

No. 112

FEBRUARY 2006

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THE PRACTICAL HOBBY MAGAZINE

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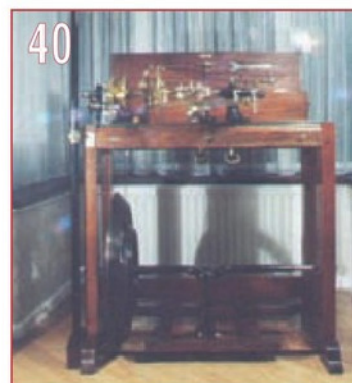

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On the Cover

Many of the smaller
budget machines are
not equipped with
indexable
handwheels, which if
fitted offer a great
improvement in
convenience and
hence accuracy.
Maurice Rhodes
describes his
conversion for a
Unimat 3 lathe on
page 16.



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1/4" Rnd	£0.28	£0.54	£0.39	£0.98	Aluminium, Brass, Copper, Steel and Stainless Steel tube.
1/2" Rnd	£0.78	£1.65	£1.18	£2.90	Black Mild Steel.
3/4" Rnd	£1.44	£3.79	£1.97	£5.49	Nickel Silver Round.
1.0" Rnd	£2.26	£6.35	£3.35	£8.40	Phosphor Bronze,
1/4" Hex	£0.34	£0.66	£1.00	£1.65	Silver Steel and Ground Flat Stock.
1/2" Hex	£0.78	£1.94	£2.10	£3.78	Spring steel.
3/4" Hex	£2.14	£4.50	£3.60	£8.80	Sheet in Brass, copper, mild steel, Aluminium, and Stainless.
1.0" Hex	£3.39	£7.38	£4.55	£12.50	
1/4" Sqre	£0.42	£0.97	£0.50	£1.70	
1/2" Sqre	£0.98	£3.15	£1.47	£4.14	
3/4" Sqre	£1.94	£5.42	£2.65	£5.98	
1.0" Sqre	£3.54	£10.84	£4.95	£8.98	

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Steam in the Air • Kelly • £22.39

In the early days of flight, when man was thinking of powered flight rather than drifting around with the wind in balloons, or gliding beneath flimsy wings, steam was the only possible motive power; here Maurice Kelly looks at all the ideas proposed for propelling airships and aircraft by steam engine, as well as less viable ideas such as ornithopters. The problem was one of weight, and the real legacy of many of these brave experiments was to be in lightweight, high pressure steam units rather than successful flights. The coming of the lightweight IC engine largely stopped the idea of using steam power in aircraft dead in its tracks, so it is ironic that the one verifiable successful example of steam power being used in a controlled flight over a decent distance was to take place in 1933. But whilst it may depend on your definition of "controlled" and "distance", as this book shows, it is just possible there were other successful steam powered flights long before the Wright brothers. Fascinating stuff. 158 pages. 100 B & VV illustrations, 10 in colour. Hardbound.



Watch Movement Manufacture • 1912 • £ 6.95

From MACHINERY MAGAZINE of 1912 came the series of articles combined here to show how the 'South Bend Watch Company' mass produced watches, and especially the tools developed and used in this process. Is this of practical use today? Just possibly. Is it interesting? Oh Yes! Mechanical watches were classic examples of very accurate mass production techniques, and seeing how this accuracy was achieved is both instructive and fascinating. 64 pages. Over 60 drawings and illustrations. Paperback.



LMS Locomotive Profiles No. 9 - Main Line Diesel-Electrics Nos. 10000 and 10001

• Hunt • £16.60

The latest in this excellent series abandons steam, and looks instead at one of the two pioneering diesel electric designs on Britain's railways, the other being Bulleid's one on the Southern. No's 10000 and 10001 were designed by H.G. Ivatt and his team, with considerable input from English-Electric, but only 10000 was actually an LMS engine - by 3 weeks. The Twins were uncommonly handsome engines, and they certainly grabbed attention as they journeyed up and down the WCML! Here you get their full history in every way, including a number of original drawings well reproduced, as well as numerous B & V photos. 80 pages. Paperback.



Smith's Work • 1899 • Hasluck • £ 7.95

Examples of Paul Hasluck's "Work" Handbook series pop up throughout our booklist. In many ways, most of the information in this book can be found in other books, but what makes this different is, firstly, it is aimed at amateurs, so the explanations are perhaps that bit fuller and clearer as a result. Secondly, this book strays into the forging and making of cranks, which we cannot recall seeing elsewhere to any extent. So it is definitely worth adding to your blacksmithing library, even if you are not a Hasluck addict - many are! 160 pages. 211 illustrations. Paperback.



Everything I know about Women I learned from my Tractor • Welsch • £15.39

Tractor restorer, writer & broadcaster Roger Welsch (aka "the sage of Dannebrog, Nebraska") divulges the secrets of handling women, as they came to him whilst he tinkered with his Allis-Chalmers tractors, in particular the dreaded secrets of Woman School. No, we don't get it either; but all true men should read this is a side splittingly funny, and politically incorrect book (for your eyes only, if you value your life). 216 page unillustrated hardback.



Dangerous Electricity! • pre 1914 • £ 5.75

This is a collection of articles reprinted from pre WW1 issues of *Mechanics & Electricity Magazine* and *Modern Electrics Magazine*, on high voltages and high power machines. The latter are mainly Tesla coils, but also include an X-ray set, an induction coil, a small carbon-arc furnace, coil winding and a water rheostat. There is an element of danger in all these, but what takes the danger 'biscuit' here is instructions on building a plunge battery with mercury, potassium bichromate and sulphuric acid..... 64 inexpensive, but reckless pages, well illustrated with drawings and some photos. Paperback

Prices shown INCLUDE U.K. delivery

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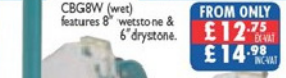
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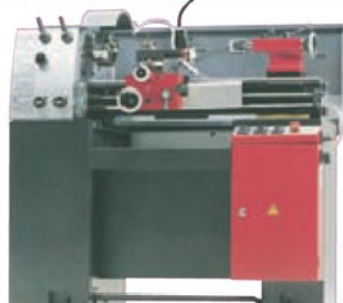
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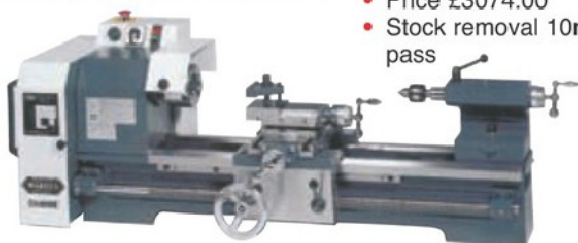


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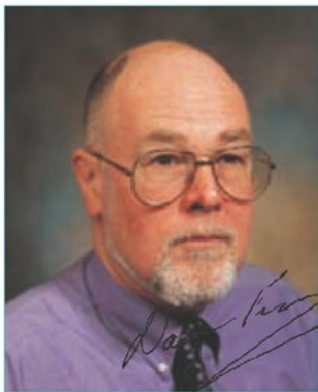
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MYFORD SPARES & TOOLING

Change Gears:
20T-E10, 21T-E10, 22T-E10, 24T-E10, 25T-E10, 26T-E10, 27T-E10, 28T-E10, 29T-E10, 30T-E10, 31T-E10, 32T-E10, 33T-E10, 34T-E10, 35T-E10, 36T-E10, 37T-E10, 38T-E10, 39T-E10, 40T-E10, 42T-E10, 43T-E10, 44T-E10, 45T-E10, 46T-E11, 47T-E11, 48T-E11, 50T-E12, 51T-E12, 53T-E12, 54T-E12, 55T-E12, 56T-E12, 57T-E12, 58T-E12, 59T-E12, 60T-E12, 61T-E12, 62T-E12, 63T-E12, 64T-E12, 65T-E12, 66T-E12, 67T-E12, 68T-E12, 69T-E12, 70T-E12, 71T-E12, 72T-E12, 73T-E12, 74T-E12, 75T-E12, 76T-E12, 77T-E12, 78T-E12, 79T-E12, 80T-E12, 81T-E12, 82T-E12, 83T-E12, 84T-E12, 85T-E12, 86T-E12, 87T-E12, 88T-E12, 89T-E12, 90T-E12, 91T-E12, 92T-E12, 93T-E12, 94T-E12, 95T-E12, 96T-E12, 100T-E22, 127T-E35.



ON THE EDITOR'S BENCH

Move to ten issues

As part of the business development programme for Special Interests, it has been decided to change from the historic eight issues per annum to ten. The publication dates for Model Engineers' Workshop throughout 2006 will therefore be: issue 112- 3rd Feb; 113 - 10th March; 114 - 13th April; 115 - 19th May; 116 - 23rd June; 117 - 28th July; 118 - 1st Sept; 119 - 6th October; 120 - 10th November; 121 - 15th December.

In the workshop

I recently received a phone call from a friend, enquiring whether I still had the TIG welding set. He had acquired a five inch gauge locomotive whose silver soldered copper boiler showed a number of leaks around the fire door ring. Conventional reheating would be a bit time consuming, and the idea was to employ the TIG torch as a localised heat source.

When he popped round later, a makeshift welding bench was set up and the boiler supported on its smoke box end. As I don't do much welding these days, and any former skills have got a little rusty, I felt it prudent to pass the torch to the visitor. Deft handwork would be needed, so rather than wear normal welding gauntlets, he produced a sheet of insulating material, cut a hole a little larger than the fire ring, and placed it over the boiler backhead, leaving just the work area exposed. This had the effect of reducing the radiated heat, which in turn, kept the hands reasonably cool and allowed a lower power setting. With the welding current set at around 100amps, it did indeed prove possible to raise the temperature sufficiently to locally repair some of the leaks, using conventional silver solder. Subsequent testing indicated partial success but one or two leaks were still present. So a further session is planned which will probably employ a combination of conventional preheating coupled with TIG.

Time and toys

In conversation recently, with a long standing acquaintance, it was interesting to compare notes on a common problem. As a pair of "old boys", we had each, over the years acquired a number of "big boy's toys". Unfortunately, nowadays, due to the demands on time for business, family, etc. neither of us was finding it possible to make available sufficient "playtime" to enjoy them. As a result he was considering

whether to dispose of an interesting motorcycle, and I recently accepted an offer for the Lotus Europa. It is now in the hands of a dedicated Lotus enthusiast who plans to compete in hill climbs and sprints. 2006 will probably see a further cull of the toy box.

The many shades of stainless

In addition to the letters appearing in Scribe a Line, several readers faxed or phoned with information relating to the coefficient of expansion for stainless. In particular, Dyson Watkins pointed out the extent of variation depending on the particular grade of stainless. For a typical austenitic stainless, he suggested $15 / 10^6$ per C degree, while for Invar the figure is $1.7 / 10^6$ per C degree. Thus there is a factor of roughly 9 to one between these two materials.

Travel to Sandown

I have commented before that in spite of advances in vehicle technology, motorway travel gets slower each year. It used to be the case that following an accident, getting traffic moving again was a high priority. Nowadays, it seems that roads are closed for many more hours so that the accident investigators are able to insert their tuppenceworth. Forensic science has developed many new techniques, and the various police forces seem determined to make use of them, which, in the case of road incidents leads to extended analysis paralysis. Perhaps if the police were called upon to make a payment of say £20.00 per person per hour delayed, it might focus minds on getting the country moving. So it was that this year I decided to try and travel by train. In the past the sleeper service has proved its worth in efficient use of time, and I am one of those who becomes totally ticked off by the cattle truck mentality of air travel. Surprise, surprise, early in December, the local station could not take a sleeper booking for the 30th as they did not yet have it on their screen. "Come back in a few days time." Several days later the performance was repeated. On Monday 12th, I phoned the central booking line only to be told that all standard class seats for the southbound journey on the 27th were sold.

I find it increasingly difficult to identify real benefits accruing from eight years of the present government. Rail is potentially the most fuel efficient mode of transport, and therefore should be encouraged in the context of global warming. What a pity it has become so near impossible to use for these longer journeys. I had therefore decided to make the journey once again by car, however the weather reports on 26th

& 27th December prompted a rethink. Bookings were hastily made for a return journey by daytime train. The journey was uneventful, except that queueing for tickets for both London Underground and for South East Trains, in each case took rather longer than the actual journey time. Again, so much for progress.

Once again the exhibition was a great success, with opportunities to meet up with old friends, and make a few new ones. Notes on the workshop equipment displayed will appear in a future issue.

Replies to phone calls etc.

As regular readers will be aware, I operate from a home/office in the wilds of Perthshire. One of the interesting facets of the work is the variety of phone calls, letters, and emails received from readers. Many are intended for publication, but some are requests for advice, queries relating to past issues, or in some cases, initial enquiries concerning work, which might be written up for publication. Where required, replies by post are sent out, and I am happy to respond to messages left on the answering machine to conventional UK landline numbers. But please note that calls from mobile or 0870 etc. numbers are not returned.

Hacksaw video

Elsewhere in this issue will be found the concluding article describing Richard Wightman's 12 volt power hacksaw. Following enquiries from interested readers, I did approach Richard to see whether it might be possible to take his hacksaw to Sandown Park for exhibition. Unfortunately, given the relatively short notice, this did not prove possible. However, Richard is also a video enthusiast and has put together a DVD detailing the construction procedure for the saw. Some readers may feel this would be a useful boost to confidence before building the saw, so copies can be obtained from Richard at a nominal cost of £5.00 including postage. Contact Richard K Wightman, 21 Beech Drive, Syston, Leicester, LE7 2PR

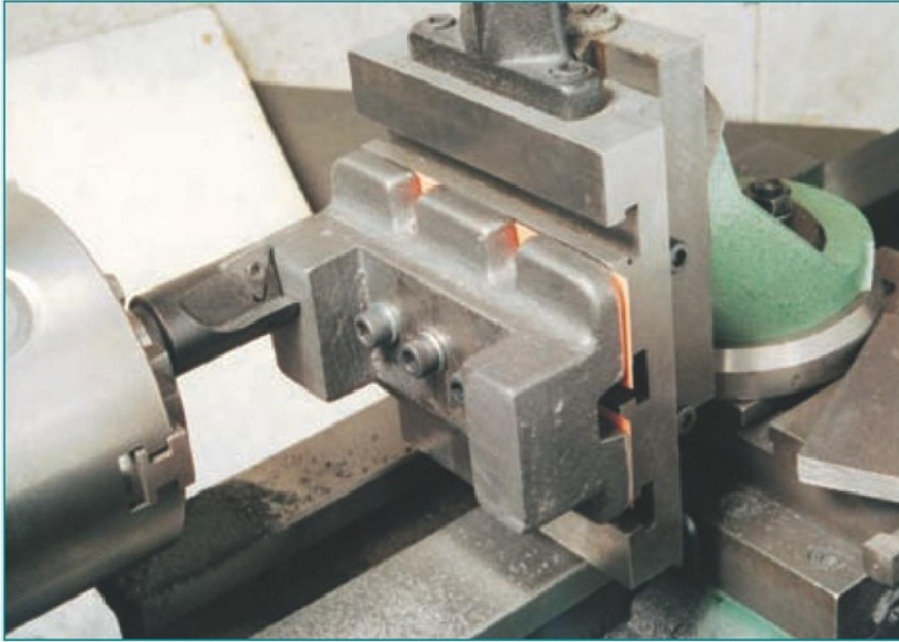
Dates for the Diary

April 8th -9th, Large Scale Model Rail at the Warwickshire Exhibition Centre, Leamington Spa. Organised by Meridienne Exhibitions.

May 5th 6th 7th National Model Engineering and Modelling Exhibition, Harrogate. Anyone wishing to exhibit at Harrogate should contact Lou Rex on 01977 661 998.

THE LATHE ONLY WORKSHOP 5

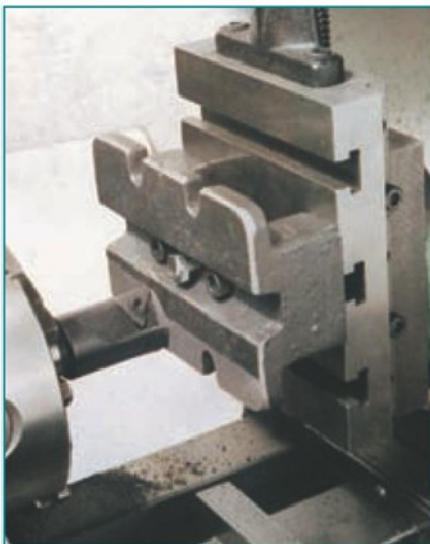
A small vice



1. The first faces being machined, note the card packing.

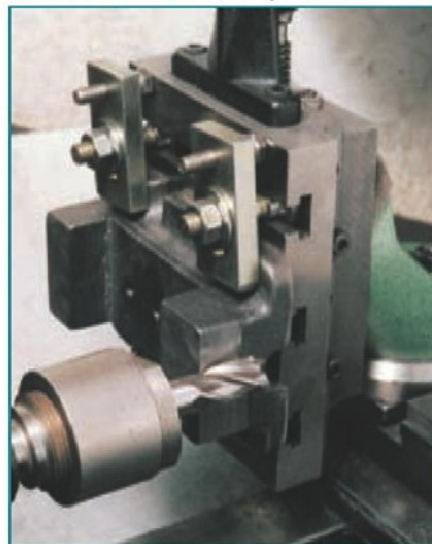
Woking Precision Models (ref. 1) may be better known within the model engineering fraternity for their range of i.c. engines, however their catalogue also contains a useful range of workshop equipment items. This small vice, available as castings from Woking, is an ideal project for the lathe/vertical slide format. It is though, like all the other items in this series, equally applicable to those with a fully equipped workshop. Its size, 1½in.

2. Machining the underside surface.



wide by ½in. deep jaw, opening to 1½in, makes it ideal for the workshop owner who works, at least sometimes, with smaller size components. However, I have often struggled to position a delicate component in an oversized vice and am sure that this little vice will be beneficial on

3. The five faces, inner and outer ends, and base were machined at this setting. Because of the lack of a positive helix on the tipped tool an end mill was chanced on the casting. Actually, all the casting in this series machined easily.



Harold Hall constructs the Woking Precision Kit

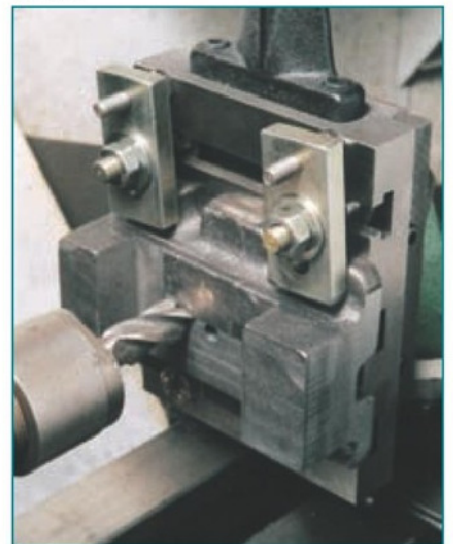
a regular basis, and will likewise also be for many readers of this article. The vice has two fixings on each side spaced at centres equal to the T slot spacing on the Myford vertical slide. It is unlikely that these will line up with the spacing on slides from other sources, but then, who needs four fixings for such a small vice.

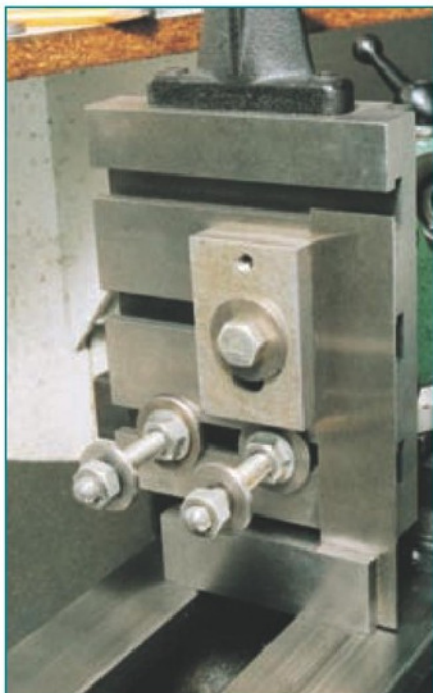
No drawings are supplied with the casting but I have provided sketches for those who prefer some guidance dimensions. These do not include dimensions for overall length, width, etc., as it is pointless spending time working to specific dimensions. It is quite permissible to deviate from the dimensions given, should the reader wish for any reason, e.g. available milling cutters, etc.

Manufacture Body

Using a file or perhaps a finisher, remove any obvious high spots from the base of the casting and test against some flat surface to make sure that it does not rock excessively. To enable the casting to be clamped to the slide, drill three holes 6.1mm diameter along its centre. For

4. Machining the base. Note the assembly is not relying only on the two clamps above, a screw through one of the castings fixing slots can just be seen below.



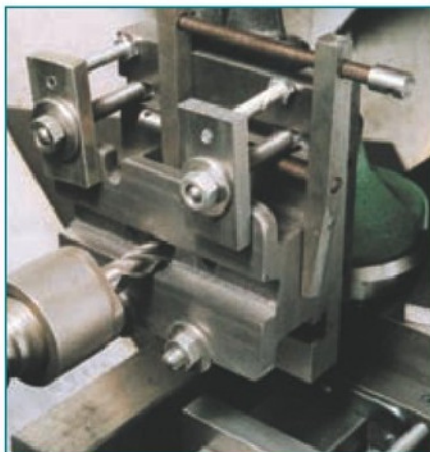


reasons that will become apparent later, ensure the holes are central in the surface on which the jaw will slide. With some packing between the casting and the slide, fasten the casting using the three holes just drilled. The packing can be soft copper, or even as I used, thin hard card. Machine the upper faces of the two ends of the casting as seen in **Photo 1**.

Reverse the casting, positioning the now machined faces against the slide and fix with the two outer screws. Whilst it is unlikely to be a problem, I took the precaution of supporting the centre of the casting to prevent the fixing screws causing the casting to bow. To do this, I placed a longer screw in the centre hole screwing this into a T nut. Also placing a normal nut onto the screw on the hidden side of the casting and ran this up against the casting and very lightly tightened prior to fully tightening the outer screws thus making it impossible for the casting to bend.

With this set up, machine the base of the casting as illustrated in **Photo 2**. If the available traverse of the slide does not enable you to machine both sides at this setting, as it did in my case, fit and set the saddle stop so that the casting can be turned over and the other side machined at the same level. This is necessary as you will carry out roughing and finishing cuts and will need to be able to return to the setting for finishing on the second side. As I said in my introductory article for the series, I really do believe that a saddle stop is all but essential for milling on the lathe.

With the base now machined it can be returned to the slide without packing. Fix, using screws through the vice's own fixing slots at the lower edge and bar clamps above, making sure that it is reasonably horizontal. Machine the four faces, that is, outer and inner ends, **Photo 3**. Whilst I prefer to use tipped tungsten carbide tooling on the outer surface of cast iron, using their outer cutting edges to machine the inner and outer surfaces of the ends may cause excessive load on the vertical



slide arrangement. To avoid this, depth of cut (not width) will need to be kept to a bare minimum making the process a time consuming exercise. Using a conventional end mill with its positive helix angle and rake will considerably speed up the task. However, if you have a choice of end mills, well used and little used, use the older cutter just in case you encounter a hard spot. Incidentally, I found all the castings used in this series very easy to machine and free of hard spots. For more explanation regarding the pros and cons of using tipped tooling see issue 108 page 15. Having machined both sides of the jaw at this single setting ensures that they will be parallel. This will also enable a square to be used off the outer face for setting up when in use after completion. Whilst still on the slide also machine the surface on which the jaw will eventually slide,

Photo 4.

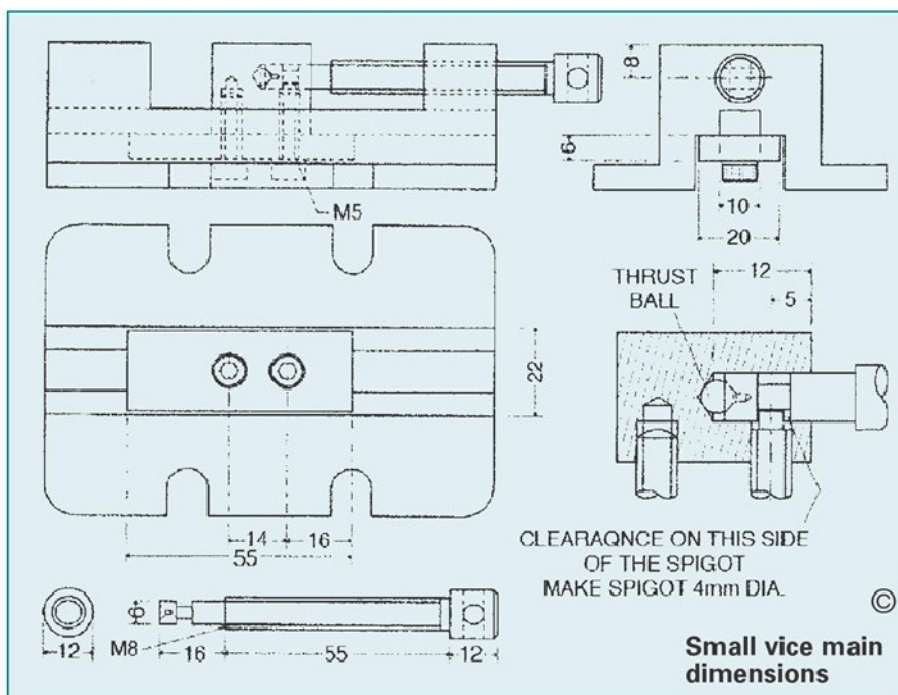
Once more, reverse and mount the casting on the slide with the two top faces against the slide surface. With two T nuts in the lower slot, place a stud in each one and with a washer and nut, lock them onto the slides surface, doing this at a pitch of $1\frac{1}{2}^{\circ}$ in, the pitch of the vice's fixings. The next stage is to make the slot in which the vice's jaw will slide. An essential

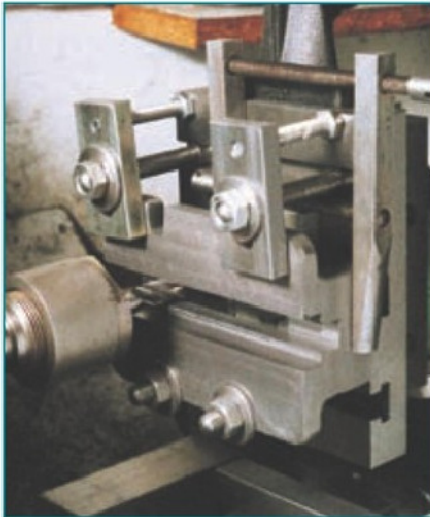
requirement for this is that the slot must be at right angles to the vice jaw. As this has already been machined some means of achieving this objective is necessary. For this purpose mount a short length of steel on to the slide's surface setting it accurately using an engineers square off the lathe's bed, **Photo 5**. Use a toolmakers clamp to hold the vice jaw against this and clamp the casting to the slide using two nuts on the studs and two bar clamps above, **Photo 6**. It is essential that the four fixings must be progressively tightened so as to avoid the casting tilting.

Carry out preliminary machining, sides and bottom, for the area where the jaw keep plate will fit followed by machining the slot in which the jaw will slide, **Photo 7**. Despite the jaw having limited movement the slot runs the complete length of the casting. Centralising the slot on the drilled holes will ensure that it is adequately central, not easy to measure by other means. With the slot finished, return to the keep plate slide and finish mill both base and sides of the groove. The body will need further machining after the jaw has been completed.

The Jaw

This is not an easy item to mount for machining due to its small size, irregular shape and taper that runs from the working face back. Mount an angle plate, such as that described in the last issue, on to the slide and on to this mount two supports for the jaw. These are positioned against the web on the bottom of the jaw that eventually will slide in the slot in the vice. The web is tapered as mentioned and the support pieces are angled to suit. This is just apparent from **Photo 8**. The jaw is then held in place using a bar clamp mounted from the angle plate and its working face machined. Now with a flat face, the jaw can be mounted directly onto the vertical slide as in **Photo 9**. Note that the piece of bar has once more found a use in the lower tee slot to act as a support for the jaw, thereby preventing the jaw from being pulled from the clamps holding





7. Machining the groove in which the jaw moves.

it. This simple bar really is an essential piece of kit!

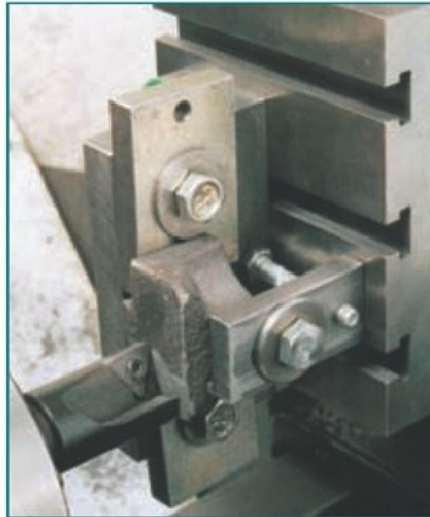
With two parallel machined surfaces the vice can now be used. As I prefer to machine by traversing the cross slide wherever possible, I chose to mount the vice horizontally on the vertical slide. However, with the workpiece central in the vice jaw, as should be the norm, it was not possible to get the workpiece low enough for machining. The workpiece was therefore moved to be bottom of the vice jaw and a tee nut and screw used as a jack at the top to keep the jaws parallel, thus ensuring that the workpiece was secure. The web was machined, **Photo 10**, and tested to be a close fit in the slot in the body, but a little on the tall side.

Now on the body, measure the distance from the face on which the jaw is to slide to the face on which the keep plate is to slide. Add to this say 0.002in. and with a suitable piece of metal and a feeler gauge or two, or three, create a pack to this dimension. Place this on the sliding face of the jaw and using the saddle carefully bring it up to the cutting edges of the end mill and lock the saddle. Check that the pack will just move without play. At this setting machine the face on which the keep plate will be mounted. If you have slip gauges they would be even better, as would be using a depth micrometer. Do though aim to be on the high side, you will file a little off later.

Jaw keep plate

Now make the jaw keep plate but drill it initially with tapping size holes. Clamp this to the jaw making sure it is central across the width and with 20mm projecting at the front. Drill through the keep plate into the jaw with tapping size holes, tap the holes in the jaw and then open up those in the keep plate to clearance size. However, there is not a lot of room for the clamp so it will almost certainly be a case of drill one hole, fit a second clamp, remove the first clamp and drill the second hole.

Next stage is to establish the required fit of the jaw and keep plate into the main body of the vice. The method I adopted for this is simple and consists of fixing a file in the gap where the keep plate slides, placing the jaw into the groove in which it



8. First stage with the jaw.

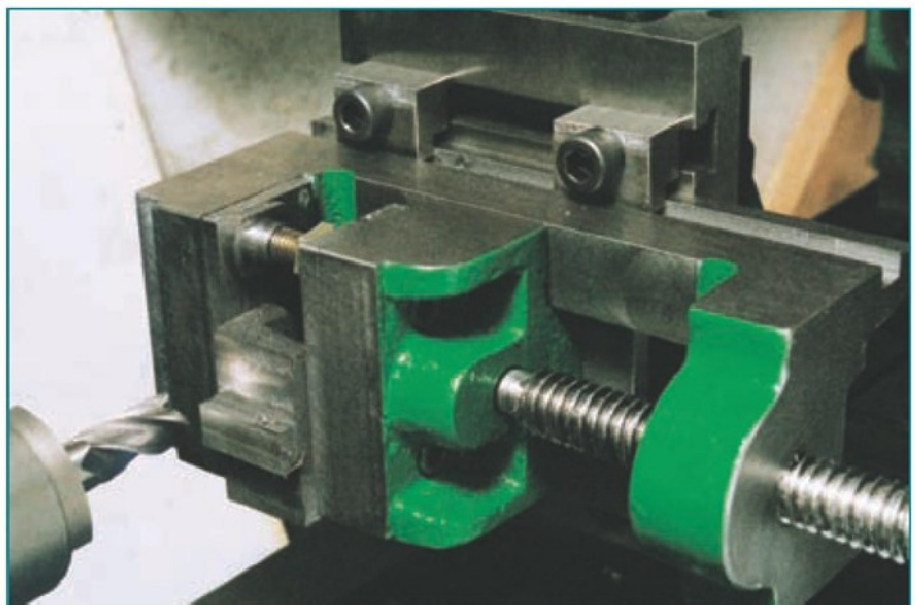
slides and move it back and forth until jaw and body have almost the same dimension.

Assemble the jaw with keep plate on to the vice body but place a thin shim, or piece of copper wire, between the keep plate and vice body so that the jaw is firmly fixed. Mount the assembly onto the vertical slide using a single fixing through the centre of the vice. Make sure that the clamp plate is firmly against the jaw to give it added security. Machine the top face of the jaw and then a light finishing skim over both ends and the jaw to bring them all to the same level.

Again, mount the angle plate on to the vertical slide but this time horizontally and mount the vice on this as shown by **Photo 11** and machine the edges of the vice fixing web. Having machined the first side turn round with the machined edge against the slide and machine the other. I do hope you have taken my repeated advice and set the vertical slide face accurately parallel to the cross slide movement.

For the next operation it is essential that the slide is upright and that the tee slots are perfectly horizontal else the vice sides will not be at right angles to the jaw face.

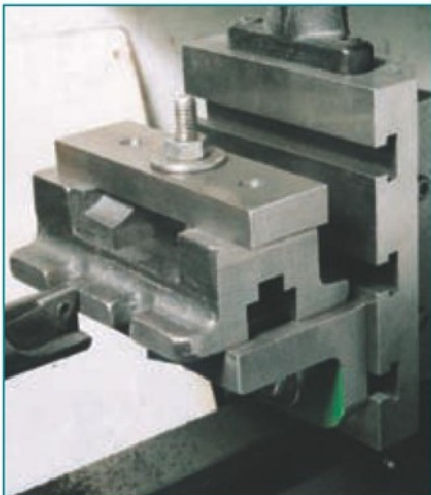
10. Finishing the web on the base of the jaw.



9. Facing the second side of the jaw.

But of course, the slide should always be set this way, unless set off at a specific angle for a particular purpose. Once more place the locating bar into a tee slot and use this to position the assembly for fixing to the slide, as illustrated in **Photo 12**. It occurs to me, that I have not to this point in the series, taken note of the fact that a few vertical slides have vertical tee slots. In this case, it will be necessary to use an engineers square off the side of the slide to position the supporting pieces that will need clamping to the table. The support also is an aid to repeatability where a part has to be removed and rotated for machining on the reverse side, as it does in this case.

With the assembly positioned, first machine the side of the vice stepping down the face in increments of around $\frac{1}{16}$ in. Follow this by machining the fixing face doing this also in stages, setting the saddle stop at this position, and for the final pass



11. Using the angle plate from the last issue.

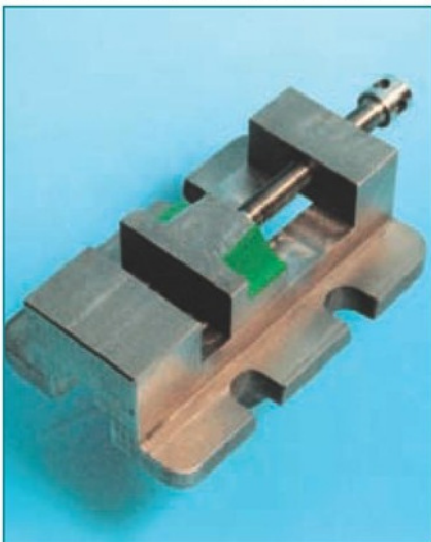
once more machining the vices side, say 0.002in. deep. As I have said elsewhere, at this depth the helix prevents the cutter taking an over wide cut. Having completed the first side, turn over, once more locating it against the bar in the tee slot and repeat the sequence for the second side. Having done that the milling operations are now complete.

Move the jaw to the fully open position and the vertical slide parallel with the lathe's axis and drill for the operating screw, **Photo 13**. First, drill at the size required in the jaw (6mm) then at the tapping size hole through the vice end only. Note that the tailstock is being used to feed the saddle for the drilling operation. Whilst still on the lathe place the tap in the drill chuck and tap the vice body. Being cast iron the chuck should provide sufficient grip for the operation or at least to get the thread started on course, which is essential.

The Feed Screw

Set up the lathe for turning and turn the two outer diameters with the workpiece supported by the tailstock centre. The position of the groove is important as this must only be used for opening the vice, the end of the screw, with the ball, being used to provide the gripping force.

15. Finished vice, viewed from above.



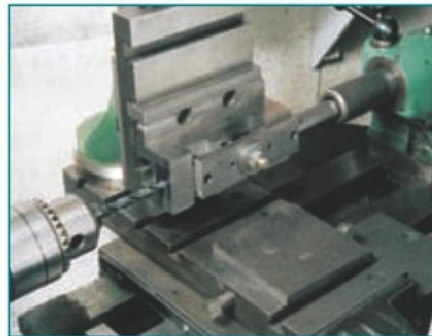
12. Machining the first side and vice fixing web.

Remove the tailstock to the other end of the lathe, place the jaw over the screw end and measure the distance from the jaw to the larger diameter. From this and the location of the keep plate/jaw withdrawal screw you can determine the position of the required groove. Return the tailstock centre and machine the groove, **Photo 14**. The tipped tool seen being used in the photograph is ideal for this type of work and also for parting off at small diameters.

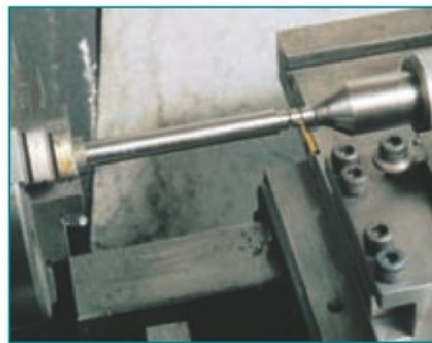
So that the vice works correctly it is essential that the thread does not wander along the length of the screw. This is not as easy as may first be thought. Using a tailstock die holder would seem the approach to take but at this diameter it is unlikely that the chuck will have sufficient grip. The easiest way out of this is to machine the part from hexagon bar material, if this is not available then the thread can be initially screw cut and just finished off with a die. The latter is the way I would take myself except for the fact that I like to keep to metric threads but have a lathe with an imperial leadscrew. The way that I chose to make the thread was using a die in a guided die stock, these perform the task with ease even if making very long threads.

Drill the Tommy bar holes, two at ninety degrees, and the vice is all but complete. Incidentally, the subject in the next issue is a cross drilling jig that will enable the cross drilled holes to be made with ease.

One of the keep plate fixing screws also doubles as a jaw withdrawal device and needs a 4mm spigot turning on one end, also the length will be quite critical. Assemble, jaw, keep plate and feed screw and test the screw making adjustments as necessary. Should changes be necessary to the groove in the feed screw in will be easy to return the screw to the lathe for machining in view of the centre in the end of the screw.



13. Drilling for the feedscrew.



14. Producing the groove on the end of the feedscrew, its position being critical.

Assembly

File the four corners of the base to remove the rough surface of the original casting, chamfer/debur edges and assemble and you have acquired a very useful small vice, **Photos 15 and 16**. As mentioned above, the subject in the next issue is a cross drilling jig. This is a very capable item and well worth making for anyone who does not have other facilities for what can be a tricky task.



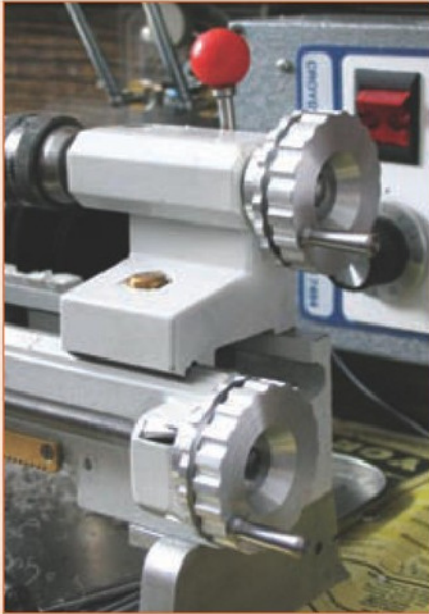
Supplier

Woking Precision Models. 27 Petts Crescent, Littleborough, Lancashire, OL15 8ED, Tel 0780 8446915 or 01706 377 508 E-mail graham@wokingprecision.co.uk Web Site www.wokingprecisionmodels.co.uk

16. Showing underside detail



FRICTION DIAL HANDWHEELS FOR THE UNIMAT 3



1. Completed handwheels fitted to tailstock and leadscrew.

The handwheels of my Unimat 3 were used mainly for their primary function; that of moving the saddle, or the barrel of the tailstock, etc. Probably a shortcoming more of operator rather than machine, I was aware of inconvenience when trying to use the division markings. Having noted the particular division, from which to add or subtract the amount of feed required, the starting point after taking a few cuts, soon became uncertain or forgotten; the job would have to be re-measured and a

Maurice Rhodes describes his indexable conversion

new starting point selected on the handwheel. As the machine aged, so the divisions became more faded, so it was decided that a new set of handwheels with fresh markings (rather than a visit to the opticians) would solve one of the problems. Furthermore, if they were made with a separate index sleeve as many of the larger machines have, then the other problem of not having to remember a particular division would also be solved. It was also decided that a larger diameter handwheel, would also give much better visibility and control, compared to the size of the original. **Photo 1** shows the new handwheels fitted to the tailstock and the lead screw.

Index Dials

My starting point here was the material, and a piece of aluminium tube, cut from a television aerial mast, was utilised for the sleeve. The inner and outer dimensions do not need to be quite so precise, but if a set of three handwheels is to be made, then these diameters should be the same for all three wheels, whatever the final size turns out to be. This will be a benefit when it comes to using the mandrel and jig. After taking a skim off the inside of the tube, to give it a smooth bore, trim one end square. Next a disc of aluminium alloy $1\frac{1}{4}$ in. in. dia. x $\frac{1}{4}$ in. thick is required for the thumbwheel. Centre drill in the chuck and open up the bore with a boring tool to give a press fit (or Loctite) with the squared end of the

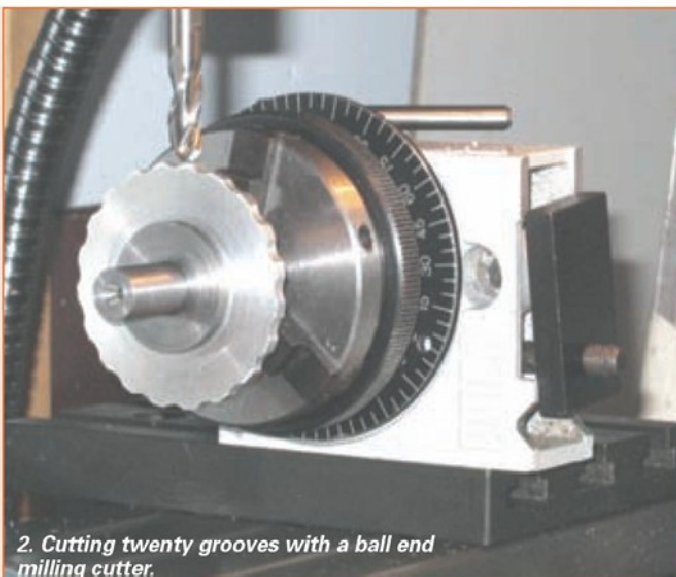
tube which will become the index dial.

Mount the assembly in the chuck set with it's jaws reversed to hold the thumbwheel and turn the index dial to length.

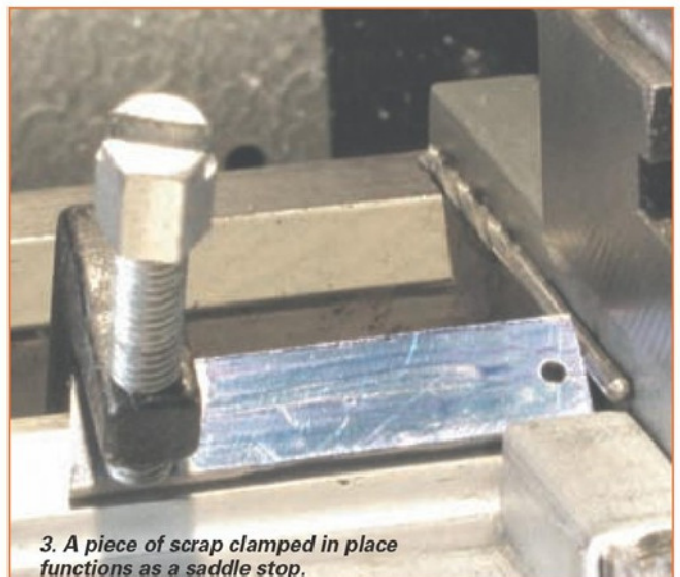
From a short length of about $\frac{3}{4}$ in. dia. mild steel, centre drilled at each end and a $\frac{3}{4}$ in. length of 1in dia. mild steel, make a slightly tapered mandrel, which will hold the index dial firmly, when milling the circumference of the thumbwheel. The suggested design for this is given in **Sk 1**

Mount the index dial assembly first on the mandrel and then (using the axle of the mandrel) in the lathe chuck set on the dividing head which has had the 40 division plate fitted. Set up the mill/drill attachment and using a ball-nosed end mill, cut 20 grooves around the circumference of the thumbwheel, as shown in **Photo 2**, then return the chuck to the lathe without disturbing the workpiece.

A slotting attachment or saddle stop would be handy to make the division marks, but if neither is available, then a piece of $\frac{1}{4}$ in. or $\frac{3}{8}$ in. scrap clamped to the lathe bed will suffice. With a 'V' shaped tool set sideways in the toolholder, set the stop for the long division or 0.1mm. marks, turn the lead screw until it reaches the saddle stop. When the long marks have been cut, lay a suitable sized drill bit between the stop and the saddle, as illustrated in **Photo 3**, and cut the shorter 0.05mm marks. Remove the mandrel and replace it with a parallel stub of mild steel, turned to the same diameter as the bore of the sleeve, in order to support to the tube



2. Cutting twenty grooves with a ball end milling cutter.



3. A piece of scrap clamped in place functions as a saddle stop.

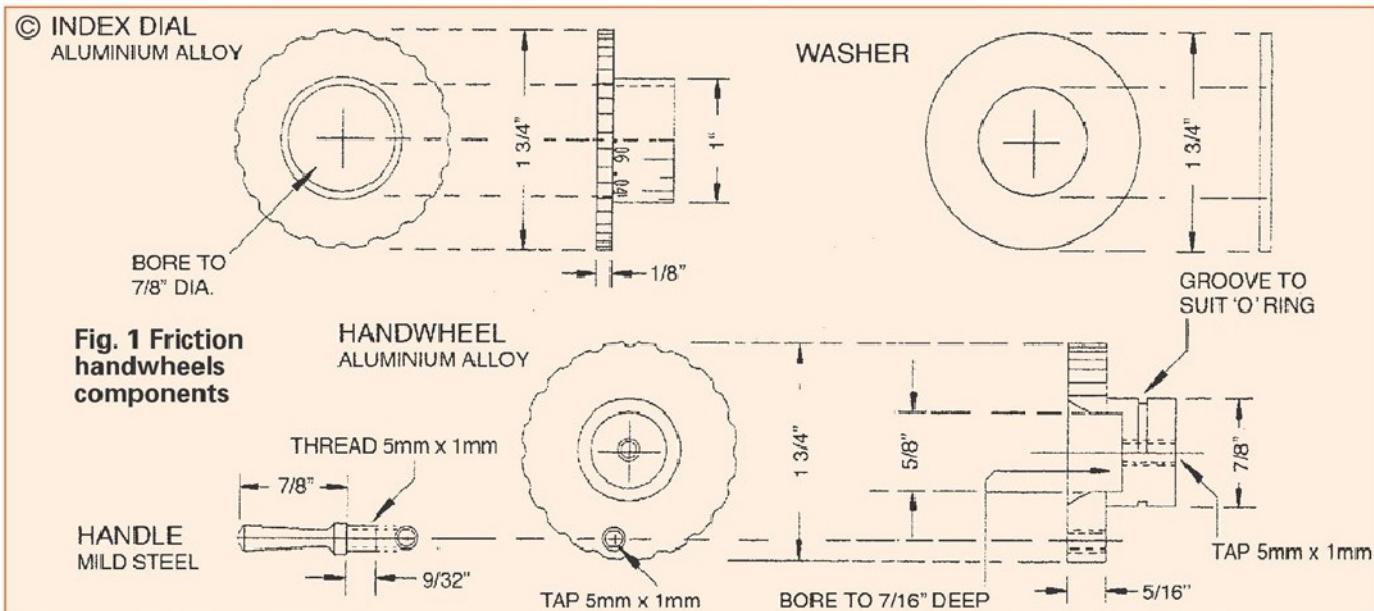
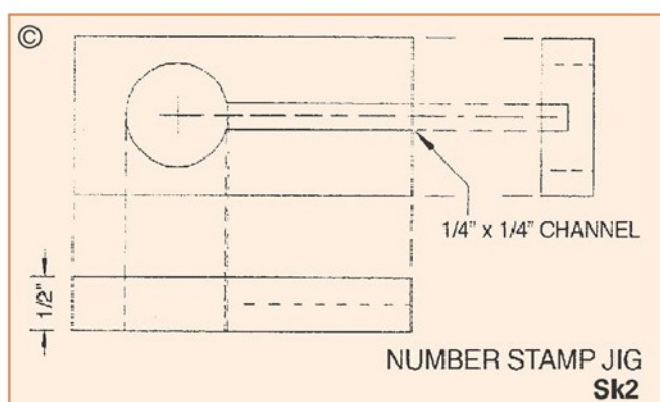
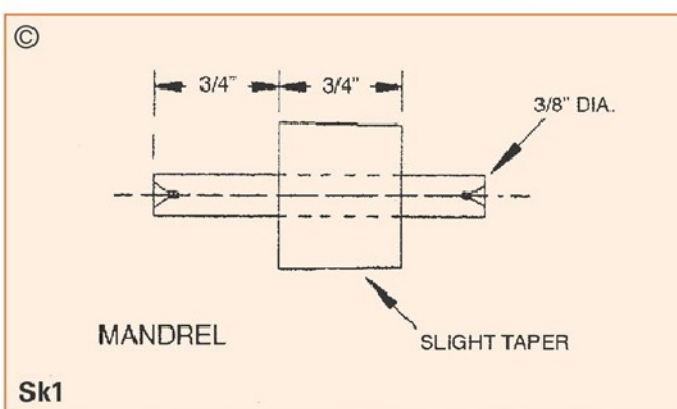


Fig. 1 Friction handwheels components



wall. Set the work in the jig and stamp the numbers as shown in **Photo 4**. The jig is made from aluminium alloy and only the necessary dimensions have been shown in **Sk 2**. Looking down the channel that takes the number stamp, gives a view of the

long division marks, which need to be numbered, in the same manner as the original wheels. Highlight the marks and numbers, with black ink or paint, then, remount the workpiece on the mandrel, which is now set between centres on the lathe. Take the finest cut from the surface of the index sleeve, to leave a clean set of marks and numbers. Finally before removing the workpiece from the mandrel, take the sharp edges from the thumbwheel using a file or lathe tool.

A washer made from something like Perspex or acrylic, is required, 1 1/2 in. in diameter and having a bore equal to that of the index sleeve.

Handwheels

The handwheels are also made from aluminium alloy 1 1/2 in. dia. and to save a bit of turning, the stock piece was held in the vice and rough cut with a hacksaw and then sliced off for turning in the lathe. With the blank set in the chuck, turn the smaller diameter until the index sleeve will slip easily but not sloppily over it, face off what will become the inner face and then the end (allowing for the thickness of the plastic washer). To provide the necessary resistance or friction between the two parts, an 'O' ring is used which is of the type easily obtained from a plumbers or DIY store and costing a few pence. Cut the groove to the width of the 'O' ring to be used and to a depth which will allow the index sleeve to turn with a resistance that,

after a thin film of grease been added, you feel comfortable with; one that allows the thumbwheel to be easily adjusted, when required, yet with enough resistance to prevent upsetting the adjustment, when using the handwheel. Drill and tap M5 through, then reverse the blank in the chuck to face and counterbore the other end. Remove the chuck etc. and mount them on the dividing head to form the circumference as with the index sleeve.

Handles

The handles are quite straightforward and can be simply a length of rod, threaded at one end to fit the handwheel. **Photo 5** shows the handwheel components before final assembly.

No provision has been made to prevent the index dial and handwheel from parting, nor has it been found necessary, but a thin 1 in. dia. washer can be slipped over the leadscrew before fitting the handwheel if required.



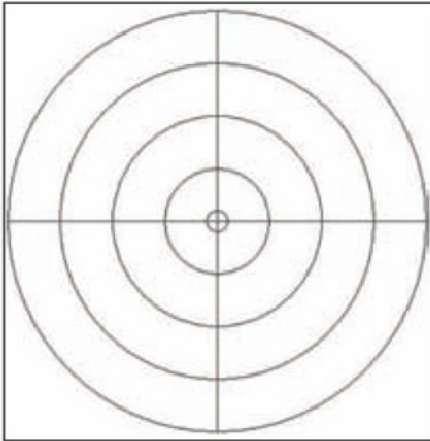
4. A jig helps align the number punch.



5. Component parts of a handwheel.

WEBCAMS IN THE WORKSHOP

Dick Stephen & Tony Jeffree apply this technology to centering and optical magnification.



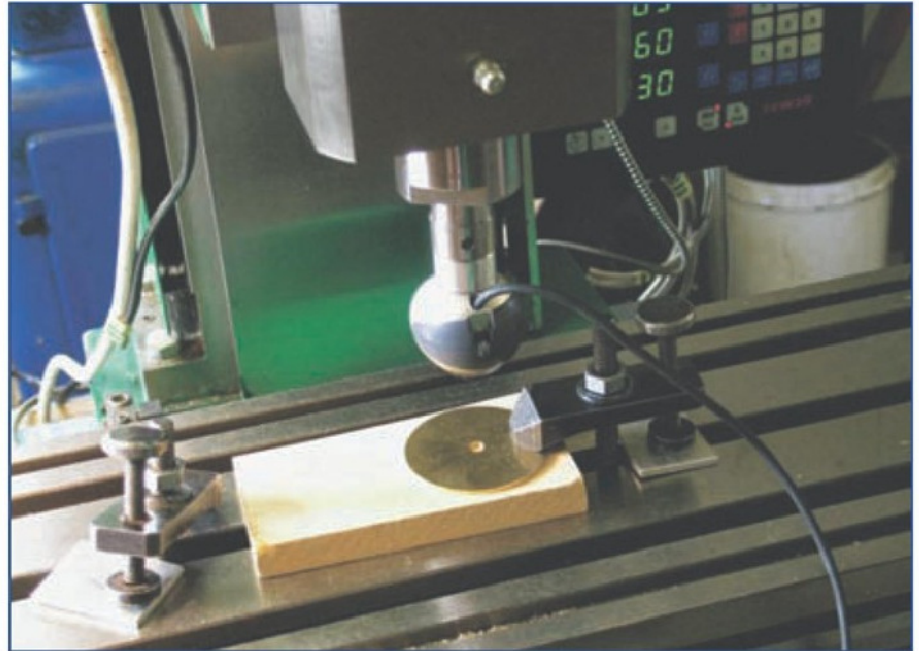
1. One of the graticule designs available on the website.

Raison d'être

Model engineering today in the UK is by and large a pastime indulged in by retired individuals over the age of 65. By this age some of these people will, unfortunately, have begun to suffer from failing eyesight. One of the authors (Dick Stephen) is one of these, and he is finding that loss of visual acuity is making some operations in the workshop increasingly difficult. When the two of us were talking on the phone a few weeks ago, Tony suggested that a webcam would make the ideal basis for a centering microscope for use in a mill or a lathe. For those of you that have not come across these devices, they are small, inexpensive, often relatively low resolution, digital



3. Set up to centre Trust camera.



2. Webcam fitted via Morse taper to the X3 mill.

cameras that plug into a computer, and can be used to record still or video images, for example to allow a continuous video display on a website, take still photographs, or allow two or more people to "video conference" on-line. It seemed to us that if we could somehow interpose a graticule on the image that one of these cameras produced on a PC screen, then we would have the basis of an excellent centering device.

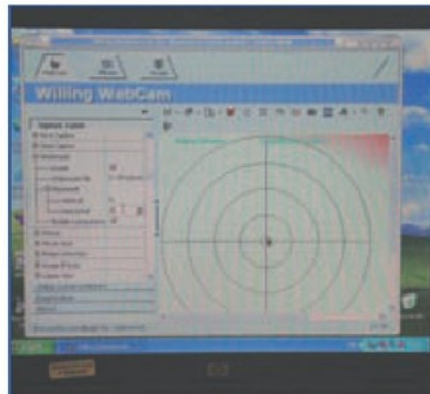
Some years ago, Dick made himself a centering microscope for use with his lathe and mill (recently featured in *MEW*, and now available as a Hemingway kit). However, Dick's deteriorating eyesight makes using the microscope increasingly difficult, so a centering device based around a much larger display on the 14-inch screen of a laptop would certainly make centering a lot easier. Quite apart

from that, the potential seemed to exist for building a useful device at minimal cost and minimal machining, which is always a bonus, as it leaves more time for doing what we bought the equipment for in the first place (if any of us can remember what that was these days!)

Development process

We kicked around a good number of ideas – some better than others, and some totally impractical – and were initially thinking in terms of dismantling the camera and inserting a glass graticule between the lens and the CCD (the image sensor that is the "film" in the digital camera), so that the image transmitted to the PC would already have the graticule superimposed on whatever scene the camera was pointing at. This could certainly be made to work, but could prove to be a complex miniature machining task, as the size of the CCD on these cameras is very small (around half a centimetre across) and the focal length of the lens correspondingly short, leaving little room to play with, and there would be a need (as on Dick's optical centering 'scope) to provide adjustment of the position of the graticule to centre it relative to the centre of rotation of the camera.

We decided that the best approach was to get a couple of cheap cameras, see what they looked like "in the flesh", and no doubt inspiration would strike. Dick located a likely suspect on Ebay – a very cheap camera, only a couple of pounds to



4. The graticule centre should coincide with the centre spot.

buy, built into a chromed metal tube 30mm in diameter and 80mm long. So we both bought one on auction, to discover the catch – the “seller” was apparently based in the USA but the product was to be shipped from Hong Kong, and once postage was added on, they ended up around a tenner each – still pretty cheap for a usable camera.

While waiting for these devices to arrive, we turned our thoughts to other approaches to the graticule problem. Clearly, the ideal would be to electronically (within the computer) superimpose the image of a graticule over the image from the camera, thus obviating the need to physically insert anything between the lens and the CCD sensor. After a lot of searching on the Web (as always, Google is your friend here!), Tony came across a “shareware” software package, intended to be used to create a live “webcam” display on a website, that showed promise as the basis of the display end of the unit. We also came across a number of other camera options closer to home, as will be described later.

Webcam Centring Unit - requirements

Software

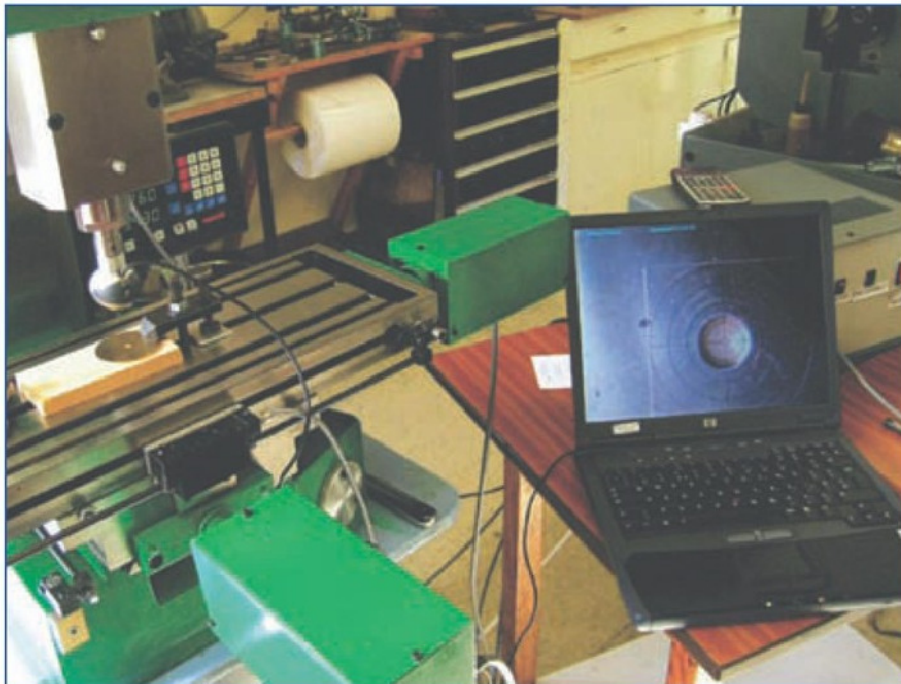
Willing Webcam Lite available from <http://www.willing.com/> as a download for \$ 14.95 ex. VAT. You can pay for this with a credit card. The software can also be downloaded on a trial basis – you get to play with it for 21 days before registration and payment is required for further use.

Following payment of the registration fee, Willing will email you a registration code to enable you to install the software permanently on your computer. There is no limit to the number of your own computers on to which you can install the software.

Willing Webcam is the only webcam software we have found that can easily be adapted for this particular application. The important feature is that Willing Webcam allows a “watermark” to be superimposed on the image derived from the camera. The watermark can be any image file that you choose to add to the video picture generated by the camera – if you were using the Willing Webcam software for its intended purpose, you might choose to superimpose a copyright statement on the image, for example. However, in our application, we use a drawing of a graticule (see below) as the watermark.

Hardware

1. Any PC or laptop computer with a USB port. This unfortunately means a relatively up to date machine.
2. A webcam. There are lots available on Ebay for less than £10. It is worth checking the postage charged on Ebay as you may be able to get one a lot cheaper in your local computer store. A lot of the webcams on Ebay come from China with Chinese software, as was the case with the one in the metal tube mentioned earlier. Fine if you can read Chinese, which we could not! We eventually used a Trust 150 webcam for our initial experiments, bought



5. The mill (left) and laptop (right) showing the graticule accurately centered on the image of the hole.



6. Webcam arranged for assembly work.

from PCWorld for under £15.00. If you use the same model you should be aware that the Trust 150 software is for Windows XP only. Dick Stephen tried to install the software on Windows 2000; the XP driver totally corrupted Windows 2000 requiring a complete re-installation of Windows 2000.

Having experimented with the Trust 150 camera, which is a relatively low resolution device (640X480 pixels), we feel that this is just about on the lower limit of what is acceptable for this application, and readers might consider using a higher resolution camera – again, there are examples of 1.3 megapixel webcams to be



7. Webcam and laptop arranged for a turning application.

had via Ebay for around £15-£20, and computer stores such as PC World will also stock these higher resolution cameras. The greater resolution gives a clearer image that is less prone to pixellation when displayed on the computer screen, and hence should be better suited to accurate centering.

Other 640 X 480 camera units are also usable. For example, the PC-Line product range includes a very slim model, only about a centimetre thick, called PCL-W310 that is also very promising, and that Tony plans to use on his Taig mill; the Trust camera is also available badged as Packard Bell VGA Webcam, model PB-WC100.

A final note on camera choice – some of the more up-market webcams have auto-focus capability. While these may be very useful for some other applications in the

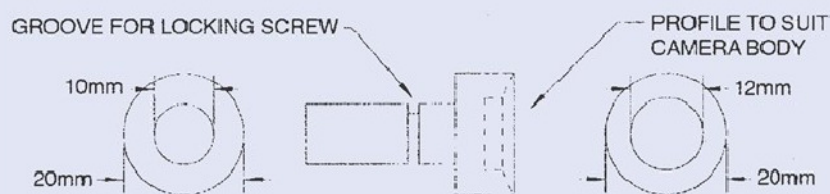


Fig. 1 Camera spigot

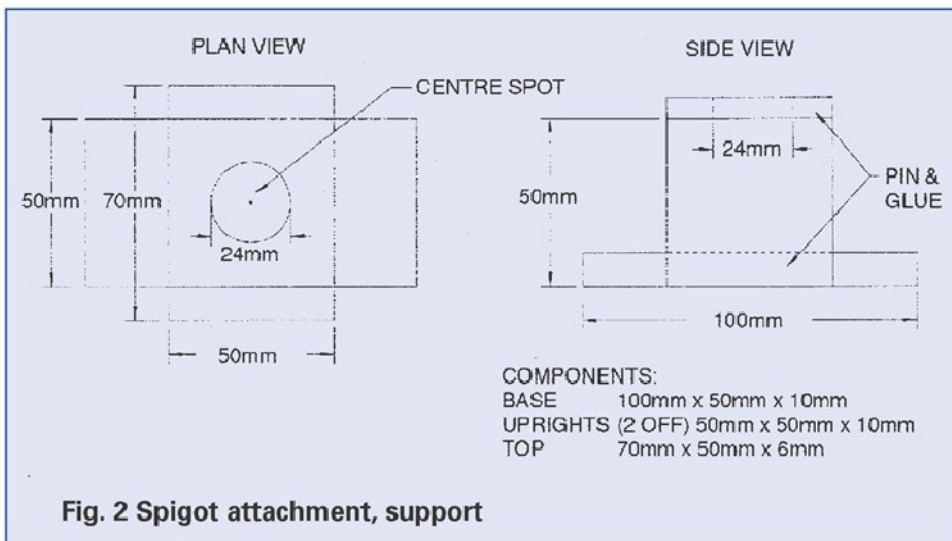


Fig. 2 Spigot attachment, support

workshop, as discussed later in the article, they are less suitable than a manual focus camera when in use as a centering microscope, as the auto focus mechanism may change the optical axis of the camera when focused at different distances, and hence generate errors in centering.

The Graticule

The graticule for the unit can be drawn using any available CAD programme. To convert the drawing of the graticule into a watermark, Adobe Image Ready 7 and Photoshop 7 software packages were used, as described later in the article. Alternatively, to assist readers who do not have access to these two programmes we have made a number of watermark graticules available for download from Tony Jeffree's Web site here (<http://www.jeffree.co.uk/Pages/graticules.html>). There are links to four graticules on that page; if you click on one of the links, the graticule will display. If you wish to download it, use the "file" menu to save

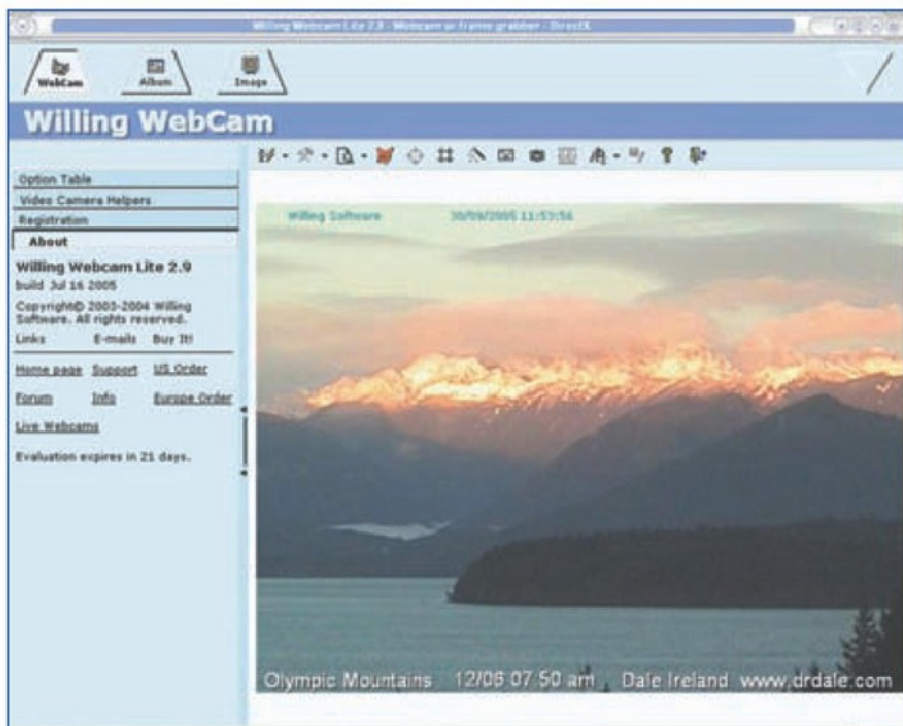
the file on your local machine – note that you should not change the ".png" extension to anything else. **Photo 1** illustrates the design of one of these graticules; this image is taken from the "graticule.png" file to be found on Tony's website. Readers may of course wish to design their own graticule.

Willing Webcam can use a number of different image file formats, including the familiar JPEG (.jpg) file format; however, for this particular application we ideally need a graticule image where the lines of the graticule are opaque but the background is transparent. Some file formats (for example, .jpg and .bmp) are incapable of representing a transparent background, so some manipulation of the image is required in order to produce the desired effect. A quick and simple alternative is to use a .jpg image and use the "transparency" adjustment feature of Willing Webcam to make it "translucent" – a transparency setting of around 10%-15% isn't too bad and produces a usable result.

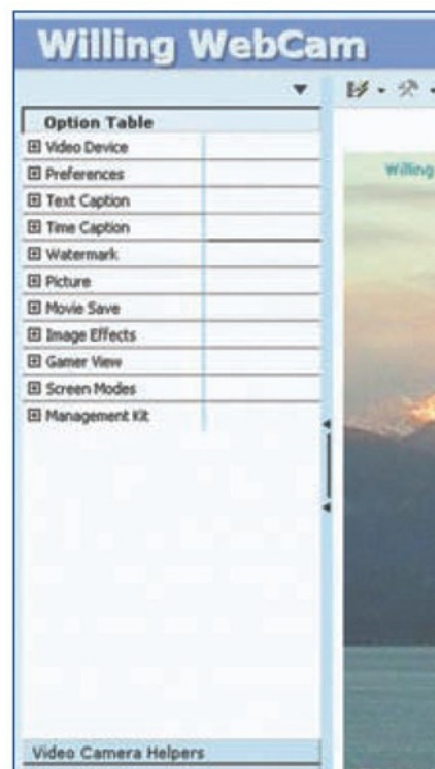
The procedure – for converting the CAD drawing to a transparent watermark is as follows:-

Having completed the drawing of the graticule, using a CAD program, save it as a bit map file (i.e. a .bmp file) on your computer. Dick used Adobe Image Ready 7 and Photoshop 7 to convert the drawing into a watermark. Using the Adobe software the procedure is as follows. Open the .bmp drawing of the graticule in Image Ready. You may need to Zoom in on the drawing depending on the dimension of the graticule. Click on Layer and set the drawing as Layer 0. Now go to Select and click Select all. A dotted line should now surround the entire border of the graticule. Now select the Magic Eraser Tool. This tool is hidden under the eraser tool in the tool bar on the left of the screen. Place the Magic Eraser in the white area of the drawing and left click. The background will now take on a chequer board appearance. Now select Optimise, which you will find in the Window pull down menu. Left click the transparency box in the Optimise table. Now go to Select and left click Deselect. Save the graticule drawing, now as a .psd file. Willing Webcam does not recognise the file extension .psd, but it will load .PNG files. The .psd file you have just saved must be converted to a .PNG file before you can use it as a watermark. The conversion is done in Photoshop 7. Load Photoshop 7 and open the .psd file of the graticule. Resave the file now as a .PNG file. The file extension .PNG is one of the available file extensions in Photoshop. Save the graticule file in My Pictures in the Willing Webcam folder.

Similar procedures for producing a graticule with a transparent background can be adopted using other image editing software packages – for example, Tony found that it was possible (although not terribly straightforward!) to achieve the



Screen 1



Screen 2

desired result in Adobe Photoshop Elements, again with the help of the Magic Eraser tool.

Having downloaded the Willing Webcam Lite program from the Willing website, you can install it on your computer and then install the graticule. Once you have followed the installation screens, run the program, and you should see something like the screen shown in **SCREEN 1**. At the left of the screen you will see tabs marked Option Table, Video Camera Helpers, Registration, and About. When you register the software you will be sent a registration code that you install via the Registration tab.

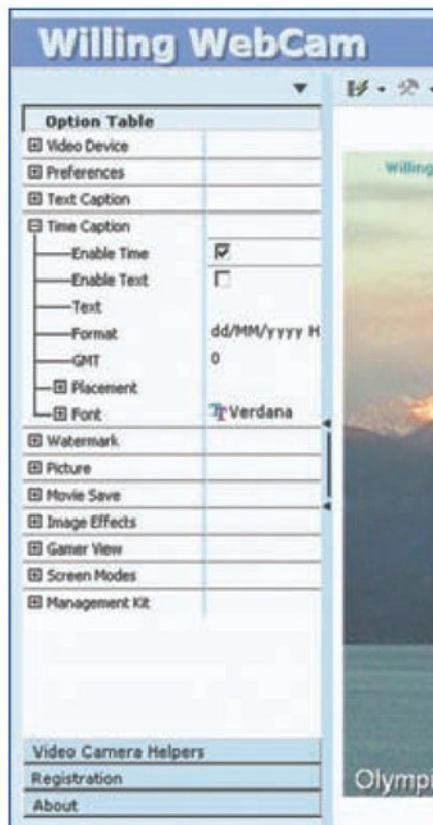
Click the Option Table tab and you see a display like **SCREEN 2**. Note that for several of the screen illustrations, only the left hand section has been shown. Click on the "+" sign next to Time Caption and you should see **SCREEN 3**. Uncheck the box next to "Enable Time" and the time display at the top of the video window should disappear. Click the "+" sign next to "Text Caption" and you will see **SCREEN 4**. Uncheck "Enable Text" and the "Willing Webcam" text should disappear. Click the "+" sign next to "Video Device". If the "Video Window Size" shows anything other than 640 X 480, change it to 640 X 480 as **SCREEN 5**. You may now need to re-size the Willing Webcam window to make the whole of its video window visible. Click the three "-" signs next to Video Device, Text Caption and Time Caption, and click the "+" next to "Watermark". The window now looks like **SCREEN 6**. Check the "Enable" box, and select the watermark file; if you have made one yourself or downloaded one from Tony's website, the best place to keep them is in the "C:\Program Files\Willing Webcam Lite" subdirectory. The file "graticule.png" from the website is suitable for a 640 X 480 display; "simple grat.png" is suitable for a smaller display size. Select "graticule.png" as the graticule file and the display looks like **SCREEN 7**.

You can now adjust the "Placement" coordinates to move the graticule into the centre of the display, as seen in **SCREEN 8**. The coordinates need to be set at 40, 122 to centre the graticule. This is a temporary setting – it will need to be adjusted in order to properly align the device at a later stage. It is also possible to "drag" the watermark around the screen using the mouse for rough positioning, although this feature is disabled if you move to "full screen" display mode.

Plug in the camera (having installed its drivers as per its instruction leaflet), and you should be able to set up the software so that you will see the camera display in the video window of Willing Webcam. Click the "Video Device" tab in the Options Table and you can select the video camera, as shown in **SCREEN 9**.

Focussing the camera

The lens on most manual focus webcams is fitted on a threaded mount. This allows the lens to be screwed in or out to focus the image. Unfortunately the thread and lens mount is not that precise, and the lens consequently not very secure in the camera body. For accurate and repeatable



Screen 3

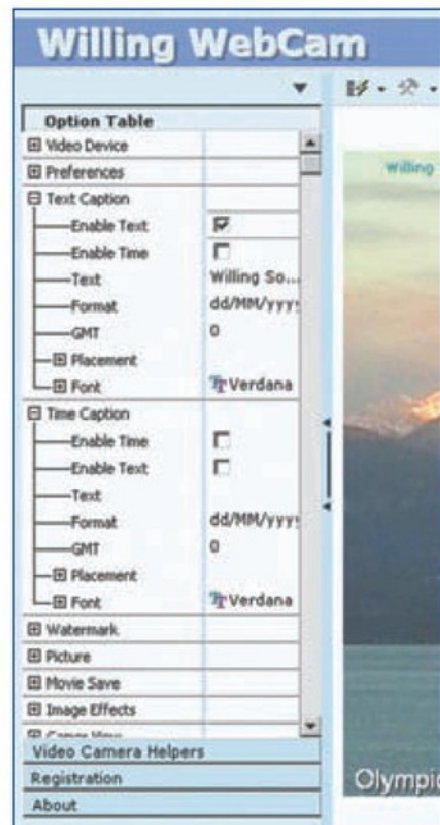
centring, the lens must be secured firmly in the camera body; focussing of the unit when attached to the mill spindle is then done by using the Z-axis feed.

There are two ways of securing the lens in the camera. The first approach is to adjust the lens in the camera to give a working distance of about 50 mm, and then use a few spots of super glue, applied where the lens meets the camera body, to secure the lens so it cannot move. Alternatively, the method we used was to tighten the lens against a Perspex spacer ring to lock the focus at the right setting. The thickness of the spacer ring (1.3 mm for the Trust 150 camera) is adjusted to give a working distance of about 50 mm between lens and workpiece. The ring is made of a suitable diameter to fit over the lens's focusing thread; with the Trust camera it is necessary to dismantle the camera to insert tie spacer ring, but this is simple to do.

Constructing the camera unit

Photo 2 shows the completed unit installed in Dick's X3 mill. The spindle fitting for this unit is a No.3 Morse taper; however, if there is a more suitable fitting for your particular machine, you would clearly use that. Tony, for example, has a Taig mill, and his version of the unit uses a plain 1/4in. diameter shank that will fit one of the standard Taig collets. For the Morse taper version, the camera is glued to an aluminium spigot with epoxy resin adhesive (but see "Adjusting and securing the camera" below before doing this). The details of the spigot for the Trust 150 camera are shown in **Fig 1**. If you use a different camera you will have to design a suitable spigot.

The end of the Morse taper adapter, which can be made from a Morse "blank



Screen 4

arbor", is bored and reamed 10mm to take the spigot as a close sliding fit, and the arbour is drilled/tapped to take a set screw that will engage with the circular slot shown in the spigot. This allows the camera to be rotated in the Morse taper adapter so as to give an upright image on the computer screen.

It is worth cross-drilling the Morse taper adapter to take a Tommy bar. This Tommy bar serves two purposes; firstly, it allows the unit to be secured in the spindle without holding the camera, and secondly, with the tommy bar placed in the same orientation relative to the spindle, enables the unit to be always replaced in the same orientation with an upright image on the computer screen.

Adjusting and securing the camera

Hopefully, you now have Willing Webcam running on the PC, displaying the video stream from a camera attached to the USB port, and with a graticule overlaid on the video image and centred on the video window. The centre of the field of view, in turn, needs to be coincident with the axis of the spindle of the mill. The utmost accuracy for this positioning is not necessary, as the final centring of the unit will be done later.

The next problem is to fix the camera to the spigot in such a manner that the axis of the spindle fitting/spigot coincides with the optical axis of the camera. This is fairly important, as misalignment of the camera will result in loss of positioning accuracy, either if the camera is rotated, or if the height of the camera above the work is varied. This proceeds as follows.

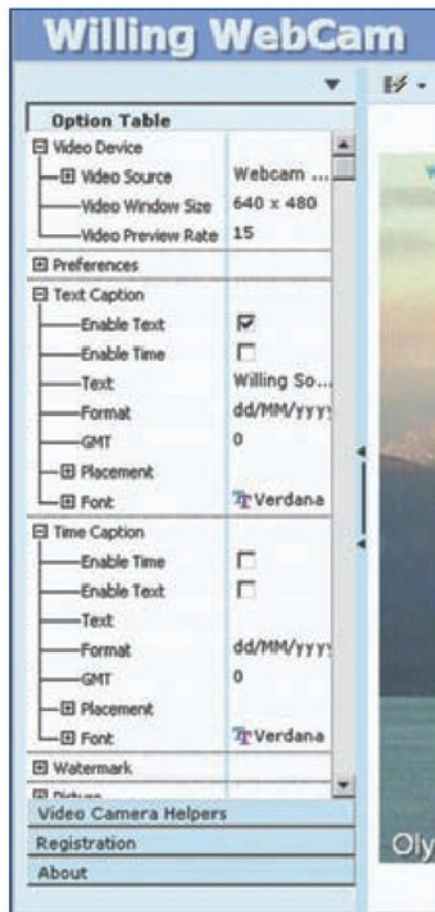
Photo 3 and **Fig 2** show the set-up used to centre the Trust or Packard Bell camera

units; a similar approach can work for other cameras too, adjusting the top plate according to the body shape. The frame can be made out of any scraps of 10 or 12 mm ply or MDF. This consists of a baseboard, which will be clamped to the mill table, with a "bridge" constructed over it from two uprights and a flat top. The top has a circular hole cut in it such that the camera can be supported in the hole, lens pointing downwards, with a lens-to-base distance of 50mm or thereabouts. Initially, make the base, attach the two uprights, and clamp the base to the mill table. Glue a piece of white card on to the base as shown and make a small mark roughly in the centre with a black pen. Centre the spindle accurately on this position. If you have a digital readout, zero both the X and Y co-ordinates; this will enable you to accurately re-position the spindle if you have to move the table for any reason.

Attach the top of the frame, which will support the camera body. The top is made out of a scrap of ply or MDF with a hole cut in it a bit smaller than the size of the camera body. This hole allows the camera to be focused on the centre spot. Focus the camera onto the spot on the card. Manipulate the camera orientation and position until the centre of the graticule on the PC screen coincides with the image of the centre mark (see **Photo 4**). Secure the camera in position with Plasticine or Blu Tac as shown in **Photo 3**. Fit the camera spigot in the spindle. Attach the spigot to the back of the camera body by applying some slow set epoxy (this is preferable to quick set epoxy, as it will, surprisingly, actually set harder in a shorter space of time) to the back of the camera and lowering the Z axis so that the camera spigot touches the camera back, and leave to set hard overnight.

Final centring of the unit

Remove the plywood support from under the camera. Clamp a piece of scrap brass sheet or any other scrap onto the mill table and drill a small hole part way through. Fit the camera into the spindle and focus it onto the hole just drilled. If

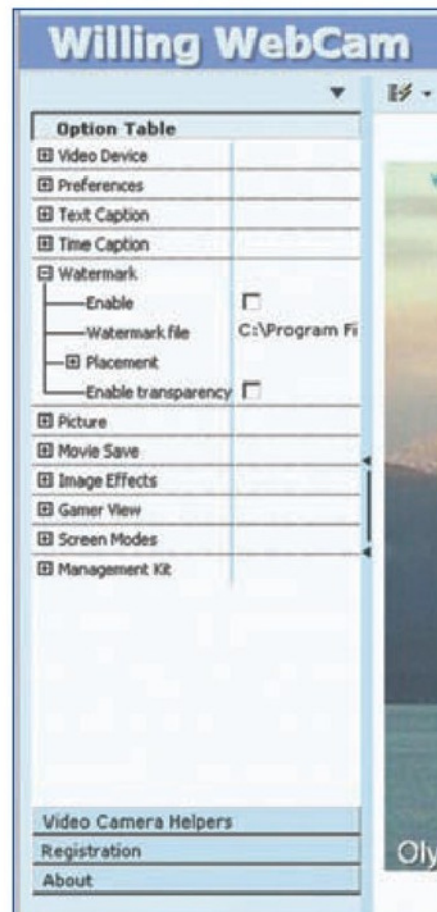


Screen 5

the optical axis has been nicely lined up in the previous stage of construction, this hole should appear close to the centre of the graticule. Using the positioning facility in Willing Webcam, accurately position the centre of the graticule on to hole, as shown in **Photo 5**. The unit is now ready for routine use.

General points

Although the camera software is able to adjust to some extent for changes in light levels, these cameras are rather crude, and can easily be "swamped" if the level of illumination is too high – the result is a

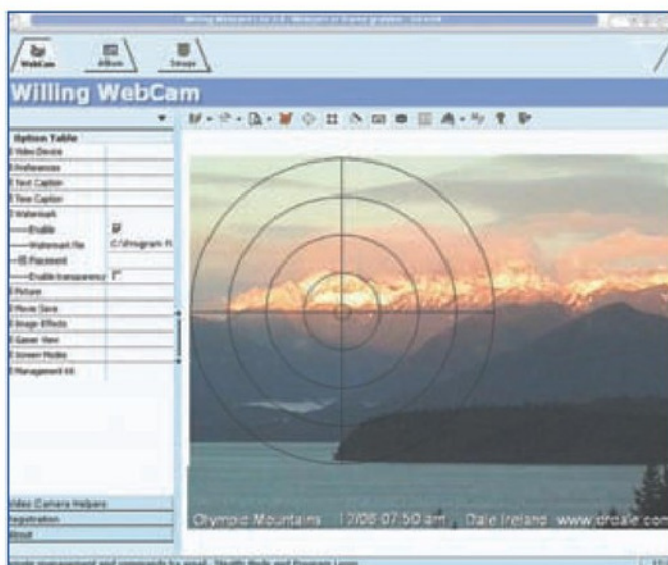


Screen 6

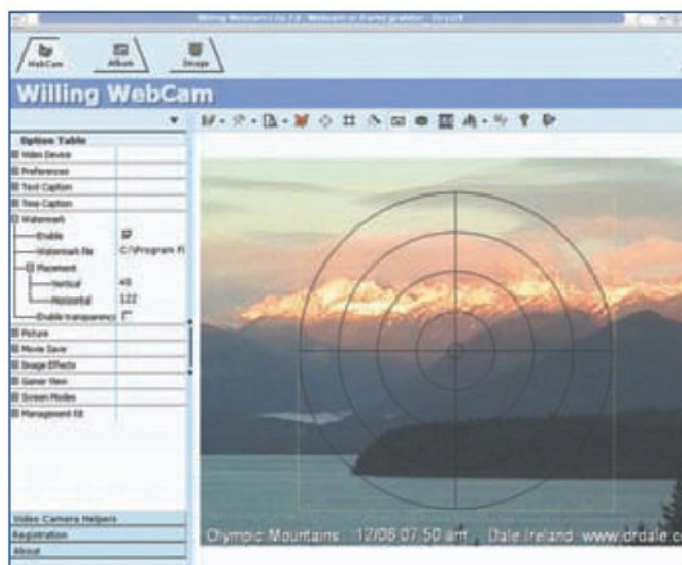
white screen with no detail. The solution is either to reduce the level of illumination, or to attach a filter to the front of the lens if the image is still too bright. You can improvise filters by cutting up the fogged ends of 35mm negatives, coloured cellophane, etc.

Other applications of webcams in the workshop

Before starting to look at the centering microscope problem, Dick had already



Screen 7

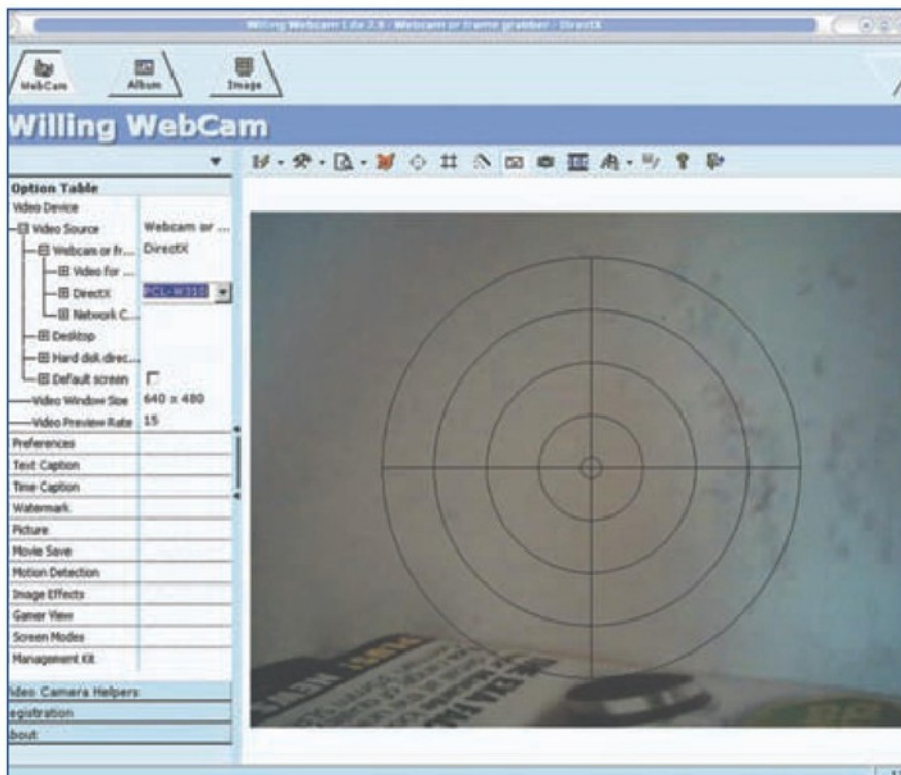


Screen 8

begun to explore the idea of using CCTV in his workshop as a visual aid. Having a laptop already installed for his CNC mill, using it with a webcam was a clearly the way to go. The next step was to explore suitable applications for this new technology.

Dick's main workshop interest is clock making, particularly rather complex ones. These frequently require the assembly of some rather small components. Recently he has been making a balance wheel escapement using an escape wheel just over 8mm in diameter and pallets to match, salvaged from an escapement that used to turn the street lights on and off. The assembly of this platform was very difficult as Dick could only just see the parts with a powerful headband magnifier. He had managed to complete the platform by the time he tried the webcam set-up shown in **Photo 6**. The design of the gantry set-up was dictated by the design of the particular camera mounting and the need to obtain an upright image of the object.

Photo 7 shows another very useful application on the lathe for turning small, difficult to see objects or when a lot of swarf is flying off the tool. In either situation it isn't advisable to have your head too close to the work. Similarly there are situations when milling, where it is very difficult to see precisely where the tool is even if one has a digital readout fitted. A conveniently positioned webcam solves this awkward problem. For these applications, Dick used a 1.3 megapixel camera to give a higher resolution display, which is obviously of



Screen 9

benefit when using the camera effectively as a low-power magnifier. He found that at the kinds of focusing distances that were convenient for this application, the set up produced a useful magnification of around 2.5 times the

size of the object. If greater magnifications are needed, the camera can of course be made to focus more closely; however, this brings with it a reduction in working space between the camera and the object.



IN OUR NEXT ISSUE

Coming up in Issue No. 113 will be



Cross Drilling Jig

In this episode of the Lathe Only Workshop Series, Harold Hall describes building this useful kit, available from Hemingway.

X3 – CNC, Further Options

Tony Jeffree outlines variations on the theme for converting the X3 Mill to CNC operation.



Mini Vice

Get a firm grip of small parts with this one from Bob Loader



Broadband Internet Access

Now that this facility is more generally available, Mike Haughton takes look at ways, means, benefits and security.

Issue on sale 10th March 2006

(Contents may be subject to change)

MULTI-FACET SHARPENING OF LARGER DRILLS



Les Riley describes an ingenious jig.

for bigger sizes. Building a Quorn was an option but still would not easily accommodate the sizes I now use.

I have accumulated a broad selection of Morse taper drills over time, both Imperial and metric up to the No. 3 shank size. My hand sharpened drills are acceptable for 'blacksmith' type work but lack the finesse that lathe or milling work require. Giles Parkes' article on the adaptation of a Worden grinder to produce four facet drills set me thinking. Like Giles, I did not want to make loads of collets or holders but a few were acceptable. It occurred to me that if I was sharpening No. 1, 2 & 3 Morse drills then only three holders were required for these drills.

One stage further

To quote from Giles' article, "any grinder on which you can set angles and fine feeds will do". Well it just so happened that about the time I re-read that article, I bought a bargain Jones & Shipman 540 surface grinder. A surface grinder has fine feed; it moves back and forth across a grinding wheel and is adjustable for large and small drill lengths. Also by using the magnetic table to anchor the sharpening jig it is ready in seconds and put away equally fast.

However, by the time I was two thirds through making the jig, I bought a bargain Jones & Shipman 310 tool and cutter grinder too. A couple of quick

1. Cross drilling the main body for clamp location.

Several factors share the inspiration for this device. Derek Brown and Giles Parkes for their articles on the four and six facet sharpening method, the desire to build a 4inch scale traction engine requiring larger equipment and the current national economic circumstance.

Many years ago I bought one of the splendid 'Reliance' drill grinding jigs to sharpen up to about $\frac{5}{16}$ in. dia. at a push, but I have always had to sharpen larger drills by hand and the results are somewhat hit-and-miss.

As professional engineering firms are leaning heavily towards CNC everything, there seems to be a lot of good, older machines coming onto the market at low prices nowadays. This is particularly true of the internet sources, mainly Ebay, but also applies to company closure auctions and similar sales. Having now acquired larger milling and turning equipment able to use bigger drills, the time had come to think about the problem further. I have made one of Derek Brown's excellent diamond pad and block devices for very small drills and wanted something similar



2. Finishing the ER taper



3. Milling slots in holder



4. Morse taper holders, ejector, and fixer.



5. Milling the arc slots and Graduating the Main Body, the vice is mounted on a rotary table

modifications to the baseplate then enabled the fixture to be easily used on this instead. I have included a drawing giving rough dimensions. None of the values are of any particular consequence, other than the angles, but give the basic sizes of the jig.

Description

In common with the usual spirit of home workshop, the jig was built around available materials. Thus the detail given in **Figs 1 and 2** may be subject to variation, depending on the contents of your own material stock. My rather fancy, all curved base plate was a profile cut inspection cover that someone never finished. The main body was a large chunk of steel offcut; it could be replaced with alloy, I suppose. None of the machine work is special, just heavy. **Photos 1,2,3,4,5** show some of the items during manufacture and **photo 6** the 'finished to test stage' jig in use on the surface grinder. **Photo 7** is the unit now modified to fit the J & S 310. **Photo 8** shows setting the drill parallel to the holder with a square when using the

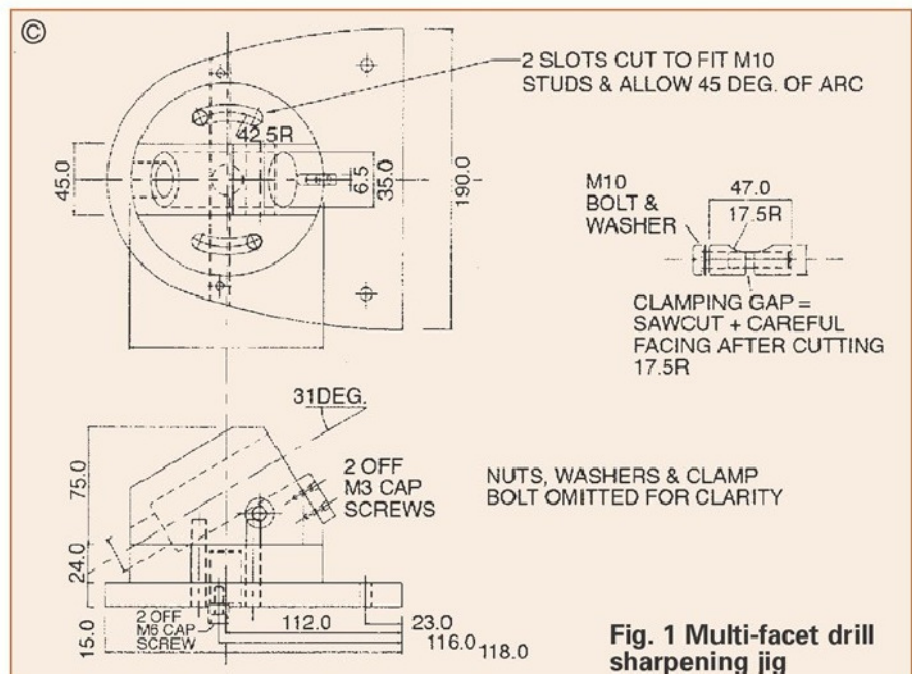


Fig. 1 Multi-facet drill sharpening jig



6. The jig in test use. Note the end face locates on the table fence for alignment.



7. The baseplate now modified for the J & S 310. The jig is using the ER holder for a parallel drill. Note the base now fixes against the location strip underneath.



8. Setting a drill parallel to the holder with ER collets



9. Example Tips – 6 facet, right and 4 facet, left.

later ER holder. **Photo 9** shows the resulting tips (6 facet on a drill of 1.5in. dia. and 4 facet on one a little smaller) and **Photo 10** illustrates the completed jig and holders.

I have never found that my workshop needs demanded any variety in tip angles so the drills are held at the 118 degree included angle by the main body and this is fixed for all drills. The various facet angles are set by rotating the main body

and clamping with the two studs in the arc slots. The drills are set in the appropriate sized holder for their taper with the drill tips aligned by eye with the 180 degree slots. To make this easier I milled a diameter line (**photo 3**) right across the face of the holders with the tip of a small centre drill. A sharp tap with a suitable blunt object (preferably copper or aluminium) then fixes the drill in the taper. This alignment by eye is the only part of

the process that is not fixed or measured. The holder is then inserted into the main body with number one 180 degree slot engaged on the key. As may be seen on the holders, these slots have been stamped 1 & 2 to make it easier to remember which cutting edge is which.

I have found it best to grind the 25 degree facets first, then the 10 degree and then the fifth & sixth facet (45 degree) clearance if desired. The clamp is tightened and the drill advanced slowly to the wheel. Grind until a full facet is produced and any lip damage removed. Note the reading on the crossfeed, wind back a bit, slacken the holder clamp, rotate 180 degrees, re-clamp and grind the second side to the same reading.

After the angle setting to 10 degrees and few careful licks will give the 10 degree facets and then you may put on extra clearance with the six facet facility if desired. To do this merely set the main body angle to 45 degrees and instead of the 180 degree slots, locate the drill holder in one of the 22.5 degree slots. Grind the facet, note the crossfeed reading and do the same again using the other 22.5 degree slot.

As with the other methods of producing the facet point, you will see whether things have gone according to plan by the geometry of the resulting point. Any of the facets can be re-visited to correct a problem.

I debated as to whether to mill push ejector slots in the holders but decided that a suitable bit of brass from the scrap box (**Photo 4**) was all that was needed. It just fits up the end of the holder and a sharp tap pushes out the drill.

I subsequently bought a set of ER32 collets and decided to try an arrangement based on the ER system described by Giles Parkes for my smaller parallel shank drills. This can also benefit No.1 and some No. 2 Morse sizes too. A fourth holder with an ER32 nose machined on it was made. The main body of the device has a clearance hole right through to allow any extra length to be accommodated when drills are held this way. I use a commercial closing bezel from another chuck.

When setting the cutting lips on drills in

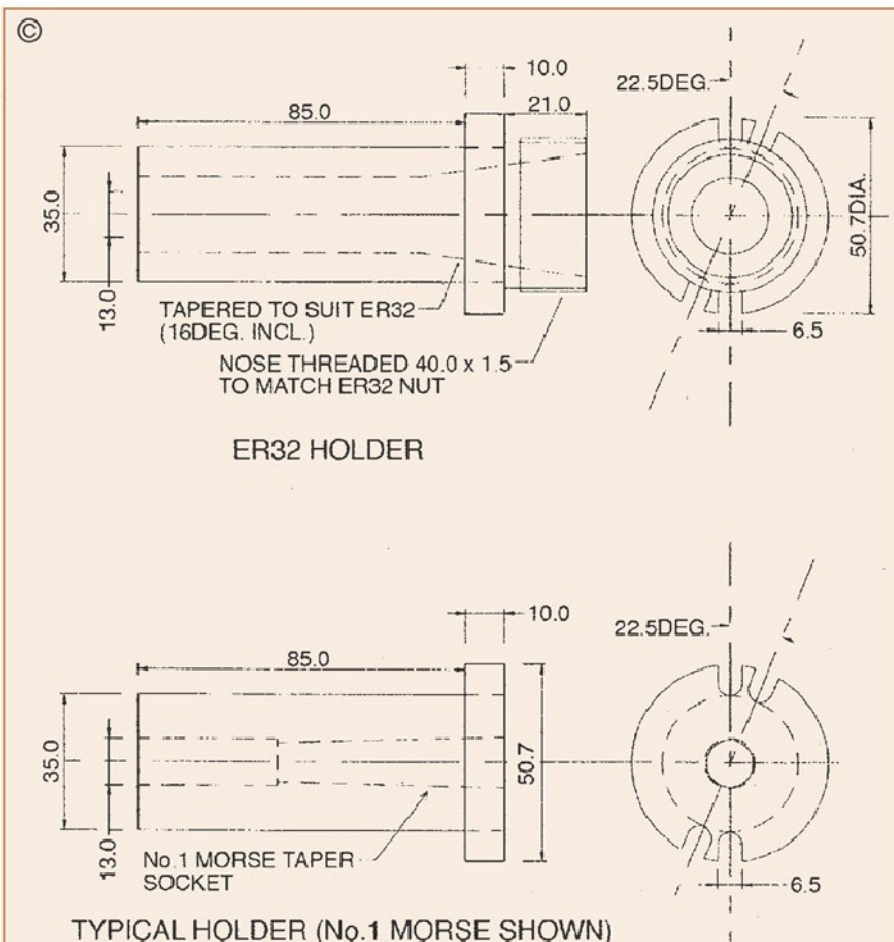


Fig. 2 Drill holders



10. The Completed Unit

the ER holder, it is possible to use a suitable sized square to set the first lip vertical, then tighten the collet (photo 8)

Results

One of my drills did not seem to sharpen properly. It was ground at 25 degrees to the same crossfeed reading on both lips but it had been ground well off centre. My only conclusion was that the drill was out of alignment so on removal from the holder I rolled it along the mill table and sure enough, the tang was bent slightly. Another drill passed the rolling test but was still not evenly ground and when placed in the lathe chuck whilst in the holder it showed 10 thou difference

between lips with the DTI. So this method tests the straightness of your drills too!

Rather than spend ages at the grinder I have adopted a policy of sharpening a drill when it becomes necessary to use it. The first time you convert to a multi facet point it does take a bit longer to do the job as you are grinding away the old shape, and obviously, the larger the drill the more meat to be removed. Casualty drills can be sorted out quicker by freehand grinding back to approximate shape first.

I was rather dismayed when I first tried using some of my newly sharpened 2MT drills in the lathe to drill the hole in the 3MT holder. The drill was opening up a comparatively large pilot hole and only

drilling on the outer $\frac{3}{8}$ or so of the tip. It juddered and did not seem to be cutting properly. On inspection there was no apparent problem, the lathe was only going at 96 rpm for a 51/64 drill and there was plenty of clearance on the tips and both were cutting at once. The problem turned out to be that I was not feeding the drill fast enough!

Having summoned up some courage I gave plenty of feed with the tailstock and had the coolant on also and was rewarded with two lovely curly ribbons of swarf and a very smooth cutting action. This problem is not found when cutting with a small pilot hole.

Conclusion

Whilst not everybody will have a surface grinder or a T & C grinder, the whole point of this hobby is to achieve results by ingenuity. I am certain the principle could be modified to suit whatever you happen to have in your workshop.

I am happy to answer questions on the jig by email to les@staffordshirechina.com



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Sharpening Small Drills by D A G Brown – ME issue 4119, 5th-18th May 2000
Twist Drill Sharpening by the Four Facet Method by Giles Parkes – MEW issue 64 Feb/March 2000
 Conversation with D A G Brown at the Midlands Exhibition

POWER-FILE HOLDING FIXTURE



Showing the Powerfile located in fixture, clamped in vice

This item came about as a result of finding that the Black and Decker Powerfile could be a mite awkward to hold and apply to work with the delicate touch desired. As can be seen from the photo, the Powerfile is made as a narrow band hand held liner. The accessory firmly grips the tool such that the whole assembly can then be accommodated in a bench vice. This then leaves both hands free for holding/ guiding the work which can be a major advantage on intricate items.

Construction

Mark off for large hole 3 $\frac{1}{2}$ in. from base on 6 $\frac{1}{2}$ in. dim. and centreline on 4 $\frac{1}{2}$ in. dim. Clamp the two pieces together and drill pilot hole through. Separate and trepan/bore both pieces 2 $\frac{1}{2}$ in. diam. These may have to be done from both sides depending on the length of the cutting tool. The motor cover is not round but this

George Wilkes describes a neat convenience accessory

out of roundness can be accommodated when the parts are split. Make up sandwich of two larger and two smaller pieces. Glue, square up, flush edges and clamp together. Drill for eight off woodscrews (four each side). Stagger these screws (so they don't meet) and screw together. Mark off four holes on top edge of assembly, drill four holes to 4 $\frac{1}{2}$ in. deep to suit 4in. wire nails or whatever is available for pins. Mark centre line of large hole all round, indent pieces, saw through. Catch fixture in vice clamping over the 4 $\frac{1}{2}$ in. dimension. Locate power-file in fixture and secure by rubber shock cord around fixture and vice. Now you are ready with both hands free. Don't forget your safety glasses.

MATERIAL REQUIREMENTS

Mine was made from $\frac{3}{4}$ in. plywood and dimensioned basically to suit the availability of the materials. Thus the sizes I used were:

6 $\frac{1}{2}$ in. X 4 $\frac{1}{2}$ in. X $\frac{3}{4}$ in. plywood (2 off)
 4 $\frac{1}{2}$ in. X 2 $\frac{1}{2}$ in. X $\frac{3}{4}$ in. plywood (2 off)
 2in. woodscrews (8 off)
 4in. wire nails (4 off)

A SELF-BUILD DRO FOR CHINESE SCALES 2

Mike Haughton concludes his description, with consideration of mounting, guarding and comparative performance.



13. Scale fitted to Z axis of Centec mill.

Mounting the scales on the Mill

Obviously the solutions to this problem vary with the mill. On my Centec 2A I measured the maximum movement of each axis and then attempted to match this to the available scale sizes. Note that the advertised measuring length of a scale can usually be exceeded by 10 to 20mm. e.g my 5in. / 130mm bar will actually measure 5.5in. / 140mm and is 9in. / 230mm overall length.

My plan was to do away with the adjustable stops on the 3 axes and use the freed up tee slots to mount the 3 scales. I wanted to avoid drilling and tapping into the mill castings, but for the Y and Z-axes I couldn't avoid it, and used M4. I used horizontal style scales, as they are cheaper, mounting them to suit the axis mounting positions.

The key points on installation are rigidity and at the same time avoiding any stresses on the scale that might move the measuring head out of its normal sliding axis along the beam. To test this out, turn on an un-mounted scale and try to displace the measuring head, front to back,

up and down and twisting. You will probably see small changes in the reading due to capacitance changes as the head moves relative to the beam. Adjust the gib strips to get the smallest change consistent with free sliding. Most models have a thin spring gib strips and there is usually some adjustment available. Make sure the gibs are well adjusted. I found that the gib strips on my scales were not flat, they appeared to have been sheared from sheet and showed bright wear points after a few months use.

Following a recommendation in one of the Internet Groups, I removed all the scale gib strips and flattened them by rubbing on fine emery on a glass plate to improve their "slide-ability". This process does bring benefits. You will see the gibs in my photos of a scale being taken apart in part 1 of the article. The horizontal scales I used had two mounting holes at one end of the beam and nothing at the other end.

Scale guards

My previous experience with Chinese scales has taught me that that they have to be protected from the ingress of swarf, chips and fluids. Introducing a guard that

provides this protection causes several problems. The use of the four pin data plugs shown in **photo 10** takes up too much room. I abandoned them and soldered directly to the data tracks on the scale pcb. It is essential to provide cable clamping. See **photo 12**.

On two axes (X and Y) I have used simple guards made from alloy angle and on the third, the Z-axis I used a piece of rectangular alloy section 2in.x1in. and only one alloy mounting block for the scale. **Photo 13** shows Z-axis before the guard was fitted and **Photo 14** after, with cable clamp.

Mounting the DRO on the mill

The DRO unit has to be securely fixed, yet adjustable for height, tilt, etc. The DRO buttons have to be accessible for, preferably, one hand pressing as there are a lot of functions available. I was fortunate to be able to use the tee slotted motor mounts on the right of the machine gearbox to secure the DRO mounting arm, which was constructed from 25x25mm square steel tube. I decided that adjustment of the DRO position was desirable and to achieve this the ends of



14. Protective cover fitted to the scale shown in Photo 13

some of the square tubes were filled with short lengths of square bar. This particular bar wasn't a tight fit in the tube, so to secure it a couple of 6mm holes were drilled through the tube wall, stopping a couple of mm into the bar. The holes were then filled with weld and any excess ground off. See **photo 15**.

Rather than drill into the ABS case of the DRO, I epoxied a simple base made from 1in. square HE30, 6082 alloy on to the bottom edge of the case. See **drawing 2** and **photo 15**. The 8mm Bristol handles and knobs came from Axminster. Ref.14

Replacing the batteries, and ground loops

The Shumate DRO provides a regulated power supply for any Chinese scales attached to it, and in theory, the scale batteries could then be dispensed with. I found that with just one scale and the DRO mounted on the machine the fast mode makes the scale and the DRO quite jittery, removing the battery gave less stable readings, more jitter. Adding more scales made things worse. This was after the machine was earthed via its mains lead. Referring to the User Group for inspiration, it appears that the battery cells, even if they are not actually powering the scales, provide a useful capacitance effect. The recommended action is to solder a pair of capacitors across the battery connections; a 330 μ F electrolytic to take care of low frequencies and a 0.1 μ F non electrolytic to take care of high frequencies. The problem I had was finding units small enough to fit in the battery space.

I first soldered a 0.1 μ F capacitor across the power lines from the DRO to the scale data connection, the small blue blob in **Photo 4** (part 1 of the article).

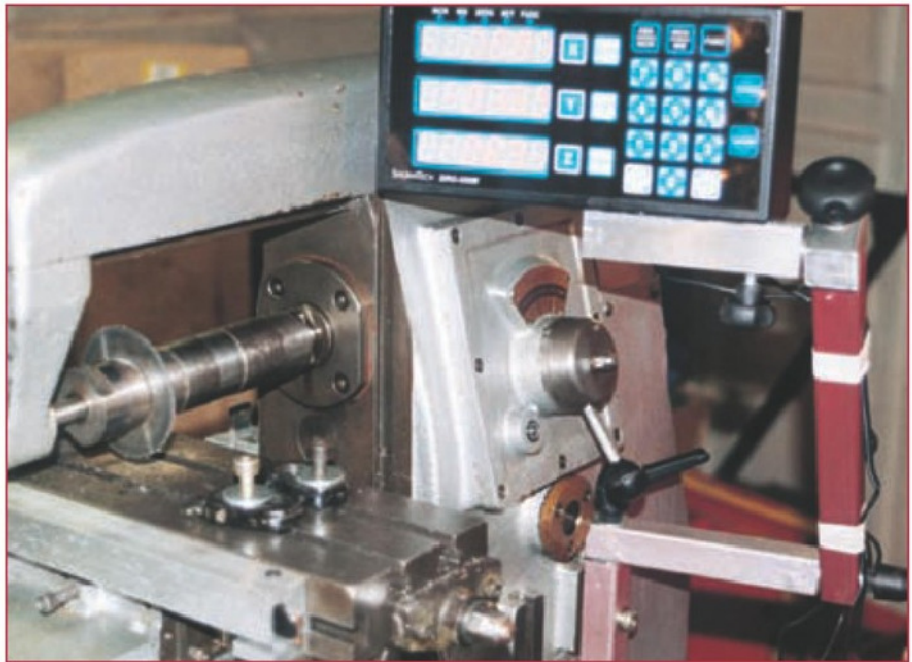
330 μ F turned out to be a non-preferred value at Maplin so I experimented with 220 μ F, 6.3volt.

I have found that repeated dismantling of the scale heads to add capacitors and solder in leads results in stripped threads etc and an alternative approach could be to use a small Dremel type grinding wheel or circular saw to increase the size of the opening where the data cable cover fits. I used the soldering iron to clean out the sides of the opening. By this means I could more easily solder directly to the data connector without taking the scale head out of its case and off the beam.

My experience has shown that both capacitors are essential for operation without batteries. Read the ShumaTech website and experiment to get the best results for your set up. I didn't find switching the mill motor on and off had any noticeable effect on the scale readings.

A comparison with a Newall Microsyn

Whilst I was struggling to complete this project I bought a Chester 626 vertical mill with 2-axis Newall DRO system, factory fitted by Chester. (Ref 20) This gave me the opportunity to compare the two systems, especially the performance of the Chinese scales against the Newall Microsyn linear encoders. Even with a discount the Newall



15. Mounting arrangements for SchumaTech read out head on Centec.

system (Ref 13) is much more expensive (about four times more) than the Shumate / Chinese scale DRO, but has greater accuracy and resolution and is physically much more robust, - industrial strength! You pay your money etc...

The Newall Microsyn sensors I have are the 10micron accuracy version and come with certificates of calibration, graphically showing the deviation from absolute along the scale length. I wonder what metrology equipment is used to measure that? I certainly didn't get certificates of calibration with my Chinese scales. 5micron Microsyn versions are also available. 10-micron accuracy is +/- 0.0004in. Best of all, the Microsyn linear encoders carry a long no fault guarantee. (In the UK at least)

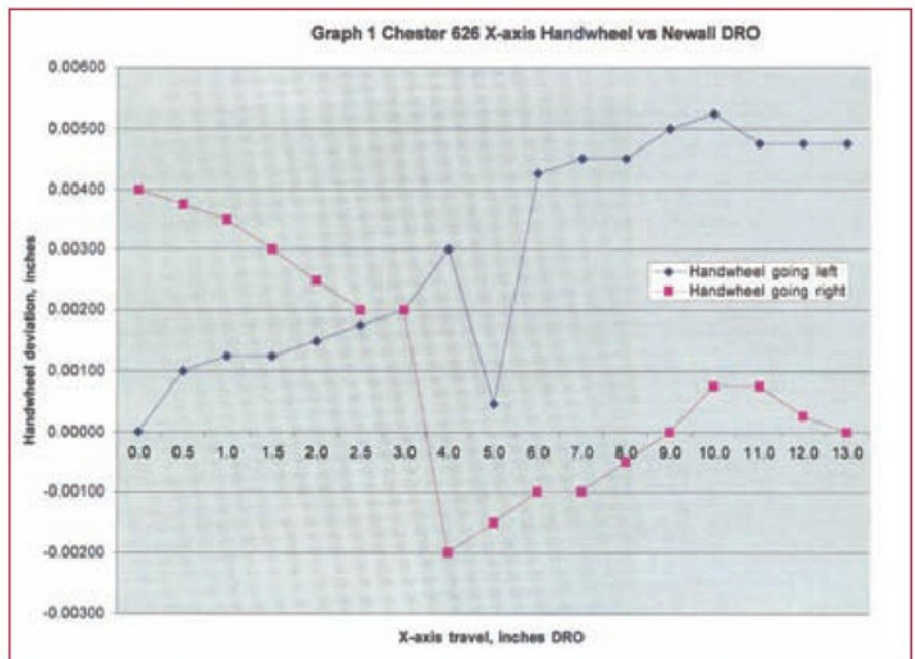
The Newall Microsyn scales are surprisingly small and carry an IP67 (NEMA 6) environmental rating. Withstands dust, dirt, oil, water and coolant: High tolerance to shock and vibration. The Newall

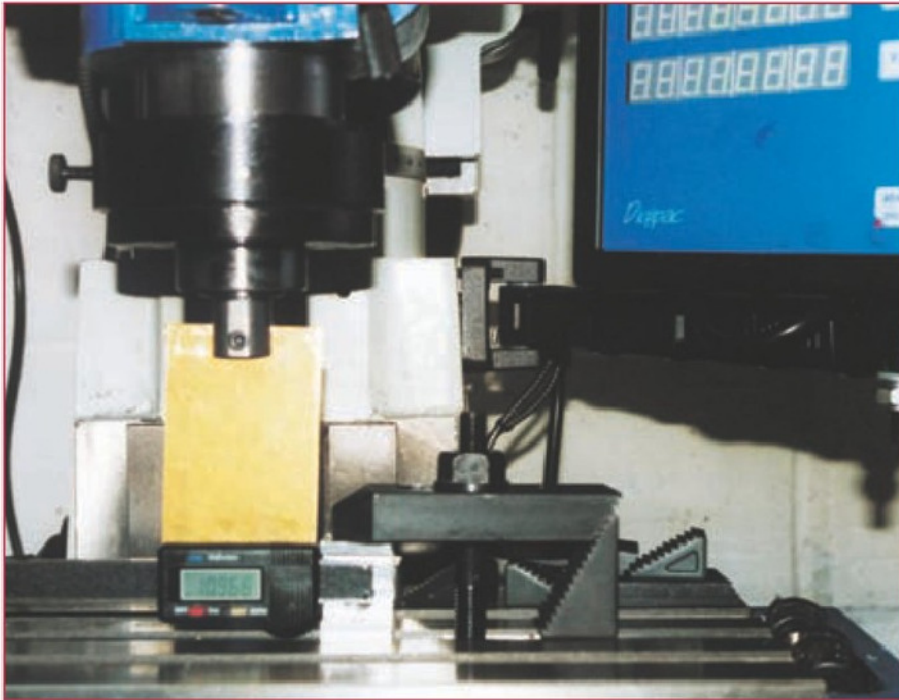
measurement seems to be unique and is based on stainless steel balls packed into a carbon fibre tube. At major trade shows, Newall frequently demonstrate their industrial systems operating with the scales immersed in a container of coolant. Details of the systems are available on the Newall website. (Ref 13).

The unit supplied to me by Chester is a 2-axis Digipac, industrially rated, but lacking many of the electronic bells and whistles of the Schumate design. For those who are not familiar with the IP system of rating enclosures, the information given in **Table 1** may be of interest.

My Digipac DRO displays to 0.0001in. and the readings are rock steady. By comparison my home constructed Shumatech DRO indicates 0.0005in. with a LED and is jittery in the 0.001in. digit.

As a temporary measure I mounted a Chinese scale onto the table of my Chester 626 mill so that I could compare the readings of the two scales and the x-axis





16. Set up for scale comparison. Note the vertical height of the brass plate may have introduced slight distortion.

hand wheel graduations. See **Photo 16**. The Chinese scale was mounted in two of my alloy blocks and clamped to the mill table. A brass plate was bolted to the back of the scale head and to a split adaptor held in a $\frac{3}{4}$ in. R8 collet. All the sets of measurements were made with table movements in the same direction, to eliminate the effects of backlash.

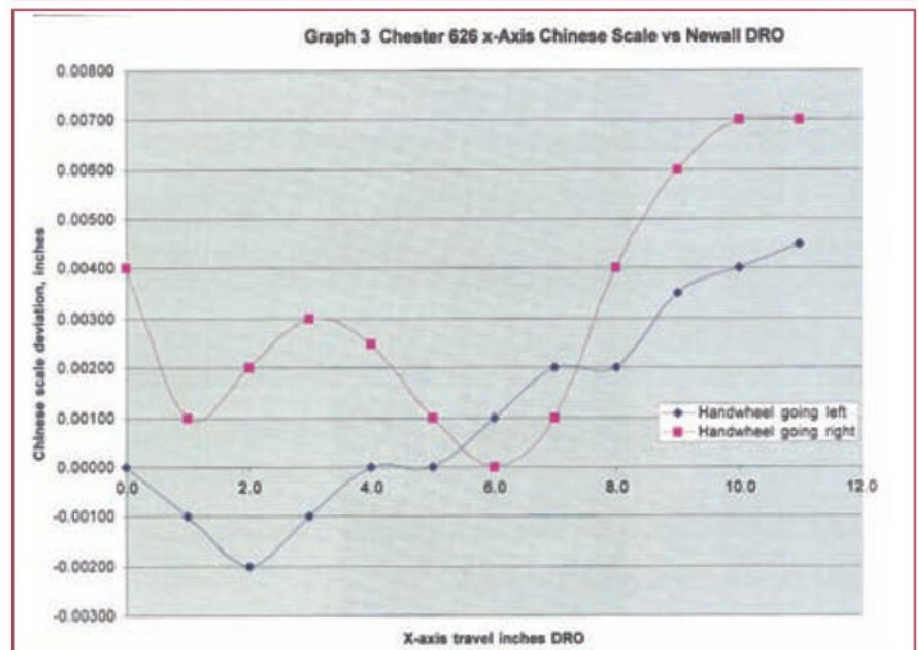
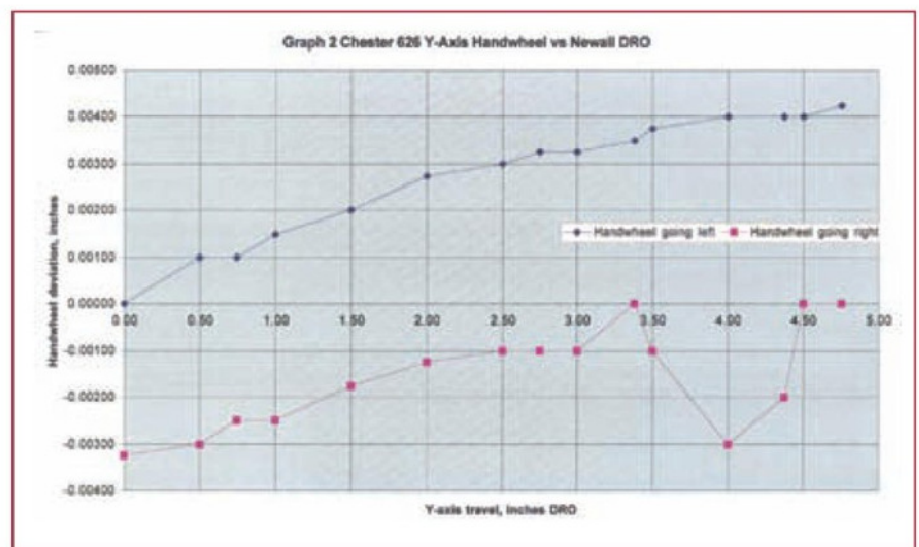
Several Internet discussion groups have questioned the accuracy of the lead screws on these Chinese VMC type mills, so this was an opportunity to see how the Chester 626 version behaved. I measured the deviation in readings from the Newall DRO and found that the X-axis dial to be +5thou (+0.005in.) over a 13in. travel. The Y-axis showed a +4thou (+0.004in.) over a 5in. travel. Taking measurements every inch indicated by the DRO, and more often in random locations, showed signs of small cyclic errors superimposed on the general + deviation trend. Making these comparisons with the table moving left or right gave similar trends, but they were not the same, perhaps indicating differences between the left and right flanks of the screw and nut? See **Graphs 1 and 2**.

My findings are that the Chester 626 (VMC) X and Y lead screws, on my machine, are pretty accurate. My Machine is Imperial and has quite large dials graduated in 0.001in. It's easy to guesstimate 0.00025in. from the dials. I carried out the experiment by adjusting the hand wheel in one direction to get a DRO reading then measured the difference between the DRO reading and the hand wheel.

My comparison between the Chinese scale and the Newall Digipac / Microsyn DRO initially threw up big discrepancies. In fact they were so big, up to 40 thou (0.040in.) in an 11in. travel, that I searched the manufacturer's websites for accuracy data. Although most Chinese scale manufacturers are economical with accuracy data, I found that that most claim resolutions of 0.01mm / 0.0005in. and some an accuracy of $\pm 0.05\text{mm} / 0.002\text{in}$.

over a 300mm length. Clearly I wasn't getting anywhere near that accuracy. Coming back to the problem a few days later, I found that the battery in the Chinese scale was giving a low warning, (a flashing display). Changing to a new battery immediately gave better results. See **Graph 3**. I don't pretend to know what's going on in **Graph 3** except to say that you need a new battery (not needed with DRO system) to get the best results from these scales. It is also possible that the improvised mounting arrangement shown in **Photo 16** which features significant offset, which would apply a bending load to the scale, has created anomalies.

Following a phone discussion of this, our editor conducted a quick X axis experiment using a similar Shumatech system, again using an Arc Euro Trade scale, fitted to a 1970's vintage Myford VMC mill, and checked just against the lead screw dial reading. This indicated an unexplained 0.002in discrepancy over the first 0.200in of travel, (the extreme end) but thereafter, at each 0.200in. step for the remainder of the travel, the handwheel position was within an estimated two tenths (of a thou) of the zero at each revolution. So either both the scale and the



DRO Table 1 I.P. Protection levels

1st IP#	Degree of protection against access to hazardous parts & ingress of solid objects	2nd IP#	Degree of protection against the ingress of water
0	No protection	0	No protection
1	Protected against solid foreign objects of 50mm Ø and >	1	Protected against vertically falling water drops
2	Protected against solid foreign objects of 12.5mm Ø and >	2	Protected against vertically falling water drops when enclosure tilted up 15°
3	Protected against solid foreign objects of 2.5mm Ø and >	3	Protected against spraying water
4	Protected against solid foreign objects of 1.0mm Ø and >	4	Protected against splashing water
5	Dust protected	5	Protected against water jets
6	Dust tight	6	Protected against powerful jets from any direction
		7	Protected against the effects of total water immersion up to 1M
		8	Protected against the effects of total water immersion beyond 1M

lead screw on this machine are pretty accurate, or if they are not, then the inaccuracies progress in parallel. Chances are the former is the case.

In summary

This has been a very interesting project and the ShumaTech DRO is capable of very good results. Driving the Chinese scales in "Fast Mode" makes it far easier to arrive at a required point quickly. Scott Shumate has done an excellent job on the design of this DRO and should be congratulated. After using the system, I agree with those who have written that once you have a good DRO system you'll wonder how you ever managed without it.

I hope the above account of my

experiments will inform and encourage other prospective DRO builders. Because quite a wide range of skills is required to construct and set-up these DRO systems they could usefully be taken on as a club collaborative project, different members contributing their own skill set. Internet, PCB assembly, mounting scales and commissioning are areas, which come to mind.

The ShumaTech DRO carries much on board "intelligence" to run features such as bolt hole circles, centre point location, etc. In my opinion the weak link is the general frailty compared industrial kit. But the scales and the DRO are inexpensive. The ShumaTech DRO case design may not compare with the ruggedness of an industrial unit, but again, neither does the

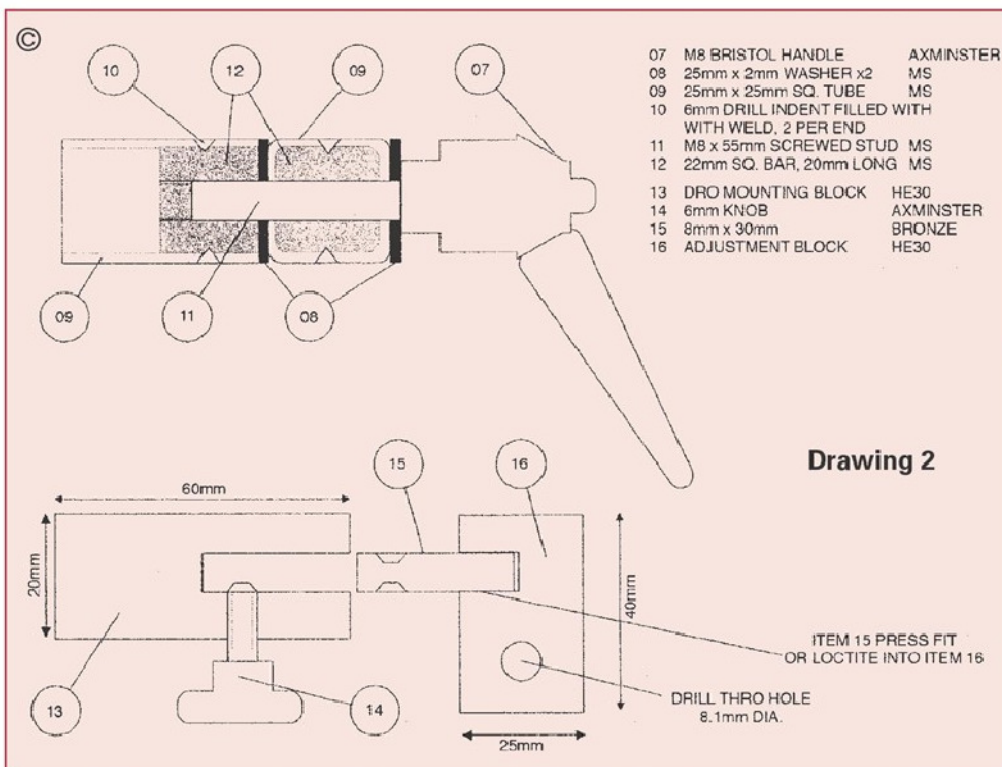
price. If you feel that building a DRO from a kit of bits is beyond your capabilities and you don't fancy a club collaborative effort, there are members of the Yahoo user Group who offer completed cases and assembled and tested PCB's for sale. Look on the Internet.

What's next?

I'm aware that a new breed of better-protected and more expensive Chinese scale and caliper is starting to appear, but I haven't been able to try them out, so far. In industry, "glass scales" have long been used to feed positional data to DRO's and machine controllers, and in fairness, it must be noted that these too, were not happy to operate drenched in coolant. Thus there has always been a need to provide effective protection. "Glass scales" were originally plated glass strips with precision engraved or photo etched lines that were read by a light source and detector. Over the years, with the advance of electronics, fragile filament bulbs have been replaced with light emitting diodes and photo diodes or phototransistors now are used as sensors. If you are interested in more detail of how measurements of this type are made, look at the Jenix (ref 9), Heidenhain (ref 16) and Renishaw (ref 15) websites. These systems are capable of resolutions far, far smaller than anything most of us will ever need or could ever use on home workshop equipment.

Scott Shumate is now producing inexpensive add-on boards, QCC-100, that convert the 5volt quadrature data protocol output produced by many "glass scales", strip and rotary encoders to the Chinese scale standard. A QCC-100 is required for each axis fitted with one of these sensors.

Strip encoders can be found in some inkjet printers and rotary encoders are also used in some systems. Glass scales are getting cheaper and the lower precision ones will, I'm sure, start to figure in the home workshop fairly soon. US members of the Yahoo ShumaTech Group, Ref 7 have been importing and successfully using Jenix Ref 11. glass scales with the QCC-100 and DRO-350. You can check out Ref 19 for some details. These scales are supplied with industrial strength protection against physical abuse and mounts to suit most machines. I have been unable to find a Jenix importer to the UK, but no doubt one will appear as interest in this topic develops.



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LOW VOLTAGE POWER HACKSAW ②



11. Slots in the base were formed by chain drilling-

Base

We can move on to making the base (Fig 4). This is made from a piece of channel 45mm high x 95mm wide x 3.3mm thick x 525mm long. It already contained a few holes from an earlier application but these merely served to add lightness. The swinging arm of the saw is mounted on a vertical post bolted to the side of the channel. The post is made out of a piece of 185mm x 50mm x 8mm steel. Drill two 2mm holes at one end and clamp the post to the channel, use a square to make sure the post is true and vertical. Drill through the two holes with a 2mm drill then open out the holes in the post and the channel

to 8mm. Cut a piece of 30mm x 4mm steel to 120mm in length and drill two 8 mm holes in one end to match the holes in the post. Drill a 4mm hole in the other end. This bolts on with the post to form the counter balance spring lower mounting. The pivot for the swinging arm I turned from a piece of brass hex but a nut and bolt with a shank would do. Drill a 10mm hole at the top of the post to accommodate the pivot. The position of the pivot is such that the swinging arm is parallel to the channel at the bottom of its cut. Drill a hole for the on off switch and two 5mm holes tapped out 6mm for mounting the micro switch bracket, which is made from a strip of steel 135mm x

Richard Wightman concludes the description of his wiper motor powered hacksaw.

25mm x 2mm, sturdy enough to hold the switch but thin enough to be bent into place when setting the switch.

Stop

When the saw finishes cutting through the work piece it will drop slightly before switching off the power then come to rest on a stop. The stop will in fact have three functions. Firstly a stop, obviously, secondly it can be used as a depth of cut limiter and thirdly as a prop to keep the saw out of the way while setting up the work piece in the vice. Cut a piece of 30mm x 4mm to 145mm in length to make the stop mounting post. Drill two 2mm holes at one end and clamp in position on the channel checking with a square. Drill through the channel with the 2mm drill then open out the holes in the channel and the post to 6mm. Drill a ¼ inch hole at the top. Cut a block of steel 25mm x 25mm x 22mm and drill through to 5mm and tap out or ¼ inch Whitworth. (The thumb screw I found is ¼ Whit. but you could probably use M6) Cross drill the block to 6mm. A 6mm length of steel bar bent over at one end forms the adjustable stop. Bolt the stop post to the channel with two 6mm nuts and bolts. The block is bolted to the top of the post with a ½ inch long ¼ Whit bolt. The 6mm steel bar drops through the hole and is held in position with the thumb screw. The bar length is designed so that when it is allowed to drop to the bottom it is in the correct position for the saw to rest when the power is cut.



12. - then sawing and filing.



13. Components for power connection.

Technical drawing of a metal plate assembly, showing dimensions and callouts for various components and features.

Top Section:

- Overall width: 50
- Overall height: 185
- Top left corner: DRILL 11mm
- Top center: DRILL/TAP 6mm
- Top right corner: DRILL/TAP 8mm
- Bottom left corner: DRILL 8mm
- Bottom center: DRILL 12mm
- Bottom right corner: DRILL 8mm
- Bottom edge: 4mm THICK, DRILL 5mm, DRILL 8mm
- Bottom width: 120

Middle Section:

- Overall width: 30
- Overall height: 145
- Top left corner: DRILL 1/4"
- Top center: DRILL THRO 6mm
- Top right corner: DRILL/TAP 1/4" WHIT
- Bottom left corner: DRILL 6mm
- Bottom center: 1/4" WHIT THUMBSCREW
- Bottom right corner: 6mm STEEL ROD
- Bottom width: 20

Right Section:

- Overall width: 25
- Overall height: 35
- Top left corner: DRILL 6mm
- Top center: 25
- Top right corner: 2
- Bottom left corner: 25
- Bottom center: 50
- Bottom right corner: 25

Bottom Section:

- Overall width: 525
- Overall height: 95
- Top left corner: DRILL 10mm 55mm CENTRES
- Top center: 2 x 8mm SLOTS x 110mm LG 53mm CENTRES
- Top right corner: DRILL 8mm 46mm CENTRES
- Bottom left corner: 45
- Bottom center: DRILL 6mm
- Bottom right corner: 83
- Bottom width: 183

Fig. 4 Base and associated components

20

DRILL/TAP
12mm

Fig. 5 Vice parts

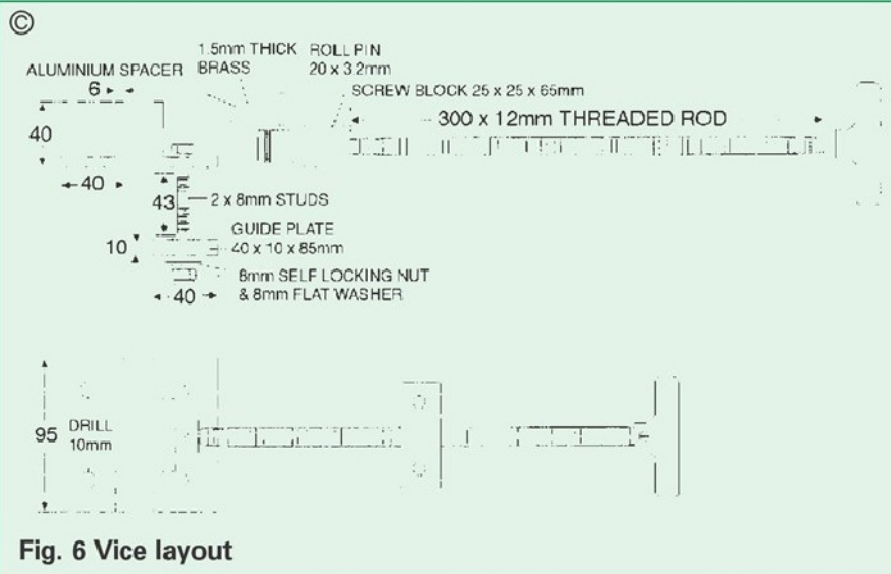


Fig. 6 Vice layout

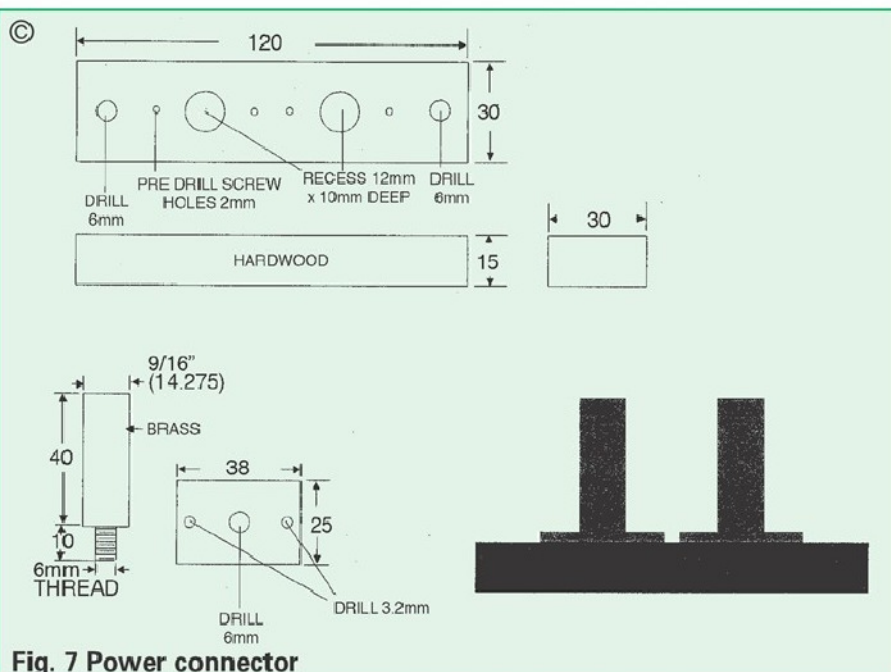


Fig. 7 Power connector

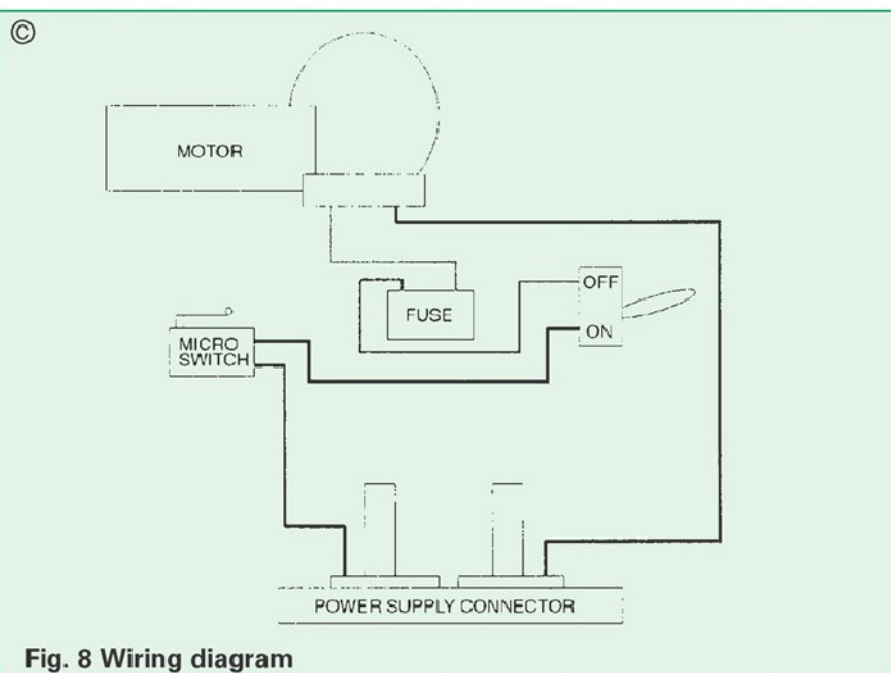


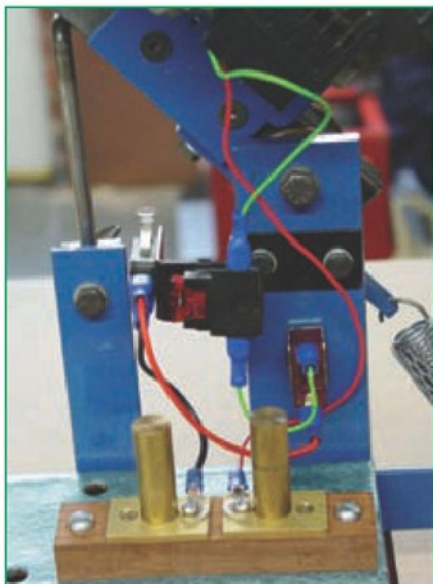
Fig. 8 Wiring diagram

Vice

Last but not least we will need a vice to securely hold the work piece during the cutting operation. The two vice jaws are made out 40mm x 40mm x 6mm angle iron cut to 95mm in length. The components are given in Fig 5, and the assembly layout in Fig 6. Now you would think that angle iron would be 90 degrees wouldn't you but the bit I was using wasn't as is clearly demonstrated in the photos. Although this is going to be a fairly crude vice it will work a lot better if the jaws close together reasonably well. To get over this I clamped the two jaws back to back in the milling machine vice and took light cuts until the two faces were reasonably flat. The same could be achieved in the bench vice with a flat file and a square. The fixed jaw of the vice simply bolts onto the channel with two 10mm bolts, making sure it is as square as possible. Two brackets 26mm high x 22mm x 25 wide with 10mm holes in are bolted on using the same jaw mounting bolts. (These brackets were an after thought; their use will be demonstrated later). I wrestled for some time about how to make the movable jaw and eventually settled on the method here. After all this does not need to be a precision machine vice but simply good enough to hold the work secure and reasonably square while the saw does its work. Two slots need to be cut in the channel 8mm wide x 110mm long with centres 53mm apart. I did this by drilling a series of holes using the bench pillar drill to remove much of the waste and then milling out on the milling machine. Alternatively use flat and round files to complete the slots.

The movable jaw now has two 6.8mm holes drilled at the same centres as the slots and then tapped out to M8. Acquire or make two 8mm studs to the dimensions shown. Cut a piece of 40mm x 10mm x 85mm steel and drill two 8mm holes on the same centres as the stud holes and slots. This piece fits inside the channel and helps to guide the movable jaw. A 300mm length of M12 threaded rod is used for the vice screw. The screw block is made from a piece of 25mm x 25mm x 65mm long. Drill and tap 12mm to take the vice screw and then drill the two 8mm mounting holes. Clamp the screw block in place on the channel checking for square and drill through with the 8 mm drill. A 1.5mm thick x 32mm x 45mm 'U' Shaped piece of brass with a 6mm thick x 45mm x 10mm aluminium spacer is fixed to the rear vertical face of the movable jaw with two 6mm bolts screwed into threads tapped into the vertical face. Two small brass studs are also fixed to the vertical face of the movable jaw with 6mm countersunk machine screws (their use will be demonstrated later). File off any protruding threads to leave the vice jaw smooth.

The end of the vice screw is fitted with a turned and internally threaded brass boss with a groove in it held in place with 1/8 inch steel roll pin. The movable vice jaw is simply pushed forward by the brass boss pushing on the rear vertical face of the jaw and pulled back by the action of the groove in the boss, which is located in the 'U' shaped slot in the brass plate. An alternative to a turned brass boss could be

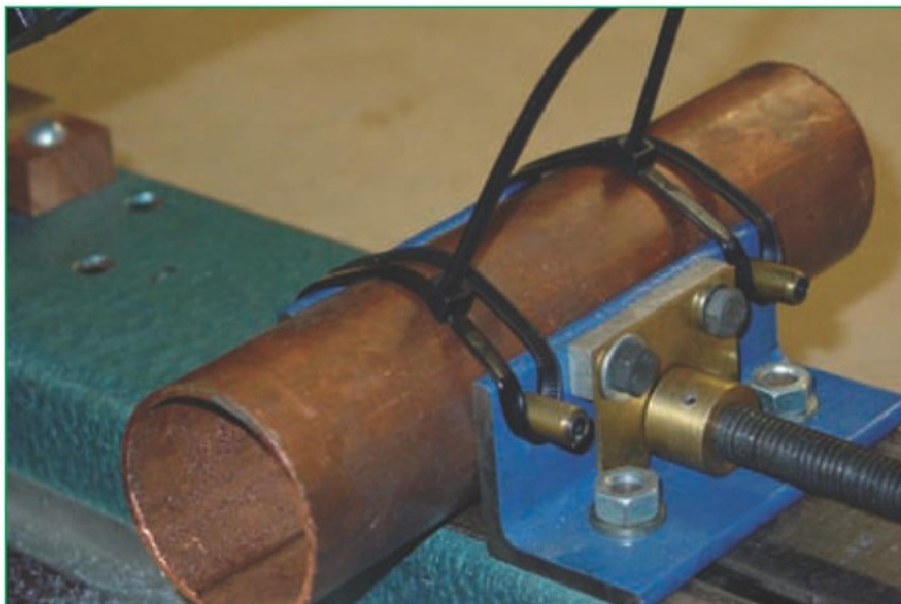


14. Electrical wiring showing position of microswitch, fuse, also rear of On/Off switch.

to fit two nuts with a 1.5mm space between them and then drill and pin the nuts in place, file the nuts round and make the slot in the 'U' shaped piece of brass to suit. Once all the parts are fitted to the movable jaw all protruding screw threads and heads must be filed flush. I found a hand wheel in the scrap box that I used on the vice screw, and held it in place with a grub screw. As an alternative cross drill the end of the screw and fit a short length of bar. The vice does not need to exert any great pressure, just enough to hold the work piece.

Mounting and painting

Two lengths of $\frac{1}{2}$ inch x $\frac{1}{2}$ inch aluminium angle are pop riveted to the sides of the channel to allow the saw to be fixed on to a 140mm x 30mm x 535mm piece of wood, this makes it easy to clamp to the bench or fit into a workmate type bench. I think that just about covers everything on the mechanical side. Steel has a nasty habit of corroding so with the dregs of a few tins of Hammerite I painted it up a little. Don't paint where the saw slides on its swinging arm or where the movable vice jaw runs though. Connecting the power supply to the saw is via two brass rods mounted on a hard wood base (Fig 7). The hardwood insulates the power from the metal of the machine. To make the power supply connector first cut a piece of hardwood to 120mm x 30mm x 15mm thick. Cut two pieces of 3.2 mm thick brass 38mm x 25mm. Drill a 6mm hole dead centre of each piece and then drill and countersink two screw holes in each piece. The brass rods I made in the lathe by cutting off a 50mm length of $\frac{1}{2}$ inch diameter and turning the first 10mm down to 6mm and threading with a 6mm die. Alternatively drill into the end with a 5mm drill and then tap out to 6mm. Mount the rods on their respective brass plates with a 6mm nut or bolt. Mark out the hardwood block and recess where the nuts will be with a 12mm drill to a depth of 10mm. Drill two 6mm holes for mounting the block on



15. Using cable ties on vice brackets for large round stock.

the saw frame. Hold the brass plates on the hardwood block and mark the screw holes. If you use brass screws like I did it's best to pre drill the screw holes with a 2mm drill to avoid the screws snapping off. Hold the hardwood block on the saw base and mark through the mounting holes. Drill out to 5mm and tap out to 6mm. Although the base is only 3.3mm thick it will take enough thread to hold the block securely enough. Screw the hardwood block to the base with a couple of pan head machine screws. Screw the brass plates and rods onto the hardwood block with one brass screw in each.

Connecting up

Anything with crocodile clips, e.g. the battery charger, jump leads off a battery or even an adapter made up that plugs into the car cigarette lighter socket can now be quickly connected to the machine. The electrical side of things is dead easy; the wiring diagram (Fig 8) could not be much simpler. All you need is to find the two wires on the motor that give the fastest speed. One will be common earth; the others will be for the different speeds. Cut the unwanted wires out of the plug. Use crimp type electrical connectors throughout to make good connections. Take one wire from the motor to the brass rod and connect with a brass screw in the unused screw hole. The other wire from the motor goes to the fuse holder. (I used a 10 amp fuse, the same as the fuse rating on the car the motor came from). From the fuse holder to the on/off switch, from the on/off switch to the micro switch and finally from the micro switch to the brass rod making the connection with a brass screw into the last unused screw hole. The switches and fuse holder can be obtained from Maplins or car accessory shops. Incidentally if you reverse the + and - wires on the power supply it just makes the motor run in the opposite direction. I have run the motor in both directions and fitted the blade in both directions and as far as I can see it makes no difference what so ever to the performance of the saw. In operation the saw runs reasonably quietly. It's not the fastest thing in the world but

sipping tea while a machine does the work for me is a lot better than doing it by hand (and Ben's a lot happier as well). There is a fair bit of hard work in making this tool but once made, cutting metal becomes a pleasure and not a chore. It will of course cut any material that a hacksaw is normally capable of cutting so it is not restricted to metal only.

A few afterthoughts

The brass pivot that the swinging arm mounts on could do with being bigger. There is some play there, which becomes greater at the far end. I had to experiment with large plastic and brass washers to get rid of as much play as possible. It was while clearing up that I noticed the wiper arm spindle is ground and hardened and runs in two bronze bushes in an aluminium housing, this I am sure could be easily adapted to make the swinging arm pivot.

The counter balance spring was a modification as there was too much forward pressure on the saw blade. A series of experiments were conducted using mole grips and lead weights until an ideal balance was found. It was then just a case of finding a spring with the right pull to make the counter balance. This is not an exact science but more a case of playing about until it felt and sounded right. Perhaps if the motor were fitted to the rear of the swinging arm pivot thus forcing the arm to naturally tip backwards would be a better idea. Different weights could then be added to the front of the swinging arm to give the best cut.

The reason for the brackets and studs on the vice jaws is to help hold down larger round tube sections by the use of plastic pull straps. This may be seen in Photo 15. I'm sure there is a better way but I haven't thought of one yet.

An easier way to make the power supply connecting rods would be to use copper pipe (central heating pipe, $\frac{1}{2}$ inch). Flatten one end for about 30mm and bend over at 90 degrees. Drill a couple of holes and screw onto a piece of wood. Make the electrical connection to one of the screws or solder directly on to the copper pipe.



A BACK-GEAR FOR THE MILL-DRILL



1. General view of the mill-drill, with the cover off to show the arrangement of the belt-drive. The cover of the back gear modification can be seen beneath the motor support plate.

Background

The article which appeared in Issue 103 of MEW, on a slow-speed adaptation for the VMC mill and the mention of the editor's adaptations to the same machine (Issue 105), prompted me to write this short article describing my own modifications to a Chester Champion Mill-Drill. The mechanism, involving a simple back-gear, is undoubtedly applicable to many other mill-drills, so the details I leave to the ingenuity of the reader.

The Chester Champion is a machine I can strongly recommend, robust and accurate, and with a usefully large capacity, particularly given its modest price which is currently substantially less than I paid ten years ago! However, as with many such budget machines, its

limitation, as supplied, is its lack of low speeds. The Champion has four speeds from the belt drive: 1640 to 400 rpm, according to the ads, but as measured on my machine rather faster, namely 1750 to 430 (see the Quick Tip section below), which is fine for drilling and light milling but much too fast for making large bores, using fly-cutters and so on. Whilst electronic gadgetry is available to give continuously variable speeds, this substantially increases the overall cost! So after collecting the mill-drill from Chester, and setting it up on my bench, I soon decided to make some mechanical modifications to give a lower range of speeds. Initially, I was planning something along the lines of the VMC mod mentioned above, i.e. using a large pulley. Unfortunately this is not really feasible on the Champion Mill because of the way the machine is built, with only about 15 cms between the motor spindle and the driven milling spindle (see **Photo 1**). Although one could introduce a third, intermediate 'jockey' spindle this would necessarily have to hang out at the back or side of the machine somehow, making the whole thing rather cumbersome and compromising its compactness, which for me, with limited space available, was one of the attractions of the machine in the first place.

Geared approach

I soon decided that any compact solution had to involve gearing and, having quickly abandoned the idea of an epicyclic mechanism (too complicated), I decided to introduce a 'back gear' as used on most small lathes such as my own Myford ML7R. The back gear has always struck me as a particularly brilliant mechanism - dead simple, very compact, but supremely effective. I wonder who first dreamt it up?

I'm afraid I haven't prepared any detailed drawings and measurements, but I'm sure most readers will get the idea from the attached photographs and the sketch diagram, **Fig. 1**. Some details of my construction are somewhat crude - a prototype I would like to think - but the idea was to make something reasonably simple and quick, and the fact that it has worked a treat for the last ten years has mitigated against improvement.

First, the choice of gears. The ratio was chosen to give a good range of speed with neither any overlap nor an unreasonable

'gap' with the un-gear range. 6.25 turned out to be about right. The physical size of the gears is important as well: too big and the mechanism will not fit in the limited space available. Whilst I had originally planned to use helically cut gears, a few enquiries showed that these would be prohibitively expensive so I decided to use Myford change-gears as on my lathe. Two 50 tooth and two 20-tooth gears were acquired at modest cost from Myford's parts counter, these being just about the optimum size, and providing the desired overall 6.25 speed reduction. In fact this was the only financial expenditure on this job, the rest of the stuff came out of the 'scrap box'.

Modification and construction

The first part of the modification involved cutting a hole through the bottom of what I shall call the motor mounting plate. This is the item which projects untidily

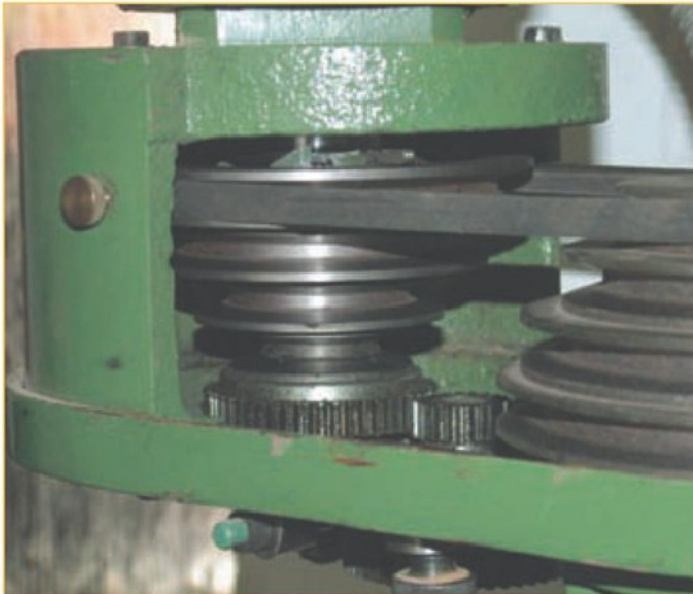
Mike Sumner of Nottingham describes a neat modification to obtain slow speeds on a Chester Champion mill-drill.

leftwards from the top of the mill in **photo 1**, on which the motor and pulley assembly stands. It is in fact a fairly substantial casting fashioned like a tray, the vertical sides of which give it its strength. The actual base of this tray is fairly thin and, so, having dismantled it from the machine, the hole was readily drilled, sawn and filed to shape. The hole, of course, is needed to accept the extended motor spindle and the back-gear assembly itself. For convenience, it needs to be large enough to pass the small gears through, and also needs to be elongated sufficiently to accommodate all the lateral movement required in order to change and tighten the drive belt, and to engage and disengage the back-gear.

As supplied, the motor had a very short spindle protruding from its housing: this was keyed into the top of the pulley cone, which originally had a 'neck' extending upwards a couple of centimetres beyond the large end. But as can be seen from the photos and **Fig 1**, to fit the back-gear, the motor spindle needs to be long enough protrude through the bottom of the mounting plate. The original plan was to replace the entire spindle of the motor with a longer one, but this proved to be impractical - in fact I couldn't even get the motor apart and didn't want to risk damage by applying too much brute force. So an extension was made from $\frac{1}{2}$ in. diameter silver steel. This diameter was chosen because of the availability of bearings (see below) and also because it matched the bores of the Myford gears; the 20-tooth gear is so small it would not take anything much larger.

To fit the extension, the outer end of the motor spindle was turned down to a matching $\frac{1}{2}$ in. and faced accurately square. A shallow recess was cut into the end to mate with a corresponding lug on the extension. Then the ends of spindle and extension were drilled and tapped axially and screwed together with a threaded stud, well Loctited in. No really, it works! Because I was unable to disassemble the motor, to face and drill the shaft, I mounted the entire motor in a wooden cradle clamped down on the cross-slide of the lathe, whilst the cutting tool or drill was held stationary in the headstock. Then the motor was powered up and cutting and drilling proceeded in more or less the conventional way.

Whilst the drive pulley was originally keyed to the motor spindle, it needs to be able to rotate freely on the spindle when the back-gear is engaged. I happened to have



2. Detail showing the back gear. The lever to engage and disengage the key which locks the pulley to the motor drive shaft can be seen at the top of the pulley cone.



3. View of the back-gear from beneath, showing the lever which carries the bearing in which it runs, and the pivot-bolt at the end. The white plate serves to steady the assembly against the motor mounting plate. The black knob on the right clamps the gear in position, engaged or disengaged.

two suitable $\frac{5}{16}$ in. shielded ball-race bearings in my drawer of such junk - these had been rescued some years before from an old washing machine. What would we do without them! A length of steel tube was bored out accurately to size to form a sleeve which acts as a spacer between the bearings and also helps to reinforce that dubious join in the motor spindle, assuring that parallelism is maintained. The upper bearing and the spacer tube were 'glued' to the shaft with Loctite stud-and-bearing fit - I hoped I wouldn't need to get this lot apart again!

A thick-walled aluminium alloy tube was cut to length and seats turned in either end for the ball races- the lower bearing was Loctited into the tube. The upper part of the pulley cone was then bored out to accept the alloy tube, and the lower part, too small in diameter to take the tube, was opened up to allow clearance around the extended motor spindle. The 50-tooth gear destined to be fixed to the bottom of the pulley cone was also bored out to clear the motor shaft. To assure concentricity between the pulley cone and the gear, a locating disc was made from aluminium alloy (Fig 1). A rebate was turned in the top surface to fit exactly over the bottom of the pulley, and a similar rebate was turned in the top face of the gear-wheel, to fit over the outer diameter of the disc. Then the gear, locating disc and pulley were drilled, tapped and fixed together with Allen screws.

The pulley assembly was keyed to the alloy tube and held in place with yet more Loctite and a retaining Allen screw. The whole lot was then pressed back onto the motor spindle, a nice tight fit. Another tubular spacer sleeve was fitted over the outer end of the spindle extension to bear on the inner race of the lower bearing (Fig 1). A 20-tooth gear was keyed to the end of the extended motor spindle, to bear against the lower end of the sleeve. This gear, and thus the whole assembly, was held in place with a washer and retaining screw which is threaded into the end of the motor shaft (Photo 3). This again was Loctited into place to avoid disasters!

Some means of locking the pulley to the motor spindle is needed for when direct drive is required. In my case I used a key, no more than a flat piece of steel about 4 x 12 mm in section, which passes through a hole cut through the alloy tube bearing housing, and engages in a slot cut into the motor spindle. The precise details of this mechanism I will leave to your imagination, but in brief, the key is moved by means of a curved lever fitted to the top of the pulley; it is pivoted at one end, passes through a hole in the outer end of the key in the middle, and snaps into locating catches at the other end, against the tension of a helical spring. The spring is needed to counteract the centrifugal force when the pulley is spinning, which would otherwise fling the lever and key

outwards. It ensures that the lever and key stay in the desired place, i.e. either engaged or disengaged. The catch and handle-end of this lever can just be seen in **photo 2**. This is perhaps the most unsatisfactory part of the whole assembly, and I'm sure readers could suggest a better solution, but on the other hand it has worked, so far, without a problem, somewhat exceeding my expectations in fact!

Back gear assembly

So now for the back-gear proper. This is simply a short shaft of $\frac{5}{16}$ in. silver steel, with the gears keyed on to either end. The top 20 tooth gear is Loctited on, but the bottom 50 tooth gear is retained by a screw and washer, as described above (Photo 3). The shaft runs in a thin-walled sintered bronze bearing extracted from an old Picador block,

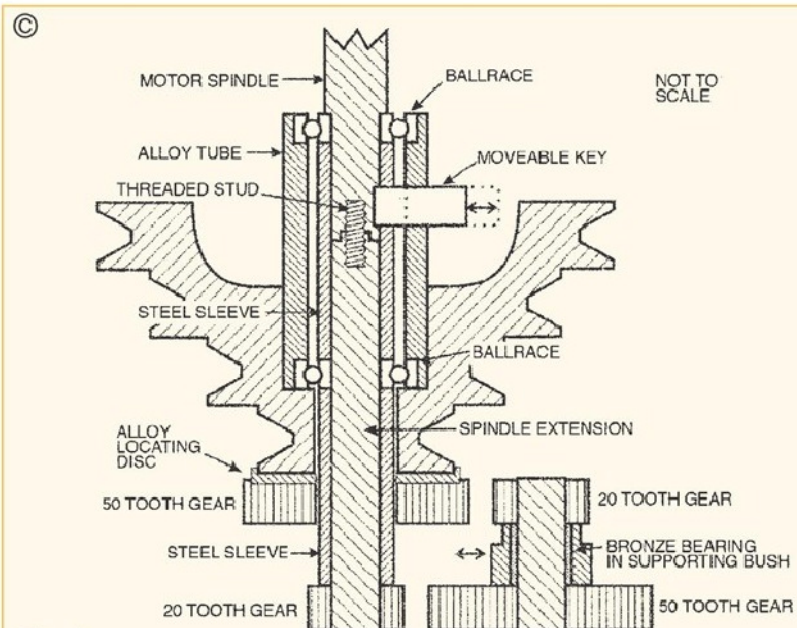


Fig. 1

also found in the junk drawer. Because the back gear runs at relatively low speed and because the bearing size looked reasonably generous, I thought a single solid bearing would be adequate, and so it has proved to be. The bearing is let into a larger steel bush to give it support. A small hole drilled through the side of this bush allows for occasional oiling of the bearing.

To allow for movement to engage and disengage the back gear, before insertion of the bearing, the steel support bush was drilled and tapped across its diameter. A short length of steel bar was screwed into each side to form a lever and handle. A hole in the end of the lever pivots on a bolt screwed into the motor mounting plate. All this can be seen clearly in **photo 3**. The lever is locked into position (engaged or disengaged) by means of a slotted steel plate attached to the end of the handle: this plate can be clamped to the motor mounting plate with a knurled knob. Again there is scope for a more elegant solution here, but it works! The top of the steel bush is fitted fairly tightly into a hole in the white plate which can be seen behind the gears in **photo 3**. This plate bears against the motor mounting plate, giving some additional stability to the assembly, and also covering most of the large and ugly hole I had cut into the mounting plate. With hindsight, it may have been better to put this plate on top of the motor mounting plate, or better still, to have a flange on the top end of the bearing bush which would then rest on the edges of the hole in the motor mounting plate, thereby supporting the weight of the back-gear. With my arrangement, the back-gear is

supported solely by the pivot bolt and locking clamp. However, as said above, there is little force, other than the rotational one, acting on the back-gear and the present arrangement has proved perfectly satisfactory in operation.

The back-gear is in a potentially dangerous position. If you are in the habit of peering closely at the work under your machine when it is running, it could grab your hair and take your scalp off. So to avoid such trauma, a protective cover over the gears was fashioned from thin-gauge steel plate.

So, there we have it. I now have access to eight speeds: 1750, 1100, 690, 430 using the direct drive, and 280, 175, 110 and 70 using the back gear, a nice smooth progression with a factor of just over 1.5 from one speed to the next, if you care to check! To use direct drive, the back-gear is disengaged, by swinging it out of the way to the right, and the sprung lever on top of the pulley cone is released, and the pulley turned by hand until the key snaps into its slot, locking the spindle and pulley together. To engage backgear, the sprung lever is pulled back to engage with a catch, pulling the key out of the spindle. The backgear is then swung to the left to engage with the gears on the motor spindle and pulley and locked in position with the knurled knob.

Quick tip on speed measurement

It is possible to measure speed of a rotating shaft with a fair degree of

accuracy if you have a reasonably musical ear, or have a musician in the family! Fit a gearwheel, slitting saw or such like, with a known number of evenly-spaced teeth, on to the shaft and set it rotating. Rub a piece of card or plastic against the teeth, so that it generates a steady, more or less musical-sounding note. Carry this note in your head (or record on tape or dictaphone) and rush to the nearest piano or keyboard. Find the same note on the keyboard, or get your tame musician to play the same note on his or her instrument. Assuming the instrument is tuned correctly, the frequency of the note in Hertz (Hz, or cycles per second) can be found from the following table. Starting from the A below middle C they are as follows (to the nearest 1Hz):

A, 220; A $\sharp$ /B $\flat$, 233; B, 247; C, 262; C $\sharp$ /D $\flat$, 277; D, 294; D $\sharp$ /E $\flat$, 311; E, 330; F, 349; F $\sharp$ /G $\flat$, 367; G, 392; G $\sharp$ /A $\flat$, 415.

An octave higher, and the frequency doubles so the next A has a frequency of 440 (generally used as the standard for tuning musical instruments). Similarly, an octave lower, and the frequency halves. So, first deduce the frequency of your note, divide this figure by the number of teeth on your musical gearwheel, multiply by 60 and you have the speed in revolutions per minute of your rotating shaft. It also follows, of course, that if you use something with sixty teeth, or holes etc. that no conversion mathematics are necessary as the division and multiplication will cancel.



CHESTER LUX GEARED HEAD MILLING MACHINE

Bill Spalding describes an addition to his workshop.



1. Compound angle set up for drilling steam passages.

Prompted to buy

In July 2004 I took delivery of my machine after all the due deliberations regarding what I should buy etc, etc. It is not as if I am new to the game, I am building steam locomotive number three and up until then had the use of the club milling machines. However we were given notice to quit from our workshop / meeting room so whereas previously, I was just two minutes down the road from the club shop, using our new relocated facility at the time became impractical.

Choice of machine centred around the basics, value and maximum capacity for money, convenience and reliability in operation, and fitness for purpose – in my case for model engineering, typically in seven and a quarter gauge. I am a retired mechanical engineer and chose the machine from a brochure, having never actually seen one – when delivered I was not disappointed. I am well aware of the strengths, weaknesses and limitations of this type of machine, but it has proved to

be well able for the job and certainly fit for purpose.

I chose the geared head version for convenience and have found no real problem with the spindle speed range to date, 95 – 1600 rpm although I would have preferred a top speed of nearer 2200 rpm for the smaller cutters and drills, however that is what we call compromise.

A big plus for this machine is its rugged construction, complete with a cast column and dovetailed vertical slideway. This means that in contrast to a round column machine, there is no requirement to relocate the machine spindle during tool changes. Another is the working area and travel of the table – 820mm long x 240mm wide area and 550mm longitudinal, by 200mm cross travel. This, taken with the four T slots is excellent capacity for a machine of this type. I regularly use a 5 inch vice, a Vertex type Dividing Head and an 8 inch Rotary Table. Any of these is easily accommodated.

The spindle taper of my machine is MT.4 which gives additional strength and rigidity and is conveniently versatile – there is a drawback however when open ended sleeves are in a certain



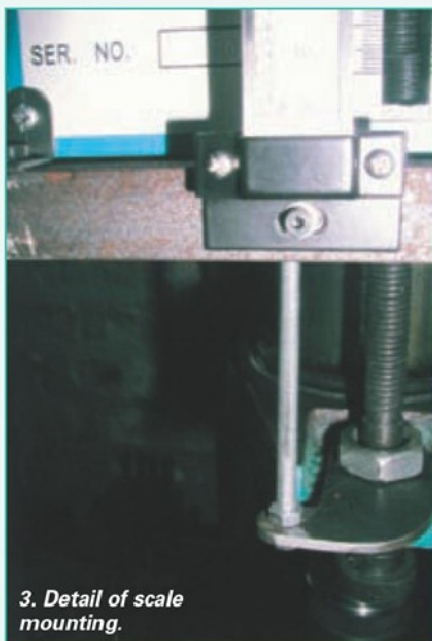
2. Vertical scale fitted to head.

configuration, they can be awkward to remove from the spindle. This then requires a removal aid to be made and used in conjunction with a drift but at the end of the day is no great problem. A very useful feature is that the head tilts 90 degrees left and right.

Vertical digital scale

Indexing job to cutter on the X and Y axis by the handwheels is no problem and is certainly accurate enough for the purpose and exceeded my expectations. The "weakest link" however is cutter to job indexing accuracy and repeatability on the Z axis. This is a common complaint of this general type of machine where a combination of milling and drilling is intended via the quill. I have successfully resolved the problem by fitting a vertical electronic digital scale unit, which was purchased for less than £20 at the last Harrogate exhibition.

This has transformed the machining accuracy on the Z axis. You can now tell



3. Detail of scale mounting.

exactly where the cutter is in relation to the job and any stickiness in the quill is readily detected. The unit is dual metric/imperial readout. A useful feature is zero – setting with Plus and Minus Preset buttons – all in all excellent value for money. The attachment detail for this is illustrated in the accompanying photographs.

Work experience

I have done a wide variety of work on my machine and have been completely satisfied with its performance. I am not known in our club for taking gentle cuts, if you are going to spend time creating swarf, then do it as fast as possible. It's rigid enough and powerful enough to munch metal quickly. Awkward jobs like machining steam cylinder castings (requiring angles to be set in two planes) or drilling return cranks for lock pins on 7/16in.g wheel sets for example, it handled with ease. The latter stretched the machine to the limit as can be seen on the attached photographs, but this particular job would probably have been beyond the daylight capacity of most comparable budget machines.

Delivery

Ordering and delivery was prompt from CHESTER U.K. and they couldn't have

been more helpful. Certainly as a former professional I felt that I had got a good package i.e. machine, stand, accessories, clamping kit, five inch machine vice on a rotary base, Pozi chuck set with metric and imperial collets all for under £1400 at the time. There was however one drawback – the "package" was delivered by a national carrier whose driver came armed only with a hand operated pallet truck and my driveway is covered with red chips. I can't complain, however I just was not sufficiently forearmed. Thus the load was deposited on the pavement outside my house. Be warned, never underestimate the weight and awkwardness of this kind of load. I must admit I was ill prepared but between my neighbour and me, we managed to pinch bar the pallet the forty feet or so on to hard standing in front of my workshop before it (the pallet, being designed for fork lifts and pallet trucks, not pinch bars) gave way. And by the way it was raining at the time! Assembling the machine on to its stand was also an interesting exercise, which involved much rope, timber, and sweat, but no tears.

In conclusion, I would recommend this type of machine to any like-minded model engineers who would benefit from that bit of extra capacity without moving up to a near Bridgeport size machine.



4. Head moved to upper limit to accommodate wheelset.

HOME WORKSHOP TECHNOLOGY



There is necessarily a marked difference in the technology used in the home workshop and that used in commercial industry. Few amateurs can afford the types of machines and tooling needed for the efficient manufacture of parts usually in high volume, required by the economics of business. This article contemplates where we have come from, where we now are, and where we might be headed in the future.

History

Back in the 1700's few people had the time or interest to make things as a hobby. Certainly there was cottage industry, but its output had to be sold to put bread on the table. Some retired sea captains made model ships, (or ships in bottles) again often to produce income. Other folk knocked up rough toys for their children.

However a spark of interest arose among the leisured classes, particularly those not especially devoted to reading and writing pursuits, to fill in idle time indoors in bad weather or in the evenings. For example the Swedish king, Adolphus Frederick left running the country to his queen, Louisa Ulrica, (the sister of Frederick the Great of Prussia) and amused himself in wood turning in a well-equipped workshop in the Chinese summer house of his palace at Drottningholm outside Stockholm where it can still be seen today by tourists.

The industrial revolution really got under way in 1798 when Eli Whitney set up his

Philip Amos takes a historical overview

small arms factory at New Haven (USA), with division of production labour and the manufacture of standardised interchangeable parts for muskets. This was followed in short order by the invention of the screw cutting lathe by Henry Maudsley in 1800. Forerunners of the milling machine were invented by Diderot in 1772, Robert Johnson in 1818 and Eli Whitney in 1820; and James Nasmyth in 1829 developed his nut milling machine.

After the wars over the period 1700 to 1815 a period of peace engulfed most of Europe (and certainly the UK) for a century. During this period it became fashionable for gentlemen (and some ladies too) to amuse themselves with woodwork, - turning, fretwork and so on, as well as ornamental turning and work in ivory.

So it was that some firms set up specifically to cater for the needs of such people. Prominent among these was Holtzapffel & Co in London. In order to provide guidance to his customers and so promote trade Charles Holtzapffel put together a wealth of information which he intended to publish in 6 volumes - the first coming out in 1843 and others following in 1846, 1850, 1881 and 1884. Charles Holtzapffel died in about 1849 and the series was continued by his son John Jacob Holtzapffel, but in fact the last volume (6) was never completed. It is believed that the final batch of lathes was made around 1913, but not completely sold until about 1927 by which time the company was pursuing other interests, finally disappearing prior to World War 2. **Photo1** shows a Holtzapffel lathe.

During the 1800's many men trained in the mechanical trades, and in retirement some of these used their skills to produce models - possibly of those machines they had made full size during their working lives. Gradually working hours reduced so that some leisure time became available and thus the retirees were joined in home workshop activity by others still at work in the trades. Others with no trade background (e.g. clergymen) also became involved by just general interest - many of these latter by virtue of reading hobby newspapers and magazines. Some of the contributors to these publications collected together their writings into "how-to" books.

Early home workshops

How were these early home workshops equipped? Almost certainly the majority had only hand tools and not too many of them either. Only people with independent incomes would have been able to afford any type of machine tools and in those

days treadle lathes (**photo 2**) and flywheel drilling machines would have been the order of the day.

The lathe

In the early years of the 20th century a number of companies began to manufacture small metal cutting lathes intended for the home workshop users, and more people began to find the necessary funds to purchase them. Some built steam engines to drive line shafting to run their lathes, drilling machines and grindstones; and later others built gas engines for the same purpose. It was not until the 1920's that electric power became available to drive home workshop machines and then usually on a line shafting basis.

The techniques

The practices of turning, boring, drilling, reaming and threading could now be undertaken. Square shapes required sawing, filing and scraping. Joining was to be by riveting, soft soldering and perhaps brazing.

In the 1930's some companies began to manufacture small hand shapers, and to provide attachments for lathes to allow light milling to take place. Some of these shapers, like the Perfecto, shared the general geometry of the early industrial machines. After World War II there was a tremendous quantity of surplus machine tools available for disposal. Most of these were too large for the home workshop, but many small ones were snapped up by lucky amateurs. Small mills, such as the Centec, Raglan, and Senior were available, but at a price. The lower cost Taiwanese mill/drill, (bearing much similarity to the Dore Westbury) appeared about 1960 and rapidly sold all over the world. Small air cooled electric welding sets became freely available and in more recent times the reducing real cost of both MIG and TIG sets, have made these a real possibility for the home workshop.

Present status

So by now surely the home workshop can be as well equipped as industry? Not at all. In some respects, progress in machines and techniques in industry has in fact accelerated, leaving the amateurs wallowing in their wake.

So what is the home workshop person to do about this situation? For most of us, it really doesn't change anything. The challenge has always been to devise some method by which some desired component can be manufactured with the means available to the person concerned



2. Treadle Lathe

i.e. the materials, tools, machines and processes that can actually be used in that person's own workshop - or to which he/she can get access - at a club, technical college class, local garage or whatever. This is really the main interest for many home workshop people - overcoming this challenge by a combination of knowledge and skill, design and expedience.

Ever since home workshops have existed, their users have found ways of adapting their equipment to the solving of the problem at hand. Often their machines are asked to take on tasks much heavier than their makers ever intended; it says much for the extra capacity that the designers have incorporated in the machines, that usually they survive.

Since the widespread distribution of domestic electricity, most workshop machines have been driven by individual single phase motors. More recently, the falling price of inverters has made them attractive, giving the attendant advantage of variable speed. Some of the most recent oriental machines include variable speed DC drive systems as standard.

Relation to industry

Those trained to a trade in industry can use their background knowledge and skill to address these home workshop challenges. Newcomers to the hobby may learn by experience, but will learn faster in evening classes, or with a mentor in a club. But all will benefit from learning about the ideas of others - how these people have overcome particular problems.

This information is mainly to be found in books and magazines about the hobby, and in more recent times by videos and the internet. The Workshop Practice Series of around 37 books provides excellent guidance for home workshop use.

Textbooks and manufacturer's catalogues provide a wealth of information, but distilling out of those the facts useful in the home workshop is often quite difficult. For example the manufacturers of cutting tool materials publish complete books of data to allow selection of precisely the correct grade of cutting material to machine a particular alloy at high speed to fine tolerances and surface finish. This is of critical importance in industry if making say a thousand or a million parts. But if the home workshop requirement is to produce just one, this information is of little interest. On the other hand if one refers to Tubal Cain's "Model Engineers Handbook" you can find general information for the useful selection

of cutting tool materials for general purpose use in the home workshop.

If you are in the business of making or repairing micrometers, then you will have a use for optical flats to check the finish of the anvil faces - but in the home workshop experience in the appearance of the work and the application of a fingernail drawn across comparative surfaces may well suffice.

In industry most important surfaces these days are ground or lapped, whereas in past years they would have been scraped. In part the reason for this is the restricted number of people with the necessary manual skill to effectively scrape surfaces true, but also to the much longer time required to achieve the result by scraping.

Computer numerically controlled machines nowadays effect most of the work in industry, whereas only a few years ago the control of volume part dimensions was done with jigs and fixtures, or with automatic lathes/screw machines. Technological developments over the last twenty years now make it commonplace for component details and machine programmes to be electronically transmitted from designers to manufacturers who may be on opposite sides of the world. Modern machines may operate with up to eight axes so that creating the complex programme can only be achieved effectively by computer.

The future

Does this mean the home workshop has to move to CNC machines in the future? Yes if you have an interest in computing and linking your computer to a machine to produce a tangible output. You may well find this approach satisfying, especially if you regularly produce a family of components, which are geometrically similar. The advances in software now make it very easy even for the amateur to produce programmes for complex profiles, which would be difficult to achieve manually. On the other hand, there is still a tremendous feeling of accomplishment hammering out a piece of red hot steel on an anvil, using a Swiss file to finish a small part to perfection, or simply exercising manual dexterity to delicately apply a cut on your chosen machine.

It is still a case of "you pays your money and you takes your choice".

Priorities

Tool acquisition is prioritised by availability of funds and urgency of particular jobs. A home workshop is not a tool collection; so avoid the "nice-to-have" items until you get to be fully equipped with the essentials. Most folk start a home workshop by acquiring some hand tools, usually including a portable electric drill. Next comes a solid bench with the largest vice one can afford or has space to accommodate. A bench grinder becomes desirable to keep tools sharp.

If you are starting out setting up your machine shop, then it helps to have some idea of what you intend to build, which in turn will influence the size and weight of machinery you need. The first machine to acquire is a lathe, and in my view the bigger the better within reason; you can



3. Myford ML7 lathe, this one with an added drive for power cross feed.

usually do little jobs on a big lathe but not vice versa. Metric calibration seems easier to use than imperial, but an imperial lead screw allows the use of a screw cutting follower dial, while a metric lead screw may not. With a 127 tooth change gear exact metric threads can be cut. A gap bed will give extra radial capacity close to the chuck; a Camloc system will allow rapid chuck changes; taken with a No.3 Morse taper in the tailstock, centre height about 150 mm and between centres distance of a metre, screw cutting Norton gearbox and a geared headstock and you have an ideal home workshop tool.

If you intend that your lathe will also function as your mill, then you may wish to consider the traditional Myford with its Tee slotted cross slide (photo 3), or one of the newer generation multi purpose machines (photo 4) which allow vertical milling operations as well as turning.

Going beyond the lathe, a mill or mill/drill enables a very wide range of machining work to be undertaken, after which consideration should also be given to a bandsaw, which saves much manual effort, and a tool and cutter grinder for keeping those expensive milling cutters sharp.

Conclusion

The equipping and use of a home workshop is an intensely personal matter. There are of course a number of constraints - available space, available funds, the envisaged nature of activities, environmental considerations (local authority, neighbours, health & safety aspects). But in the end it is YOUR workshop, to do what YOU want.

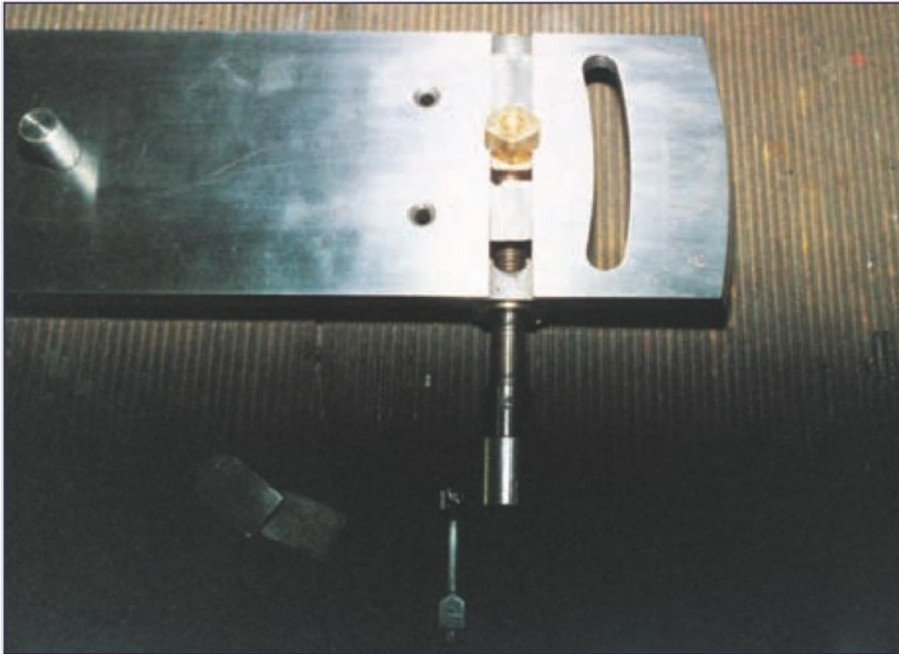
So it can all be you-beaut-gee-whiz electronically controlled gizmos, or a cupboard full of hand tools. Are you going to make watches, or pull along wooden trains for the grand children.

Only YOU can decide.



4. A multi-purpose machine from Warco.

TAPER TURNING ATTACHMENT (2)



10. View of adjustment screw

Recess for guide bar adjusting screw

The guide bar was then removed and, with the base plate clamped down and the rotary table locked the slot for the swivel adjustment screw was cut, this is shown in Fig. 5. A 14mm slot drill was first used to cut the central portion of the slot completely through the base plate followed by raising the cutter and cutting a 0.100 in deep trough across the plate from side to side. The cutter was then changed and a 17.5mm/ 0.690in. x 0.080in. tee slot cutter was run across leaving the slots for the shutter and an 0.020in. thick wall at the surface. Fig. 1 has a scrap sketch of this.

(Note: Figs 1-4 appeared with part 1 in the previous issue.) Whilst the cutter is in this position, centred above the adjusting screw slot, the base is unclamped and the guide bar is replaced but upside down for the last rotary table job –using the rotary table simply as a clamping/ positioning device. Locate the guide bar on the centre stub, clamp and mill the slot for the adjusting screw nut in the underneath of the guide bar. The previously used 14mm slot drill was used cutting the slot 0.975in. long and 0.625in. deep, widening the cut to 0.575in. The centre of the recess is given by the cutter position as used to cut the slot across the base plate. While the guide bar is upside down, relieve the under face by 0.020 to 0.015in. except for 2in. at each end and 3in or so in the centre. This is to improve the clamp action and remove the opportunities for swarf to be trapped under the bar.

Adjusting screw and housing

The next component is the housing for the adjusting screw, the screw and associated bits. The housing was cut from 4in. of 1in. x 1/2in. of black bar. After cleaning up the bar it was back to the miller –with a vice mounted this time – the 14mm wide recess was cut about 0.35in. deep. The 4 holes were then drilled for the fixing screws –first drilled tapping size - then the housing was clamped in position on the underside of the base plate, holes drilled approx 0.3in. deep, tapped and the housing holes opened up to 3mm. The housing was then reattached to the base plate, using the 4 x 3mm screws this time, set with the housing vertical (in the miller) and the 0.5 in dia bore for the screw bearing bushes was produced (centre, drill and ream). Fortunately, it did not run off-centre despite being drilled on the joint line, possibly due to the two parts being similar material of similar hardness and a good helping of luck. I did consider using a ball end slot drill to cut the half-bores in each piece but it all worked out nicely.

The adjusting screw (Fig. 5) was turned up from “a handy piece of bar” (lead EN1A) and the bushes run up from a piece of bronze. Trial assembly is now possible with the bushes held in one half of the housing with a drop of “glue”.

The nut (Fig. 6) was milled from a piece of round bronze bar, the lower part was made a close fit in the base plate slot, the shoulders of the trapezoidal part run on the upper surface of the base plate. The

Malcolm Leafé concludes his description of this award winning device, designed for a Smart & Brown lathe

flat angled surfaces of the upper part of the nut which engage with the slot in the underside of the guide bar were milled oversize and trimmed with a file to reduce lost motion whilst accommodating the swivel movement of the guide bar. The knob for the screw was deliberately kept small (if larger it may prove awkward at the back of the lathe) and so, to improve the speed of adjustment, a swivel-out handle was arranged. The knob design is “to taste” and the handle is retained in open or closed position by a spring loaded 3/8in. dia. ball in the rim of the knob.

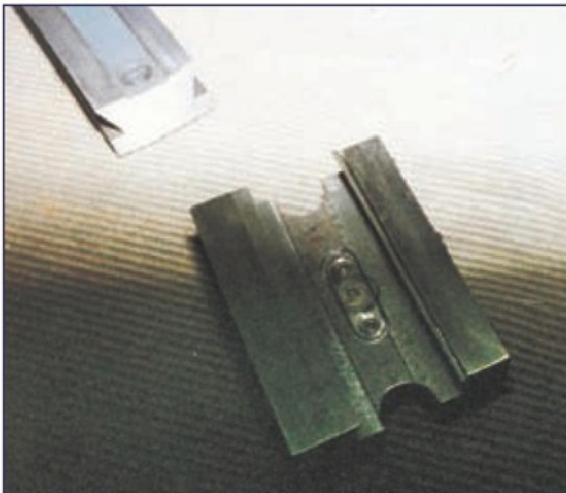
Having made the enclosed housing for the adjusting screw and then placing it in an ideal position for filling it with swarf I then perforce, fitted a sliding three part shutter to protect the screw. The shutter needed an inordinate time to devise; it varied from steel to plastic via aluminium, from 2 piece to 5 piece and finished up as 3 pieces in 0.015in. steel sheet (Fig. 3). The long slot in the centre part of the shutter is vital to its function as are the 0.035in. turn-ups at the end on each section –they do need careful bending and a little jiggling. Photo 10 shows the adjusting screw fitted with the shutter partially assembled i.e. I hadn't yet decided how to do it.

A simpler design would be created by omitting the adjustment screw and thus its housing and one base plate slot. Fine adjustment would be then by the usual tapping technique.

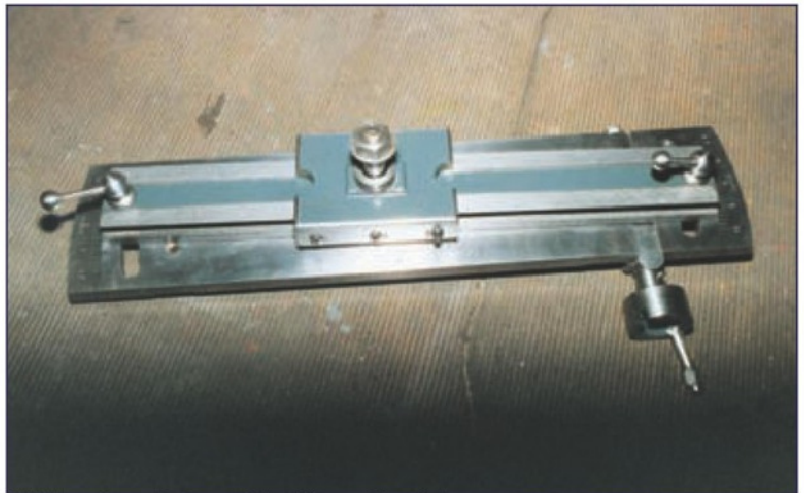
Slide

We now have an adjustable guide bar and base plate mounted on the lathe and so the next element is the TTA slide which controls the cross slide. This is another simple piece of kit but it does require some careful measurement to correctly link with the cross slide, I found that this could be easily controlled late in the construction. In the event that outwardly similar lathes do vary in dimensions then you can press on with the construction and sort it out near the end. I would bet any money that my S&B has a different cross slide from any other.

I used a 4in. x 3in. x 1in. lump of cast iron as the starting point for the slide, this was hacked from a scrap machine fixture and was obviously machinable to a fair finish. Running against the steel guide bar, cast iron is a traditional choice of material. The slide could be shorter to increase the travel but 3in. x 4in. is felt to be close to



11. Underside view of slide showing the fixing of the central stud.



12. Top view of baseplate, slide and guide bar

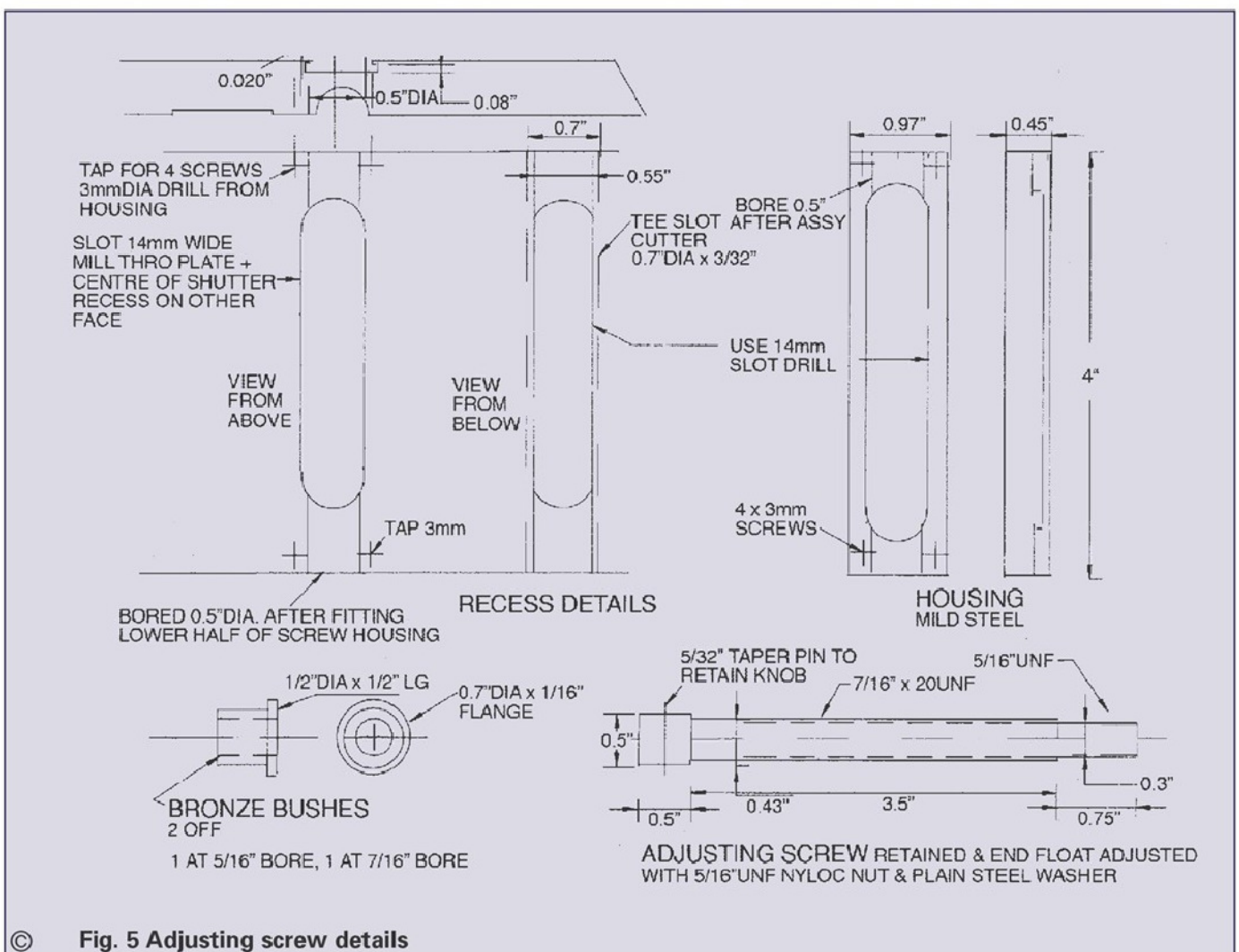
the minimum to maintain the proportions for a narrow guide. After squaring up the block it was machined (the long suffering miller again) to the dimensions in Fig. 7, but was left flat topped. The dovetails were machined to size after careful measurement of the guide bar dovetail and, whilst in the inverted position on the miller, the 0.64in. dia through hole was bored – size is to choice – make the corresponding part to fit (Fig. 3).

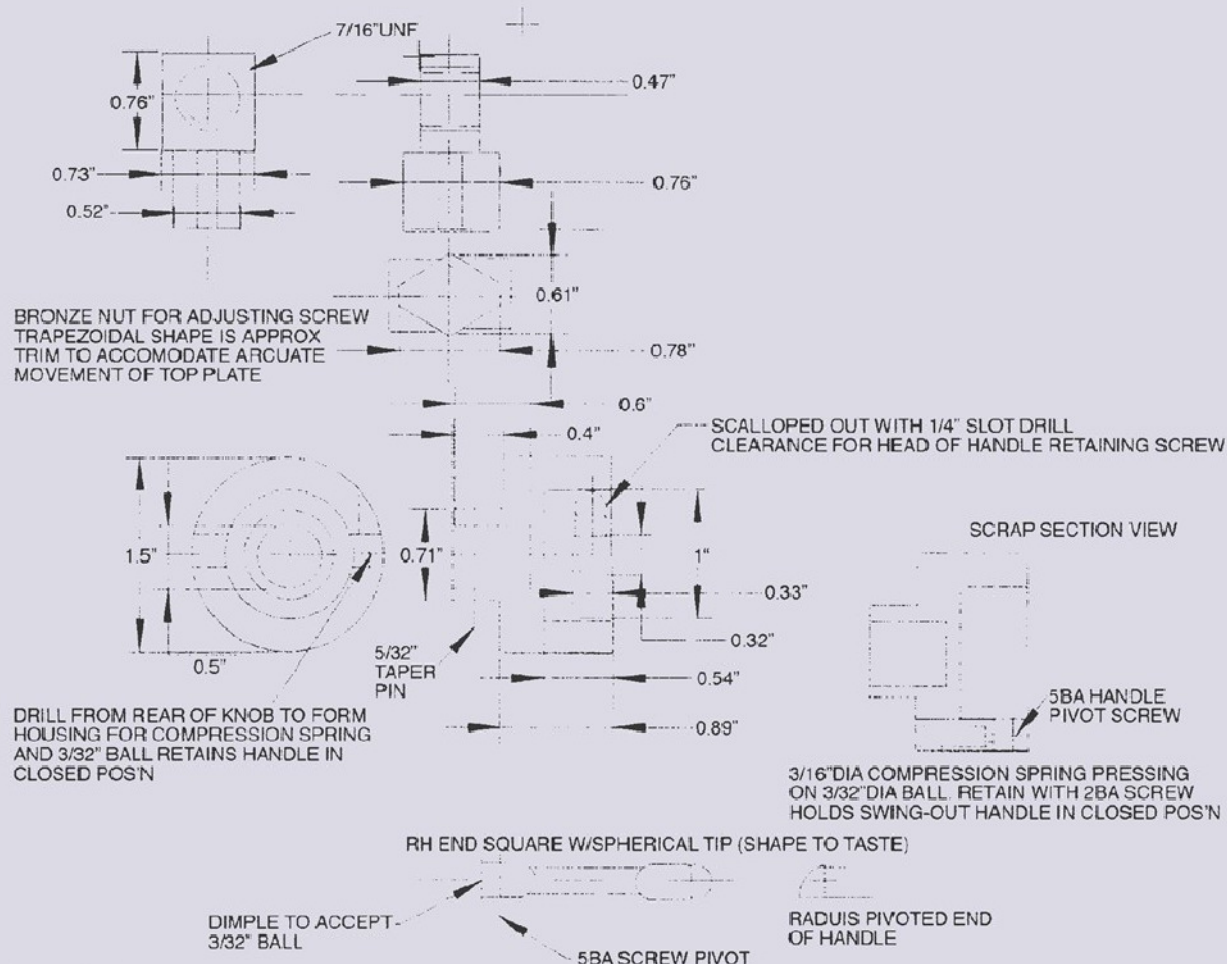
The gib dowel holes, gib screw holes and counterbores were drilled with the part set on its side in the milling vice. It is

useful to next make the gib piece from $\frac{1}{2}$ or 0.1in. steel. Mill or file to size, angle the edges appropriately and clamp it to the dovetail using a piece of say $\frac{1}{2}$ in round bar and a toolmakers' clamp. The dimples for the screw tips can then be drilled together with the through holes for the dowels and, after deburring, it can be tried for fit. The outer end of the dowels should be domed and the inner ends pushed through the gib piece and filed to match the angle – if this is not done there will be an insufficient length of dowel in contact with the gib to support it properly.

Alternative construction

The slide could alternatively be made from sections screwed together. A flat top plus two side pieces with a handful of screws. Dovetail type slide ways are easily machined in a lathe using a piece of large hexagon bar as the mount. Screw and dowel the blank to one face of a piece of hex bar, say 1in. or 1½in. A/F then attach this to the faceplate and turn up a 60 degree angled face. I used this technique





© Fig. 6 Knob, handle, nut

years ago when building a milling machine.

Slide – attachment details

Work on the slide, from here on, depends on actual dimensions of the lathe in question; this is also a convenient stage at which to assemble all of the bits made so far. The TTA should be assembled and attached to the rear of the lathe bed – any old bolts can be used to retain the guide bar to the base plate – and the adjusting screw etc can be left scattered on the bench or neatly stored in a labelled drawer to suit your taste and style but, the slide needs to be fitted. A repeat performance with a clock gauge may be useful, either to cause you to think, smilingly, “how about that then” or to reach for a file.

The cross slide needs to be extended over the TTA slide in order to measure the distance between the underside of the cross slide and the top of the TTA slide – all S&Bs may be identical but I do not know for certain, I’ve only got one of them. You may need to remove the locking nut from the cross slide handwheel thus freeing the slide in order that you can extend the cross slide sufficiently far – this will be good practice for the future. Such manoeuvres were unnecessary on my lathe as an accident some years earlier had removed about 2in from the end of the cross slide (nothing to do with me, honestly). Instead I had to clean up the end

of the lathe slide and make a replacement add-on part from a handy chunk of CI. To digress, having seen a large lathe fall from a forklift truck, I think I know what kind of accident may have befallen my S&B. The large lathe concerned was mine; the bits were placed in a convenient skip.

Having the said dimension to hand it is time to make the centre part of the TTA slide which will connect to the cross slide when in taper mode. The S&B provided cross slide taper nut appeared to have a half-angle of 8deg 5min, I presumed that this meant that the included angle was actually 16deg. I took up a piece of 1 in bar, drilled it through 5/8 in and followed this with a boring bar with the top slide set to 8deg. on the old Drummond lathe (see Fig. 3) – wouldn’t it have been nice to be able to use auto feed for this? The S&B taper nut proved to be a fair fit – OK but not splendid. Patience would probably have been, not only its own reward, but would have given a good fit – but after all the earlier procrastination, urgency ruled. A rummage produced a selection of old taper bridge reamers of all sorts of tapers, one of them was tapered at about 11deg. 30min. not close but a good start. A quick-ish fiddle with the T&C grinder and it was 16deg. As the reamer had spiral flutes and this was a one-off job, the relief was restored, in a quick and dirty fashion, by hand grinding. The reamer was pushed down the taper hole and, as a dab of blue showed, all was well...well, as well as I ever expected. The S&B nut can now be firmly

pushed home and the end of the piece of 1 in. bar skimmed so that the end of the taper portion of the S&B nut is level with the end of the piece of bar. Skim the circumference of the bar and reverse it in the chuck – use a 4-jaw or soft jaws in the 3-jaw so that the taper will run true. Bearing in mind the dimension measured previously, turn the stub of bar to fit the hole in the TTA slide (leave it less than 0.001in. larger than the hole) and bring the shoulder to such a length that, when pressed into the slide the total height of the top of the stub plus the projection on the TTA slide exactly fits under the cross slide when all is assembled. As a final step, press the stub prepared above, into the TTA slide. The slide can now be popped in to a vice on the miller and any excess length of stub protruding through the slide can be trimmed off underneath. At the same time you may cut the recess for the plate, which will mount the retaining stud (slide centre piece stud on Fig. 3). Photo 11 shows the underside of the slide with the attachment stud fitted.

The stud is simply a short 3/8in. UNF stud, with a step turned at the bottom which serves to locate it in the bottom plate,peen it over and silver braze, clean up and fit. The S&B taper nut should be put into the centre stub and screwed down on to the stud until it is snug, then turn the slide over, drill and tap for 2 off 4mm countersunk screws. Deburr and fit the screws. A few minutes can be spent removing and refitting the nut and thinking, “that turned out nicely.”

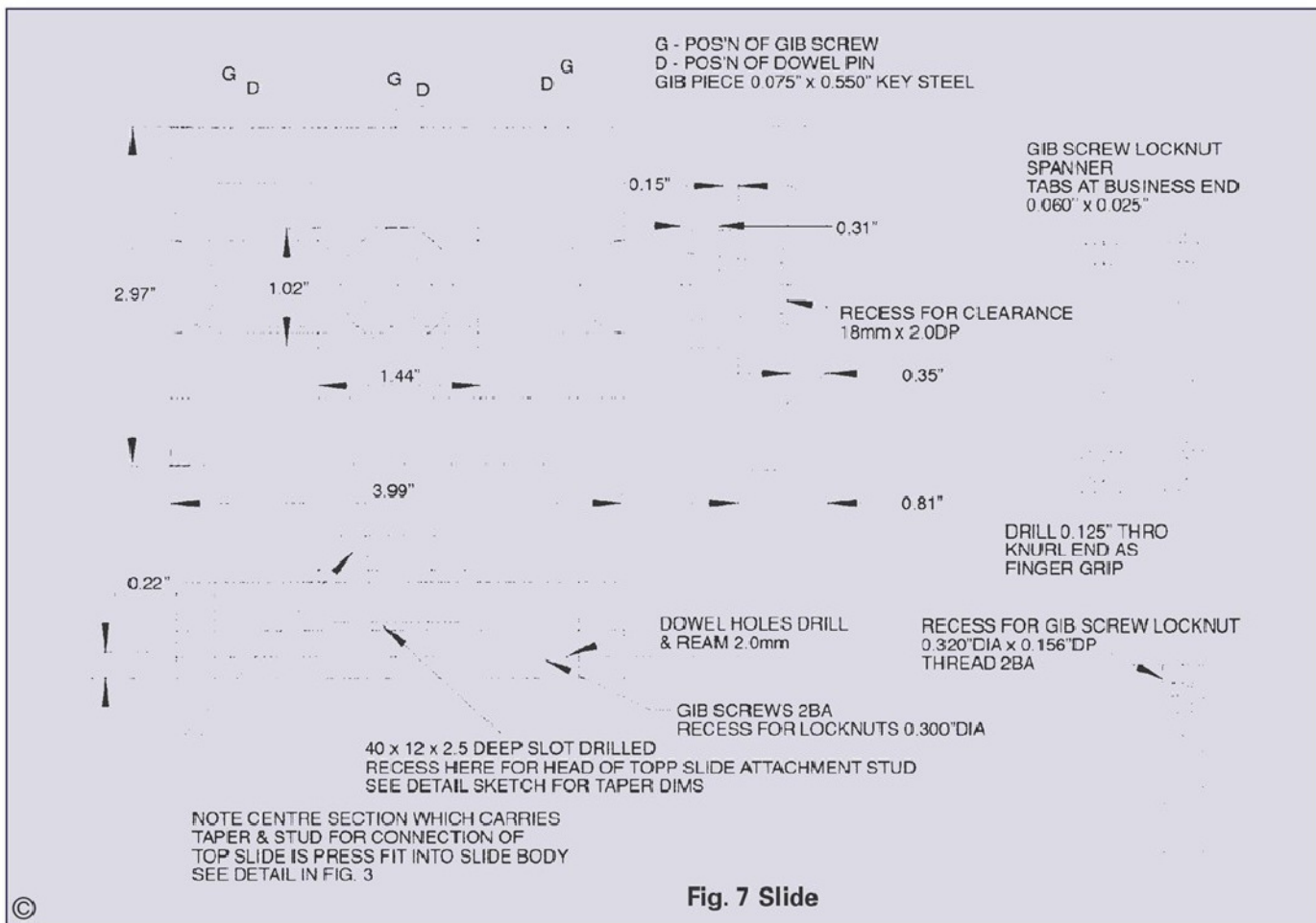


Fig. 7 Slide

Other lathes

Anyone who has another make of lathe can safely ignore all this kerfuffle and devote some time to deep thought. I suggest that, in many cases, a piece of MS flat of modest dimensions, possibly 6 or 7in. x 1 $\frac{1}{2}$ in. by $\frac{3}{8}$ in. can be fitted to the top of the cross slide using the existing tee slots or rear- toolpost fastening holes in such a manner that it will overhang the TTA slide. A suitable short shouldered stub can then be fitted to the TTA slide and machined to a length so that it just touches the bottom face of the MS strip. Both can then be drilled to take a suitable bolt passing through the lathe slide, steel strip, perhaps through a bush, screwed into the TTA slide.

Cross slide feed screw disconnection

The matter of detaching the cross slide screw may require some changes to be made to the lathe, unless you settle for stripping the cross slide feed screw/ dial/ index each time to remove it. Depending on the lathe it may be possible to change the nut mounting to make the fasteners removable from above or, if there is space, to alter the nut to a nut within a sleeve arrangement with means for freeing the nut. On the 5 in "Twin bed" Drummond I have schemed to alter the cross slide nut so that the locating spigot is removable from above. It will only be necessary to slacken the top slide bolts, push it clear of the spigot which is at the front of the cross slide and having

provided a suitable thread in the spigot for an extractor, pull it out. Replacing it may require patience but I am sure that ME's will come up with their own ingenious ideas.

Guide bar clamping nuts

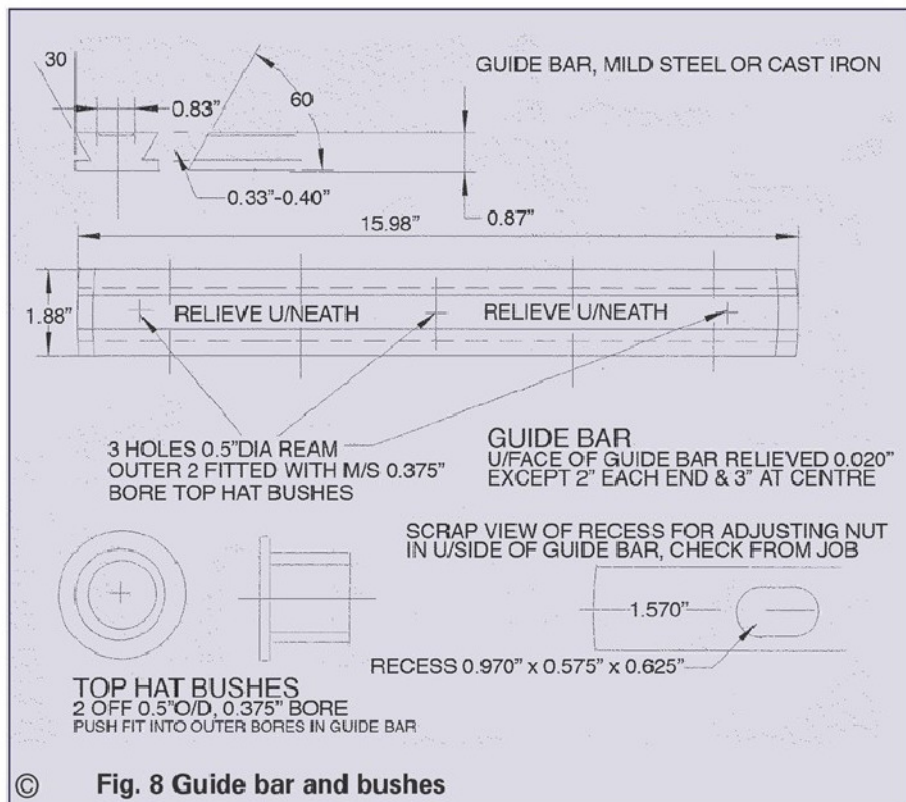
There remain a few components to make before the job is finished. We need two curved nuts to fit the arcuate clamping and swivelling slots in the base plate. I used a piece of 1in. x $\frac{1}{2}$ in. black bar. After cleaning it up to thickness it was mounted on a chunk of 4in. x $\frac{1}{2}$ in. plate via couple of $\frac{1}{4}$ in. screws in the scrap ends of the piece and clamped it to the rotary table on the turret miller. It was set it to the radius of the slots and I machined the tee nut step to size. The same set up was used to cut the part-formed piece into two nuts by feeding radially with a $\frac{1}{16}$ in. slot drill, the cut being taken to within 0.030in. of cutting through. The bolt holes were drilled in the miller to save changing the set-up, and the job was removed and hacksawn into two nuts. After deburring the nuts were tapped $\frac{1}{8}$ in. UNF and each tee nut was then mounted on a $\frac{1}{8}$ in. UNF mandrel in the lathe three jaw and the smaller step turned to match the radius of the ends of the curved clamp slots to allow maximum travel of the nuts. (Fig. 3) To finish off the clamping arrangements two lock screws will be needed. I made a couple of "two-ball" screws but hexagon bolts and a spanner will do just as well.

The end holes in the guide bar (Fig. 8) were drilled $\frac{1}{8}$ in. for convenience when milling the curved slots, so a couple of top-hat bushes were turned up, $\frac{1}{8}$ in. o.d. x $\frac{1}{8}$ in. bore to push into the holes to suit the $\frac{1}{8}$ in. lock screws. The heads of these two sleeves also serve to stop the TTA slide from being pushed / falling from the end of the guide bar when the TTA is not in use.

The machining part is complete, time now for deburring, "pushing-up", radiusing edges etc.

Assembly

Much of the device will have been assembled as you have progressed but a few comments may be useful. I suggest that you build the adjusting screw assembly to the base plate as a first step (having checked that it will all fit together as a preliminary stage). Pop the bearings into one half of the housings -the base plate half is preferred -with a dab of glue if you so wish, and fit the screw and nut. Enter the nut from the top of the baseplate, having first slid the centre portion of the shutter into its slot, as the nut fits through the shutter. Assemble the knob/ handle as made to your taste and fit the four retaining screws. Now crank the nut to its extreme positions and fit the outer parts of the shutter, this may/ will require some fiddling and adjustment of the turn-ups on the relative parts. Turn the assembly over, squirt with oil and fit the bottom of the housing and the four retaining screws. Push/ press the centre pivot into the centre hole of the base plate



© Fig. 8 Guide bar and bushes

from underneath using a touch of glue on the bottom flange if needed.

The next stage is to fit the support brackets and the raising blocks, (the correct way round is best but I did try the opposite hand approach a few times) locate them and fit the screws. The base plate assembly can now be fitted to the lathe with the tee nuts/ tenons etc. It should fit snugly without any signs of "pulling up" when the tee bolts are tightened. The device is getting heavy now and fitting it to the lathe in two stages eases the load. The base plate and guide bar are shown assembled in **Photo 12**. The support brackets are now awkward to fit and I would not recommend this approach. Fit the brackets first.

The assembly of the guide bar/ slide is obviously the next bit. Presumably the centre part of the slide has been pressed in to place so the connecting stud can be fitted from underneath. Fit the S&B taper nut from the top side to locate the stud correctly and fit and tighten the two screws underneath the slide to retain and fasten the stud. Remove the S&B nut. The gib screws/ locknuts and dowels can be added to the slide body; put the gib piece in position and poke the dowels through. The slide can now be slid on to the guide bar and the gib screws nipped up to remove the slack. Press the two top-hat MS bushes into the holes at the end of the guide bar and it can safely be waved around (not really recommended), as the slide can no longer fall off the end. Prepare the tee nuts for the curved slots and the clamp bolts whether hex bolts or fancy ball clamp screws. Place the guide bar on the centre pivot whilst easing it over the upstanding part of the adjustment nut and fit the tee nuts/ clamp bolts. Done.

Control your impatience, before putting the thing to work, fit a clock/ magnetic base either to the TTA or to the lathe slide

and set the TTA parallel to the saddle movement. Clamp it up and scribe a fiducial mark at both of the sloping curved ends of the guide bar, in line with the zero of the graduations previously engraved/ scratched on the base plate. If you decided not to graduate the base plate, simply line it up and mark a zero reference line on both parts. Now you can have a go.

Wind the cross slide towards you as far as it will go, undo the locknut in the centre of the cross slide handwheel and, with an Allen key, remove the taper nut. Now for a bit of Slipping and Sliding. Slide the TTA slide and the cross slide into alignment and slip the taper nut into the appropriate hole in the cross slide –the near one for boring and the far one for turning. Tighten it. Turn the top slide as near as possible through 90° and re-fix. The top slide is used to put the cut on. Unclamp the TTA, adjust and Robert's your mother's brother. The attachment of the cross slide to the TTA

slide is shown in **Photo 13**. The picture is actually of the replacement end of my cross slide attached to the TTA but it is the same in practice.

Alternative thoughts

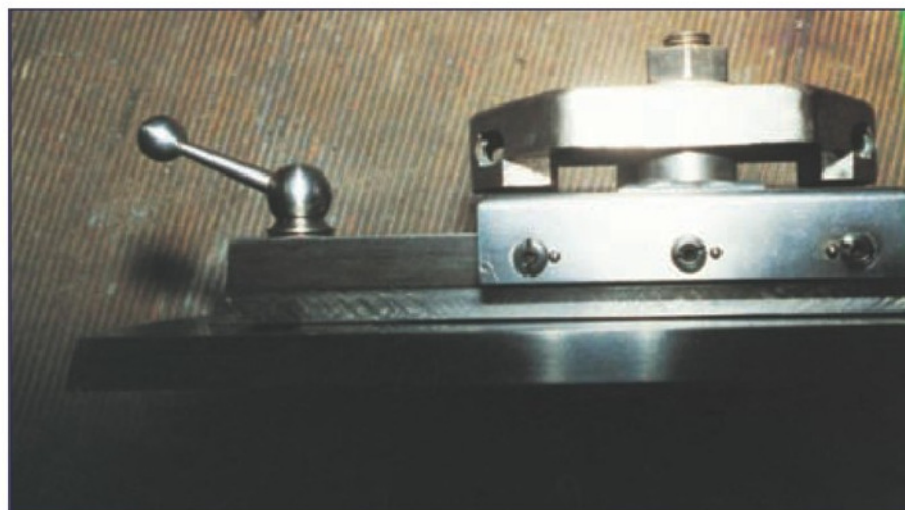
The device, as made, involves a lot of milling. If you are milling on a lathe then I suggest that eliminating the dovetails and the "for appearance" curved and tapered ends on the various members would ease the task. The adjusting screw could be omitted and perhaps made at a later date. The milling remaining is limited to the curved adjustment slots which can probably be cut with a loco valve gear link milling attachment as suggested previously. The clamping tee nuts could be altered to avoid having to mill the curved recesses for the nuts as designed. The TTA slide is smaller than the other components and can probably be managed on a vertical slide – I have machined vice castings larger than this with a combination of v/slide and angle plate. Alternatively the slide can be fabricated by screwing together CI or MS rectangular sections.

Concocting a variety of lathe mountings is best resolved using your knowledge of your machine but bedway mounting is probably universally applicable with suitable L shaped brackets and clamps.

Alternative construction

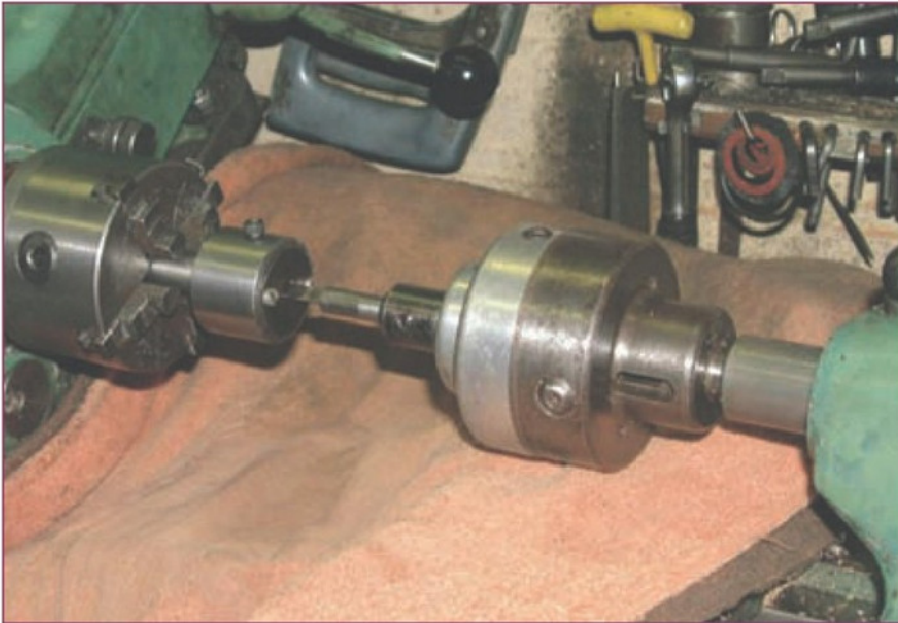
A further construction alternative, which is almost milling-free, would be to make the guide bar from say, 1 in. dia. rod and to use a slide made from 1½ in. square bar, bored through and equipped with collet type closing devices at both ends to provide adjustment of fit. Make two brackets to fit the bedways –one of which could provide the angular adjustment by an eccentric disc arrangement. An attachment to the cross slide would be required but, you are in business. I still like dovetails though.

In regular lathe use I find that the slide bar and slide get in the way of clearing out the swarf tray and so, when not in use I remove the clamp bolts and slip the guide bar/ slide off and out of the way. The base plate still has sufficient sharp edges to make you take care.



13. Coupling of TTA to lathe cross slide

DRILLING FLAT SIDED HOLES



1. Method 1 Triangular bit in use on lathe.

Giles Parkes discusses techniques.

size of the finished hole. For example a square hole $\frac{1}{8}$ in. square is made by a triangular bit with equilateral sides of $\frac{1}{8}$ in., and for a hexagonal hole a five sided bit is used. The tip of the bit must be properly formed and the motion of the bit is a combination of rotation and gyration, somewhat akin to an internal gear arrangement. This is achieved by the use of a fully floating chuck held in a drill press or lathe tailstock, which holds the tool axis parallel to the spindle centreline, but allows the axis to move off centre. Floating chucks are available from Horley Drill Services as are special drill bits, but at a price.

Two versions of a floating tool holder were described in MEW Nos 86 and 103 by Dyson Watkins, which I think would cope with small holes; I use a floating reamer holder which came from the scrap yard. It would seem that the greater the hole size the greater the amount of float needed.

The square holes produced by the triangular bit have a radius in every corner which can be inconvenient, but Mr Throp described a slotting bit - M.E. Vol 144, 1 December 1978 - which can readily be used to remove the radii; alternatively, the corners can be removed from the mating male square. The drill bits are not difficult to make with a Stent or other tool grinder or can be milled and filed from silver steel and suitably hardened. I have not had great success with silver steel but my heat treatment may be a bit haphazard. Bits ground from high speed steel are much better in my experience.

Construction of the Bit

The cross section of the bit for a square hole is an equilateral triangle. Fig. 1 shows

Background

The traditional way of making a square hole in the home workshop has been to drill it round first and then open up the round hole to the required square by filing. Filing accurately is a skill only obtained by years of practice and I don't have the necessary long years ahead of me to devote to filing practice. Hexagonal holes require even more skill. Filing is all very well if there is somewhere for the end of the file to go but for blind holes it is almost a non starter. Commercially, through holes might well be broached, a process which we may think of simplistically as an extension of filing, while blind holes or those progressing to a smaller hole, may be forged or punched. Typical examples would include sockets in Allen screw heads, and the squares and twelve point holes in socket sets.

For use by the amateur, I propose to describe two methods. Long square holes can be drilled by the first method and the second will take care of blind holes.

Method 1

The first method was described in MEW No 14, Dec92/Jan93 p.14 and bears reading. A round hole is drilled first and then a special bit is put through the round

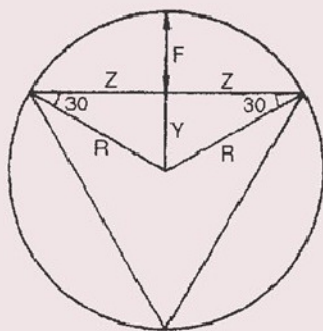
hole guided by a plate with a square hole in it and fixed to the work. It is essential that the bit has one less side than the required hole, and the size of the flats on the bit are the same as the width of the



2. Detail of guide for triangular bit fixed to work.

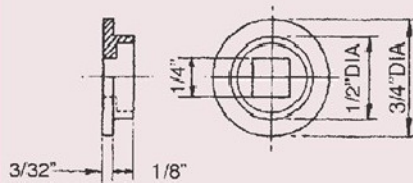
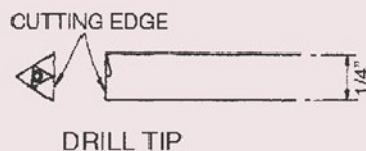


3. Floating chuck with drill bits, guide plate and holder.



$$\begin{aligned} Z/R &= \cos 30 \\ Z &= R \cos 30 = R \times 0.866 \\ \text{SIDE} &= 2Z = \text{DIA} \times 0.866 \\ \text{DIA} &= \text{SIDE} / 0.866 = \text{SIDE} \times 1.155 \\ Y/R &= \sin 30 = 0.5 \\ Y &= 0.5R \\ F &= \text{DIA} \times 0.25 \end{aligned}$$

Fig. 1 Geometry



DRILL GUIDE

MAT'L:
TIP - HSS OR SILVER STEEL, HARDENED
GUIDE - SILVER STEEL OR GAUGE PLATE
HARDENED

Fig. 2 Drill tip & guide for 1/4 in sq. hole

square hole, which leads us shortly to the wobble broaching method. In use the guide must be fixed to the work so that it cannot move. A normal drill slightly smaller than the square is used through the guide to remove the bulk of the hole in the work, and this is followed by the triangular bit in its floating chuck. The tip of the bit must be in the guide before the machine is started and the bit is fed into the work with plenty of lubrication. Radiused corners are then removed as described.

Method 2

The wobbly broaching mentioned above in the production of the guide is a different method but it produces only relatively shallow holes - but works for blind ones. For this a bit the same shape as the hole is held in a special holder set at an angle to the axis of the hole and allowed to wobble round with the work. I am grateful to Joe Black and David Brinkerhoff who wrote an article in The Home Shop Machinist Sept/Oct 2002. It was this that first set me off on wobbling and I make every acknowledgement to them. Similar devices are believed to be in use in industry, though I have no specific details of suppliers.

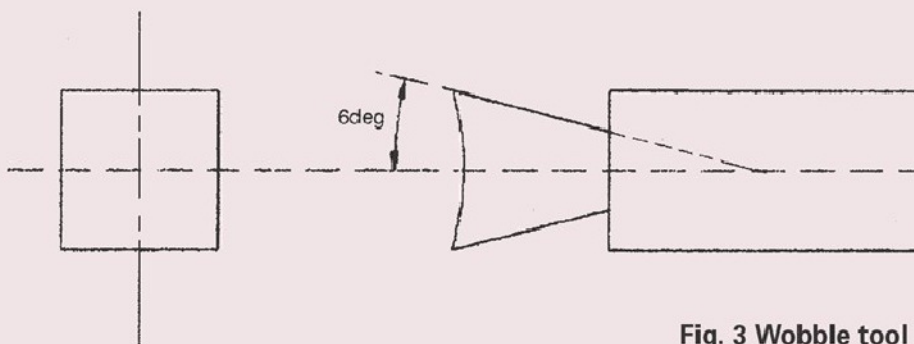


Fig. 3 Wobble tool bit

the calculation involved for the diameter of the blank and the important number is 1.155. Multiply the size of the square required by this number to give the o/d of the blank.

Turn down a piece of silver steel to this size and then machine the triangle with a dividing head or whatever kit you have for dividing. A length of hexagon drilled and reamed to hold the blank will produce a good triangle when held in a milling vice and rotated 120 degrees three times. The triangular section should be about 1/4 in. longer than the depth of the hole required,

and a small land should be left at every corner for added strength. The cutting edges are formed on the tip and backed off as shown in Fig. 2 by filing and the silver steel can then be hardened and tempered to light straw for the whole length of the triangular section. The faces can then be polished. Making this drill bit from high speed steel on any tool and cutter grinder is not difficult and provides a better tool in my opinion.

Next a drill guide is required as in Fig. 2 and again this can be turned and filed from silver steel before hardening. This of course involves accurate filing of the

Construction of Wobble bit

My bits are made from HSS and the tip of the bit is the same shape as the desired hole. Behind the tip the shape is relieved at a clearance angle of 6deg. to the axis and the length of relief dictates the maximum depth of the hole - you have to leave enough metal in the centre of the bit for strength. The tip of the tool must be hollow ground to provide end relief, and it is my practice to leave the square on the



4. Grinding a cutter on the Stent.



5. Method 2 Wobble tool fitted to boring head, also showing cutters and hexagon jig.



6. Grinding the end of the tool using a spherical stone.

end slightly bigger than required and then hollow grind the end down to size.

Fig. 3 is a diagram of a tool for a square hole but the general theory is applicable for a hexagon or other shape with any number of sides of equal length.

The device which holds the toolbit and allows it to rotate and wobble is a bearing housing on a spigot, the spigot being held in a boring head. The recess for the bearings is bored at an angle of 5deg. in the body of the housing and the toolbit holder, either drill chuck or special holder is a press fit into the middle of the bearings.

The body of the housing is held by its spigot in a boring head in the tailstock which allows it to be offset to bring the tool tip concentric with the hole in the work centre. Thus the tool is set at an angle of 5deg. to the lathe axis or axis of the work. Fig. 4 is a diagram of the device.

In use the device is held in the boring head in the tailstock. The work is held in the lathe chuck or collet and a round hole is drilled at a size slightly less than the AF of the square or hexagon. The wobble bit is then brought up to the work and the boring head is offset so that the tip of the



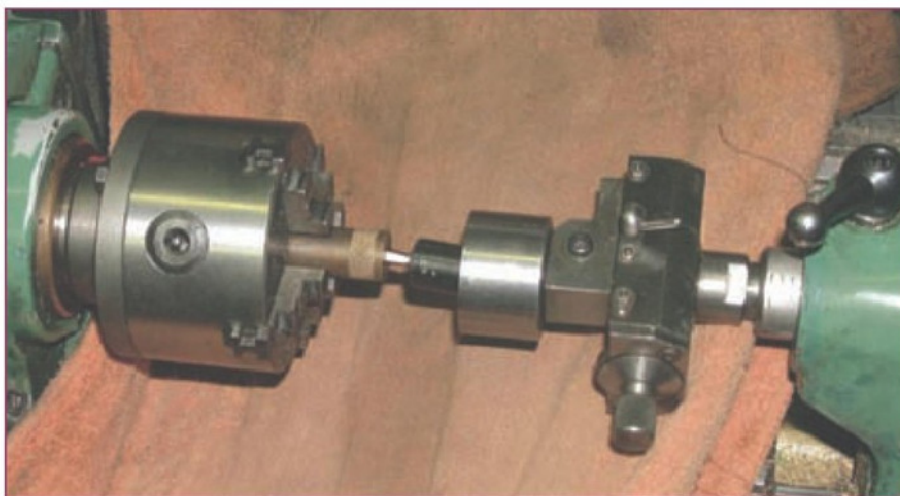
7. Rotary wobble tool viewed from above.

angled wobble bit is at the centre of the work hole. It is important that the boring head offset is in the same plane as the 5deg. angle of the tool - ie the boring head offset is in a horizontal plane and the tool is at 5deg. to the axis of the lathe in the same horizontal plane. The tool tip is held against the work with slight pressure from the tailstock and the lathe is started, maintaining and increasing the pressure. The tool will appear to rotate with the work but as pressure is maintained, it will slowly feed into the work, pushing the swarf before it. Stop the lathe before extracting the tool then remove the swarf and if you want to go deeper re-insert the tool into the hole before starting the lathe again. The speed of rotation and the pressure of the feed are very much trial and error.

If you appear to be making no progress it is probably because the initial round hole was not quite big enough and you will have a star shaped depression in the end of the work. Stop before it is too late, enlarge the hole and try again. When I first tried this device I thought it would never work, but persistence paid off. I now allow enough additional material to be able to clean up the face of the work after making the hole.

The version proposed by Black and Brinkerhoff noted above proposed a thread to fit a chuck for the tool bit but I dispensed with the chuck and drilled and reamed a $\frac{1}{16}$ in. hole with a grubscrew to hold the bit as shown in Fig 4. This is to reduce the overhang. I also used two bearings (they used just one and a suitably elongated housing for greater rigidity).

The wobble broach can be used in the lathe, mill or drill press with either tool or workpiece rotating as long as the angular offset is maintained between machine axis and starting hole. As an afterthought, it may be feasible to mount a simple bearing housing on the vertical slide and then rotate the slide to give the 5 degree offset.



8. As photo 7 but viewed from side.

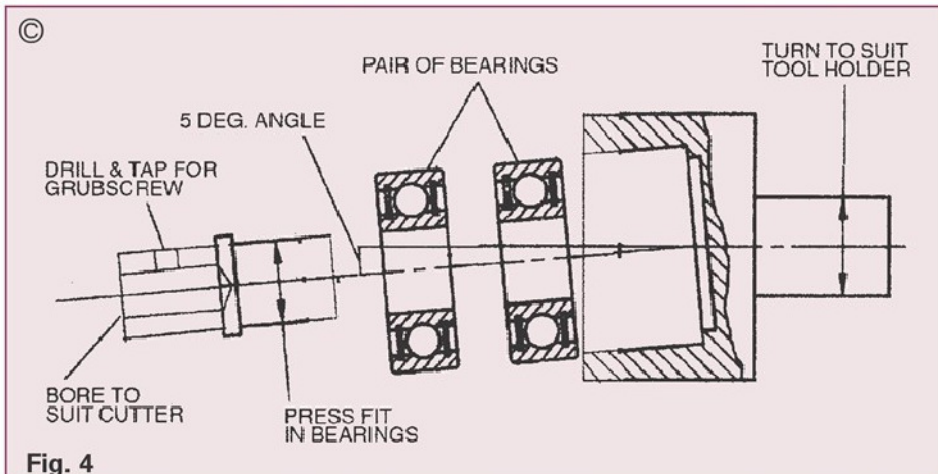


Fig. 4

1. Swarf handling equipment is a striking feature at this end of the lathe.



LATHE OR MACHINING CENTRE?

Dave Fenner takes a look at one aspect of latest manufacturing technology

Occasionally, comments are aired in these pages regarding the manner in which technologies available to the amateur and professional are both moving ahead, but nevertheless diverging. A recent conversation about subcontract work had led to an invitation from Steve Bruce (Managing Director of Bonspiel Engineering Ltd. - Dundee) to have a look at their latest acquisition, a Star SV32 Swiss type CNC sliding head lathe. With a price tag approaching £170,000 pounds,

one expects to see something a little out of the ordinary, and is not disappointed. Photo 1 shows the machine from the "output end".

Company background

Bonspiel was started in 1989 by Eddie Bruce, his son Steve, and third partner Paul Carver, focussing their capacity initially on small diameter medium volume

work. At the outset, a solitary Star RNC16 sliding head lathe sat in the middle of a 2300 square foot factory, but was kept running 24 hours a day, seven days a week. In those early days, one partner would be volunteered to interrupt his week-end golf to pop in to the factory and load a batch of material into the magazine bar feed thus ensuring continuous production.

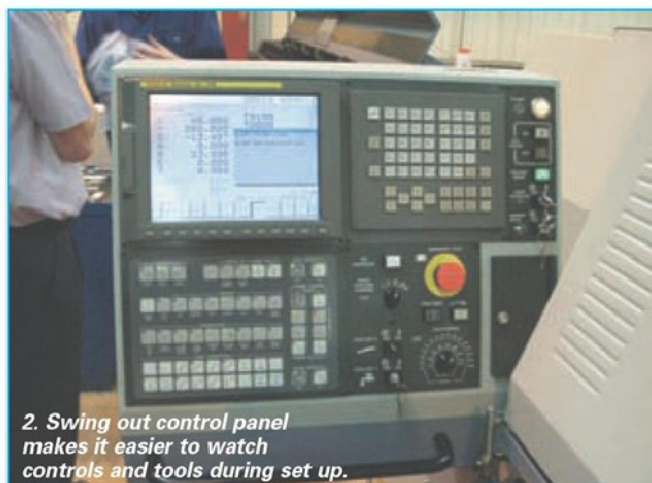
Regular additions of new machines forced a move in 1994 to a 5000 square foot unit, and again in year 2000 to a purpose built facility of 10,000 square feet. This now houses some two dozen Star CNC lathes together with facilities for centreless grinding, and the back up inspection and quality control facilities expected of an ISO9001 company.

Sliding Head - the basics

The centre lathes that we amateurs (and many professionals) are familiar with, will feature a rigid fixed head stock, which will hold and rotate the work but allow no axial movement. The turning tools then move radially to give a specified diameter, and axially to give length features. Drills and taps may be fitted to the tailstock either directly or via a multi-station turret. On a basic sliding head machine, the tools move only in a radial plane, and thus control the turned diameter. Length features are controlled by axial movement of the entire headstock, carrying the workpiece, (bar material) which is located in precision collets. The feed mechanism also allows the material to be fed forward by a precise amount. Thus on even a fairly basic machine, long thin diameters can be turned by a repetitive sequence of turning and feeding, without the use of a steady.

Machine developments

Over the years, a number of improvements have been designed in, to raise productivity levels. The introduction of a secondary spindle allowed machining to continue on the rear face of "component one" while the primary machining of "component two" took place simultaneously. The addition of powered rotary tooling meant that where necessary, hexagonal or other shaped parts can be milled from round bar, all within the



2. Swing out control panel makes it easier to watch controls and tools during set up.



3. In this view of the work area, the primary spindle, gang toolholder and turret can be seen.

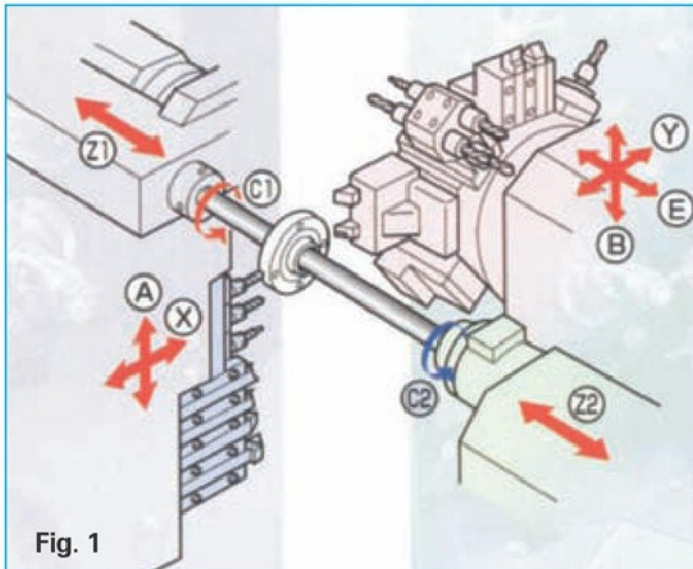


Fig. 1

machine cycle. It also became possible to cross drill and tap before the part came off the lathe.

Software advances

In earlier years, programming was undertaken by Eddie and Paul, writing G code, line by line. This sounds time consuming, but in fact when you're really adept at it, even fairly complex parts can be handled quite quickly. However, the latest machine operates in what the manufacturers describe as nine axes, and it is often possible to bring multiple tools into simultaneous operation. Given that there is also the second spindle to consider, it is easy to see how the complexity has been stepped up, making comprehension and optimisation by the human brain much more difficult. Programming has therefore become very much a process of drawing the component in CAD, then letting the computer work out the best way of machining it. Eddie and Paul have recently retired, so programming is now in the capable hands of Dave Webster.

Latest machine – Star SV32

The number 32 relates to the nominal maximum component diameter, although it will actually just make 33mm. As you approach the machine the first item to strike you is the swarf handling system, seen in **photo 1**. A sizeable



5. Coolant passages are visible at the tip of this 8mm drill.

conveyor deposits the swarf in a large (roughly metre cube) bin designed for easy movement and tipping. An air blast system separates much of the coolant from the swarf to reduce consumption. Coolant here is a neat oil rather than the milky suds, and the particular brand has been dictated by the later gold plating of many parts. (In spite of scrupulous cleaning, it has been found that some cutting oils cause imperfections in the plating.) A second conveyor drops finished parts in a plastic box. As you get closer, the gaze moves to the large swing out control panel and screen, (**photo 2**) then as the sliding door/guard is pushed back it becomes possible to examine the spindle and tooling arrangement, (**photos 3 and 4**). **Fig 1** reproduced from the Star brochure illustrates the general layout of the principal elements and the motion paths of the various tools. Thus, whereas the earlier basic machine had just one spindle, and tooling moving only in a radial plane, we now have two spindles, gang tools moving in the radial plane, turret tools moving axially and radially, and the option of fitting driven tools (drills, taps, milling cutters etc.) to both the gang toolpost and the turret.

Looking round the back of the lathe, one finds an unidentified cabinet. "Ah" says



4. Showing the secondary spindle

Steve, "that's the high pressure coolant". Specially designed toolholders and tools allow coolant at 2000 p.s.i. to be delivered right at the tool tip. This means that a hole of diameter just 0.250in. can be drilled to a depth of over three inches in one pass. No pecking, no pulling back to clear swarf, just one continuous cut. With coolant being delivered at that pressure, the swarf is blasted backwards, and the cutting edge is kept cool giving considerably enhanced tool life. **Photo 5** shows a typical solid carbide drill which features internal passages for "through the tool" coolant delivery.

The main spindle runs up to 7000rpm and is powered by a 7.5 hp motor, while the powered tooling will give 5700 rpm from 3.7hp on the turret.

Results so far

As can be seen from **photo 6**, components are being "turned" which include such features as internal keyways, milled hexagons, and even an integral external key. Not so very long ago, sliding head machines produced parts, which required significant second operation work to be undertaken on manual machines. The SV range clearly allows a great variety of parts to be produced and completely finished within the machine cycle.



6. The variety of parts made on the SV32 include features such as external hexagons, internal keyways and integral external keys.

TRADE COUNTER

Please note that, unless otherwise stated, Trade Counter items have not necessarily been tested. We give news of products and services which have been brought to our attention and which we consider may be of interest to our readers.

Digital handwheel from Arc Euro Trade

Following the interest generated by the optional digital handwheels available for the C3 Mini lathe, Arc Eurotrade have developed a kit which can be fitted to the cross slide of any Myford ML7 lathe (not Super Seven). The complete assembled unit contains:

- Rotary encoded Digital Unit: reads up to 0.001mm, and 0.0001" (switchable), Zero and On/Off buttons.
- Ball Handle and Cross slide end plate assembly
- 2 x Needle roller thrust bearings and 1 x ball raced bearings to remove potential backlash
- 20 TPI leadscrew and bronze nut (20 TPI being the correct pitch for the rotary encoder in the digital unit)

Thus in addition to adding the digital facility, fitting the unit also renews the feedscrew and nut, and adds needle roller thrust bearings for improved "feel" and reduced backlash. It's a simple matter to take off the old assembly and fit the complete new unit. Price will be £125.00 including VAT and UK mainland carriage.



Winter Offers from Tilgear

Due to the lead time producing this magazine, it was unfortunate that this flyer arrived just too late to include in issue 111. Officially, these offers expire on 31st January, but John Tilbrook assures me that he will honour the prices given in his winter offers brochure while stocks last. The range of offer items is predominantly aimed at woodworking enthusiasts, but there are a good many items, which should also be of interest to the amateur engineer. A grinding jig may be intended for chisels and planes, but the same device should also work well for turning tools. A laser saw guide priced at just £12.75 plus VAT may be designed for attachment to a power saw to aid accurate tracking, however, the same device may also find other uses in alignment, levelling, etc. Other items of general interest would include products such as the diamond sharpening laps, the steel band clamp, and the low cost angle grinder.

If you are not already on the Tilgear mailing list, then you may wish to give them a call on 01703 873 434, to ensure that you receive notification of bargain offers in the future.



New products from Engineers Toolroom

Reg. Pugh has been in touch to let me know about two new machines and his expanding range of CNC conversion accessories. The BMD 20 milling machine offers a good sized table (500 x 180mm) a dovetailed column and no less than 300mm of vertical head travel. Other features include 600watt variable speed (to 2250rpm) and inclinable head (45deg. left and right). Price is a very competitive £869.50. The range of lathes is now augmented by the BL 712V, again a 600watt variable speed machine with spindle speed ranging from 150 to 3000 rpm. Leading dimensions are: swing over bed 180mm, between centres 300mm, headstock spindle No. 3 MT bored through 21mm, tailstock No.2MT. Price for this is £559.00



For enthusiasts undertaking CNC conversions similar to Dick Stephen's X3 mill, Reg. now offers a range of components covering stepper motors, cast mounting bells, couplings, etc, and perhaps best of all a cut to size facility for M16 x 2 ballscrews and nuts. This means you can order just the length required (up to about 2metres) rather than being stuck with the next size up from a manufacturers catalogue.

Cheap Ballscrews

Again at the Model Engineer Exhibition, Key Solar Systems showed a number of pre-owned ballscrew units, each of 4mm pitch and about 350 mm travel, ideal for low cost CNC conversions. After my comments about these last year, the stock was cleaned out, and a waiting list formed. A limited number is back in stock, but first come first served. Their product range also includes a number of electrical/ electronic items, also used

glow pug motors and carburettors. Key Solar Systems can be contacted by phone on 01633 280958 or by post to 4 Glanmor Cres. Newport, NP19 8AX



Scribe a Line

Tony Jeffree writes:

Oh, I CE, its RoHS now is it? And what's WEEE got to do with it? Or, "Beware, Here Be More Euro-Crappel!"

Hot on the heels of CE marking, the Euro-crats have managed to invent another raft of legislation, in the name of protecting our environment, and in the process, making it even harder than it already was to manufacture anything for sale in this country, at a competitive price, especially if, like me, you are involved in small-scale manufacturing of electronic devices.

Electronics is an increasingly important weapon in the Model Engineer's armoury, so these developments will, directly or indirectly, affect anyone involved in our craft, as a manufacturer, a supplier, or as a consumer.

First, we had CE...

The CE marking legislation, as some will know, is aimed primarily at all aspects of product safety; a laudable aim in itself, as it prevents us from selling dangerous toys to small children, or selling electrical goods that will supply 240V to the metal case. On the other hand, there are some aspects of this legislation that can have significant consequences for small manufacturers.

My own interest in manufacturing is CNC devices of one kind or another; these generally use low voltages for the interesting bits (less than 70V or so), and therefore, some of the CE regulations that apply where dangerous voltages are involved relate only to the power supplies used. However, all electronic and electrical circuitry has to comply with the legislation that relates to so-called "Electro-Magnetic Compatibility", or EMC; in simple terms, the device must not transmit electromagnetic energy, that could upset other devices in the vicinity, and also, the device must be sufficiently immune to EM energy, that its operation is unaffected by other devices operating nearby. So, your neighbour's telly better not go on the blink when you start up the CNC mill in your workshop; similarly, your CNC mill better not run amok when your neighbour switches on their toaster.

Testing for conformance to EMC is not simple. The only way for a small manufacturer such as myself to demonstrate compliance is to employ a testing house. If all goes smoothly, you are looking at the cost of a full day of testing; more if some re-working is needed to make the device compliant. So, after stumping up for two or more days' worth of lab time, you get a test report and a bunch of impenetrable graphs from the testing house. After checking against all other relevant legislation, you can then apply the "CE" mark.

Self-certification

"But CE is a self certification scheme", I hear you all saying, "so why not just slap the sticker on your product and hope no-one catches you out?" Well, in reality, I am quite sure that some manufacturers, large and small, do just that. When asked, you have to be able to provide your customers (or the trading standards authorities!) with a "Declaration of Conformity" to the standards called out by the legislation. This is where the self-certification bit comes in; the declaration of conformity is basically just a statement by the manufacturer that the goods comply; nothing more. The difficult bit is that, as the maker of the declaration, you potentially have to be able to back that up with hard facts. Waving your product in front of a tranny radio and deciding that it doesn't cause any interference won't cut much ice if a customer or the authorities decide to push the point.

Now, this is where some of the consequences start to become apparent. It is all very well doing this kind of testing on a volume product line where you can spread the cost over the first few hundred units, but the CE legislation covers all products, including one-offs or very limited production runs. Effectively, anything you sell within Europe has to comply with CE, unless you are selling components that have no evident "end user" functionality until they form part of something bigger.

So when, as often happens in business, someone wants you to provide a one-off or short production run "special", in theory you should put it through any relevant compliance testing before you slap on the all-important CE logo and bank the customer's cheque. Net result – any such "special" would need a minimum price tag of a few thousand, before you have even put pencil to drawing board, simply to cover the cost of product testing. An interesting case in point is the made to order PC business. Individually, the case and most of the components are CE marked, but that is potentially meaningless unless they have been shown to be CE compliant built up in the chosen combination.

The conclusion that I have to reach here is that, if you take any budget product that has any significant aspect of customisation associated with it, the probability is that if push comes to shove, the seller will find it difficult to demonstrate CE compliance.

Enter RoHS

"What on earth is RoHS?" I hear you say. It stands for "Restriction of Hazardous Substances", and is concerned with preventing potentially dangerous toxic materials from being brought into contact with Joe Public, and preventing those

goods from polluting the environment when they reach the end of their useful life.

RoHS covers, among other things, toxic heavy metals, such as mercury, lead, and cadmium to name but three. What the RoHS directive does is to severely limit the use of these metals in the manufacture of electronic and electrical devices. Now what I build doesn't use mercury or cadmium as far as I am aware. However, lead is a different problem altogether. Lead, combined with tin, is a major component of the traditional soft solders that have been in use for donkey's years in electrical and electronic devices – as a means of making electrical connections on circuit boards, but also in many more obscure places, such as the "tinning" on component leads, the internal connections within the more complex components, and so on.

What RoHS requires is that the percentage of lead in any of the materials used in the construction of the device is very small – less than 0.1% of "any homogeneous material". So traditional lead/tin solders, and their use to "tin" the leads of components, are right out. Now, "Lead free" solders have been around for some while, but there are problems; they don't "wet" the joint as easily, they require higher temperatures (~40 C degrees) to melt, and they are not nearly as good in terms of long-term reliability. Apparently, they tend to suffer from "whiskering", where over time, whiskers of tin can "grow" from a joint, with the resultant possibility of shorting to an adjacent solder joint. For this reason, it will not surprise you to know that medical, military, and aerospace equipment are exempted from these requirements; however, there are no exemptions that I have come across that would affect the kind of equipment that we might want to use in Model Engineering.

The higher soldering temperatures mean that some components, even if they are actually lead free, are unsuitable for lead free soldering due to heat damage issues; hence, we may also need a redesign to make use of substitute, "lead-free compatible" components. And of course, the CE testing merry-go-round springs into action again, because there's no guarantee that the re-designed product still complies with EMC.

Now why is lead such an issue? I know that during the last century, we poured millions of tons of lead into the atmosphere in the form of waste products from the combustion of leaded petrol in IC engines, and decided rightly that that was not a terribly smart idea. We also banned lead from paints, particularly on items that children might put in their mouths. Again, this was a good move. However, where's the danger in lead on printed circuit boards and other electrical/electronic uses? I can't remember a single occasion when I have been tempted to suck on a PCB.

Apparently, the big issue is "leaching" of lead into water courses as a result of scrapped electronic devices being dumped in land-fill, and hence, lead polluting the environment.

Now, colour me cynical, but I can't help feeling that this is all based on political posturing, and probably has approximately the square root of...a very small number...to do with reality. Firstly, the effect of any such leaching would likely be insignificant compared the background level due to the historic use of lead in petrol. Secondly, there must be far bigger fish to fry in the overall environmental scheme of things than banning the use of lead in the electronics industry.

One thing that makes this lead-free business seem faintly ludicrous to me is that contrary to popular opinion, lead-based solders appear to pose a minimal risk to the people that actually do the soldering (the soldering temperature is too low to vaporize the metal, and handling solder isn't a problem), but the fluxes used in soft soldering can produce toxic fumes on heating, and, due to the higher soldering temperatures used with lead-free solders, the fumes from the flux are more dangerous than with lead/tin solders! Their recommendation in the RS (Radiospares) information leaflet on RoHS was to install fume cupboards/hoods to extract the fumes (presumably to ensure that you blast the toxic fumes at passers by, or your next-door neighbours, rather than your employees!)

Time for WEEE...

OK – so far, we have CE directives that affect the design end of the process, and RoHS directives that affect the way products are manufactured. So the logical addition is to come up with regulations that affect the final disposal of electronic and electrical products. Ta-da – cue drum roll – enter the WEEE directives. The acronym stands for "Waste Electrical and Electronic Equipment", and is nothing whatsoever to do with a well-known bodily function, despite the fact that phrases "Recycling WEEE" crop up regularly in discussions and papers on this topic.

Essentially, the WEEE regulations are aimed at increasing the percentage of electrical and electronic equipment that is recycled, rather than being sent to land-fill sites. Recycling in this context could mean refurbishment, salvaging and re-using circuit boards, salvaging and re-using components, and finally, segregating anything that isn't salvageable in any other way into material types so that they can potentially be re-used as raw materials.

You will start to see the "WEEE symbol" (a picture of a wheellie bin, crossed out) appearing on electrical and electronic devices, indicating that special arrangements need to be made for recycling. Beyond the appearance of these stickers, the full implications of WEEE aren't entirely clear as yet – but the principle seems to be that the manufacturer (or importer) will be responsible for making arrangements for recycling of EEE waste.

We've seen some of this already, in the shape of the fiasco that resulted from the regulations governing disposal of CFCs in refrigeration equipment; companies set

themselves up in the 'fridge recycling business, hired a warehouse, filled it with crumbling/leaking 'fridges, pocketed the fees for recycling them, and fled the scene, leaving said pile of 'fridges to be disposed of by the local authority.

Timescales

CE has been in place for a few years now; however, as the CE mark is essentially a statement that the product complies with all relevant legislation, the list of things that CE encompasses will expand over time – and when RoHS comes into force on the 1st of July 2006, this will be an additional requirement for CE-compliant products.

Clearly, goods that have been manufactured prior to that date may well not be compliant, so there is an exception for goods that are "placed on the market" prior to the cut-off date – "placed on the market" means either imported into the EU, or manufactured in the EU and fed into the supply chain. Interestingly, this definition appears to allow importers to "stockpile" goods that don't comply and were manufactured outside the EU, but doesn't allow EU manufacturers to stockpile in their own warehouses – they would have to be transferred to the distribution chain in order to be exempted.

WEEE seems to be a different matter altogether – although it was intended to come into force at the same time as RoHS, it seems that the government hasn't quite sorted out how it will all work yet, so the deadline for that will be somewhat delayed.

Consequences

Long term, this is all placing an increasing burden on European manufacturers, and consequently, one of the primary consequences I can foresee is increasing prices to the consumer, decreasing availability of EU-manufactured goods, and an increasing barrier to small European manufacturers entering the electronics market. This may well also be the last straw for some of the smaller UK manufacturers – personally, I am having to think very hard about whether this is a business I want to continue to be in post-1/7/06.

Short term, there's a lot of EEE that we currently import from overseas that doesn't comply with RoHS right now, and where the manufacturers are not subject to similar legislation and deadlines within their own countries. I know from email exchanges in some of the CNC-related discussion groups on the Internet that, although the USA is heading in the general direction of lead-free manufacture, some of the US-based companies that supply CNC products into the DIY market will still be manufacturing non-RoHS compliant products after 1st July 2006; hence, any distributors of their products over here will have problems supplying to the UK market after this time, unless they have put a good "stockpile" in place. I am quite sure that the same applies to products currently being imported from Asia and the Far East – those nice cheap lathes and mills with variable speed drives, the cheap digital scales and micrometers, and so on. So, for importers, suppliers, and manufacturers faced with this deadline, options might include:

- Continue as normal, and hope they won't get found out, or
- Stockpile non-conformant product in the supply chain to tide them over while the compliance issues are sorted out, or
- Dump their existing non-compliant stock onto the market, and switch to some other product line that doesn't have the same issues; or
- Switch to selling EEE in "kit" form, thereby circumventing the whole problem, as it will still be legal to sell non-compliant components and Lead/Tin solder, and the regulations do not apply to end users.

Although number 1 looks enticing, there's an unpleasant "kicker" here; the penalties for non-compliance with CE as a whole don't seem to be terribly onerous, and may amount to little more than a smacked wrist for a first offence, but as far as I can gather, selling non-RoHS compliant goods will be classed as a criminal offence, and rumour has it that the compliance authorities are keen to get "stuck in". Unfortunately, in such situations the soft targets (the small businesses) often get picked off first.

I'm sure that many importers will take the second option – which will, of course, make it even harder in the short term for the UK manufacturers to compete.

I would not be at all surprised if some take the third option (in fact, I know of cases where this is already happening); in the short term, this will be good for the consumers, as there will be some bargains to be had!

The fourth option could clearly be viable in some cases, but I'm sure the average Model Engineer wouldn't very much appreciate being supplied a variable speed lathe where the electronics consisted of a bag of components and a set of instructions!

In theory, the playing field ought to be level, as the legislation applies to everyone; however, as with all of these kinds of regulations, the ones that tend to get penalised are the ones that comply with the letter of the law – their costs go up, while those that cut corners find their profit margins going up instead.

Non-European manufacturers do not directly fall under the jurisdiction of the EU; it is the importer that potentially pays the penalty for non-compliance, not their suppliers. So, the importer either needs to have compliance documentation from the manufacturer, or to prove the product via a testing house. Hence, I suspect that there will be an outbreak of "document engineering" happening here – where compliance documentation may be made available to the importers, but it may not be worth the paper it is written on.

The bottom line

So where does this all leave us? For me, the title says it all...we have more European mumbo-jumbo to deal with, which makes our own manufacturing base even less competitive and its products more expensive, and in this case, it doesn't seem to benefit either the consumer or the environment terribly much. The one sector that seems to benefit is the European bureaucratic machine, which seems to go from strength to strength as it finds more parts of our lives that it feels the need to regulate.

Malcolm Leafe writes:

May I thank everyone who rang and tried to email me (I am sure that BT really are apologetic about the latter) in response to my requests in issue 109 of MEW. I received a large number of replies offering information and copies of the tables for my "Precise" gauge blocks - the apparently odd values are now explained and turn out to be rather clever.

I also received some replies to my query about the M&W Micro 2000 digital micrometer - one respondent was especially helpful and the instrument is now operating with much greater precision. I believe that I have telephoned / mailed everyone but in case I have inadvertently overlooked someone, thank you for your enthusiasm, knowledge and interesting conversations.

Problems solved - all it took was a letter to MEW and some enthusiastic readers.

Bill Douie writes:

An excellent and practical article on aluminium and its alloys, (MEW 110) mentioning inter alia a gas furnace. Whereas I do not wish to bleat, there have been, in the past, questions about and requests for information on induction furnaces, which have, so far, resulted in little useful information.

I do appreciate that this is an expensive method and is complicated technology but surely this is offset by the versatility of the process and the ease with which quality, easily controlled, melts can be achieved, including high temperatures as required for steel and stainless, to say nothing of copper and bronzes.

Can there really be a dearth of contributors who have sufficient knowledge (or energy?) to write on this subject. It would surely be of interest to those of us who wish to attack problems other than aluminium and cast iron. I doubt whether this subject is as shrouded in mystery as we might think as the process is commonly used in the jewellery industry.

Two challenges then for readers/contributors: Tell us about the process and where small furnaces might be obtained. And, more tricky, tell us about the technology and how to construct a simple furnace ourselves.

Hugh Castellan writes:

1. I suggest that Frank Campbell contacts US Digital Corporation in the US for encoders. Email sales@usdigital.com website www.usdigital.com They manufacture a wide range of encoders and accessories at very reasonable prices plus the Dollar/ Pound conversion advantage. There is only some possible VAT plus PO handling. US Digital have a very useful chat room for one to one conversation. I am using a special version of their Type H15S giving 2000 pulses/rev for screw cutting.

2. Reference Ted Wale's article. It is essential to check the vertical height of the

tailstock centre of your lathe as a drilling centre will never be accurate if this is not inline with the headstock centre. I discovered that my tailstock centre was 5 thou high which did not help in drilling holes or tapping etc. The base of the tailstock was replaced by me at the same time as my lathe had a regrind at Myfords but I fitted the base myself. I took the tailstock to Myford's open day last year to have this fault rectified. I then discovered that the tailstock height is obtained by selection and that there is only a nominal height for the base plate.

Robert Demachy of Norwich writes

Your recent editorial about the Workshop Police raised the issue about reactivating guns and a government suggestion that workshop machinery should be registered. Putting aside the simple obvious point that it might make a lot more sense to register (or ban) deactivated weapons rather than the equipment used to make everything from nuts and bolts to model steam trains, I wonder if Whitehall might not be suffering from a common delusion, that of being informed by TV.

Some time ago, in an episode of Murphy's Law, the title character played by James Nesbitt was shown reactivating guns. He was working undercover to locate a gang of ruthless armed criminals. His role was to present himself to the underworld as a gunsmith, skilled in the art of reactivating guns on villain's premises using whatever tools the villain provided. Although the details are a bit hazy, it seemed that he had about two days to prepare himself for this specialist role which included teaching himself to use a lathe, reactivating automatic guns with various deactivations, and produce accurate weapons. Needless to say he pulled it off. Could it be that someone in Whitehall has been watching too much television? My advice to Whitehall? It's not real mate!

With September past we've shed the usual bunch of local school lads we employ in the holidays to mark out and cut metal and do the odd bit of fitting. Matt returned recently at tea break to say hello and talk about his 'A' Levels. He won't be going on to do engineering. One of those 'Arts' degrees beckons. 'What are you doing?' I asked. 'Geography, English Language...' 'What are you doing in English Language?' I asked. 'Child Centered Speech.' Matt went on to explain, 'Men don't know how to talk to children, they make them cry.' No, really. Well, perhaps he'll learn to spell 'harebrained' properly. (Sorry David!) Then again, maybe not. You see in today's education if you can show why you're right even when you're wrong then that's just as valid. After all, the student might be lacking in self-confidence in which case he must be encouraged to believe in himself at any cost.

Let's see how that works with 'hairbrained'. To the precision engineer a 'hair' is not just a small thing, it's a variable standard. 'How big is a thou?' an apprentice would ask. 'Well, a human hair is about 2 to 3 thou thick'. Simple. 'Hairbrained' - a very small brain. This is useful too for the BBC who include the

hair in their own measuring system: cannot be seen with the naked eye, the size of the human hair, the football, and the football pitch. As I bent to pick up my copy of 'Model Engineers' Workshop' (bottom shelf) my eye caught a completely new display. Outgrown its former locations of spread about the lifestyle section, this subject now has its very own rack - 'Living Abroad', 'International Homes', 'Homes Worldwide', 'Homes Abroad', 'French Magazine', 'Spanish Magazine', 'Living France' Now, why would anyone want to go and live abroad?

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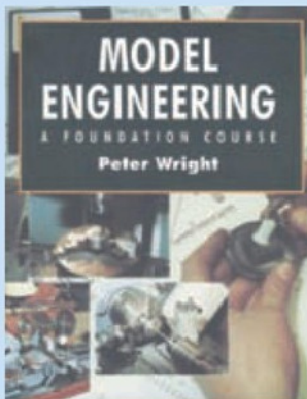
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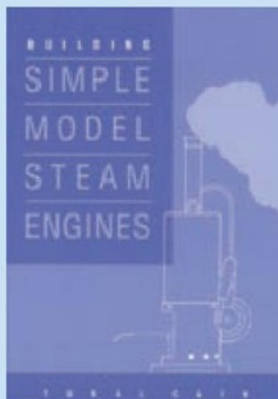
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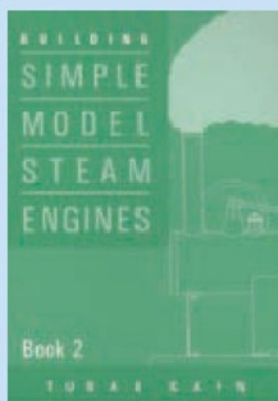
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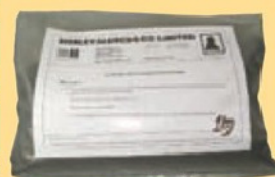
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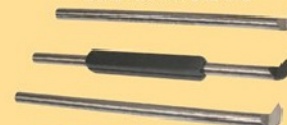


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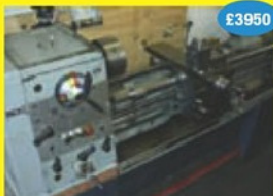
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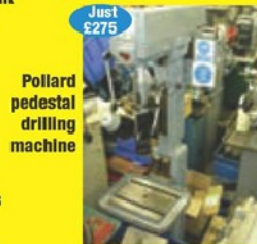


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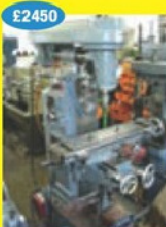
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WIDE SPEED RANGE
POSITIVE QUILL LOCK
TAPER ROLLER BEARING SPINDLE
IMPERIAL OR METRIC MACHINES
CAST IRON COLUMN

STANDARD ACCESSORIES

1-13MM DRILL CHUCK & ARBOR
EAGLE FACE MILL CUTTER
T3 TILTING TABLE
DRAWBAR (M12 THREAD)
NVR SWITCH GEAR
INTERLOCKED CHUCK GUARD
MANUAL & PARTS LIST

SPECIFICATIONS

DRILLING CAPACITY	25MM
END MILLING CAPACITY	25MM
FACE MILLING CAPACITY	65MM
TABLE WORKING SURFACE	190X585MM
MOTOR	1HP
SUPPLY	240VOLT
NET WEIGHT	200KGS

EAGLE 30 MILL/DRILL

PRICE: £875.00 INC VAT

FREE DELIVERY UK MAINLAND

FEATURES

WIDE SPEED RANGE
HEAVY DUTY TAPER ROLLER BEARINGS
QUILL LOCK
ADJUSTABLE GIB STRIPS
HEAD ROTATES 360°
LONGITUDINAL TABLE STOPS
GRADUATIONS IN IMPERIAL OR METRIC

STANDARD ACCESSORIES

1-13MM DRILL CHUCK & ARBOR
EAGLE FACE MILL CUTTER
V100 MACHINE VICE WITH SWIVEL BASE
DRAWBAR (M12 THREAD)
NVR SWITCH GEAR
INTERLOCKED CHUCK GUARD
MANUAL & PARTS LIST

SPECIFICATIONS

DRILLING CAPACITY	32MM
END MILLING CAPACITY	20MM
FACE MILLING CAPACITY	76MM
TABLE WORKING SURFACE	730X210MM
MOTOR	1.1KW 1.5HP
SUPPLY	240VOLT
GROSS WEIGHT	287KG

LUX ROUND COLUMN MILL

PRICE: £975.00 INC VAT

FREE DELIVERY UK MAINLAND

FEATURES

HEAVY DUTY TAPER ROLLER BEARING SPINDLE
HEAD TILTS 45 DEGREES LEFT OR RIGHT
HEAD ROTATES 360 DEGREES
EASY CLUTCH-TYPE MECHANISM FOR ENGAGING FINE DOWN-FEED
POSITIVE QUILL LOCK
ADJUSTABLE GIBS ON TABLE
ADJUSTABLE STOPS ON TABLE
GRADUATIONS IN IMPERIAL OR METRIC

STANDARD ACCESSORIES

1-13MM DRILL CHUCK & ARBOR
EAGLE FACE MILL CUTTER
V100 MACHINE VICE WITH SWIVEL BASE
DRAWBAR (M12 THREAD)
NVR SWITCH
INTERLOCKED CHUCK GUARD
MANUAL & PARTS LIST

SPECIFICATIONS

DRILLING CAPACITY	32MM
END MILLING CAPACITY	28MM
FACE MILLING CAPACITY	80MM
TABLE SIZE	210X730MM
MOTOR	1HP
SUPPLY	240V
WEIGHT	280KGS

“POWERFUL MILLING/DRILLING AT AFFORDABLE PRICES”

CHESTER UK LTD CLWYD CLOSE | HAWARDEN INDUSTRIAL | PARK HAWARDEN | CHESTER | CH5 3PZ

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