

No.244

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AUGUST 2016

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COVER FEATURE

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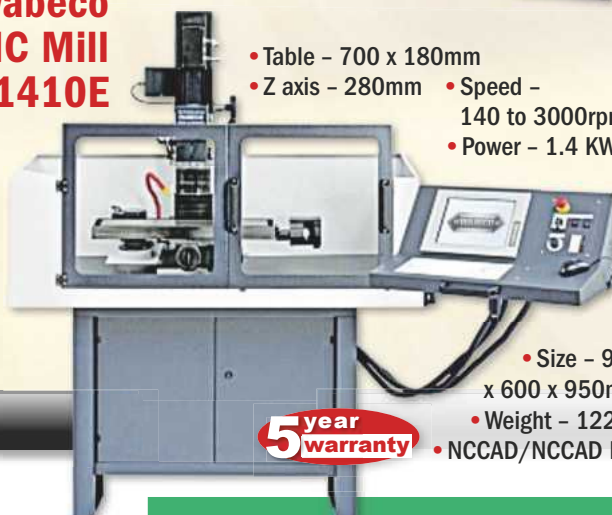
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On the Editor's Bench



A New Series

Regular readers of Model Engineers' Workshop will know that, for various reasons, I have shied away from running any long series in the magazine. I have always stated, however, that this is not an absolute rule, and from time to time I may well present a longer series.

This issue sees the start of GearCutter by Alan Aldridge, a series which I expect to take about six parts describing the construction of a 'Jacobs' style machine for cutting and hobbing various types of gear. There are several reasons why I feel GearCutter will be of interest to readers. Chiefly, of course, this appears to be a well designed machine and many people enjoy the challenge of making their own gears. But there are two other reasons: the first is that the machine comprises a variety of components such as slides, ratchets and universal joints as well as different machining challenges all of which are interesting in their own right. Secondly, the series will conclude with a description of the Eureka device for relieving cutters, as originally designed after an illustration in an old catalogue by Professor Dennis Chaddock and Ivan Law. We will be presenting Alan Aldridge's metric re-drafting of the drawings for Eureka with Ivan's blessing, and I am sure this will be welcomed by a generation that does finally seem to be moving away from working in imperial units.

As currently prepared, the series covers the construction of the various parts of the machine and its use for basic cutting for gears. If reader reaction is positive, we will consider following the series up with further information on using spiral hobs and more complex gear types. These techniques have been covered by articles in Model Engineer and MEW in the past, but possibly not in the detail they deserve. Do share your thought on this series through the online forum.

On My Bench

This month most of my workshop time has been getting my stepper motor powered telescope GOTO drive up and working. It hasn't been lost on me that although the 'software' would change, what I have made is pretty much a 3D printer controller with stepper motors and heaters! Perhaps that will be a future project?

I have also been trying out a new Clarke pillar drill from Machine Mart. Much larger than my old machine from the same source, it has been an interesting experience. More to come in the next issue!

So far my progress with Kittiwake has been limited to some cleaning up of the castings. Those I have tackled so far have turned out to be in good condition. I'm experimenting with a few different approaches to cleaning them and I will report back via the ME forum.

Hardness Tester

I'm afraid that due to unexpected circumstances, Rod Jenkins' hardness tester article has been held over to issue 245, I'm sorry for any disappointment.



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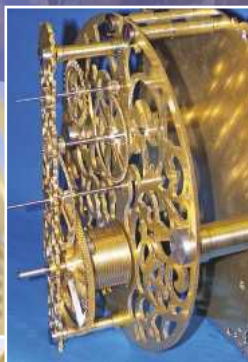
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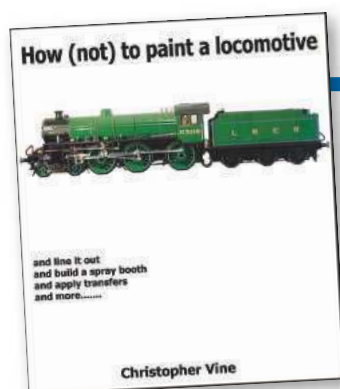
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in the September issue

Once you have enjoyed this issue, look out for the next, packed full of more tools and techniques!



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ON THE COVER >>>

Small but capable of useful work, this compact dividing head is based on components for a light dividing attachment designed by Edgar T. Westbury



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Modifying a Tap Wrench

Laurie Leonard



There are many styles of tap wrench, some designed for specific duties others just supplied as part of a 'tap and die kit'. A couple of examples are shown in **photo 1**. The one shown in **photo 2** was made by me at Derby Tech when I was a Student Apprentice. Note the relatively fine thread on the adjusting screw and the knurled locking ring to stop the screw undoing in use thus holding the tap firmly. The one shown in **photo 3** was home made to drive a No2 Morse taper refurbishing reamer – rather a large one. **Photo 4** shows a wrench, gripping a tap, supplied as part of a kit but the adjusting thread is rather coarse, the screw thread is sloppy and rather a lot of force is required to grip the tap and stop it slipping. This has resulted in bad wear on the end of the adjusting screw, **photos 5 & 6**. This article describes the modification made to overcome this problem.



Examples of tap wrenches



Tap wrench made on a workshop course

Modifications to the Tap wrench Screw

As the adjusting screw starts to bite on the edge of the tap the latter starts to chew into the screw. The tap will be hard but I suspect that the end of the screw is not. The tighter the screw is hardened down the more it is chewed as the tap is fixed

but the screw end is rotating. If the end of the adjusting screw could rotate relative to the main threaded portion, then once in contact with the tap it should then remain stationary thus eliminating the problem.

The end of the damaged adjusting screw was faced off, **photo 7**, (note the damage on the screw thread probably caused by

over tightening). This was achieved with a carbide insert tool but the operation did not show any sign of the screw being hardened. The thread was identified and tables consulted to find the core diameter so a hole could be drilled to accommodate the spindle of a freely rotating end. **Sketch 1** relates to the modification of my wrench

and gives an idea of dimensions that can be used and how they were arrived at.

A hole was drilled and reamed in the old screw to take the free rotating end. As the adjusting screw tightens, the thrust will force the free end onto the screw and inhibit free rotation so some method must be introduced to take this thrust. The simple introduction of a suitably sized ball bearing into the blind bore before the free end was inserted was found to ably accommodate the thrust.

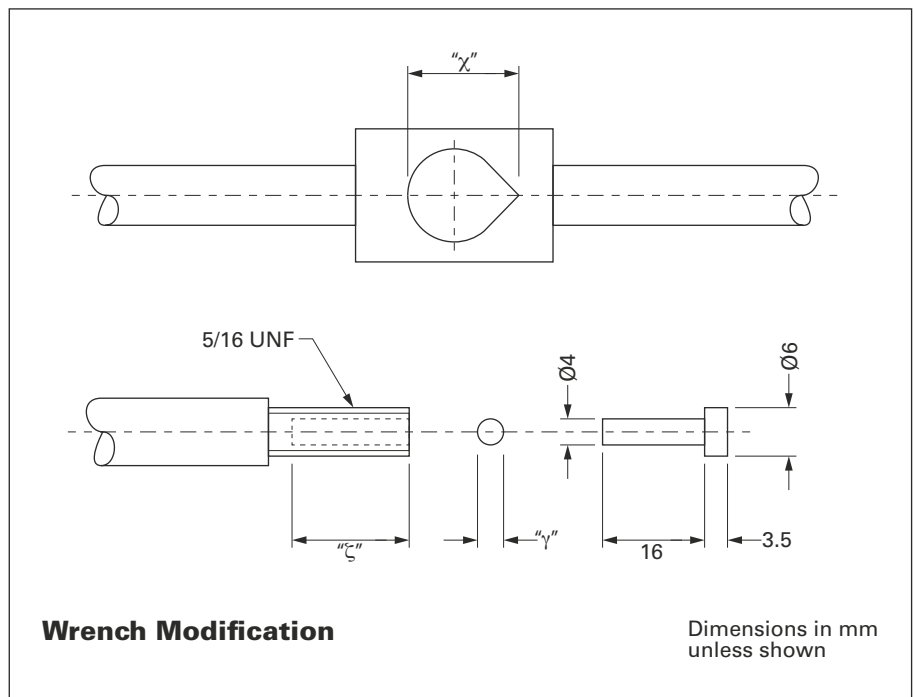
Photograph 9 shows the modified tap wrench assembled.

Design Thoughts

The set works well in practice. I had intended cutting a small 'vee' in the free end to register on the edge of the tap to prevent it rotating when being tightened up, and thus going back to the original problem, but this has so far not been found necessary.

Mention has been made of the need to size the free end spindle in relation to the adjusting screw core diameter to ensure sufficient strength remains. The length of the free end spindle also needs to be considered. It needs to be long enough to remain parallel within the adjusting screw and that when unscrewed to permit entry of the largest tap the wrench will accept it does not fall out and thus permit the ball to fall out, **photo9**.

As an aside refer to **photos 10 & 11**. Mention has made of the use of a fine thread on adjusting screws to provide better locking. The wrench here has in fact achieved the opposite by combining a right and left hand thread. It provides more jaw travel per turn of the screw but at the expense of locking torque. ■



Sketch Notes

The length of the freely rotating spindle to be larger than space in the wrench, 'x', so that it will not fall out when the adjusting screw is retracted far enough to admit the largest possible tap that the wrench can take.

The adjusting screw had a thread of 5/16 inch UNF. Reference to tables gives a core diameter of about 6.6mm. The freely rotating spindle diameter was chosen as 4mm to give adequate wall thickness in the adjusting screw. The blind bore in the spindle was reamed to 4mm.

The ball diameter, 'y' was similarly selected at 4mm and was found to be just under when measured with a micrometer. It entered the bore without force.

The length of the blind bore, 'z', was set to give a slight clearance between the back of the enlarged face of the freely rotating spindle and the end of the adjusting screw. This provides clearance but does not cause the adjusting spindle to be unduly unscrewed reducing the number of engaged threads in the wrench when accommodating large taps.

The enlarged face of the freely rotating end was chosen at 6mm, just smaller than the tapping size of the 5/16 UNF thread so that it would pass down the tapped hole in the wrench body.



Tap wrench made to turn a Morse 2 taper tap



Wrench from kit gripping a tap



Wear on the end of tap wrench screw



The damaged end



Assembled wrench after modification



Facing the end



Relationship between free end length and wrench capacity



Jaw arrangement of another design of tap wrench



Fixed jaw removed to show double adjusting screw

A Swing Out Magnifier

Howard Jennings improves the viewing in his workshop



Presbyopia is the condition that affects our sight as we get older. My optician announced I needed reading glasses and so the inevitable took its course. I have been lucky that my sight has been extremely good, not needing any real magnification aids right into my late forties. Reading glasses, I rapidly found, are a 'right nuisance' never on when you need them.

The constant 'on off' wrecked pair after pair, even titanium frames! Then high technology stepped in. On a suggestion from the assistants at the opticians I tried a single contact lens correction for reading in one eye? Yes, you did read that correctly, one eye! Your brain, or in this case, my brain, corrects and allows me to see distance with one eye and read with the other. Clever things brains, that's where the real high tech is. The full adjustment takes two or three days but essentially it works the minute you are fitted and walk away from the opticians. I could drive, read and see fine detail immediately- NO GLASSES! (Except safety glasses.) Not a solution for everyone, especially with taking the lens in and out. However, my soft lens is worn continuously day and night for a month before being disposed of and replaced.

Workshop

In the workshop it was back to normal or so I thought. Not quite so fast, one eye (although you don't notice it) cannot be as good as two. So my sight is a bit short of how it was. I needed something 'hands free' and instantly ready to go on a job. I had an 'anglepoise' type illuminated magnifier that I had bought at a show some years ago. I had tried clamping it to the bench using the clamp socket bracket supplied with it. I found it was always in the way or not at the right height. I wanted something that could swing out and reach well across my bench and be able to view things in my vice (more later).

TV inspiration

Inspired by television brackets, I chose the twin arm articulated bracket design as seen in **photo 1**. Before going further, this is not designed to be 'pretty', it is fabricated from bits of rusty steel from the 'semi scrap' box. I painted it only because I hate seeing rust on working equipment. The joints are



The arms of the swing out magnifier

simple turned pegs made to fit tubes made from bar drilled to the same diameter as the socket diameter of the magnifier, 1/2 inch **photo 2**. I chose this dimension so that one arm could be removed and the magnifier sited on one arm, or another arm can be added. In practise, I have found the two arm articulation very flexible but the option is always there...

The inner hinge you will notice is a bit different in construction. It is made out of an abandoned project where I had drilled through some steel bar. I just made a couple of short bushes to 'top and tail' it then welded the plates on to form the hinge using the hinge pin to jig it together, waste not want not!

All parts are welded together as you can probably see in the photos. I can do a reasonably strong weld, not to the standard of some professionals I have met, but passable. If welding is not one of your skills, then I would suggest brazing or silver solder joints, and then mill 'socket slots' into the tubes and plugs to give the joints a bit more strength over a butt joint.

A small fabrication point worth considering. I have 'canted' over the socket tube at the wall bracket about 3° from the vertical as shown in **photo 3**. This 'encourages' the arm to stay back when out of use. On the job I have found that the 'stiction' in the joints tends to keep the bracket in position. It helps to have



Arm showing male and female joints



The arm joint is angled slightly



Magnifier in folded position



Bracket for anglepoise lamp

full engagement of the plugs in the tubes. I also use a bit of copper base grease on mechanisms like this. Many of you will be familiar with this type of grease as it is used in car braking systems, for slow moving joints which have to stay free. In this case it keeps things moving without being 'too free'.

Mounting

The photos show that my bracket uses a piece of angle steel for mounting. I have wooden uprights at the back of my bench which support a piece of 9mm plywood. My hand tools needed at the bench are mounted onto the plywood which is clamped to the wall. This makes it easier to re-site the workshop in the future. **Photo 4** shows the magnifier folded out of the way. Such a bracket can be connected to the wall in your workshop in a variety of ways, such as a straightforward flange.

Uses

This swing out magnifier has become a 'regular' in use at the bench as it is ready at a moments notice. It gets involved with tool inspections and sharpening, marking out, looking inside machines and even looking for metal splinters in my skin!

One day I was using a wood saw I have had for years and it became obvious that it was blunt. I had a number of thick timbers to saw up that day. I was just closing up the workshop and looking to head off and buy a new saw. Then I thought, how about sharpening it? So I set to work with the saw clamped in the vice and sharpened it with a diamond file using the magnifier over the vice. The magnifier helped me enormously by enabling me to guide the file and get



Lamp and magnifier can work together

the alternate teeth angles correct. It took me fifteen minutes and I was back on the original job and finished it that day. This is instead of what would have been an hour round trip to buy a new saw, leaving aside the fuel cost. Yes, this is nothing new, wood saws were, in my lifetime, so expensive that re-sharpening was the norm. But I was amazed at the real time saving I had



Bracket for shaper lamp

achieved here by just having the magnifier to hand.

Got the bug

Fresh from my success with the swing out magnifier, I made a couple of other brackets for lights as you can see in the photos.

Photo 5 shows a simple socket bracket to carry a lamp that I can position over my



Illuminating the shaper

bench vice and the immediate area. It is mounted in a similar way to the magnifier bracket which you can see positioned over the vice see **photo 6**.

I also had an old table lamp I picked up at a jumble sale. I have needed a lamp over my shaper for years. So I fabricated this single articulated lamp bracket, **photo 7**, angled to clear the shaper ram. The whole thing, **photo 8**, is bolted to existing screws which hold down the machine table raising screw cap, **photo 9**. The tricky bit with this



Looking down at the attachment point

bracket was the angled arm made of (semi scrap) square section tube. To produce the cut-outs for the plug and socket I set up the square tube at the angle I wanted in the milling machine vice. I set up an end mill similar in diameter to the section of the plugs and sockets to be welded, centred on the square section of the bar. With care I found I could machine both ends of the bar in one setting. This needs a machine with a good throat depth. An alternative I considered was to mount the bar on the centre line of the lathe using an angle plate or maybe the tool mount. Again, feeding in an endmill or slot drill in the chuck to form the cut-out. It should be straightforward to turn over the bar to produce the cut-out on the other end. Of course, you could turn the sockets and plugs from solid square bar and cut plain angles on the tube. The only limit is your ingenuity to make the materials you have to hand work for you.

Safety

My lamps are fitted with fluorescent low wattage bulbs. They don't run as hot as their old incandescent counterparts. But if you break one there is a shower of glass together with the compounds used to enhance the fluorescent effect. LED replacements are now getting such that they can match the light output of the fluorescents. Some of you may remember how the early versions of fluorescent bulbs struggled to match incandescents. Now, LED replacements are steadily reaching the point where they can match any existing bulb. I will gradually replace the fluorescents with LED which are much more resistant to accidental damage.

Finally

Well here we are. Really useful brackets for your lights that can be made in a few hours but will last for years. I hope by writing this short article there is inspiration for your workshop. ■

In our Next Issue

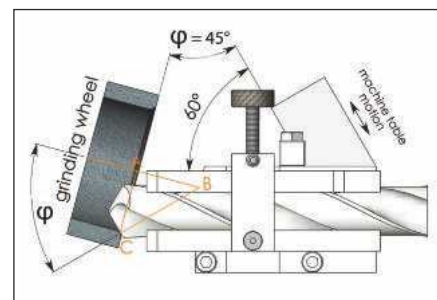
Coming up in issue 245
On Sale 12th August 2016



John Ashton details his kit build of the Acute Tool Sharpening System.



Marcus Bowman explore producing irregular shapes using CNC.



Jacques Maurel explores the challenging world of drill sharpening.

DON'T MISS THIS GREAT ISSUE - SEE PAGE 28 FOR OUR LATEST SUBSCRIPTION OFFER

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



Iwata Workstation Range

The Airbrush Company are pleased to announce new products from the Iwata Workstation Range. The specialized Professional Maintenance Tools make assembling and reassembling airbrush nozzles, caps, needle packings, O-rings and air valves quick and easy. The kit comes with a two-sided Iwata Air Valve Guide Wrench, Soft Jaw Pliers, Needle Packing Screwdrivers (for 1.2mm and 1.4mm diameter needles), Nozzle Wrench, a protective Needle Tube and easy-to-follow instructions with diagrams. All of the items fit securely within a soft-sided zippered case, with room to carry up to three airbrushes. The tools and case retail at £76.75 from airbrushes.com

Maid of the Loch: Volunteers Needed

A call for volunteers to help with the restoration of the paddle steamer the Maid of the Loch between now and August has been sent out. Some of the tasks include the following work:

Main engine and paddles: Uncouple paddle wheels and support. Allow for easier engine turning. Open up crosshead bearings and big ends. Open, Examine, measure and record the bearings, looking for any indication of misalignment. Open up valve straps and check as above and record. Replicate the reversing engine valve and test operation of R engine on hydraulics and air.

Cylinders: Remove covers and measure cylinders as far as possible to identify wear, ovality etc. if possible, drop out pistons to release rings for measuring. Dismantle and assess mechanical packing.

Paddles: Sample test the bronze bushes for the feathering gear. Once recoupled, open up the paddle bearings for evaluation. Check for run out on the paddle shaft.

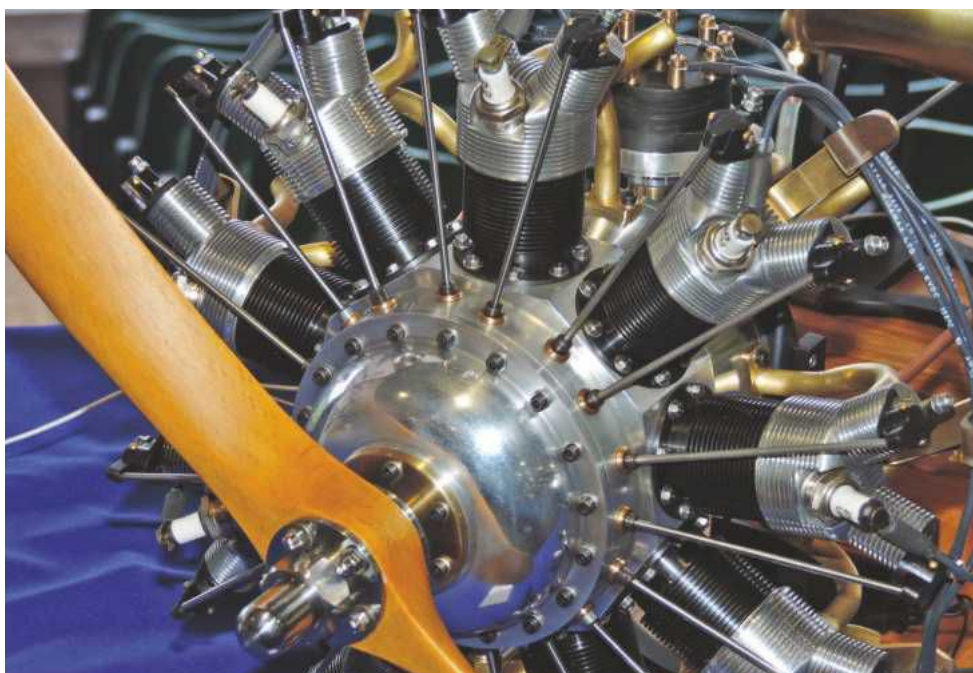
Please spread the word and, if you are interested in being involved, contact Jim Mitchell on jimscottmitchell@gmail.com

The Model Engineer Exhibition at Brooklands

A quick reminder that the 2016 Model Engineer Exhibition will take place on 16, 17 and 18 September at Brooklands Museum, Weybridge, Surrey.

The event will feature the World Class Competition, individual loan models, fantastic displays by Clubs and Societies, a cross section of traders and suppliers and all this against the backdrop of one of the best museums of historic transport and engineering in the country. The exhibition promises to be something completely new, refreshing and invigorating as well as thought-provoking and inspiring.

Early Bird tickets are available to purchase at <http://tinyurl.com/MEXBrooklands> where you will also find all the information you need about the venue.



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Single Phase Fractional Horse Power Motor Connections

Ted Fletcher gives some guidance on what's inside your motors – together with advice on the regular query about reversing the direction of rotation of a motor.

The following details are applicable to almost all run of the mill single phase AC motors which may be found in a Model Engineer's workshop here in the UK. These motors are usually 4 pole (1425 rpm), or 2 pole (2850 rpm), 4 pole being the most common. No electrical theory is needed to sort out the connections of a single phase motor. There are five basic types single phase motors which we, as model engineers, might come across.

Split phase induction (two windings and centrifugal switch) these motors have a poor starting torque, and were fitted to many washing machines prior to front loaders. **Fig. A.**

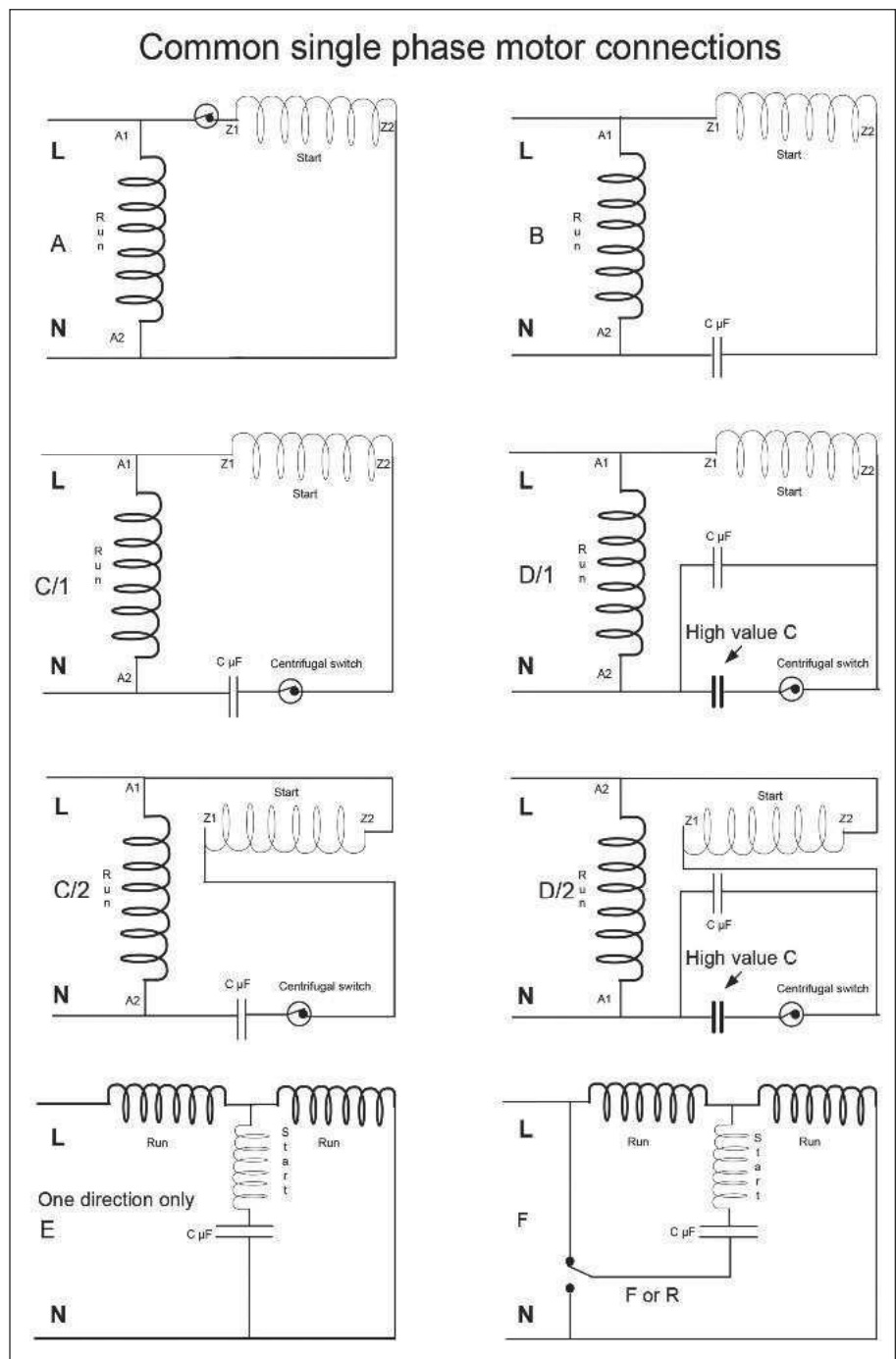
Capacitors start (two windings, a capacitor and centrifugal switch) these motor have good starting torque, and were fitted to most Myford lathes. **fig. C/1.**

Capacitor start and run (two windings two capacitors and centrifugal switch) these motors have good starting torque and are often fitted to DIY compressors. **fig. D/1.**

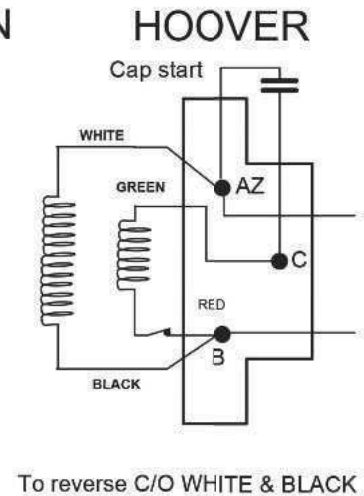
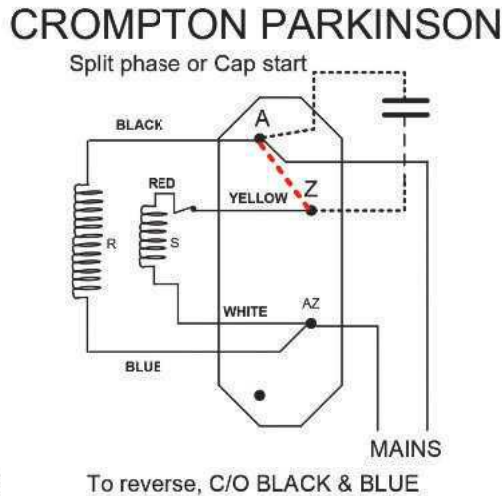
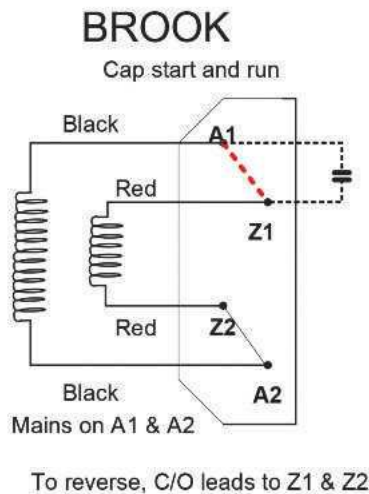
Permanent capacitor, two windings, a capacitor in the start winding circuit, no centrifugal switch. These motors are noted for constant speed and their quiet running. Fans and oil burners, etc. **fig. B**

Swing connection, these motors are often found on cheaper bench grinders, DIY tile cutters, wired for a single direction of rotation only. Once dismantled and for those in the know, these motors can be reconnected to be used for cross slide lathe grinders etc. **fig. E.**

All the motors listed above have TWO winding within the motor stator. First, relating to items 1, 2, 3 and four, there is the start winding, which is short time rated. It has a centrifugal switch in series with it and often a capacitor as well. The start winding was the last to be installed when the motor was being manufactured and so it's easy to see and locate when the motor is dismantled. Note, also when looking inside the motor, the start winding is usually displaced about 90° out of alignment with the run winding, yet another clue. Also, the start winding wire is usually much thinner than the run winding and consequently has a much higher resistance when compared



Typical manufactures circuit diagrams



Note how different manufacturers used different wire colours and terminal markings.

with the run winding resistance. Not always though, as some times there are less turns on the start winding, therefore two windings can almost have the same resistance, which can be confusing. But, as you now already know the location of the start winding, that should not be much of a problem.

The second winding is the run, which is continuously rated. It has much thicker wire and so usually it has a lower resistance when compared with the start winding. At stand still both windings are connected in parallel one to the other and the centrifugal switch, which as previously stated, is in series with start winding, it will be closed. Then, when both windings are connected in parallel to the electric supply the motor starts up and accelerates away, at about 75% of full speed, the centrifugal switch opens, therefore the start winding is now open circuit and the motor continues to run on the run winding only. If you are about to buy a second hand motor use your nose and have a good sniff around the motor, if it has that special burnt varnish/insulation smell, best leave it with the seller. It could be electrically OK, but maybe not.

Assuming that your motor has recently been acquired and you haven't tested it in anyway, first of all you should carry out an insulation test using a 500 volt DC insulation tester, often referred to as a Megger. This test is the electrical equivalent to a boiler pressure test, in effect you are looking for electrical leakage as opposed to steam/water leakage. There quite a few different makes of insulation testers on the market, but the name Megger is like Hoover is to vacuum cleaners, **photo 1**.

Link together ALL the terminals including the capacitor, connect the insulation tester set on the 500 volt range, one lead to the frame (the Earth) the other to the linked terminals. Under test,



A Megger insulation tester

the meter should read infinity or there about, indicating very very low electrical leakage, safe to use in other words. Next, with the Megger now on the low OHMS range check each winding for continuity. A multimeter analogue or digital type or a battery and bell set will also be OK for continuity testing the two windings, defiantly not for insulation testing.

Now for a short explanation about ohmmeters. First and foremost always read the instructions, on the back of some older meters, **photo 2**, before use.

All ohmmeters require an internal battery, so when a DC current from the ohmmeter itself, via the OHMS range circuitry, is applied to a circuit under test a small current flows. It is this current which causes the meter needle to deflect.

Before attempting any testing, it is

important to zero the meter on the OHMS range. If you have difficulties zeroing your meter check the internal battery, especially if the meter doesn't get a lot of use. Some make of batteries, even when new, have high internal resistance and so are not powerful enough to drive the meter on the high resistance range. Worth knowing as you may be looking for a fault on your meter, when it was the battery after all. Try a second battery before scrapping your multimeter. Note also, on most ohmmeters the zero ohms position is to the right side of the scale. To zero the meter, connect the leads together and adjust as necessary, and then take a reading on the motor winding.

Analogue types, those with a dial and needle, which are usually found on multi-function test meters. The cheap ones usually just have AC and DC volts, ohms and DC milliamp ranges, but not amps. AVO meters and many other similar meters have, what to some may think a peculiar terminal arrangement. On the OHMS ranges only,



Instructions for an Avo Meter



The selection switches for an Avo

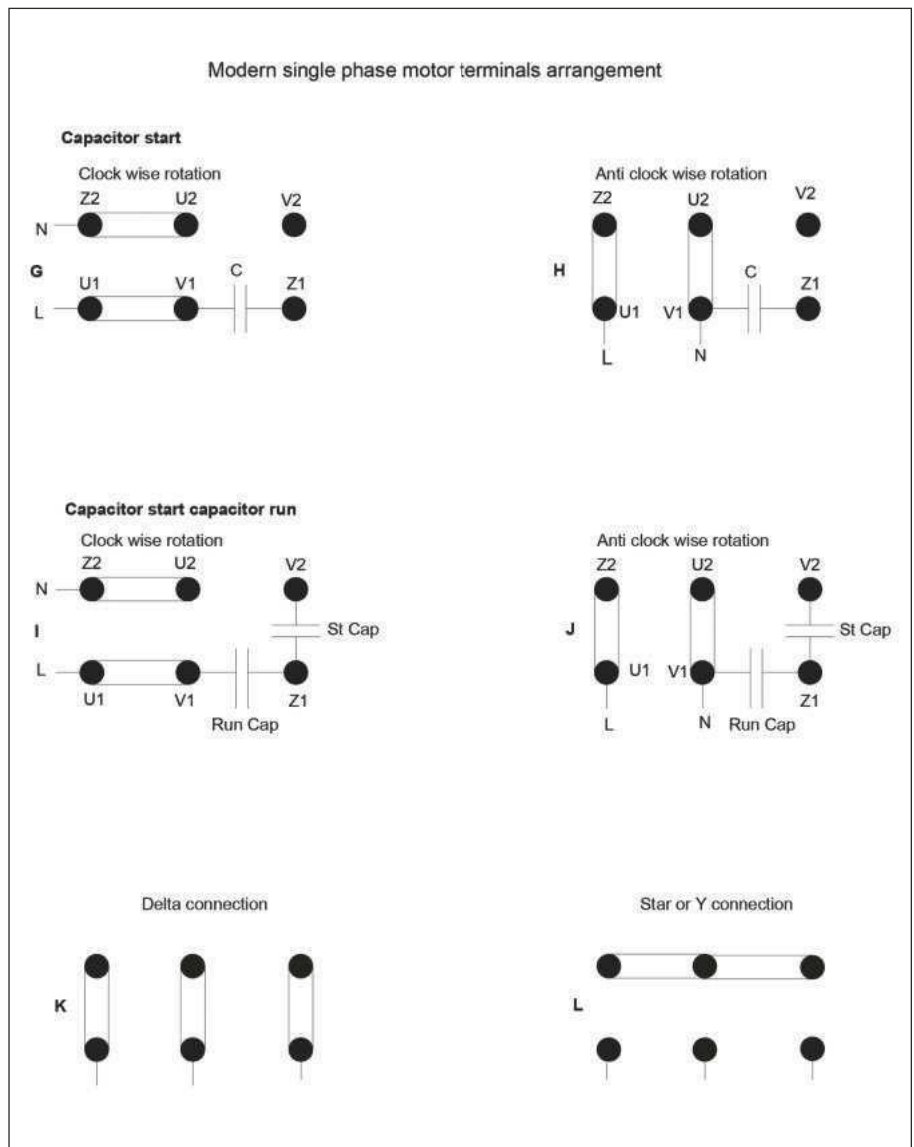
the RED terminal is actually the negative terminal of the internal battery and the BLACK terminal is the positive of the same battery. Beware, as that can be confusing if you get around to testing other electronic components such as diodes, but not here on single phase motors testing. **Photo 3.**

Low resistance large needle deflection to the right of the meter scale, high resistance small deflection. But for simple continuity a battery and bell is all you need. Digital multimeters are now cheap and rugged with no moving coil to damage. Aldi has had some of their WORKZONE ones for 7 or 8 pounds, which are suitable for continuity testing and, as bonus, should you need it, amps range as well, **photo 4.**

Generally, the thin start winding will have a high resistance (that is for type a motors) in the range of 20 to 40 ohms, these wires are easily broken, photo 5. I'm sure you all already know that copper, work hardens, so be very careful not to wriggle the leads around more than necessary. The run winding could be up to 10Ω but more likely 4 or 5Ω, these value are dependent on the size/rating of the motor (KW or HP). That is why I mentioned as an aid to winding identification the location and difference in ohmic value of the two windings. If either test is unsatisfactory insulation or continuity, then if you dismantle the motor, it might enable you to locate and rectify the fault. I suggest you follow my instructions and if you haven't previously dismantled a motor, I recommend you have a digital camera or phone with a camera, a pencil and paper handy and take plenty of photos and notes.

Dismantling.

Again proceed with care. Using a scribe and 6 inch rule, scratch marks on both end shield ends straight across onto the stator. Two scribe marks across on the drive shaft end and one scribe mark across on the no drive end. Don't centre punch the end shields or stator, scratch marks are enough. You might crack or chip the castings when using a hammer and centre punch. These alignment marks are for easy reassembly.



Get them right and the motor rotor will revolve freely, with a simple flick of the wrist once the motor is reassembled. Next remove the through bolts and, using a hide face mallet, give a sharp rap on the end shields, definitely not on the motor shaft as that is sure way of breaking the centrifugal switch, the motor will almost fall apart. If the motor is stubborn then carefully use a hammer and brass drift, not too vigorously though.

Once dismantled do not attempt to clean out any fluff or any other debris between the winding with compressed air, but use a small, clean paint brush and vacuum cleaner to suck it out. Compressed air usually contains particles of water unless you have water trap, which is what we don't want inside any electrical devices. Also the pressure of the compressed air will force any debris further in between the coils, possibly causing the motor to overheat and burn out. On some makes of motor the windings extend



A digital multimeter



The windings of a typical motor



Rotor removed from case

beyond the end of the motor carcass. I have been asked in the past to attempt resuscitate a damaged motor, when it's all too obvious that someone has been working on the motor with the windings rubbing on the bench top, a sure way to ruining a good motor. Use four pieces of wood to form an open top box to mount the stator on, so that the windings are dangling down inside the box. If your motor is old and the lead out from the winding is perished rubber, you can carefully slide on some heat resistant glass fibre sleeve in place over the perished rubber. When withdrawing the rotor be careful not to scratch or damage the windings.

On older motors the natural resin based winding insulation varnish is not as flexible or tough as that on modern motors with synthetic type and it can easily be damaged (scratched away). If you have been a bit careless don't despair, small quantities of air drying varnishes are available on the web or from your local rewind shop, which can be applied in the workshop and left to dry. Give them several coats as necessary. Store the rotor carefully on the bench, don't let it roll off onto the floor, bending the shaft or damage the centrifugal switch mechanism, photo 6. Have a good look at the centrifugal switch mechanism which is attached to the motor shaft. The spring loaded bob weights or whichever type of switch is used on your motor, should move freely with a snap action after being operated by hand, it mustn't dither, don't oil it/them, **photo 7**.

Remember, I said the start winding is short time rated so it is important the centrifugal switch opens quickly. Also, should the switch dither it's not unknown for the capacitor to fail, the reason being, if the switch is fluttering it may leave the capacitor fully charged at peak mains voltage, then the switch closes at the opposite half cycle, impressing double mains voltage on the capacitor insulation.

Next check the centrifugal switch contacts to see if they are clean and are not just blobs of weld due to arcing taking place over the years of use. The contacts can be

cleaned up a bit using a piece the finest grade of wet and dry folded back to back. The contacts themselves are attached to insulating board material, paxolin or fibre board within the non-drive end shield, on British made motors. Some makes of motor use a plastic type material to form a heel with which to actuate the centrifugal switch, this slowly wears away. If the heel is badly worn, the contacts will fail to open, the start the winding will be in continuous use, consequently it will quickly over heat and burn out. I have in the past built up the heel with Araldite, prolonging the life of a good motor.

If your motor is a capacitor start, that's the type with a cylindrical device mounted on the side of the motor with two leads, which connects into the motor terminal block, unfortunately there's not an easy way for the average person to check a capacitor other than to change it, like for like (substitution) and it might not be a faulty after all. Motor start capacitors are special AC electrolytic type and often the tolerance

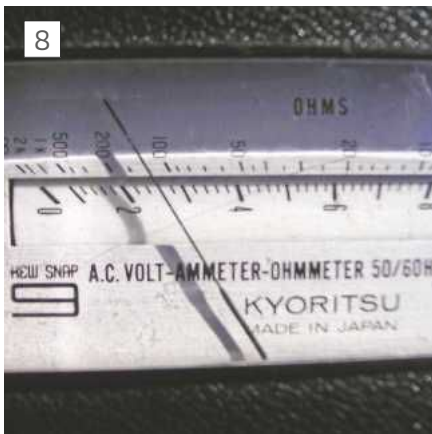
is $\pm 20\%$. Capacitors are pretty reliable and in capacitor start motors they are only in use for a very short period in time, every start up in fact. Should you be so interested there was an article on capacitors in MEW 123 page 52 onwards.

In former times, the two motor windings were generally marked as Z1/Z2 for the start winding and A1/A2 for the run winding. Whilst there was a British Standard for the colour code of the wire and for the terminal markings it was largely ignored by most manufacturers, they used colours which was available to them, fig. F. The new current nomenclature for the run winding is U1/U2 and the start remains as before Z1/Z2.

Until relatively recently capacitor start capacitor run motors were not common on hobby machines fig. D1. In these motors one capacitor, the smallest value one remains connect in circuit whenever the motor is running, it is therefore known as a continuously rated capacitor. Whereas the larger μF value one which is special AC electrolytic, is short time rated and is only



A centrifugal switch



Measuring no-load current

in use on start-up (two in parallel initially, then when the centrifugal switch opens one on its own)

By now hopefully you have located and fixed the fault, and being very careful when reassembling the motor, it's very easy to damage or trap a lead to the windings creating an earth fault or short circuit. When reassembling the motor slide in the rotor into the stator, look out for those scratch marks you made earlier. Next, push in the through bolts in one at a time. Partially tighten diagonally opposite bolts a bit at a time, check again for those alignment marks which you made earlier on the stator and ensure the rotor turns freely as you assemble the motor. Once all 4 bolts are in place, give their nut a final twist tight. Finally, prior to connecting the motor to the electric supply once again, carry out another insulation resistance test using a 500 volt DC Megger. The insulation resistance test is most important, it will tell you how good or bad the electrical leakage is, hopefully its zero, and the insulation resistance reading will be infinity. Photograph 8 shows the motor no load running current after the insulation test had been carried out.

Having now got your motor up and running but unfortunately it rotates in the wrong direction. To reverse direction of rotation of a single phase motor, you have to change the relationship between the TWO windings one to the other, simply altering the electric supply connections is counterproductive. To reverse direction of rotation ONE of the windings either start or run but NOT both, need exchanging. I think most of us will be working on older motors, so change either A1-A2 or Z1-Z2 whichever is most convenient. For example suppose the motor is initially connected supply live to A1/Z1, neutral to A2/Z2, to reverse D.O.R. connect supply live to A1/Z2, neutral A2/Z1. Some motors have terminals marked AZ and T, AZ and A are the run winding whereas terminals T and Z are connected to the start winding, this can be confusing, be cautious. Photographs 9 & 10 show a selection of terminal boards.

Now referring to fig. C2 it shows how the capacitor start motor in C1 above can be reversed. Also fig. D2 it shows how the

capacitor start and run motor in D1 above can be reversed. Next look at figs G and H again capacitor starts and finally figs I and J to see the more modern terminal connection arrangement, which is much easier to work on and understand.

As previously mentioned some cheap motors as used on bench grinders and tile cutters have what is known as a swing start winding fig. E. The run winding is centre tapped (120 volts each way) and one side of the start winding is connected to the centre tap, the other side to a continuously rated capacitor. As the start winding is connected to the centre point of the run winding it can be rated for 120 volt as can the capacitor which is a cost reduction for the manufacturer. Looking at fig. E you will see by disconnecting the start winding to the capacitor there are two circuits one from L to the previously disconnect wire and the second from N again to the disconnected wire, both should have the same ohmic value. Using a single pole change over switch (two way) the motor can be easily reversed fig. F. Always ensure that the motor is stationary before operating the switch toggle from forward to reverse. I used a tile cutter swing start motor on my tool and cutter grinder, and used a 4 pole with centre OFF switch to give forward and reverse. Some single phase motors were not intended to be reversed Fobco and Meddings drilling machine motors are a couple of examples. It's not realistically possible to change the direction of rotation of these motors as the fourth connection is often buried within one of the coils. Not saying it is impossible but not easy, and it's very easy to break a wire very close to one of the coils, such that it is almost impossible to solder a wire in its place.

A few years ago a friend bought very



9



A pair of motor terminal boards, showing their markings

nicely made Chinese capacitor start, capacitor run motor which rotated in the wrong direction. To gain access to the connections I had to take it apart and noted that the centrifugal switch was mounted at the drive end which made it easy to work on and to reverse direction of rotation as well. Apparently the latest version of the motor has all the connection readily accessible in the terminal box, so it is now easy to reverse direction of rotation. Also, I see that many of the imported motors have a terminal box layout as shown in fig. G, H, I, & J which have similar in appearance to that of a three phase motor figs K & L. This has caused a bit of confusion to my friends, as they thought that a three phase motor can easily be reconnected to run on single phase, and vice versa, not so as yet, but who knows what the future holds. ■

10



Another variation of terminal board

THIS PARTING-OFF PROBLEM

By B. Terry Gspin

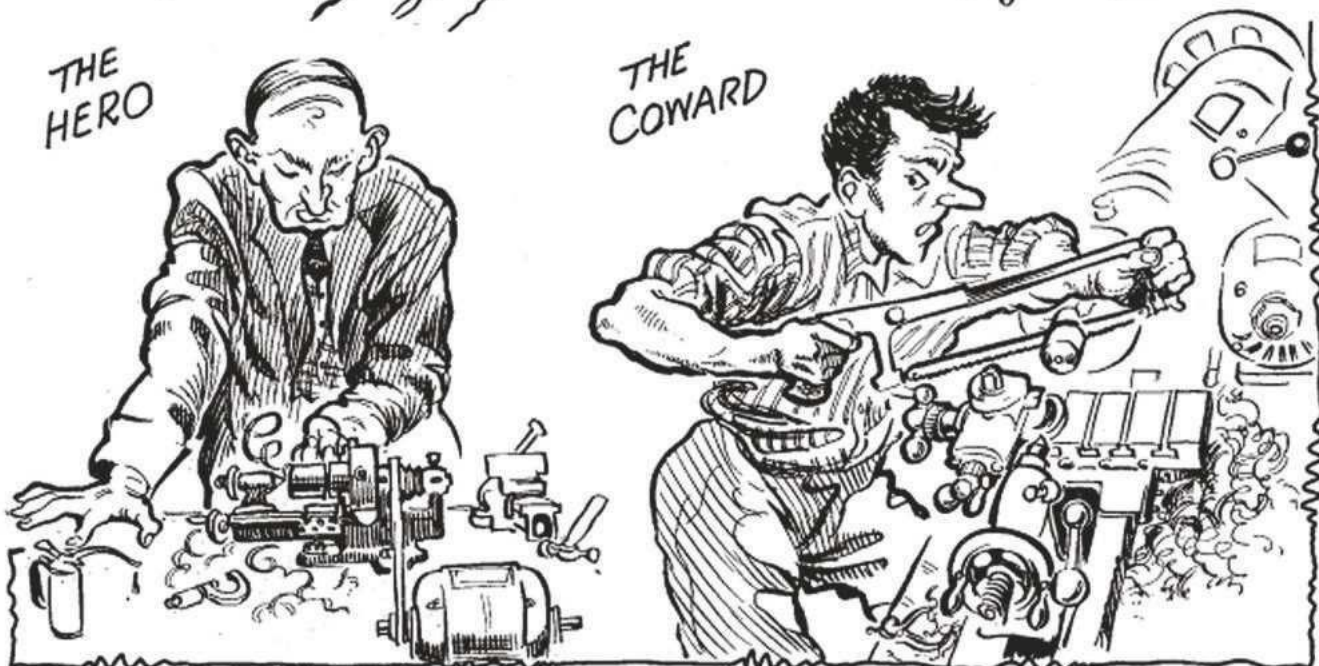
THE CHATTER FIEND

THE NONCHALANT BACK-TOOLPOSTER

AN INADVERTENT DIG-IN

THE HERO

THE COWARD



Machining Squares with an Angle Gauge

Richard T. Smith makes good use of his free subscription gift.



The shaft with a square at each end

As part of a latch mechanism I needed to make the component shown in **photo 1**. There are square sections at each end and a pair of holes in line with a flat plus two tapped holes at 90 degrees. I don't have a rotary table so I needed another way to index the work. If a shaft is rotated 90 degrees at a time under the same final cutter position a true and centred square results. If the centre of rotation is offset from the centre of the shaft the result is no longer true to the shaft. So even with a rotary table the shaft has to be accurately centred. The collet block jigs you can buy solve this by locating the shaft in a collet and sitting the block on each accurately machined face in turn. The accuracy is determined by the jig. However, you have to buy the block and buy a collet so while cheaper than a rotary table plus a chuck it is still not a cheap solution. A truly round shaft can be accurately rotated in a V block – or in my case slightly less accurately in a slot in the table – which is free.

The next problem was how to achieve the 90 degree at a time rotation. I have the digital angle gauge which was a free gift with a Model Engineer's Workshop subscription but it needs to sit on something. I had available a 50 mm square by 24 thick machined block of aluminium which I had made up as an exercise on the lathe. I thought if I attached it to the end of



Setting up with the angle gauge

the component on a sacrificial extension I could sit the gauge on each face in turn and set them level with the bed. The block serving as an indicator and not as a physical locator. A quick check showed that the block could sit in the end of the table recess while the component sat in a table slot.

At first I was concerned about how I could drill an exactly centred hole in the block but eventually realised that as the block is simply an indicator it doesn't matter if the block is off-centre. The shaft rotates accurately in its location and you simply have to use the gauge to set each face of



Machining the first square...

the block parallel to the bed in turn.

The block was drilled centrally 10 mm dia. and cross drilled and tapped M5 for a grubscrew. The component was turned with reduced diameters for the two squares plus a sacrificial 10mm dia. extension for the block to clamp on. **Photograph 2** shows the setup on the mill. The triangular scrap clamped to the bed gave a stop which the component located against, the block was located where it was free to rotate, and the clamp held the component firmly. The gauge was zeroed each time on the bed then transferred to the block face and the component rotated to a zero reading and the clamp tightened and the reading checked again. Incidentally tightening the clamp sometimes changed the reading by 0.1 degrees. **Photograph 3** shows the first flat cut at 0.5mm below the initial cutter contact. The cutter setting was locked and each flat cut in turn. I measured across the resulting flats and found a difference of 0.1 mm which was fine for the intended use. If the locating diameter of the component had been machined true rather than left as found I expect this error could have been reduced. The cutter was then lowered using a clock gauge to measure the movement and the four flats remachined. Resetting every time was a little tedious, however, the setup had cost me nothing so I'm not complaining. **Photograph 4** shows the second square being machined. This was

an occasion when having a round column proved useful as I could swing the head around to get a better reach. To drill the holes required I held the component in the vice seating the reduced diameters each side of the centre section on small MS blocks.

I have some MS hexagon and I will use this to make an alternative block so that I

can machine hexagons easily. The gauge could be used to set the block faces at measured angles to the bed so for example, at 45 degrees with the square block you could get 8 divisions, or with the hexagon block you could get 12. With a little thought and calculation all sorts of things are possible! ■



... and the second

Build the Twist n' Punch

Mogens Kilde takes beginners step by step through the making of a useful optical centre punch.

In this little weekend, or two weekend, project I will describe how to make a new version of the well-known optical centre punch tool. The idea of this tool, compared to previous versions, is that you do not have to remove the optical lens and replace it with the punch, when using the tool. The design of my tool can be seen in the general arrangement, **fig. 1**, and all description of the making of the tool should be made with reference to this drawing.

The first part to make is the inner body of

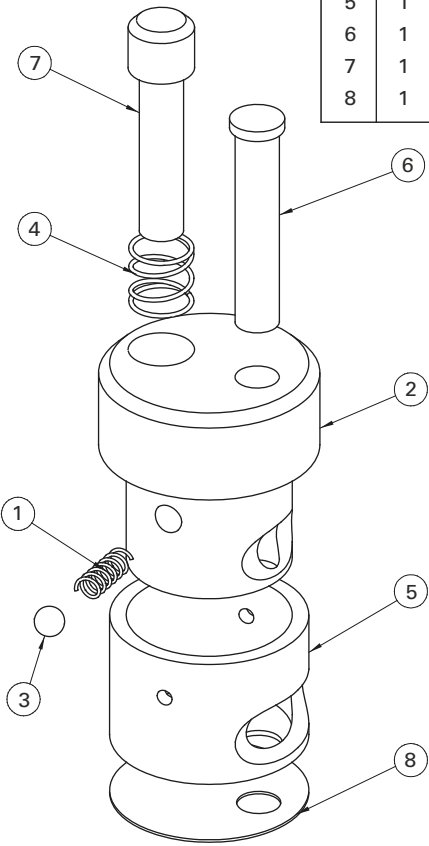
the tool, **fig 2**.
This part is made from Ø40 mm mild steel. After cutting a lump a little over size, compared to the drawing.

- 1. The part is faced off in the lathe and the diameter Ø30 mm is turned according to measurements in the drawing.
- 2. The part is turned round in the chuck and work piece cut to final length in the lathe, also the 2x45° chamfers are turned.

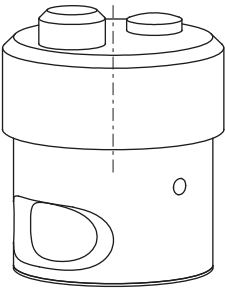


Fig. 1

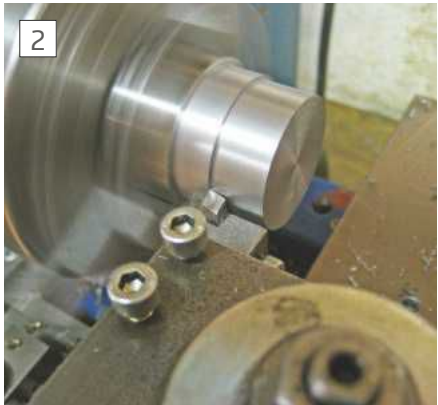
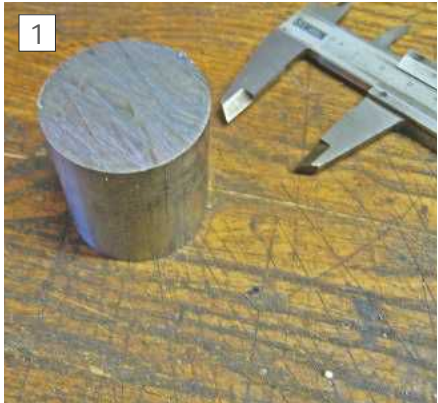
Component list			
ID	Qty	Name	Part no.
1	1	Locking spring	1025-01
2	1	Tool inner body	1025-02
3	1	Lock ball Ø5.5mm	-
4	1	Lifting Spring	1025-04
5	1	Tool outer body	1025-05
6	1	Loupe	1025-06
7	1	Punch	1025-07
8	1	Adhesive friction pad grit=800	1025-08



Click 'n' Punch



Assembled Tool





3 & 4. To ensure a good grip on the inner part of the tool, as you will be turning this part when the tool is in use, I made a knurled grip on the outer diameter.

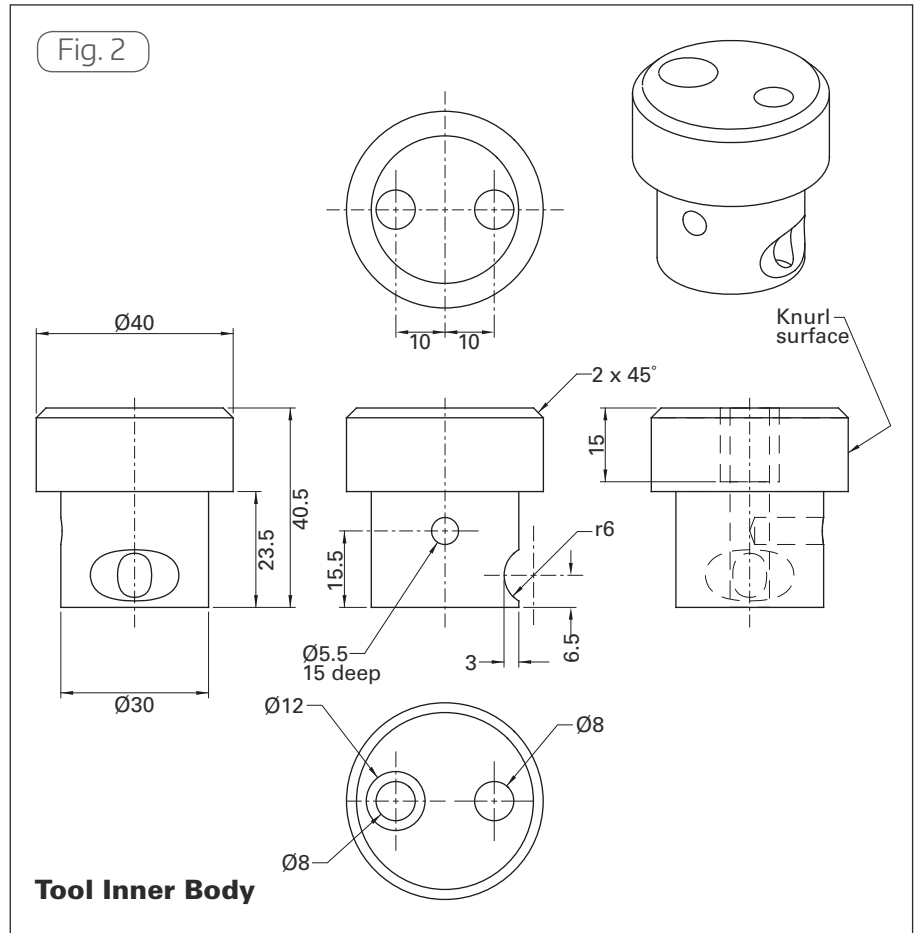
5. Next the work piece is placed in the milling machine, locating the exact position of the work piece by means of a centring bar and bright torch light.

6. I made two Ø8.0 mm holes 10 mm one each side of the centre line.

7. The holes are supposed to guide respectively the punch and the optical lens, and are reamed to ensure precise diameters.

8. After placing 2 lengths of Ø8.0mm cold drawn bars in the reamed holes, I can mount the part in the vise accurately square to the Ø8.0 mm holes, and can now make the Ø5.5 mm hole for the locking ball.

9. The position of this hole and the size of the hole must be absolutely precise, by this I mean that the hole must be absolutely square to the Ø8.0 mm holes and placed exactly on the centre line of the work piece. Also the size of the hole must be with no play for the locking ball, so before you drill, do check the size of the steel ball.



10. In this setup, the locking spring and the ball are checked for good function, **fig 3**.

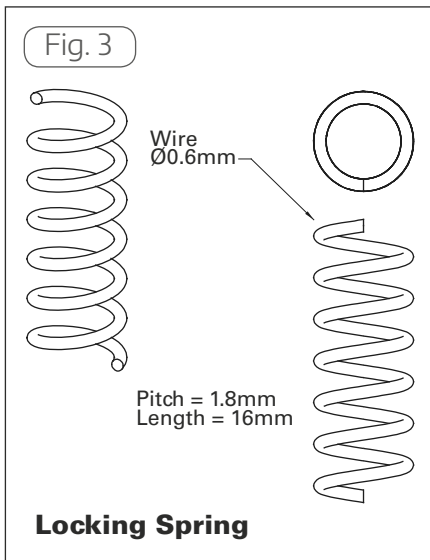
11. Please note that the ball and the spring were found in the 'good to have stock', so you can use what you have available of similar size.

The next job is to drill the Ø12 mm and 15 mm deep hole, this hole will accommodate the lifting spring for the centre punch.

12. The work was done in the bench drill using a twist drill. The final job is to make the light port for the optical lens. Again the part is placed in the milling vice and positioned with parallel Ø8.0 mm bars.

13. The light port is milled with a Ø12 mm end mill. After removing all sharp edges and burrs the part is finished.





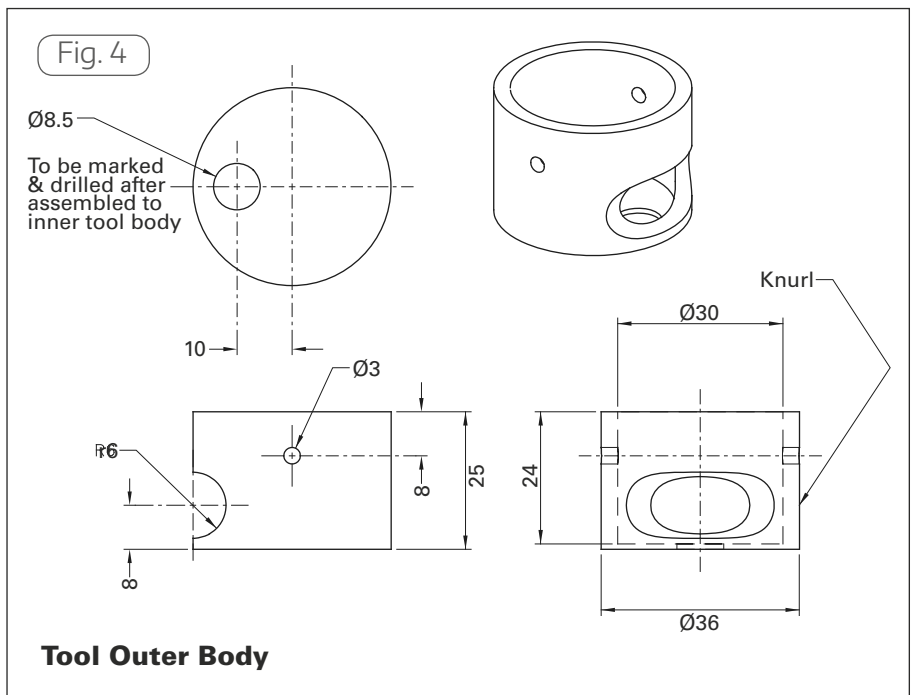
Next part to make is the outer body of the tool, **fig 4**.

14. This part is also made from a length of Ø40 mm mild steel.

15. As part of the outer diameter is to be turned to Ø36 mm, I cut a piece approximately 30 mm longer than the final length.

16 & 17. Here the dimension is critical as the outer part must fit to the inner part with no play, that is, free movement but no play.

Next the part is faced off. Here I made a small error, the outer body will also have a knurled grip I should have cut first. Despite my error I was able to do the knurling on the cut off part, but it is best to do the knurling before the part is cut to final length.



18. After facing off to exact length the part is centre drilled...

19. ...and a large drill is used to start the boring operation.

20. The Ø30 x 24 mm boring job is done with a boring bar in the lathe

21. The work piece is set up in the milling vice and just as the previous job in the mill was the light port in the inner tool body, the



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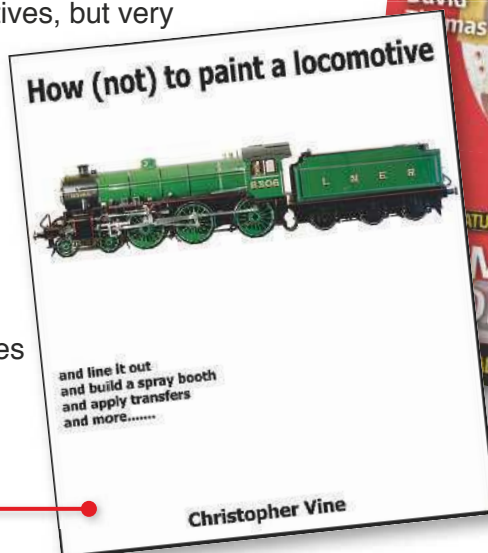
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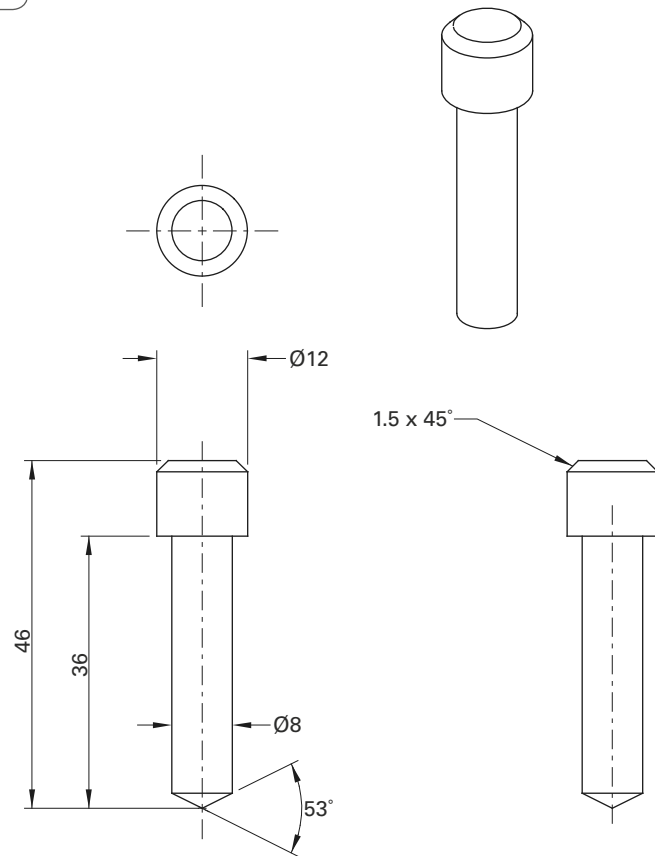
next operation is to mill the light port in the outer tool part.

22 & 23. Without removing the workpiece, the centre line of the part is zeroed in and the $\varnothing 3,0$ mm hole is made.

24. After removing sharp edges and burrs, next the locking spring and locking ball can be mounted into the inner tool body, the whole thing is mounted into the outer part, if things has gone well the two parts shall lock in a position where the light ports are corresponding.

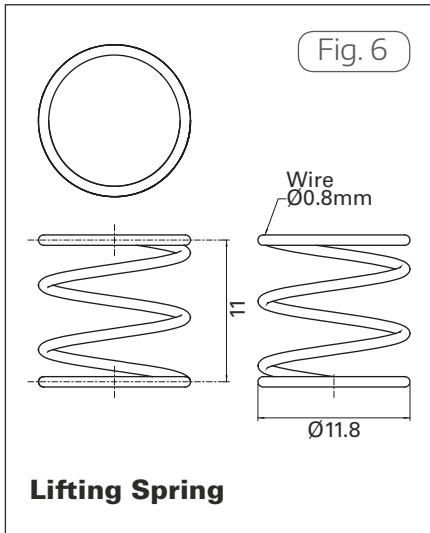
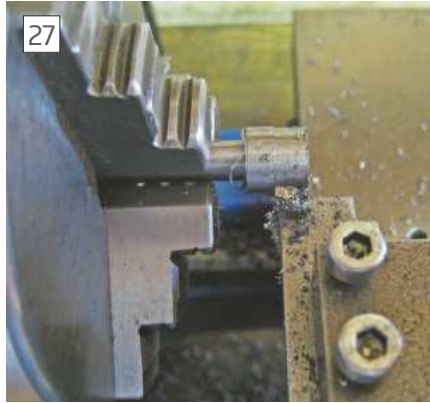


Fig. 5



Punch





Now is a good time for a coffee break!
Next part to make is the punch, **fig 5**.

The punch fits in the hole with its lifting spring, **fig. 6**.

The punch is made from some Ø16 mm hardenable steel (UHB ARNE) that's in my stock.

25. First job is to turn the end point of the punch, this is done in the lathe with the compound slide adjusted in appropriate angle.

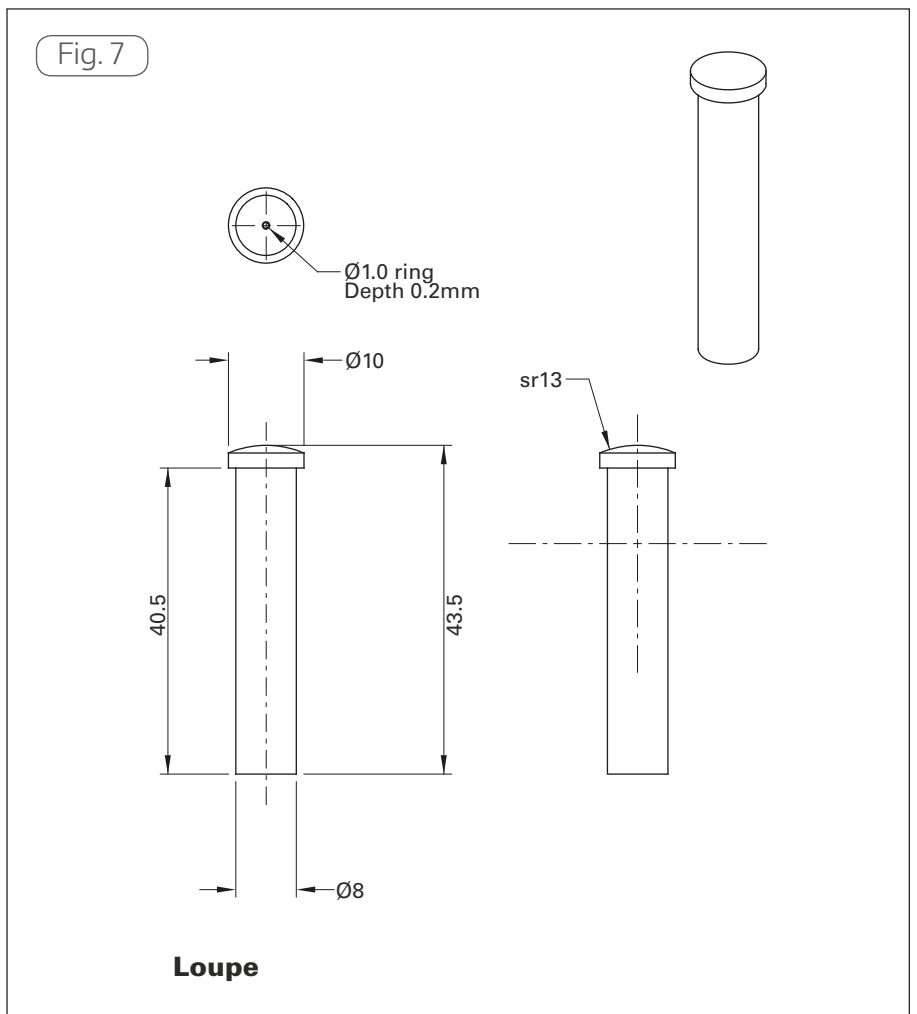
26. The outer Ø8,0 mm diameter is turned, and again this dimension must meet a running fit to the holes in the inner part of the tool

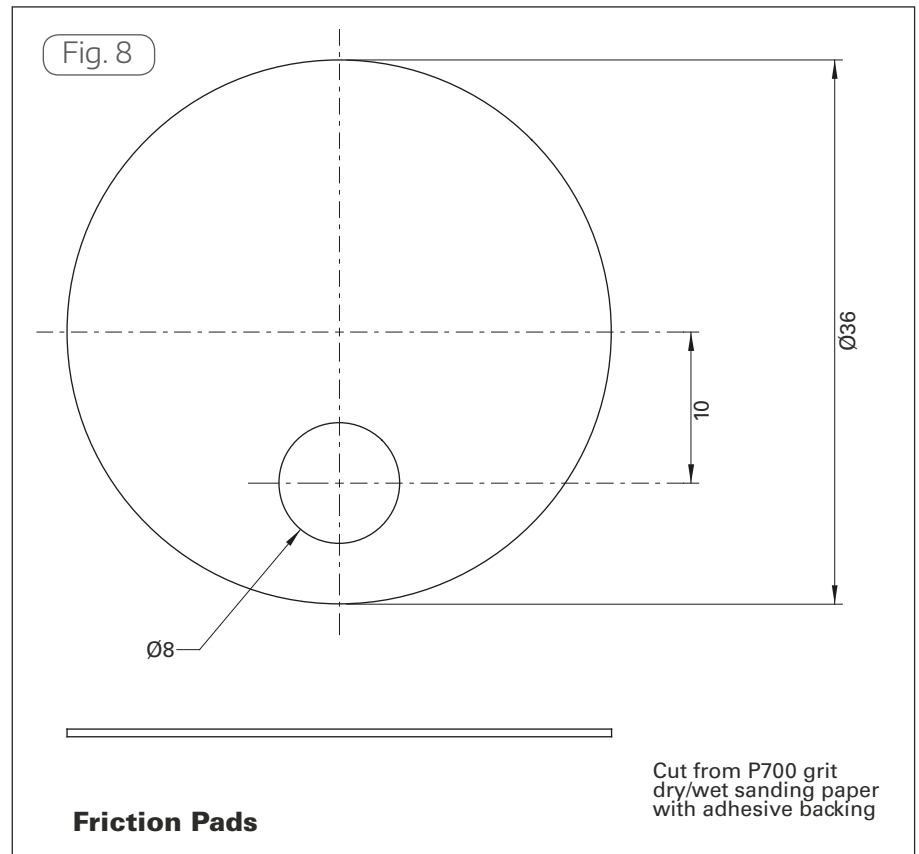
27. The work piece is cut off a little over size in length and the outer Ø12 mm diameter is turned, finally the total final length according to the drawing is turned.

28. Next the tip of the punch is heated to cherry red and drop into some old engine oil, hereby pointed end of the punch is hardened.

29. When only the tipped end is heated, the other end, where you will be hammering is still soft. To end the job on the punch, the part is polish to nice finish

30. In figure 4 of the outer tool body is shown a Ø8,0 mm hole in the bottom of the





part, as it can be hard to find the correct position of this hole, I've waited until now to drill this.

At this stage of the project and with the tool assembled, I can make an exact punch where the hole is to be drilled

30 & 31. After making the punch mark the hole is centre drilled and finally drilled with a Ø8,0 mm drill in the bench drill.

33. The next and final part to make is the optical lens or loupe, **fig. 7.**

This part is made from some Ø10 mm PMMA also known as acrylic or perspex.

Firstly, one end of the lens is faced off and polished with very fine grit [P1200] polishing paper, next a Ø1,0 mm circle was marked with the cutting tool in the lathe

34. Next the outer diameter is turned according to the drawing, once more make sure the measures end up with a nice fit to the Ø8,0 mm hole in the inner body of the tool.

35. To finish the optical lens, the Ø10mm end must be turned with a radius of approximately 13 mm. The sphere, which will provide an enlarged image of the centre, is polished and the lens is ready to be inserted into the tool.

36. When starting to use my new optical centre punch, I found that the tool tended to slip on the surface of a metal plate, and I decided to apply a P700 grit grinding paper with adhesive backing to the tool, **fig. 8.** This way I obtained a very good friction between the tool and a hard surface like a metal plate.

37. Here are two punch marks, placed spot on to the intersecting point of two scribed lines using the tool.

38. Here's the view when the tool is placed over a work piece. ■



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Gear Cutter

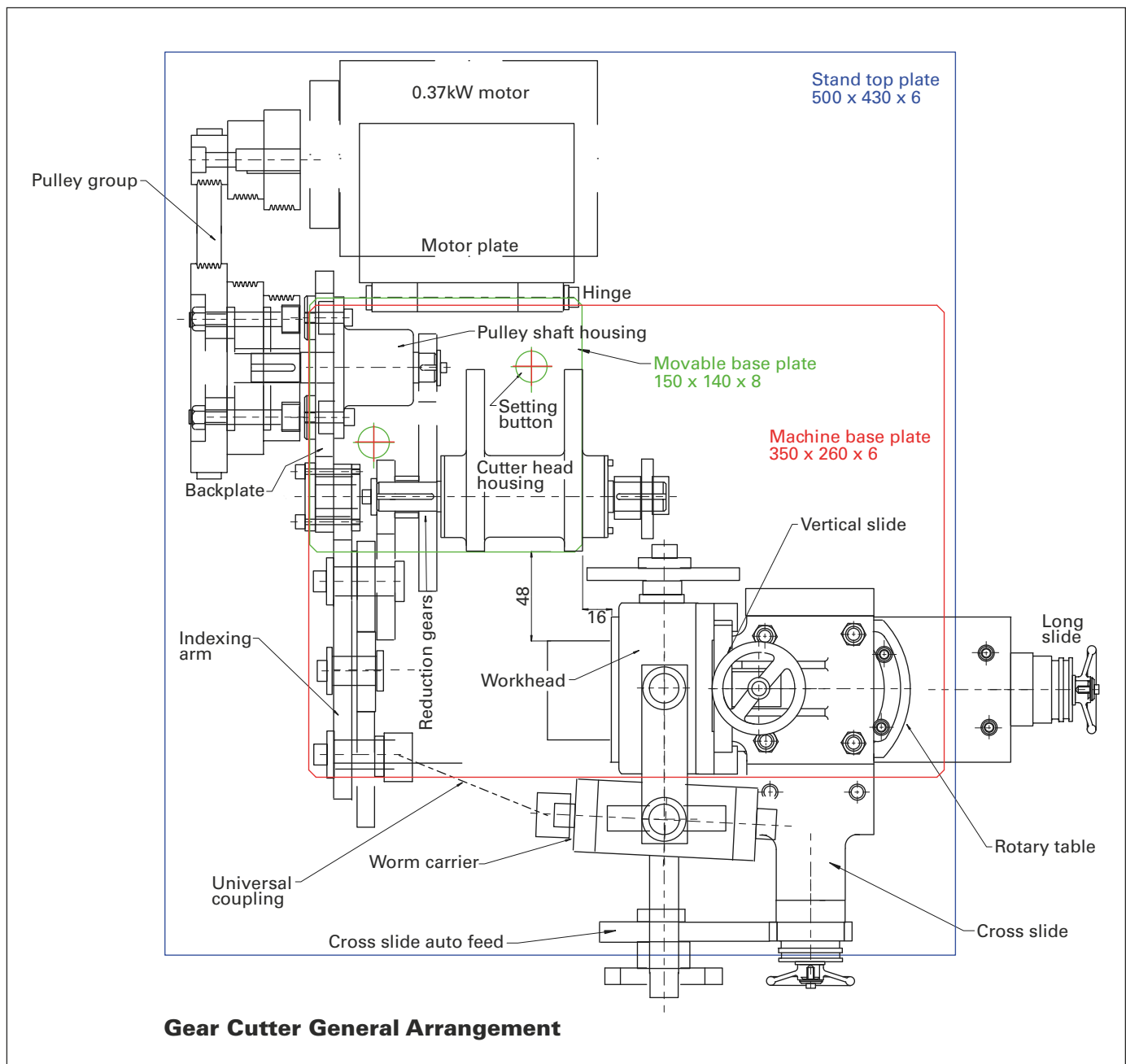
Alan James Aldridge describes a flexible machine for the production of gears in the home workshop

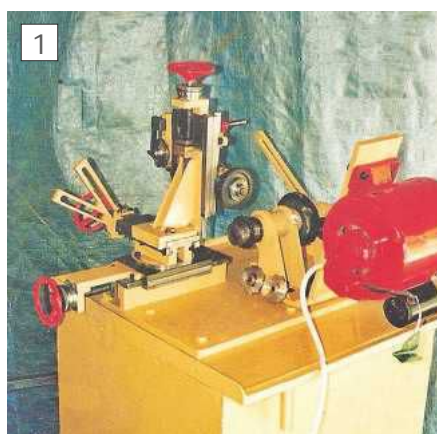
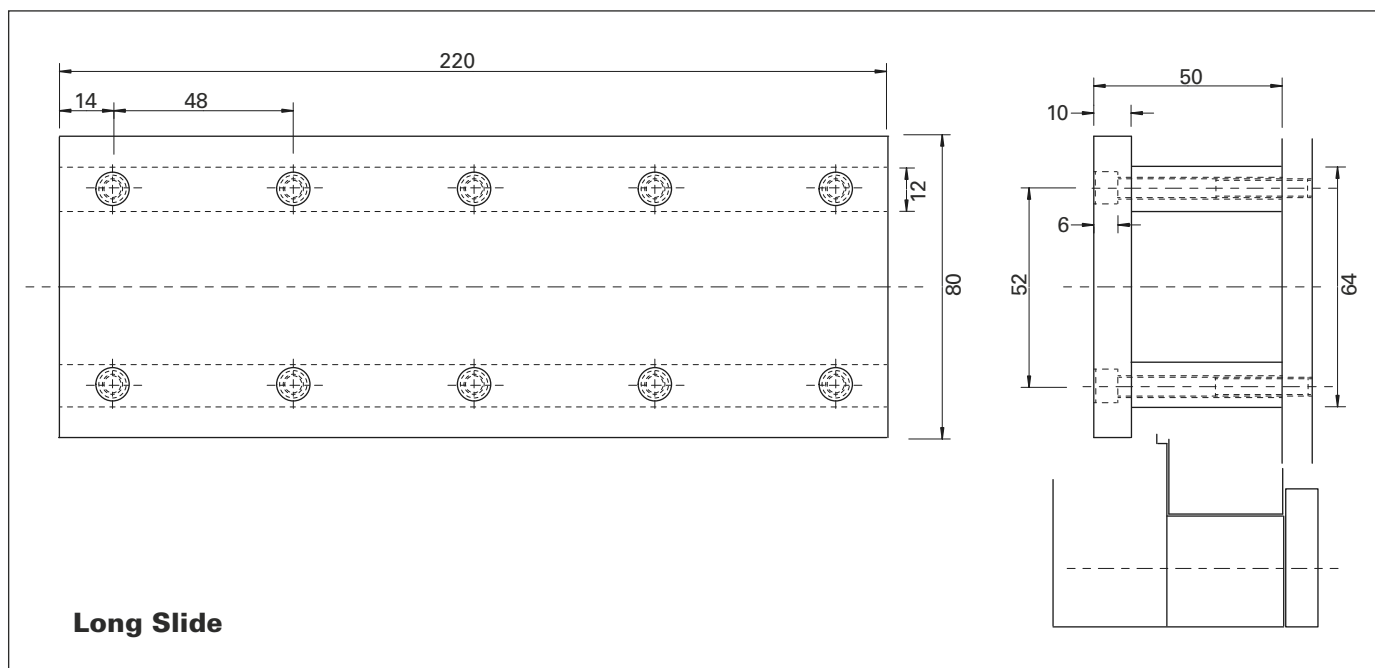
When I decided to make miniature petrol engines in my workshop I looked hard at my facilities to see whether I had sufficient machines and machine attachments for the job. Out of that survey came several requirements, machines for cutting and finishing cams, a sturdy vertical slide and divider, some other smaller equipment, like a port cutter, and a gear cutting machine. The gear cutter was

thought to be necessary as I was following the work of both Edgar T. Westbury and Len Mason almost without question in the early stages of building petrol engines and they employed gears for the timing and oil pump drives. Ultimately, gearing was not employed in the first petrol engine, but the gear cutter has earned its original cost and more, in doing odd jobs and some commercial work for one off small gears and gear trains over

some years and has paid handsomely for equipping my workshop.

The gear cutter was modelled to a limited degree on the early work of Eley who described a machine in the late 1940s (**ref. 1**) reference text: A Gear Cutting Machine, J. S. Eley, Model Engineer, Vol 100, issues 2499-2505 inclusive> and more so on the later work of Jacobs in the latter half of the 1970s (**ref. 2**) <reference





A general view of the gear cutting machine

text: A Gear-Cutting Machine, T. D. Jacobs, Model Engineer, Vol. 142, issues 3529-3533, also see 5641 & 4642>, who made a light machine with a lot of additional equipment which permitted the machine to tackle just about any gear type one could name. The work of Duplex, which was a pen-name of

Norman Hallows and Ian Bradley, as well as that of Martin Cleeve and Dave Lammass also proved to be immensely useful as well, especially with regard to the mathematics of gear cutting, change wheel selection and indexing devices. There is little doubt for those new to gear cutting that it is a step up in terms of knowledge required to sort out the immense amount of new terminology, mathematics and the fiddly add on parts that will complete the machine, which is really not a mystery as long as one has guidance. The main gear cutter is a relatively a simple piece of equipment to make and use.

The basic GearCutter to be described is not a massively complicated machine in any way (**photos 1, 2**). All the basic parts which make up the machine are well within the capacity of most of us and our workshops with much of the work having repeats for tables, slides and the feeding systems. The machine differs from those that preceded it as it is more substantial in its construction, larger in

size, and mounted on its own stand. In its basic form with only the vertical slide and rotating table sat on the lathe cross slide it is capable of cutting spur and bevel gears up to 200 mm in diameter.

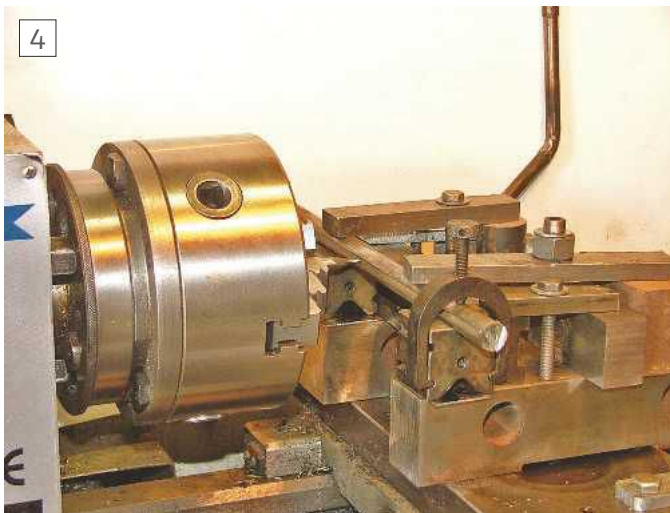
The real advantages of the machine come with building of the special slides, rotating table and the stand, when the number of gear types which can be machined multiplies and to some extent automatic feeding can be applied, which replaces hand feeding, with all the problems associated with patient, regular incremental feeding over a long span of time to gain fine finishes. The actual time to make a gear wheel, once one has all the necessary machinery and cutters to hand, is comparatively quick. A 60-tooth spur can be made from raw steel in less than 90 minutes.

It requires additional equipment for other gear forms to be cut, and still more equipment to produce hobbed gearing, but this is the right way to go as this type of cutting and gearing will permit high



A view of the machine from the far side





Set up for milling a long flat in the lathe



Setting the parts of the angle square

speed trains with little trouble, whereas single tooth cutting will be found wanting over time. The definition of high speed is open to interpretation, but a petrol engine turning over at 2500 rpm is high speed.

The real difficulties in gear cutting have little to do with the construction of the actual machinery but more with the additional equipment required. As the wheel size grows the shape of the flanks of each tooth change from, in the smaller sizes, well rounded flanks to the biggest sizes where the teeth resemble more a straight sided triangle and at the ultimate size the wheel turns into a straight line rack. In each gear train, to be able to cover the full range of tooth profiles from smallest diameter to the biggest, the rack, requires 4 to 5 cutters. Changing from one diametric pitch to another requires another set of cutters. Hobbing will reduce the cutter numbers to one for all gears sharing a common diametric pitch or module. In short, hobbing fulfils two functions; it provides smoother running gears and drastically cuts down on machining time. However, a hob is not a get out of gaol free card; the making of the one hob, will require some alteration to the gear cutter. Essentially this means cutting one's own gear and arranging them on an arm stretching from the original cutter head to the back of the worm drive with a universal joint in between to get the synchronous drive between cutter and gear being cut. One should also make a second arm and set of gears to join the gear drive feed into the hob. But we will have the basic machine to make all these gears.

As described, the machine is capable of being set up to make gears with spiral hobs, and if the builder is willing to buy such hobs and make suitable holders for them, then they will be able to use the machine this way, guided by the articles mentioned above. As far as this series goes, we will conclude by describing the production of gear cutters using the two-button methods using either the Eureka or Duplex backing off devices, and using these cutters with GearCutter.

Even making a single tooth cutter in the workshop requires another cutter and in most cases there has to be yet another attachment for backing off the first cutter's teeth for much the same reasons one would sharpen a standard lathe tool for clearances and rake. Making cutters for cutters is a lengthy, detailed process but not difficult, just a lot of work. The cutters have to be in a hardenable tool steel and the heat treatment can be given to a professional, but it is possible in the home workshop for smaller cutters. Backing off requires a special lathe attachment, but for aluminium, bronze, brass and, to a lesser extent, cast iron gear wheels, backing off can be ignored under some circumstances. The other difficulties associated with gear cutting are finding the information required and being able to understand and apply the mathematics of gear cutting. This is where the work of Duplex, Cleeve, Unwin and Lammas comes in very handy. The mathematics, by and large, can be reduced to running a finger down lists.

Much of the work in producing the machine is routine. In my own design, my workshop facilities have dictated how I have gone about making specific components so the slides are all square not dovetail vees, which I would have preferred, but the necessary take up of clearances works well so guidance is square and well controlled. It does require some hand work but model engineers should be good at that. Although based on the Jacobs design the materials do not include much aluminium, which predominated in the original machine. A larger machine demands everything is in steel. Fabrication employing nuts and cap screws with bright steel sections is the general rule for the construction, which reduces machining though there will have to be some on relatively long length. My large milling machine vice is completely built up in a similar fashion to the gear cutter and is used, and abused, almost on a daily basis. The vice has never been taken to pieces or serviced in any way and apart

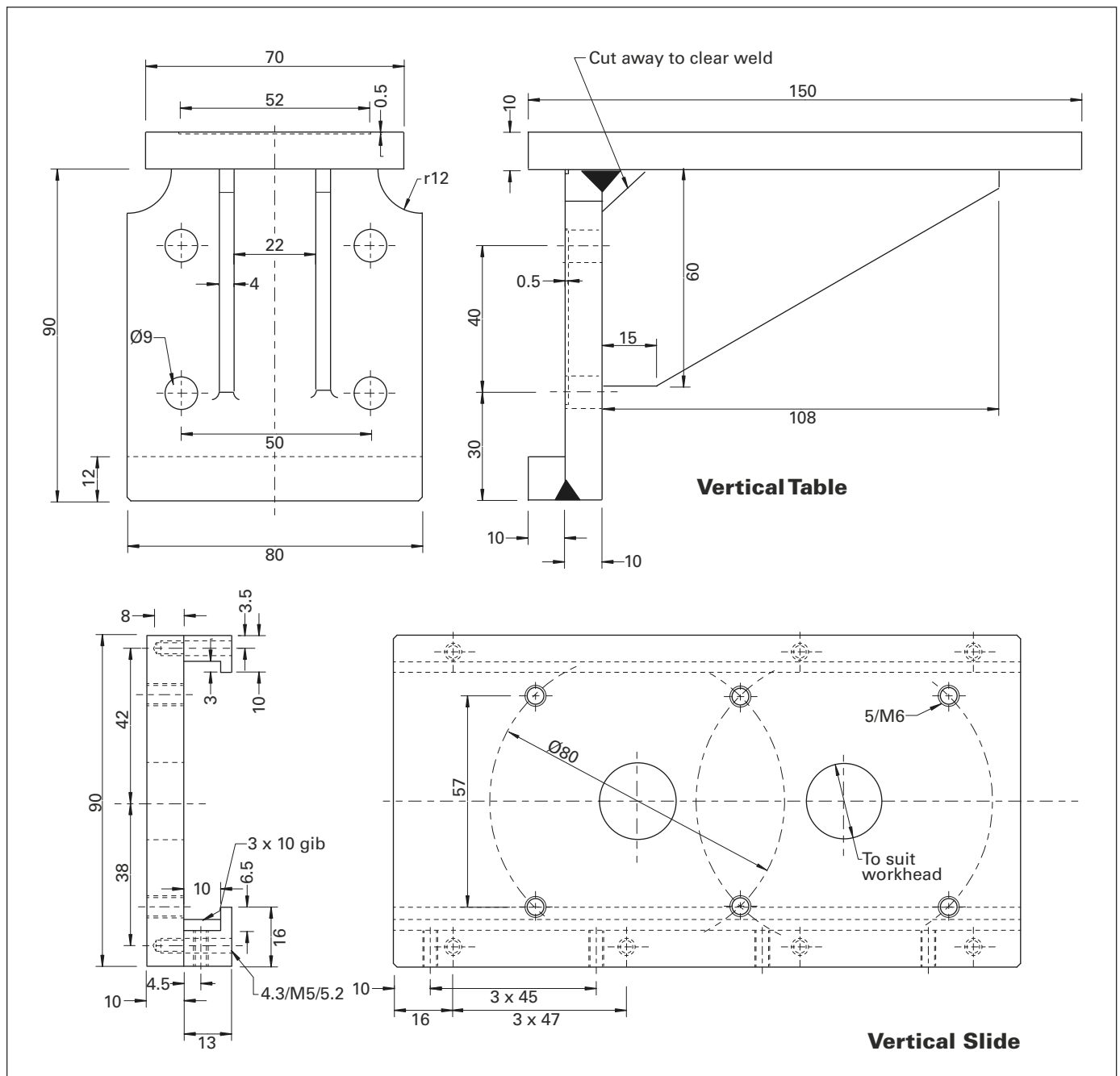
from some machining scars is as good as when it went in use 25 years ago.

The main parts of the gear cutter are described in groups as the building of a slide or a table is much the same in manufacture though the lengths and widths of the item may differ. Once the groups are complete one can proceed to a building up of assemblies for putting down on the lathe. A three week burst of energy saw all the necessary gears made for the gear cutter so the lathe's wheels are no longer used at all on the gear cutter. One will note that the photographs show aluminium wheels which does quite well in the low power service of driving the worm and the feed of the workhead into the gear being cut.

Stand and Machine Base

There are three main baseplates for the machine. The first is the big 5 or 6 mm plate that forms the top of the stand. On this stand two separate thicker plates of smaller dimensions, shown in green and red on the drawing (**fig. 1**). Both these plates should be selected on the basis that they are flat all over, particularly the smaller one. These plates can be guillotined, which was not the case some years ago but suppliers have better machinery for cutting, one could go as far as a laser cutting, if preferred, but the guillotine will do. Steel makers produce a better quality all round product as well. A commercial machine would be surface ground but I am not prepared to pay the price for this work. By careful selection and understanding the limitations flat undressed steel plate will do.

The stand is made from steel sections, angles and square tube. I think once one has finished the gear cutter its overall size will demand a separate stand, as not only is the machine fairly big, as is the Jacobs equivalent, but there will be a considerable amount of gear which will steadily accumulate over time as more and more gears are made. With respect to the top plate the plate should have a guttering as a plentiful supply of cooling oil will also be a part of the machinery. In fact, instead



of a built in suds pump I made a trolley to service a lathe, a milling machine the gear cutter and a cam cutter. The pump comes from a washing machine, which is more than adequate for squirting a healthy stream of cooling liquid to where it is most needed. The gutters around the top plate are fabricated from light angle with welded corners and stitched connections to the big plate. The sealing of the gutters is with epoxy resins. There has to be return line to the trolley pump tank.

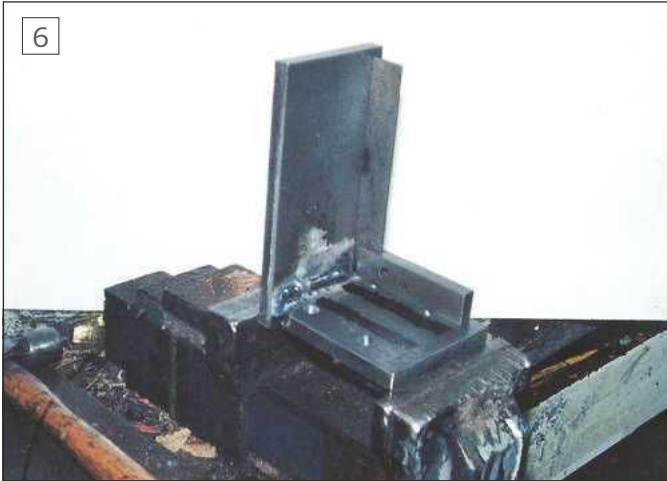
The drawing only shows one but there are two possible machine layouts, the normal for spur gears and most others, but there is a special situation for cutting reamers and other long helical teeth cutters where the green table is swung around 90 degrees to the slides. To accommodate the switch around there will be four holes in the

green base and the underlying main base plate, in red, positioned to be clear of the machinery. Two will be plain through bolt holes the other two will be for two buttons or dowels. For the present the four holes are only required for the standard set out for spur gears. The bolt and buttons and their holes are leakage paths. A commercial household sealant is applied to them, which can be cleaned out easily when a move takes place and re-applied as and when required. For plotting the positions of the holes the accompanying drawing shows convenient formulae. Note when the turnabout happens the motor and cutter head turn through 90 degrees which needs space behind the machine stand. I think over several years I have moved the base around only some four times.

Getting to the best operating position of

the gear cutter with two positions available possibly means the machine should have wheels so it can be wheeled out and turned about to the most convenient position, but that does not usually fit well with rotating workshop machinery, as the machinery sets up vibration and the stand "walks" around. Initially, I had two legs with wheels, and in practice, it was stable enough for most gear cutting. It is now quite heavy due to the large amount of accessories and equipment for the gear cutter, which made manoeuvring the stand tiresome and the stand now has four wheels, which have brakes, to rid the stand of moving problems during cutting operations. The drawing just shows the basic stand as we all have our own ideas as to the best ways of storing stuff.

In the Jacobs machine the use of



Checking alignment after initial weld



Bracing piece tacked in place

cooling oil was simply through having a trough that sat under the cutter, which continuously picked up a small amount. I wanted more than a small amount to wash out the shavings and to cool the cutting edges. The suds pump and tank was originally made for the lathe and sat close to it on small stand. The unit is absolutely utilitarian in construction. The tank is an old oil can, to which has been attached with four lugs for the fixing screws that hold it to the trolley base. The pump can be bought at any household spares store. The type is immaterial, though it appears that there is a single design that fits all. The pump is attached to the can on one side in an aluminium 'casing' which offers a support and some protection from external knocks. The original had a top tank with the suds falling under gravity and a ball operated valve that shuts off flow, but the trolley mounted unit delivers directly to the machinery these days. The complete installation is a closed circuit so a continuous stream of fluid from tank to the jetting arrangement, on to the work, into the trough around the stand top edge and back to the bottom tank, cannot overflow. One will quickly find out when the tank has run dry. The tank has a drain plug. Filling of the tank is simply by dumping fresh oil/water emulsion into the top of the trolley or into the machine tray. A standard on/off switch is sited under the top plate of the trolley to switch off the pump when not required. The usual pump comes with a filter section and has large pipe connection in plastic, which has to be reduced from 25 mm to something smaller for the direct connection into the tank which has a steel fitting brazed in place. In the interests of space saving the pump unit can be screwed on to the tank connection rather than having an intermediate coupling. The delivery side is simpler with a steel screwed barrel fitting and a 13 x 8 mm reinforced plastic tubing delivery pipe. There should be a steel connection at the trough around the machine tray, welded in, so the piping does not come outside the stand outer dimensions. The final connection to the work area is with flexible

piping. **Photograph 3** shows the motor and pump and the connection to the tank. The aluminium cover runs around two sides and over the pump and motor.

Tables

There are three combinations of tables and slides. The first is the long table (**fig. 2**) which carries the slide on which the rotating table sits, and on which is another slide that supports the vertical slide, to which the workhead is fastened and in turn the gear blank. This moves lengthwise on the table below it to align the cutter to the gear wheel blank. The three slides and tables allow the gear blank, to be cut, to move in three planes and rotate to meet any combination of gear cutting requirements. All the tables are built to a similar plan, with bright steel sections bolted together and machined only where necessary. There is also the relief on the underside of slides. One can argue that this is not a necessity when using bright steel sections but it is used by me on all slides as a matter of course. I have the machinery to make the job quick and easy, but one can

cut the slotting with a milling cutter in the lathe and the work on a vertical slide. The value of this relief is that the slide bears on the outer edges of the backing table and not the centre where it might wobble.

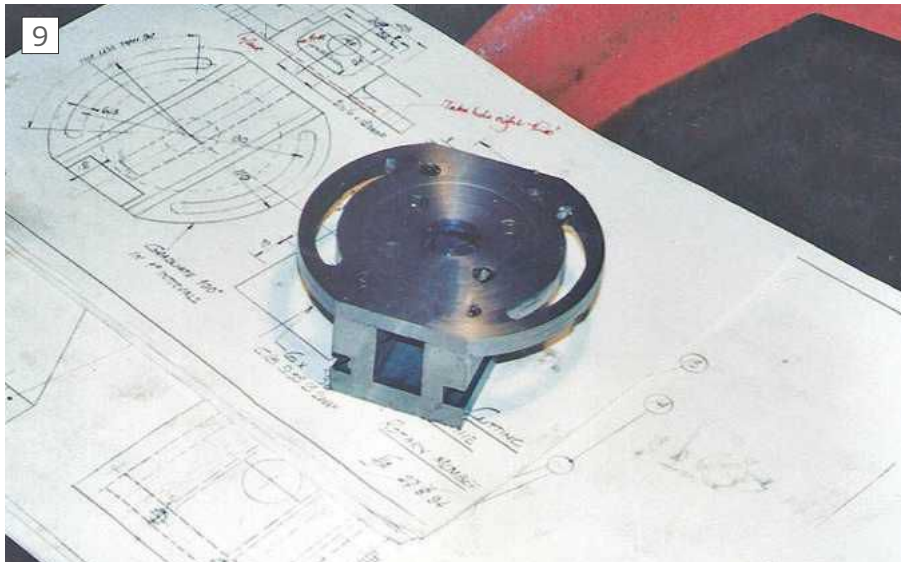
There are plenty of fixing bolts and holes, which tend to get in the way of each other so measuring has to be quite exact. All slides are built to the same construction plan but differ in detail here and there. For instance, the bottom slide for the rotating base has a long tail which enables long travel of the workhead. Rather than use a very long plate to incorporate the slide proper and the tail, the pair are split with the tail made from plain black steel. Some effort is needed to get the tail and slide to have a flush fit at their joint. All screws are cap heads so the countersinking of heads is simple and neat.

The underside of a slide has two guideways made from key steel 12 mm square. These pieces are milled or used as bought if the size is correct but without a milling machine the lathe has to do the job where their size has to be reduced.

Photograph 4 shows, not a gib strip, but



Facing off the bracket.

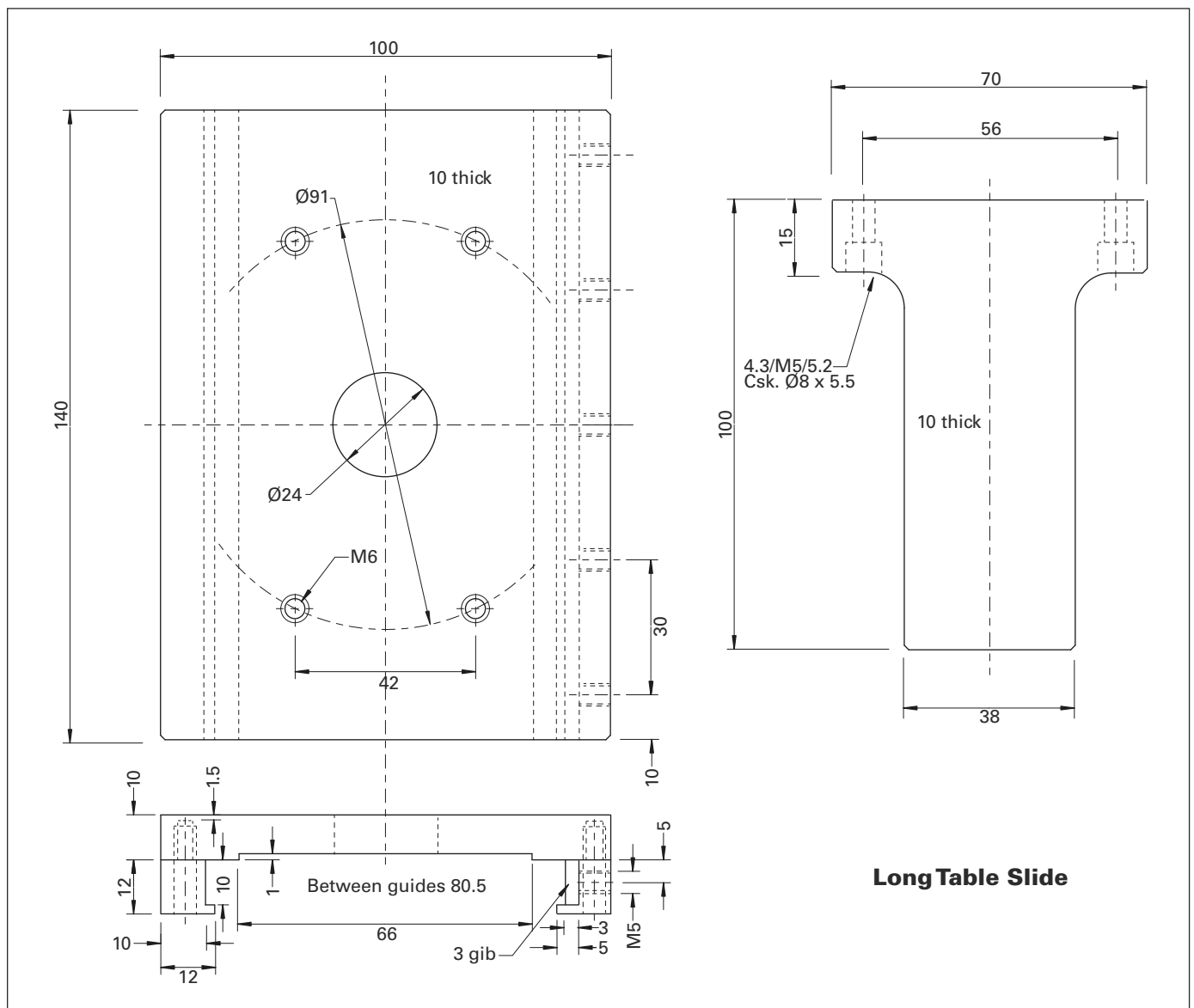


The rotating table

only reach into the gaps between clamps, therefore, a long ground bar, bright steel will do but is second best, is part of the assembly held separately from all the other bits and pieces and properly set out with the dial indicator before the rest of the assembly is put down. It would be a good idea to machine all these gibs, one after the other, to avoid having to do the preliminary setting out of the setting bar several times, which takes a long time. Each gib strip sits against the ground setting bar and is strapped to it with toolmakers clamps and similar tooling. Lightness of touch is essential so the setting bar is not accidentally moved. An alternative is to employ a vice and vertical slide for the same work aligning the slide and then adjusting heights with the slide to bring the work on line. One can check the best setting with a dial indicator as well. ■

a long shaft being milled for a keyway, but the process is exactly the same for the flat strip. The work is lifted to the centre height by spacers, generally bright steel sections,

but I have ground bars as well. Homemade strong backs are pulled down to clamp the assembly. Alignment is critical in this work and here the usual dial indicator can



Long Table Slide

Scribe a line

YOUR CHANCE TO TALK TO US!

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

TIG Welded Boilers

Dear Neil, I enjoyed your MEW No.243 Doncaster review almost as much as I did the actual show which I attended on the Friday. A couple of points if I may, you extol the TIG welding from Steam Technology and refer to the absence of expensive silver solder. On the basis of my own 7 1/4" gauge Black 5 boiler there is approx. £1K of solder used. Although Steam Tech do use Silver Solder for the bushes etc. they are certainly not cheaper, in fact I know of at least one case where they were more expensive than another commercial conventional model boiler maker. I did not look at their sectioned samples (I will next time), the rear one in your photo is welded both sides but the front tube section certainly appears to be a "battered" joint, I would have thought, from past experience, to have seen at least some weld on the "inside" corner but it is remarkably square with no penetration spill.

Finally, do you know of a source of "glue" for acrylic, I deliberately say glue, because a simple solvent approach will not solve a problem, want some bulk in the material used. I could dissolve acrylic shavings in solvent I suppose, but tedious.

Ken Willson, by email



Clogged Up!

Dear Neil, I was only joking, but was sure that my shop would be considered the 'Most Congested' (Reader's Workshops, MEW 243). All that stuff is contained in a shop 10' 9" by 6' 9" external, with 19mm external cladding, on a 50mm frame with 12mm ply lining, and the photo does not show all that is in the foreground.

At least, when moving, I no longer kidney punch myself on the handwheels of the ML7 as in the previous smaller shop! What a difference an extra 10" in the aisle makes!

Howard Lewis, by email

Leadscrew Techniques

Dear Neil, I have been reading with interest, John Pace's excellent article on ACME lead-screw milling (MEW #241 et seq). John has provided a very graphic description of his encounter with the 'dig-in' problem. My advice would be that the correct way to have approached this was to have anticipated the problem by using an easy to fabricate accessory.

I am referring to a 2-part drive-end coupling (i.e. the left half is clamped and centred in the chuck while the right half is socket-coupled (use a spot of superglue - heat to break the bond when finished) to the head-end of the proto-lead-screw. The two coupling halves are joined by a soft, mild-steel shear-pin appropriately dimensioned according to the likely maximum normal cutting forces and refined with a few off-lathe shock-torque experiments (the trigger-point can be fine-tuned by machining a circumferential groove around the shear-plane, the depth of which being determined by experimentation) in other words, I have described a 'mechanical fuse' that, if triggered will, in the first instance, protect the lathe and its drive-train from mechanical damage (an easy No. 1 priority qualifier!) and secondly, either avoid entirely or else limit spoiling the workpiece. An essential accessory adaptor for 'high-stakes' machining projects!

His next - and related - issue concerns pick-up from and gouging of the brass follower fingers. The correct steady rest to have used is

one equipped with hardened roller-tipped support fingers. Over the years there have been several such projects published all utilising roller bearings of sufficient width to bridge over at least two thread crests. However, for this particular application the roller design can be 'gazumped' by a spring-loaded single ball arrangement sized such that its periphery will smoothly roll and ride in the developing thread-form. It almost goes without mention but that the steady should have attached to it a drip-feed lubricator to keep the contact-point well lubricated.

Finally, he was remiss in not commencing machining operations with a roughing cut using a V-form threading tool with a 90° included angle. This would have substantially reduced the extreme loading on the ACME form tool for the finishing cuts, in turn, reducing - if not entirely avoiding - the micro-flexing of the ACME tool-tip which I suspect is primarily the culprit of the 'dig-in' phenomenon.

Together, these three measures could have avoided the need to resort to milling the thread (albeit that a portable milling head is extremely useful in other machining operations).

John is to be applauded for candidly disclosing these problems and I hope that he is not dissuaded from future articles by my criticisms as they were intended to be constructive.

Andre Rousseau, France.

We would love to hear your comments, questions and feedback about MEW

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Fixed Column for an X1 Mill



Mike Cox undertakes a fixed column modification to his Sieg Super X1L mill

I have had my Sieg Super X1L (SX1L) mill for several years. It has served me very well during that time. It is a small machine, **photo 1**, with only a 150 watt motor so big cuts are not possible but this can usually be overcome by taking a succession of smaller cuts. I have made a number of modifications to the machine to improve its capabilities, such as adding stops, converting it to belt drive and adding a power feed on the x axis.

The one feature of the mill that I have never used is the tilting column. One reason for this is because it took me so long to get the mill to tram correctly when I first had it that I have been reluctant to do anything that might upset the tram. The other reason is that it is usually relatively easy to mount the work piece at an angle and this negates the requirement to tilt the column.

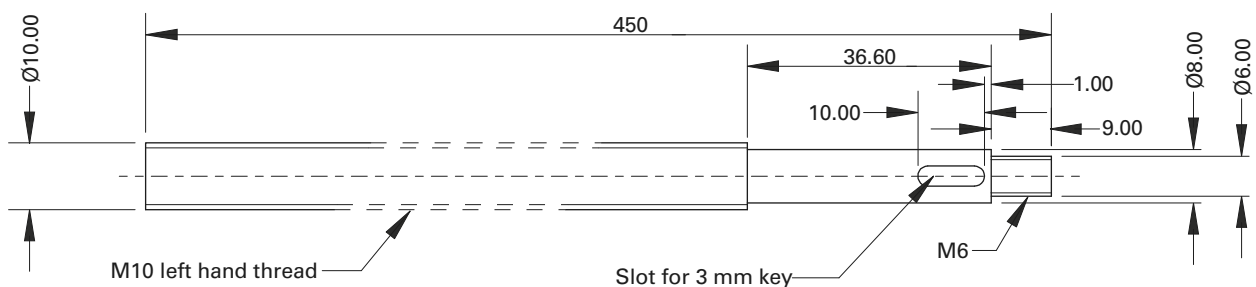
There are other disadvantages to a tilting column. Any tilting mechanism introduces some places where unwanted movement can occur and this can reduce the rigidity. In the case of the SX1L tilting mechanism it is actually fairly robust and I do not think this is a big problem. The other downside of the SX1L tilting mechanism is that it limits the downward movement of the headstock. This is not a problem in normal use but it becomes a problem if the height of the column is extended using riser blocks.

The mill was mounted in a small tray that was barely the size of the base of the mill. This did not catch any oil that dripped off the end of the mill table. The base casting was also quite rough in places and the roughness collected oil and dirt.

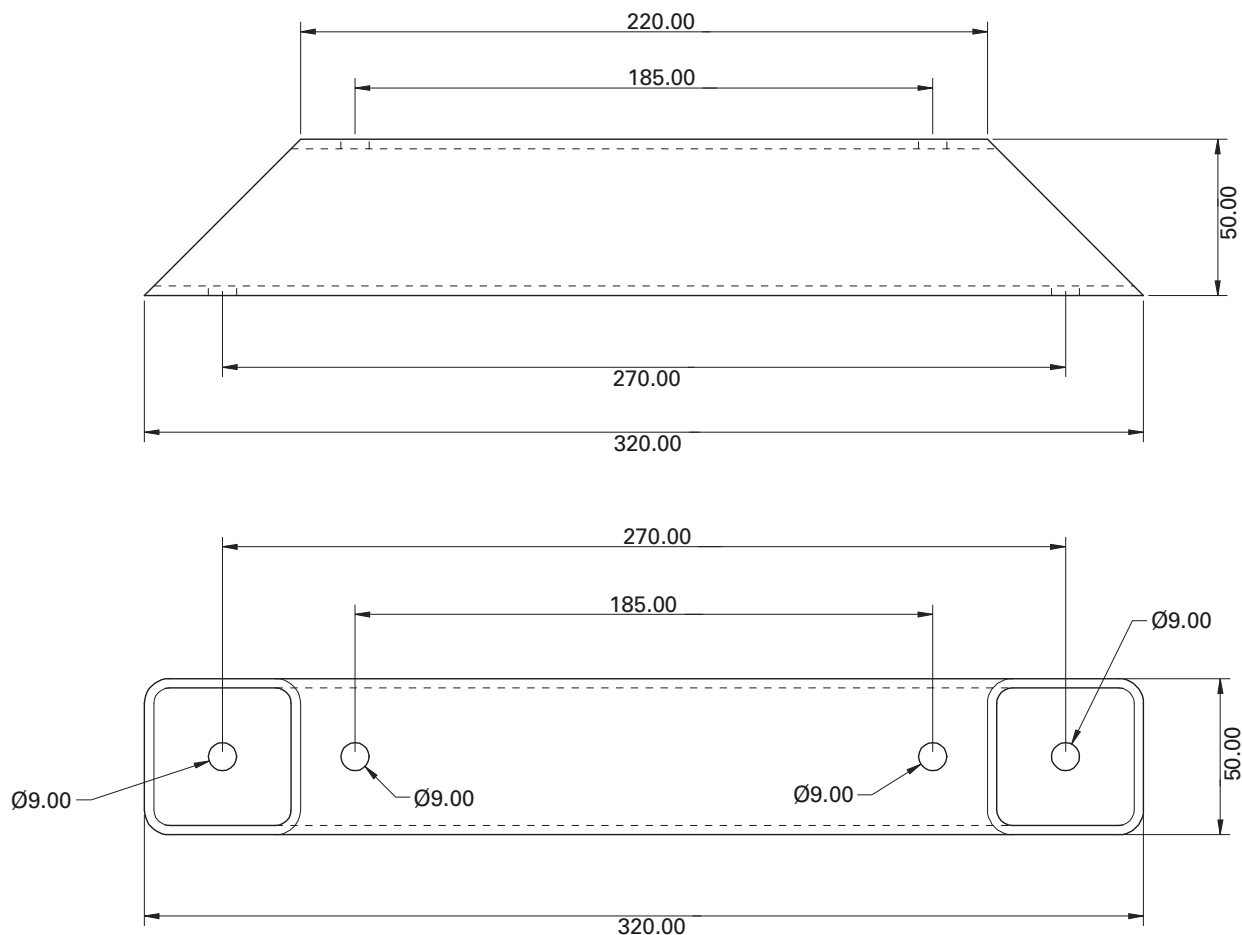
The project described here was instigated to get rid of the tilting mechanism and



General view of the mill after modification.



The Leadscrew



Mill Riser Blocks

Mat'l: 50 x 50 x 3mm steel box section, 2 off



The end of the extended leadscrew after machining.

to increase the range of height of the headstock above the mill table.

A secondary objective was to mount the mill in a much larger tray on raising blocks so that any oil and swarf were contained rather than messing up the bench. I also wanted to remove some of the rough spots from the base casting and repaint it in order to improve the appearance and make it easier to keep clean.

Project planning

The first task was to source the fixed column. I purchased the mill (product code 080-030-00215) from ArcEuroTrade (ARC). They did not list the fixed column as a standard option or as a replacement part. However, I left an enquiry on their website asking whether it was possible to get one. The following day I had a telephone call from ARC and after some discussion about

what I was proposing to do they agreed to supply the fixed column as a special order. This had to be ordered from Sieg in China so there would be a bit of a wait. The fixed column is a spare part to the original X1 mill not the SX1L. I understand that ARC have now added it to their spares section for the X1 mill on their website.

Whilst waiting for the column I searched eBay to find a suitable tray. I found a good sized plastic tray from a supplier of garden products that was 790 x 400 x 50 mm. It was described as 'Garland Maxi Garden Tray Black'. This was intended for standing plant pots on but was actually the perfect size for the mill. I already had some 50 x 50 x 3 mm square box section steel that I could use to raise the mill to the height of the tray.

I also ordered some 20 x 75 mm bright mild steel bar to make a mounting plate for the column and some 25 x 50 mm steel for the column raising blocks. When this arrived I carefully checked it for dimensional uniformity and straightness. There was not more than 0.06 mm variation in thickness or width of the bars along the length. Straightness was checked against a steel rule.

The z axis leadscrew is threaded M10

with a left hand thread. I planned to increase the length of the leadscrew so I needed to source some M10 left hand threaded rod. This was not straightforward. I eventually discovered a company called GWR Fasteners that supply M10 left hand threaded A2 stainless steel in 500 mm lengths as a standard item. This was duly ordered and it arrived very quickly.

The last item I needed to acquire was some paint to roughly match the colour of the mill castings. I had some parts of the mill that I had removed when I did the belt drive conversion. I went to a few stores with the top of the gearbox cover to try to find a colour match. It turned out that the local Wilko store had gloss exterior paint in the colour Signal Red which was a good match.

The final part of the planning was to think carefully about whether any parts would need to be milled to do the conversion, since these would have to be made before dismantling the machine. At first I thought I would need to mill the steel for the fixed column mounting plate and riser blocks. However, since the steel supplied was of uniform dimensions and straightness I decided that milling was not necessary. The only part that would require milling was a keyway in the z-axis leadscrew.

Photo 1 shows the finished fixed column modified mill. The new fixed column is clearly visible. Also visible in the photo are the belt drive at the top of the headstock, the power feed on the x axis on the left hand side and the x axis stops along the front of the milling table.

The leadscrew

The leadscrew, **fig 1**, was a simple turning



The finished mill riser blocks.

job that was carried out on the stainless steel M10 left hand threaded rod. One end was turned down to 8 mm for a distance of 45.5 mm. The end of this was then turned down to 6 mm for a length of 9 mm and then threaded M6 using the tailstock die holder. The rod was then cut to length on the bandsaw and the other end faced and chamfered in the lathe.

The bar was gripped by the 8 mm section in a small vice mounted on the milling machine table and the key slot was cut using a 3 mm slot drill. This operation must be carried out before starting to dismantle the milling machine.

The end of the finished leadscrew is shown in **photo 2**.

Having made the new longer leadscrew the mill could now be dismantled. ArcEuroTrade publish an excellent guide to dismantling and reassembly of the SX1L mill available as a free download on their website.

The tray and mill riser blocks

The tray required little preparation. It had some shallow ribs, about 1.5 mm deep moulded into the back. It was placed in position on the bench.

Two mill riser blocks were made from 50 x 50 x 3 mm box section steel, **fig 2**. They were cut to length on the bandsaw and then drilled as shown. **Photograph 3** shows the finished mill riser blocks.

The base of the mill was then attached to the risers using M8 bolts. The base was positioned in the tray and holes drilled through the tray and bench at the outer hole positions of the risers. Before bolting the risers down a 1.5 mm thick penny washer was positioned between the tray and the bench at each hole position so that the tray did not distort at the ribs.

The adaptor plate

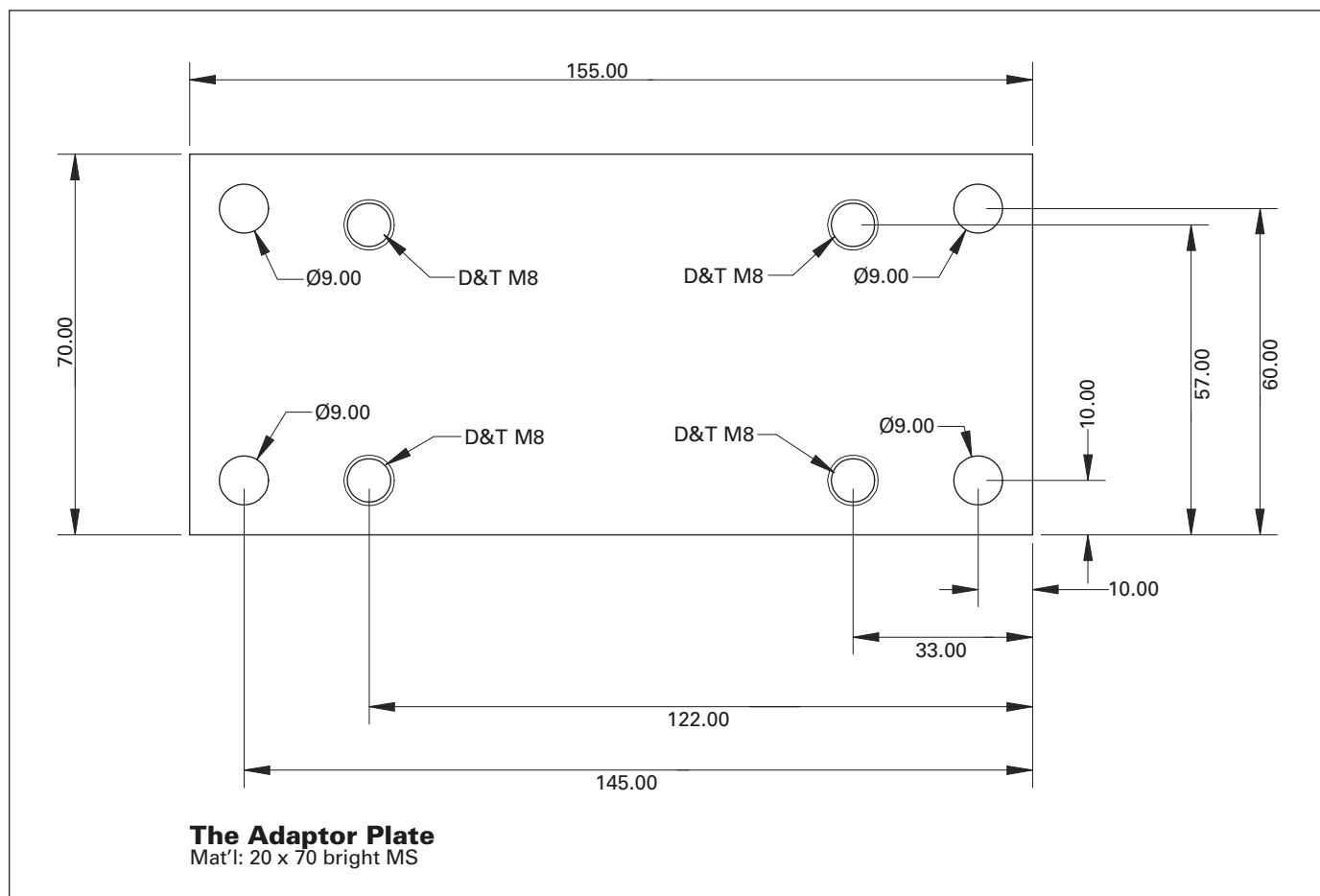
The base of the fixed column is smaller than the base of the tilting column so an adaptor plate is required, **fig 3**. This was made from



The base of the mill with the riser blocks and support plate.



The base after cleaning up and painting.



The new column fixed to the support plate and riser blocks.

20x 70 mm bright mild steel. This was cut to length, marked out and drilled as shown. The centre holes, for the fixed column were drilled out 6.8 mm and then tapped M8. The outside holes were drilled out 9 mm. All the holes were carefully de-burred after drilling and the plate was gently rubbed in a figure of eight motion on wet silicon carbide paper supported on a flat granite slab to remove any high spots. Note: All critical dimensions should be checked against actual machine measurements before marking out and drilling since ARC advise they may vary a little.

The column riser blocks.

The two column riser blocks were made from 25 x 50 mm bright mild steel bar, **fig 4**. These were cut to length and drilled as

shown in the drawing. They were carefully de-burred and rubbed on silicon carbide paper as described above.

Photograph 4 shows the base of the mill with the two column riser blocks and the adaptor plate in position.

The base was carefully cleaned up using a small grindstone in a Dremel type tool to remove the rough spots on the casting

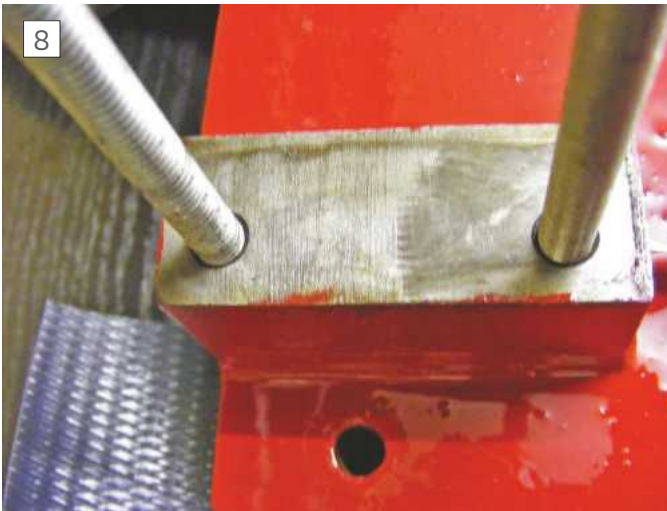
so that it could be painted. The base was detached from the mill riser blocks and plastic strips placed under the base to prevent the paint going on the riser blocks, **photo 5**. At the same time the column riser blocks were painted with the same red paint and the adaptor plate was painted matt black.

Assembly

The adaptor plate and riser blocks are



The set up for trammings the mill.



The left hand base pad.



The mill column mounted on the milling table for truing up the base pads.

attached to the base using M8 studs. The new column was then attached to the support plate using M8 screws, **photo 6**.

The rest of the mill was then reassembled with the new longer leadscrew replacing the old one. The finished conversion was shown in **photo 1**.

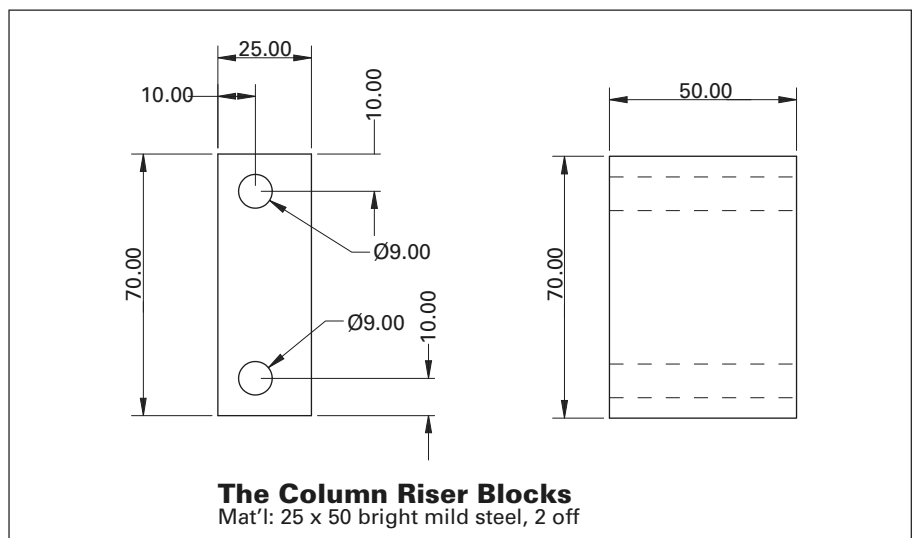
Tramming the mill

Photograph 7 shows the set up for tramming the mill. This consists of a brake disc which is lying on the mill table and a dial gauge that is held in the drill chuck on some extender rods that can sweep round the disc. Brake discs are manufactured to extremely high dimensional tolerance so they provide a very good test surface. The disc shown is a Ford Fiesta disc that was purchased on ebay.

In principle tramming the mill should be straightforward. If the column leans forward, then some shim is placed under the front of the raising blocks. If it leans back, then the shims are placed under the back of the raising blocks. If it leans to the right, then shims are placed under the right hand block and if it leans left then the shims naturally go under the left hand block.

When I started this procedure it was impossible to get consistent results. The column would tilt one way, correcting shims would be inserted but instead of improving the tram sometimes the opposite was observed. I remembered that when I first had the mill it was very frustrating trying to adjust the tram for the same reason.

I dismantled the mill to investigate why tramming was so difficult. I had checked the steel that I used for the adaptor plate and riser blocks so I was fairly sure that these were not the cause. On removing the column and the riser blocks from the base of the mill and making a few checks the reason for the difficulty in tramming was obvious. **Photograph 8** shows the left hand pad that the column is fixed to. It can be seen that the surface of the pad appears different on the left hand side of the photo to that on the right hand side of the photo. Close examination shows that the machining marks go in different directions



on the two halves. Placing a straight edge on the right hand side of the pad it was possible to slip a 0.3 mm feeler gauge under the left hand end of the pad. The right hand pad was similar but the lack of uniformity was not so marked. On reading the ArcEuroTrade guide to dismantling and reassembly of the SX1L mill I noticed that they do indeed recommend filling or milling away the centres of the two mounting pads presumably to eliminate any column rock and difficulties in tramming.

Since I had the column off the machine I decided to make some short adaptor bars that would allow me to mount the column on the milling table, **photo 9**. Note the new extended leadscrew in the photo. This enabled the mill headstock to be lowered right down to close to the bottom of the column and with a 12 mm milling cutter in the spindle it was possible to sweep the tool, using the milling table handwheels, over the two pads on the mill base to true them up. A total cut of 0.35 mm was necessary to bring both pads to the same level all over although this was made with light cuts in three passes. It should be noted that machining the pads in this way ensures that the pads are exactly parallel to the movement of the milling table.

Photograph 10 shows the appearance of the left hand pad after the machining operation. This operation would have been impossible with the old tilting column because it would not have been possible to bring the headstock down low enough because of the pivot casting.

The mill was then dismantled again and reassembled with the column mounted on the base pads. The mill was then re-trammed. This was a very straightforward operation and only a small piece of aluminium foil was required under the front of left hand riser block to bring the mill into perfect tram.



The left hand base pad after milling.



The headstock at its lowest height.



The headstock at its maximum height.

Conclusions

Apart from the problems tramming the mill the whole project was very straight forward. Even the tramming problem was very easily solved once I realised the possibility of mounting the column on the mill table and using the mill itself to true up the mounting pads.

The much larger tray that the mill is mounted in should prevent oil from being sprayed over the bench and catch the drips from the milling table. The current arrangement of the tray with the mill riser blocks also solves an annoying problem

that I had because the y axis handwheel used to rub on the edge of the old tray. Now the tray does not restrict the y axis movement.

The clean up of the base casting and repainting it has made the surface much smoother and it should be easier to clean.

The standard SX1L mill from ArcEuroTrade has a spindle to table range quoted as 45-265 mm. After the modifications described here the spindle to table range is from 17 mm to 350 mm, **photos 11 & 12**, which is a really useful increase.

The ease of tramming is much improved

now that the pads on the base casting have been machined. I have to thank the staff at ArcEuroTrade for their help and technical support throughout this project.

Suppliers

Column and advice. ArcEuroTrade Ltd.
Website: www.arceurotrade.co.uk

M10 LH threaded rod. GWR Fasteners Ltd.
Website: www.gwr-fasteners.co.uk

Steel. M-Machine.
Website: www.m-machine-metals.co.uk ■

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One Man and his Lathe



Anthony Reid tells a Tale of Two Lathes, South Bend and Boxford.

For many years I have had a South Bend 9-inch lathe model B, manufactured in 1942. Although it still produced good work the motor was playing up, often sticking and needing a nudge to start it. Recently I was offered a Boxford 4½ inch CUD at a knock down price. I conceived the idea of using parts from the South Bend to convert the Boxford to a BUD. It did not quite work out like that but the story may be of interest.

As most engineers will know the Boxford 4½ inch lathe is, like several other brands, a close copy of the American South Bend but with several worth while improvements. My workshop is very small, a divided off bit of the garage. The South Bend is rear drive by three speed flat belt, plus the back gear ratios. The countershaft carrier sits behind the lathe on the same wooden bench and also mounts the motor driving to a ten-inch flat pulley so it takes up quite a bit of space, **photo 1**. One of the main advantages of the CUD arrangement for me was that it was much narrower and would give me more room, also it was five speed by pulleys plus several other small advantages, but I wasn't prepared to give up my auto traverse on both axes.

The lathe was delivered to my workshop by three strong men, **photo 2**. On its stand



The South Bend

it is very heavy. All the main dimensions and arrangement of both lathes are the same so it appeared that I could swap the apron and lead-screw and the Boxford would become a BUD and the American machine a model C which I would then sell, but not

without regret after all this time. I would probably need a new cross slide screw as well if that on the Boxford didn't already have the auto drive gear. Naturally I had sought advice on the project and it seemed to be straight forward. **Photo 3** shows the difference in the two aprons. The lead-screw has to go with the apron as it has the auto drive key-way unlike the Boxford one. I discovered when I removed the SB apron that the top of the cast in bearing that retained the worm for the auto traverse was broken, the crack can be seen in the photo. Surprisingly this doesn't make much difference once the lathe is assembled since the worm is retained by the lead-screw and the remaining bit of the cast bearing locates it laterally. I made a new cover for the worm wheel sump with an extension that goes up over the top of the broken bit and holds it more or less in place.

The South Bend apron fitted the Boxford no problem until I tried to move the carriage with the hand wheel when it became obvious that there was something wrong. Removed it and compared the two more closely. The Boxford drive pinion has two more teeth than the South Bend! The fact that the American lathe has a slightly coarser pitch rack and pinion is noted just in passing in lathes.co.uk's website but I had



The Boxford as delivered



The two aprons



The inverter

missed it.

My first thought was to change the pinions. This proved not possible as the South Bend pinion was longer than that on the CUD due to the differences in the apron castings, the bosses for carrying the pinion shaft being raised on the outside of the A/B apron and the inside of the C apron. OK I thought, what about changing the rack. The rack on the SB is secured by countersunk screws through the bed, that on the CUD by recessed socket screws of a slightly larger diameter. So I could conceivably drill and tap the SB rack to fit the Boxford but not vice versa. I wanted to end up with two good lathes and I wasn't keen on modifying the SB bed.

Before going any further I thought I had better try the Boxford apron on the SB saddle anyway. It didn't fit. The top of the apron was too wide for the rebate in the saddle. It seems the two lathes are not siblings but cousins. With the difficulties mounting I decided to abandon the project and instead spend a bit on the SB to gain at least some of the advantages I had sought.

First thing was a new motor. I had always been put off going to three phase because of the cost of the inverter but with cheaper Chinese items available I decided to give it a go. The 1.5 kW inverter was £75 delivered, on Ebay, **photo 4**. The first one arrived with the case broken in transit but the seller changed it with no cost to me. Next a new 1/2 HP three phase TEC motor, again on Ebay for £58 delivered. The motor was quite a bit smaller and lighter than the 1/3 HP single phase I had been using allowing the countershaft arrangement to be moved nearer to the lathe bed.

Before fitting that the job was to replace the original drive arrangement of a wedge belt from a V pulley on the motor to a ten inch countershaft flat pulley, with poly V multi rib pulleys and belt, the advantage being that much smaller pulleys could be used. There is a fund of design information for these belts on the web and I decided that an eight rib J section belt would do the job.

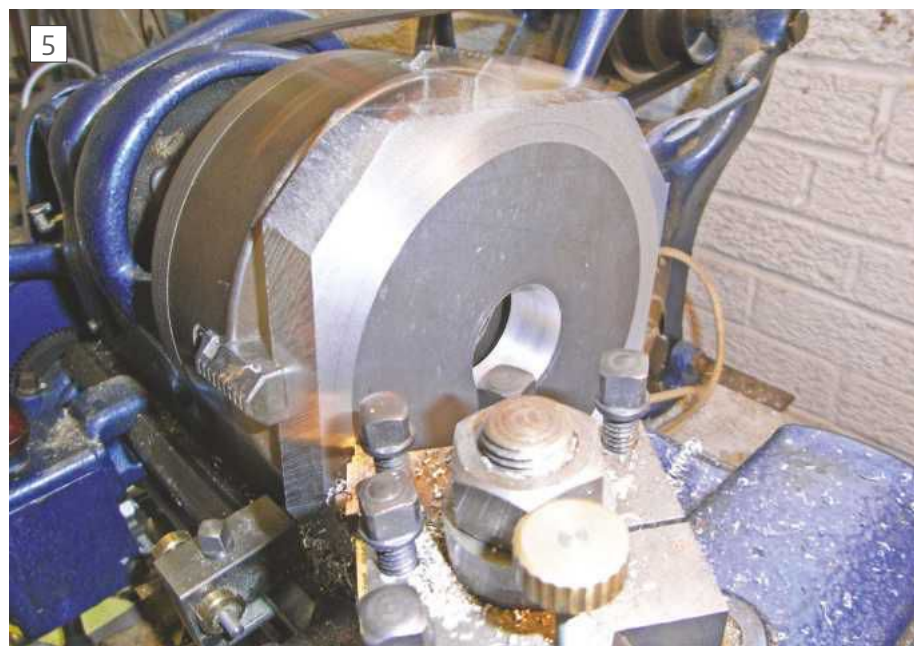
I chose to make the pulleys from

aluminium. The motor pulley was easy enough from 1 1/4" bar, the V ribs cut as for the larger pulley below. For the driven pulley to minimise expense and machining I decided to make it from 22mm aluminium plate with a separately made hub both to take a grub screw to lock it to the countershaft and also to provide a means of holding it in the lathe while the rim of the pulley was machined. The hub was made first from 2-inch bar stepped down to 1 1/2" for the thickness of the plate and drilled and tapped for the locking screw. The 22mm plate was bored and faced to be a snug fit on it, **photo 5**. Skimmed face to the hub shoulder it was secured to the hub with a high strength anaerobic adhesive. To be on the safe side, though probably unnecessarily, I drilled and tapped the adhered junction for three grub screws parallel to the axis to mechanically lock it.

With the hub fitted I could grip it in the chuck to enable machining the large diameter. The other side of the blank and

hub assembly was faced, (this and the previous operation is where I bless my powered cross travel) and the the periphery machined. To machine the V grooves I ground a tool to as near 40° as possible, set the top slide to 20° and mounted a dti parallel to the bed and touching the carriage. With the tool just touching at the right hand edge of the first groove and the carriage locked I wound the top slide in 85 thou. Then wound it out moved the carriage the 2.34 mm of the belt rib pitch, locked it again and cut the second groove and so on. **Photo 6** shows the arrangement. (Sorry about the mixed dimensions but the belts are specified in metric and my imperial clock gauge had just broken.)

Now I could mount the new motor and pulleys, ascertain the length of the poly rib belts required and order them. I would need a new one for the three step flat pulleys as well. A slight digression, following a tip on a SB forum I had long been using a poly rib belt as a flat belt to drive the lathe. A ten



Facing the pulley blank

rib J belt is just less than an inch. They are much cheaper than made for the job jointed flat belts. It worked well for a while but the rubber started to get polished and was slipping more and more. Thinking about this I remembered that as an apprentice many years ago one of my jobs was to paint belt dressing onto belts from an overhead shaft. Nowadays it is sold in aerosol cans, mainly for automotive use. One application two or three years ago and belt slipping problems were completely eliminated.

The downside of using an endless belt of course is that the spindle and back gear has to be removed, as well as the countershaft, to fit it. **Photo 7** shows the South Bend spindle removed. After more than seventy years running I could detect absolutely no wear on it, confirming the legend that the SB bed will wear out before the bearings. With the new shorter belt fitted the belt tensioning arm was far too long. A new adjustable single threaded rod was made fitted into cylindrical stubs at each end instead of the original left/right adjuster on bars with bent ends which had served up till now. **Photo 8** shows the new drive system. I shall probably add a tensioning roller to the motor belt as they do stretch slightly over time, and it will improve the small pulley wrap around.

The bench and lathe could now be moved back against the wall both making it more rigid and gaining me seven inches of valuable workshop space and incidentally stopping tools and swarf falling into the hard to reach void behind the bench.

A few words about the Chinese inverter, it's early days but up till now it's been doing what I ask of it without trouble. There are well over a hundred different parameters that can be set but in practice about ten will suffice for most users. The manual is very comprehensive but does take some wading through. The only item in it I have found misleading is that PD013 must be set to 1 initially or there may be no output. The numbers on the display are altered using the up/down arrows but what is not immediately obvious is that the active digit which flashes can be moved along the display using the double arrow key. As delivered the voltage was set to 220, the base frequency 50 Hz and the run up and run down time were set to 18 seconds. I set mine to 3 sec. run up (PD014) and coast stop, i.e. the power is removed (PD026). Should you wish for some reason to have a controlled run down (PD015) then there is provision for an emergency stop button and even DC braking. Setting PD001 to 1 gives external control so I can use the original South Bend switch to start and stop. I won't go through other setting but to say that the voltage output should be set to the motor name plate value, 230 v in my case, the minimum and maximum frequency can be set, I am using 20 and 75 Hz for these initially until I see how the motor likes it. I haven't tried external potentiometer control of the speed yet, I'll see if I need it.



Machining the v-grooves



The South Bend spindle

The inverter does have one serious fault though in that there are no proper cable restraints. I made up some cable grips out of plastic. The whine from the fan is slightly annoying, I will probably try disabling this or at least slowing it down once I have more experience with the inverter as I am operating it well below its stated rating of 2 HP.

Some may think it was a lot of work to gain a few inches but it is valuable space to me, and I needed a new motor anyway and now have a lovely smooth run up and variable speed as well, and I keep my well loved South Bend. Now I just need those large diameter cross and top slide dials. And I have a Boxford to sell. ■



The new drive

A Drill Chuck for a budget mini drill



Unable to buy a proper chuck to fit a budget mini drill, Alan Wain resorted to modifying an alternative type to suit.

A few years ago, on a whim, I bought a mains-powered budget mini drill on 'special offer' from my local Aldi supermarket; it must have been cheap, otherwise I wouldn't have bought it. The drill has speed control and has been very useful for intricate grinding and cut-off jobs, as well as proving its worth under my ageing car on more than a couple of occasions. In my opinion, the tool is let down by the poor collet chuck system widely used with these mini drills. Usually made from brass, the collets don't grip very tightly and soon wear out if the tool spins. Also, to use a reasonable range of drills, special types are required on a common size shank.

Although not difficult to make, replacement collets purchased commercially seem outrageously priced for what they are and I have resorted to making some when I ran out. I browsed the internet for a proper chuck to fit mini drills but could not find one suitable for the 8 x 0.75mm thread on the spindle of my example. What I did spot during my search, were small chucks with a 1/4-inch hexagonal drive, sometimes referred to as 'screwdriver chucks' because they fit battery-powered screwdrivers. This jogged my memory that I actually owned such a chuck that had languished, unused, in a drawer for so long that I can't remember how or why I had acquired it. The unmodified drill and hexagonal drive chuck are shown in **photo 1**.

Duly resurrected from idleness, the chuck was taken apart to see how it could be modified for use on the mini drill. The first thought was to simply drill out the backplate and re-thread to fit the 8mm spindle. However, after careful measurement I realised that this wouldn't work because the mini drill spindle is too short, and 4mm of the available 14mm of thread are shrouded by the nose of the drill body. The disc that pushes the jaws to close them would have to be extended to meet the tip of the mini drill spindle. The measurements also revealed that axial travel of the jaws is 8.25mm from open to closed, leaving only 5.75mm of thread engagement with the spindle when fully open. Drills larger than 4mm are unlikely to be used with my mini drill, so I settled on this as an approximate maximum



The original drill and cheap chuck

capacity, thereby reducing the required axial travel to 6mm. This would give a minimum thread engagement of 8mm. An essential requirement would be to use the thread shrouded by the mini drill body. This could be achieved in three ways: reducing the unthreaded portion of the backplate; adding a threaded spigot to enter the mini drill body and removing the overhang from the nose ring. This combination addressed the thread/travel requirements but the shaft is still too short to push the chuck jaws closed, hence the extended 'jaw pusher'. **Fig.1** shows the general arrangement and components designed according to the measurements made. The 4.95mm spigot on the jaw pusher keeps it co-axial with the end of the spindle and shares the closing force to prevent possible distortion of the spindle tip.

Not having the 8 x 0.75mm metric fine tap needed, the job had to wait a couple of days until my order arrived from Chronos.

Now, to the workshop. I made the jaw pusher first and this is a very simple job of turning the diameters and lengths in one session to maintain concentricity. I had

previously measured the bore and depth of the mini drill spindle with the help of drills. Even so, I still resorted to trial and error to achieve an easy but slop-free fit for the smallest diameter. The length of the small diameter was also finalised by trial and error, turning small amounts off the end, trial fitting and checking with a loupe for zero gap between the 7.5mm diameter and the tip of the spindle. With no gap, both diameters should be bearing on their respective parts of the spindle. After parting off (I hack-sawed mine off in the vice) I reversed in the chuck to face off.

My first attempt at the backplate ended in disaster whilst turning the spigot after reversing in the chuck. Being cautious of damaging the threads, although protected, I clearly didn't tighten the chuck sufficiently and the work twisted and was ruined. For the second try, I machined the part the opposite way around so as to turn the spigot first. The only problem with this is that the chuck body could not be 'tried' for a good fit; therefore the threading operation had to be done carefully to ensure the correct depth of thread. From



The new chuck fitted to the drill

thread data charts for standard metric threads of 1mm pitch, I established the difference between maximum and core diameters to calculate the required in-feed of 0.615mm. By keeping cuts very small and making three or four passes at the final in-feed, I achieved as near perfect a fit as I have ever managed. Cutting threads on a Hobbymat lathe is tedious because there is no clasp nut on the lead-screw. This means the cutter must be wound out and the spindle reversed to return the tool to the start of the thread each time before putting on the next in-feed. For that reason, I

was exceptionally pleased with myself for successfully cutting my first thread by dial only. Although parted off in the lathe, instead of re-chucking to finish the face, I filed the inside end whilst holding in soft vice jaws. I didn't want to risk a repeat of the previous attempt.

After assembly the chuck worked well, closing fully whilst using the full length of spindle thread, **photo 2**. The last part of the modification was to reduce the length of the plastic nose ring. The thread moulded into the original is limited to two opposing sections. This and the curvy outside shape

influenced the decision to make a new ring instead of shortening the original. The nose ring thread measures 18.5 x 2.0mm and, being a through thread rather than blind, I thought it would be a good exercise for my first foray into internal threading in the lathe. I also thought that nylon would be a forgiving material and a good substitute for the moulded plastic original.

I had two unsuccessful tries at this. Despite putting in plenty of time grinding a threading tool and mounting it to allow for the helix angle, the resulting parts just wouldn't screw onto the nose of the mini drill. In fact I bruised the first turn of the male thread whilst trying to screw on a ring that I was convinced should fit. I have since read on forums that nylon is not the easiest of materials to work with.

I settled for making the part from aluminium, leaving the outside diameter parallel in case there is a future need to mount the mini drill. **Photograph 3** shows the manufactured chuck components and replacement nose ring, along with the redundant original chuck parts in the background.

What does it work like? Quite well as it happens. I have no idea how concentric the chuck itself is but Swiss watch accuracy can hardly be expected of an item available new on eBay for as little as £4. Consequently, I see little value in trying to measure run-out, especially for a tool that will almost always be hand-held. It does seem to run smoothly with no noticeable wobble at drill points.

All in all this has been a successful and satisfying project. At least now I don't have to make new collets for my mini drill before I can use it. ■

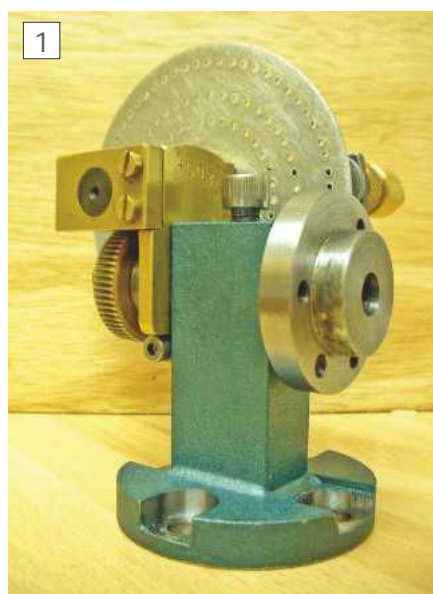


The new and old components

A Small Dividing Head.



Stub Mandrel tells the story of how recreating a 1930s Edgar Westbury design led to making a unique light dividing head. On many 3 1/2 inch centre lathes there is little space for even the smallest of rotary tables on the cross slide, particularly with a chuck attached. The ML7 can benefit from an extra long cross-slide, but this option is not available for many other lathes.



The finished dividing head, without a chuck fitted

Inspired by an undimensioned plan in a mid-1940's issue of *Model Engineer*, I made a small dividing attachment. The drawing was a reprint from an article by Edgar T. Westbury from the inter-war period. This fine drawing deserves another airing, **fig 1**. I followed the design reasonably closely, a simple head and tailstock mounted on a bar held in a toolpost mounted body. The whole device rather resembles a watchmaker's turns, and could serve as such, though the provision of a geared spindle in the headstock makes it far more versatile.

The body and endstocks were made from a 5/8 by 7/8-inch mild steel bar that was once the foot of a display board. The critical operation was making the bores of the two endstocks truly parallel and equally spaced. This was achieved by soft soldering the two pieces together, and relying on holding the pair firmly against the body of the four-jaw chuck. In the end I produced a rather simpler shape than Westbury's elegant stocks, that were presumably made from castings.

The main bar was a length of 3/8-inch stainless steel of 'boot sale' provenance and the (first and second) spindles were made from a large high-tensile bolt. The most involved tasks were making the internal taper on the nose, and milling the keyway. The latter job was done with the spindle locked in the device's headstock, itself clamped in the toolpost.

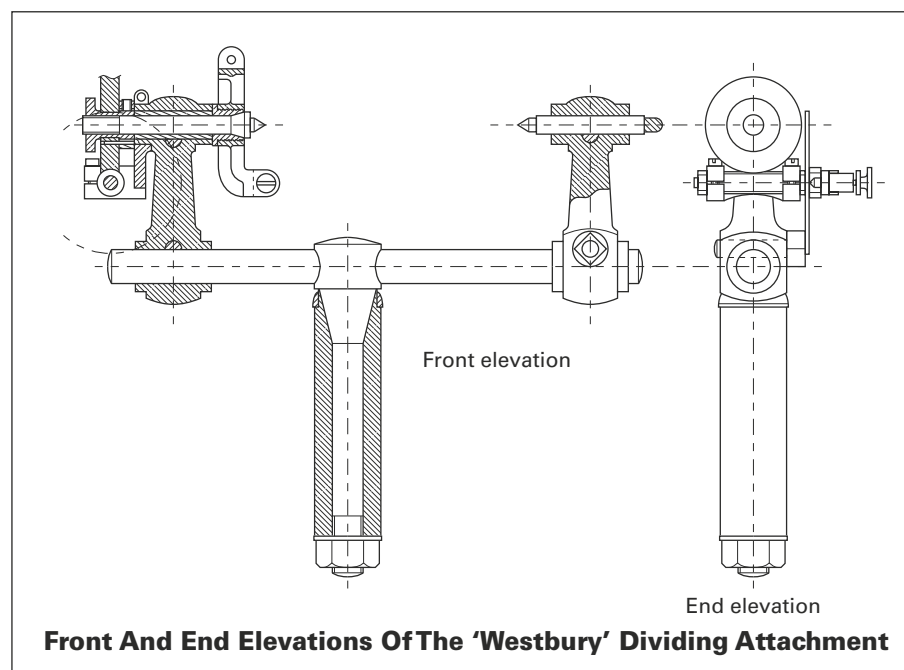
Instead of boring the spindle for (presumably) 8mm collets, I decided to bore a simple self holding taper and provide a small drawbar. The taper was made with a simple silver-steel reamer, turned to size and ground halfway. This was run into a pilot hole with plenty of oil without any problems with chatter. I turned up a handful of matching blank tapers in mild steel at the same time, which proved to be a wise deed. The drawbar was from 1/16-inch steel, and can be seen fitted to a hardened 60° centre



20 TPI gear hob

This is the story of how I came to make a small dividing head, entirely from odds and ends, aside from its chuck, **photo 1**. Even the smallest rotary tables can be awkward to use on smaller lathes, and if your lathe does not take screw-on chucks the George Thomas type dividing head

can be difficult to adapt for them without making excessive overhang or a custom backplate. If you have these problems, then perhaps this article will show a way to make use of a small, inexpensive lever scroll chuck to provide a device for precision division work on small lathes.

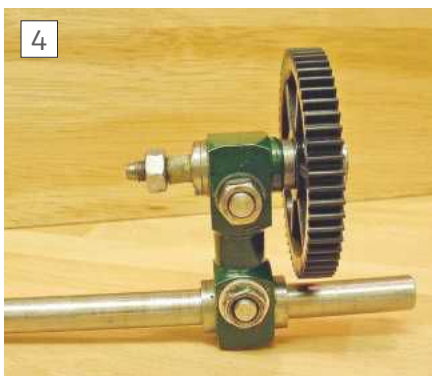


alongside two spindles, **photo 2**.

The dividing part gave me the opportunity to use the attachment to cut its own worm wheel by free hobbing. I later used it to produce a larger wheel for a rotary table. Both feats were accomplished in the same way, following a simple technique outlined in M.E. by Geometer (Ian Bradley, one half of Duplex) in his Workshop Tips during the 1960s. The first step was to turn a flat-topped worm thread on silver steel bar. The pitch for the worm was 20 tpi. This was chosen as I had a length of 1 by 1/4 inch brass flat for the wheel, and 20 tpi was both easy to set up and gave as near a 1-inch diameter 60-tooth wheel as possible. One portion of the thread was left a few thou 'full' and this was separated, fluted with an end mill, hardened and tempered for use as a hob, **photo 3**. The other portion was further machined to form a suitable spindle on the end of the worm. Before leaving the lathe, I also turned up the blank for the gashing tool, which was finished by filing. Both hob and gashing tool were crudely relieved using a grindstone in a mini-tool on the outer edges only.

Turning up a blank was no problem, starting with an inch square of brass, bored and keyed to a special spindle for the dividing head, but held in the three jaw chuck for turning to a circle. This was then transferred to the headstock of the dividing attachment. A 60-tooth changewheel was fixed to a short mandrel held in the taper at the opposite end of the spindle, as shown in **photo 4**. To provide indexing a simple detent of spring steel was improvised, allowing the changewheel to be indexed around one tooth at a time. Each tooth-space was carefully gashed out with the above-mentioned tool, held in the three-jaw chuck. The attachment showed its worth at this stage, as it made angling the blank to get the correct gash angle very easy, a job that was done by eye. I needed to take two attempts at gashing – the first blank failed as slight movement of the main shaft meant cut 61 wasn't in exactly the same place as cut 1. The second time I took care to clamp everything firmly in place, but difficulties in clamping the bar would continue to be a problem.

The next stage was remarkably easy –



How a changewheel could be fitted to the original spindle



Spindles, drawbar and centre for the original light dividing device

the spindle was set up so the blank was horizontal and at centre height, and the hob mounted in the three-jaw chuck. With more experience I would have used the four-jaw, but the chuck was as inexperienced as I was, and the hob ran true enough. Helped by the soft nature of the brass, spinning the hob at about 200 rpm and gently advancing the cross-slide, the wheel cut itself. Every so often I gently moved the saddle from side to side a little, so that more than one part of the hob did the cutting. I finished up the job by running the wheel along the full length of the hob. To cut the rest of this part of the story short, the next task was to fabricate the worm-cage from brass flat, relying on hand fitting to get a good mesh with the worm wheel, **photo 5**. In short I was very pleased with the quality of mesh.

I mentioned that I used the same technique to make the worm and wheel for a rotary table. This was to be 2 inches in diameter, to match a 10 tpi worm. My initial attempts were a fiasco, until I realised that I had wasted my time on a sheet of CZ108, a hard grade of brass. While I'm sure this would make excellent pinions if cut by a proper tool, my crudely relieved hob, **photo 6**, just bounced off it unless I used so much force the set-up distorted! I ordered a piece of leaded CZ120 'engraving' brass, and got a decent result first time. The remnant of 'hard stuff' eventually became a gib strip.

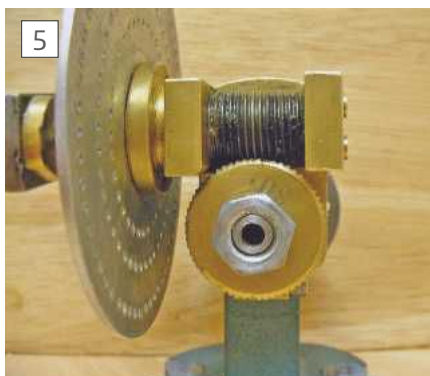
The next issue was how to index the worm? I had left the end of its spindle

rather short. Once I had made a mounting bracket for the index plates, I only has a short stub on which to mount a simple handle and detent, without any space for attaching index arms. The original detent, shown alongside an index plate simply screwed in and out. This was replaced with a sprung detent.

Making the index plates was therapeutic – though a few hundred holes is not in the same league as several thousand tender rivets! I wish I had taken care to space the rows more neatly – they were meant as an experiment and ended up good enough to use, **photo 7**. The plates are just 16-gauge aluminium, so I don't expect them to last forever, but I won't replace them until they start to wear, then I will make new plates from brass or steel. The design of the blanks allows them to fit directly to the end of the spindle in place of the worm and wheel for direct dividing. By using changewheels on the other end of the spindle in the same way as for gashing the worm wheel indexing the index plates was easy. Each hole was centre drilled to the same depth in the lathe, a high speed being needed, but giving neat conical holes.

The handle itself was made up as it went along. While the detent is a bit clumsy-looking, the free-turning brass handle is pleasant to use, **photo 8**.

Despite the success in making the head and tailstocks, I was frustrated by the difficulty of gripping the 3/8-inch rod at the



The worm and hobbled worm-wheel



The original 20 tpi hob compared with a 10 tpi version



One of the index plates with the original, unsprung, detent



The new, sprung, detent and handle



The remaining components of my 'Westbury' dividing attachment



The original tailstock, showing the driving plate

heart of the device. It appears that the central spindle in Westbury's design was split, so that it gripped the rod as it was drawn in. Despite many tweaks, I could not get adequate grip for even the lightest operations, and I wonder how the Westbury got the arrangement to work. A pin, running in a slot in the bar was tried, but it lacked accuracy and weakened the clamp, which then broke. In the end I made a new clamp rod, with a different taper – steeper than the socket – which allowed a much stronger grip. In contrast Westbury's cotter pin arrangement for the endstocks worked perfectly.

No parts of the original light dividing head have been scrapped, but the worm and wheel arrangement was 'half-inched' for the new dividing head. I have reassembled enough of the parts to give an indication of how it looked, **photo 9**. The photograph also shows various items including index plates, a spare spindle, taper reamer, some taper mandrels (all but one are unused blanks) and the original index.

Even with the improved grip, the device was suitable only for light tasks. Workholding was not simple either, essentially limited to small mandrels made to fit the custom taper socket or holding work between centres and using a driving dog, **photo 10**. Although a simple faceplate could have easily been made to fit the device a small chuck would have been an

ideal solution.

At the other end of the scale, the rotary table I had made in the meantime was too big for some jobs with its solid 4-inch square base. It was fine when I finally got a milling machine, but you could see the worktable droop when it was mounted on the drill press. With a chuck attached there was hardly any space left to use it on the lathe or with large drills.

Some sort of compromise, a smaller device but still with reasonable workholding capacity and good rigidity was needed. Around this time my father bought an old Unimat, from a friend who wanted to give it a good home, for £20! Impressed by this piece of precision engineering that was now mass-producing foot-long warship gun barrels, I realised that its small scroll chuck could be attached to the dividing mechanism from the Westbury device. For some reason Dad didn't want to art with his chuck but at a Model Engineering exhibition I found some 63mm scroll chucks at a knock-down price, plain or with a 14mm Unimat mounting. I bought a plain back chuck, meant to be mounted on a spigot and secured with three screws.

To give a reasonably solid base a slice was cut from 2 inch diameter mild steel, and trued up in the lathe. A slot was milled to take a section of 7/8 by 5/8 inch bar as an upright. Four recessed mounting holes

to take 6mm mounting bolts were milled in the base to allow t-slot mounting along and across the axis of the lathe, **photo 11**. The front recess is to ensure its bolt does not interfere with the chuck, the others are just so that all the bolts can be the same length. Two counterbored 5mm capscrews hold the upright in place on the base. Careful hand fitting was needed to get the upright vertical.

With the two parts firmly joined, the base was mounted on the lathe, and a dial indicator in the chuck used to check it was square when saddle was traversed. With a centre in the headstock the base was lined up crosswise, and the saddle locked by tightening all three gib-screws. A 1/2 inch hole was then bored and reamed to size.



Attachment points allow mounting across or along the lathe axis



This view shows the chuck backplate

A previously made brass bush was fitted in the hole, and itself bored just less than 3/8" at the same setting. One end of this bush had a 1/8 by 0.550 inch diameter flange, to mount the dividing apparatus, and a 7/16 inch ring made to fit the other end. These parts were well fluxed and assembled together with the upright, and silver soldered in place.

Cleaning these parts was an opportunity to try out a sulphamic acid based limescale remover as a pickle. Used while the work was warm, not hot, it removed the easyflo flux in a few seconds, leaving the surface very clean. A dural bar was gently wrung into the bore as a mandrel, and skimming cuts taken to clean up the two bushes. Finally, a 3/8" reamer was put through the bush by hand to bring it to size.

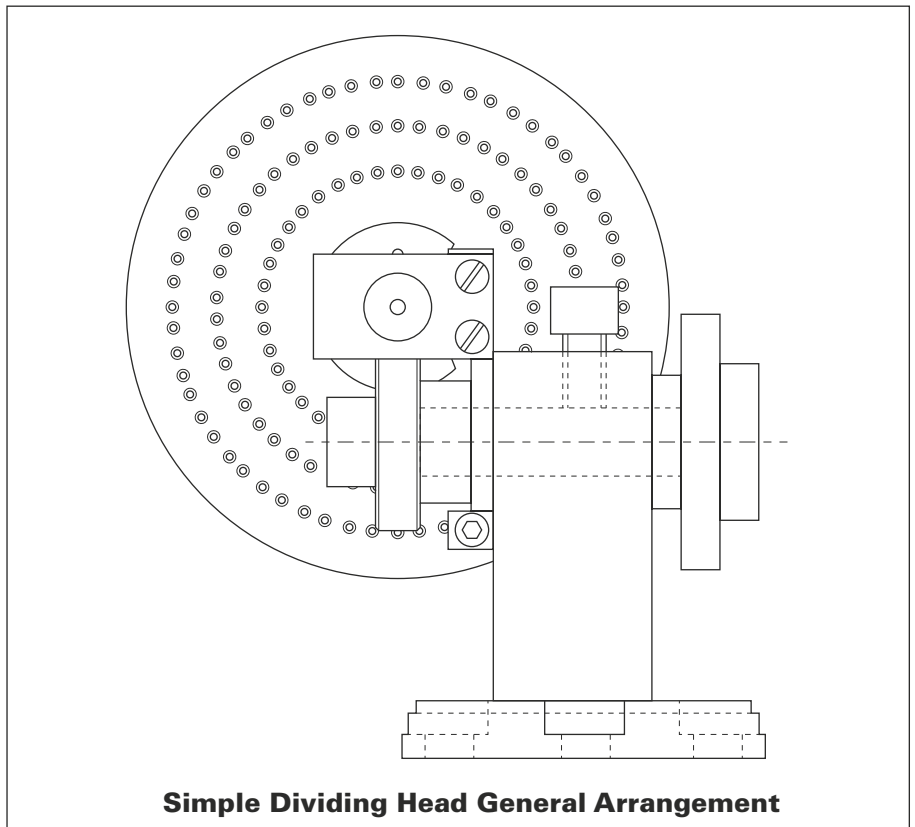
The chuck needed a backplate 36mm in diameter, **photo 12**, but the spindle would be only 3/8 inch in diameter. I did not want to chew the entire thing out of a single chunk of steel and, as luck would have it, that day I found an M16 bolt big enough to make the spigot, but not the flange out of. Holding the head of the bolt in the three-jaw chuck I carefully faced and centred the other end. Supporting the small end with a half-centre, I roughed it down to just over 3/8 inch. I also turned a true face on



Looking down on the simple 'working parts'



The dividing device attached to the lathe



the inside of the bolthead. I then reversed the bolt and turned the head down to just larger than the chuck's 22mm register. I drilled a blind 1/4 inch hole and, using the home made reamer, opened this into a taper to take the stock of little mandrels made for the original dividing head.

I then drilled a 3/8 inch hole in the middle of a piece of 1/4 inch steel plate. This was opened up with a file until it was an easy fit on the spindle, and silver soldered to the back of the bolthead. Rather than finish turning the spindle between centres, I continued to use the three-jaw chuck for work holding. With the narrow end of the spindle in the three-jaw chuck I found I

could get concentricity of no worse than a thou, and I went ahead and turned the backplate and the register to diameter (but left this over-length at about 9mm). I then reversed the spindle, gripping the register, but for I could not get it to run true.

For a long shot, I cleaned the taper socket and popped in a little taper mandrel with a 3/4 inch long stub on the end. I had produced a collection of these at the same setting as I used to make the taper reamer. To my surprise and relief the rest of the spindle now ran true, so I supported it with the tailstock centre and started work. Aside from the section that has to be a good sliding fit in the upright, I copied all the



Drilling an inlet port for a small IC engine



Fluting an aluminium knob

dimensions of the rest of the spindle from the shorter spindle of the light dividing attachment. This meant I could use the original spacer, worm wheel and fixing nut, photo d. One day I will make a nice knurled brass nut to replace the ugly M8 nut! Finally, I drilled through 3/32 inch and carefully tidied up the end of the spindle without the tailstock centre in place. The trusty little mandrel was removed with due reverence! I then reversed the spindle a last time, reduced the length of the register to a shade under 6mm, and re-bored the taper to its final depth. Remarkably, all this ill-advised reversing and resetting did not seem to cause any problems with the final accuracy of the spindle, the muse of engineering must have been watching over my workshop that day.

The three M4 holes for the chuck retaining screws were positioned by spotting through from the chuck itself. I hand filed a flat for the spacer grub screw and milled a 1/16 inch slot for the wormwheel key. The latter operation was performed with the new spindle locked in the body of the original light dividing head!

Provision for locking the spindle was added with a simple M6 tapped hole in the top of the pillar. A concave brass pad shaped to a good fit on a 3/8 inch bar was prepared to drop in the hole and put to one side with a bright plated screw.

The device was then reassembled to ensure everything lined up. It was then broken down, the two parts of the base separated and degreased. They were warmed over the workshop heater and re-

assembled with a little two-pack epoxy in the joint. Small fillets of epoxy were made around the join to help create the illusion of a casting, see photo 11 again. The base was given two coats of matt textured Hammerite before final assembly.

The final result was a small but versatile device, **photos 13 & 14**. On the lathe it gives an excellent set-up for delicate rotary milling operations, such as milling ports in the cylinder barrel of a small compression ignition engine, **photo 15**. This was a delicate operation that would have been clumsy to do on even a small milling machine, but it was easy on the lathe. Despite the relatively small size it is rigid enough for any work that can be held in its little lever scroll chuck, **photo 16**. ■

Readers' Tips



TIP OF THE MONTH WINNER!



Watching the Wheels Go Round
Our winning tip from Phil Robinson will be welcomed by anyone who hate winding vice jaws in and out.

I always find initially setting the milling vice a bit tedious, especially if moving from a thin piece to a thick one or vice versa. My vice has 24 turns from open to closed, and the big handle is too clumsy and can't do a full turn without fouling some part of the machine. The gibs are set too tight to turn the screw by hand.

So I thought the handwheel shown in the pic would be a good idea, and so it has proved to be, it doesn't foul the vice and is so easy to use. This one is made from an old Myford ML7 tailstock handwheel, which was in terrible condition. The outside rim was turned down to get rid of deep pits and remnants of chrome and the inside only needed a short filing session for a piece of square tube to fit into it and be brazed in place. A quick coat of paint and ready to go.
Phil Robinson

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Fixing a Fixed Steady

Howard Lewis carries out a little remedial work



Fitting the fixed steady (not the best example of precision engineering) to my lathe, **photo 1**, involved placing a hand between the clamp block for the steady and the bed of the lathe, to hold up the loose clamp bolt, whilst fitting the nut and washer to the other end, above the foot of the steady. Positioning the steady above one of the apertures in the lathe bed risks dropping the bolt into the swarf in the chip tray beneath, whilst providing no greater access.

Finally, I grew tired of such frustrating activity, and made up a means of making the bolt captive. It was easy to hold the clamp block in the milling vice by the

machined recess along two of the sides. An end mill was used to produce a recess, on the underside of the clamp block, very slightly wider than the across flats size of the bolt head, and longer than the cast in slot.

The recess was made deep enough to accept the bolt head, after the underside of the head had been faced, and the shank turned, to remove the rather large radius under the head, **photo 2**.

This solved the problem of the bolt turning whilst the nut was being tightened, but it was still not captive, and so could fall before the nut had been fitted. At one end of the slot a hole was drilled and tapped

M5. A small piece of, otherwise scrap, sheet metal was cut to be 12mm longer than the length of the milled slot, and roughly the width of it.

A 5mm clearance hole was drilled, on the centerline, 6mm from one end.

Once the clamp bolt had been put through the slot, and the sheet metal secured in place with the m5 setscrew, the bolt was retained, **photo 3**.

With the clamp bolt now captive, the days of groveling between the steady and the lathe bed are over and fitting the fixed steady is so much easier. ■



Recess for the bolt head

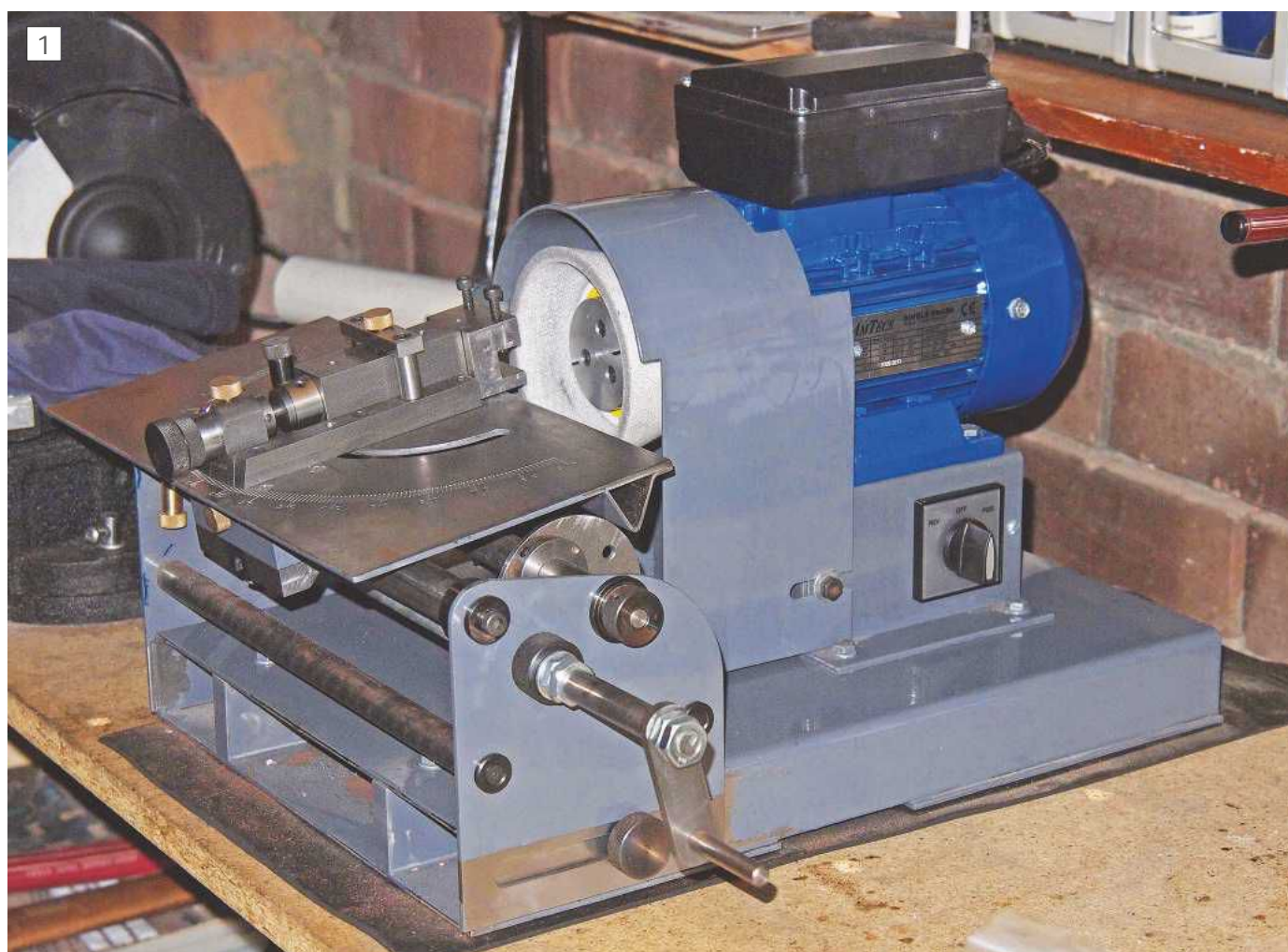


Retainer for the bolt

An improved guard for the Worden



David Thomas addresses safety and reduces dust spread with this accessory for the popular tool and cutter grinder.



The Worden with the original wheel guard

The Worden tool and cutter grinder is justifiably popular for its versatility and effectiveness and the one I built has proved its worth in the workshop. However, the lack of effective dust control on the Worden is a problem particularly in a small workshop where separating grinding tasks from everything else is difficult. Fortunately, the design of the motor now supplied with the kit offers a way to

improve on the existing wheel guard and add a way for collecting the grinding dust.

Introduction

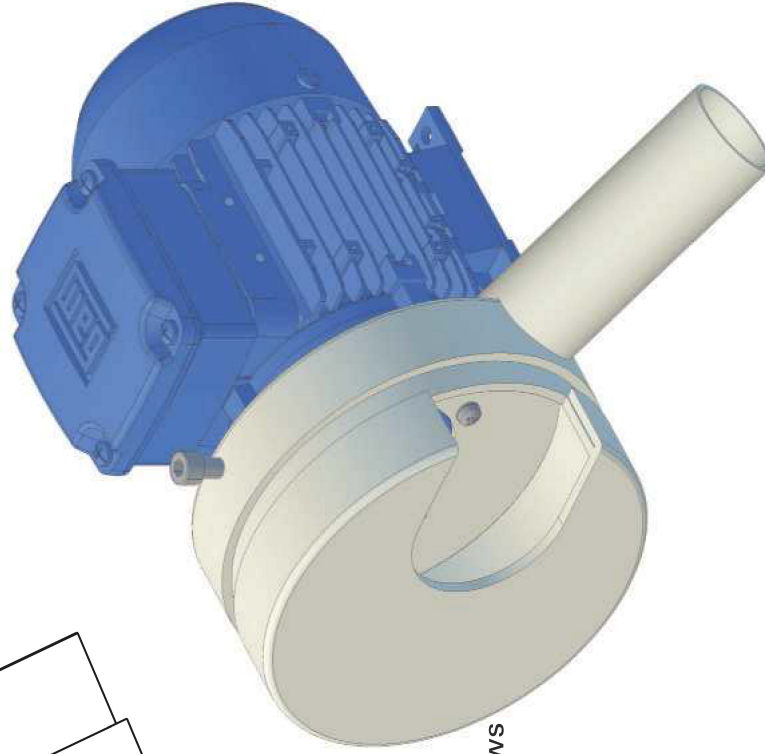
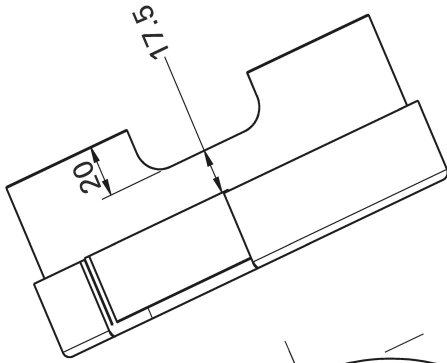
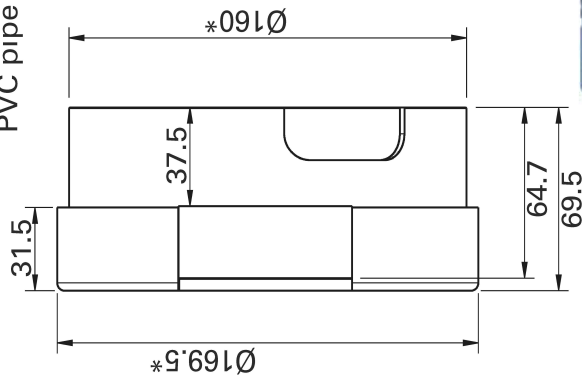
The design of the Worden, **photo 1**, has evolved over time from the original work of George Thomas and the latest contributions from Jim Whetren, **Refs 2-5**, make the machine very versatile and an excellent choice for a small workshop.

Having decided on the Worden as the next project I bought the full kit and kits for all the attachments from Hemingway then looked up all the MEW articles that referred to building or modifying the Worden. It was clear from these that development was mostly complete but at least two possible limitations remained:

The lack of vertical height adjustment, tackled by Jim Whetren in Ref 4,

Assembled Front Cover

From 150mm PVC pipe and pipe cap. Joint made with PVC pipe cement or cyanoacrylate



M8 cap screw for light clamping.
With screw removed the hole
gives access to wheel securing screws



Attach with four M5 screws
into existing tapped holes
in motor flange

Note: dimensions marked with * are measured from bought-in material

General Assembly & Front Cover



In use on the bench with the replacement guard.

The problem of grinding grit and debris being blown forward and into the mechanism by the draft from the motor cooling fan, Jim Whetren also offered a solution to this, Ref 5.

The solution to problem two that I am going to describe, **fig. 1, photo 2**, does not require any permanent modification to the basic machine and has proved effective in reducing the grit problem and adding some very useful air-cooling as a bonus. The new design of grit guard should also simplify the later addition of a vertical height adjustment feature. My thinking was triggered when I received the kits and it was clear that the motor was to one that had both foot and face mountings, **photo 3**. This gave me an idea for a simple solution, so simple in fact that when I shared the idea with Kirk Burwell of Hemingway Kits his response was 'Why didn't we think of that?'

Materials and construction

The largest item is attached to the motor is the finishing disc, which is 150 mm in diameter. With this in mind 150 mm PVC sewer pipe and fittings were chosen as the material. These are easily worked and need a minimum of modification. Two pipe caps, a short length of 150 mm pipe and a stub of 40 mm waste pipe

are needed, hopefully UK sizes are close to those available here in Australia. The smallest length of 150 mm pipe I could buy was one metre - when this was

standing on end outside the workshop the dog thought this looked just like his own personal lamppost...

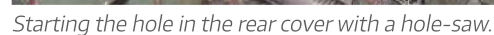
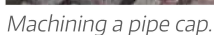


The motor flange that makes it possible.

The face of the grinding wheel needs to be as close as possible to the grinding rest but the flanges on both the pipe caps are too deep as bought. They both need to be reduced by 10 mm to bring the wheel face close to the back of the front cover. The covers were too large to be held on the outside by my largest chuck so the faceplate was the only way to go. The machining forces were only going to be

bind together in use, I found this out the usual way.

The rear cover, **fig. 2**, needs a 60 mm central hole to fit over the motor flange, four clearance holes for 5 mm screws and a radial hole for the extraction duct. Rough out the central hole using a hole-saw with the pipe cap held on the outside of the outside jaws of a 3-jaw chuck, **photo 5**,

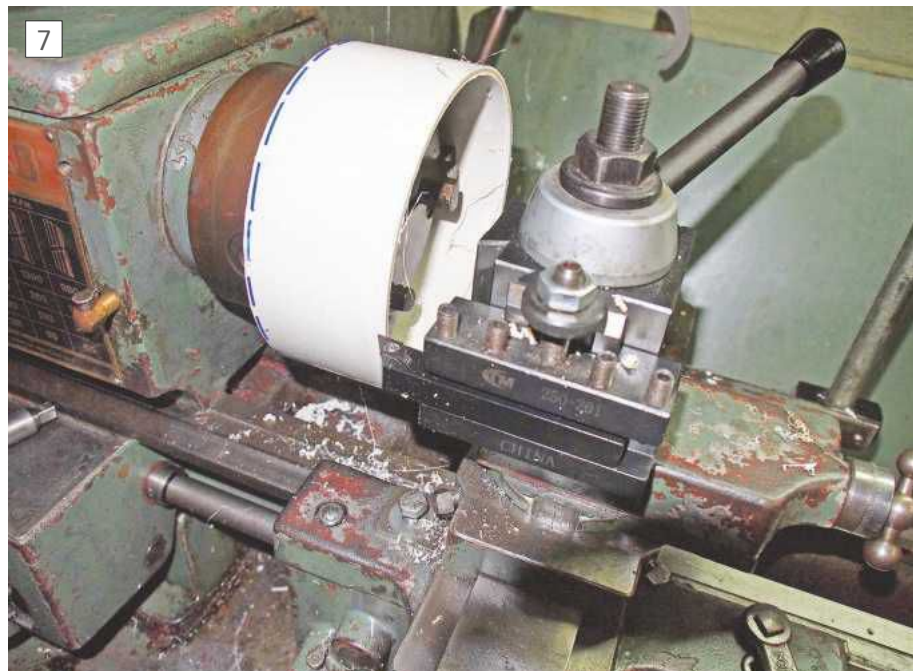




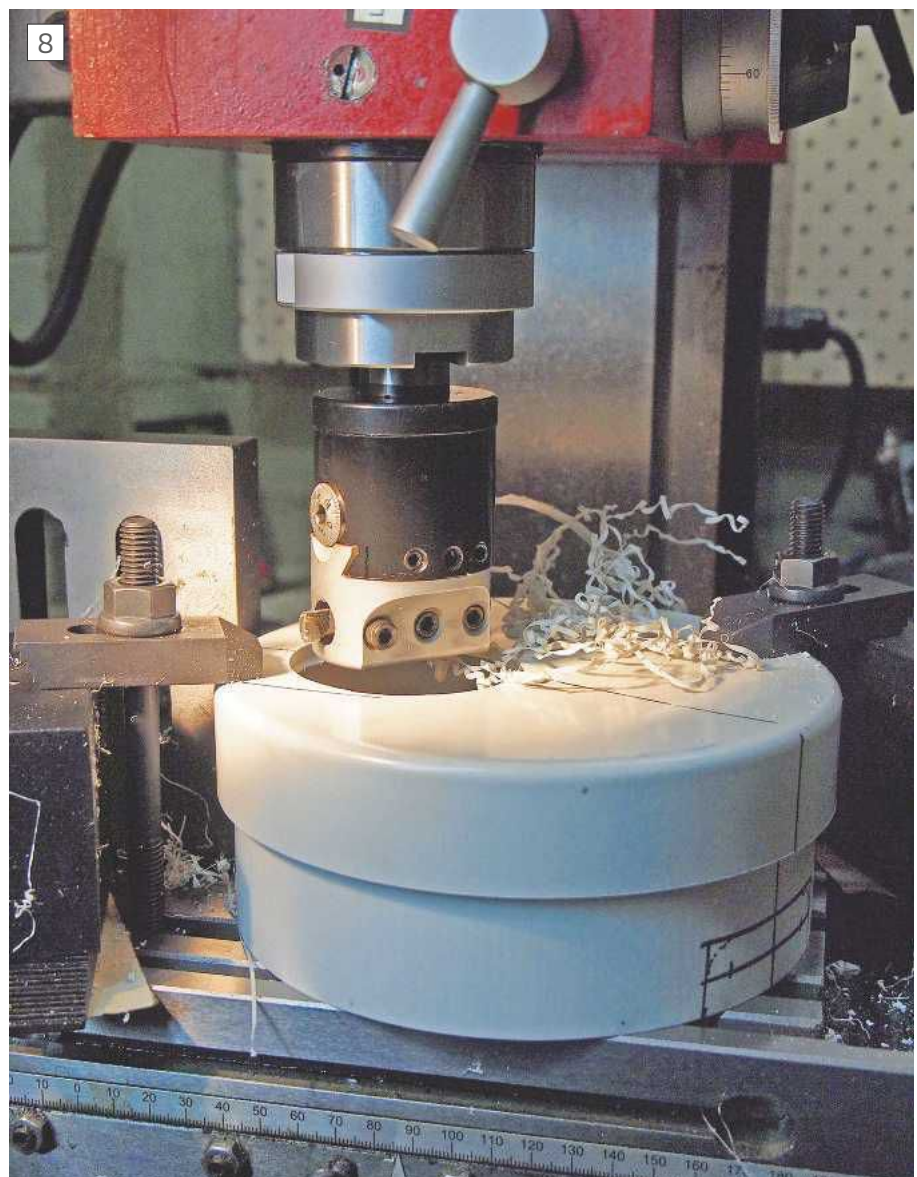
A hole-saw again, this time roughing out the duct exit.

then clean it up to size with a boring bar. The 57 mm hole saw I used just cleared the chuck jaws as it emerged from the back of the work but you need to check the clearance here. Keep the scrap from the hole-saw for later. While the cap is still on the chuck mark in the 75 mm pitch circle for the fixing screws and scribe two lines at right angles across the diameter to give the hole centres. Drill 5.2 mm to clear the screws. The drawing shows an M8 hole at the top of the rear cover that is intended for a short screw to clamp the front cover in position. The clamping function has proved to be unnecessary but the hole is needed for access to the screws that secure the grinding wheels to the motor shaft.

The vacuum hose attachment points to the right at 25° below the horizontal but this can be varied as necessary. To help with marking this out you can make a sufficiently accurate false centre in the 60 mm hole using two pieces of duct tape at right angles with their edges passing through the fixing hole centres. Again, the hole for this was roughed out using a hole-saw intended for woodworking, **photo 6**, and then cleaned up by hand. If I had thought ahead, I would have removed the pilot drill from the hole-saw as soon as the cut was established and this would have avoided the need to fill the hole that it left. The duct itself is a stub of 40 mm PVC waste pipe chosen as the closest I could find to a fit for the nozzle of the Karcher workshop vacuum cleaner. This can be machined or shaped by hand to a good fit on the outside of the rear cover. The part-circular hole remaining in the end can be filled with a piece of the scrap from the central hole turned or filed to fit. Anyone with the gear and materials for PVC welding can use this for assembly; I used cyanoacrylate adhesive to hold



Turning the body of the front cover.



Boring the access hole in the front cover.



Milling the duct clearance in the front cover.

things in place and then backed this up with generous fillets of epoxy.

Front cover

The front cover is made from a pipe-cap and 65 mm of pipe, **fig. 1. photo 7** shows the pipe being held on the outside of the jaws of a 5 inch three-jaw chuck for cleaning up to length. Even on a 5 inch centre-height lathe, Hercus 260 ATMH, this required a bit of creative juggling of the tool holder. The grip of the chuck isn't very secure and shallow cuts and a sharp tool are necessary, however, this operation could almost as well be done by hand. The pipe-cap is turned to depth and the moulding riser removed as described above then the two parts are glued together. Cyanoacrylate is not a good choice here as it is likely to grab before the two parts are fully engaged, ordinary PVC plumbing cement is the best choice

because it sets very quickly but epoxy will certainly do the job. This joint needs to be strong, as it will carry all the loads involve in fitting, removal and rotation of the front cover in use.

With the two parts firmly glued together the front face can be cut away to give access to the face of the grinding wheel. The part can be clamped to the table of a drilling machine and the hole started with a hole-saw then finished by hand. Alternatively, the work can be done on a mill, **photo 8**, roughing out with the hole saw and finishing by boring and milling. In use, the cover can be rotated so that the work can approach the wheel from either left or right and therefore two cutouts are needed in the edge of the cover in the way of the outlet duct. These can be formed using a 20 mm end mill with the cover clamped to an angle plate, **photo 9**. This is the only task where I have been able to use such a big cutter in the X3 mill.

In use

Setting up involves adjusting the front cover to expose the part of the grinding wheel needed for the task in hand, **photo 10**, then the workshop vacuum cleaner is attached to the exit duct. After that all you have to do is turn on the suction and carry on as usual with the Worden, the only difference being the possible need to wear ear protection as the vacuum motor and the

high airflow create a lot more noise than the Worden itself. The front cover cannot be used with the finishing disc, **photo 11**, or with the plane blade sharpening attachment. In the first case the cover pushes the work table too far from the disc front for safe use and in the second the blade being sharpened has to traverse too far and fouls the cover. Without the front cover most of the debris is not collected however the air flow still provides some useful cooling of the disc or grinding wheel and the work.

With the rear cover in place, changing grinding wheels requires a long hex key and screwdriver to reach the grub screws in the wheel hub. This is only a problem with the finishing disc where you are working blind; marking the edge of the disc to show the position and type of each screw helps.

Developments

The current design works well with the standard wheel, diamond wheel and the finishing disc. For other wheel types, it will be necessary to make new front covers using similar materials; perhaps the rest of the one metre of 150 mm pipe will eventually get used.

As mentioned earlier, using this design should simplify the addition of a height adjustment feature to the basic Worden and that project has been added to the list of things to do. ■

Acknowledgments

WEG Australia P/L, 14 Lakeview Drive, Scoresby 3179, for permission to use their CAD model of the motor in the drawings.

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Whetren, J: Living with the Worden MEW 127:39-46 July 2007
Using the Worden tool and cutter grinder MEW 143:41-48 October 2008
Worden wheel height adjustment MEW 145:46-49 December 2008
Worden Modification MEW 104:46-49 February/March 2005



In use with the Worden slitting saw sharpening attachment.



In use with the finishing disc.

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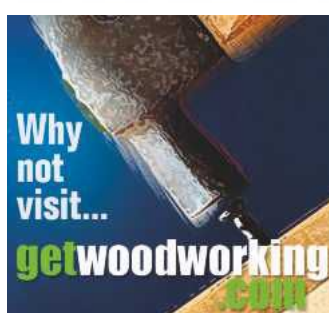
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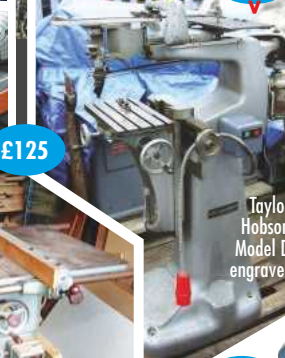
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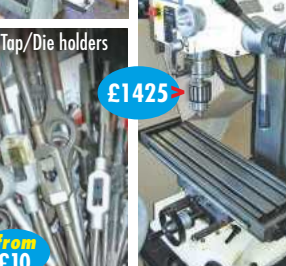
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