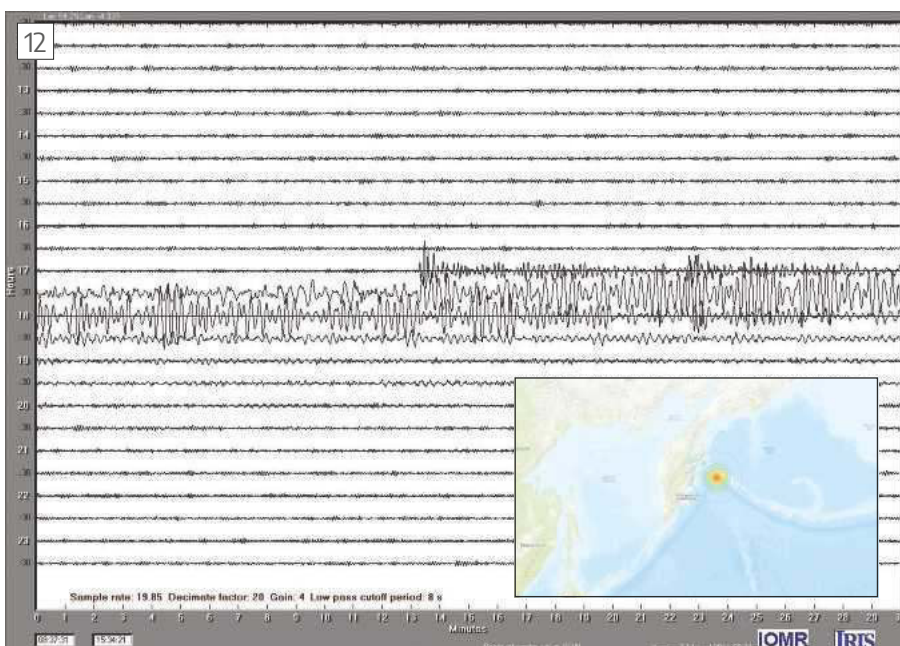
equipment in the UK and are the company hobbyists are most likely to turn to when seeking a small cutter, such as their LS3020 or LS3040 desktop machines. These are priced comparable to a small lathe and so could warrant inclusion in your workshop if funds permit. Bear in mind that you will need to budget more if your workspace is confined and without mains water, in which case you may want to add a laser fume filter and a water chiller unit. A small laser cutter will increase your speed of work and enhance creativity if your hobby includes making model aircraft or boats, railway buildings and scenery, or dolls houses and their scale furniture. Mention this to the Domestic Goddess and funds will be released immediately!

So what performance is available from a typical desktop cutter with CO2 laser tube? Steve Cockerham of HPC kindly provided some answers:

- The minimum kerf (i.e. slot width) in 3mm acrylic can be as small as 0.12mm with a standard lens.
- The minimum hole diameter in 3mm acrylic is also 0.12mm with the standard lens.
- It is possible to cut holes or pockets in 3mm acrylic to within 3mm of the edge of the material without causing deformation, although it may be possible to reduce this by taking special measures.
- When fitted with default 35W laser the maximum thicknesses that can be cut is 5mm in acrylic and 6mm in ply. With a 60W laser tube these figures increase to 12mm in both acrylic and ply.

The running costs of a desktop laser are comparable to a typical filament light bulb, with further power needed if a fume trap and chiller are used. Laser tubes typically last 1500 hours and are easily replaced with spares being held in stock.

As mentioned earlier, a smooth edge finish is achieved when cutting acrylic, making



M7.2 earthquake from eastern Russia detected on 20th December 2018. Ground motion is plotted 30 minutes left to right, then down a line to repeat.

this technique ideal for creating edge-lit signs or 'propeller clocks'. In my experience a microscopic burr is sometimes left on the edge of acrylic parts, presumably due to plastic flow and this needs to be removed to obtain the best joints in flat mating surfaces. A burnt edge is left on balsa, MDF and ply, although this does not significantly affect adhesion with PVA or balsa cement.

At present very few of us are using chemical machining at home to produce small metal parts in brass or other alloys, and there remains plenty of scope for experiments in this area and in the related field of **electroforming** where metal is added rather than removed over a foil template. In my workshop I am attempting to make the intake valve for a pulsejet engine by chemical machining copper beryllium shim as a much safer alternative to milling, since this alloy is hazardous in the form of dust or swarf: this is one of the few cases where the method seems imperative.

My experience of waterjet cutting has highlighted the immense potential of this method for producing parts with tight radii or small kerfs and holes which would be tedious to produce on the milling or CNC machine, because of the tool changes and high spindle speeds required. Moreover, the costs are probably acceptable, no stock needs to be kept, and it means that one's emphasis can switch from hacking metal to enjoying the design process using your new 3D modelling skills! Laser cutting at home or via a custom service offers similar liberation. An important point to note is that waterjet cutting, in contrast to laser cutting, is a cold process; in other words, it has the advantage of not creating a Heat Affected Zone which can affect the temper of the material or leave an oxide layer. Similarly, chemical machining involves only modest temperatures (sufficient



The new Wazer desktop waterjet cutter: the first possibly 'affordable' hobby machine. Image courtesy of Wazer Inc.

to optimise the chemical reaction), although the thickness that can be processed is much less than in the other methods.

Recently there have been some exciting developments in the waterjet cutting arena where efforts have been made to bring this technology onto the desktop at prices that are almost 'affordable'. Launched by Kickstarter, the Wazer is the first example of such a machine with a price that might be within reach of some of our larger model engineering societies, **photo 13**. Following this trend and further up the £scale is the Protomax machine which is finding its way into schools and colleges. If you fancy building your own waterjet cutter then buy a cheap domestic pressure washer and follow one fellow's build in the video listed in the **Resources**.

To complete this article, I gathered together all the parts that I had ever commissioned

in metal and acrylic from several contractors (laser and waterjet). I then measured all possible dimensions and hole sizes in these parts and compared them to the prescribed values in the DXF files that had been sent. The result was two tables of discrepancies for the errors in laser and waterjet cutting. These errors are plotted in millimetres against the size of the prescribed DXF dimension, **photo 14**. What is interesting is the much tighter tolerance of waterjet cutting, which even appears to decrease as the width of the required cut increases. In contrast, the greater error in laser cut parts appears to be constant, emphasising once again the fidelity of the waterjet technique. ■

Resources

Gibson Girl Box Kite:

www.aerohistory.org/gibson/manuel-anglais.html

Fluxgate sensors:

www.sensorland.com/HowPage071.html

Chemical machining:

www.precisionmicro.com

Brian King & Azien Watkin, Photo Etching. Workshop Practice Series, Special Interest Model Books, 2005.

Lehman seismometer: <http://psn.quake.net/lehmntxt.html>

Suppliers of hobby and industrial laser cutting machines:

www.hpclaser.co.uk

Flame polishing acrylic: for an example see www.youtube.com/watch?v=jg3yQpuFV3c

Laser ply suppliers:

www.slecuk.com/balsa-wood/Birch-Plywood.html

Laser cutting services:

www.cutlasercut.com

www.hobbytronics.co.uk

www.cut-tec.co.uk

Diamond Technology Innovations:

www.dtiinside.com/waterjet-cutting-heads-2/

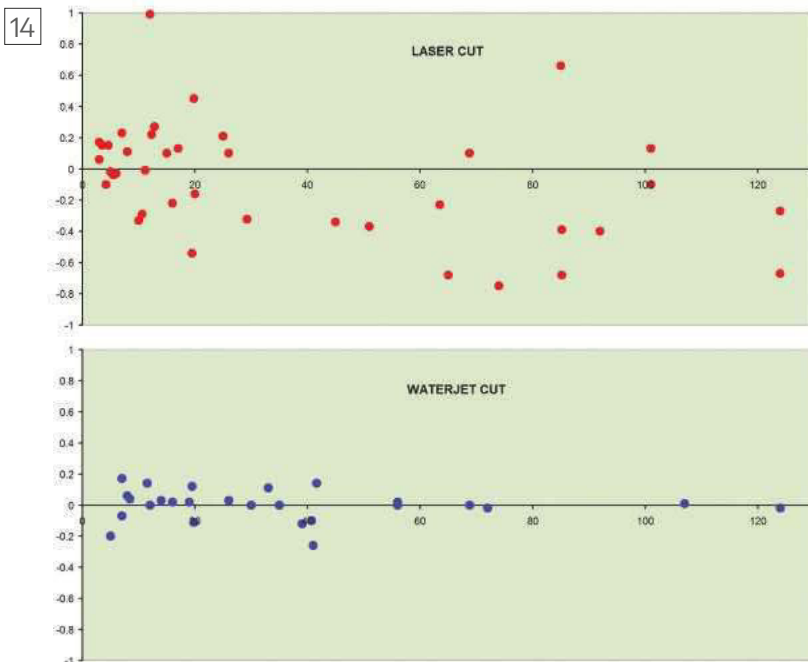
Precision Waterjet: www.precisionwaterjet.co.uk

Desktop waterjet cutters:

Wazer www.wazer.com

Protomax www.protomax.com

DIY waterjet: www.youtube.com/watch?v=Lg_B6Ca3jc

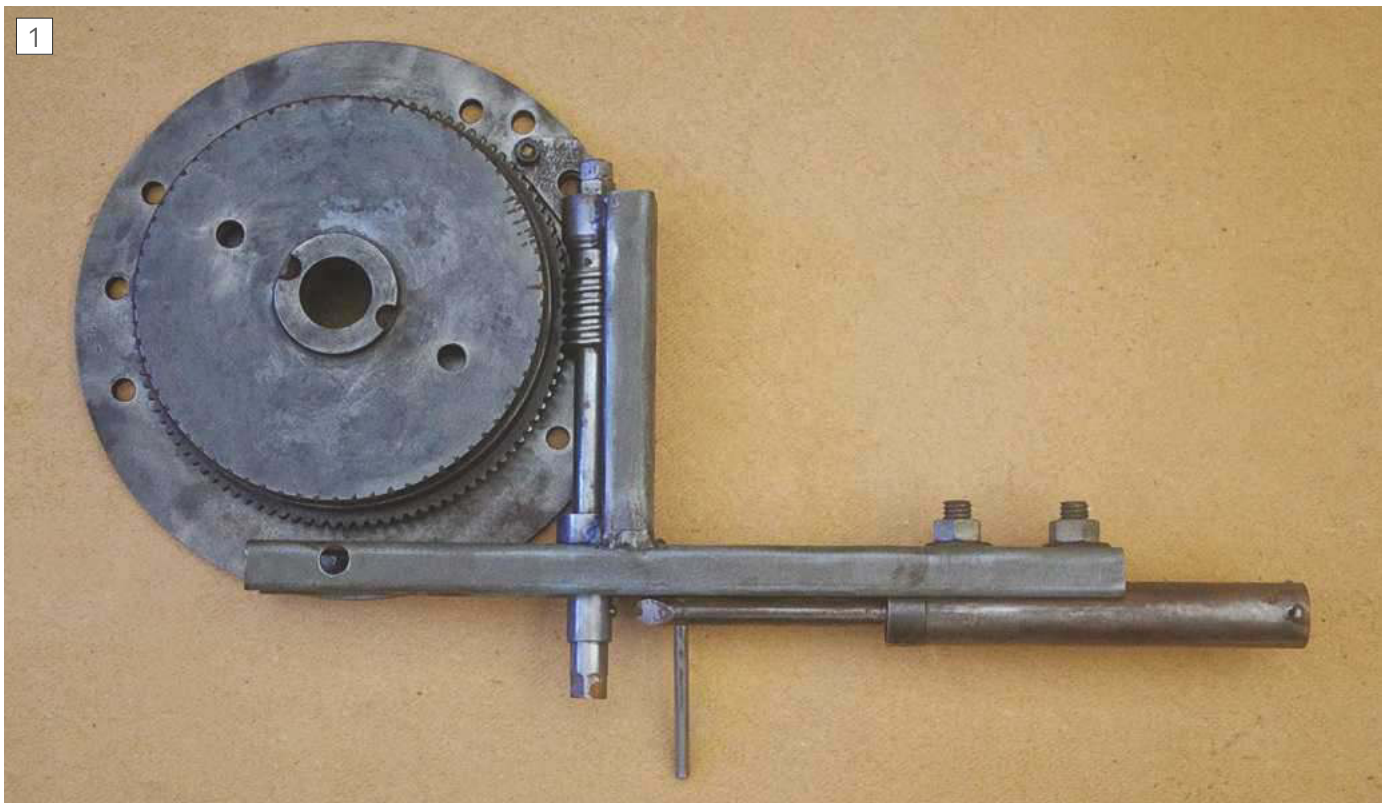


Graphs showing errors in laser and waterjet cutting expressed as the difference between a dimension measured in a supplied component and that which was defined in the CAD file (Y axes). Data are based on many acrylic and metal parts of varying sizes (X axes). Units are millimetres.

A Rotary Table from Scrap



Terry Cleife explains an interesting approach to improvising a rotary table



The finished rotary table

When overhauling an antique petrol engine, a set of DP16 timing gears had to be made. They would be three spur gears with 70 teeth and two with 140 teeth. At this point it was obvious that the 140 tooth blanks at 8.875 inches OD would not fit vertically in the usual way under the cutter of the horizontal mill. Some lateral thought was therefore required. The solution was to make a worm and wheel rotary table to mount the blanks horizontally on the mill table then cut the teeth using the Z axis. The scrap box as usual provided enough material for a zero cost option, **photo 1**.

A flywheel from an electric start lawnmower had a ring gear in good condition with 103 teeth for use as a worm wheel. A worm was produced to engage with these teeth in a flat plane and mounted in a bracket that hinged to allow rubbing contact on adjacent teeth which eliminated backlash. An index gear was keyed on the worm shaft and turned by a spanner. It is locked by a flattened detent with a V notch. This made it possible to cut the 70 tooth and 140 tooth gears using



The components



The end float arrangement

only a 70 tooth lathe change wheel indexer by locking either a tooth or tooth space as required, **photo 2**.

The flywheel inner surface was perfect regarding finish and lack of distortion so a car brake disc was used as the hub by machining the raised portion to achieve a close running fit in the flywheel. An arbor was then made for each gear blank and threaded for a bolt passing through a car camshaft belt sprocket. This sprocket, via shims adjusts vertical end play of the flywheel. The brake disc then had holes drilled for mounting to the mill table and the worm assembly fitted, **photo 3**.

In use a gear blank is mounted on a bespoke arbor with a flange bolted concentrically in the flywheel and the gear cut by feeding upwards on the z axis. The

calculations are no more complex with 103 worm wheel teeth than with any other number. To cut 70 teeth divide 103 by 70 (answer 1 remainder 33) so 1 turn plus 33 teeth (103 teeth) on a 70 tooth index wheel would index a gear blank one tooth space. To cut 140 teeth the index gear is rotated through half of 103 tooth spaces (51.5) which is why the detent has 2 positions able to engage either a tooth or a space between.

The gear cutter used on this job might be of interest because a high degree of accuracy was required for reasons of silent operation and durability. Therefore 6 single tooth cutters of rack form and 20deg. pressure angle were made from gauge plate and assembled as a gang, **photo 4**. ■



The 6 gauge plate cutters before assembly

In use a gear blank is mounted on a bespoke arbor with a flange bolted concentrically in the flywheel and the gear cut by feeding upwards on the z axis.

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MODEL ENGINEER

● Blowers

Peter Kenington exposes the humble steam raising blower to the winds of change.

● Magdalen Road

Jeremy Buck tackles the complexities of valve setting on a 5 inch gauge A4 locomotive with piston valves and conjugated valve gear.

● Tram Truck

Ashley Best completes the brake gear to finish off his Brill tram truck.

● London Exhibition

John Arrowsmith reports from the London Model Engineering Exhibition at Alexandra Palace last month.

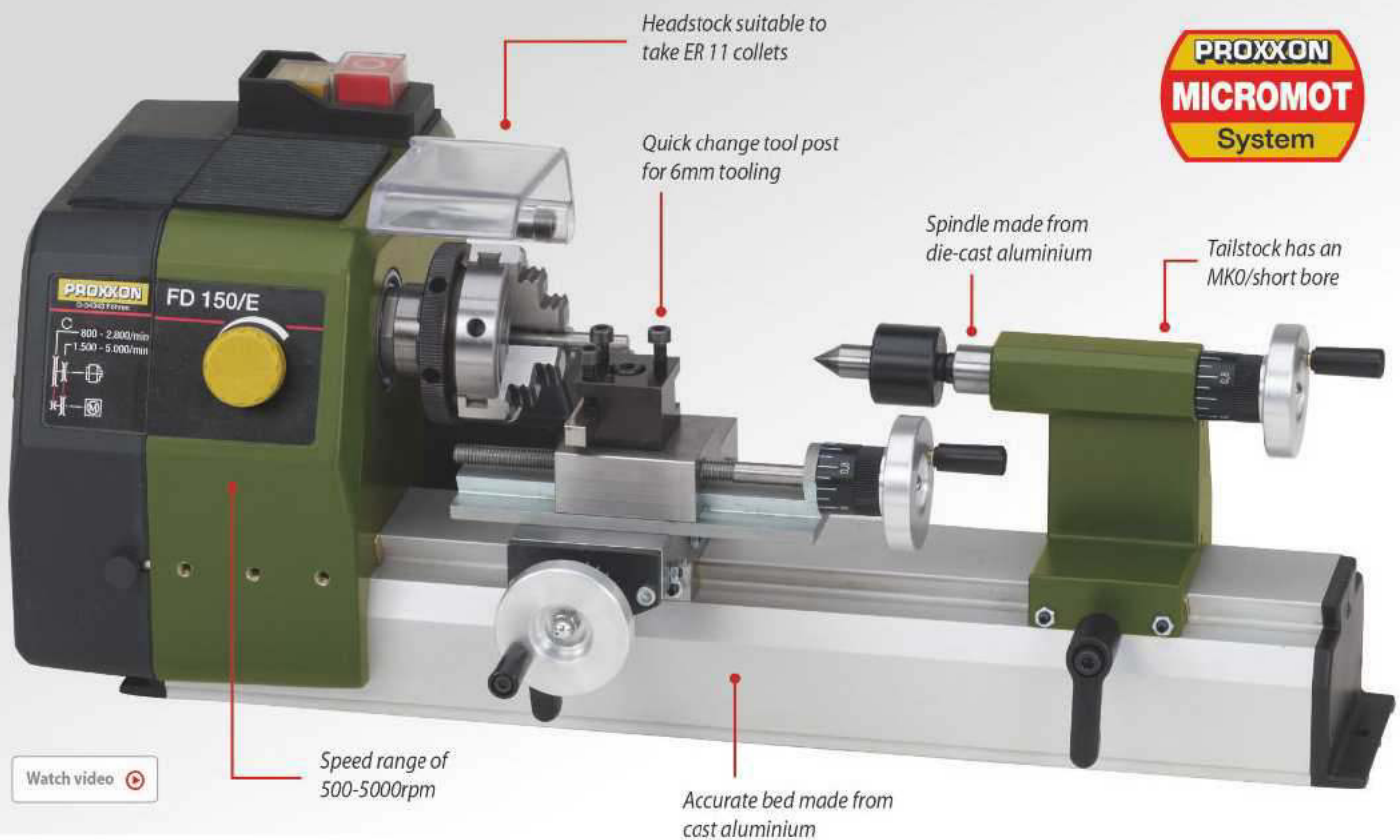
● Beam Engine

David Haythornthwaite machines the cylinder port face, bore and end covers for his 1 inch scale Model Engineer beam engine.



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Repairing a 'Safe-D-Speeder'



R. Finch saves a useful device from the scrap box



The Safe-D-Speeder

About 20 years ago, I was given a Mason Master 'Safe-D-Speeder' epicyclic speed reducer, **photo 1**, which I thought might come in useful one day, so I kept it in one of the drawers of my tool chest. When the D-speeder was made in the 1950s, electric drills were pretty well all single speed of around 2800 rpm and had 1/4 inch capacity chucks. If there were a need to drill into masonry or use a larger drill, then the only speed reduction method was to use the D-speeder with its 3/8 inch chuck. The method of use was to hold the 1/4 inch input shaft in the electric drill chuck and the masonry drill bit in the chuck on the D-Speeder, whilst gripping the outside of

the casing with the hand to stop the body rotating. This gave a four to one reduction in speed and consequently a four times increase in torque. If the drill bit jammed in the hole, the outer casing would try to rotate and, unless you had bionic hands, it would slip in your hand and not stall the electric drill.

As I already had a two speed drill, I never used the de-speeder until I came to use a 100mm hole saw to drill an access hole through a floorboard for installing new cables for my Internet connection. My drill, even on low speed (850 rpm), was still rather too fast for such a large hole saw and it tended to overload the drill. I then

remembered the D-speeder that had lain unused for all those years and dug it out, only to find that it had almost seized up. It was very stiff to turn and clearly needed a bit of attention.

The instructions

The instruction leaflet described a method of adding grease by removing the chuck, filling the rear of the chuck with molybdenum disulphide grease and screwing the chuck back on, **photo 2**. This should have forced grease into the mechanism and freed it up – or at least that was what I hoped would happen. It didn't – the grease merely came out of the threads as the chuck was screwed



The chuck removed and the inner spindle revealed



The custom puller

on. Therefore, I made a 3/8 UNF female adaptor to screw onto the male thread of the D-Speeder and fit a grease nipple to the other end, thus allowing grease to be forced in. That didn't work either. I then had to work out how to dismantle the gearbox.

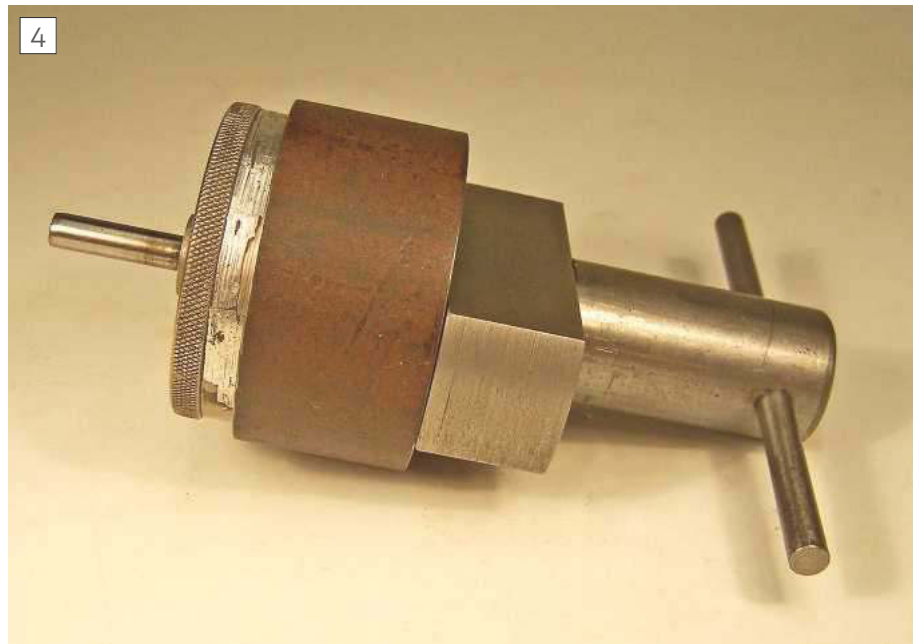
Fortunately, the instructions did state that '...Care should be taken not to force open the two halves of the gear casing when forcing the grease in. If it is apparent that this is happening the housing should be clamped lightly in a vice before continuing to screw down the chuck...'. As a consequence of this it was obvious that the case should be able to be pulled apart to allow grease to be put in. It was also clear that the front bearing, where the far end of the input shaft rotated in the threaded sleeve onto which the chuck was screwed, was the problem as the grease would not pass down the bearing.

Splitting the casing

At first, I thought that this might be as big a problem as splitting the atom but, fortunately, there was a narrow line between the outer case and the epicyclic outer gear around the periphery of the front of the case on the same side as the threaded chuck mount. This is just visible in photo 2 and provided a narrow rim (arrowed) for a puller to rest on whilst the epicyclic outer gear and the threaded spindle for the chuck were pulled out. I made a circular support for the casing and a bridge piece to go across. The bridge had a plain hole for a puller shaft with a female thread to fit the chuck mount at one end and a plain fine male thread at the other. I made a simple handle with a matching fine female thread to use to pull on the chuck thread and separate the body, **photo 3**. Maybe the handle was a bit too large, but it was a short end left over from another job and served the purpose well enough. This was assembled onto the D-Speeder, as in **photo 4**, and the case was slowly pulled apart.

Freeing up the spindle

Having dismantled the gearbox, it was apparent that the problem of stiffness was caused by the input spindle almost seizing in the epicyclic outer gear. It took a little gentle



The puller in position ready to split the casing



The gearbox dismantled

persuasion to remove the input shaft from the internal gear as that was where the problem lay. Once apart, the parts of the epicyclic gearbox were cleaned up, **photo 5**. I ended up cleaning out the bearing in the central mount for the gears using a 1/4 inch reamer to remove the roughness and galling in the bearing due to lack of grease. I also polished the shaft with fine steel wool, thus allowing the spindle to rotate freely again. The gears were then reassembled into the casing, **photo 6**, and a liberal dose of grease applied.

Re-closing the casing

This was again a simple job of placing the assembled gearbox against the circular support with the bridge piece to allow clearance for the input shaft. Similar clearance for the output shaft male thread was by the use of a short length of thick walled 1 inch bore pipe. The assembly was then closed up using the bench vice as in **photo 7**.

Summary

The original gearbox had partially seized due to lack of lubricant. It was a straightforward exercise repairing this piece of very old equipment. Making the puller was simple and relatively quick, using bits from the scrap box.

The Safe-D-Speeder is now a useful tool to add to my collection. ■



The gears reassembled into the outer gear



Closed up in the vice

Simplicity Jig No 2

John Harding moves on to a simple to use jig for sharpening four facet drills



Jig number 2 for four-facet drills.

Purpose of making this Jig, **photo 1**, is for holding larger size drills up to 20mm using the Stevenson Collet Block. **Photograph 2** shows sharpening a drill which came with a four-facet point. Previously sharpening had been by holding it in a vice and judging the angles. The difficulty with this is being able to keep the flanks level.

Construction

This is as for Jig No.1 (MEW 290) just requiring setting the appropriate angles. Making this jig resulted in what is actually a Mk 2 version of Jig No.1, correcting the design error(s) in No.3.

Use

Large size drills are normally only used for opening out pilot holes, so finishing the drill to a point does not arise. Out of interest a 13mm drill was taken to point, **photo 3**. This drill sees frequent use for drilling plate washers in the lathe and now goes through



Sharpening a four facet drill (guard removed for clarity).



Tip of 13mm drill.

without a pilot hole. The one experiment with a 5mm drill failed.

Conclusion

The jig lives up to its intended purpose plus the bonus of the improved Jig No.1 Further work has to wait for a enough blunt drills! ■

Garden Tractor Refurbishment



Stan Nesbitt uses his workshop to rescue some garden machinery



Flywheel still on crankshaft stub.



Remains of the S800

When I spotted two scrap Westwood ride on lawnmowers for sale locally I acquired them intending to recover pulleys, bearings, drive belts and engines etc. for use in other projects. These older Westwood tractors are heavily built using sheet steel throughout. The engines were Briggs & Stratton. I was horrified to discover on one engine that part of the crankshaft had been sawn off to recover the cast iron pulley. However, the pulley was found amongst other parts still

firmly attached to the piece of crankshaft!

Photo 1.

After further examination I concluded that it was worthwhile refurbishing the smaller unit, the S800, **photo 2**. I managed to purchase an 8 hp Briggs & Stratton engine which only needed a de-coke, the valves re-grinding and a new set of piston rings. This engine has both a pull start and electric start which is a useful feature if the battery is flat, **photo 3**.

Where the paint work fails, surface rust

quickly appears especially where panels are bolted together. Nuts and bolts on these American machines are all imperial so I had to dig out the appropriate and seldom used spanners. An electric impact driver proved very useful and avoided shearing rusty examples, **photos 4 & 5**. These older models were fitted with expensive and well made gearboxes having five forward and one reverse gear and incorporating a differential. Later models like the Lawnflite use a simple adjustable double pulley which provides



**8hp B&S unit.*



Chassis before...



... and after.



Underside showing drive train.

for speed changes. A differential is fitted between the rear wheels and it uses a separate forward, neutral and reverse control lever, **photo 6**.

Only one gearbox was included with the two scrap Westwoods and it required a new bevel drive gear and a set of axle needle roller bearings, **photo 7**. To remove road wheels on these mowers they should slide off, but they can often become rusted solid to the axle. Some wheels will tear themselves apart without releasing the hub. The hub can then be removed by making 2 or 3 longitudinal cuts with an angle grinder, **photo 8**. New hubs can be turned and welded back into the wheel centres. Only slow speeds are used in the garden and this procedure if done carefully will be quite satisfactory. From experience I think it is advisable not to attempt to start these older engines until they have been partially dismantled to check that everything is in order. See **photo 9** of a blown engine which failed due to a broken con rod. It is always good practice to scrape the cylinder head clean, re-seat the valves



Gearbox opened up. No synchromesh here!



Wheel with split hub.



Crankcase and broken conrod.

and check that tappet clearances are correct. Parts of these steel garden tractors are heavy and to install the gearbox I made up a jack from the base of an office chair, steel pipe and a scaffolding foot to provide for height adjustment, **photo 10**.

Much of the paintwork may be intact but it is preferable to remove all the paint and reduce to bare metal. Rust preventative should be applied where necessary prior to a red oxide primer. A brush finish should be

quite satisfactory for this job. My existing ride on mower purchased in 2000 and is still working well so I needed only a tractor for general use in a large garden.

Another garden tractor was acquired when I spotted a 12.5 hp Briggs & Stratton engine for sale on Gumtree with the tractor considered as scrap, but it was given to me as part of the deal. After dismantling and painting this tractor is now in service again and has proven a great asset to me.

Two useful attachments are shown in **photos 11 & 12**. The rake is height adjustable and can be used on gravel areas, on lawns and for tilling new ground. I needed to buy the spring steel tines, but the other pieces were from my scrap box. The garden trailer started life as a heavy duty fiberglass tank but now is very useful as a trailer for hauling heavy materials such as soil, gravel and timber around a large garden. ■



Light duty jack from a chair.



Lawn rake.



Utility trailer.

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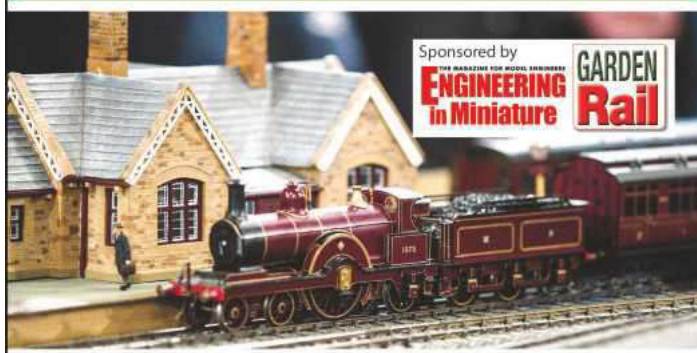
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The Modular Dividing Head

Ted Hansen makes a flexible system for dividing using standard change gears, including an explanation of its use with various popular lathes. Part 3

Start, therefore, with the arms in the position to make a cut. Lock the arms to the index plate using the outer clamp screw, lock the spindle to guard against any shifting, and make the first cut in the work piece.

Unlock the spindle and release the outer sector arm clamp screw. Advance the sector arms (still locked together at the correct spacing) until the trailing arm is against the plunger and lock them in this position. Now, lift the plunger and advance the worm the required number of turns plus the required number of holes (in this case 3 full turns plus the 12 holes set out by the sector arms). Insert the plunger into the hole against the leading arm. Lock the spindle, make another cut and repeat until the job is completed.

For divisions not listed in the chart:

To check if a holes/teeth/divisions combination is possible, the formula is "number of holes times number of teeth divided by the division wanted". If this gives a whole number, the division is possible and the result is the total number of holes which must be moved to obtain the desired division. In our example above, $36 \times 40 / 12 = 120$, which is a whole number.

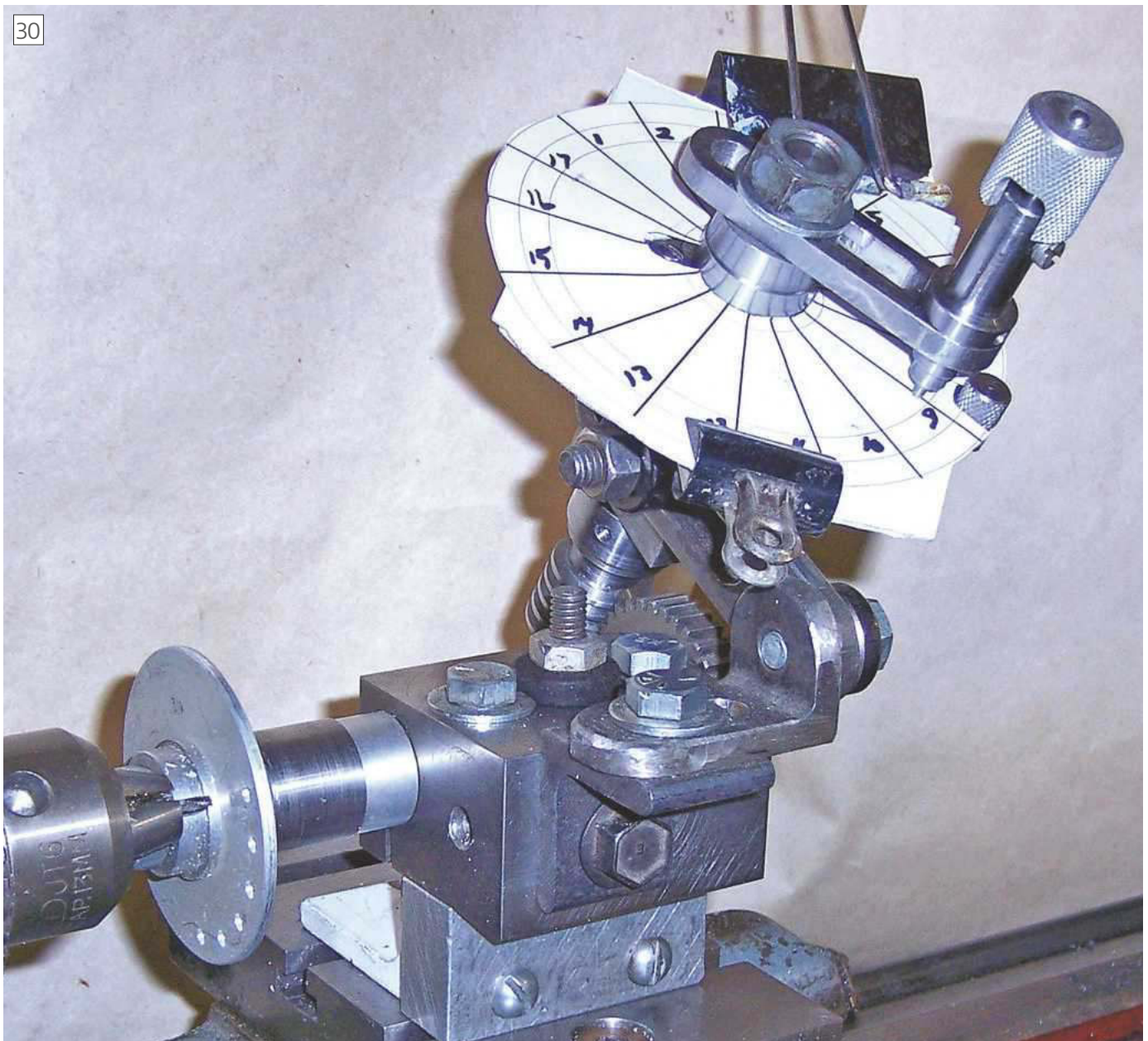
Since we want usable measurement units instead of something absurd like 120 holes on a 40 hole circle, divide again by the number of holes in the circle to get the number of turns. $120/36$ gives 3.3333 or "3 remainder 12". The "remainder 12" is the number of holes to be advanced in addition to the whole number or

Once we know a given division is possible, the formula can be simplified to just "number of teeth in the indexing gear divided by number of divisions".

Table 6

Gear	Divisions Chart for South Bend and Equivalent								
	25 Hole Circle			36 Hole Circle			22 Hole Circle		
	36	40	42	36	40	42	36	40	42
2	18t	20t	21t	18t	20t	21t	18t	20t	21t
3	12t		14t	12t	13t 12h	14t	12t		14t
4	9t	10t		9t	10t	11t 18h	9t	10t	11t 11h
5	7t 5h	8t	8t 10h		8t			8t	
6	6t		7t	6t	7t 24h	7t	6t		7t
7			6t			6t			6t
8		5t		5t 18h		5t 9h	5t 11h	5t	
9	4t			4t	4t 16h	5t 24h	4t		
10	4t 15h	4t	4t 5h		4t			4t	
11							3t 6h	4t 14h	4t 18h
12	3t		3t	3t	3t 12h	4t 18h	3t		4t 11h
14			3t 20h		2t 24h	3t			3t
15	2t 10h				3t 18h			3t 11h	
16				2t 9h	2t 8h	2t 12h	2t		
18	2t	2t		2t				2t	
20	2t 20h		2t			2t		2t 18h	2t 20h
21							2t 14h		
22							2t 11h		
24	1t 11h	2t 15h	2t 17h	1t 18h	1t 24h	2t 27h			
25				1t 12h		2t 20h			2t 11h
27						2t 18h			
28									
30	1t 5h		1t 10h		1t 12h				
32					1t 9h				
33			1t 5h				1t 2h		1t 6h
35	1t			1t	1t 4h	1t 6h	1t		
36		1t			1t			1t	
40			1t			1t			1t
42							18h	20h	21h
44	20h			27h	32h				
45					30h				
48	18h	20h	21h	24h		28h		16h	
50									
54									
55									
56						27h			
59									
60	15h				24h				
63						24h			
66			15h	18h	20h		12h		14h
70			14h			21h	11h		
72	12h			16h	18h				12h
75								11h	
77									11h
80						18h			
81									
84									
88									
90	10h				16h		9h	10h	
96					15h				
99							8h		
100	9h	10h							
120					12h				
125		8h							
360					4h				

30



Generating a 17 hole test plate using a temporary paper indexing guide.

turns. This matches the information on the chart which gives 3t 12h for this example.

Once we know a given division is possible, the formula can be simplified to just "number of teeth in the indexing gear divided by number of divisions". The integer (whole number) part of the result gives the number of turns. The fractional part of the result multiplied by the number of holes in the circle gives the number of holes to be moved in addition to the number of turns. i.e. 3.333 is the same as 3 turns plus .333 x 36 (=12) holes.

Indexing Primes and other 'impossible' divisions:

Extending the range of the attachment beyond what is available from the normal gear and hole combination can be done by replacing the indexing plate or the plunger overarm with any suitable dividing guide and using this to index the rotation of the worm. The dividing guide can be anything, a measuring tape wrapped around a styrofoam

disc, a hole circle made from perforated metal "pipe hanger" strip around a wooden disc, a paper pattern or a protractor. It doesn't have to be super accurate although it should be reasonably close.

The final plate created will be much more accurate than the temporary guide because of using the worm attachment instead of direct dividing. The reason is that a rotational error in the worm gear causes only a very small error in the rotation of the workpiece. For example, 1mm error on a 100mm diameter temporary guide plate causes a rotational error of 1.146 degrees in the worm. This small error in turn results in an error of only 0.01mm (0.0004") (1.146/360 times the pitch of the worm) at the spindle.

As a trial, since 17 is a prime number not available from any of our normal gearsets, I made a 17 hole test plate using a paper pattern as an indexing guide.

The 17 division paper pattern was printed from the computer, glued to a piece of heavy

31



The worm module mounted on the headstock of a mini lathe.

In a way, however, the MDH is never really complete; additional indexing gears, spindles, work holding attachments and mounting accessories will accumulate as the need arises.

card stock and secured to the index plate with paper clips. Working through the calculation above (using a 36 tooth gear) gives $36 \times 17 / 17 = 36$ which is a whole number, confirming the division is possible. The calculation also tells us that each division will require advancing the worm by 36 marks on our division guide. Since the guide has 17 marks, 36 marks is 2 full turns plus 2 additional marks. **Photograph 30** shows the setup.

The index lines were about 0.025" thick and the normal plunger with its blunt tip was used as a pointer. No special care was taken to be exceptionally accurate, but I was not deliberately sloppy either. After the job was completed, I discovered I had a small amount (perhaps 0.002") of free play in the engagement of the worm. The accuracy of positioning the pointer could not have been any better than plus or minus 1/2 the thickness of the index lines however the hole spacing in the resulting test plate was accurate to within plus or minus 0.002" (0.05mm).

Other Uses:

Photograph 31 shows the worm module attached to the headstock of a lathe to index work held in the lathe spindle. An expanding mandrel holds the indexing gear in the spindle hole.

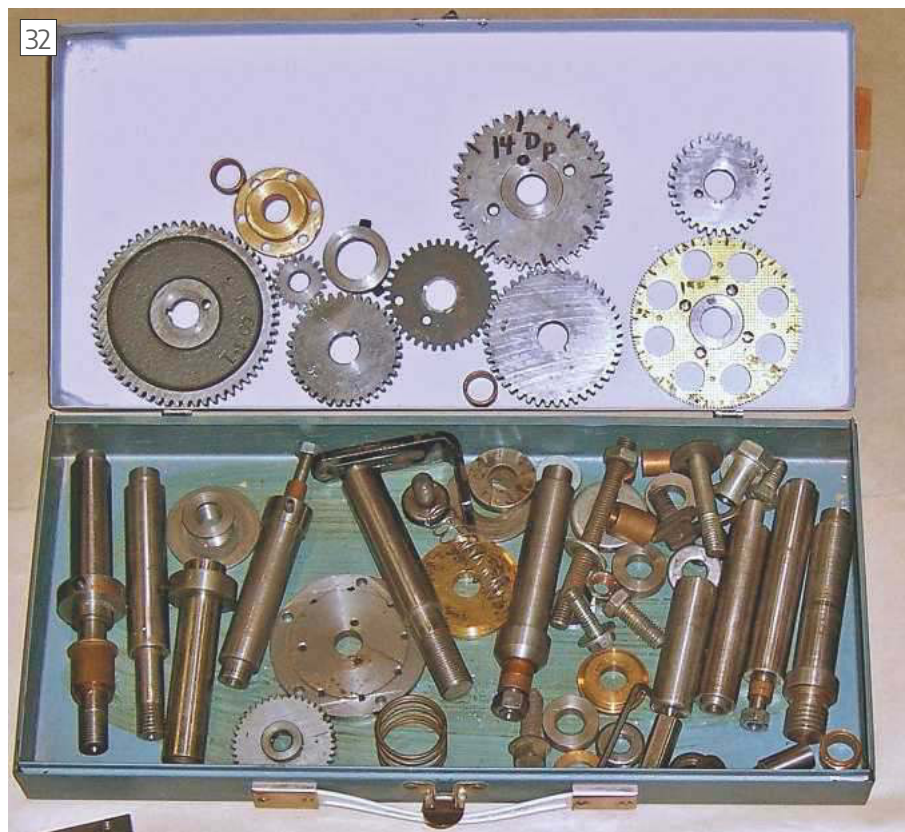
Conclusion:

The addition of the worm module completes the construction of the Modular Dividing Head. In a way, however, the MDH is never really complete; additional indexing gears, spindles, work holding attachments and mounting accessories will accumulate as the need arises. **Photograph 32** shows some of the accessories I have accumulated over the years. ■

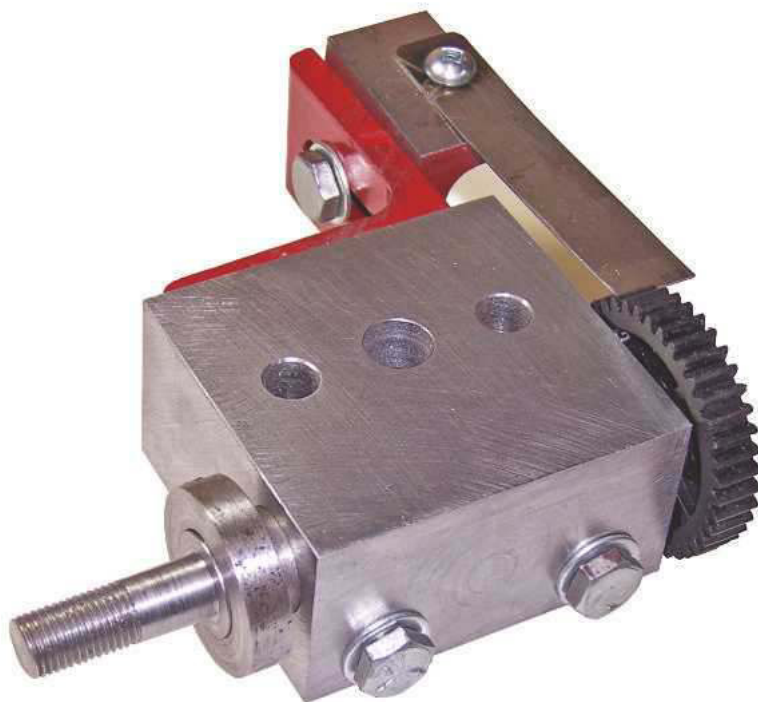
References:

Martin Cleeve: Gear Cutting and Indexing Model Engineer vol 132 issue 3291-3293 February-March 1966

Martin Cleeve: Aids to Gear Cutting and Indexing vol 132 issue 3299-3300 June-July 1966



A variety of spindles, mount sleeves, mount brackets and other accessories accumulated over the years.



J.A. Radford: Indexing Attachment for a Myford Model Engineer vol 134 issue 3336 January 1968

Geo. H. Thomas: Dividing and Division Plates Model Engineer vol 144 issues 3586-3588 (June-July 1978)

Geo. H. Thomas: Versatile Dividing Head series, Model Engineer vol 145 (1979)

Opening the spindle bore on a Mill



Brian Wood had to enlarge the bore on his Dore-Westbury Mk II miller

Summary

I recently replaced the 3 Morse taper ER 25 collet chuck on my mill but without really thinking about the implications of the drawbar diameter it was going to need.

On taking delivery I discovered it needed a drawbar with an M12 thread, the spindle bore was drilled through at 3/8 inches diameter.

This short article records the steps I took to open the bore out and the method of attack used on this particular machine.

Introduction

The change of chuck became necessary when the first two threads on my previous ER 25 collet chuck started to pick up on the nut, making it difficult to engage the nut without risking a crossed thread. Other threads on the chuck were also beginning to crumble. The chuck wasn't actually that old either, maybe three years or so, but it uses a drawbar thread of 3/8 inch Whitworth which of course suited the Dore Westbury mill very well indeed.

The chuck is hardened throughout which effectively ruled out the possibility of lightly chasing the 1.5 mm thread for the closing nut. In the end I made a working repair to it by turning off the first two threads and followed that with a little fine grade valve lapping paste to bed the remaining threads of the chuck and nut together again.

Photograph 1 shows the result.

It is still a useful chuck but is now 'under notice of eviction' in case of further thread deterioration.

However, it is such a useful piece of tooling I decided to replace it anyway. The replacement came this time from Arc Euro



Damaged thread on old ER 25 collet chuck

Trade, the previous one was from RDG. Both are well respected companies and there was no bias made in my choice of replacement other than to avoid another fully hardened component if I could.

On receipt, I realised I couldn't fit the required 12mm drawbar down the mill to secure the chuck, oops! **Photograph 2** shows a section of M12 thread held off in the mouth of the drive tube on top of the quill.

The new chuck was also hardened, and the hardening included the drawbar thread as well. Sleeving it down for a 3/8 inch Whitworth thread instead would leave a very slender wall section of only 0.019

inches in the sleeve material separating the two threads. The risk of distortion and then jamming once inside the spindle was a very real possibility.

I looked again at the choice offered by RDG with a view to returning the Arc version unused, but they too have now altered the specification to 12 mm drawbars, so I was stuck with the situation whichever way I played it.

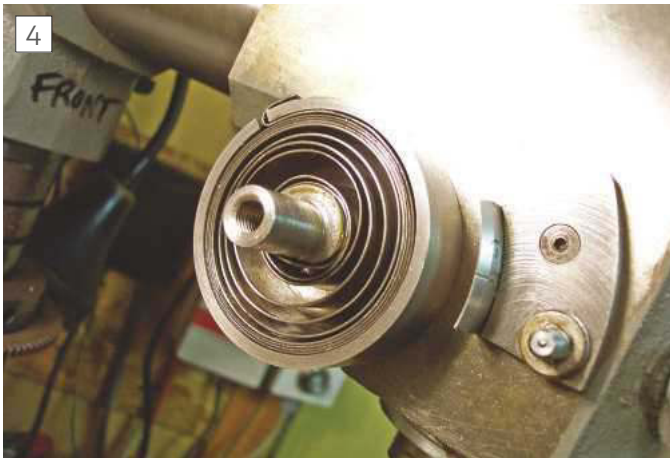
I could of course continue using an even older ER16 chuck I had made on a 2 MT blank fitted into my open ended 3-2 MT adaptor as before, but that severely limited what I could hold in the way of cutters and drills and was



Slug of M12 thread in the mouth of the hole of the drive tube



Return spring housing



Outer cover removed to expose the spring and inner housing



Spring removed, note the drive peg to hook onto the spring tab

the main reason for choosing the larger ER collet size.

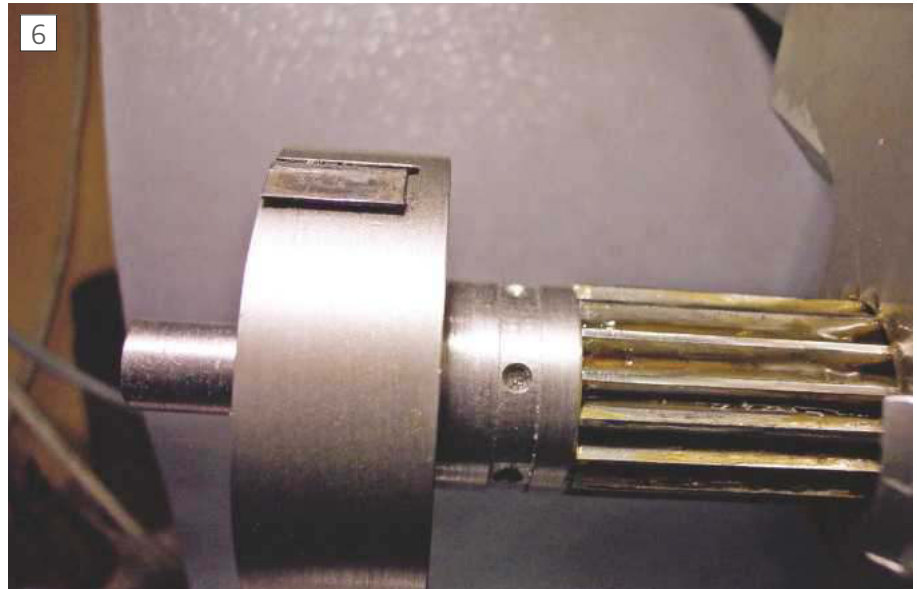
Getting into the quill

I built my mill about 25 years ago and a brief check of the drawings showed that the whole quill and spindle could be released by removing only the down feed capstan.

It is not a difficult operation either as it is held in position by the housing for the return spring. **Photograph 3** shows the housing complete, **photo 4** shows the spring exposed and **photo 5** is the view with the housing and spring removed. Clearly visible here is the slotted peg which anchors the spring onto the winding section of the capstan shaft. The housing is tensioned and then held in position by a short socket head grub screw from the underside of the head casting in one of the six dimples shown here in **photo 6**.

With those items removed, the capstan can be withdrawn; be prepared for the weight of the quill and spindle as it is released to prevent it crashing into the milling table.

Photograph 7 shows the capstan



The grub screw dimples for tensioning the spring

unit and **photo 8** the quill complete with spindle. **Photograph 9** shows the spindle components laid out for inspection. My mill

has a 3 Morse socket, hence the use of a taper roller bearing at the lower end.

This is instead of an angular contact ball



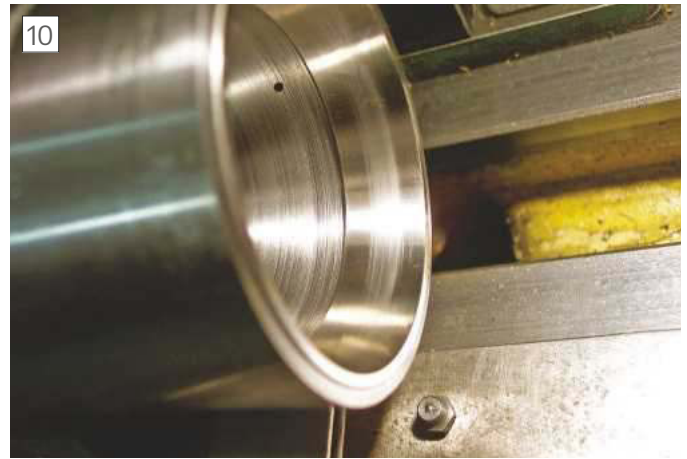
Capstan shaft complete



Quill with spindle fitted



Spindle components laid out for inspection



View of taper roller bearing seat



Evidence of the degree of heat needed to break the loctited joint



SDS drill after drilling the drive tube

bearing to match the one shown at the drive end of the quill, those were provided as a pair for machines with the 2 Morse taper socket.

It was very gratifying to see the excellent condition of the quill and spindle after 25 years use. The preload for the bearings was still as I had set it initially to just take out any play and 'nip' the bearings. **Photograph 10** is a view of the lower bearing seat with only the lightest roll marking from the taper roller bearing. The small hole also visible here is a drilling for greasing, one of the modifications I incorporated into the build.

A lot of heat was needed as can be seen in **photo 11** to break the Loctite joint of

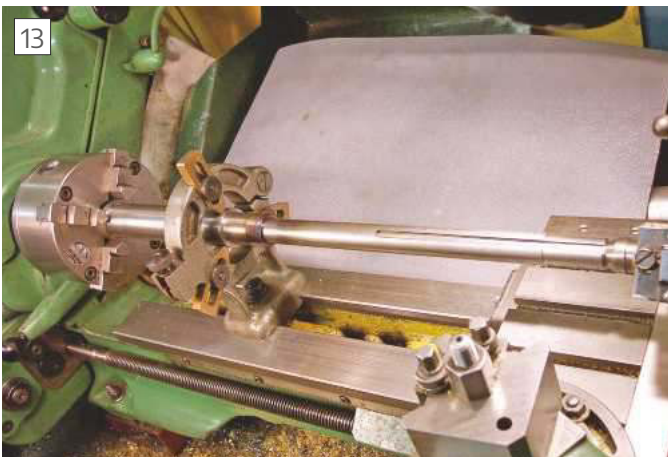
the drive tube to the lower spindle; the assembled spindle was much too long to drill through in one hit.

I have a long Bosch SDS masonry drill of a nominal 12 mm diameter. It finished the hole at 12.6 mm diameter and is seen here in **photo 12** after drilling the tube. The point needed sharpening to cut metal after which it happily rattled it's way through the tube satisfactorily. The keyways in the tube for the two pegs in the bronze drive plate have a wall section of about 0.85 mm over the new hole diameter

The quill itself was given support by a fixed steady and was drilled with a conventional

twist drill to break through into the Morse taper socket. The components were loosely assembled again to be sure that the short slug of 12 mm thread would drop through the new drilling.

Photograph 13 shows the drive tube and quill assembled once more and held as shown under light axial compression for a new joint in high strength Loctite 603, left to set overnight. Finally **photo 14** is a view of the new drawbar. The whole job nicely occupied a weekend. ■



Drive tube and spindle reunited



New drawbar

Yet Another Bodge-Up!



Peter Shaw finds a use for some aged homebrew slot drills.



Cutters sleeved & unsleeved and an MT3 direct collet.

One of the first things I learned when I first became involved in model engineering was that it was possible to make ones own cutting tools out of hardenable steel, e.g. silver steel, with the first two tools being a three-lobed countersink tool, and a metric thread cutting tool. Both were successful, and both are still in use today, some 30 years later. As a result of that early success and buoyed up by L.C. Mason's comments in his book "Using the Small Lathe", I decided to try making a set of slot drills and a set of endmills. Now Mason explains how to make slot drills, or as he calls them, slotting cutters, but only mentions endmills in passing, indeed he describes slotting cutters as the homemade version of the endmill. Perhaps that should have told me something!

Mistakes!

I bought myself some imperial sized silver

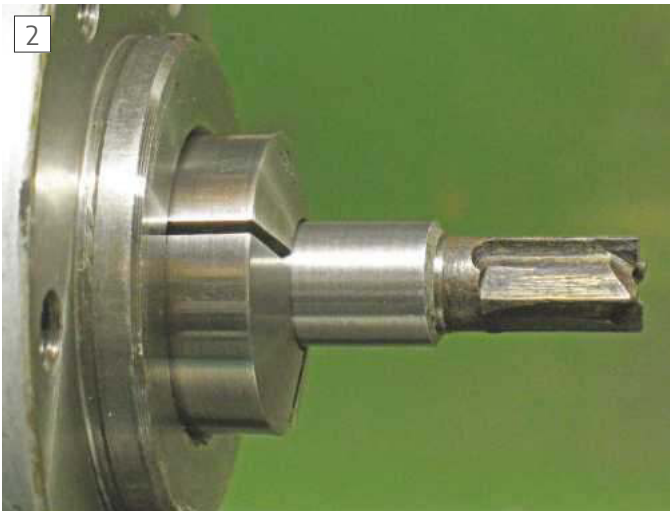
steel – which was rather silly as early on I made the decision to work only in metric, indeed all my machinery and measuring equipment are metric, ok, some are dual marked, but I have never used the imperial calibrations. Furthermore, as both my lathe and, eventually, my milling machine had MT3 tapers, I also bought a set of metric MT3 direct collets. The result was that I ended up with a set of imperial cutters and no means of holding them except by means of a chuck – and this is generally thought to be a bad idea.

Another mistake was that I made the cutters in total 1½ inches long, and no, I do not know why I did it.

Overall then, I ended up with a set of cutting tools which I could not hold safely, hence they were placed in a drawer to collect dust and rust pending a decision as to what to do with them.

30 years later...

By now I have acquired a number of commercially made endmills, two of which had become somewhat the worse for wear and were really only of use for roughing out. It was on such a roughing out job that I became somewhat overenthusiastic and succeeded in shattering both endmills, and it was whilst I was looking at my remaining endmills that I began to wonder if any of the home-made cutters could actually be held in a direct collet. It turned out that the 5/16 inch cutter measures 7.938mm and that a single turn of paper brought it up near enough to 8mm such that it could be held in a 8mm direct collet. Much to my surprise the tool actually worked and produced a fine swarf, that is, until the paper lost its grip. But the principle had been set – make some metal sleeves to bring the external diameter up to the nearest metric collet size



Sleeved cutter mounted in collet and headstock.

and at the same time lengthen the cutter somewhat.

Modifications

Photograph 1 shows the first two endmills so modified, their equivalent sized slot drills, and a direct collet. There is a problem. Ideally, I would have liked to silver solder the two parts together, but the heat would have destroyed the hardness of the cutter. Similarly, soft soldering may have caused some tempering of the tool. I therefore decided to make the internal diameter of the extension piece a push fit to the cutter, and then fasten the two parts together using an equivalent to Loctite 603 retainer.

Photograph 2 shows the modified 5/16 inch cutter mounted in a 10mm collet, which in turn is mounted in the lathe headstock. Note the small amount of overhang compared to that if these cutters were used in a chuck as Mason suggests.

Results

Photograph 3 pictures the results with the left hand item showing that the 1/4 inch cutter could be used to enter a piece of metal and mill it. The right hand item was in a very rough state to start with, so I used the 5/16 inch cutter over the full surface. Neither surface could be described as good, but they were level. Mason states that, for the slotting

cutters, "You can run these cutters at a fair speed, the cleanest result coming from a light cut." My initial speed was 355rpm, so for later tests I used a speed of 1000rpm with a much better result as shown in **photo 4**. In terms of depth of cut and at 355rpm, everything was unhappy at 0.2mm, but reasonable at 0.1mm. At 1000rpm, cutting was better, but 0.1mm still appeared to give the easiest cut.

I also tried brushing on some cutting fluid. Now Tubal Cain, in his book "Milling Operations in the Lathe" says that brushing on cutting fluid when turning is usually satisfactory, but in milling a flood of fluid is required to wash away the chips, otherwise the damp chips will simply form a mush which will clog the clearance spaces and tend to wedge under the cutting teeth. This is indeed what I found. He then says that for most of his work, he tends to reduce the cut to allow dry milling, and certainly testing dry at 1000rpm would tend to confirm this.

The final part of my initial testing was to try a full width cut using the endmill, even though this is not recommended. Once again, I was surprised to find that the 5/16 inch cutter was completely happy cutting full width, and this actually made cleaning up the test piece much easier – cut full face along the centre line, and then take two further narrower cuts to clean up the edges.



Results of 1/4 inch & 5/16 inch cutters at 355rpm.

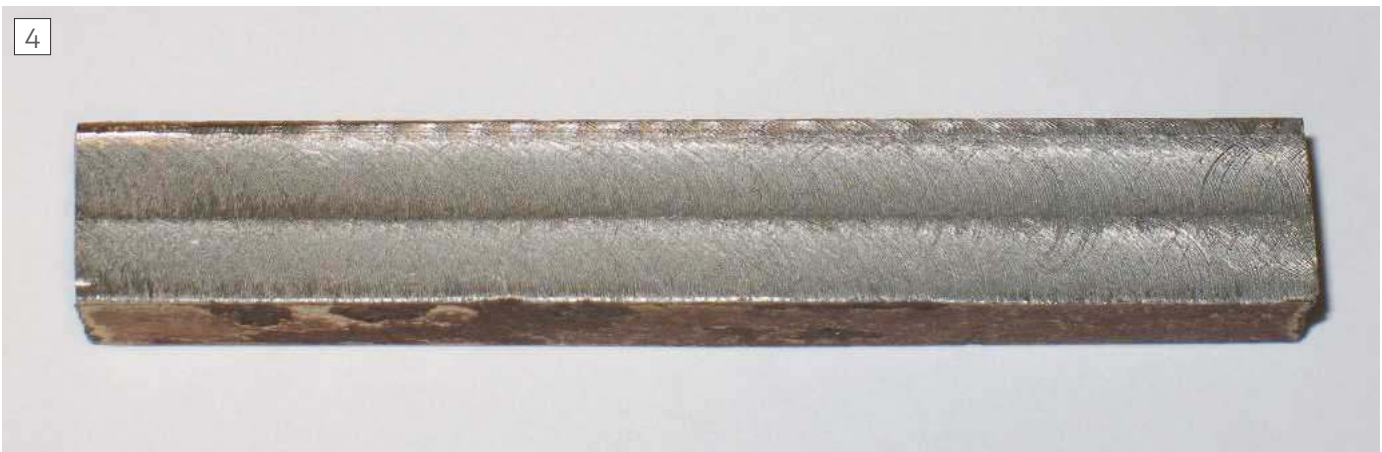
Further mods

Having proved that the idea of making and using sleeves was indeed feasible, I set about repeating the exercise for the remaining cutters. I did run into two problems, one being that I made a sleeve slightly too large for its cutter and hence on testing the retainer failed. After cleaning up I used Araldite Steel, and this appears satisfactory. The other problem was that I made the sleeve too thin for its cutter, and hence the sleeve broke during testing. The remedy was to make a new, larger, sleeve and use the next size up collet.

During final testing I attempted to use the slot-drills/slotting cutters to plunge cut a hole. All but one of the cutters created a pip thus preventing any depth to the hole. This suggests that although I deliberately made one cutting edge longer than the other, I perhaps did not get it right. Another possibility could be slackness in the gibs as there was a fair amount of vibration whilst attempting this procedure.

Conclusion

The idea of making cutters with four teeth is somewhat more difficult than making cutters with two teeth and is probably not worthwhile, especially when the two teeth cutters work as well as they do, albeit with a limited depth of cut. ■



Result of machining at 1000rpm.

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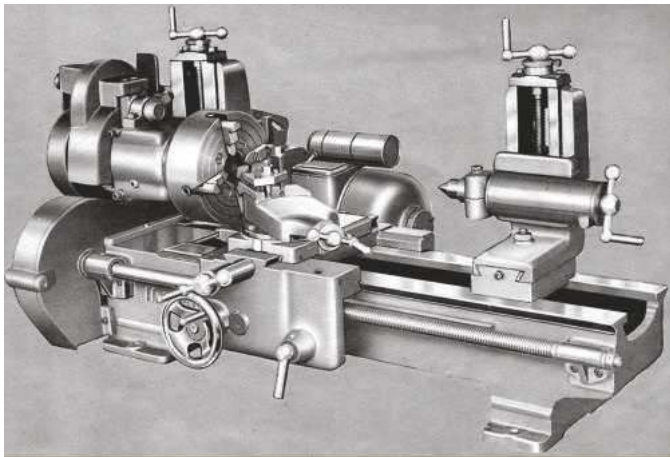
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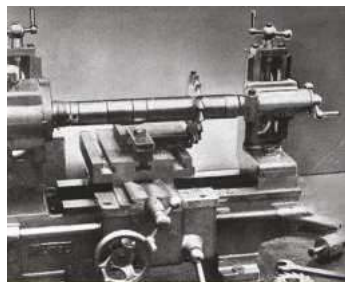
YOUR CHANCE TO TALK TO US!

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

Machine of the future



Dear Neil, 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 that is required is a rise and fall head and tail-stock and a milling table to replace the tool post. DRO and CNC mechanisms are already available.

Geoff Harding, Somerset

Further letters or short articles on this topic from readers would be most welcome – Neil.

Bicycle Crank 1

Dear Neil, I'm surprised that you published the article "Repairing a bicycle crank" (February's MEW). Pedal cranks are safety-critical: their fracture would lead at least to a cyclist being injured and, if a collision ensued, possibly killed.

The article describes enlarging the pedal spindle's hole in the crank by some 6.7mm (from its original 9/16" to 21mm diameter) thereby significantly weakening the crank by reducing the cross sectional area of crank material surrounding the pedal spindle. The final paragraph of the article suggests threading this hole, which would further weaken the crank. Even welding the repair bush in place (discussed in the article) would not restore the crank to its full strength because 100% penetration would not be achieved. Welding might weaken the crank due to the unknown composition of its alloy and the effect of heat.

To reduce weight and cost, the crank's designer will have decided upon the minimum dimensions required to safely withstand the maximum load that would be applied to the crank. Although the article reports several months of using the modified crank with no fracture occurring, this is no reason for complacency. It means only that the crank has not yet been subjected to sufficient load, perhaps due to a steeper hill or a heavier cyclist, to fracture it. The only safe solution to the author's problem is to buy a new crank of reputable make, hopefully with evidence (e.g. CE marking) to prove its suitability (a lesson from buying the substandard pedal spindle which created his problem.)

We modify safety-critical items at our peril. Years ago, the owner of a carpentry business asked me to re-bore the cutter block from his commercial spindle moulder because its central hole had become slightly oval and no longer fitted the spindle. He blamed his machinists for over-tightening the cutters' securing bolts. I'd not met the man previously, but a mutual friend had suggested my services. After he left, I had time to think about the job, realising that any intervention by me would render me legally liable if the block were to fail and cause injury. I telephoned him, and eventually he revealed that the cutter block had already been bored out to fit a larger spindle than intended. Just like the bicycle crank, the cutter block had been weakened by enlarging its mounting hole. Resisting his persuasion, I declined the job, relieved that I had avoided being misled. I wondered if the man's request had been declined by any professional machinist, leading him to me in the expectation that I wouldn't ask pertinent questions.

Ian Moignard, by email

Ian did suggest that publishing the article suggested our endorsement, I should point out that every issue of MEW does state 'Reliance placed on contents of this magazine is at readers' own risk', although we do try to avoid promoting dangerous practices. In this case, I was aware that Alex is a professional engineer, so I thought it was best to seek his perspective on this issue, see below – Neil.

Bicycle Crank 2

Dear Neil, thanks for forwarding this. I would certainly agree with Ian's central point that modifications to safety-related components should not be undertaken without a sober consideration of the implications. Maybe I should have covered some of this in the article, but I was trying to keep it brief. I did consider the safety implications of the modification at some length before embarking on the project. The pedal will have been designed for the heaviest, most powerful cyclist and then with a substantial safety factor included. I am neither heavy nor powerful and I was designing for myself not the worst case. On my pedal there was plenty of spare metal around the boss. I did not have to remove much metal, but taking account of the amount of material remaining at the boss after machining, I performed some conservative stress calculations and concluded that the force required to reach the yield stress of the metal was rather greater than could be applied without structural failure of my leg first.

The earlier failure showed that the material of the crank failed by yielding rather than by brittle 'catastrophic' fracture (and through collapse of the thread rather than the surrounding material). Any failure would therefore most likely be gradual and noticeable and I did not think that a brittle fracture caused by fatigue cracking was likely due to the absence of stress raisers. Anyone who has tried dismantling by brute force a joint bonded with engineering adhesive will appreciate that sudden failure of the bonded boss insert was also unlikely, although failure of the bonded joint was by far the more likely cause of failure.

In the unlikely event of catastrophic failure, this would most likely happen when standing on the pedals going up-hill at slow speed, where the impact of an unscheduled dismount would be less severe. On completion of the job I did some fairly agricultural strength testing, which gave me further reassurance.

My mental risk assessment concluded that the risk of sudden failure was very small and the consequences tolerable, the severity of the risk being somewhat less than other cycling hazards. Whilst risks cannot all be avoided entirely, they can be assessed for severity and impact and choices made accordingly.

Alex du Pre, by email

Tailstock Alignment



Dear Neil, further to Pete Barker's article in MEW290 on tailstock alignment, one potential problem not covered which may catch some out (as it did me initially) is checking that the tailstock quill is parallel with the bed.

When first purchased, my otherwise excellent WM180 produced tapered drilled holes, with larger drills rubbing badly on the flutes. Over the first couple of months I checked and adjusted the tailstock alignment many times (using methods similar to those described in Pete's article), something seemed to be moving? Eventually I realised that alignment was dependent on the amount of quill extension. By extending the quill around 60mm, locking in position and running a DTI along it's side, I found it was running out 10thou over this distance. Dismantling and thoroughly cleaning the tailstock did not resolve the problem, so I temporarily fitted a 10 thou shim between the tenon and tailstock (which is 60mm wide) on one side which successfully rectified the misalignment. Photo attached showing shim folded to 'L' shape, so that I could easily check it's there and it can't slide in too far.

Two years on, this 'temporary' solution is still in place and holding true, as I haven't got round to the permanent solution of machining the tenon yet. It may be a rare occurrence, but if similar problems are experienced by others it may be worth checking.

Brian Wates, by email

Sand Blasting Cabinet

Hello Neil, I enjoyed Graham Meeks article on sand blasting, Graham's articles are always to a very high standard. However, I was hoping for something that covered larger equipment suitable for the motorcycle or car restorer. Is there any chance that you could get someone to write such an article?

Barry Robinson, by email

Would any reader like to rise to Barry's challenge? – Neil.

A Day at Ally Pally



Jason Ballamy visits the London Model Engineering Exhibition 2020

Alexandra Palace (there is a bus for those who can't face the hill!)

The third Saturday in January saw me making the annual trip across London to attend the London Model Engineering Exhibition which was held over the 17th to 19th of the month at its now usual venue of Alexandra Palace. Arriving

at about 9.30 parking was easy and after a leisurely walk up the hill, **photo 1**, I made my way to the queue of advance ticket holders waiting for the doors of the Great Hall to open at 10.00am.

Once inside I made my way around the

trade stands making a few purchases as I went, there were no major items that I specifically wanted but I did make a list of materials and other consumables that I like to pick up at the shows as it helps to support the traders that make the effort



Star Wars droids

to attend and the saving in postage and packing on one or two purchases pays for the admission and any more goes a good way towards covering fuel costs.

Although the days of “show special offers” seem to be a thing of the past I did get a couple of good deals, Jenny from JB Cutting tools (no relation!) threw in an extra cutter when I bought four ball nose carbide milling cutters from her and Noggin End who I often purchase from, as they tend to keep a few more metric sizes than some of the other ME suppliers, rounded down the cost of a bundle of metal.

As I walked up and down the isles they did seem to be a bit wider than in previous years and there were also a few large areas with nothing which although making it easier and more comfortable to move around is also a sign that less of the hobby specific trades are finding it economic to attend shows or having to cut down the number that they take a stand at. Though having said that there were one or two new faces including a new metal supplier, unfortunately they did not have the size steel that I was after despite having a good range of other metric sizes and several grades of steel.

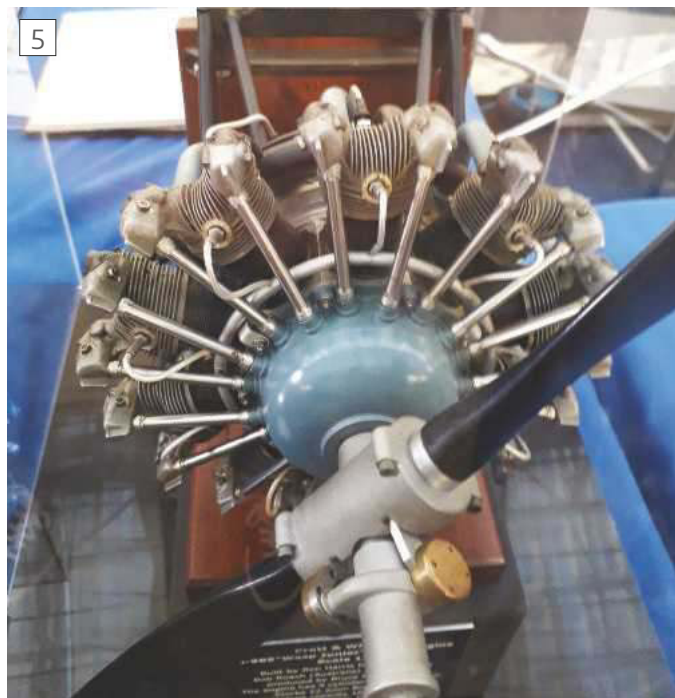
The club stands were as usual dominated by Loco models though this show does tend to get more boating club displays than others, presumably due to several being within a reasonable distance of the show venue. It also features clubs not necessarily associated with mainstream model engineering such, including the British Model Flying Association, Tamiya Truckin’, Meccano and Lego end even some ‘Star Wars’ droids, **photo 2**. For those that looked carefully there were a couple of traction engines and a smattering of small stationary steam engines but not much other variety. Maybe it is just a fact



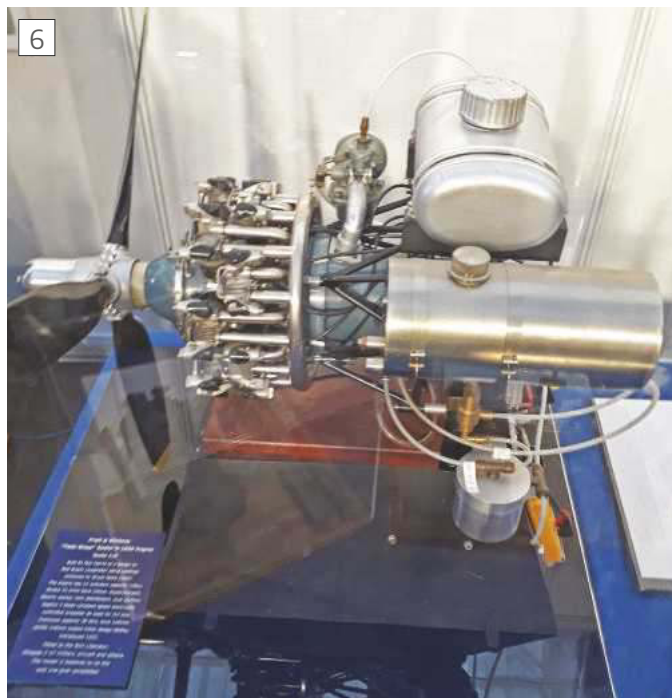
Society of Ornamental Turners demonstrating their hobby.



A V8 in the making on the SMEE Stand



Pratt & Whitney 9cyl Wasp Junior in 1/6th scale by Ron Harris



Pratt & Whitney 18cyl Twin Wasp in 1/6th scale by Ron Harris



Display of models built by Peter Bamttree



Miniature Myford Super 7



Portable pressure tester and Unimat SL complete with travel case

that the clubs that do put in the effort to display their members work are only Loco orientated but it would be nice to see some other subjects on display and not just model engineering related as there are many who have a home workshop but no interest in making actual models preferring to use their machines for such things as car and motorcycle restoration. One notable exception is the Society of Ornamental Turners with their fascinating specialised lathes by the likes of Holtzapffel, **photo 3**.

As those that visit the ME Forum will

know Locos are not really my thing, so I was happy to see that the SMEE stand along with the well travelled EDM machine only had one on display. The remainder of their quite large stand had some fine examples of IC, **photo 4** and stationary engines. The two Pratt and Whitney engines by Ron Harris that I had not seen displayed before were very well made and a credit to the maker, **photos 5 & 6**. Also of interest was a collection of stationary engines by the late Peter Bamttree several of which were the popular designs by Anthony Mount,

castings for which are available from Polly Engineering, **photo 7**. Another model that seemed to be drawing quite a bit of attention was a 1/3rd scale Myford lathe that looked to be correct in every detail, **photo 8**, at least to a non Myford man like myself, this was about the same size as a tidy Unimat SL complete with aluminium travel case that they also had on display, **photo 9**. Carrying on with the portable theme was a compact hydraulic test pump and gauge by Martin Gearing.

At the far end of the stand the SMEE had



10 Potential model engineers of the future getting to try their hand at turning.



11 Members of SMEE in their blue coats in conversation with attendees

a lathe set up giving demonstrations and were actively encouraging attendees to have a go which is a great way to get those who may never have used a lathe before a chance to see what it is like, as you can see from one of the photos they look to have found a new young member, **photo 10**. This was the only stand where someone came up to me and asked what my interests were which makes a nice contrast to many where the stewards seem to be tied up in their own conversations, **photos 11 & 12**.

A last-minute request to write this review from our Editor Neil, who I had arranged to meet at the show, had me doing another round of the club stands in search of suitable subjects to grace the pages of MEW. Apart from the previously mentioned items on the SMEE stand tooling and other workshop items were rather poorly represented on the club stands with only the set of tools used in the construction of his injectors by Simon Tilbury on the Ickenham and District stand being the only real candidate, **photo 13**.

Whether this is just that the clubs prefer to show their member models or whether it is more indicative of what I see as a move away from making tooling by those new to the hobby I am not sure. It does seem that many new comers are often short of workshop time due to work and family commitments but have enough disposable income to purchase many of the smaller items that at one time would have been made as apprentice pieces or often as a project at home to learn to use hand tools and machines, the fact that a ready to use item such as an angle plate or vee blocks can be purchased from one of our suppliers of Far Eastern manufactured tooling for the same or little more expense than a raw casting must go some way towards now making this the route to follow for many.

The photos that accompany this article are a combination of those taken by myself and Neil Wyatt which I hope will give those that were unable to attend some insight to what they missed. ■



12 Another view across the SMEE stand



13 Various tools used by Simon Tilbury in the making of injectors

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A Topslide DRO for a Boxford Lathe

Egret fits a removable readout to his lathe



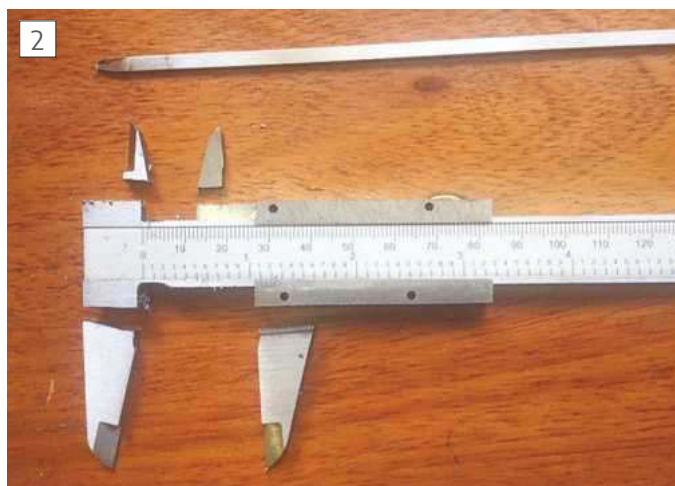
DRO fitted to Boxford

I have recently ordered two axis DRO equipment for my 1984 Boxford VSL lathe but shied away from including a reader for the topslide, as this would require

accurate angular measurement of the topslide setting and associated trigonometry to give a readout in X and Y axes. This means most hobby users would only perform the

summing function when the topslide is set at (or very close to) zero degrees.

With the topslide set at 0 degrees a reader can be used. Consoles such as the Easson



Vernier dismantled



Carriage with unwanted parts cut off

ES12C 3 axis unit incorporate software to sum two inputs and so are able to use three inputs and combine two of those to give a two axis readout. For angular settings of the topslide the summing can only be done by the operator using trigonometry, in which case one might prefer a cheap stand alone reader on the topslide, avoiding the need for signal cabling and minimising costs.

I therefore decided to make an experimental DRO using a cheap digital vernier with the objective of showing me how useful a DRO is on the topslide, seeing how much it gets in the way, seeing whether it can be securely and accurately fitted without drilling and tapping into the lathe. Crucially it needs to be quick and easy to fit and remove.

Lessons learned would help me evaluate the merits and feasibility of making a removable reader to work with the Easson 3 axis Readout.

The fixing method adopted has proven amazingly successful and works very well at the most useful 'zero degrees' setting. While it stops the topslide being set at an angle, it can be removed so quickly that this really is not an issue. Furthermore, it does not interfere with routine machining operations as it is well out of the way of both the toolpost and the topslide handwheel.

I was so pleased with the outcome that I thought others might like to try the approach.

Adapting the Vernier

The vernier used was a 150mm Powerfix vernier, shown dismantled in **photo 2**, which I had lying unused in the workshop.

The reader head comprises two main parts. A shallow stainless steel channel or carriage and a plastic top casing which holds the electronics.

The reader head is easily removed from the caliper blade by removing the label from the back of the head, unscrewing four self tapping screws and removing the clamping screw from the side of the carriage. The two screws retaining the stop bar at the end of the blade were also removed so that the reader head could be slid off the end of the arm.

When removing the carriage take care to note which way round the pressure leaf spring is fitted. It is located at one end over a pin at the end of one of the adjusting screws. Also take care when refitting the carriage as the top edge of each of the channel sides has a very thin strip which hooks over the arm and is very vulnerable to damage during reassembly.

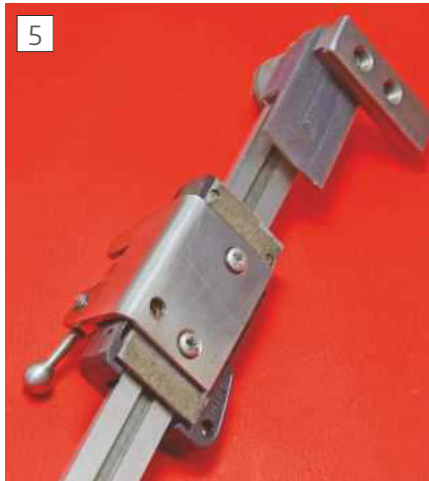
The depth rod was then ground off where it is spot welded to the underside of the carriage and any residues of the weld smoothed off, **photo 3**.

On my vernier it was necessary to use a fine slip stone to carefully smooth surface irregularities from each side of the blade so that the carriage slides along more sweetly. A better quality donor item would avoid the need for this.

The caliper arms and excess length of the blade were then cut away using a thin metal cutting disk in the angle grinder. The stainless steel is very hard and unfriendly to drills and hacksaw blades. I left small stubs of the



Modified vernier blade and bearing pad



Underside of completed DRO

caliper arms on each side to help the slide to register within the mounting block and then rounded the end of the blade to suit.

An 8mm hole was drilled at the end using a tipped drill (I don't think HSS would touch the hardened stainless steel) to receive the pivot/fixing bolt which bolts down into the tee bar fitting in the tee slot at the front of the cross slide. For lathes which do not have this front tee slot you will need to devise an alternative fixing.

Two holes were drilled and tapped into the underside of the vernier carriage for fixing of

the new right angle bracket which forms the yoke engaging with the topslide.

Mounting the Vernier Slide to the Cross Slide

The vernier blade is fixed to the cross slide by clamping it down to a tee bar within the conveniently located tee slot. The end of the vernier sits in a plastic pad machined with registers on either side to ensure that it rotates with the vernier slide. This pad both holds the slide at the correct height above the cross slide (giving clearance for the vernier carriage) and also ensures that the slide sits parallel to the cross slide surface. The 'Nylon' type material used provides a nice smooth movement on the cast iron surface of the cross slide but without distortion. Brass or aluminium would probably work equally well if the corners are radiused slightly, **photo 4**.

The original intention was to lock the mild steel tee bar within the tee slot of the saddle using a grub screw, however the grub screw has not proved necessary as the pressure applied by the pivot bolt can be adjusted to afford exactly the right amount of grip.

The bolt used to fix the slide down to the tee bar first passes through a rubber bush with steel washers either side, before passing through the hole in the slide bar and then the plastic carrier and engaging the thread in the tee bar. It is the compression



Clamp bracket components)

of this bush that makes the unit easy to remove but adequately secure in use.

The bolt squeezes down and compresses the rubber bush sufficiently to hold the slide bar firmly in place. Once the required compression has been achieved any excess length of bolt can be trimmed off and a blob of thread lock applied if so desired to retrain the bolt in the tee bar.

Fitted in this way the reader can be swung into and out of engagement under firm friction and indeed the tee bar can be slid in and out of the tee slot using firm hand pressure only. It shows absolutely no sign of movement when the DRO is in use. It therefore meets my criteria of being accurate but still quick and easy to fit and remove.

Connecting the Vernier Saddle to the Topslide, photo 5

I initially tried to connect the vernier saddle to the topslide using an L shaped aluminium block. The block was secured to the front and end of the topslide using a row of 10mm diameter Neodymium magnets glued into counterbored recesses in the block. This was not a success as the magnets tended to slip on the painted surface of the topslide.

I then looked at how I might connect a yoke to the oiling nipple on the side of the topslide.

Initially this looked too flimsy until I realised I had an oiler with a square body which could be used to replace the Boxford oil nipple. This fitted a dream and provides a firm and true surface onto which a yoke can connect.

I have put the old oil nipple on one side in case I ever decide to put things back as they were. It would not be difficult to make a



Clamp bracket assembled

similar square body and fit the original oiler on the front or top of the body.

An angle bracket was made to fit underneath the vernier carriage and pass up behind it in front of the side of the topslide. This bracket, **photo 6**, is secured to the underside of the vernier saddle using two short countersunk head screws, **photo 7**.

The vertical section of this bracket has a rectangular cut out creating a yoke to fit around the oil nipple block. The yoke cut out gives slight clearance such that the slide arm can be swung around into position with the yoke sliding around the block.

That clearance would ordinarily introduce backlash into the connection. To avoid this backlash I made a small 'over centre' cam arrangement with a little ball ended operating lever. This locks the yoke tightly to the side of the topslide oiler block and there is no backlash at all. Again, it takes seconds to release and lock the yoke in place and the arrangement also allows very slight angular positioning of the topslide away from zero degrees if you wish – it just seems to work!

To make the cam was a simple matter of drilling the pivot hole off centre in a piece of brass rod using the lathe. Putting a 1.5mm shim below one jaw of the three jaw chuck gives sufficient offset to provide the required cam action. This worked fine for me, but the surface of the cam can always be relieved with a file if it is shade too tight.

The ball ended lever is tapped and threaded into the side of the cam and the cam itself held in place with a suitable screw tapped and threaded into one arm of the yoke (retained with another blob of thread lock) and having a stiff spring washer under its head to provide friction to prevent the cam coming undone in use.

Dimensions given throughout are indicative only as the arrangement would need to be sized to suit your application. Additionally, an alternative to the tee slot mounting might need to be devised as this feature is only present on certain lathes. More significant is the successful use of firm sprung mountings and cam action to accurately secure the DRO in place while enabling rapid fixing and removal as required, **photo 8**. ■



DRO swung away from topslide

Theasby's Wrinkles

A Lashed Up Lathe



The lashup-lathe.



Sophisticated drive train.

Geoff Theasby makes a temporary lathe for a long, thin rod in the middle of the night

I had what I thought was a brilliant idea! I had to reduce the ends of an Acetal bar by 1 and 2 millimetres, but it was too long for my mini lathe and too fat to pass through the chuck/spindle.

I tried a couple of ideas, but they didn't work very well, then at 2 am it hit me, and I had to get up and go to my workshop and try it out.

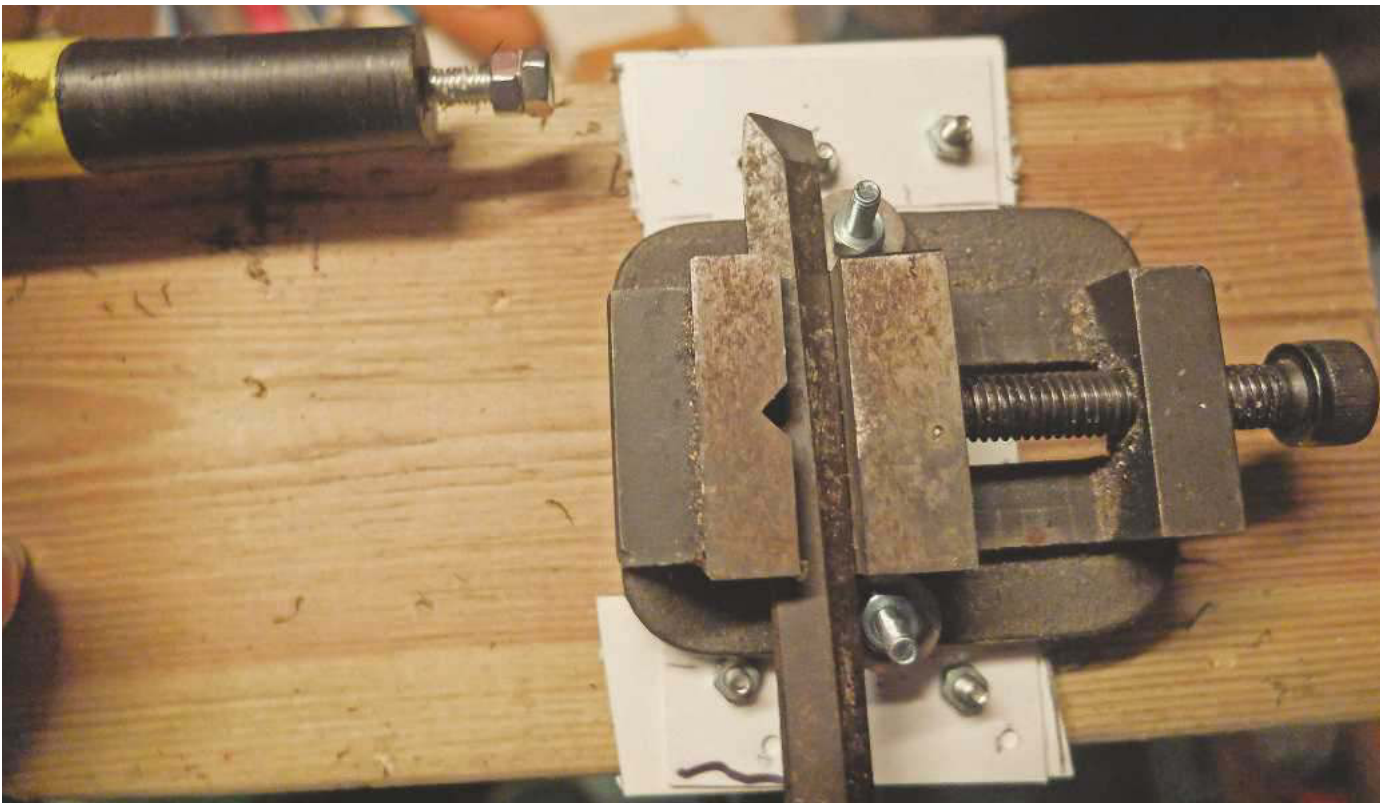
A baulk of 2 x 4 from my scrap bin, two

'bearings' made from ply, one end of the rod internally tapped M4, a bit of studding, with a couple of locknuts, and driven by an electric screwdriver. A woodworkers chisel, in a small vice, would be used as the tool.

Today's idea was to make a sliding 'carriage' from Plasticard to carry the tool. There is enough slack in it to push it against the work enough to remove shavings. It

works like a charm, doesn't gouge the work, and it takes several passes to remove enough material, so there is little danger of removing too much.

It's crude yes, and if more delicate readers wish to lie down in a dark room until I go away, I shall respect their views. However, it solved my problem at zero cost, with materials to hand, in a few hours. ■



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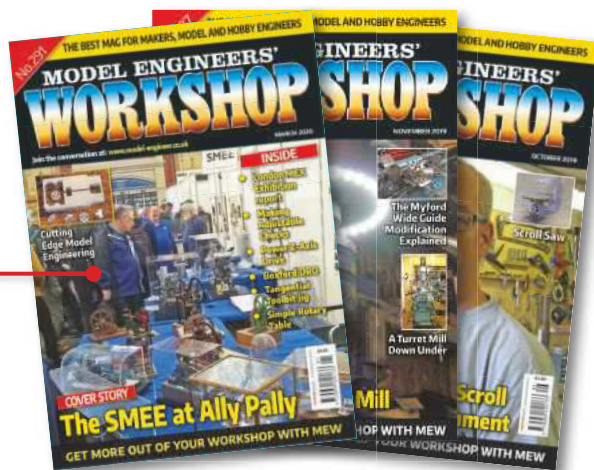
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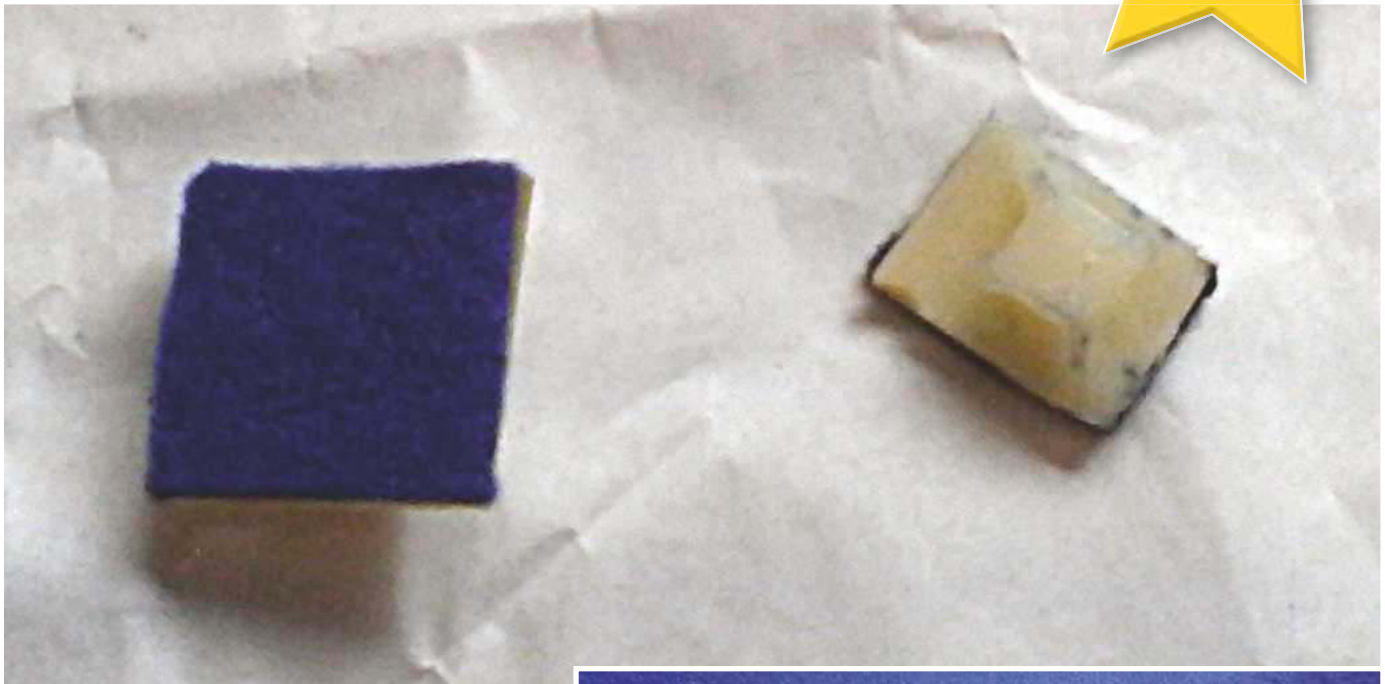
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Readers' Tips



A Blueing Pad



This month our lucky winner of £30 in Chester gift vouchers is Adrian Revill with a simple but handy tip for applying engineers' blue.

While scraping the dovetails on my milling machine, I decided that I had enough of trying to put on Engineers Blue using bits of tissue.

Some appropriately coloured felt and self adhesive zip strap pads gave me the perfect pad to put on the blue, I even trimmed one down to fit the dovetail.

Adrian Revill



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

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

Workshop Press Tooling

Part 2



Top beam & bottom packing

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

Top beam piece

The top piece was made from the other part that was left after cutting the base from the same material this was 20 x 33 x 125mm. I used this on its side this is to give more support to the to the bending piece as this is normally done by the vice jaws so the 20mm face was marked out in the centre and also drilled and tapped M8 to a depth of 15mm.

To hold the arbor to the chuck I used a piece of 5/8" steel and cut it to 40mm this was then faced and a chamfer put on one end then the other was drilled and tapped M8 also to a depth of 15mm these operations were done on the lathe.

The top piece and the 5/8" chuck pin are held together with a piece of M8 studding



The parts assembled



The finished bender



Centre punch mark on end

25mm long. The finished top beam and the bottom packing are shown in **photo 14** before assembly and **photo 15** shows the parts assembled.

The assembled parts and the vice mounted bending tool are shown in **photo 16**. In this photo you can see the top section is deeper in section to give the support as earlier. The photo also shows the damage sustained when an early job's material was harder than I thought.

Radius bending tool

Having made the square bending tool, I then made the radius bender as not all bending jobs required to be square. To form the half round in the die I thought about clamping a second piece of steel together with the die and then drill through the centre of the two this would then give the half round that is required in the die.

The die

To achieve this, I cut two pieces from the same material this is 20mmx 60mm to length then with two clamps holding them together they were marked out and centre punched was put the lines this centre mark is show in **photo 17**.

These pieces were then put in the drilling machine vice which was clamped to the drill table and using a long 6mm drill they were drilled through then the 8mm drill, **photo 18**. I went up in stages of drill size about the next size up from my drill box having got to ½" with drills I then used 17/32 reamer next and to finish the hole a 9/16 reamer was used this size gives about the right clearance for the ½" bar that is going to be use for the former, **photo 19**. This size of half round is ok up to 1mm material.

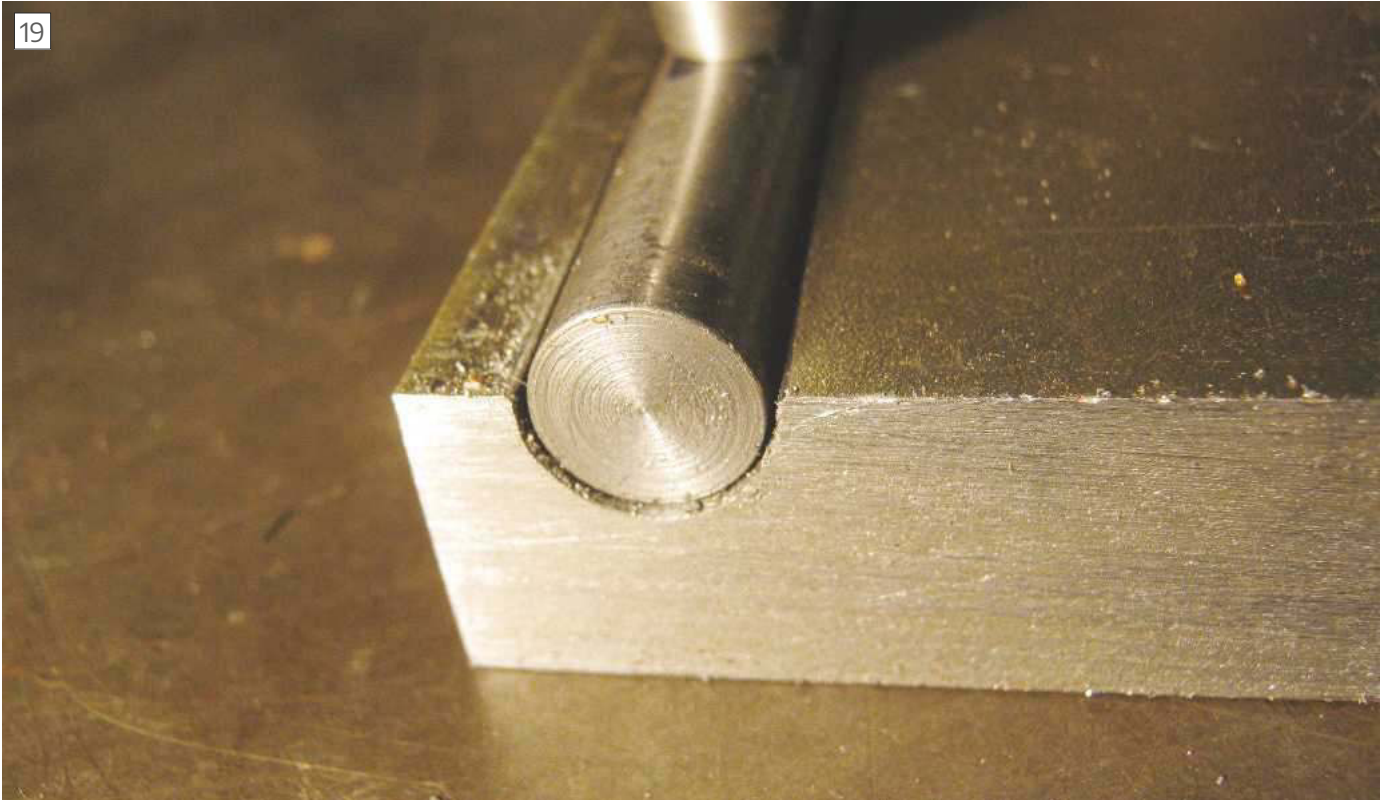
The finished hole before reducing the size of the plate is shown in photo 20, the finished size of the die is 20mm high 28mm wide 72mm long.

The former

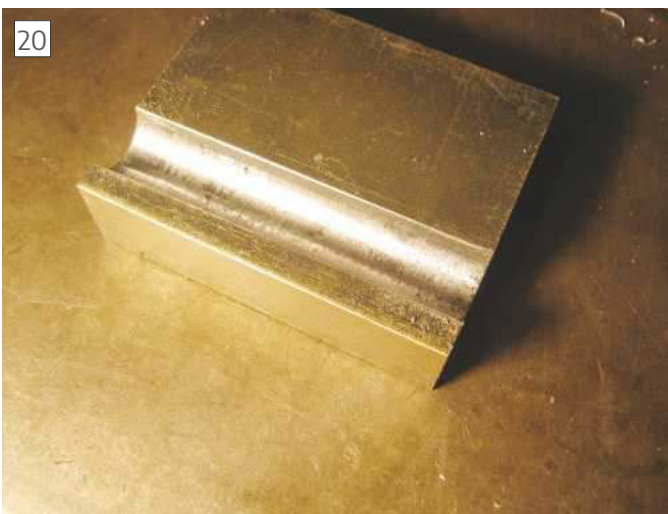
The former was made from some ½" mild steel and is 72mm long with an M8 taped hole in the centre of its length the part that fits into the press chuck is made of also mild



The first drill



The former & die



The finished hole



The former finished



The complete round bender



The test piece

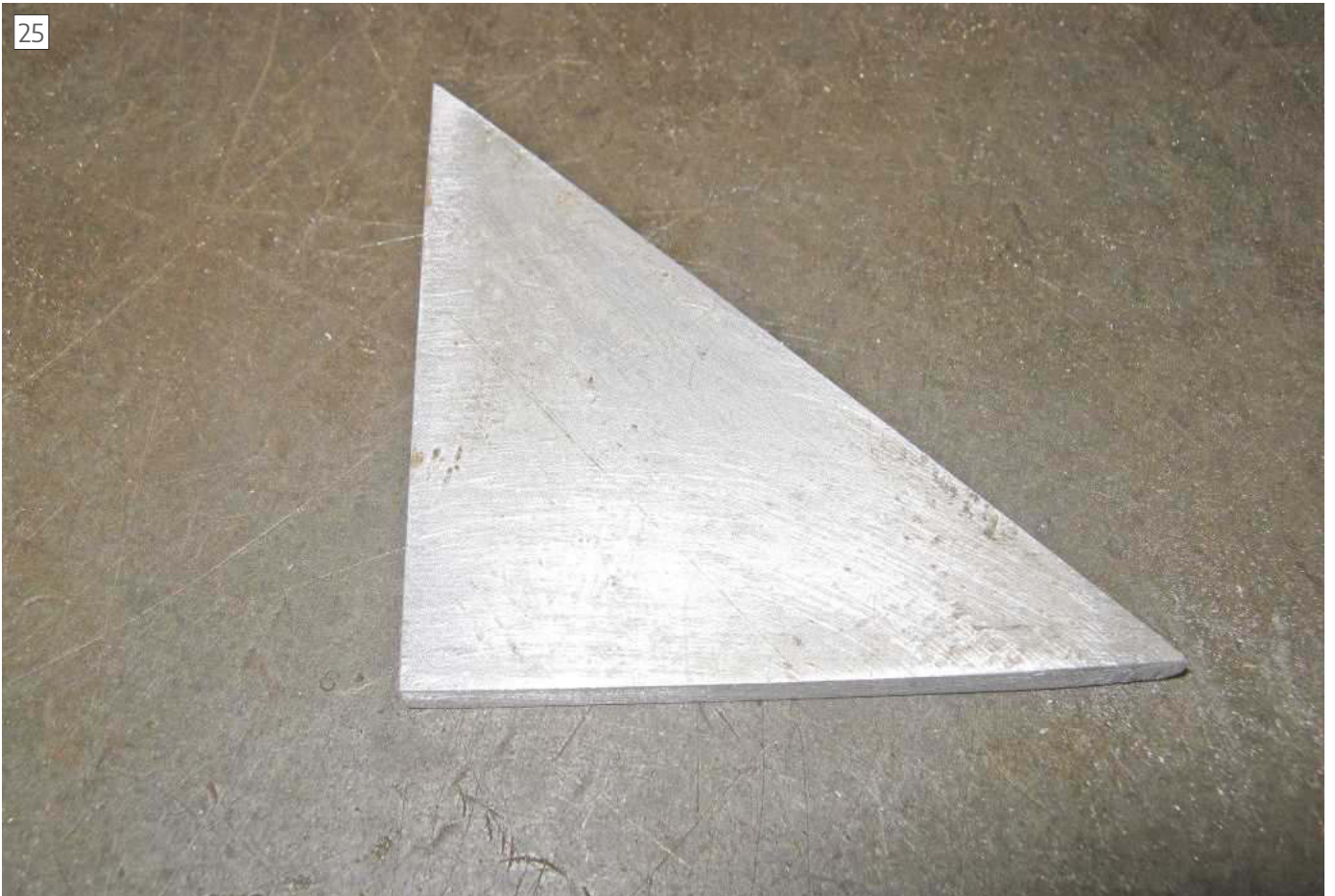


24



Cutting new base

25



The aluminium square

26



Setting the angle

steel and 5/8" in diameter its finished length is 60mm this also has a M8 thread in the 10deg tapered end to attach them together with a small length of studding, **photo 21** shows the finished former.

The complete tool is shown in **photo 22**. A test piece is shown in **photo 23**, the finished size of the former is 1/2" diameter, 72mm long and the arbor is 5/8" diameter and 60mm long.

New square bending tool

Having made a square bender by alterations to a purchased one, I thought that I should make one from scratch in the same manner as the round corner bender.

The first bit to be cut was the die, this was cut from the same material as the radius bender but cut at 40mm, the cutting operation is shown in **photo 24**. This was also cut on the bandsaw as before. To machine the block it would need to be set at

45 degrees in the milling vice this was going to be a problem as the part was smaller than my normal squares would be unable to measure the angle; the only answer was to make a small square for this job.

The square is made from 4mm thick aluminium. I cut this from a sheet with a hacksaw the square sides are about 65mm long. To make this into a square I used a file with a combination square to check the sides. The finished square is shown **photo 25**.

27



The marking out lines

28



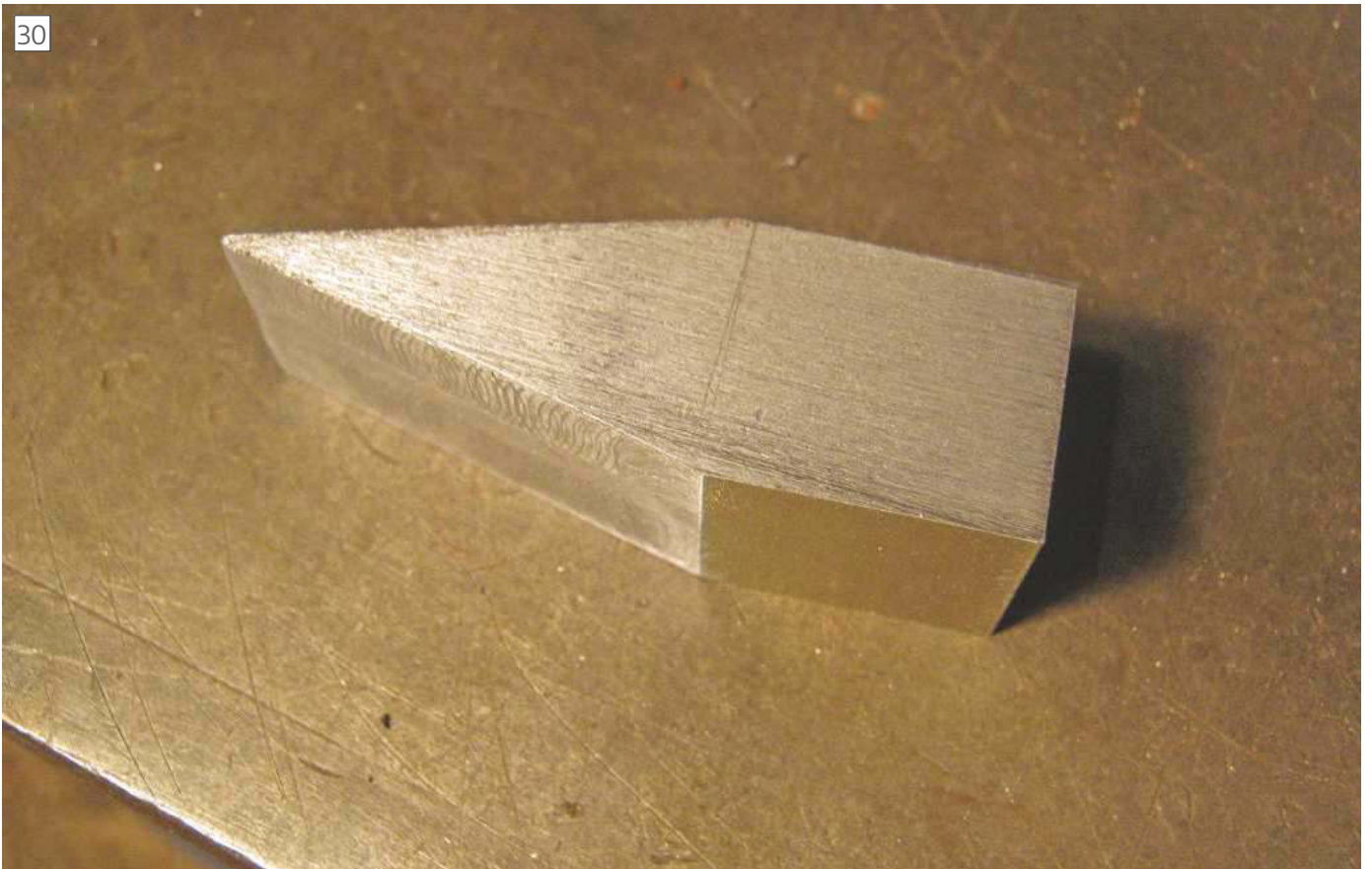
Vee die

29



Cutting and marked lines

30



The finished machined former

31



The former parts

The block was marked out on one end to show the shape and size that the vee will be, it was then put in the machine vice and set to the angle with the aid of the square. Setting up can be seen in **photo 26**.

The milling was then started, this I did by bringing the cutter down in stages to the depth required. **Photograph 27** shows the second pass just starting, also the marking out can be seen in this photo, the machining was finished to the lines in the marking out, the vee block or die as it is now, is shown in **photo 28** after the machining was finished.

The next part to be made is the former, this was also cut from the same material this time it was 20 x 20 x 60mm long. To mark it out I put a line across the length at 35mm then I found the centre on the end. These three points were then marked to form a long point. To machine the piece, it was put in the milling machine vice at an angle. To help the positioning the blade off a square was used to align the line with the top of the vice jaws, this line can be seen in **photo 29** where the machining is starting the finished part is shown in **photo 30**. After milling the tapers, the square end was drilled and tapped M8.

The former requires an arbor to hold the former to the chuck this was made from a piece of 5/8" diameter x 55mm stock this was faced both ends, one with a chamfer. The other end was drilled and tapped M8. To hold them together I cut a piece of M8 studding

20mm long the parts are shown in **photo 31**.

The arbor and the former were then screwed together, **photo 32**, the completed tool is shown in **photo 33**.

How wide you make the former and its vee block are determined by the job it is required to do. This one is designed to bend parts in the corner of the job, if the requirements are for a larger job then you can make both parts wider.

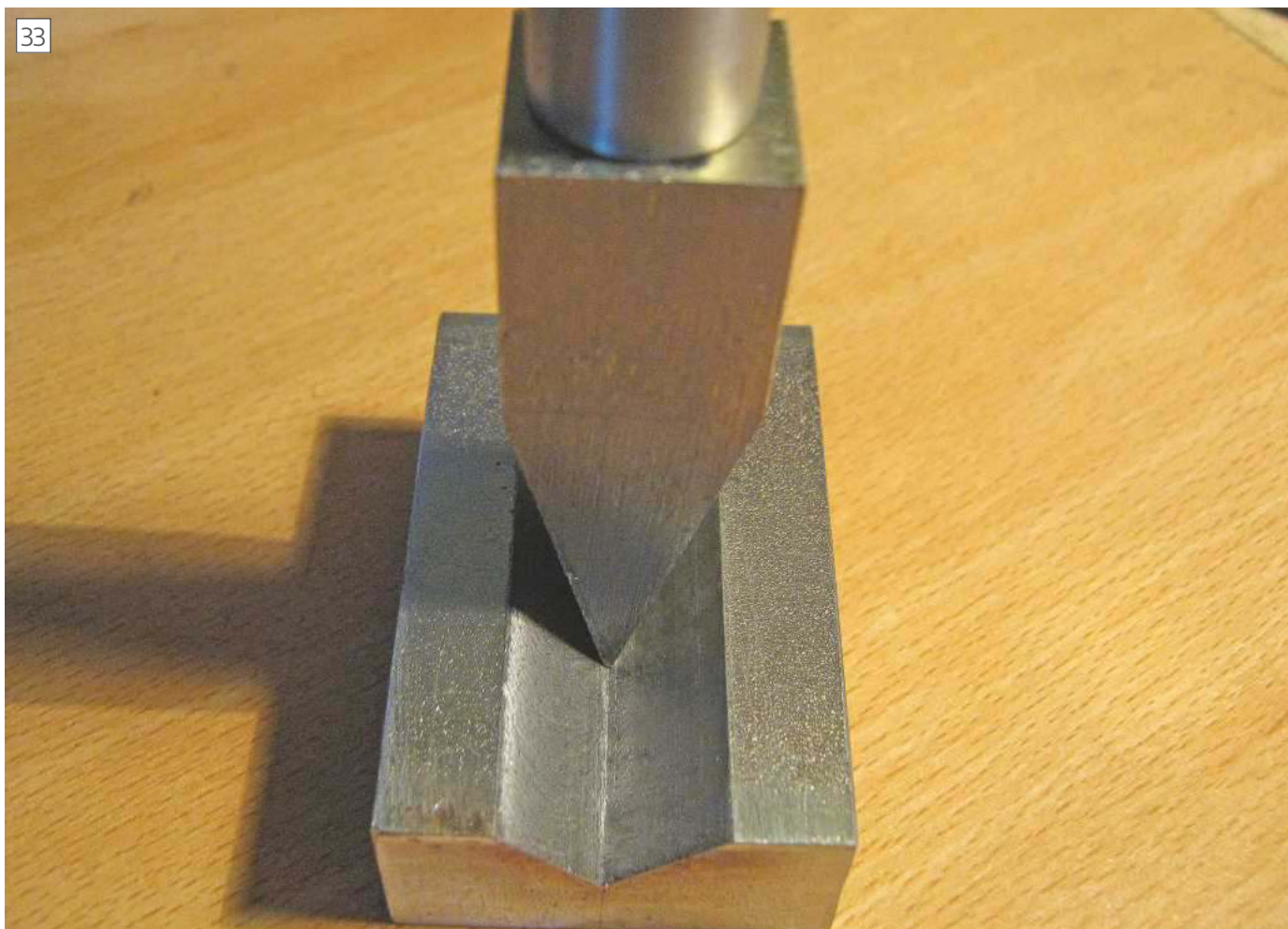
The broach

The next requirement was a broach, this I was going to make but by the time I had priced up the tool steel and the cutting wheels to make one it was going to be cheaper to buy one. ■

32



The assembled former



The former & die

In our Next Issue

Coming up in issue 292

On Sale 20th March 2020

Content may be subject to change

Look out for our April issue, number 292:



Stew Hart explains how to make and use a 'sine protractor' for setting accurate angles.



Graham Meek introduces his special attachment for tapping small threads.



David Smith makes a set of holders for a Myford M lathe.

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On the Wire

NEWS from the World of Hobby Engineering

Direction and Ambition

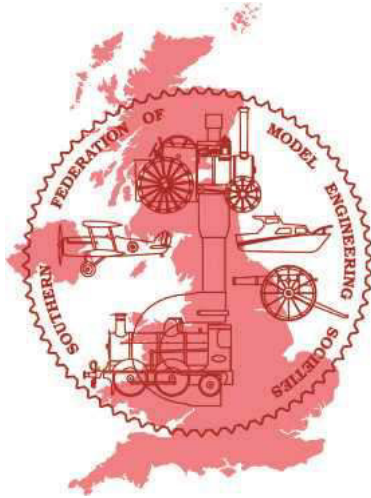
Bob Polley, Chairman of the Southern Federation of Model Engineering Societies (SFMES), notes how this volunteer organisation provides services to more than 200 affiliated clubs. These services have traditionally been concerned with boiler testing, club insurance and health and safety matters. SFMES has recently been conducting a review of the longer term prospects for the organisation, and necessarily of the hobby it supports.

Everyone is aware of changes in the hobby, from negatives including reduced numbers of home workshops and training classes and increased legislation affecting both club and individual members' management and conduct, to positives such as the increased use of and interest in modern processes and products and improved communications through the use of computers and the internet.

No organisation can afford to be static, especially in the face of such change as our hobby has experienced and which will doubtless continue. SFMES therefore recognises the need to take stock of its own activities, the way it carries out its business and the need to reflect the interests of modern clubs and their membership as well as those of more traditional societies.

A volunteer organisation striving to meet the needs of its member societies, SFMES is setting out to get input from affiliates at the next AGM to be held 14th March 2020 at STEAM Museum in Swindon to guide its future direction and ambitions. For this to be effective, as many affiliated clubs as possible need to be individually represented at the AGM so, if your club is affiliated, please respond to the distributed invitation and try to attend.

If your society is not currently affiliated but you believe your club's views could assist SFMES in their considerations, or would like any further information, please contact me at BobPolley@SFMES.co.uk.



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Motorising the Z Axis of a Chester Champion 16v Mill

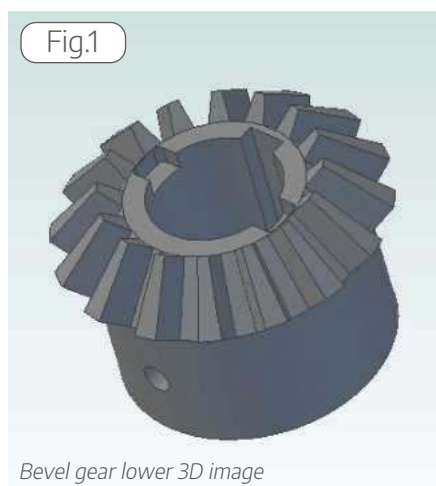
David George carries out an extensive upgrade to this popular bench milling machine.



The Chester 16V Mill



The Z-axis handle is situated on top of the column, behind the head.



Bevel gear lower 3D image

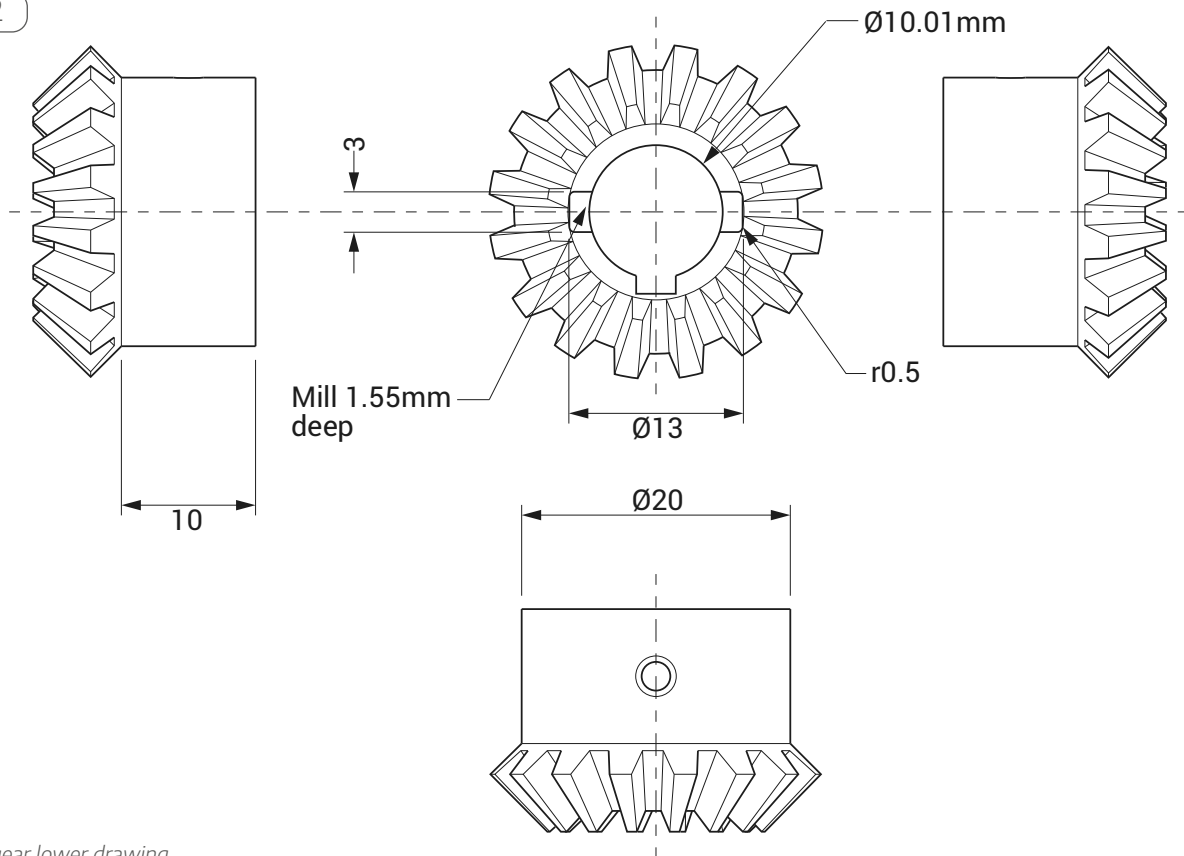
I had a new mill from Chester, **photo 1**, and it seemed to do most of what I expected except for the Z axis handwheel being where it was at the back of the mill behind the head, and being a bit short of stature I found it difficult to use especially when boring a long hole for example, **photo 2**.

I had a thought that I could fit a handwheel to the side of the head, so I took the head to bits and drew up what was there. After doing a bit of investigation I found that I could get a 12mm ballscrew with the same pitch as original leadscrew and a pair of bevel gears from Davall would fit the job with little modification, **figs 1, 2 & 3**. I would have to cut

a keyway into the ballscrew and gears to give a good drive with no play and a keyway in the ballscrew gear top to drive the dog clutch as well as a 4mm tapped hole in the end of the ballscrew to hold the clutch in place.

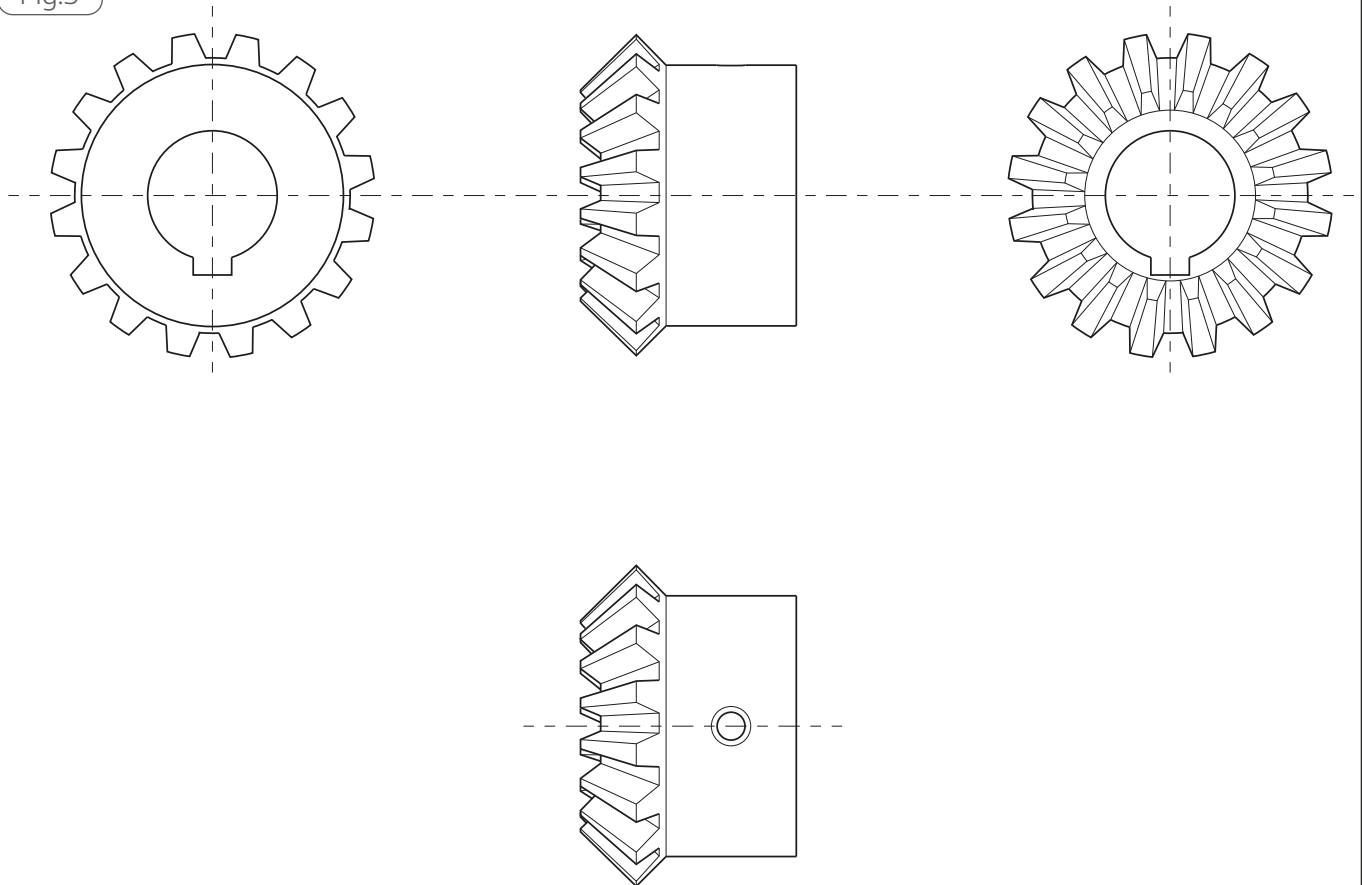
I drew up the body, **photo 3, figs 4 & 5**, and calculated the side hole in the new body and found I could use the original hand wheel. I decided to use a bronze bush for the handwheel shaft and also a bronze washer was used to space the gear to the bush to give as little clearance as possible to prevent back lash, **fig. 6**. The body was to be made from ally, easy to machine, stable, and tough enough. I started by blocking up the block,

Fig.2



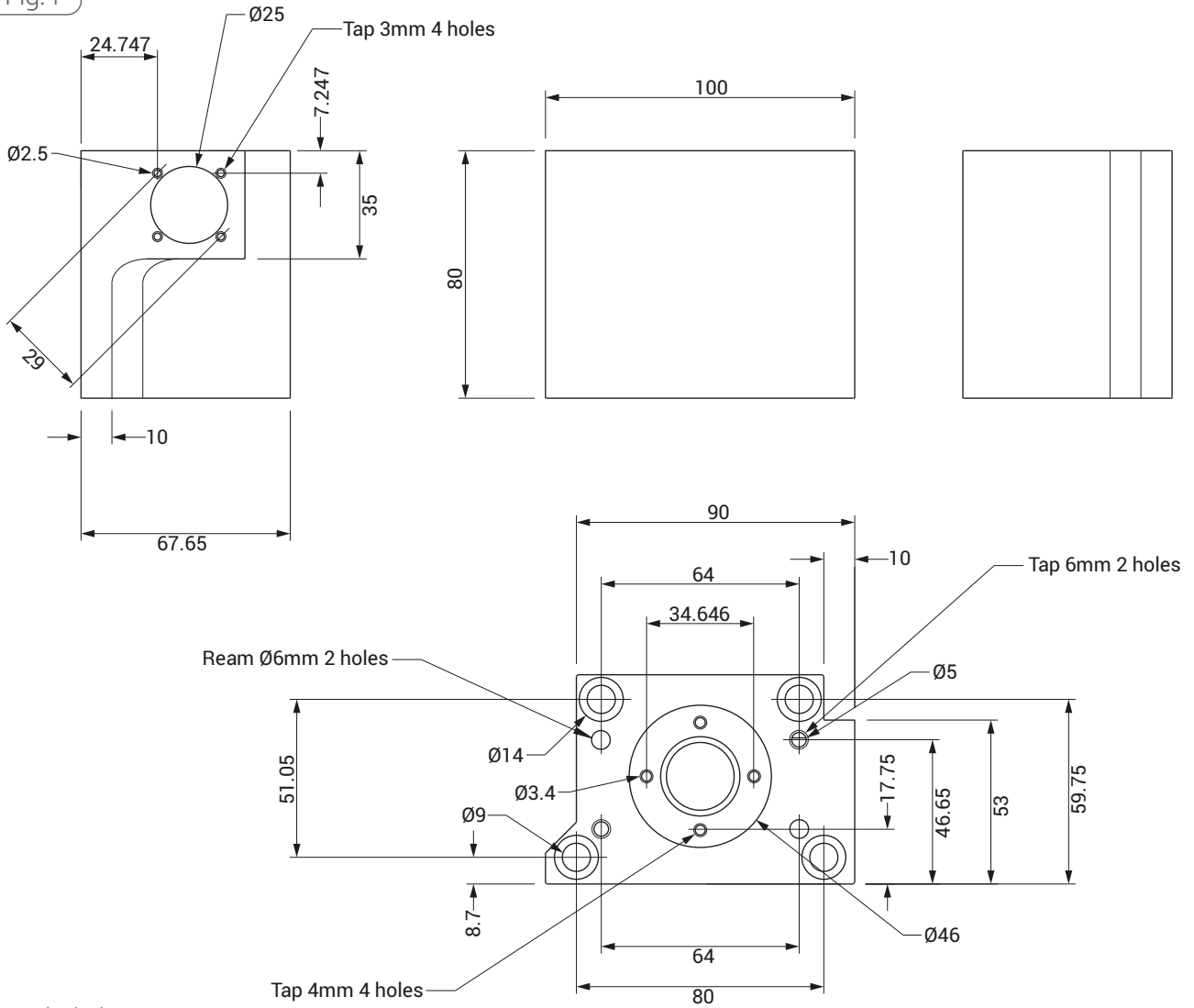
Bevel gear lower drawing

Fig.3

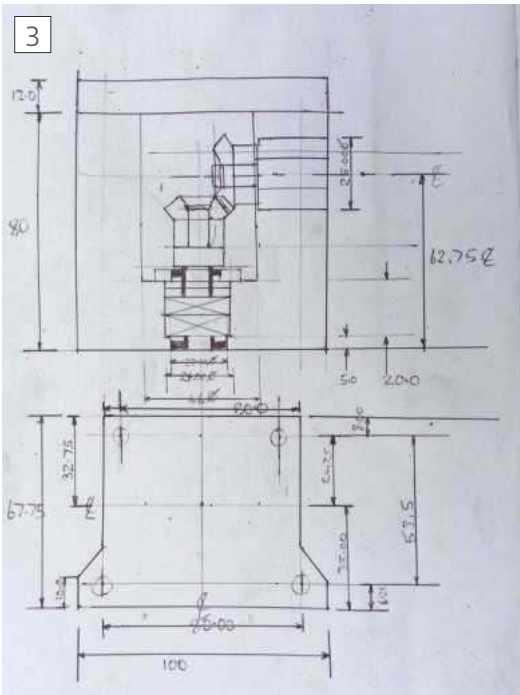


Bevel gear side drawing

Fig.4



Main body drawing



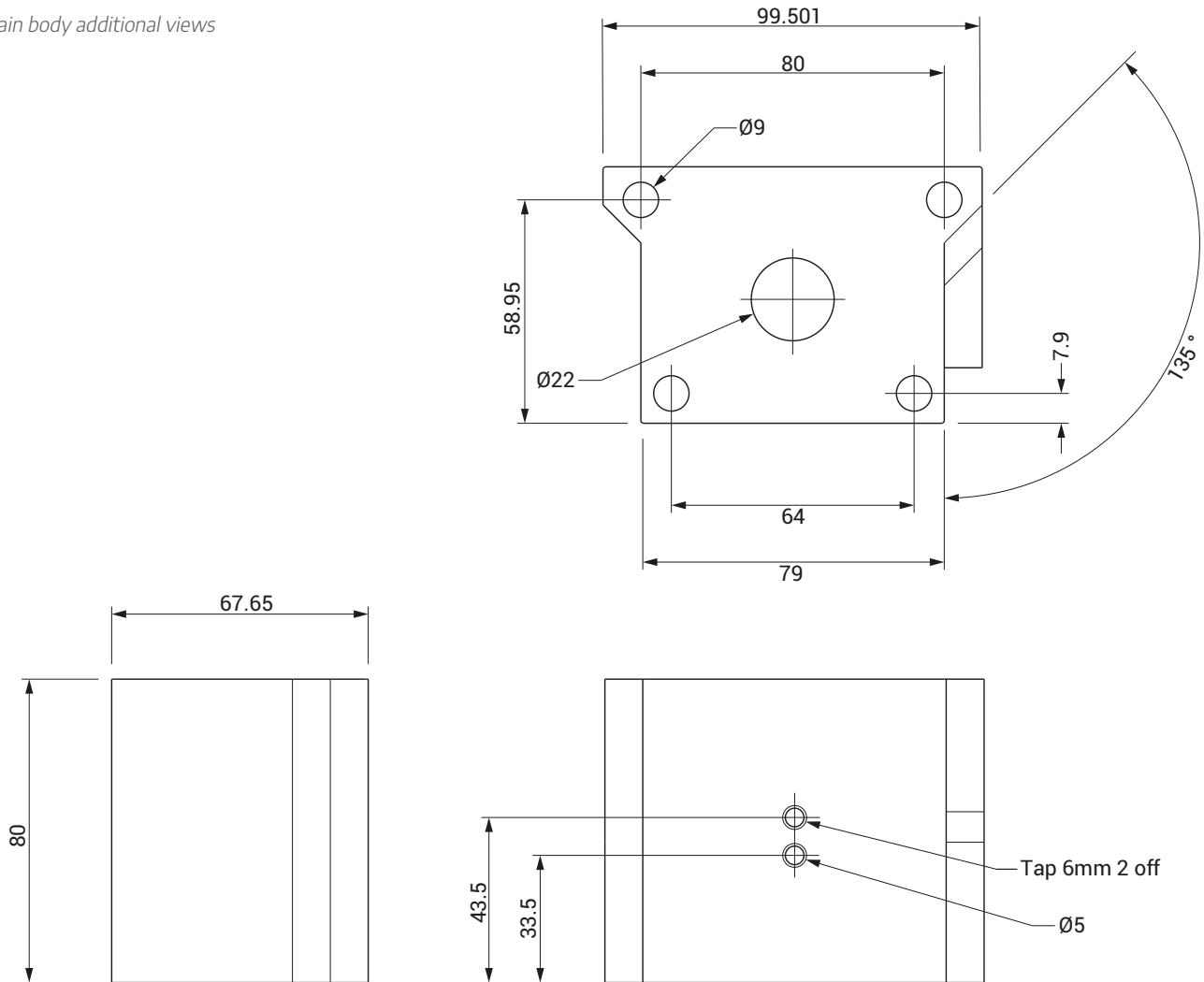
Original sketch.



Blocking up the block.

Fig.5

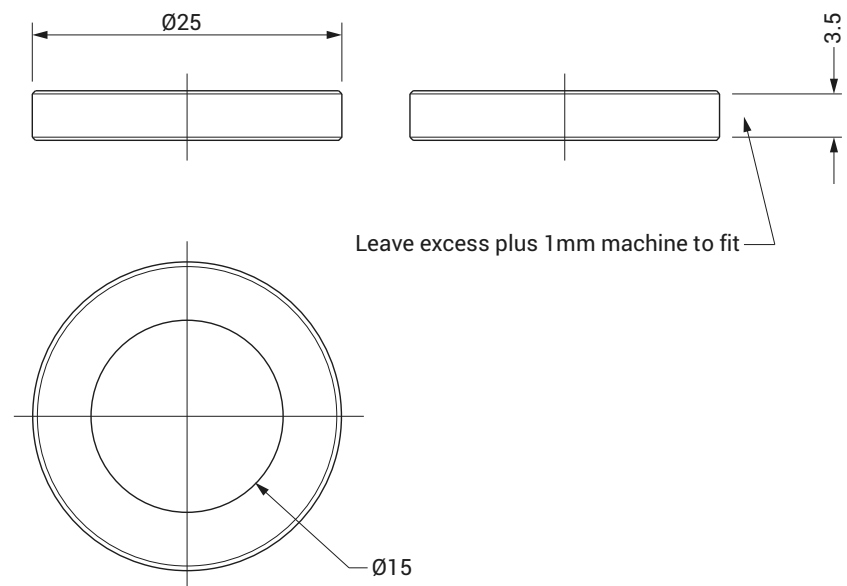
Main body additional views



I had thought that I could fit a handwheel to the side of the head, so I took the head to bits and drew up what was there.

photo 4, using my trusty angle plate and bottle square to get it square and to size. I then bored out the main holes, **photo 5**, for the bearings and seals etc. the side hole was the next to be machined for the bronze bush, **fig 7**, and retaining screws. The screw holes for the main screws to hold it in place were next as well as the screw holes for the ballscrew bearing housing down the large

Fig.6



Bevel gear spacer drawing

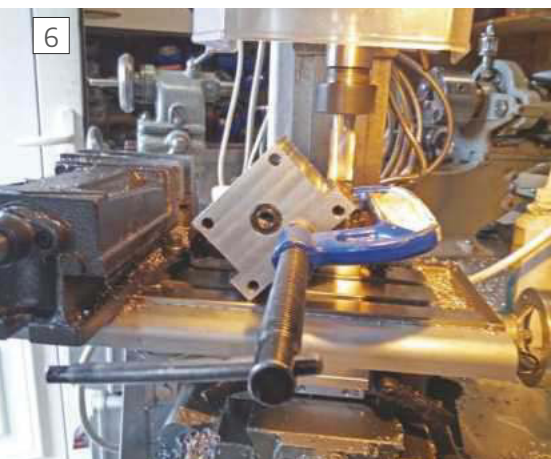


Boring main holes.

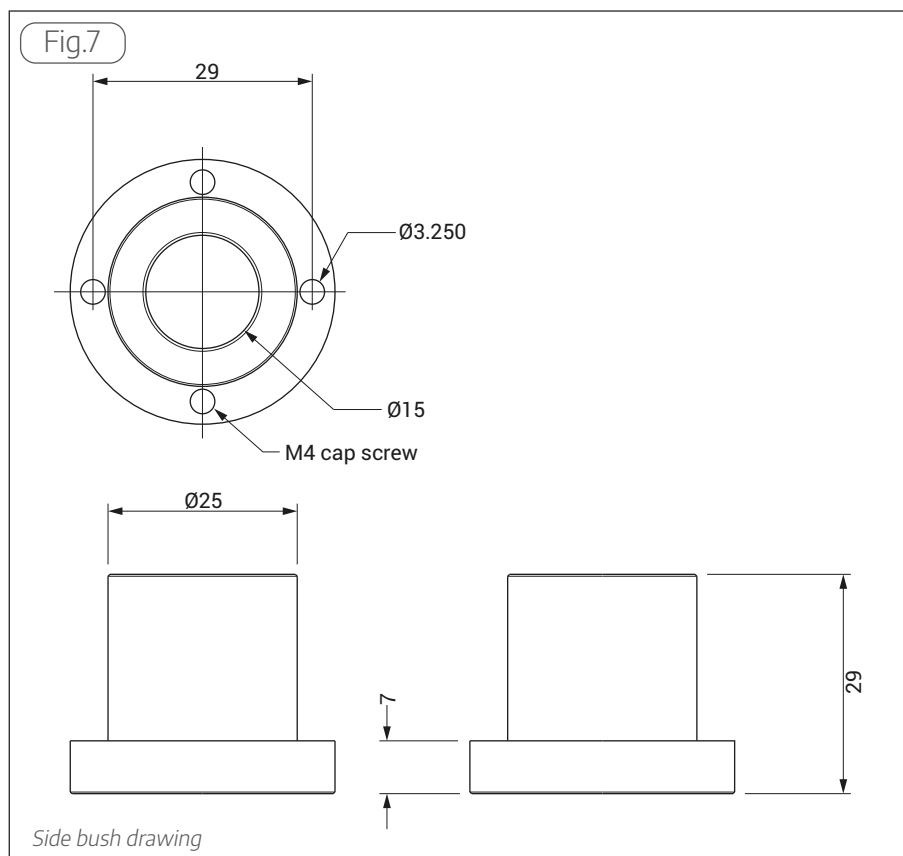
hole, **fig. 8**. The 4mm tap wouldn't reach so I extended one by gluing it into a 6mm shaft turned and drilled on the lathe.

The angle sides to match profile of machine were next machined, **photo 6**, leaving a flat for side bush to sit on and the top holes for screws and dowels were drilled taped and reamed.

● To be continued



Angled sides.





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Machines and Tools Offered

■ Myford Super 7, Newton Tesla CL750 control panel and 1hp motor, Myford stand and drip tray. Original paint. Excellent condition. Original 3 & 4 jaw chucks. Multi tool holder, vertical slide attachment plus too much else to list. £1,850.
T. 01666 504077. Tetbury.

■ Armstrong BA helicoil full kit 0-2-4-6 £30 plus postage. Myford box set imperial 2 morse collet set. £125 plus postage.
T. 01332 671126. Derby.

■ Boxford lathe 4/3 jaw chucks, 4 way toolpost, drill chuck, tooling, DTI on magnetic base, tooling, taps, dies. Boxed sets good condition spare motor on cabinet stand, metal stock, various. Private sale £1200 ONO. Buyer collects. **T. 01723 513070. Filey, Yorkshire.**

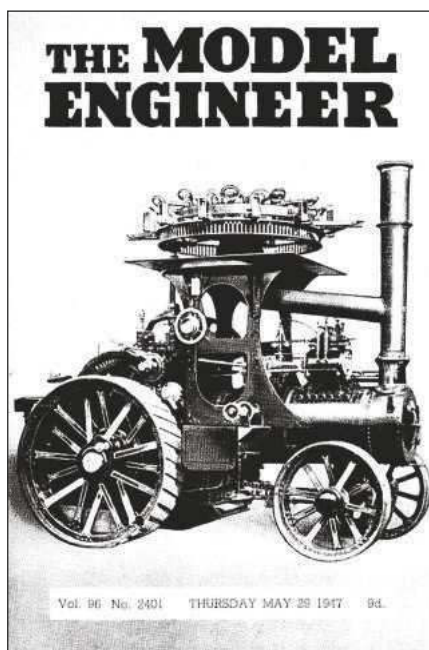
■ Chester DB7 lathe, imperial less than two years old, hardly used due to health reasons, all original accessories. Only £300, buyer collects. Proxxon PD400 plus complete set of collets, boxed never used. Cost £2470 bargain at £1000 for quick sale, purchased may 2019. Bargain.
T. 01986 835776. Norwich/Ipswich.

■ Centec vertical mill, table size 16 inch by 4 1/4 inch, autolock, £400.
T. 01670 521432. Ashington.

■ Genuine Crawford TRUGRIP 5" 5C Collet Chuck, Complete with Collets, 8, Round,

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■ Myford 'M' lathe, 1ph longbed with reverse, imperial and metric change gears, three and four jaw chucks, 9 inch back-plate on Myford stand, collect only, £350.
T. 01205 364810. Boston.



1/8" to 1" .5, Square, 4, Hexagon. Plus spare keyway keys all in a fitted Box, £350 ono Buyer collects.
T. 01429880440. Co Durham.

Parts and Materials

■ Complete sets Clarkson 5" gauge Duchess cylinders and wheel sets, frame stretchers, frame steel, assorted loco plans, would suit most 5" gauge locos. 1 to 59 Don Young magazines, good condition £100 the lot. Can post, you cover postage.
T. 01234 210640. Bedford.

■ 'LBSC' Virginia, 4-4-0 3 1/2" gauge large boiler version, drawings, manual, full set of castings, laser cut frames erected with axleboxes and axles. Good workmanship, £325. Buyer collects.
T. 01283 760917. Burton upon Trent.

■ Six 7 1/4" Driving Wheels partially machined to approx. 9 5/8" diameter with 22 spokes. Sensible offers please.
T. 01491 641466. Henley on Thames.

■ Two 7 1/4 g injectors BR/GWR pattern, unused as supplied new by Doug Hewson. £200 the pair including P&P. Pansy driving wheel castings (six) part machined. £0 the set plus P&P. Email photos of either on request.
T. 01706 822473. Ramsbottom.

■ Certified copper boiler for ANNA locomotive along with machined cylinders, leaf springs, axle boxes with ball bearings, laser cut and drilled frames, buffer beams, finished axles wheels, and more. Lost interest. £3500 ONO. **T. 01772335771. Preston.**

Magazines, Books and Plans

■ Plan starling 22.5cc in-line twin two stroke glo-plug engine, plus micrometer boring head. (plans unused) £6 including postage.
T. 01869 248558. Oxford.

Wanted

■ Vintage and antique hobby miniature black lever powered metal shaping and shearing tool with rectangular black base and red wooden oval handle on black level with gold oval or round maker's name on upper base (size unknown). [This sounds like a 'Juneero' tool, used to carry out various tasks with a 'perforated strip' construction system resembling Meccano - I had one in my teenage workshop - Ed.]
T. 01444 248011. Burgess Hill.

■ Asian lathe WARCO model 1327 must be in good order. **T. 01208 77862. Bodmin.**



Woden Attachment to Grind a Tangential Tool Holder Bit



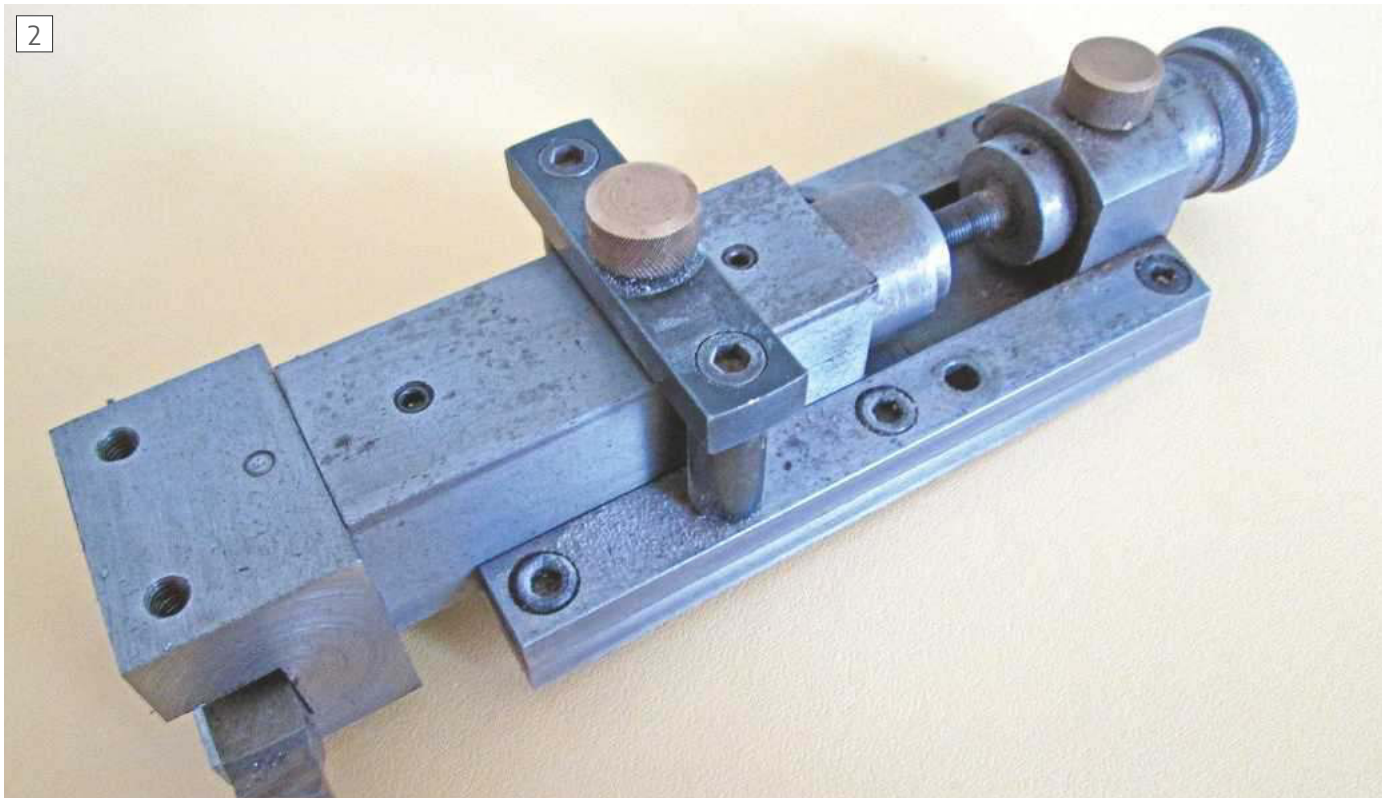
Laurie Leonard shows how to make a useful jig to speed the sharpening of tangential toolbits.

Introduction

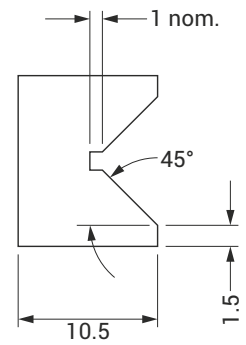
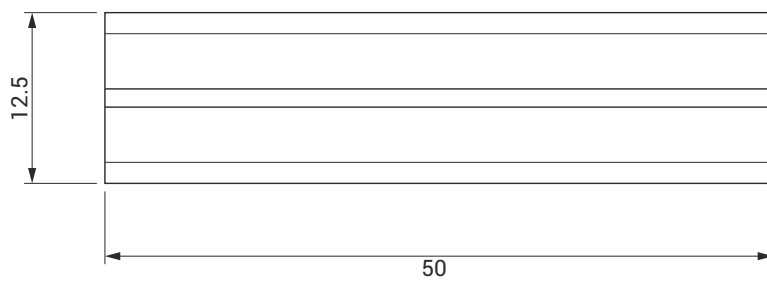
There have been several articles in magazines, e.g. **ref. 1**, and indeed on the Model Engineers' Web site, **ref. 2**, relating to the home production of a tangential tool holder. I eventually got around to making one for my Myford 7 the final task being the sharpening of the bit or tool tip. A suggested grinding jig was shown in an article which was to be used in conjunction with a bench grinder. My bench grinder has a 6 inch diameter wheel and by producing the suggested jig base out of MDF to test the suitability of using my grinder it was obvious that it was not, **photo 1**! Some sources advocate the use of the side of the grinding wheel to get a flat



Jig Base produced in MDF for testing



Main Work Slide of the Woden Tool and Cutter Grinder



Woden Attachment To Grind Tangential Toolholder Bit
Mat'l: Mild steel



Woden Lathe Tool Holder



Completed Attachment and Ground Bit

The jig could be modified to get the business end lower and reduce the curvature effect but what other alternatives could I come up with?

grinding surface and overcome problems caused by the curvature of the wheel but for other authorities this is considered a no- no and is not something I like the sound of when considering the stresses on the grinding wheel. The jig could be modified to get the business end lower and reduce the curvature effect but what other alternatives could I come up with? Time to press my trusty Woden Tool and Cutter Grinder into service?

Making a Carrier for the Tool Holder Bit

The main Work Slide for the Woden is shown

in **photo 2**, the lathe tool has been inserted for illustration purposes. **Photo 3** shows the Woden Lathe Tool Holder which will be used to carry the attachment to grind the

tangential tool holder bit.

A drawing, **fig. 1**, shows the shape and dimensions of the attachment chosen to suite the bit for the Tangential Holder made for my



Milling the "V" Groove



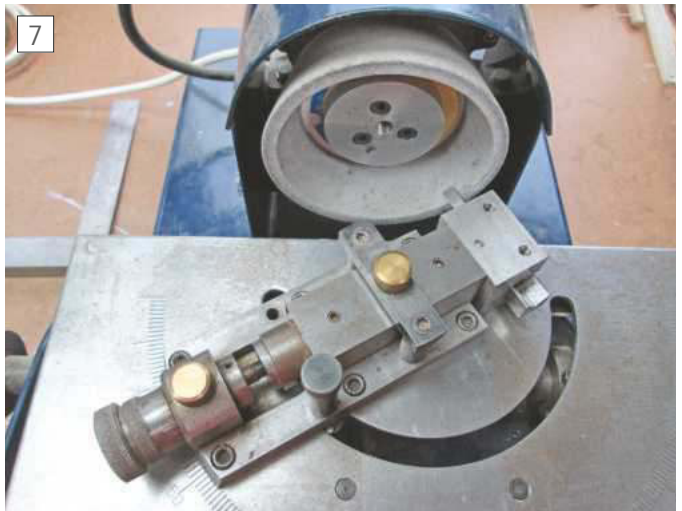
Cleaning up the Bottom of the "V"

Myford 7 which uses $\frac{1}{4}$ " square High Speed Steel (HSS) and the completed attachment is shown in **photo 4** with a sharpened bit resting on it.

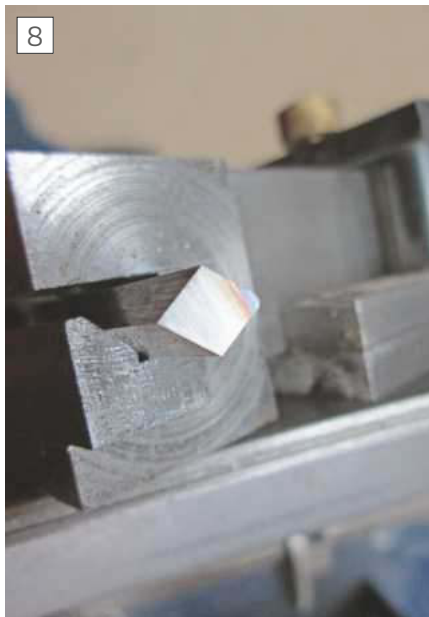
The piece of half inch square steel stock for the body was supported on a "V" block and held in the machine vice on the mill. A "V" groove was milled in it as shown in **photo 5**. A slitting saw was used to clean up the bottom of the "V" and provide relief to ensure that the square HSS bit seated well in the attachment, **photo 6**. The piece of square stock shown was found to be too high when offered to the Woden Lathe Tool Holder and it had to be milled down to fit. Figure 1 takes account of this. The two Allen screws in the holes shown in photo 2 clamping the lathe tool bit are used to clamp the HSS in the Attachment and secure the whole in place in the Lathe Tool Holder.

In Use

Photograph 7 shows the attachment in use on the Woden and **photo 8** gives a close up



Attachment in use on the Woden



Close up of the Part Ground End

of the end of the bit part ground. The HSS stock as bought had been ground off a longer bar and the steel had suffered heating as a result, note the coloured end. Light cuts were taken until this colouring had been removed as the nature of the steel could not be trusted in the coloured state. **Photographs 9 & 10** show the sharpened bit in situ on the Tangential Tool Holder.

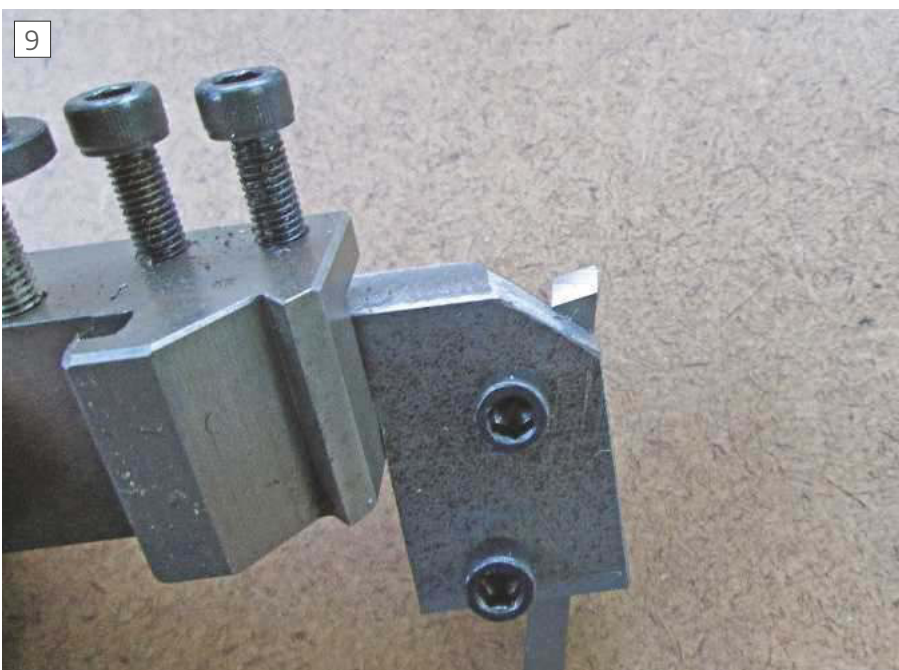
Conclusion

Not a major engineering feat but the attachment produced a good working solution to a minor problem. ■

References

1 MEW Number 179. August 2011.
"A Quick and Easy Tangential Tool Holder",
Michael Cox

2 www.model-engineer.co.uk



Sharpened Bit in Situ on Tangential Tool Holder



Bench Lamp

Rod Renshaw makes a brace of handy small bench lamps.

As I have got older, I notice that things I used to do without really thinking about them have got more difficult, especially if the available light is not good or not well placed.

This has often caused me to think that a bench lamp that was easily moved and adjusted would be very useful but I had not got around to organising something and I often found myself using a battery torch to illuminate things, but a torch is not ideal because it wobbles and needs a spare hand to hold it.

I have an old but well-made surface gauge that I bought many years ago and that I no longer use, and I suspect many readers will have one or can pick one up at a sale. It had occurred to me that a small spotlight attached to this would be useful but the thought of finding a lamp holder and reflector and switch and flex to a transformer etc. etc. meant that it never got made.

When light emitting diodes (LEDs) became readily available, with their much reduced current consumption, I thought a self-contained lamp would be possible as a small battery would give a reasonable life, but I still did not get around to making one.

Then I was browsing in our local Pound shop and saw a "headlamp" - that is, a self-contained LED lamp intended to be worn on one's head with an elastic strap to keep it in place. This seemed ideal for conversion into a workshop lamp with a minimum of effort.

The headlamp, **photo 1**, consists of a main assembly connected to a headband by a simple hinge. The hinge pin is a long bolt with a nut to hold it in place. The main assembly consists of a plastic moulding holding a battery box, which takes three AAA batteries, a switch and a LED spotlight assembly with a reflector and seven LEDs.

Conversion is very simple:

First, remove the hinge pin and discard the headband assembly, **photo 2**.

I have an old but well-made surface gauge that

I bought many years ago and that I no longer use, and I suspect many readers will have one or can pick one up at a sale.



Inexpensive headlamp.

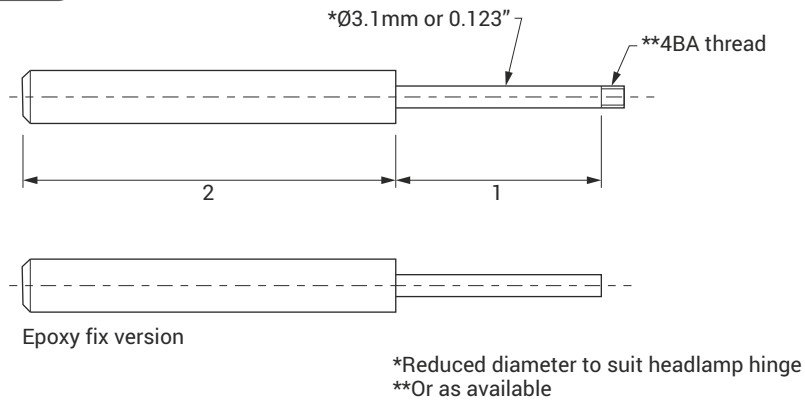


Dis-assembled from headband.



Support bar and fixings.

Fig.1

**Support Bar**

Mat'l: Ø1/4" BMS (or to suit surface gauge)

*Reduced diameter to suit headlamp hinge
 **Or as available

assemble on to the surface gauge. Job done!

Photograph 4.

I have found the lamp very useful. I use it on the table of the drilling machine, on the surface plate and on the bench. In some situations, I assemble the lamp on to a magnetic DTI base. Even in areas which are adequately lit it is often useful to have an extra light to look into an area in shadow. The lamp can be used to illuminate the workpiece or machine tool graduations etc., as needed. The lamp is small it so can be positioned very close to the job without blocking the view and the LEDs run cold, so it does not matter if one touches the lamp inadvertently. The lamp has no trailing lead and is thus very portable, and the surface gauge knuckle allows rapid and near universal adjustment. The 4.5 volt supply is not dangerous. The lamp even looks workmanlike, the plastic being Myford grey!

The lamp has seven LEDs and is about as bright as a medium sized torch, so it is not exactly a searchlight but it illuminates things well at a range of about a foot or so and the batteries seem to last a long time. I made my original lamp about a year ago and I checked just after Christmas this year and our local Pound shop still has the headlamps in stock. So, supply does not seem to be a problem in the UK and I feel sure that other shops will stock something similar in other places.

So, there it is; a useful lamp for an investment of £1.00 and a very small amount of work – and a chance to recycle an unused bit of kit.

Finally, I could not resist making a deluxe version, **photo 5**, for those prepared to invest £2.00! I like the pleasing symmetry of the twin version, it looks a little like something dreamed up for a science fiction film set, but in reality, the extra light of the twin version makes only a marginal difference.

Photograph 6 shows the 2 small scraps of steel flat and the original hinge pin from one of the headlamps used to hold the twin version together. Anyone using epoxy to fix their support bar in their lamp will have to think ahead. ■



The completed lamp.



The deluxe version.

Second, make up a support bar from a piece of round stock about 3 inches long and of a diameter to suit the hole in the surface gauge knuckle which is intended to hold a test indicator (DTI) In my case this is ¼ inch diameter. I used bright mild steel but almost any round stock would do. Turn down one end of the bar to suit the hole in the hinge on the battery box assembly, 3.1mm or 0.123" in my case but check with your headlamp. Finish the other end of the bar neatly. I threaded the extreme end of the reduced section of my bar to take a nut to hold it in the hinge, 4BA in my case but check your diameter, **fig. 1** and **photo 3**. In retrospect I think it would have been simpler to just glue the reduced end in the hinge with epoxy.

Third, fix the support bar in the lamp assembly hinge with either a nut and washer, or epoxy.

Fourth, put batteries in the box and



Support bar and clamp for deluxe version.

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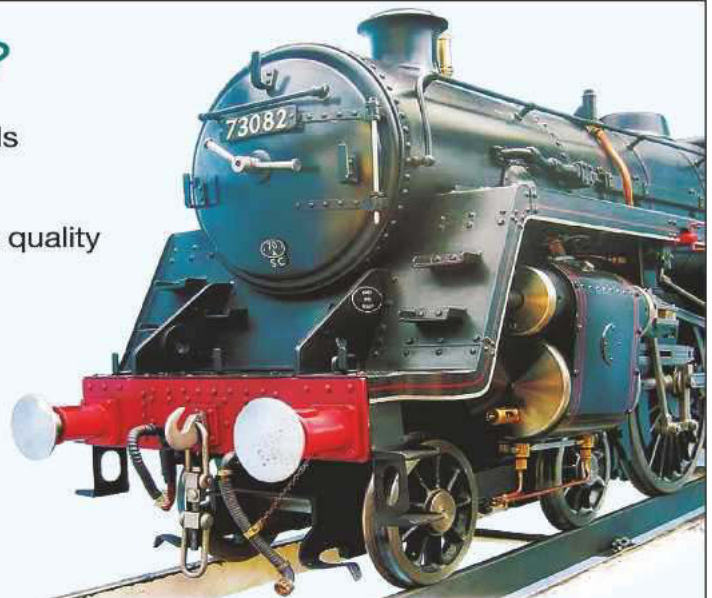
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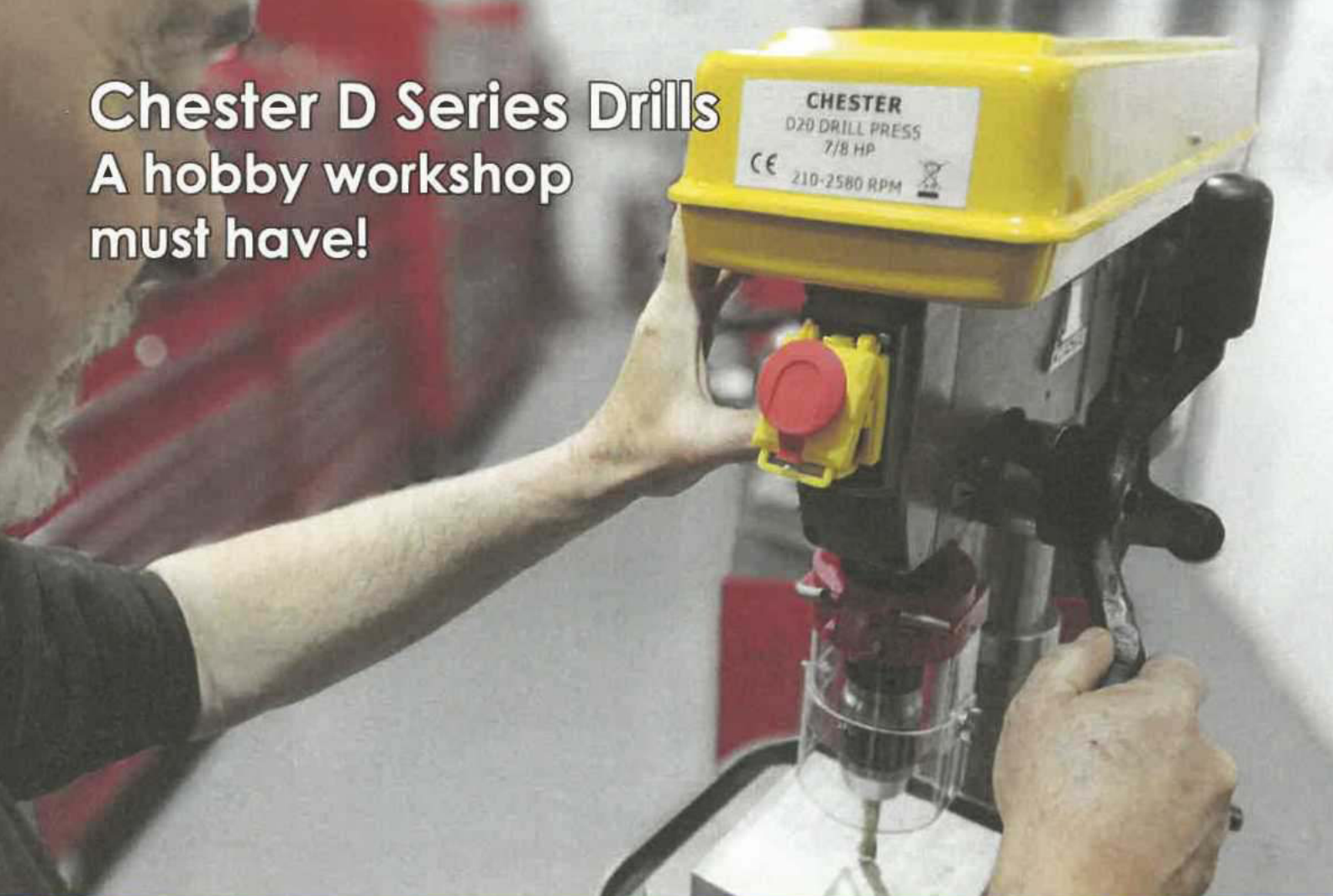
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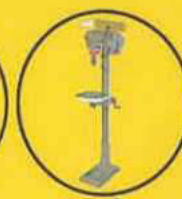
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