

No.119

OCTOBER 2006

MODEL ENGINEERS' WORKSHOP

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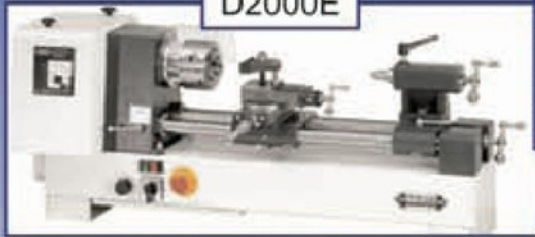
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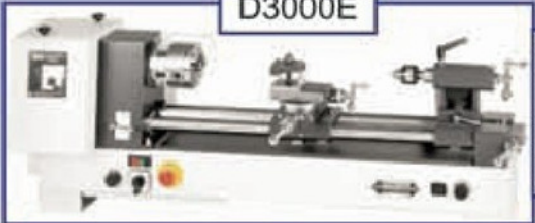
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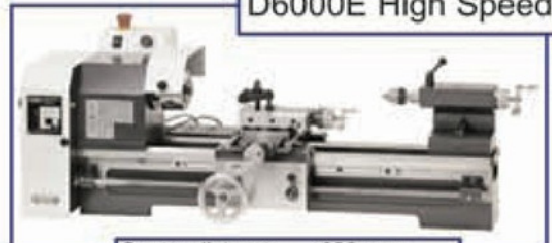
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On the Cover

*The modified gear train is evident on Jim Wilks' lathe.
His description starts on page 30*

See page 57 for our special subscription offer!



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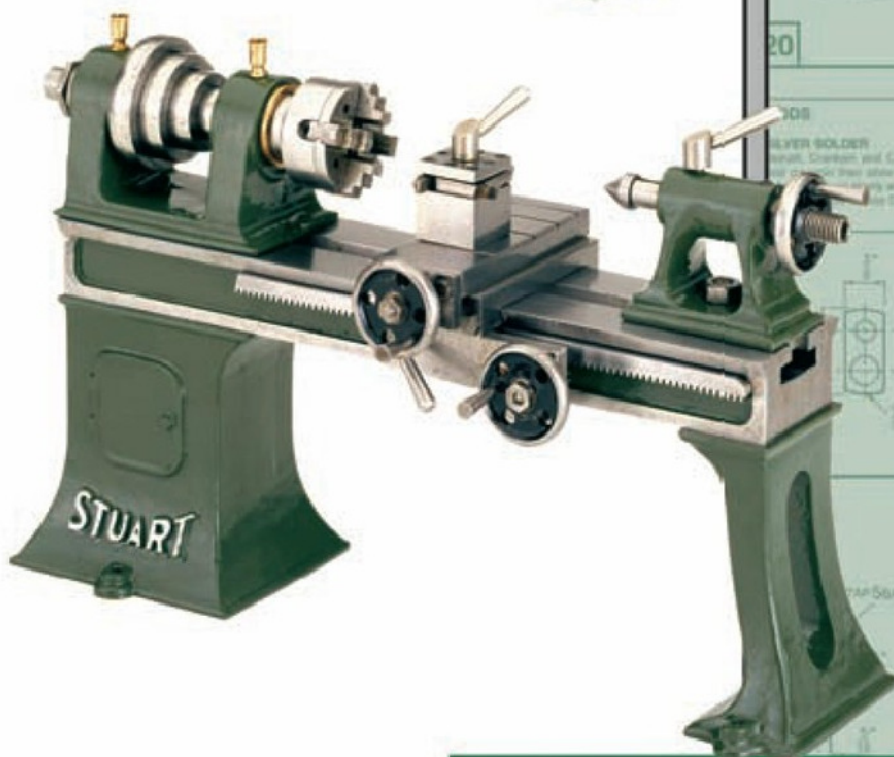
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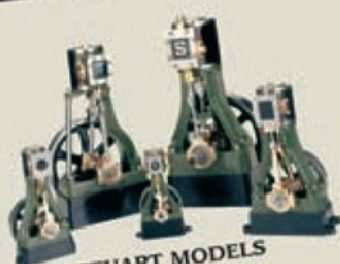
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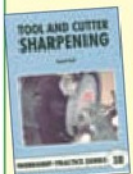


Camden - clinging to the Trailing Edge of Technology



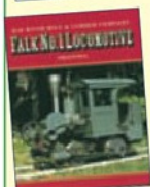
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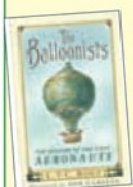
Model Marine Steam • Bray • £16.90

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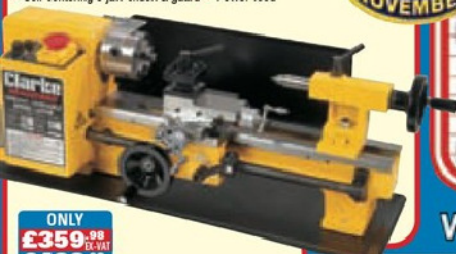
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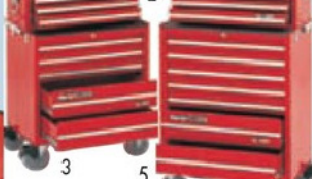


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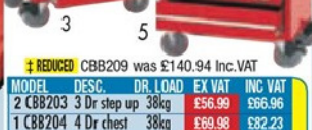
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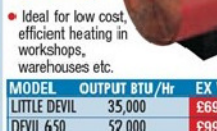


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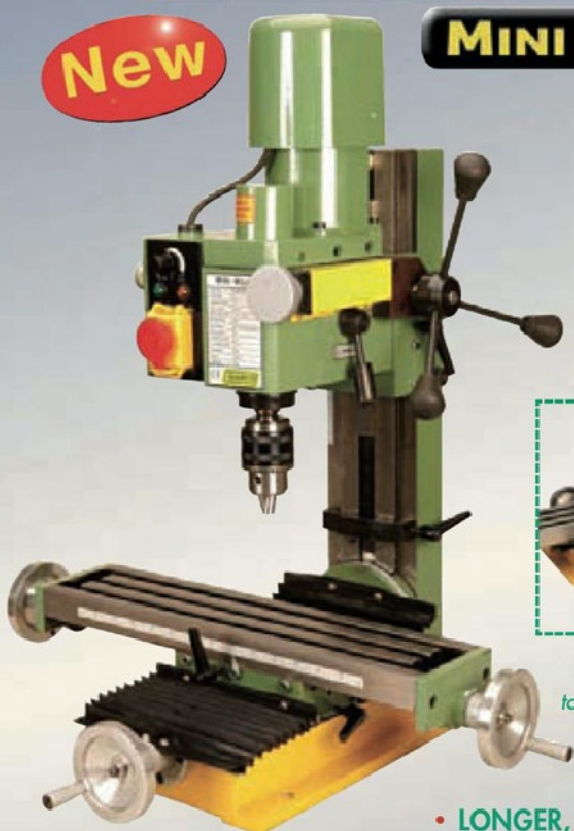
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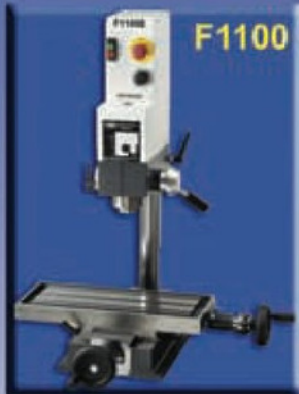


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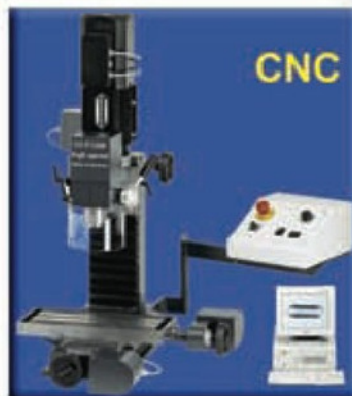
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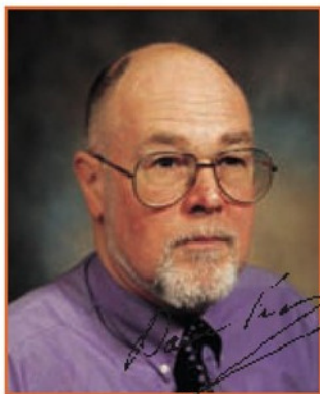
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ON THE EDITOR'S BENCH

Castings

Elsewhere in this issue will be found part 1 of the article by Alan Jackson, describing his design of lever locking topslide, as exhibited at the 2005 Model Engineer Exhibition. Alan originally designed this for a Denham lathe, then later transported it across to a Colchester Chipmaster. He also presents a version suitable for Myford lathes for which a new cross slide would be required. If any reader wishes to apply this mod to a Myford then it may be worth asking the company about the availability of unmachined cross slide castings. Managing director Chris Moore commented that he was not averse to the idea of supplying unmachined castings, but it would depend on what was in the system and at what stage.

Motorcycle lift safety

Reader John Barnard has been in touch (see his letter in *Scribe a Line*) taking me to task regarding the safety aspects of the device. It should be noted that Brian Pollitt's original design notes include the requirement for a mechanical prop to be added to ensure that the whole assembly cannot collapse in the event of hydraulic seal failure. At the time of taking the photo (MEW issue 117) this feature had not been added.

Fine surface finish

When we want that polished finish on a turned part, it is quite usual to reach for the emery paper or tape of whatever suitable grade to achieve the desired result. If however you are producing large volumes of parts, then this relatively laborious method may not be acceptable. During a recent visit to Bonspiel Engineering I was shown a method being used on a CNC lathe which we may be able to transpose to the home workshop situation. In essence the part is turned to 0.003in. oversize, then given a final treatment by being rubbed rather than cut with a diamond, working at a different feed rate.

No information was being divulged as to the speed and feed involved, but the result was significantly better than the drawing requirement and effected within the machining cycle.

Armed with this basic information, I set up a quick experiment using the wheel dressing diamond borrowed from the surface grinder. The first attempt on a bit of mild steel was run dry and a disaster.

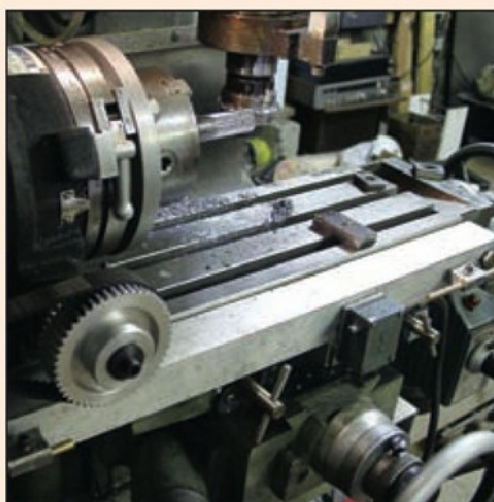
In the workshop

Although little of consequence on the project has been achieved for several months, the Bentley BR2 is always at the back of my mind, and to this end I had been thinking about the drive train for the magnetos and oil pump, which requires one large and three small gears having a ratio of 9:4. The original Blackmore design used 36DP gears, but later builders opted for more readily available 32DP with a slight increase in size. Unfortunately, my stock of involute cutters does not include either 32 or 36DP. I do however have a set of 40 DP and explored the possibility of using this size. It seemed feasible, provided the tooth numbers are raised to 63 and 28.

For dividing nowadays, I normally use a rotary table, which in standard form does not lend itself to conveniently working with these numbers. However by adding a stepper motor and belt drive system it would be possible to divide to an accuracy of 1/144000 of a revolution or 1/400 of a degree with the driver set in half step mode.

The first line of thinking was to do it as a CNC job on the Matchmaker, however I am always a bit nervous of handing over feed control, especially where expensive milling cutters are concerned. I therefore decided to do the work with the rotary table mounted on the (manual) VMC mill but use the fourth axis rotary control facility via an extension cable from the Matchmaker. The photo shows the set up on the Myford VMC. For the 28 tooth, the blank would be 0.75in. dia. $((28+2)/40)$ and this was prepared with ample length for the three gears needed. The CNC program was simply a list of the degree intervals calculated from an Excel spreadsheet, presented as W (rotary) axis moves, interspersed with M01 (pause) commands.

Execution was then a matter of starting the VMC and the CNC circuits, then engaging the table feed to arrive at a suitable length of cut, winding back, then moving across to the other machine, hitting the keyboard return to trigger the rotation to the next tooth, then back to the table feed and so on 28 times. Certainly, a DivisionMaster unit would have made this considerably easier, and it may well be that the CNC utilities from Alan Munday, on Colin Usher's website offer an alternative approach. It would also no doubt be quite straightforward to work with Compucut or one of the other CNC programs such as DeskCNC or Mach 3. The 63 tooth will be another exercise for another day, and having achieved success with the semi manual approach, I might just trust the cutting to the CNC given the number of teeth and hence the number of to and fro excursions involved. However you may be assured that there will be one or two dummy runs cutting air before it's tackled in earnest.



Material appeared to pick up on the diamond then gouge into the surface. A few subsequent trials were run using soluble coolant, and the infeed applied in steps of about half a thou. This gave much improved results and a basis for future work when time permits. It may also be noted that in the CNC situation neat cutting oil is employed, this being another variable for experiment.

Website

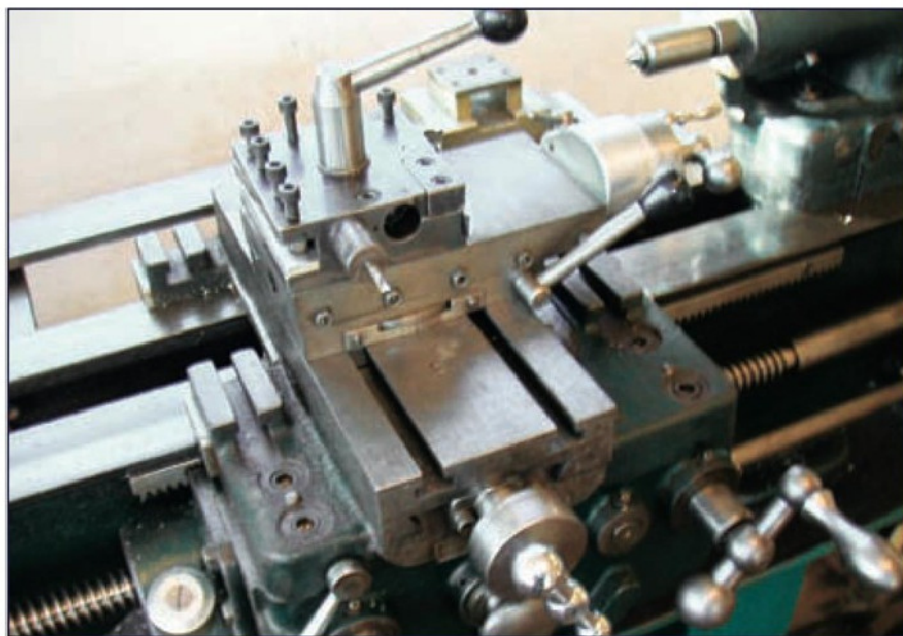
A number of complimentary comments have been received. The site is intended as a source of information and a bit of fun. If you have haven't yet looked, the address is www.davefenner.co.uk

Dates for the Diary

October 13th to 18th Midlands Model Engineer Exhibition, Warwickshire Exhibition Centre, Nr. Leamington Spa.

December 29th to 31st The Model Engineer Exhibition, Olympia 2 – the show will be back within London, more conveniently accessed by public transport particularly for visitors from north of the capital.

A LEVER LOCKING TOPSLIDE 1



1. Topslide as originally fitted to the Denham.

The method of attaching the top slide to the cross slide on a lathe has not changed much from early designs. Originally the tailstock fixing to the lathe bed and the barrel lock was carried out with a spanner and a nut and bolt, now it is lever operated. This is convenient and avoids searching for the correct spanner etc. My proposal is to be able to move and rotate the top slide over the cross slide and lock it in position using a similar lever action.

It could just be fixed in one location on the cross slide and rotated about that position and locked via the lever but there is much to be gained by being able to reposition the top slide as well. I originally designed and built this top slide in 1976 for my Denham 4½" lathe. Patterns were made for the top and cross slide and the parts machined on a Dore Westbury mill. The top slide worked so well that when I changed to a Colchester Chipmaster lathe I kept the top slide (see **photo 1**) and fitted it to the Chipmaster. The original Chipmaster cross slide has been modified by adding ½in. thick mild steel strips to form tee slots (bolted from underneath). (see **photo 2**).

A spacer has also been added beneath the tool post to adjust the centre height to suit the Chipmaster centre height. The top slide can be moved on the cross slide and locked anywhere, at any angle. It locks positively and rigidly without undue force from the locking lever. It does not move in operation when locked, even under the most arduous, intermittent, conditions. So it can be used with confidence. As with all things

we make you can always see a better way the next time.

So I have incorporated what I think are improvements to the original design, bearing in mind that the original was designed to suit the first lathe and adapted to suit the second. This is how I would now make it to suit my Colchester Chipmaster lathe. Of course it can be fitted to any lathe by adjusting the overall dimensions to suit. I have also outlined a version to suit a Myford 7 series lathe.

The description of the top slide has been split into the following separate zones on the assumption that this way I will spread less confusion, if I haven't already done so!

1. The locking arrangement, justification, description and operation.
2. Cross slide requirements
3. Top slide arrangement
4. Screw cutting retract
5. Toolpost
6. Making it

The locking arrangement, justification, description, and operation

Now the first question somebody is bound to ask is, will it move under operation when it is locked? I have done my best to answer this further on. No controlled tests

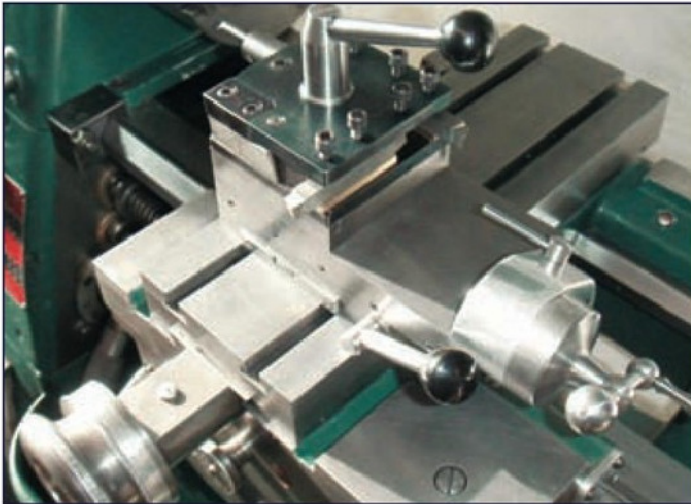
Alan Jackson describes his ingenious accessory shown at the Model Engineer Exhibition.

have been carried out, other than trying to move it by hand when it is locked. My best answer is that it seems to lock quite strongly enough. The friction grip between the flat contact surfaces and also around the chamfered annulus contact each other over a large area and combine to lock the top slide positively to the cross slide, even when the contact surfaces are covered in oil as is the normal case. This of course relies on the proviso that the contact surfaces fit together with reasonable accuracy. I made a cast iron cross slide for my Denham lathe and my Chipmaster has mild steel tee slots added to it and the grip between these surfaces has been entirely satisfactory.

It is the role of the top slide to be set at the required angle to the lathe spindle in order to generate the desired shape. Lathe top slides are generally mounted in a fixed location on the cross slide and can be rotated about this fixed position. Provision is made to set the top slide at the required angle by slackening off one or two bolts that fix it to the cross slide, which, are not always easily accessible. The top slide is set at the required angle and the bolts re-tightened.

However, in use, the area beneath and around the cutting tool is often covered with the cuttings (swarf), which have been removed from the part being made. This swarf can have very sharp razor edges and be a hazard for the operator. Therefore to reset the angle of the top slide means that the operator must generally clear the swarf to gain access to the locking bolts fixing the top slide to the cross slide and then make the adjustment and continue producing the part. In some circumstances this process may be repeated many times to complete the part. The constant slackening and tightening of the top slide fixings can lead to worn rounded nuts or clogged and worn hex socket screws. If the locking fixings make contact over a small area it can create local indentation of the contact surfaces, which can make accurate angular setting more difficult. The area around the nuts, radial slots etc. can get filled with swarf, which must be removed to get sufficient adjustment. It is also necessary to have the correct spanner or Allen key available for this operation. They are always getting lost!

Industry minimises this process by having individual machine tools set up for operations that do not require re-adjustment during the manufacture of the component. The design of many lathes has been dictated by the requirements of



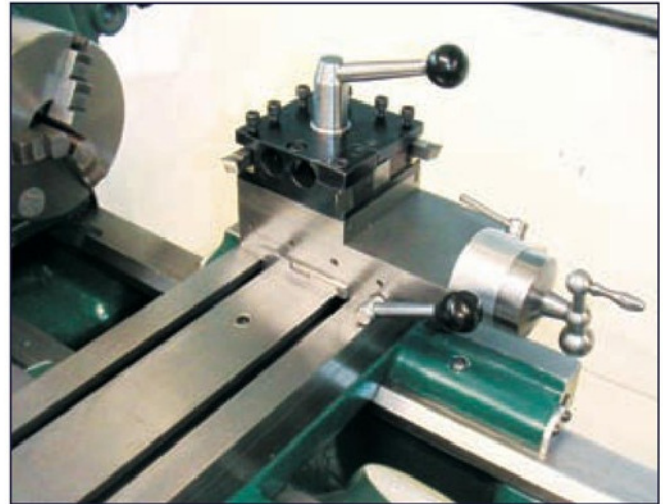
2. Occupying a typical position on the Chipmaster.

industry in the past. The top slide and cross slide is a case in point. It suited industrial lathes to have a plain cross slide and a fixed location for the top slide because any process other than the normal turning operations was carried out on a machine designed for that particular purpose. My Chipmaster lathe is a good example of this. However a model engineer's needs are manifold (I've always wanted to say this). To be able to perform a broad range of operations on one machine is an essential requirement for most of us.

The ability to move and rotate the top slide anywhere on the cross slide allows a much greater range from the lathe than is often normally possible. The top slide can be positioned further away from the lathe centre line than normal, enabling

the cutting tool to operate easily at the largest diameters possible and be quickly repositioned to operate at the centre. It saves much unnecessary movement of the cross slide by its operating screw. When the top slide is rotated, it rotates about a fixed point on the cross slide. So the cutting tool swings in an arc away or towards its desired final location. It must then be re-positioned by winding the cross slide screw to this location. This entails unnecessary operation of the cross slide screw, which takes time and will produce additional wear due to this extra movement.

There is no need to clear the new location of swarf because the top slide sweeps the swarf clear of its new position. In fact the top slide can be used to clear the cross slide of swarf by releasing the



3. Moved onto a rear position, tool set for reverse rotation.

locking lever and pushing it across the full extent of the cross slide. This action clears the swarf from the tee slots as well.

The top slide can be quickly removed and replaced by other devices as required, which can also have similar locking arrangements. It can also be parked in a position on the cross slide, away from the operator, to give good access for setting up or inspecting the component etc. This moves the sharp cutting tools away as much as possible from the operator's hands.

The top slide can be located on the far side of the component and the cutting tool inverted or the lathe spindle can be run in reverse if the chuck has a camlock fitting, or similar, which will allow safe operation in reverse. (see **photo 3**) I have found a few instances where this is very useful.

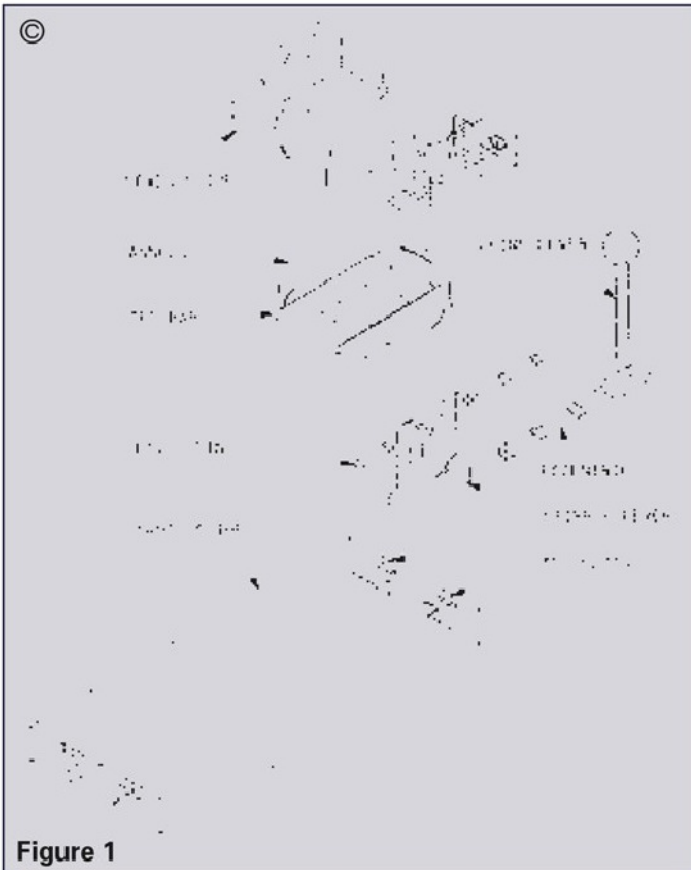


Figure 1

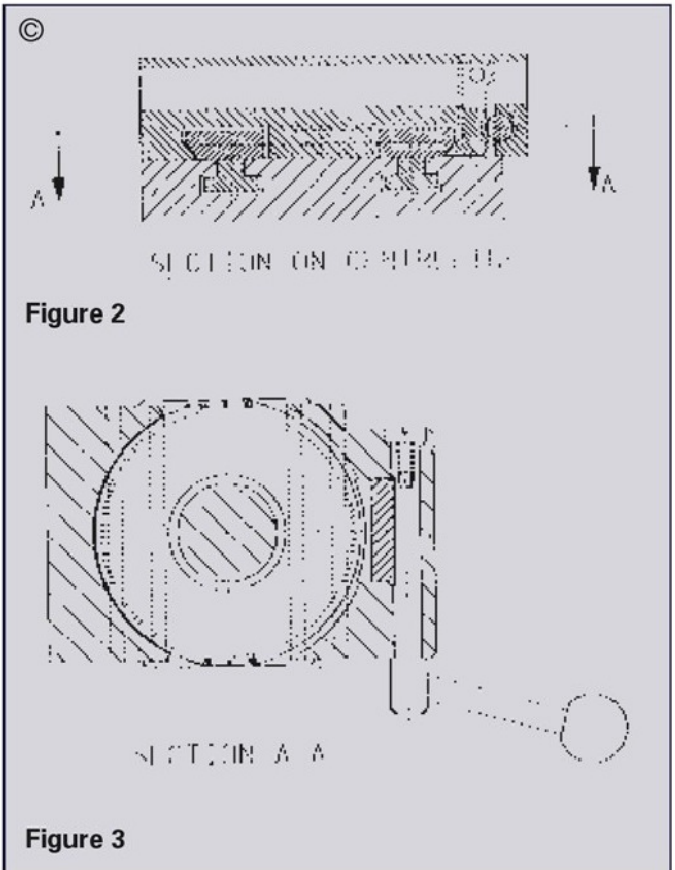
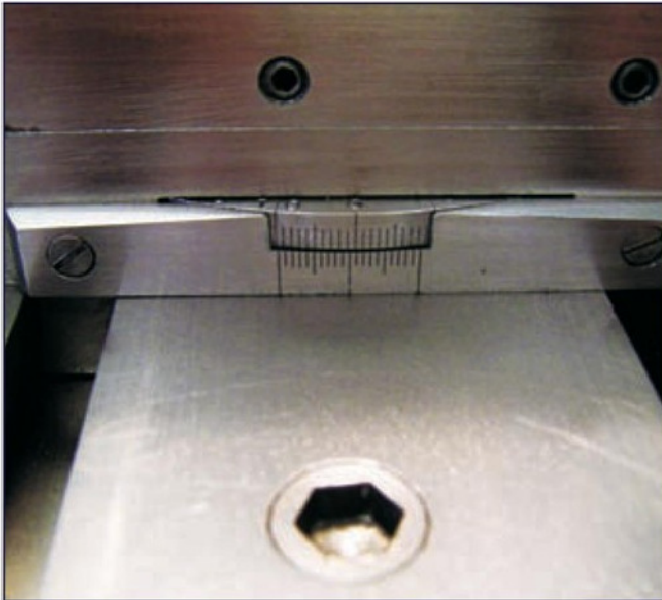
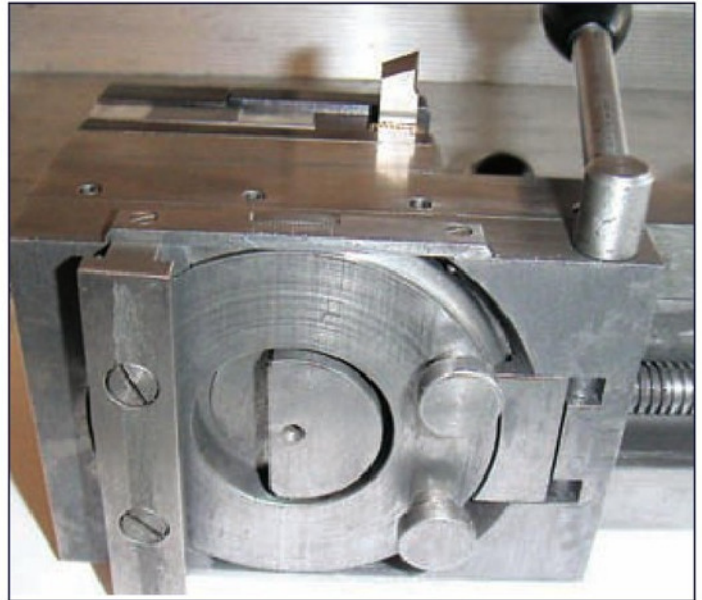


Figure 2

Figure 3



4. Detail of vernier scale.



5. Underside view of topslide assembly.

Right-handed screw threads can be cut by starting close to the chuck and moving towards the tailstock. This avoids the need to quickly disengage the lead screw nut as it approaches the chuck or a shoulder. There is good access to the component being made, it can be seen very clearly, and measurement is not impeded by the presence of the top slide. The swarf is directed away from the operator – especially good for brass and the eyes! So it can be used to gain some of the advantages of a rear mounted tool post. It does seem unfair to reserve the superior performance of a rear tool post just for a parting tool. So why not expand this area for other operations.

The locking arrangement

I will try to describe how the locking arrangement works to allow both a movable and rotary adjustment to the top slide. I apologise ahead if it seems a bit long winded, and for stating the obvious, but here goes.

Referring to **Figure 1**: Two parallel tee slots are shown in the cross slide. These tee slots extend the full length of the cross slide and are open at each end. Tee shaped bars fit, and can slide in the tee slots. The tee bars are rigidly attached in chordal (love that word) fashion to the annulus. The assembly of the annulus and tee bars can be moved freely along, and is guided by the tee slots. The annulus has a chamfered undercut in its lower region nearest to the cross slide. A circular recess is machined into the underside face of the lower top slide body. The shape of this recess is contoured to match the outer shape of the annulus. Thus the annulus can fit closely into the circular recess and sufficient clearance is provided above and at the cylindrical portions of the annulus so that only the chamfered portion of the annulus is in contact with the matching contoured recess in the lower slide.

It will be seen that only the left hand segment of the recess is in contact with

the annulus. The right hand segment has been machined clear of the annulus. This is to allow the annulus to be inserted into the recess.

A stirrup shaped lever pivoting about its pivot pins is located in the right hand part of the lower slide. The lever can rotate about its pivots to contact or just clear the annulus. At the lower right hand side of the pivoted lever is the operating spindle. The centre section of this spindle that spans the stirrup lever is contoured eccentrically to the spindle centre line. The locking lever rotates the eccentric to move the stirrup lever into contact with the chamfered portion of the annulus.

When the lever is in the unlocked position the top slide can be rotated and moved along the axis of the tee slots in the cross slide. Moving the lever to the locked position brings the stirrup lever into contact with the annulus. This can be best seen in **Figure 2**. Further force from the eccentric cam will cause the annulus to slide up the left hand portion of the chamfer in the lower slide. The wedging action lifts the annulus until the tee bars restrain it by contacting the underside face of the tee slots.

This same wedging action also slides the chamfered portion of the lower slide to move down the annulus chamfer until its underside surface contacts the top surface of the cross slide. The chamfered portion of the stirrup lever is also forced down the chamfered surface of the annulus that it is in contact with. This action lifts, or tends to lift the, annulus on the right hand side, until, it is also restrained by the tee bars contacting the underside face of the tee slots. The chamfered portion of the stirrup lever is also tending to slide down the contact face of the annulus producing a downward force on the pivot pins, and thus also brings the underside of the lower slide into contact with the top surface of the cross slide. The top slide is therefore locked into position by downward contact with the cross slide and a wedging contact with the annulus on both the left and right hand sides of the top slide. The tee bars are also forced into upward contact with the tee slots. This creates a strong locking

force over a large area to anchor the top slide to the cross slide.

A portion of the lower top slide fits into the centre of the annulus and makes contact with the cross slide, as do the outer regions of the lower face of the top slide. The annulus centre pad prevents, or at least greatly reduces, any distortion due to the bending moment when the top slide is in the locked condition. Such distortion could affect the smooth operation of the top slide. There also needs to be sufficient radial clearance between the centre pad and the annulus bore for assembly purposes. I made this integral with the top slide body but on reflection, it is better for this to be a separate part, fixed in position after installing the annulus.

On the version I made, the width of the lower top slide is narrower than the outer diameter of the annulus. Thus the annulus protrudes, and is visible on, each side of the body. The periphery of the annulus can therefore be marked with angular graduations to enable setting the top slide at the required angle. Numbers indicating the angle are stamped on the upper outside surface of the annulus.

Swarf guards are fitted to each side of the top slide as shown in **photos 4 and 5**. These swarf guards make close contact with the face of the cross slide to sweep the surface of the cross slide and thereby prevent swarf entering under the top slide. The centre portion of the upper part of the swarf guard is cut away to reveal the annulus periphery while the lower part is contoured to fit closely to the protruding shape of the annulus.

Cursor graduations are marked on the lower centre section of the swarf guards that match up with the graduations marked on the annulus. Adjustment at the fixings, make it possible to calibrate the graduations on the swarf guard to match exactly the axis of the top slide.

Advantages

The top slide can be quickly moved to the position required, set at the required angle and locked to the cross slide without

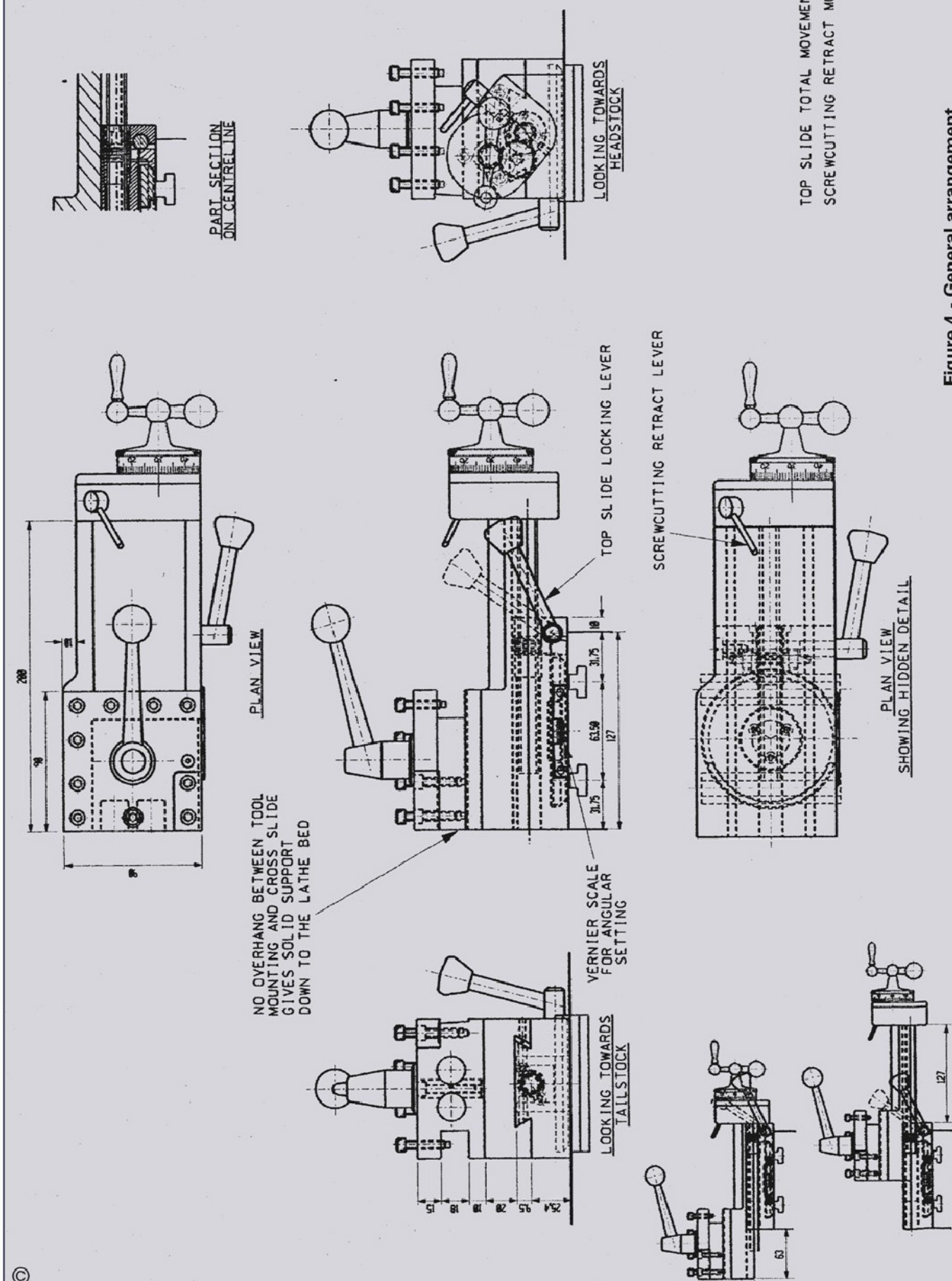


Figure 4 - General arrangement

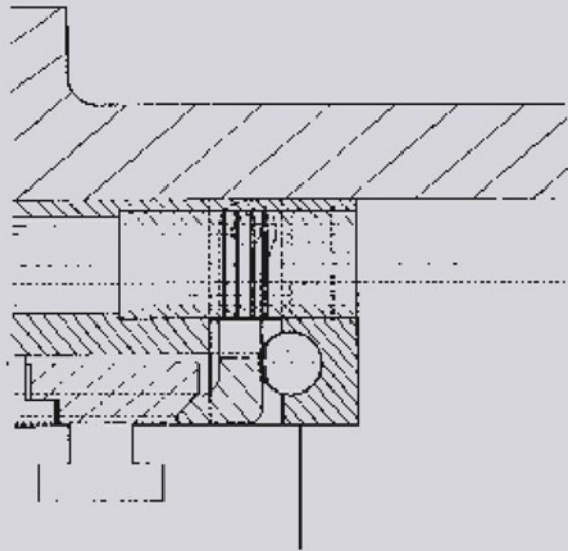


Figure 4a - Part section on centreline

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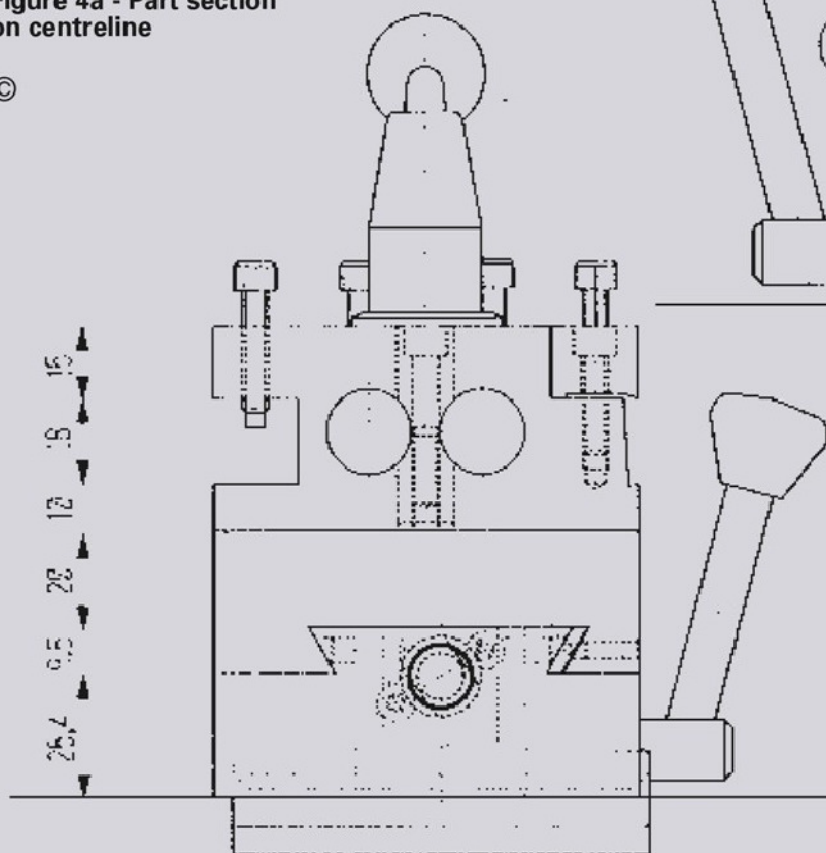


Figure 4c - Looking towards tailstock

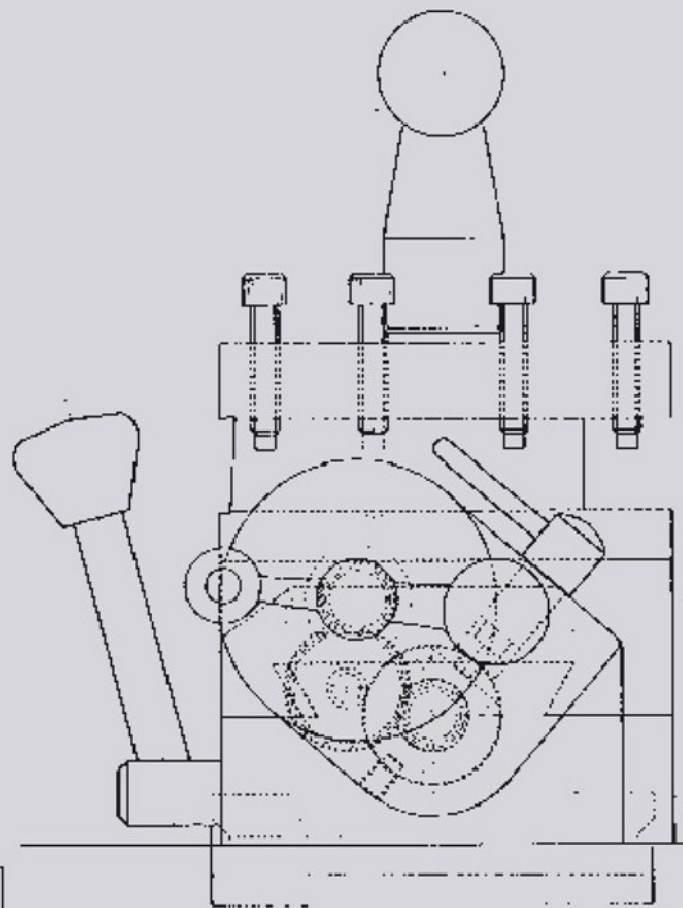


Figure 4b - Looking towards headstock

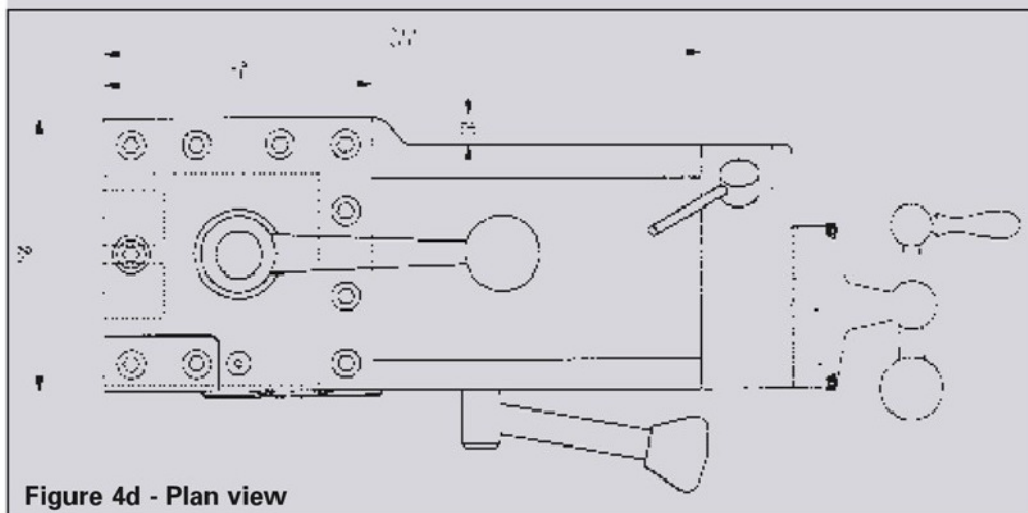


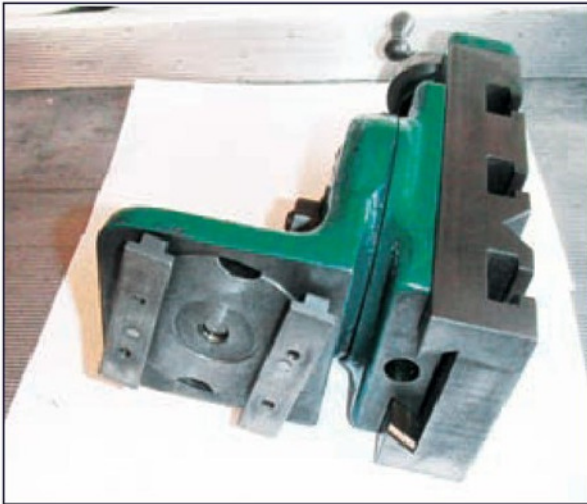
Figure 4d - Plan view

recourse to the spanners or keys normally required.

Full extent of the cross slide is available to position and rotate the top slide. The top slide usually rotates about a fixed location on the cross slide, this often restricts the scope of access available to the cutting tool.

There is no need to clear the area of swarf before moving or rotating the top slide to a new position. The sliding action, of the top slide over the cross slide, clears away the swarf in the new location.

The lever that locks/unlocks the top slide is located for easy access to the operator and is safely away from the cutting tool.



6. Modified vertical slide.



7. Component parts of topslide.

The top slide can be quickly moved or completely removed to give clear access for setting up or inspection operations. This safely removes sharp cutting tools away for such manual operations.

It is possible to place the top slide on the far side of the component for "reverse engineering".

The top slide can be removed and replaced by other devices, as required, using conventional bolted arrangements or lever locking arrangements.

Avoids extensive re-adjustment by the cross slide screw to reposition the top slide.

The top slide can be moved across the extents of the cross slide to clear the area of swarf, this action also clears the tee slots.

Cross slide requirements

The cross slide requires two parallel tee slots at right angles to the lathe axis to allow the top slide to move over the full extent of the cross slide. The top slide could be moved in steps over tee slots parallel to the lathe axis assuming that they are equally spaced, but this would be cumbersome and have little advantage over any existing arrangement. It is also good if the tee slots are open at both ends to permit mounting and removing the top slide. This also allows for swarf removal from the tee slots.

The distance between the start of the tee slots and the cross slide feed hand wheel needs to be enough to allow the top slide tee bars to enter the tee slots, otherwise it can only be mounted / removed from the rear of the cross slide. This can be done easily on lathes that have the cross slide hand wheel fixed to the carriage, by just winding the cross slide over, but it needs to be taken into account if the hand wheel is fixed to the cross slide. The distance between the tee slots should obviously suit existing equipment that will be mounted on the cross slide and is dictated to some extent by the diameter of the annulus. I have added tee slots to my lathe and this does reduce the maximum diameter

that can be swung over the cross slide. This is not a great concern for Chipmaster lathe but it could be for smaller centre height lathes. Of course a new cross slide can be made incorporating the tee slots if this is a concern. I have modified my vertical slide to suit the tee slots (see photo 6).



Later sections of this article to be published in future issues of MEW, will describe other aspects of the assembly, then give guidance on construction.

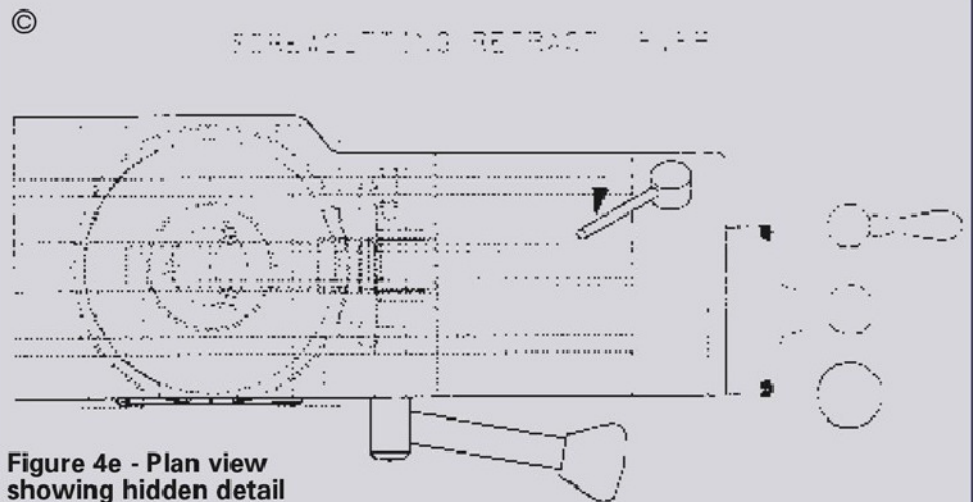


Figure 4e - Plan view showing hidden detail

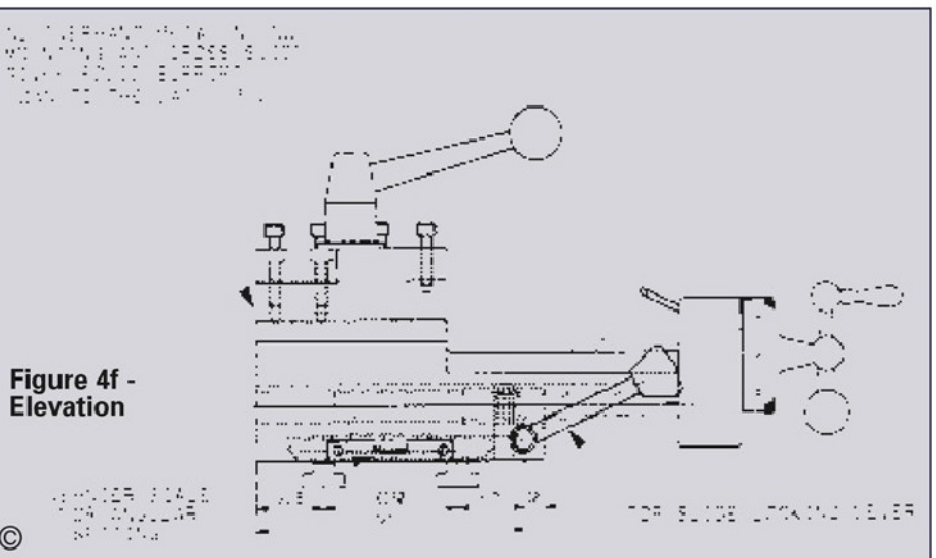


Figure 4f - Elevation

DRILL GRINDING WITH AND CUTTE



1. Test rig for the relieving characteristics.

It is widely assumed that the Quorn tool and cutter grinder in its standard configuration does not make it possible to grind twist drills conventionally to the conically shaped flanks; as we know the late Prof. Chaddock shared this opinion and suggested as an alternative the four facet method. While some commercial drills employ this geometry, it has not been universally adopted and discussions continue about the reasons why. A third method is based on helically shaped flank surfaces; again, for this variant drill grinding machines are designed and produced. It will be seen later, that a correctly ground drill contacts

the work piece only with its cutting edges and to some extent at the chisel edge; beyond this, many details of the flank's shape are not all important. It is essential that the cutting edge is given enough clearance and that the flanks are sufficiently relieved. All information for judging the shape of the frontal surfaces is contained in the relieving characteristics. These show the profile of the flank's height difference X_{R1} to the cutting edge, recorded on different circular paths about the drill's axis. The graphs start at the cutting edge, and about five evenly distributed records are sufficient to give a clear picture. The relieving characteristics

Prof. Joerg Hugel discusses drill point geometry, measurement experiments, and grinding techniques.

can be calculated or measured. The abscissa is the arc-length $\langle Arc \rangle$ of the circular path, measured from the cutting edge. Additionally the graphs are shifted to the right-hand side the distance X_{30} from the central axis to the starting point at the cutting edge to improve the diagrams interpretability.

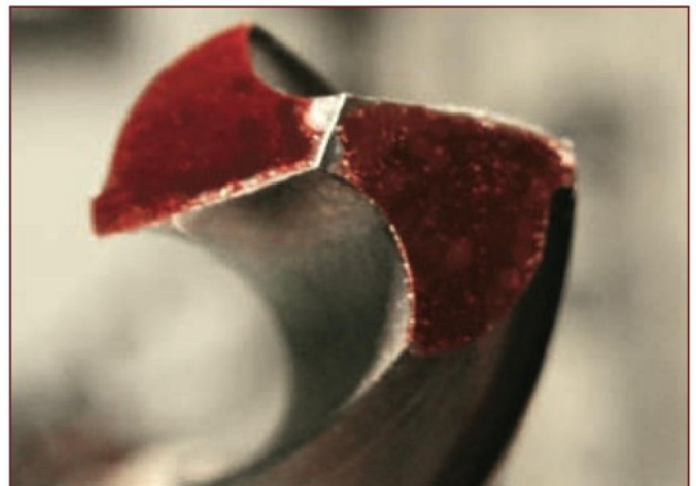
The very important clearance angles α_0 at the cutting edge are the inclination angles of the relieving characteristics at the starting points. To avoid complicated evaluations a diagram with the clearance angle α_0 as a function of the centre distance X_{30} would be useful. Both diagrams are found in **Figures 1 and 2**, for an 118 deg standard drill, ground by the four facet method. The data for the primary and secondary clearance are $\alpha_p = 5\text{deg}$ and $\alpha_s = 25\text{deg}$. All linear dimensions are related to the drill's radius. The relative figures multiplied by the drills radius $d/2$ will give the actual distances.

The angle α_0 is a parameter of the tool and would be the actual clearance angle α for a negligible feed speed. Under normal operational conditions the reduction from α_0 to α is dependent on the quotient feed speed to cutting speed. Near the centre the cutting speed is low and an increased angle reduction has to be expected. On the other side **Figure 2** shows that for the clearance angle it is $\alpha_0 > \alpha_s$ increasing towards the drill's centre, this clearance angle augmentation of course is very welcome.

It may be surprising, that the diagram for the four-facet-drill does not show the constant primary clearance angle α_p . But



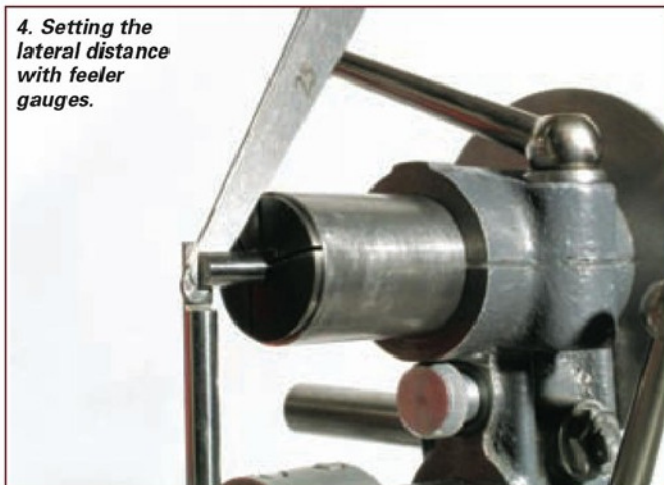
2. Machining test with the drill.



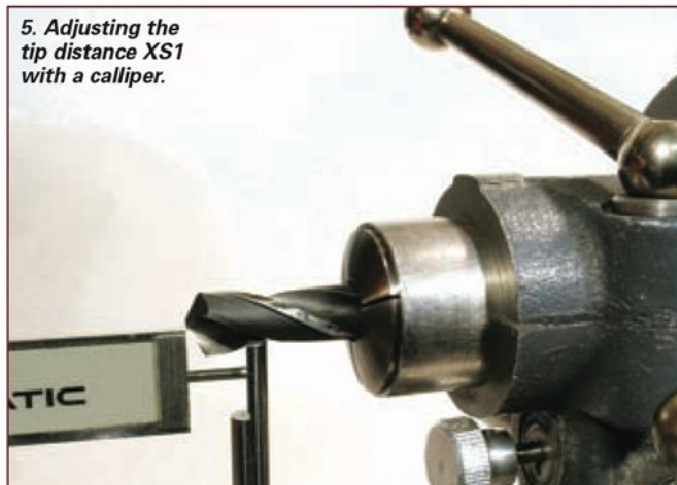
3. Markings of contact on the drill flanks.

WITH THE QUORN TOOL OR GRINDER

4. Setting the lateral distance with feeler gauges.



5. Adjusting the tip distance XS1 with a calliper.



this only could have been expected if the cutting edge would be congruent with a radial line through the drill's axis. The vector of the cutting speed then would be perpendicular to the cutting edge. But this is shifted parallel in the direction of the speed and in consequence the speed vector is rotated counter clockwise when viewing on the drill's tip. The speed vector additionally gets a radial component directed to the centre and this is responsible for the increased clearance angle α_0 . The radial speed component and in consequence α_0 are increasing towards the centre.

Conically shaped drill flanks

In several textbooks it is stated, that a perfect drill tip would be achieved if the grinding equipment can produce conically shaped surfaces according to the scheme of **Figure 3**. The textbook data for a , b , ϕ , ψ and for the 118deg. standard twist drill are found in a very interesting article of Mr. Jan Winkel in MEW 108 p.43. Without going into great detail here, it may be observed that an acceptable result may be achieved.

However, looking at existing drill grinding machines and attachments, it is evident that the directions of the cone's axes are often very different from the textbook recommendation $\phi = 45$ deg; angles within a wide range from perpendicular to parallel are found. The parallel arrangement seems to be a curiosity and in fact it is. A little grinding attachment, available on the market for several decades, operates on this principle and shown in **Figure 4**. With this little gadget, free cutting drills can be sharpened successfully. But grinding the optimum tip geometry is not possible. Either the clearance angles at the cutting edge generally become too pronounced or the flank's relief would be insufficient.

Much better drill tips can be expected

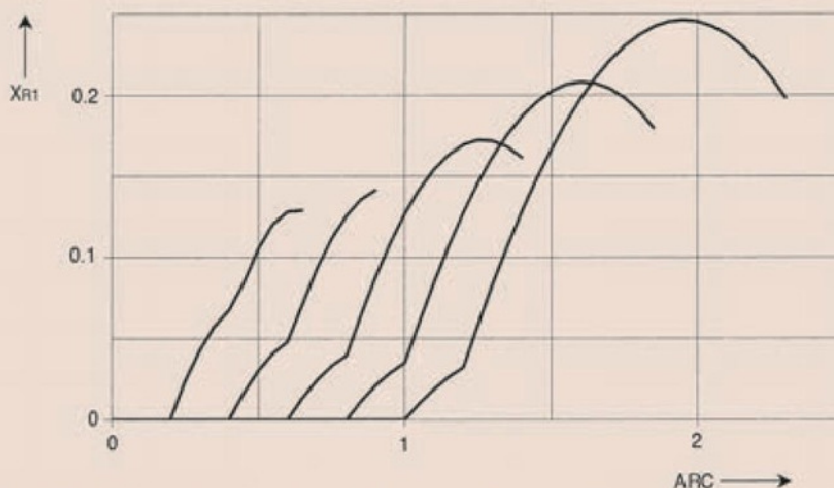


Fig 1 Relieving characteristics for a four facet drill.

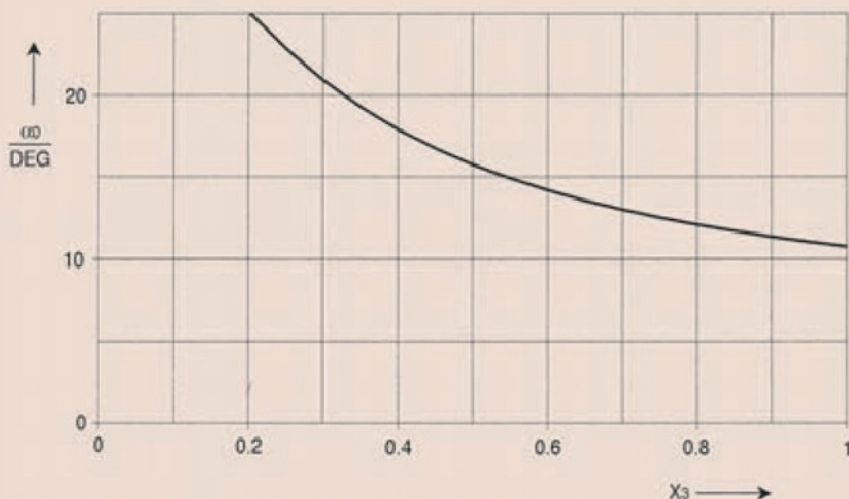


Fig 2 Clearance angle for a four facet drill.

6. Setting the drill's orientation with a try square.



7. Grinding a flank.

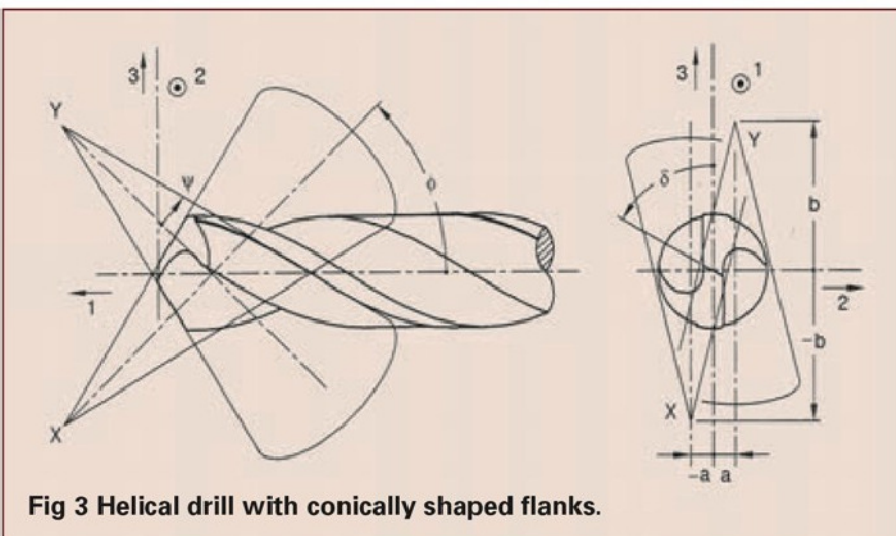


Fig 3 Helical drill with conically shaped flanks.

from grinding machines with cone axes perpendicular to the drill's axis. In fact drill grinding machines based on orthogonally directed axes for the tool and the cone, have been successfully designed and manufactured. This fact should be a good message for all owners and prospective builders of the Quorn tool and cutter grinder; more details are explained with Figure 5.

The rotary table and the cones have an identical axis and this is perpendicular to the axis of the tool holder. With the Quorn very accurate settings are possible. All sizes will become basically identical and

an exactly scaled shape; this feature is not always guaranteed for the commercially offered drill grinding machines and attachments. The data recommended for grinding 118 deg. - standard drills are listed in Table 1. Even the chisel edge angle will become the mysterious value 55 deg.

Exactly how the data of Table 1 have been calculated cannot be explained with just a few words; to find these setting parameters a special computer program was developed and applied. The relieving characteristics and the clearance angle function for the optimized parameters are

seen in Figures 6 and 7; the relieving characteristic shown as a line with a series of dots will be explained later.

The performance of two drills is identical, if their tips are identically shaped and with the Quorn it is possible to restore a drill tip to its original shape within close limits. This has been proved theoretically and experimentally; Photos 1 and 2 illustrate the use of a 10mm dia. drill used as an example. The Quorn was set up precisely using the parameters of Table 1 and perfect drill tips were an immediate result. The relieving characteristics were checked by measurement and the drilling performance tested.

With the test rig of Photo 1 a series of relieving characteristics was recorded experimentally. The drill rests securely in a V-block and was turned by a small rotary table. The whole arrangement was fixed to the table of a vertical milling machine except the digital test indicator (DTI) which was equipped with a 1mm ball tip and attached to the spindle head. The DTI is used here purely as a comparator. For the measurements of the path's radius and the relieving heights the very precise linear scales of the milling machine were applied. The measuring results have been found accurate and reliable. The height values X_{R1} in the drill's axial direction had to be divided by the radius $d_0/2 = 5\text{mm}$ and could then be compared with Figure 6. One series of recorded points are additionally shown in this figure. With an unused high quality drill identical

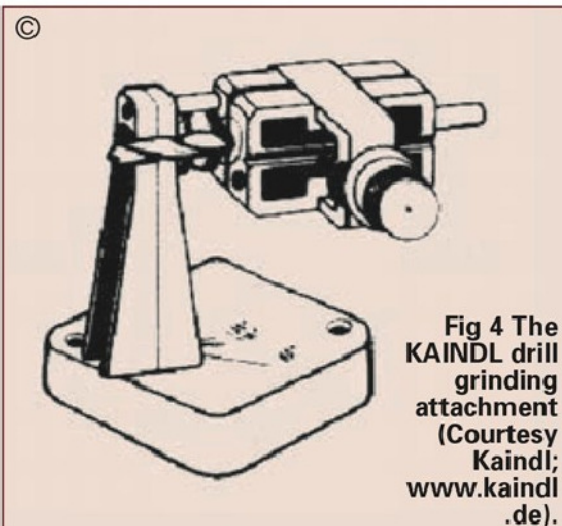


Fig 4 The KAINDL drill grinding attachment (Courtesy Kaindle; www.kaindle.de).

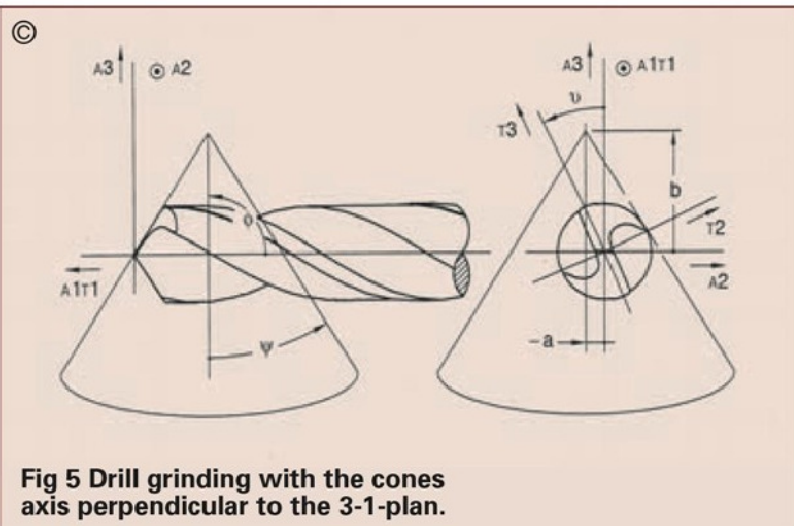


Fig 5 Drill grinding with the cones axis perpendicular to the 3-1-plan.

measurements were taken; it was not possible to detect any significant difference in the relieving characteristics between the new and the resharpener drill.

Prior to the machining test the flanks were painted with a red felt pen. Several holes were drilled into mild steel. The drill produced two equally sized long curls as seen in **Photo 2**; the holes in this case were measured 0.3 mm oversize due to a small difference in the lips length. Finally the flanks shown in **Photo 3** have been checked. It can be seen that the surfaces did not rub against the work piece and only small areas of contact are found at the cutting edges and at the chisel edge. This is an indication that the drills cuts freely as already noticed in course of the drilling test.

Practical considerations

Drills with a diameter range from 2mm to 14mm have since been ground successfully. The setting procedure now will be studied in more detail and again as an example the twist drill having a diameter $d_0/2 = 10\text{mm}$ is assumed. It goes without saying that if the drill is not set up correctly, a really good grinding result cannot be expected. The first operation is positioning the tool holder's offset in relation to the axis of the rotary table; the distance should be $a \cdot d_0/2 = 1.25\text{mm}$ and can be set either with a setting micrometer and setting pin or with two setting pins and slip gauges. Feeler gauges are used as the economy version as shown in **Photo 4**. The axis of the tool holder must be set in front of the rotary table's axis and from this the drill tip's distance X_{S1} in direction to the wheel must be set to

$$X_{S1} = b \cdot \tan \psi = 0.30 \cdot b \cdot d_0 = 12.0\text{mm}$$

This setting is shown in **Photo 5**; a setting pin and a rule or a caliper may be used. With the assistance of a try square (**Photo 6**) the lips of the drill have to be brought parallel to the table's axis. Some care is recommended here because any angular deviation is equivalent to an error of the setting parameter g .

The tilting bracket is brought to $\psi = 31\text{deg}$. Then the drill has to be turned counter clockwise $g = 25\text{deg}$. when viewing onto the tip. The index ring is set back 25 deg., fixed to the collet's holder and then both are rotated counter clockwise to zero. With the index pin this zero position will be repeatedly and accurately found as well as the position for the other lip 180deg. apart; no further reading of any scale would be necessary. The tip is moved to the front of the wheel, carefully adjusted by the front bar micrometer and ground by swinging the rotary table about its axis (**Photo 7**). With one hand the rocking lever together with the tool head is firmly held to the rear bar and must not be moved out as long as the drill and wheel are in contact; with the other hand the drill is swung around. Both lips, one after the other, are brought to an identical end position, controlled by the front bar micrometer.

The drill contacts the wheel along a vertical line and even if the rim of the grinding wheel may be small, tools with

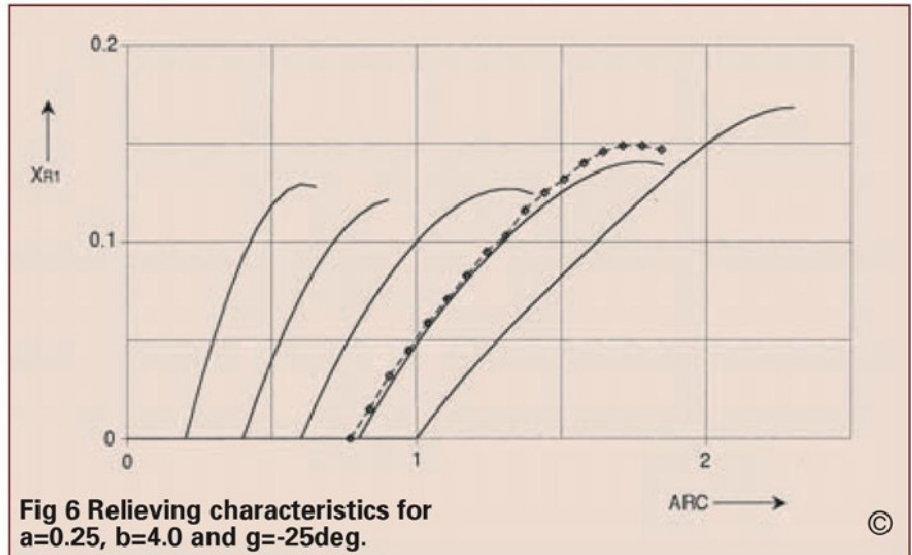


Fig 6 Relieving characteristics for $a=0.25$, $b=4.0$ and $g=25\text{deg}$.

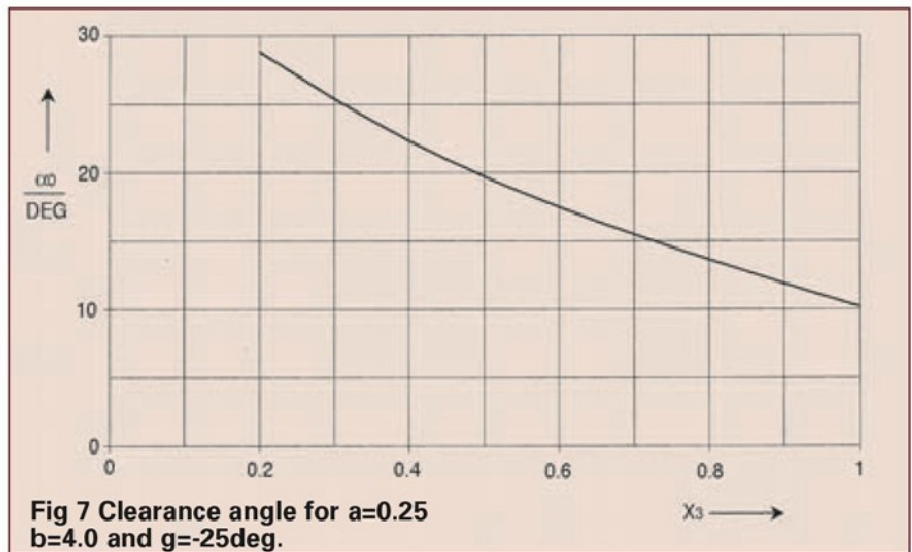


Fig 7 Clearance angle for $a=0.25$ $b=4.0$ and $g=25\text{deg}$.

large diameters can be ground. The line of contact can be sensitively adjusted by means of the rocking lever adjusting screw.

Finally the grinding result should be examined to be sure that the two lips really are ground to the same length. For this check a 10x-magnifier with a 10mm scale and 0.1mm resolution is recommended. By the way, such a magnifier is a very useful tool in the workshop for many other purposes. Rather than with a glass reticule the stage should be equipped with a metallic rule and be open at the bottom for free accessibility to the scale.

For good results the drill must be held accurately centred in the arbor. This sounds simple but sometimes isn't. In particular, lathe collets with three slots are somewhat problematic. Those collets are contacted by the two narrow peripheral lands of the drill at diametrical locations and the lines of contact are relatively short. The lands of small diameter drills can be very narrow and then may partially sink into a slot. Those collets are really not the best solution for fixing the drill. It is preferable to use collets with two or even four lips and also better are exactly dimensioned adaptor sleeves; these then may be held reliably and well centred in the three-slot-collets. The consequence of an eccentrically located drill will be the aforementioned length difference between

the two lips. If this difference is limited to some few percent of the drill's diameter it may be compensated by moving the shorter lip a small distance X_{TD} closer to the wheel than the other. With the lips' length difference L_{LD} the distance between the two settings for the front bar micrometer is calculated to be:

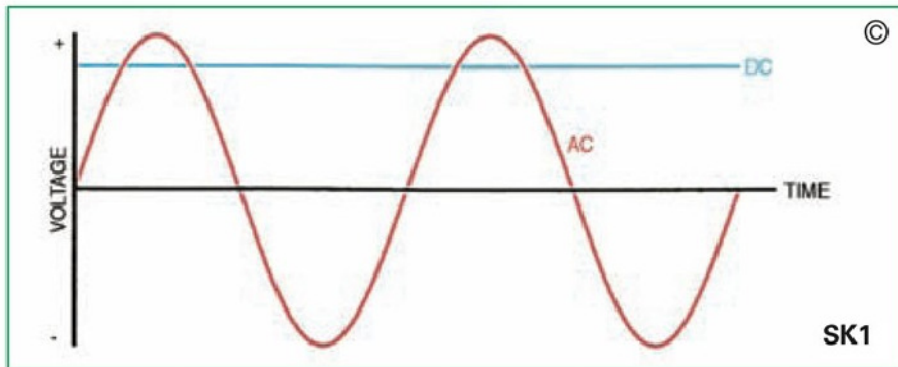
$$X_{TD} = \frac{1}{2} \sin(2\psi) \sin \delta \cdot L_{LD} = 0.36 \cdot L_{LD}$$

It could be argued, that with the Quorn and the setting angle of the tilting bracket at its limit already for standard drills other tools with tip angles less than 118deg. cannot be ground. This is true for the Quorn in its normal configuration, but with an angled mounting bar for the tool head, the problem could be overcome. This gadget was described in some detail in MEW 106 pp.18-19 and also has been applied successfully to grind drills with conically shaped flanks.

Table 1 Setting Parameters

Axis angle	φ	90deg
Cone angle	ψ	31deg
Rotation angle	g	25deg
Lateral shift	a	0.25
Tip shift	b	4

BASIC ELECTRICAL THEORY 1



Harold Hall offers a reminder those who may have forgotten it, or guidance for those new to the topic.

domestic power supply frequencies but is also used for higher frequencies, typically audio and above.

In very basic terms, much theory is equally applicable to both AC and DC circuits, typically, as the voltage increases so does the current proportionally. Unfortunately however, additional factors become important in AC circuits that complicate the issues considerably. Because of this I will start with DC circuits, dealing with AC circuits in the next issue. I must though first clarify the difference between voltage and current for those who need this, doing this using the frequently adopted comparison with the flow of water.

Voltage / Current

Sk 2 shows a tank of water feeding two outlets each controlled by a tap. One tap is fully open, the other opened only a little, the flow from one is therefore greater than from the other even though the head of water and therefore the pressure is the same for both. In electrical terms the water pressure equates to voltage and the flow to current. The control over the flow provided by the taps equate to the resistance (impedance in AC circuits) provided by two differing loads.

Another point worth considering is that with the tap fully closed the pressure is still there even though there is no flow. Similarly in an electrical circuit the voltage is still available even when no current is being demanded.

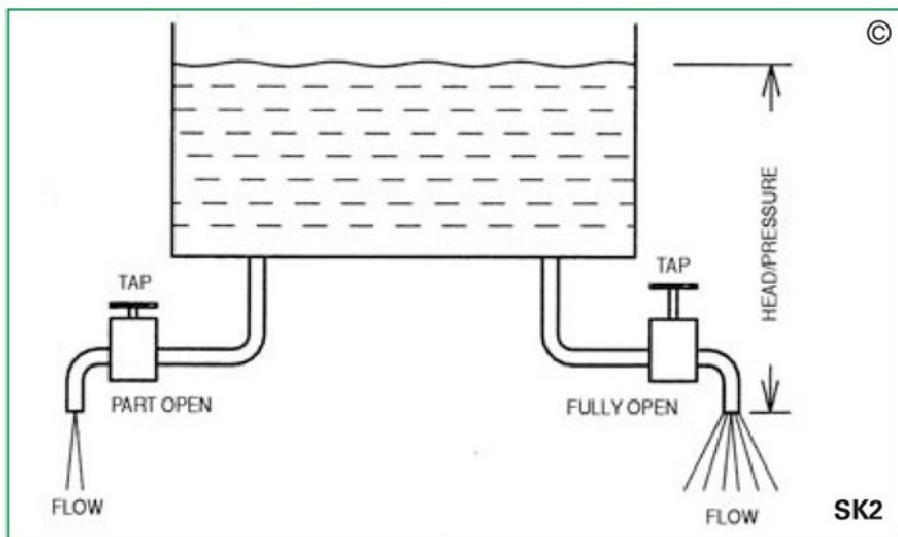
DC Supplies

Basic circuits

The most basic of circuits is where a voltage (V) is feeding a resistor (R) resulting in a current (I), **Sk 3**. In this case the current (I) is dependent on the values of V and R. Current will increase proportionally with voltage and inversely proportional with resistance. That is, typically, twice the voltage resulting in twice the current but twice the resistance resulting in half the current. The formula for this basic circuit is known as Ohm's law given by

$$V(\text{volts}) = I(\text{amps}) \times R(\text{ohms})$$

Before we expand on that simple circuit it is necessary to understand the result of using multiple resistors, this can be with



A contributor to the magazine commented that he felt some readers do not fully follow articles on an electrical topic due to a lack of understanding of basic electrical theory. In some cases, possibly not even appreciating the difference between voltage and current. Because of this, the editor has asked me to write a short series in an endeavour to improve the reader's knowledge on the subject. Whilst I believe that there will only be a few who will not be able to differentiate between voltage and current it is likely that a high proportion will benefit from some additional information. Given that much of our workshop equipment is electrically powered, this is not unreasonable for a magazine with a mechanical bias.

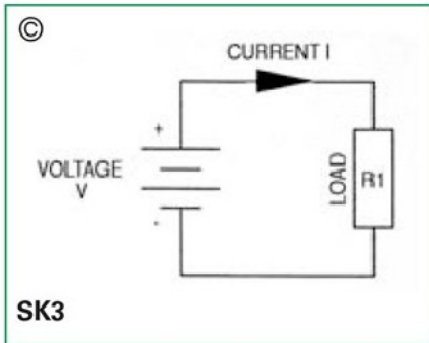
It is not my expectation that the series will enable readers to design their own electrical circuits even though for a few it may just tip the balance in this direction. For most, hopefully, it will help them understand other people's designs and to fault find at least on simpler equipment. Fault finding though on much modern electronics is a job for the experienced and even here, unfortunately, it is mostly a

case of unplug and throw away the faulty board and plug in a new replacement.

The supply

Electrical power is available in two forms, Direct Current (DC) and Alternating Current (AC). Most common will be the supply from a battery (DC) and the household supply (AC). Whilst these are the most apparent, high voltage direct current supplies are generated in a very few cases, though rare, and low voltage alternating current is very common in power supplies for electronic equipment, battery chargers, etc.

What then is the difference between AC and DC supplies? Direct current is where the supply voltage is both fixed in value and polarity, whilst alternating current rises rapidly from zero to a maximum then back down to zero, repeating this but with the polarity reversed, **SK 1**. In the UK and many other countries this cycle is repeated 50 times a second, known as 50 Hertz, 60 Hertz also being common. Hertz being named after Heinrich Rudolph Hertz the German physicist who was the first to produce electromagnetic waves artificially. Hertz is of course not just used for



them in series (**Sk 4**), parallel (**Sk 5**) or complex circuits (**Sk 6**). The total resistance, R_t , when connecting two resistors in series is the sum of the two values. The formula being.

$$R_t = R_1 + R_2$$

Placing two resistors in parallel is more complex but the resulting value will always be smaller than that of the smallest. Typically, with high and low value resistors in parallel the result will be a little less than that of the lower value, the high value resistor having only marginal effect. However, two equal value resistors will give a result of half that of one. The resulting value can be calculated using the formula.

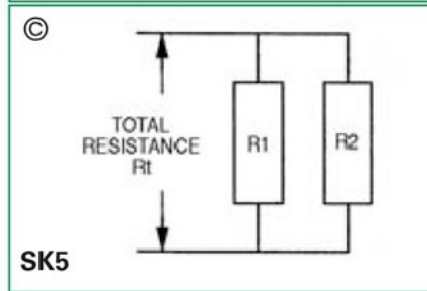
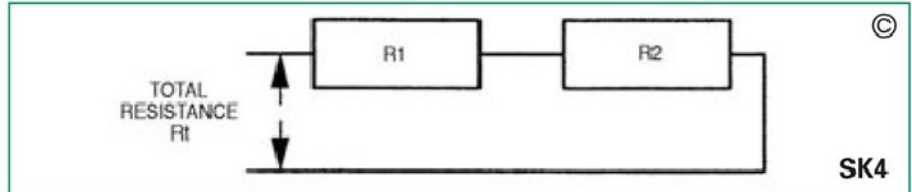
$$R_t = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}}$$

For more than two resistors the formula simply expands as follows.

$$R_t = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

The resulting overall resistance, R_t , for the circuit in **Sk 6** is arrived at by considering it in two stages. First, two resistors, R_2 and R_3 , in parallel as in **Sk 5** and summing this value with the R_1 , as in **Sk 4**.

Placing two resistors in series will be for one of two reasons. First, if the value



required is not available and has to be arrived at using two of lower value, not necessarily the same. Or second, and more likely, to tap off a smaller voltage than that applied to the circuit as illustrated by **Sk 7**. In this case the ratio of resistor values $R_2 : R_1 + R_2$ will be identical to the ratio of the output to input voltages.

$$V_o = V_{in} \times \frac{R_2}{R_1 + R_2}$$

This though is an over simplification of the situation as the output voltage, V_o , will be feeding a load that will have its own resistance value. The circuit **Sk 6** is therefore more appropriate where R_3 is the load. In this case the value of R_2 and R_3 in parallel should be used in the ratio. I suspect that some readers will consider that I am discussing resistors in electronic circuits and whilst my comments could be applicable to these they are equally at home in non electronic systems.

Another point is that whilst the explanations are in terms of simple resistors the circuits may be built from numerous types of components, for example, a heater, light bulb, the input to a transistor or even an electric motor. In these cases we are talking about the

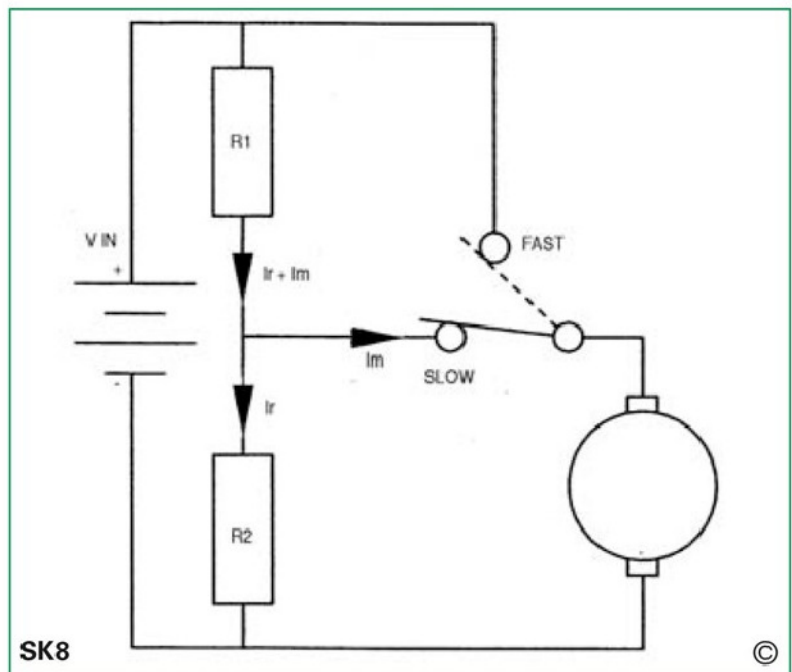
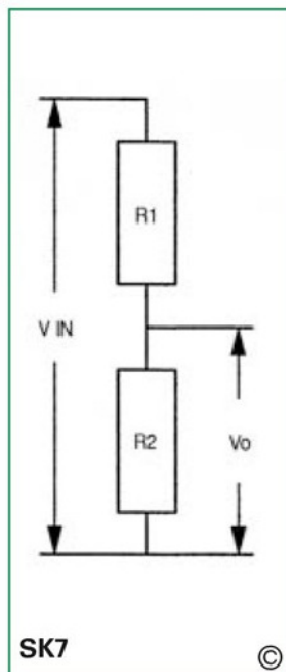
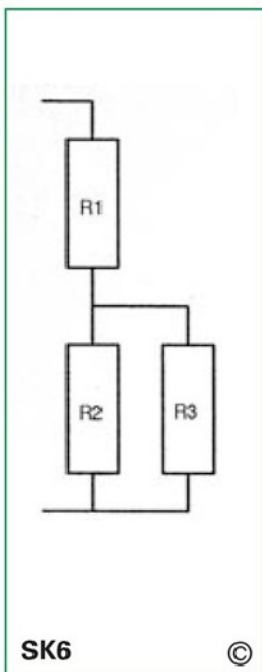
numerical value of the device's resistance (as would a resistor) in ohms.

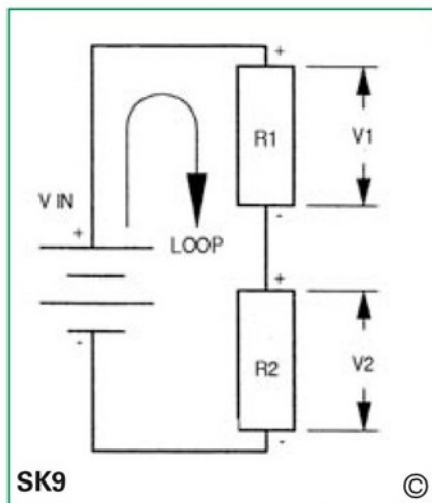
Choice of values

Considering **Sk 6**, the reader may rightly question why is resistor R_2 required, as surely the load (R_3) together with resistor R_1 will provide the necessary voltage divider? This is acceptable providing the load is fixed. A typical example would be if a 6 volt bulb requires to be powered from a 15 volt supply. In this case the resistor would require to drop 9 volts. If the bulb had a resistance of 12 ohms then the resistor would need to be 18 ohms as it requires to drop 1½ times the bulb voltage. Incidentally, it is not possible to accurately measure the working resistance of a bulb when cold (as the resistance changes with the rise in temperature) so it will be necessary to work out the resistance from its quoted wattage. Similarly, one cannot measure the apparent resistance of an electric motor whilst stationary, more about that later.

Two speed motor

At this stage one could easily fall into the trap of considering that as the ratio is the important factor the actual resistor values are unimportant, this is not totally the case. Above we have explained how for a fixed load the resistor R_2 is superfluous but in many cases the load is variable and R_2 performs a valuable function. Consider a small DC motor to power a milling machine table feed. Ideally, this should run at one speed whilst a component is being machined but faster when traversed away so as to save time. Let us consider that the motor requires 12 volts (fast) and 3 volts (slow) and draws a current of 0.5 amps at the lower speed. **Sk 8** shows the basic circuit.





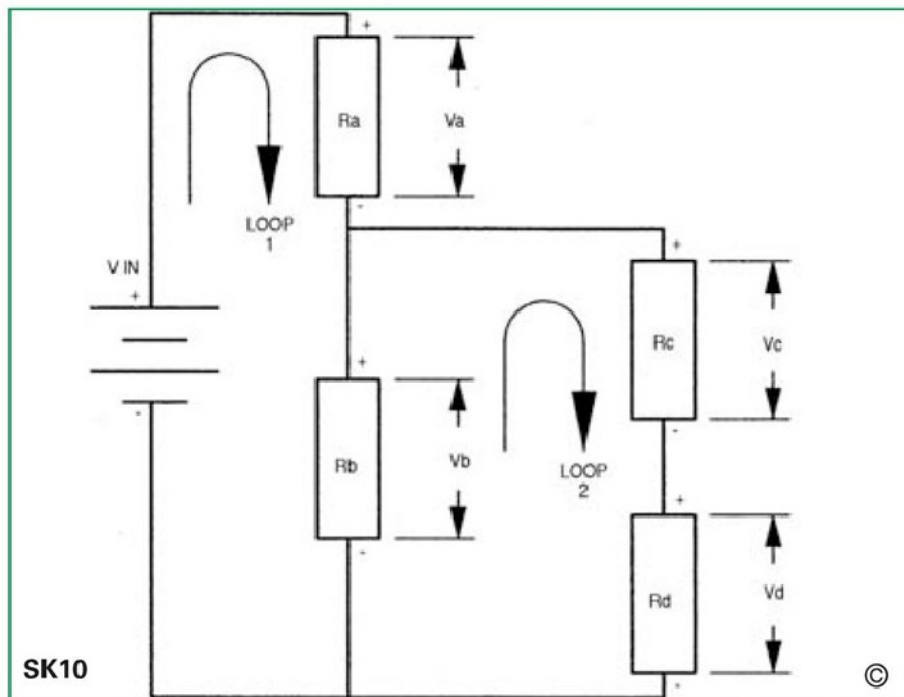
SK9

One of Kirchoff's two laws states that "the algebraic sum of all the currents meeting at a point in a circuit equals zero" or to put it in a way that I prefer, "the sum of the currents arriving equals the sum of the currents leaving". Relating that principle to **Sk 8** you will see that the current in R1 is equal to the current through the motor (I_m) plus that through R2 (I_r).

If now the value of R2 is chosen to have a value that results in the same current through it as the motor (0.5 amps), the current through R1 will be 1 amp. The value of R1 then being chosen to drop 9 volts at 1 amp. If however the load on the motor increases to 0.6 amps (say due to changes in the shape of the component increasing the depth of cut as it is being machined) then the current through R1 would appear (see later clarification) to increase to 1.1 amps. This would increase the volt dropped by R1 proportionately, that is from 9 to 9.9 volts and the voltage at the motor therefore drop to 2.1 volts. The speed of the motor dropping as a result.

Had different values of R1 and R2 been chosen so as to take a higher current, say R2 taking 2 amp at 3 volts the results would have been different. The increase in current (0.5 to 0.6 amps) through the motor would result in the current through R1 increasing from 2.5 to 2.6 amps. The volt drop across R1 would again increase proportionately but this time only from 9 volts to 9.36 volts ($9 \times 2.6/2.5$). The motor voltage would therefore reduce less than in the first case, that is to 2.64 volts rather than to 2.1 volts, the change in speed would therefore be less. From this it can be seen that the greater the current passing through the potential divider the less its output is affected by changes in the load placed on it.

I must though clarify that the above is an over simplification as the decrease in voltage at the motor is also apparent at the resistor R2 the current through this will therefore drop, compensating in part for the increase in motor current, the changes in motor voltage are therefore less than suggested. However, whilst mathematically not totally correct, the principle it attempts to explain is still valid, the greater the current through the divider compared to the load the more stable is the output. Actually, the motor voltage falls from 3 volts to 2.6 V in the first instance and with the higher current



SK10

through R2, to only 2.9 V. The principle would of course be equally appropriate to a potential divider feeding any form of varying load, not just a motor. For the mathematically minded the formula for calculating the change in V_o for a change in I_m is.

$$V_o = \frac{V_{in} - (R1 \times I_m)}{1 + \frac{R1}{R2}}$$

The suggested method of motor speed control would have been used in the pre electronic era, even for quite large motors. It should be obvious though that it is very inefficient in terms of power consumption as the divider uses even more power than the motor itself. Its use in the application used for my explanation may just be valid for the workshop owner who does not want to delve into electronic systems. In this case the potential divider could be made using more than two resistors giving more than the two speeds suggested.

The main purpose of the explanation is to highlight the fact that when setting up a potential divider, the actual value of the resistors can be almost as important as the ratio between them. I chose the case of a motor with a varying load as I felt this would be better understood, it is though equally applicable to dividers in electronic circuits. In this case though, with the load current often being in micro amps the current through the divider can be proportionately much higher and the effect of load change almost nil.

Voltages in a loop

Understanding the effect of current and resistance on the voltages in a loop is essential to the understanding of electrical circuits. Rather like the law mentioned above for currents arriving and leaving a point in a circuit, Kirchoff also provided another law for the voltages in a loop. This though is a little more complex to understand and so my version states that the sum of the voltages in a loop is always zero. Considering **Sk 9** we see that the current resulting from the applied voltage, V_{in} , produces voltages of $V1$ and $V2$ across

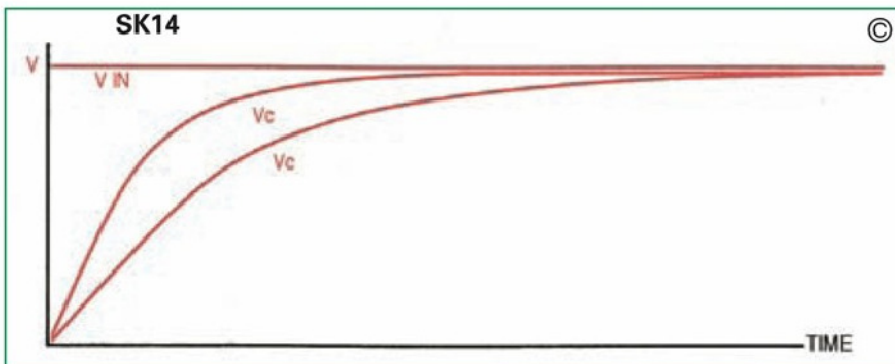
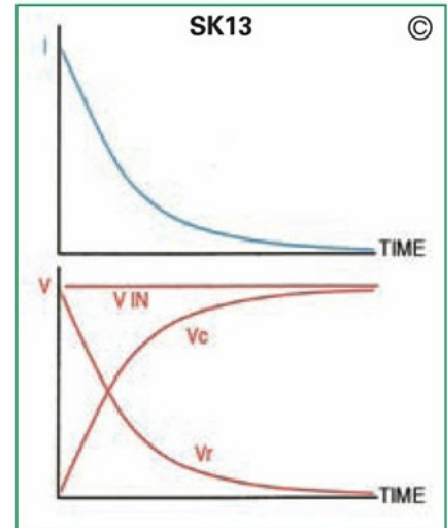
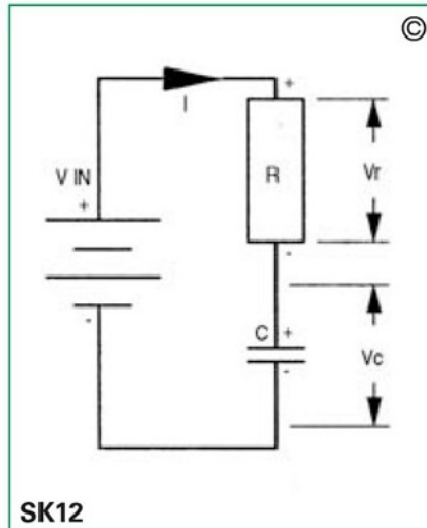
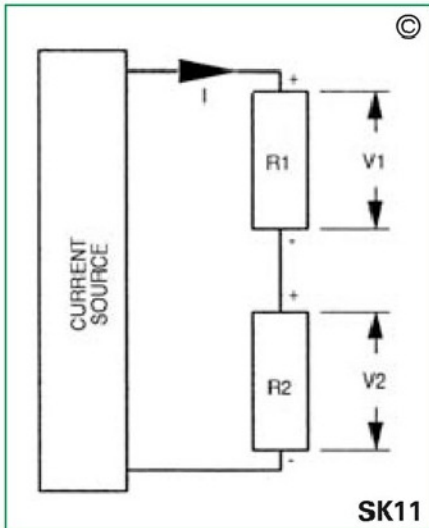
the resistors R1 and R2. In terms of the loop it can be seen that the polarity of the voltages $V1$ and $V2$ are in the opposite direction to V_{in} , it can be said therefore that the sum total of the voltages in the loop equals zero, that is $V_{in} - V1 - V2 = 0$.

So far no doubt you have assumed that the voltage source is from a battery or some other fixed voltage power supply. Frequently though, an element of a circuit is just fed from some other portion of the overall circuit, **Sk 10** shows a typical example. Here resistors b, c and d form loop 2 and again the sum total of voltages will be zero, that is V_b minus V_c minus V_d will equal zero. The same rule would also apply if we considered a third loop comprising V_{in} , V_a , V_c and V_d .

When considering **Sk 7**, it was stated that the output voltage could be arrived at purely by taking the ratio of the resistors R1 and R2 in relation to the supply voltage. It will though in some cases be preferable to work the voltages out in terms of the individual resistance and the current flowing through it. With this in mind, the law, known as "Ohm's law", detailing the relationship between volts, amps and ohms is equally applicable to an individual resistor in a complex circuit as it is to a single resistor connected direct to a supply (**Sk 3**). Considering the circuit shown in **Sk 11** where the circuit is feed from a known current rather than a known voltage the voltages $V1$ and $V2$ can be arrived at using the product of the current and the individual resistor values.

$$V1 = R1 \times I \quad \text{and} \quad V2 = R2 \times I$$

Whilst not common, a circuit may be fed from a circuit that controls the output current irrespective of the load placed onto it, in this case the above methods would have to be used, not knowing the supply voltage. The above illustrates that Ohm's law can be used to calculate the value of the unknown which ever of the three values this is, even for a single component in a complex circuit. The alternative forms of the formula being.



$$I = \frac{V}{R} \text{ or } V = I \times R \text{ or } R = \frac{V}{I}$$

Power

So far we have discussed electricity in terms of voltage (pressure) and current (flow) neither of which individually give any indication of the work being done. Back to our water tank illustration, we could have a large head of water with the tap almost closed or an almost empty tank with a wide open tap, both moving the same amount of water. This because the water would be under higher pressure in the first case compared to the second. Work being done is therefore given by the product of voltage and current in a circuit, the result being in Watts.

$$\text{Power} = V \times I \text{ watts}$$

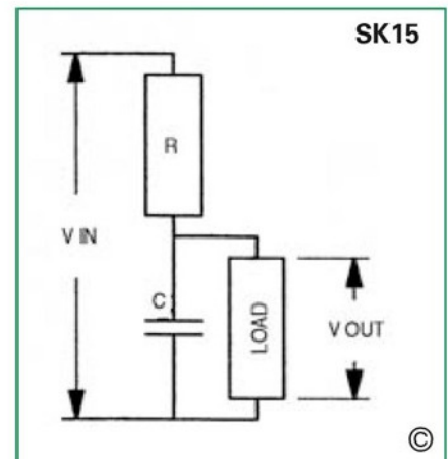
This parameter will be applicable to different components in differing ways, most simply it will be the heat generated by a heater. In the case of a heater the wattage value is the crucial value, being chosen so as to provide the degree of heating that the circumstances demand. However, in the circuits above the resistors are there to provide control over voltages required in other parts of the circuit, the power that the resistor consumes is coincidental to the working of the circuit. It is though essential to calculate individually the wattage dissipated by each so as to ensure that it is working within its limits. If not, then the resistor will overheat and fail, possibly also causing damage to adjacent components, even burn a hole in a printed circuit board, known to happen even in professional circles.

Returning to **Sk 11** the power dissipated by each resistance could be calculated

using the formula for power in terms of volts and amps, as above. As however, $V = R \times I$ then the formula $\text{Power} = V \times I$ can also be expressed as $\text{Power} = (R \times I) \times I$ that simplifies to $\text{Power} = R \times I^2$. From this it can be seen that for resistors carrying the same current the wattage consumed is proportional to the resistor values. Typically if $R1$ is twice the value of $R2$ so will be the power consumed. $R1$ and $R2$ can therefore be of differing power ratings and therefore physical size. Like the formula for Ohm's law, the formula for power consumed can be expressed in a number of ways.

$$\text{Power} = V \times I \text{ or } R \times I^2 \text{ or } \frac{V^2}{R}$$

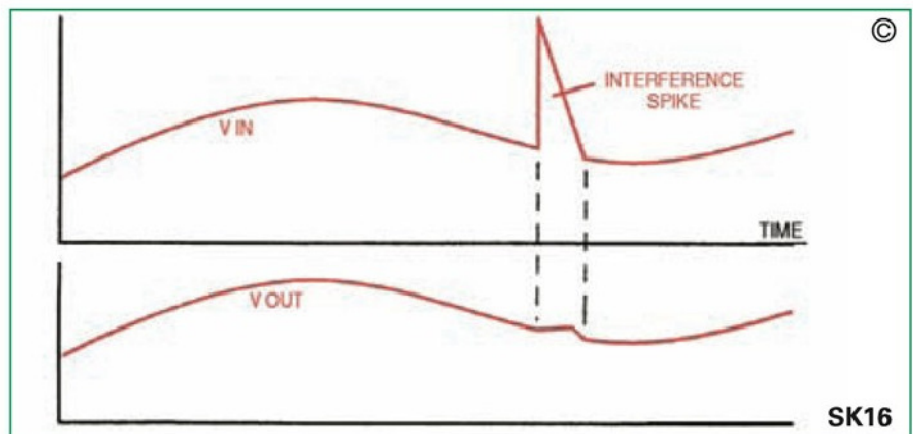
At first, it may be considered that there is an error as the second formula shows the power is proportional to the value of the resistor R whilst in the third it is inversely proportional. Please be assured that it is correct it is a quirk of how the

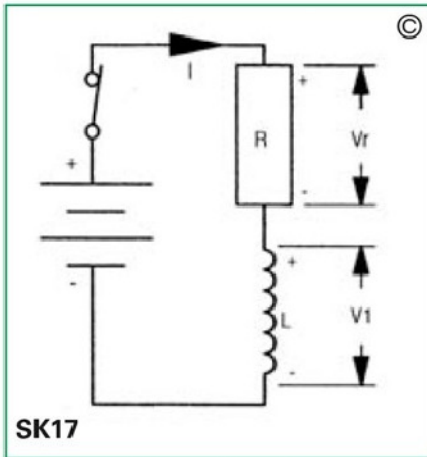


formulas are presented, one in relation to a known current and in the other a known voltage. As an interesting exercise you could attempt to arrive at the second and third formula using the first formula for power and ohm's law.

Importance of the power consumed

If you are constructing electronic circuits in the home workshop, available components, or simplifying their purchase, may dictate using resistors of a higher power rating than is needed. This though will not effect the working of the circuit in any way. If however circuits are being designed for use in aviation or space flight





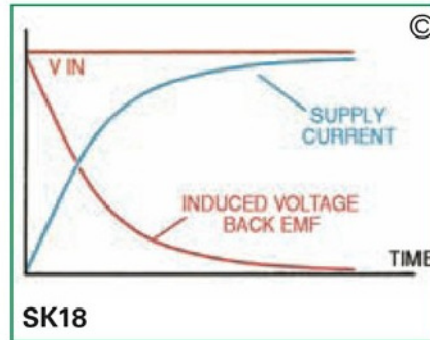
where weight is crucial, or domestic electronics where miniaturisation is important, then the power rating and therefore the physical size of component may be vital.

Consideration to the power consumed by a resistor being used to control a small motor will be equally important but again using one with a higher power rating in no way effects the working of the circuit. There is though in electronics, or in higher power circuits, a vital consideration in terms of power rating of a resistive component. A component having a larger power rating than the circuit demands will run at a lower temperature. This may be beneficial in terms of its reliability or its effect on neighbouring components.

Capacitance

Whilst the term resistance in basic electrical theory is applicable to many components, not just a resistor, capacitance is solely appropriate to the humble capacitor. Of course, capacitance is a factor in other situations. A very long cable will have significant capacitance between its individual cores and at very high frequencies be a consideration at quite short lengths. Such considerations are though beyond what can be considered basic.

Probably the most simple explanation regarding the capacitor is to compare it with a rechargeable battery, it can store power provided from one source and then make it available later, maybe to another. However, here the similarity ceases as the battery will have a nominally fixed voltage between it being charged and discharged whilst the capacitor can be charged to any



voltage value from zero up to its designed maximum. A mechanical analogy is to liken the capacitor to a spring, which will compress (storing energy) as a force is applied, releasing the energy when the force is removed.

Initially, a fully discharged capacitor is the equivalent of a short circuit (zero resistance) and will theoretically take a very high current from the power source charging it, infinite if one applies a voltage to zero resistance. The current will though be limited by the power supplies own internal resistance and of the connecting cables, it is though rarely an acceptable situation. Because of this, capacitors are invariably fed via a limiting resistor which as will be seen limits the initial current but has little effect on the value of the eventual charge voltage, only the time it takes to arrive at this value.

Let us consider the circuit in **Sk 12**. Initially, with the capacitor fully discharged (zero resistance) the circuit will be the equivalent of **Sk 3** with the resistor solely determining the level of the current. The flow of current will though commence to charge up the capacitor and the resultant voltage begin to oppose the supply voltage. Taking the example of the capacitor having reached a voltage of a half of the supply voltage (V_{in}) the effective voltage in the loop will now only be a $\frac{1}{2}$ of that originally ($V_{in} - V_c$) and similarly the resulting current. As a result, the rate of charge will decrease and will continue to do so as the capacitor voltage approaches the supply voltage, **Sk 13**. Note how, as the charge on the capacitor approaches V_{in} , the current and the resultant voltage across the resistor, V_r , both approach zero.

In theory, the capacitor will never be charged fully to the value of the voltage supplying it as the charging current will become progressively less as the two values attempt to merge. What then will control the charging time. The greater the

value of the resistor the lower will be the charging current and therefore the longer will it take to charge up, **Sk 14**. The value of the capacitor will have a similar effect, the greater the value the longer will be the charge up time, in both cases though the charge voltage eventually reaches V_{in} .

Defining the charge time, known as the "time constant" (TC), of a resistor/capacitor combination is with the mathematical product of their two values.

$$TC = R \times C \text{ seconds}$$

The resulting value is the time in seconds to reach a charge of 62.3% of the applied voltage. At five times this value the capacitor will be essentially fully charged, that is over 99%. In making the calculation, resistance must be in ohms and the capacitance in farads. Do though note that the capacitance is in farads whilst in practice capacitors are rarely more than a few micro farads, a factor of ten to the minus 6 must therefore be included. Typically, a circuit with a resistor value of 2000000 ohms and a capacitor of 25 micro farads the time constant will be 50 seconds.

The calculation is equally applicable to the discharge time with the product of the resistance and capacitance values giving the time taken for the charge to reduce by 62.3%, when the supply is removed and a discharge path provided. If a discharge path is not provided when the supply is removed the capacitor will maintain its charge, only very slowly decaying as a result of the capacitors own leakage resistance between its two sets of plates. Televisions, especially older designs, were renowned for having lethal voltages present for this reason well after the supply had been removed.

Uses for the resistor capacitor configuration are many but most if not all are there to make use of the time element. Many applications surface in electronic situations, frequently to limit the effect of interference, **Sk 15**. In this example the time constant of R and C must be short enough for V_{out} to follow accurately the varying input signal but sufficiently long not to react to the much faster interference spike, **Sk 16**.

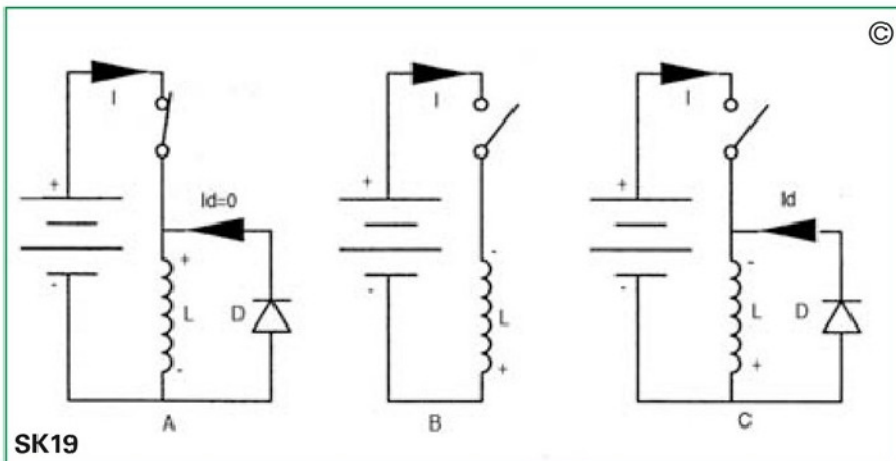
A much simpler application would be for a simple timer. In this case, a fixed voltage (V_{in}) could be applied and V_{out} triggering some device when the voltage reaches a certain level. The time delay could be anything from a fraction of a second to a few minutes depending on the values of R and C . Using a variable resistor for R would enable the time to be varied.

Whilst it is of very much less importance than in the case of resistors, I will for completeness cover the situation of capacitors in series and parallel that are mathematically the reverse of the case with resistors. The effective capacitance of two capacitors in parallel is the sum total of the two.

$$C_t = C_1 + C_2$$

In the case of two, or more, in series the result is less than the smallest.

$$C_t = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2}}$$



Inductance

The subject of inductance is much more complex than that of resistance, or even capacitance, and can only be covered here in the most basic terms, there are though some surprising similarities with capacitance. Whilst components having near pure resistance or capacitance do exist, typically a heater or a capacitor, pure inductance does not. An inductance will consist of a coil of wire that will have a resistance value and which has to be taken into account in more complex applications. For these explanations though it will be ignored.

I am a great believer in the approach that it is easier to understand the what, if you have at least a basic understanding of the why. First therefore, I will give a very brief explanation of how electricity is generated magnetically.

Electricity generation

If a wire is connected to a sensitive voltmeter and laid alongside a magnet the meter will read zero. If then the magnet is removed it will be found that a voltage is developed as the magnet is moved and will again when the magnet is replaced but will vanish when the magnet is at rest. Similarly, if the wire is taken from the magnetic field a voltage will be apparent as it will be as it is being returned. From this it can be seen that a voltage is only produced when the magnetic field strength is changing, either increasing or decreasing. Also of importance, is the fact that the value of the developed voltage is dependent on the rate of change rather than the value of the field strength. For example, fast movement in a weak field can produce a higher voltage than a slow movement in a strong field. Another important fact is that the polarity of the generated voltage depends on whether the field strength is increasing or decreasing.

The change in field strength can be as the result of the wire or the magnetic field physically moving as in a generator or, the current in a coil changing resulting in a change of field strength which then generates a voltage back into the coil itself or another wound along side, as in a transformer. If it is a self induced voltage this is called "Back EMF" being an abbreviation of back electromotive force, "Counter EMF" is also used though rarely in the UK.

Back to inductance

Let us now consider inductance. **Sk 17** shows a voltage V_{in} being applied to an inductance L via a resistor R . At the moment of switch on the magnetic field, whilst weak, will increase rapidly and will cause a high voltage to be generated in the inductors own windings, back emf as explained above. The polarity of this is such that it opposes the supply voltage limiting the current flow as a result. However, as the field strength strengthens the rate of change reduces and therefore the back emf voltage being developed. The current increases as a

result until its value is solely dependent on the applied voltage and the value of resistor R . At this point V_1 will equal zero (on the basis that the coil has zero resistance).

The graph, **Sk 18**, follows exactly that for the rise in voltage of a capacitor being charged but in this case it is the current that is increasing. The method of calculating the time taken is also similar, but this time it is the result of the inductance L being divided by the resistance R , again known as the time constant and giving the time taken for the current to rise to 62.3% of its maximum.

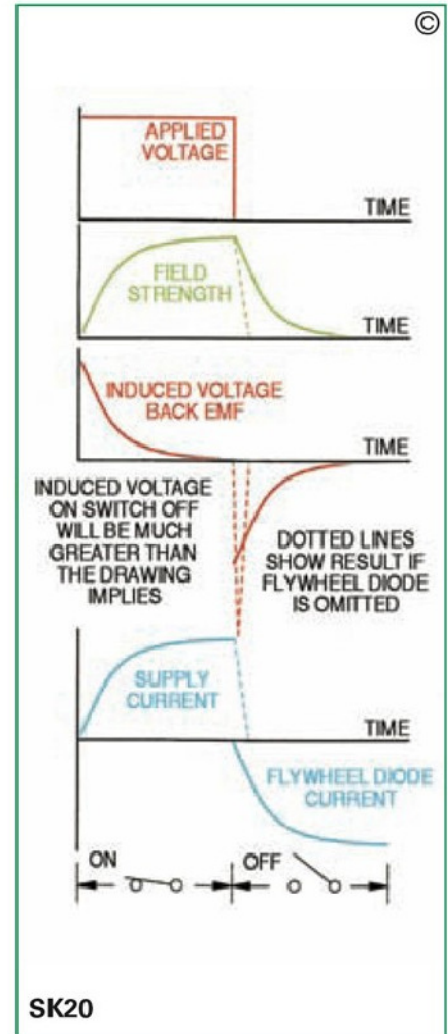
$$TC = \frac{L}{R} \text{ seconds}$$

For this R will be ohms and L in Henrys, do note though that inductors are normally in milli Henrys so a factor of ten to the minus three must be included. Similarly, as is the case with capacitance, the current will continue to rise until after five times the "time constant" the current will have arrived at its maximum. The calculation is equally applicable to the current decay time giving the time taken for the current to reduce by 62.3% when the supply is removed and a discharge path provided.

If a discharge path is not provided precisely when the supply is removed then the circumstances differ markedly from the situation when a capacitor is disconnected as an inductor cannot retain the energy stored magnetically. **Sk 19** shows an inductor (typically a relay coil) being switched on (A) and off (B). On switch on the induced voltage will oppose the supply voltage and the current will build up gradually as illustrated in **Sk 18**. As there is no additional resistance in the circuit the final current will be limited only by the coils own resistance. Whilst this sequence will delay the operation of the relay it will only be micro seconds due to the values for coil inductance and resistance resulting in a very short time constant.

Now, when the coil is de-energised (**Sk 19/B**) the field strength will commence to reduce rapidly again generating an induced voltage (back emf). However, as the field strength is reducing, the polarity of the induced voltage will reverse as the polarities shown on **Sk 19/B** indicates. With no current path available field strength will fall rapidly resulting in an extremely high induced voltage which the switching contact must break. In many cases the high induced voltage will be more than the contact can cope with, resulting in a failed switch. Also in electronic assemblies a relay may be switched by a transistor causing similar problems. Fortunately, the reversal of the induced voltage permits a diode to be added across the coil that will only conduct on switch off, **Sk 19/C**. This current will hold up the field strength reducing the rate of change and the magnitude of the back emf, **Sk 20**. For any reader unfamiliar with diodes, they are devices which act like a one way valve, and will conduct in only one direction.

The arrow directions given on **Sk 19** and elsewhere show the "conventional current" flow from the positive terminal to



the negative. At the microscopic level electrons actually travel in the reverse direction, however for our practical purposes we will consider conventional flow. Here a diode will conduct in the direction of its arrow symbol.

Inductors and capacitors compared

Whilst the calculations, and resulting waveforms, relating to the "time constant" of both inductors and capacitors are similar, there are some important differences. Most important is that a capacitor opposes changes in voltage, but an inductor, changes in current. Another important difference occurs on switch off as a capacitor can retain its charge on switch off whilst an inductor cannot, causing problems as mentioned above.

In the wider world of electrical/electronic equipment capacitors are very much more used for the characteristics they possess than do inductors. As a result, inductance can largely be ignored in the case of the equipment of interest to readers of MEW, even though it will be in existence, (in the background) for many of the components used, such as relay coils, transformers, and electric motors.

In the next issue the subject will be predominantly about AC supplies.

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.

Myford collets again available

The following announcement was received from Chris Moore, Managing Director, Myford Ltd.

"Myford Limited are delighted to advise their customers, that after a very long delay, we are once again in a position to supply our famous 11445 Patent 2 M. T. collets.

For those of you who are unaware, these collets were latterly manufactured by Crawford Collets (part of the 600 Group of companies) at Witney in Oxon. In 2003, the Crawford factory was closed and manufacturing was transferred to the Pratt Burnerd works at Halifax. Some swingeing price increases soon followed and by 2003 Crawfords were wanting to supply the same collets to Myford at £29.00 each, when the Myford list price was just £18.60 plus VAT.

In the interim period, Myford have been co-operating with a number of collet manufacturers both in the home and overseas markets, in an endeavour to find a competent manufacturer, who would be capable of producing a quality collet to the specified accuracy for an affordable price. The net result of nearly 4 years of trials and tribulations, is that we are now receiving supplies of collets, manufactured in the UK, at a price that we believe is still affordable.

Myford would like to remind readers that the main advantage of the Myford 2 M.T. collet, which is located and closed by means of a



nose piece, is that the collet features a through bore. Most other 2 M.T. collets have a blind bore and are closed by means of a draw bar. The Myford collet permits longer lengths of material to be passed through the collet, where it is then supported in the spindle against whirling, and allows the part to be machined and positioned nearer to the spindle nose to greater accuracy.

Imperial collets are available in individual sizes from 1/16in. to 1/2in. in 64th increments (32 in a full set), or metric collets in individual sizes from 2mm to 13mm in 0.5mm increments (23 collets in a full set). The price is £21.62 per collet plus postage and VAT. (Crawford Collets still list a 2 M.T. Collet at approximately £123.00!)"

Myford Ltd can be contacted at
Wilmot Lane, Chilwell Road, Beeston,
Nottingham, NG9 1ER. Telephone 0115
925 4222

LINK UP

Would readers wishing to make use of this facility please note that the maximum total value of items accepted for a 'For Sale' entry is £50.

To advertise goods of a greater value, please contact our Classified Advertisement Department. Please indicate clearly if an item is intended for Link Up.

FOR FREE

- Six off No 12AF 0.12dia. Axiflat Taylor Hobson engraving cutters. Brand new free to good home. Please phone 01908 316 073

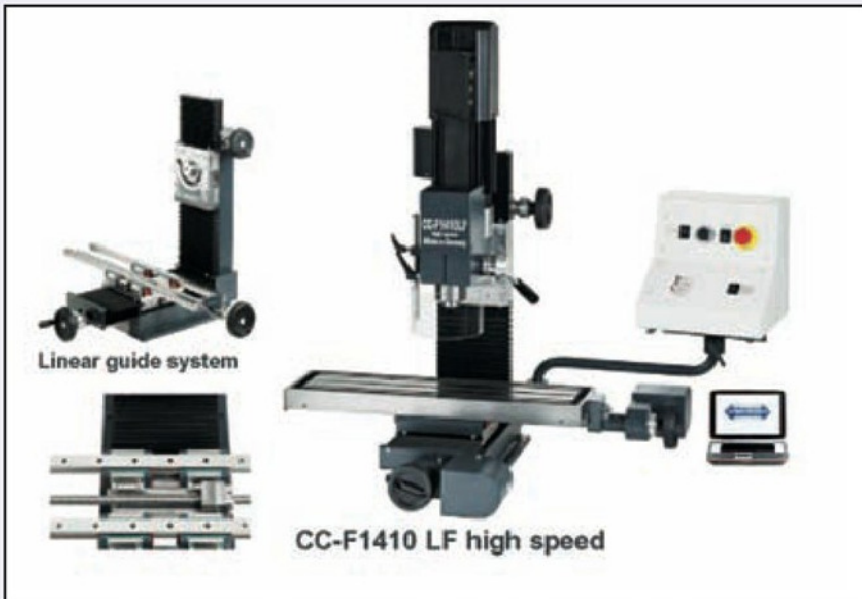
FOR SALE

- Motor reversing switch, suit Myford, Boxford or similar lathe with wiring instructions. £20. Burnard 4 jaw chuck, good condition, Myford back plate £45. Please phone 01723 362537 (Scarborough)

Brass sections from Folkestone

Folkestone Engineering Supplies is a family business run by John and Laura Bridges. They have become well known for a comprehensive materials and fastener list which has just been expanded by the inclusion of a range of brass flat, round and square sections. Folkestone offer a "cut to size" service with no waste, no minimum order value, or VAT. For more information, phone them on 01303 894 611 or write to 62 Canterbury Road, Hawkinge, Kent, CT18 7BP. The website is www.metal2models.btinternet.co.uk and email address metal2models@btopenworld.com

Pro Machine Tools



It was during a conversation with Bryan Tate of Pro Machine Tools that I learned of the latest developments to the Wabeco range. Most machine tools rely on traditional dovetail slide geometry for the various movements. This entails metal to metal sliding (just like a plain bearing), with the inevitable eventual wear being taken up by adjustable gib strips.

The Wabeco 1410 LF is now supplied for CNC use with linear bearings in place of conventional slideways, and travel now at 500mm -X and 200mm - Y. These linear bearings use rolling elements rather than sliding, and so are virtually wear and maintenance free. With this technology, it is essential to keep swarf out of the bearings, and thus concertina covers are included.

Max distance from spindle to table is 370mm. A choice of variable speed motors is offered, 2HP or 3HP, the latter giving spindle speeds up to 7500 rpm, ideal for small diameter cutters and engraving work. Three spindle choices are available, MT2, MT3, and ISO 30. These Morse taper

choices will suit many hobby machinists from the viewpoint of compatibility with existing kit. My own assessment is that the ISO 30 would be worth a serious look. This is a bit of a non-preferred industrial standard, so tooling may be found at bargain prices. Also, I recently watched a friend using an older Emco mill with this fitting, and was impressed with the ease of cutter changing due to the taper geometry.

On the software side, the traditionally offered Mill Plus gives 2½ D, upgradeable to 3D, while NC CAD gives full 3D. In addition, Mach 3 is also available, which may be configured to give up to 6 axis operation.

For more information on the Wabeco machines (or the Emco or Golmatic ranges), contact Pro Machine Tools at 17 Station Road Business Park, Barnack, Stamford, Lincolnshire, PE9 3DW, or telephone 01780 740956

Higher performance from Loctite

Parent company Henkel has announced improvements to and new products within the Loctite range. The new Speedbonder adhesives are two part acrylic products intended to bond aluminium, steel, and galvanised surfaces to a variety of different substrates which may include plastics and composites. H8000 is aimed at aluminium, H8500 at steel, and H8600 at zinc.

Improvements have also been made to several of the instant adhesives and launched two "toughened" products – Loctite 435 (clear) and Loctite 438 (black)

Arc Euro Trade

Over the last couple of years or so, a number of builders have followed Dick Stephen's lead in choosing the X3 mill as a candidate for CNC conversion. Recently, John Stevenson and Steve Blackmore have been working in cooperation with Arc Euro Trade (who supply the machine) to produce a highly specified kit of mechanical and electrical components to convert an X3 mill to CNC operation.

The conversion kit includes:

- NSK ballscrews mounted on pairs of angular contact bearings on all three axes
- 312oz.in. stepper motors driven by 7.8amp drivers de-rated to 2.8amps for cool running and reliability

- Custom made motor mountings and electrical enclosure

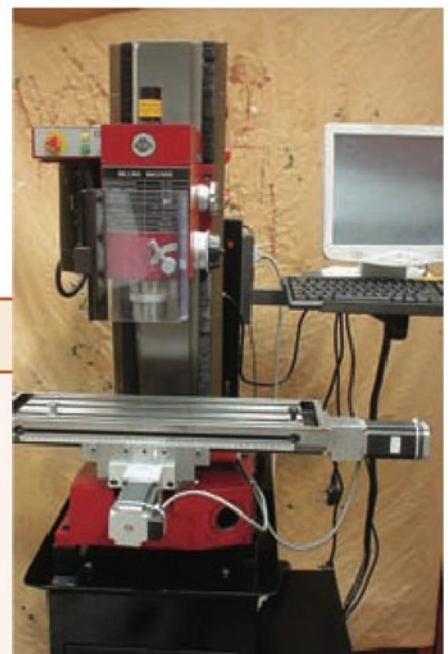
- Specified set up support time on both mechanical and electrical issues

- Picture story book giving detailed guidance for the home converter.

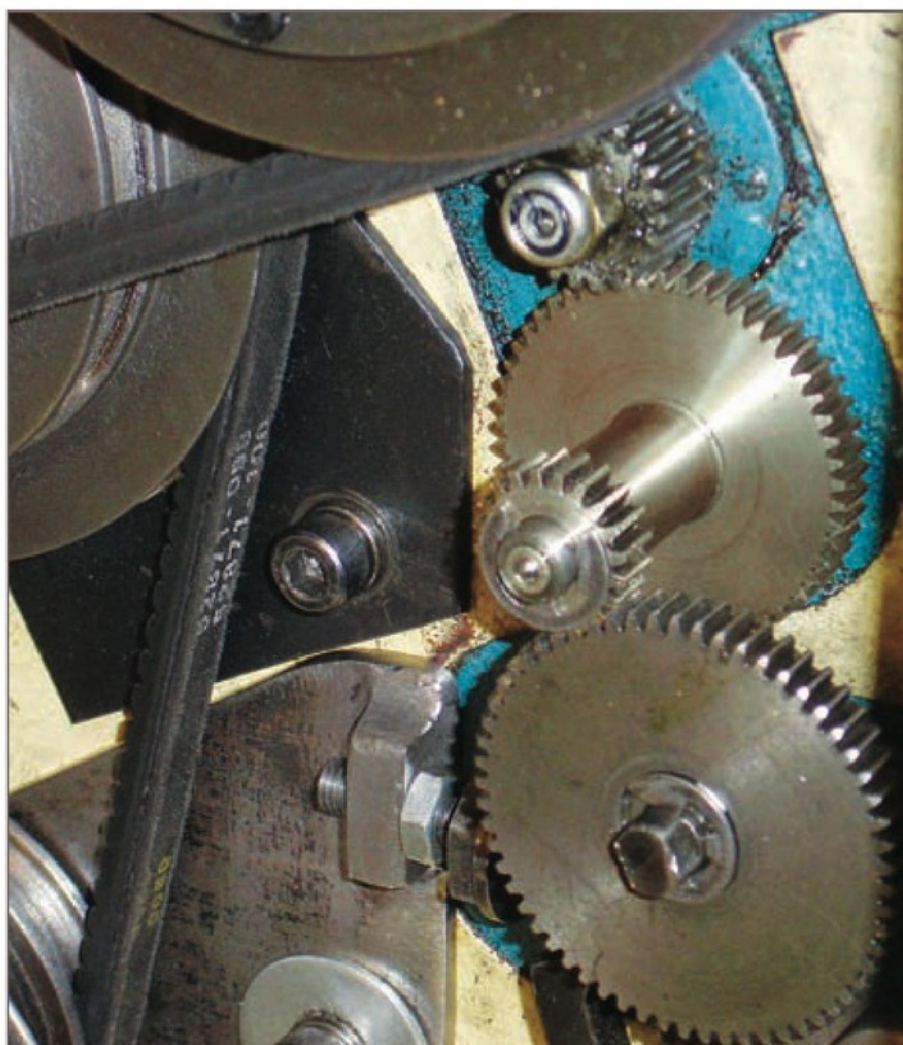
The chosen software is Mach3 which in addition to being able to control up to six axes, also permits the use of a webcam for lining up and centering. As this is accomplished within the Mach3 program, positional accuracy is maintained. The resolution of this capability is claimed to make it easy to detect moves of 0.001in.

The conversion kit is available from Arc Euro Trade, and an additional facility is available for those who would prefer to purchase a ready built machine. In this latter case, the machine and kit are passed to John Stevenson for conversion.

For further details of the X3 and conversion kit, contact Arc Euro Trade at 10 Archdale Street, Syston, Leicester, LE7 1NA, phone 0116 269 5693. If you wish to explore the option of a ready built machine, contact John Stevenson in the first instance by email to john@stevenson-engineers.co.uk



IMPROVEMENTS TO THE CLARKE CL500M ②



4. The installed compound gear for fine feed.

Following on from part one in the last issue of MEW, this second part of the article deals with the three other modifications previously discussed, the finer self-acting feed, the modification for left hand screw-cutting, and the calibrated hand wheel for the mill/drill head.

Finer self-acting feed

The preferred machine set-up would contain a Norton quick-change gearbox. However, on this machine, the self-acting feed is operated by changing the loose screw-cutting gears to give as low a ratio as possible between the headstock and the

leadscrew. However, changing from screw-cutting to self-acting feed and vice versa is fiddly, involving removing E-clips, work with spanners, and changing loose gears. This modification reduces the amount of work and the number of loose parts. It also reduces the ratio further, hence improving surface finish when normal turning.

As supplied with the machine, the gear train for normal turning is as shown in figure 4. All gears are 1 module. The 50 tooth gear and the 30 tooth gear shown in this figure, are mounted on a splined shaft, with a spacer between, hence there are 5 parts for this shaft (including the E-clip holding the assembly onto the axle. These parts were replaced by a single part

Jim Wilks describes further changes which may also be applied to the "clones" of this machine from other suppliers.

(excluding the E-clip.) Details of this part are shown in Sketch 10. This gear unit was made from phosphor bronze as this was available, but carbon steel with a plain bush could have been used instead.

It was found that the centre distance between the fixed axes of the 24 tooth gear and the new replacement gear would allow a 51 tooth gear to mesh with the 24 tooth gear, giving a slightly lower gear ratio. The second gear of 20 teeth also reduces the overall ratio.

The original external gear ratio was:

$$\frac{24}{60} \times \frac{30}{60} \times \frac{27}{63} = 1:9.72$$

The leadscrew pitch is 2mm, and to cut a 2mm pitch screw, the following gear train is stated in the manual:

$$\frac{60}{36} \times \frac{56}{32} \times \frac{24}{60} =$$

1.4 : 1 with the headstock change lever in the RH position.

Hence, the internal ratio in the headstock must be 1:1.4 (5:7) with the lever in the RH position. By inspection, the ratios with the lever in the LH position are 50% of those in the RH position, i.e. (5:14)

The original overall ratio is therefore:

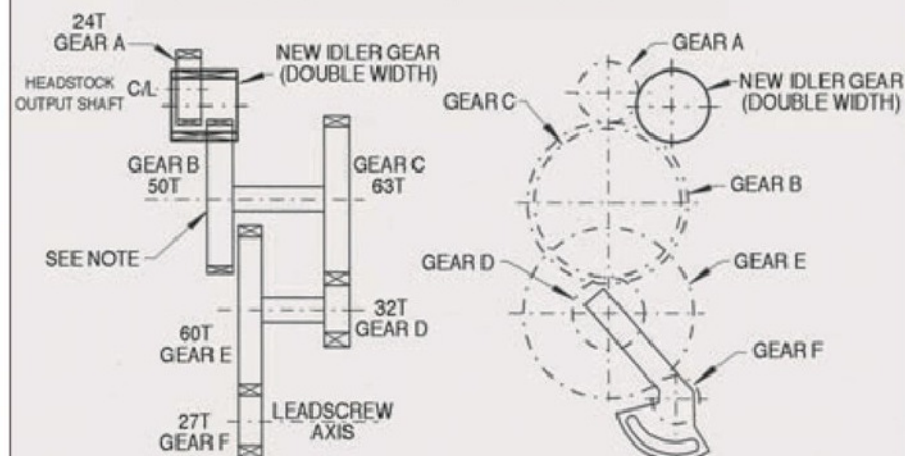
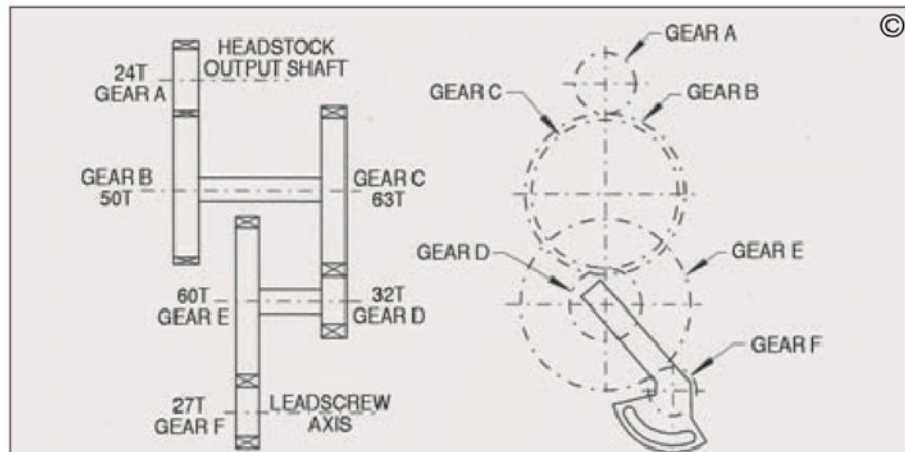
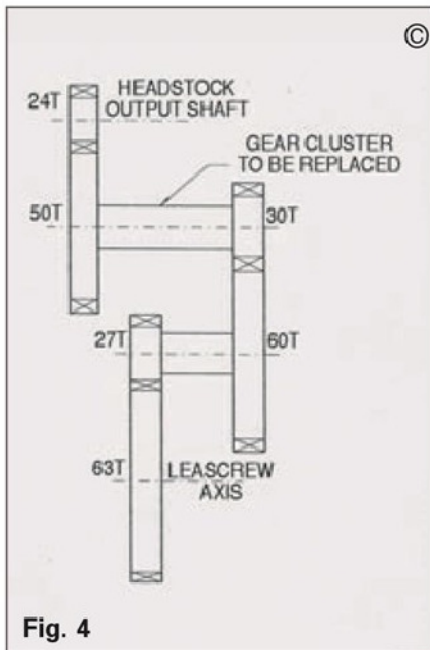
$$\frac{1}{9.72} \times \frac{5}{14} = 1:27.22, \text{ i.e. } 0.073 \text{ mm per rev.}$$

The new overall ratio is therefore:

$$\frac{24}{60} \times \frac{30}{60} \times \frac{27}{63} \times \frac{5}{14} = 1:33.32, \text{ i.e. } 0.060 \text{ mm per rev.}$$

Also, the gear mounted on the leadscrew axis slips onto a splined shaft and is held in position with a spacer, a washer and an M6 nut. The spacer and washer were replaced with a single piece as shown in Sketch 11. See photo 4 for the installed compound gear.

A project planned for the future, is to replace the $\frac{27}{60}$ tooth compound gear to simplify gear changing further. As an aside, the gear cutting was carried out with a single point fly cutter, which was ground to shape by comparing it with the supplied change gears. The gear profile was found to be perfectly satisfactory for the low speeds used for screw-cutting.



- NOTES:**
1. GEAR A
51 TEETH; 1 MODULE; PITCH DIA. = 51.00mm
20° PRESSURE ANGLE; ADDENDUM = 1.00mm
DEDENDUM = 1.16mm; TOTAL DEPTH = 2.16mm
 2. GEAR B
20 TEETH; 1 MODULE; PITCH DIA. = 20.00mm
20° PRESSURE ANGLE; ADDENDUM = 1.00mm
DEDENDUM = 1.16mm; TOTAL DEPTH = 2.16mm
 3. 10mm H8 TOLERANCE:
10.00/10.022mm DIA.

Sk 10 Gear cluster

Material: Phosphor-bronze

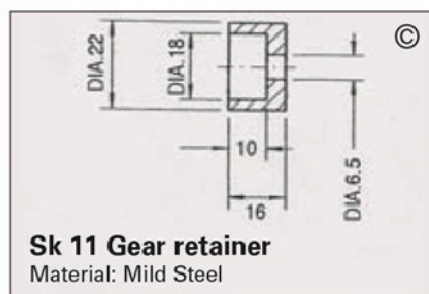
Left hand screw-cutting modification

A tumbler gear was considered, but rejected as there does not appear to be enough space in the belt guard/gear case to install it. It was therefore decided to install another idler gear between the 24 tooth gear on the headstock output shaft, and the 50 tooth gear at the start of the screw-cutting gear train.

A length of 2in. diameter bright mild steel bar was available. The largest 1 module gear to give an outside diameter of say 50mm has 48 teeth. An idler gear of 48 teeth was therefore chosen. As an example, **figure 5a** shows the set up for

Fig. 5b Setup for cutting 1.5mm pitch lh thread

NOTE: GEAR B IS MOVED AXIALLY OUTWARDS BY SLIPPING SPACER ONTO SHAFT FIRST, THEN SLIDING ON GEAR. THIS HAS THE EFFECT OF DISENGAGING GEAR B FROM MESHING WITH GEAR A. NEW IDLER GEAR CAN THEN MESH WITH BOTH GEAR A AND GEAR B.

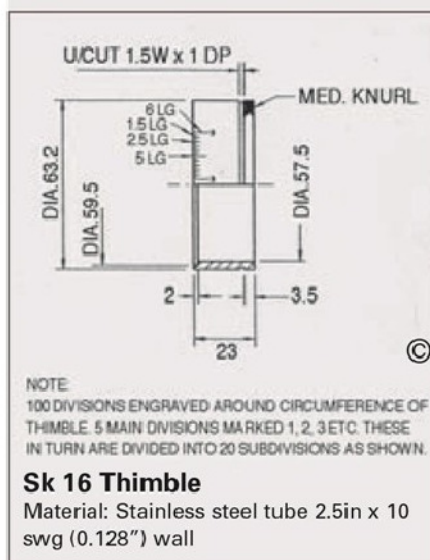
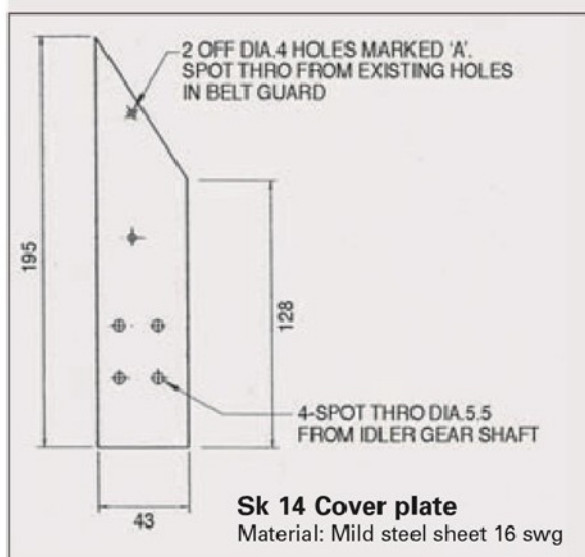
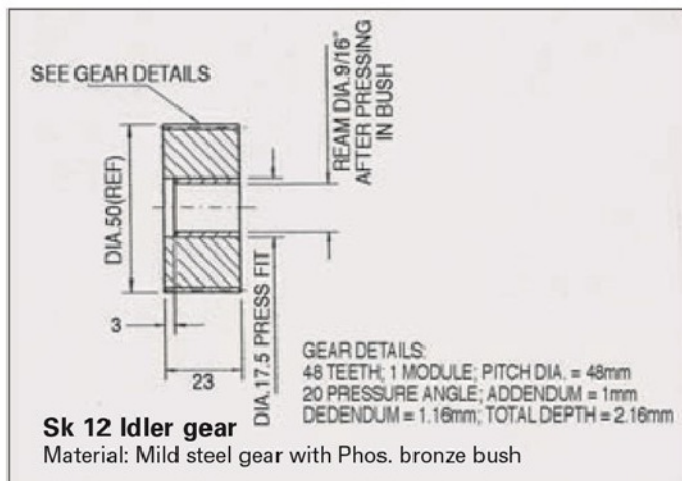


cutting a Right Hand 1.5mm pitch thread. The set up for cutting the equivalent Left Hand 1.5mm pitch thread is shown in **figure 5b**. This gear is mounted on a $\frac{1}{8}$ in. diameter shaft, which in turn is bolted to the inside of the gear case. This diameter was chosen as a $\frac{1}{8}$ in. reamer was available, and the shaft is robust enough allowing for a lubrication hole through the centre. For details of the gear, shaft and reinforcing plate, see **Sketches 12 to 14** inclusive.

The Idler Gear Shaft is bolted to the inside of the belt guard cover as shown in

photo 4. The existing belt guard cover has a small cover piece to close an opening at the side of the headstock. This is replaced by another more substantial reinforcing piece as shown in **Sketch 14**. The Idler Gear Shaft as shown in **Sketch 13** is offered up to enable the 24 tooth headstock output gear and the 50 tooth primary gear to mesh correctly, the fixing holes then spotted through, and opened out to 5.5 mm diameter to attach the shaft to the belt guard.

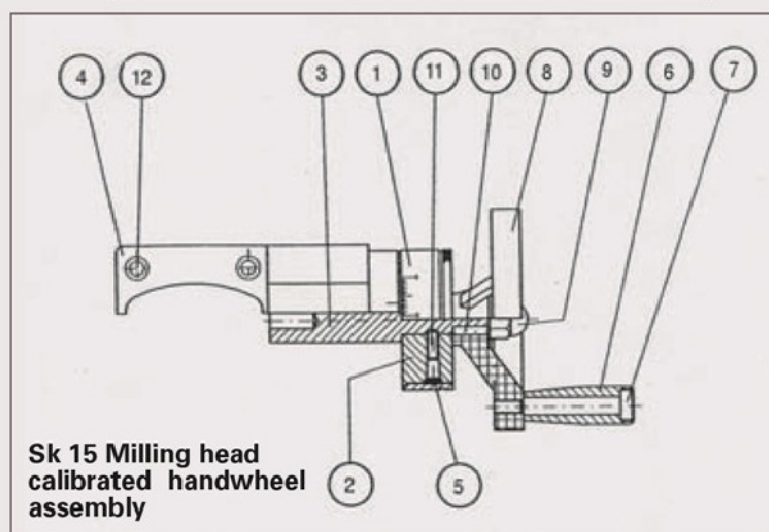
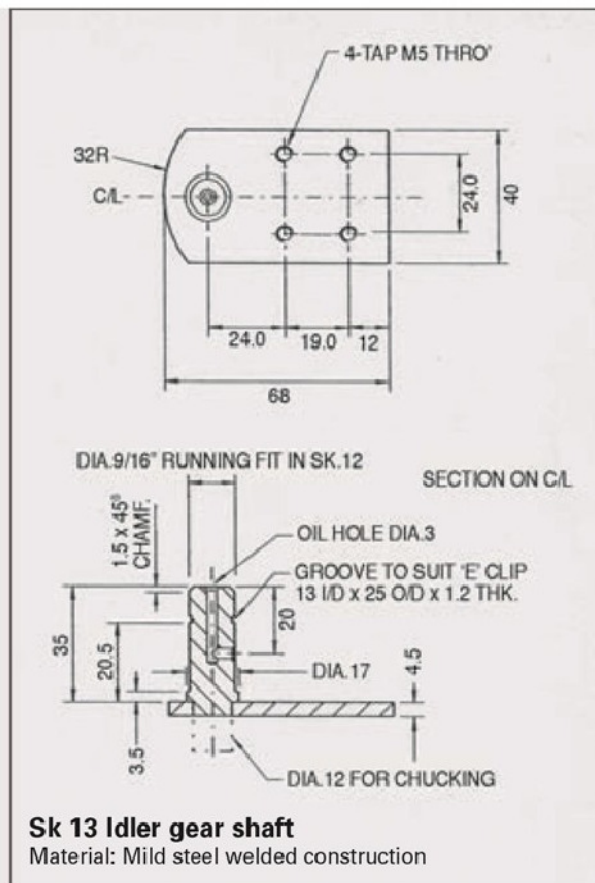
In operation, to change to Left Hand screw-cutting, the 50 tooth gear at the start of the gear train is removed from its shaft, the spacer slipped on first, then followed by the 50 tooth gear and then the subsequent gear for meshing with the next gear in the train, as shown in **figure 5b**. The new 48 tooth Idler Gear is then slipped onto the Idler Gear Shaft and retained with a 13mm 'E' clip. This procedure ensures that the 50 tooth gear is moved axially out of mesh with the 24 tooth gear, and the 48 tooth gear is wide enough to mesh with both the 50 tooth- and the 24 tooth gear, therefore changing



the direction of rotation of the 50 tooth gear. The remainder of the gear train is then identical to the equivalent RH thread. See photo 5 for the installed Idler Gear.

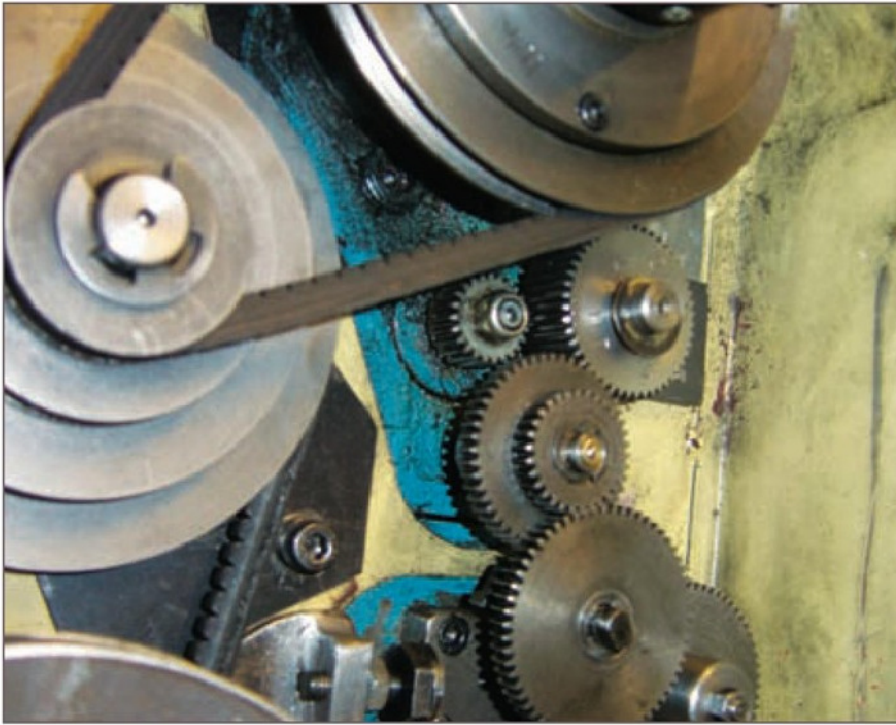
Calibrated hand wheel on mill drill head

In the milling mode, the vertical fine feed

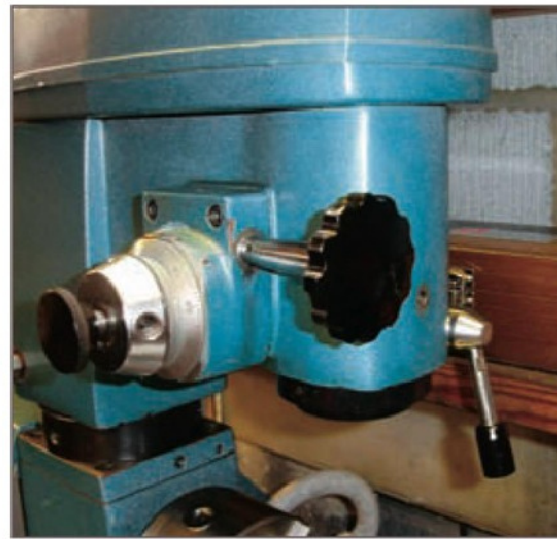
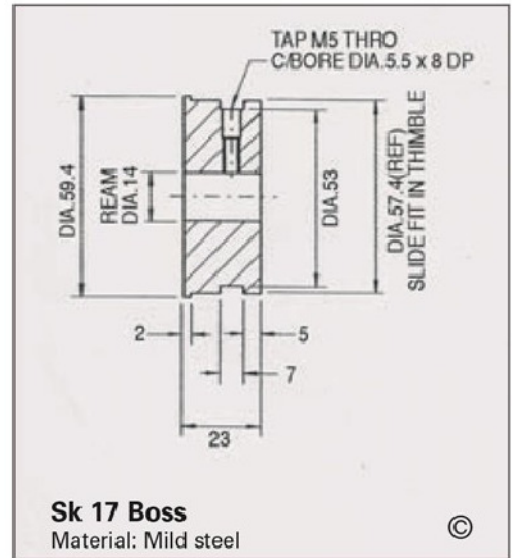


Parts List Associated with Sketch 15 Assembly

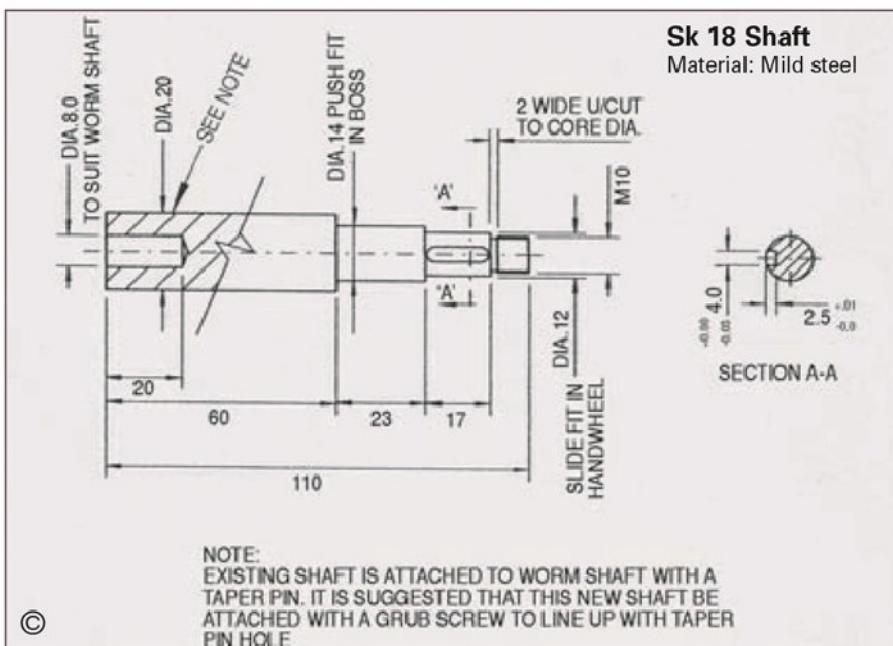
Item No.	Sketch No.	Description	Note
1	16	Thimble stainless steel #304	
2	17	Boss mild steel	1
3	18	Shaft mild steel	
4	19	Fixed reference mark stain. s & mild steel	2
5	20	Leaf spring spring steel	3
6	21	Loose handle stainless steel	4
7	22	Spindle mild steel	
8	-	Clarke tailstock handwheel cast iron	5
9	-	Acorn nut m 10 carbon steel phosphate treated	
10	-	Square parallel key 4 x 4 x 17 long key steel	
11	-	Hex socket set screw m5 x 12 long grade 12.9	
12	-	Hex socket cap screw m6 x 45 long grade 12.9	6



5. Idler gear is fitted for LH threads.



6. Down feed arrangement as received.



Construction Notes

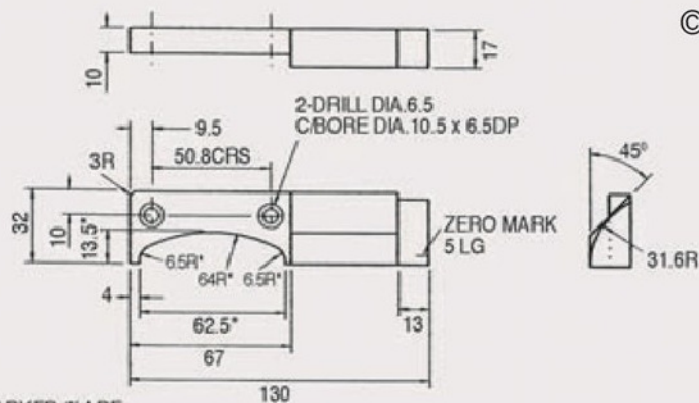
1. Boss is attached to shaft using item 11 hexagon socket set screw, deeply dimpled into the shaft.
2. This part (item 4 **sketch 19**) is shown as made from mild steel however, the section containing the reference mark was made from stainless steel to prevent rusting.
3. Leaf Spring (item 5 **sketch 20**) is made from a section of lawn mower rewind spring, and is similar to the leaf springs in the lathe thimbles.
4. Loose Handle (item 6 **sketch 21**) is shown as made from mild steel, however stainless steel was available and was used to prevent rusting.
5. Handwheel (item 8) is a spare part for the lathe tailstock; Part No ZHT 3000224 and is available by Mail Order from Machine Mart at approximately £8.31 inc. VAT.
6. Fixed Reference Mark is attached to existing cast iron housing by replacing existing cap screws with the over length screws shown (item 12).

See **photo 6** for the milling head vertical adjustment on the machine as-received, and **photo 7** for the modified shaft adjustment with the calibrated thimble installed.

of the milling head is controlled by a worm and wheel driven by a phenolic resin knob. The only calibration is on the coarse feed shaft, and the sub-division marking is in millimetres and 40 thou. only. To obtain a finer feed involves using a dial gauge and magnetic base to measure the movement of the milling head, which is inconvenient to say the least. Also, the plastic knob is small and awkwardly placed for ease of movement.

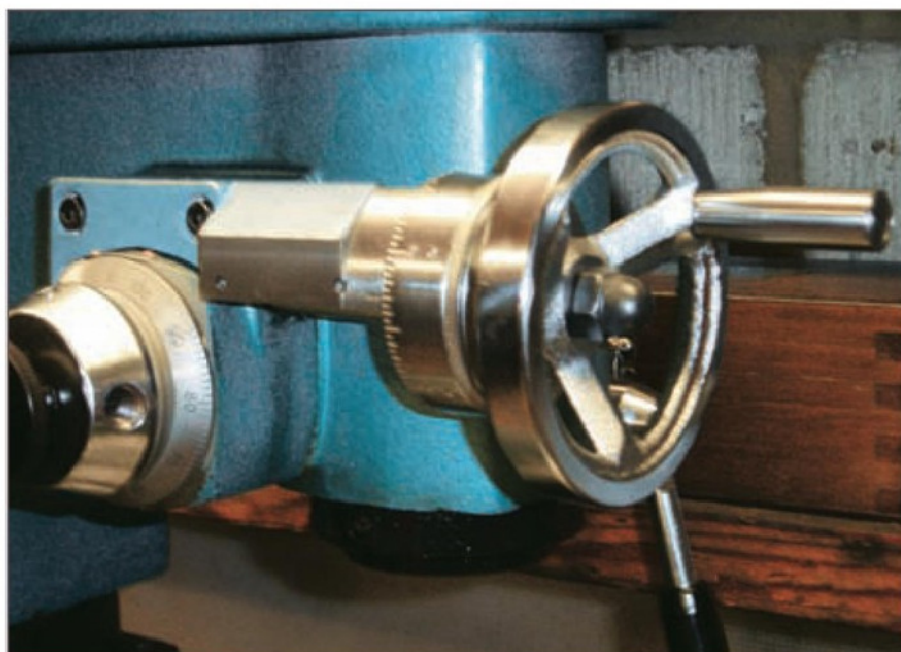
To overcome these drawbacks, the fine feed shaft was redesigned to include a calibrated thimble capable of being zeroed, and driven by a substantial hand wheel. The lathe longitudinal feed, cross slide and top slide thimble subdivisions are stated on the machine as 0.05 mm and 0.002 inches, which are near enough equal for practical purposes. For aesthetic reasons, the thimble was made to closely match the lathe thimbles. Also a spare tailstock hand wheel was obtained from Machine Mart to match the lathe, again for aesthetic reasons!

A substantial length of 2 1/2 in. O/D x 10 swg 304 stainless steel tube was available, and so this was used for the thimble. The calibration of the thimble was arrived at by setting up a magnetic base with a dial gauge bearing on the underside of the milling head. The plastic knob was marked so that the vertical movement could be



Sk 19 Fixed reference mark

Material: Mild Steel



7. Added graduated fine feed dial and hand wheel.

accurately measured for each full turn of the knob. One complete clockwise turn of the knob moves the milling head downwards by 5mm.

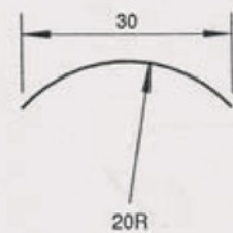
The thimble was marked with 100 divisions, so that each subdivision represents 0.05mm. The divisions were engraved with a scrap high speed steel router cutter ground to a 60deg. point. The numerals were added by stamping using a jig for alignment as engraving facilities are not available. To reduce the amount of stamping, only the full millimetres were marked.

When the new thimble was installed, it was found that rotating the fine feed shaft by exactly 19 turns actually moved the quill downwards by 96mm, instead of $19 \times 5\text{mm} = 95\text{mm}$. As this discrepancy represents the ratio between 0.002inches and 0.05mm, it is thought that the worm gearing between the fine feed and the coarse feed shafts was arranged to give a 0.200inch movement per revolution of the hand wheel rather than 5mm. As the other

machine sub-divisions are stated as 0.05 min and 0.002 inches and in practice do not cause any problems over small distances, it is felt that this discrepancy is unlikely to cause difficulties. See **Sketch 15** for the assembly and item numbers and **Sketches 16 to 22** for the detail parts. The associated parts list correlates the item numbers, sketch numbers, and construction notes.

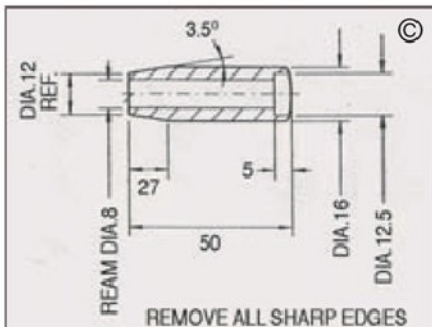
Conclusions and future work

During milling, the milling head is adjusted up and down and clamped to the circular column using a hand-tightened small



Sk 20 Leaf spring

Material: Spring Steel 24
svg x 6.5 wide



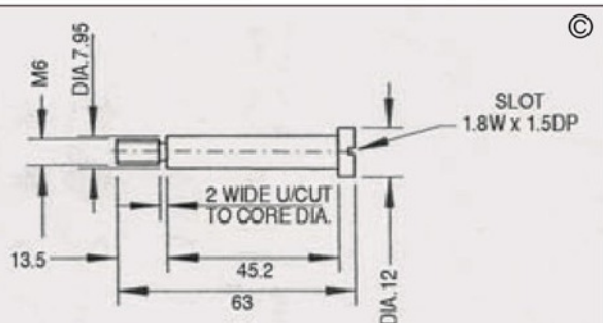
Sk 21 Loose handle

Material: Mild Steel

lever. It was found that there was insufficient clamping force to prevent the head from swivelling on the column, particularly when taking heavy cuts. The existing M10 threaded stud was replaced with a stronger silver steel stud, the M10 thread was tapped right through the casting and the hand-operated lever was replaced by a screwed rod joining nut. The greater thread engagement length was found to be necessary to prevent thread-stripping. This nut can be tightened using a 17mm A/F socket spanner and tommy bar to provide extra torque.

The success of the various modifications discussed here, was encouragement enough to try some more modifications later. One possible modification for the future would be to arrange a shear pin or overload clutch for the screw-cutting gear train, in view of the small tooth size (No. 1 module) and the known possibility of major crashes!

Watch this space!



Sk 22 Spindle

Material: Mild Steel

REVIEW OF THE CHESTER 626 MILL

Mike Haughton looks back over a year or more of using this popular vertical mill, factory fitted with an Align x-axis power feed and 2-axis Newall DRO.

The story so far...

I have gradually progressed to a Myford ML7 lathe, constructed and used a Dore-Westbury vertical mill, refurbished a Centec 2A horizontal mill and added a Chester Craftsman 12in. swing x 18in. lathe, an import. Current workshop projects include a Quorn tool and cutter grinder, a Jacobs gear hobbing machine and a Centec Automil refurbishment. Having sold the Myford and Dore-Westbury privately it was time to add a vertical mill that matched the capacity of the Craftsman lathe.

Choices, choices!

In common, I suspect, with most Model Engineers my ambitions are towards bigger machines, the only limit, other than budget, being the physical size and weight limitations of the "shop". We all want quality, capacity, versatility and precision, but don't want to pay for them! My self built Dore-Westbury vertical mill was a fine machine and gave years of good service but, for heavier work, it lacked rigidity (mass), capacity and had a round column; with all the attendant problems of relocating the cutting tool when the head was raised or lowered. It also had a 2MT spindle, which I grew to dislike. Rejecting round column mills, I had at a stroke eliminated the ubiquitous round column "Taiwanese Mill-Drill" of the type originally made popular by Rong Fu and subsequently copied by all and sundry.

There are a number of small dovetail column mills available from Chinese manufacturers such as Sieg. See www.siegind.com and www.arceurotrade.co.uk. I rejected these as having too small a capacity and not having a knee. I had been unable to find, within my budget, a vertical milling attachment and raising block for either of my Centec Mills. I have seen photographs of a late Centec vertical milling head with quill and 30 Int. taper replacing the normal 2MT. A rare

beast indeed and expensive. Using both Centec mills had taught me that a rigid "knee" mill with a dovetail vertical column was a must, since this arrangement avoids the relocation problem and can deliver plenty of tool to table height and rigidity. To raise and lower the knee a screw lift is employed and this feature more or less ensures that the mill will be on a floor mounted cabinet, as the screw has to go somewhere below the base casting when the knee is down.

If you add the ability to swing side to side and tilt the milling head left to right, the generic name that seems to have been coined for this configuration is the "Turret Mill". The phrase "Turret Mill" appears to have been borrowed from Bridgeport (Adcock and Shipley in the UK, now owned by Renold)). However the Bridgeport head also moves forward and backwards on a ram and the business end nods. There have been dozens of Bridgeport clones made around the world but they are generally bigger and heavier machines (over a tonne) than I could install in my shop. (And I suspect the average UK Home Workshop).

Since 1977 Myford have imported and sold a range of VM series Taiwanese vertical turret mills, no doubt suitably reworked and fitted with UK motors and switches. I have a Myford catalogue, dated 1988, that details the VM-C; VM-E and VM-F models. The current version of this mill, the VM-E is expensive and used versions are quite rare. The VM-E has a table size of 30in. x 7½in. (760x180mm)

www.myford.com

Researching past copies of Model Engineer show that imported turret and knee mills of the VMC type have been around in the UK at least as long as the Myford versions. As usual, Myford choose their designs very carefully for their market segment. Many of the importers have exited the amateur market.

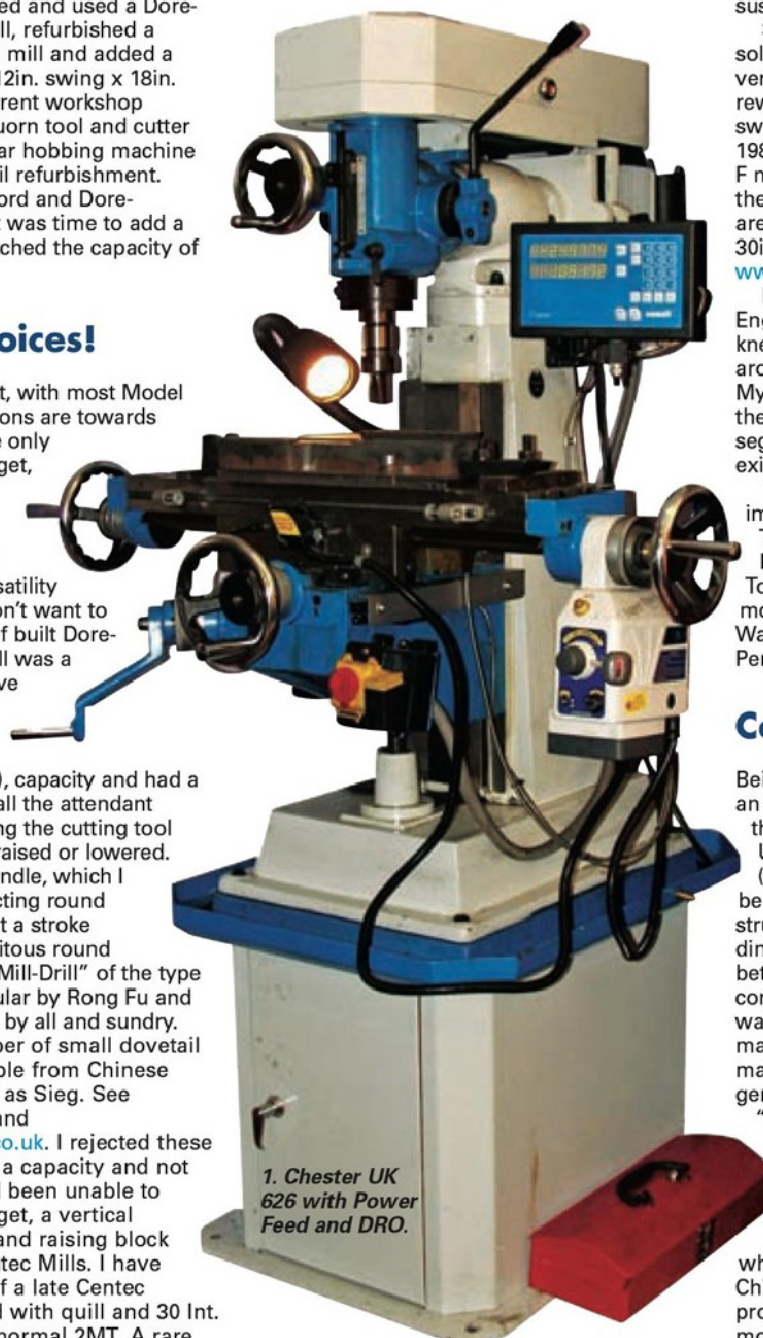
There are a currently a number of UK importers of similar sized 6in. x 26in.

Turret Mills originating from the Far East; Warco, Chester UK, Engineer's Toolroom, and maybe others. Similar models with 8in. x 30in. tables like the Warco AIS seem to have disappeared. Perhaps somebody can correct me?

Comparisons

Being a fairly cautious soul I constructed an Excel spreadsheet of the features of all the imported Turret Mills available in the UK with table sizes around 26in. x 6in.

(By comparison a Bridgeport table can be 32in. to 48in. long x 9in. wide.) I was struck by the numbers of small dimensional and specification differences between the various machines and concluded that either the importers didn't want to appear to be offering the same machine or there were several manufacturers in China producing a generic design. Somewhat like the "pattern parts" situation with cars and motor cycles. A Google search on the Internet for "6x26 mill" showed a similar situation in other countries. Lots of imports, not all the same spec. I have been told, by somebody who regularly visits manufacturers in China, that there are at least three factories producing 626/VMC mills. There are even more producing some of the mini lathes!



1. Chester UK 626 with Power Feed and DRO.



2. "Align" step down transformer on back of column.

A visit to Chester UK to see some of these mills in the flesh and compare the geared head mills (Lux and Super Lux) with the belt drive variety (626) convinced me that the model I was investigating was right for my combination of space, capacity, budget etc.

Getting the best price

I got the best deal from Chester UK at a model engineering show at Donington. Better than over the phone or website or a personal visit to the showroom! I took advantage of the show offer that included the two axis Newall DRO and power X-axis feed. My deal also included a clamp set and some additional tooling. Be prepared to bargain and stick to your guns. I chose R8 taper over 3MT and imperial over metric.

I was very careful to check that the mill would be delivered with the DRO and power cross feed fitted and the machine assembled on its base.

A friend, John, had bought a similar machine, a Warco VMC mill with power



3. Power feed and starter colliding.

feed, but no DRO, a few months earlier and we have compared notes then and since.

Delivery and installation

The machine arrived when Chester UK said it would. It came bolted to a pallet, fully assembled and embalmed in bubble wrap and just about limboed under the garage door frame on a pallet truck! Jack Cox has previously written (MEW 97) about the need for an engine lifter to assemble one of these mills. I agree. I needed one to get the machine off its pallet and then again to move it into position. As Jack commented, you will also need skilled help to move a machine of this size, I certainly did. (I was on crutches at the time! This is not a single handed task, even for the fit and robust.)

The machine weighs in at about 400Kg (900lb) and is very top heavy. It occupied the space I had cleared for it in the shop but I hadn't appreciated how much space you need around it for the table movement and to get to the right side to change the belts. So after a few weeks I moved it again. **Photo 1** shows my machine with the background electronically removed.



4. Mill electrics inside column.

You don't want to see my workshop mess.

As soon as the bubble wrap was off I powered up the machine to see all was well. The house circuit breaker (earth leakage) immediately tripped. Frantic phone calls to Chester UK! They gave permission for me to dig inside the electrics housed on the back of the column. The problem was the 110v step down transformer that supplies the Align x-axis power feed. A simple bit of rewiring and all was well without the need for Chester UK to send anybody out. Strangely, the Warco VMC also tripped John's domestic supply, but for different reasons and Warco decided on a replacement.

There was no sign of rust and the paint work was generally better quality than my Chester Craftsman lathe. The quality of the castings looks good. The painted parts look well prepared and the moving bits nicely surface ground.

In use, first impressions

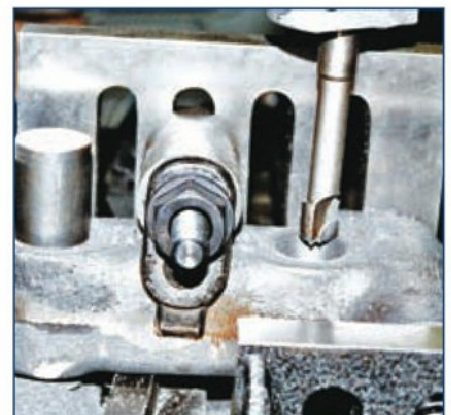
The sheer size and power of this mill, the power cross feed and the Newall DRO were



5. X-Axis linear encoder mounted on the back of the table.



6. NC style spotting drill.



7. Machining Quorn parallel bores.

far superior to anything I had owned previously. From the outset, I found myself just using the machine without any attempt to check its accuracy or indeed any attempt to dismantle it to make adjustments or rework. I just cleaned off the transport yak fat with WD40, filled the lubricator reservoir and started cutting. This machine should definitely not be regarded in the same light as some of the early oriental machinery i.e. as a set of castings requiring further machining and careful reassembly. Somehow, you instinctively know when a machine is working well.

I found this mill to be powerful enough and rigid enough to really shift a lot of metal quickly and accurately. I started with some 1in. dia. x 3/4in. Weldon shank carbide insert indexable endmills (Little Hogger from www.chronos.ltd.uk) held in an R8 split collet. I used them first on a number of iron castings and then some HE30 (6082). The results were very good indeed, the work ending up flat, square and with a good surface finish.

Manuals

Both the Chester and Warco manuals are a source of amusement. Better ones exist on the Internet from North American suppliers of similar machines or from the files of the Yahoo 626 Group. (Don't assume the spares part numbers read across though).

Toolbox

This red item can be seen on the floor in **photo 1**. The contents didn't agree with the manual manifest. Check ASAP after delivery.

The X-axis power feed

My mill was factory fitted with an Align AL-500S power Table Feed. See www.align.com.tw for details and manuals. This is a 110volt unit, the step down transformer being installed on the back of the column. **Photo 2**. I have found this unit eliminates a lot of tedious handle winding, yet doesn't introduce too much drag when turned by hand. Because it can advance the table more consistently than I can, the surface finish is much better. At the very lowest speeds available, around 3rpm, feed-rate 3/4in. per minute, the available torque falls off. Not surprising since the motive power is a brush motor with an electronic speed controller.

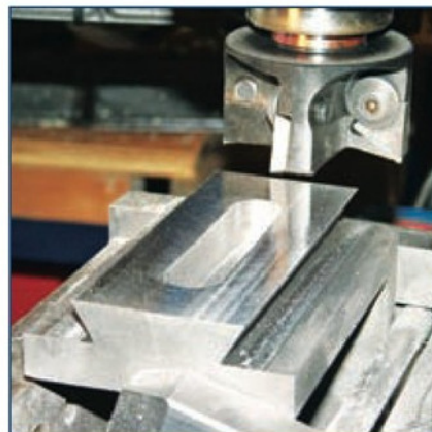
This AL-500S unit is rated at a maximum torque of 650 lb/ins, but lesser units from Align look superficially the same and have lower maximum torque ratings. Importers adverts seldom specify which "free" x-axis power feed will be supplied in their deals. Ask!

John's Warco VMC came with an Asong AS-250 self-fit unit and this unit is definitely less powerful and has a lower low speed torque than my Align unit, but looks superficially similar. I have been unable to locate a website for Asong. I definitely recommend the inclusion of at least one powered axis on a mill of this size.

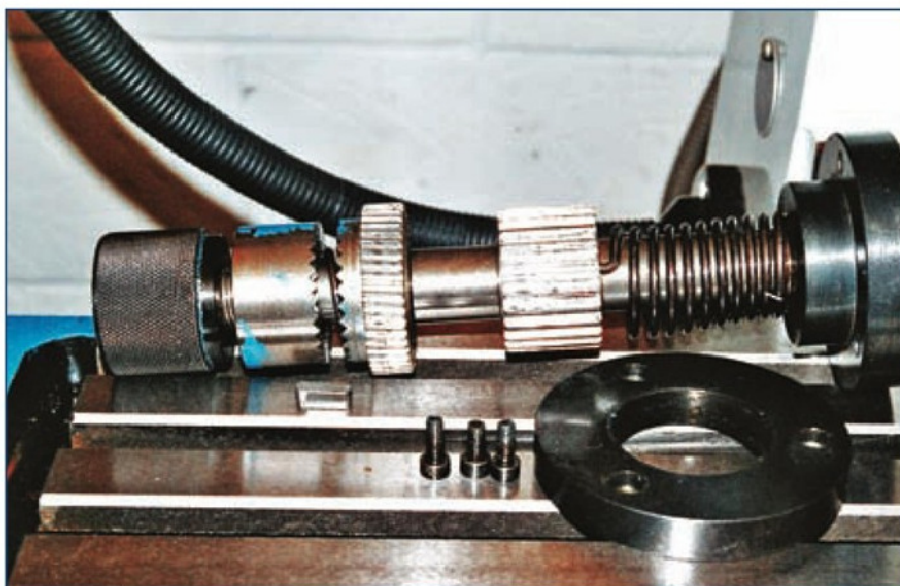
I have found two downsides to the Align x-axis power feed. One is the loss of



8. Lifting the motor pulley.



9. 60 mm diameter R8 four insert face mill.



10. Quill return spring and dog clutch.

about 20mm of x-axis travel when the table is well forward. There is a tendency for the Align unit to foul the on/off power switch. See **Photo 3**.

Secondly, and potentially more serious, is the failure to interlink the mill emergency stop button to the x-axis power unit. So if you get into an emergency situation you have to hit the E-stop and disengage the drive handle at the same time! The Mill's electrical controls are all installed inside the column and look like copies of Siemens. There is plenty of room to make modifications. **Photo 4**

Newall Digipac 2-Axis DRO

ChesterUK fitted the Newall 10 micron Microsyn™ linear encoders at the back of the table (X-axis), see **Photo 5** and to the right of the knee. (Y-axis) Both encoders (scales) are protected by lengths of 25x38mm alloy angle. The Digipac display unit is mounted on an adjustable arm attached to the machines main column. The unit is mains powered by a separate socket from the mill. In MEW 112 I have already described using the Newall DRO to measure the accuracy of the mill X and Y lead-screws. They were remarkably good

and the adjustable thimbles large and easy to read. The DRO indicated a backlash of 0.0045in. X and 0.0065in. Y as delivered. The Newall DRO gives remarkably stable readings to 0.0001in. and is accurate to ±0.0004in. per metre. Far superior to a Chinese scale, in my experience, however you pay a high cost differential. The Newall even shows the deflection caused by clamping the x or y axes and of course I don't see the X and Y backlash. The Digipac display is a fairly basic model for lathes or mills but it will instantly convert inches to mm. I have found the DRO extremely useful for setting out locations with a NC style spotting drill. The one shown in **Photo 6** is a bit oversized at 20mm. (Car Boot) This one is being used in an ER32 Collet chuck and is very good at not wandering off position.

When boring the castings for a Quorn Tool and Cutter Grinder it is necessary to maintain very closely positioned parallel bores in a number of castings. **Photo 7** shows how I achieved a good result with a 2in. boring head and using the DRO to switch repeatedly between bores. In **photo 7**, one bore has been plugged with a gauge and the third bored at right angles between the two angle plates.

Although the Newall Microsyn scales are far smaller than most glass scales, fitting the X-axis unit at the back of the



11. Checking keyless chuck taper adaptor run out.

table, **Photo 5** immediately removes 1½in., 38mm from the y-axis travel. My Chester 626 already has a slightly smaller Y-axis travel than the Warco. I have plans to relocate the X-axis scale to the front of the table as I find the lack of Y-axis travel very frustrating at times. **Photos 5 and 6** show a MS sub plate used to mount the large base casting of a Jacobs type gear hobbing machine. I found this plate useful to move the casting around to access all the machining locations. I took the base casting to a local steel stockist and they burnt a suitable piece of 15mm plate roughly to size for quite a modest cost. I then cleaned up the flame cut edges on the mill.

After some use, and after due consideration

Measurement of the run out of the R8 spindle taper with a 0.00005in. indicating clock (T500 Verdict) showed no run out. Impressive. So much for the theory that one has to replace the Chinese bearings to get good results. Naturally the run out increases as you add tooling and move further from the taper. I have had the best results i.e. lowest run out, with R8 split collets followed by a J&L ER32 collet chuck. Incidentally, the spindle uses 3 bearings, two at the bottom 7207, 6007 and a 6206 at the top. Not particularly expensive to replace should you have to. I have not had to adjust the bearing preload.

Running an indicator, mounted in a collet, over the table showed no more than 0.001in. deviation from end to end or front to back. Running an indicator mounted on the table against the rear dovetail gave a similar result. The paintwork on the mill remains good. The machine cabinet, which is substantially made, has a very thin coat of paint on the inside and I shall repaint here and protect the floor with marine ply.



12. Headroom, or lack of it!

Belts and speeds

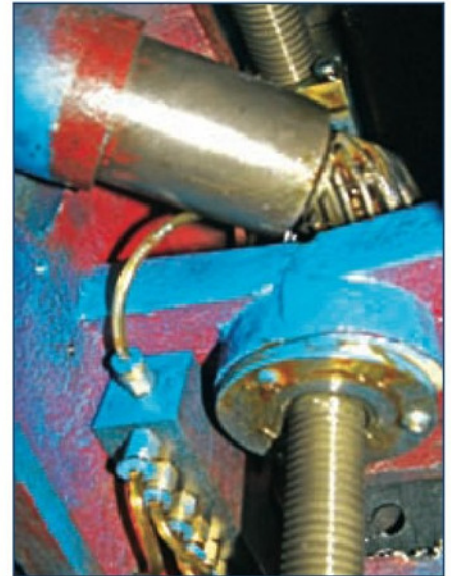
The mill was supplied with a spare set of Sunlux vee belts. Many users recommend replacing these with Gates or Fenner and some upgrade to poly vee belts. The drive is quiet but a lot of black belt rubber dust appeared pretty quickly inside the belt cover. The motor pulley was out of alignment. The pulley itself was very tight on its shaft and an improvised puller was used to lift the pulley into a better alignment. **Photo 8.** The motor platform casting still isn't truly vertical, a job for later, but I'm still using the original belts.

The speed range on 50Hz 240Volt supply is roughly 200 to 2300 in nine steps. I notice Hemingway www.hemingwaykits.com sell a kit to utilise poly vee belts and achieve lower speeds and easier belt (speed) changing. A 3 phase motor with an inverter sounds like an attractive, if more expensive alternative. In my experience lower speeds are not an issue unless you must use large fly cutters or large slitting saws. I used to use fly cutters a lot on the Dore Westbury, but don't on this mill as I have found an R8 60mm 4 carbide insert face mill (Arc Euro) gives better results, especially on cast iron. The end mill "lawn mower" pattern is avoided or much reduced. **Photo 9.** Incidentally, Arc Euro Trade very rapidly replaced this face mill, without a quibble, when I found it to be faulty.

The top speed of this mill will be too slow for those wanting to use small engraving cutters, tiny slot mills etc.

Panning and tramming the head

If I am working on smaller components with multiple machining operations (e.g.



13. Knee lubrication from below.

Vice, dividing head, angle plate(s), spin indexer etc) the table is big enough to mount three or more fixtures at the same time and use the rotation facility to pan the head to reach operations at the ends of the table. This works fine and saves time which would be lost loading and unloading fixtures from the table.

For those who may not have come across the term "trammng", it is probably of U.S. origin, and means adjusting the head to be truly perpendicular to the table. (See also Peter Rawlinson's article "Vertical Spindle Alignment Table" MEW Issue 116 page 30) It's only recently that I began to suspect that the spindle may not be truly at right angles to the table. My suspicions arose when I started using the face mill mentioned above, with light cuts it sounded like it was cutting on one insert and always on one side of the mill. A 0.001in. feeler gauge run between a machined face and the inserts seemed to confirm my suspicions. Rotating a dial gauge mounted in a collet over a sheet of float glass placed on the table showed a small (0.002in. over a 4in. swing) alignment error of the head which was removed by careful adjustment.

The Quill

The mill has the normal lever down feed like a drill press but augmented by a graduated hand wheel and worm engaged by a dog clutch. There is significant backlash in the rack and pinion that drives the spindle housing up and down and no means of adjustment for this backlash. There is, as is usual for drills and mills, a tensioning spring acting on the pinion spindle to lift the spindle up. **Photo 10** There seems to be no easy way to increase the engagement of the pinion into the rack. If you have done it let me know! As a consequence I rarely use the quill down feed, but lock the quill fully up and apply all cuts with the knee handle. This has a nice large graduated dial and if there is any backlash, it becomes irrelevant because the weight of the table and knee supply a very considerable downward force. With care, drilling even quite small holes (2mm) is possible with the knee.

R8 tooling

Because I had no R8 tooling before this mill I did start with some 2 and 3MT tooling fitted to R8 adaptors with a short home made dual screwed draw bar between the MT taper and the R8 adaptor. (Whit. to UNF) This worked but was very difficult to part afterwards. I started buying R8 tooling, mostly new imports. In a few instances the R8 drive pin in the spindle scratched the paint in the bottom of the keyway, indicating either the pin is too long or the keyway not deep enough. You can take a small "Swiss" file and carefully reduce the pin length, but it's pretty tricky to do.

R8 tooling is always tight or very tight in my in my mill, but I'm very reluctant to try to improve matters for risk of ruining the spindle. I keep a copper/leather hammer handy. Taking a micrometer to the parallel shanks shows no differences that I can measure. Say < 0.0005in.. Using the same method on an R8 / B12 chuck taper showed only the slightest movement. **Photo 11** Some R8 tooling that I have used a lot now shows concentric machining ridges on the parallel ground shank. If you paint this area with spirit marking blue or even felt tip you can sometimes see that the final grinding has not removed earlier machining marks. Talking to other users of imported R8 machines suggests that some slight variation of the size of the parallel part of the R8 socket is common.

Milling chucks

One reason why I like my R8 ER32 collet chuck is that you can do a lot of machining with different tools just by changing the collets around and leaving the R8 chuck body in the spindle. ER32 collets are limited to 20mm dia. though. Although a maximum table to spindle dimension of 315mm sounds a lot (less than the advertised spec) it is soon gobbled up with drill chucks (especially the keyless sort, **photo 11**) and table fixtures. **Photo 12.** The ER32 chuck is quite compact and with the DRO it's easy to move the table to one side change tooling and move it back again. I am aware that there is a school of thought that these collets should be used for work holding and not toolholding, however my experience here has been quite satisfactory.

There are several Internet reports and pictures of users making their own raising blocks installed in the round section above the square dovetails where the head swivels. There was also an article in MEW issue 87 by Adrian Kruger which described just such an exercise. Myford used to offer a 4in. rising block for the VMC and this is starting to look like a very useful option for the future. Because I have a lot of "legacy" screwed shank tooling I also use R8 Posilock and Autolock milling chucks. These are also usefully compact and the most secure milling chucks if you have screwed shank milling cutters.

Lubrication

The inclusion of a one shot lubrication system, which feeds the x, y and z sliding surfaces, is good, but can give a false sense of security. Many other bits in the table lift and motion screws will need periodic manual greasing. **Photo 13** is a view looking upwards at the knee drive gearing. The oil distribution on mine isn't great and would probably be improved with a non return valve after the hand pump. It's a once through system; and once through, it ends up over the base casting and into the drip tray. I don't use "cutting oil" but the drip tray isn't a place to leave any tools as it ends up covered with a nasty mix of cast iron dust and oil. Best removed with sawdust, I find. The shop vac will remove dry cuttings but not oil soaked ones.

Guards

I felt the Chester supplied rotating spindle guard was too small to be effective and I took it off. The machine didn't come supplied with the vertical rubber sheet that can be used to protect the vertical dovetail. The tapped holes are there and I plan to use them to add a swing away screen. John has a rubber sheet and swing away screen on his Warco. The rubber sheet arrangement does though, reduce the y-axis travel slightly and prevents you using the ground surface of the dovetail as a reference surface.

Tee Nuts and clamps

The tee slots on my mill are 14mm (the manual says 1/2in.) and the studs are M12.

Photo14 shows my clamp and tee nut set provided by Chester UK. It's good quality, very comprehensive and very useful. Beware, there are many different sizes of these imported sets around, make sure you get the right one for your machine, or damage to the table could result. It's a good idea to spread the upward force on the tee slots to prevent table damage. The shortest studs in my set are too long for some vices and fixtures so I often use M12x30mm Allen head HT bolts with a home made 10mm thick x 25 or 30mm washer to increase the head size. These washers' help to bridge the oversize slots in some fixtures aimed at the Bridgeport market. I usually make the 30mm size with a flat. See **Photo 15.** One minor disadvantage of the 626 table is that you can't fit tee slot devices longer than 25mm because of the end castings.

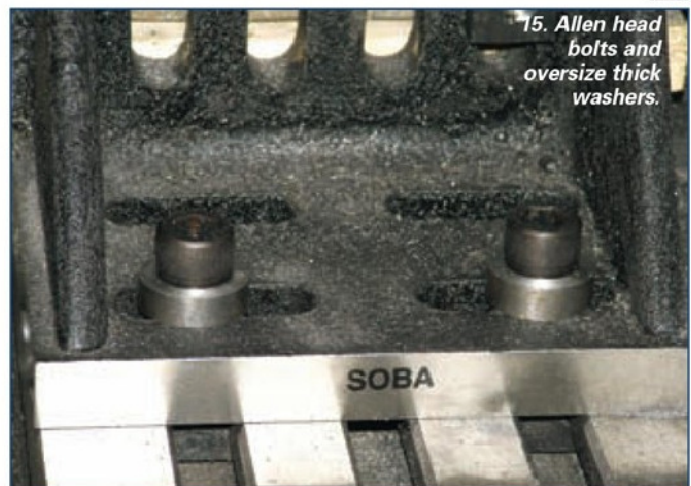
Conclusion

The Chester 626 is a very nice, capable mill and very good value for money. I don't regret getting the extra Align Power Feed or the Newall 2 axis DRO. I would certainly specify them again should I change to another larger (?) machine. The Newall DRO is simply in a different league in terms of ruggedness and accuracy from my previous set up using Chinese scales.

The delivered specification from different suppliers of these mills seems to be something of a variable feast. They are all similar, but not necessarily from the same factory. Even from the same factory / importer there seems to be quite a lot of specification drift. It will be interesting to see how much price drift there will be with increasing oil and commodity prices. If you are still doing all your milling on a lathe, the improvement in performance that's available from a 6x26 mill is impressive and worth going for.

Experience has shown that the often quoted saying "whatever you spend on a machine you will spend at least as much again on the tooling" is unfortunately true. But you can spread the tooling cost over time. I don't regret my switch to R8 tooling.

Any comments, or requests for more details mikehaughton@btinternet.com or to the Editor.





1. Completed unit with hand held box in foreground.

MORE POWER AT YOUR ELBOW 2

David Haythornthwaite describes the electronic circuitry used to power the Wabeco milling machine table drive described in the last Issue.

I am well aware that whilst many readers with electrical knowledge may be confident when constructing electronic circuits, to many of us "tin bashers" it is something of a black art. I therefore intend to describe the components and techniques used in the construction in some detail so that those in the latter category should be able to construct this item with a minimum amount of doubt and confusion. For any electronic engineers reading this, I am not an electronics expert but simply a hobbyist who has learned by practical experience.

Overall design considerations

Most of us are familiar with motors of both the induction type (AC) and of the AC/DC brush type of motor. Stepper motors are considerably different in that they run on DC current which is pulsed on and off several times per second. The motor

behaves similar to a ratchet gear wheel stepping round a proportion of 360deg. for each pulse that is provided by the control circuit. When under power, stepper motors are locked against rotation when they are not receiving pulses.

The circuit used in this project uses a bi polar motor controller bought "off the shelf" from Arc Euro Trade (SMD093064) and this is provided with low voltage pulses (+5v) to step the motor round. The pulses are provided by an oscillator using a simple and cheap 555 chip. The bi polar controller does most of the clever electronic control only requiring stepping pulses and a power supply in order to control the motor. The controller, has, in addition to the terminal for pulse input, a terminal to control the direction of rotation of the motor. Provide +5 volts to this terminal and the motor runs one way, do not provide the voltage and it runs in the opposite direction. The controller also sports a terminal called "Free". Provide +5v to this terminal and the motor becomes free for hand rotation instead of being locked.

Power supply

The power supply is a dual one and we shall call the two power supplies "Motor Supply" and "Control Supply". The "motor" side of the power supply provides 30v DC to the stepper motor controller and the supply must be capable of supplying 3 amps of current. You will see from Fig.1 that I run on a 2 amp fuse for the transformer secondary and the motor actually draws a maximum of 1.5amps, but Arc Euro Trade recommend a 3.2 amp supply. Also on Fig 1, may be seen the representation of the Arc Euro Trade driver with its row of DIP switches. Nos. 1-3 are used to set the microstepping rate, which for my purposes I have chosen to label "Speed", while Nos. 5-7 are used to set the current level to match the motor.

The purpose of the "control" side of the power supply is to run the 555 oscillator and to provide the low voltage (5v DC) to control both the direction of the motor and to power the "Free" terminal. This control power supply needs only to be able to supply about (say) 100 ma of current as it is used purely for control signals. Monitoring my unit, I see that it only draws about 25ma. My transformer has two windings, one providing 23v AC which when rectified with a bridge rectifier gives 30v DC for the motor controller. The second winding gives 10v AC which when rectified gives 14v DC. As this is to provide the 5volt supply for the control circuits the 10v supply is then fed to a 7805 voltage regulator to reduce the voltage to 5 volts. The pin out detail for the 7805 is given in Fig 2.

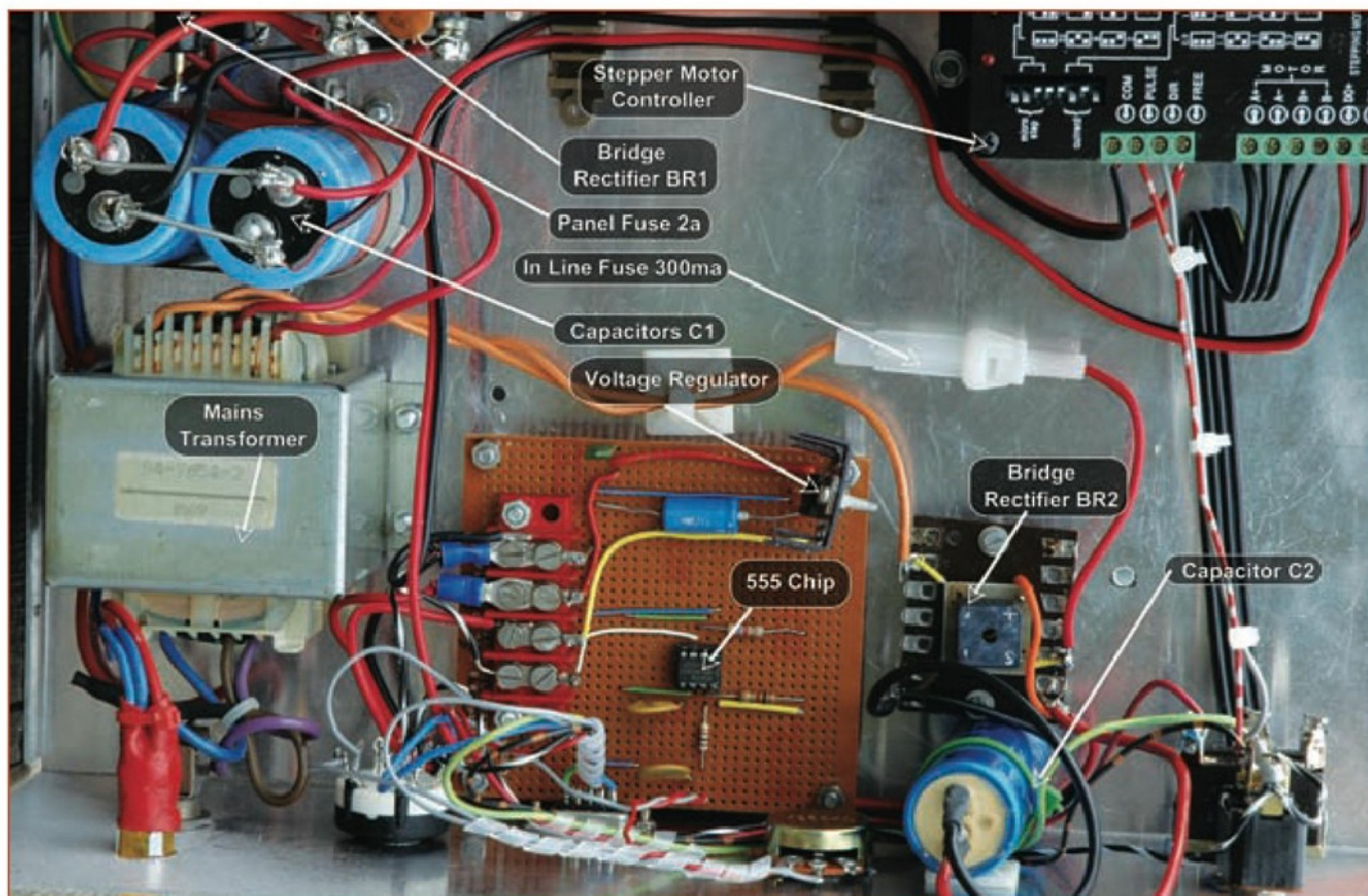
For the less electronically minded, the transformer provides two AC voltages and the bridge rectifiers BR1 & BR2 convert these into DC voltages which are not smooth. The electrolytic capacitors C1 & C2 smooth these DC supplies to give two smooth, constant DC outputs.

I was lucky in finding a suitable transformer with two windings of 23vAC and 10vAC which I had previously been given.

If you are unable to obtain a transformer with two suitable outputs, then you could use a transformer with one 25 volt winding, and use a second, smaller, transformer for the "control" supply. One of the cheap encapsulated DC power supplies, which come with almost all electronic devices nowadays could be adapted to supply the 150ma low voltage supply. I would however feed this to the input side of the 7805 regulator so that your control circuit has a regulated and stable 5 volt supply.

In selecting your power source you should bear in mind the following criteria:-

1. The "motor" supply is powering the bi polar stepper motor controller which has an absolute maximum input voltage of 40 volts. Your transformer should, therefore, not provide AC voltage of more than around 29v / 30v AC. Mine at 23volts works fine. If the voltage is lower than this then you decrease the power of the motor until at around 8 volts AC the controller will cease to work as the DC voltage has dropped below 10v. Lower voltages also affect the top speed of the motor as at lower



2. Interior view of main chassis with principal elements identified.

voltages there is not enough torque to follow the quick steps.

2. The "control" supply is powering the 555 chip via the 7805 voltage regulator. The input voltage of a 7805 must not exceed that specified by the manufacturer and this varies between +25 to +35 volts. The input voltage must also be 2½ volts above the output voltage, therefore you need a rectified DC voltage of between 8 and 25 volts DC on the input side of the 7805 regulator.

Mount your transformer in a suitable metal case and decide how you are to mount the bridge rectifiers and smoothing capacitors. My case was rather too big, but had been used before for a previous project. Having wired the mains side of the transformer, run the secondary wires via a suitable fuse to the bridge rectifiers. The output of the bridge rectifiers is taken to the large electrolytic capacitors to smooth the supply. Ensure that BR1 is capable of 3amp output. Mine was the type that bolted to the chassis for cooling which is convenient. Your capacitors C1 and C2 should be of a higher voltage than your off load voltage. Mine were both 64V and you will see from the photograph that instead of a 10,000 µf capacitor I used two 5,000 µf capacitors in parallel. These are substantial items that need mounting correctly. One word of warning. When these capacitors are charged up they contain a significant amount of power, which if not connected to any circuits will stay charged for some time. If you short out these terminals it

could weld your screwdriver to the capacitors!! Have a high wattage resistor – or a mains 15w bulb to hand and get into the habit of discharging these in a controlled manner before working on the circuit. Having assembled the power supplies, plug in the unit and check the DC output voltages.

Oscillator circuit

The 555 chip is actually a timer chip (whose pin out is depicted in **Fig 3**) which when wired into the configuration shown here forms an oscillator, i.e. the output of the chip will go from 0v to +5v and back to 0v at regular intervals depending upon the value of the 470kΩ potentiometer in the hand-set. Therefore the frequency of the output pulses and thus the motor speed is controlled by the potentiometer. You will see that the fast button on the hand control shorts out the potentiometer via a 4.2kΩ resistor R6. This has the same effect as rotating the potentiometer to the fast end of the scale. On my unit this works fine when the motor is warm, but when cold, the stepper motor cannot quite follow the fast rise in speed and stalls. You may like to increase the value of R5 to (say) something like 15 kΩ.

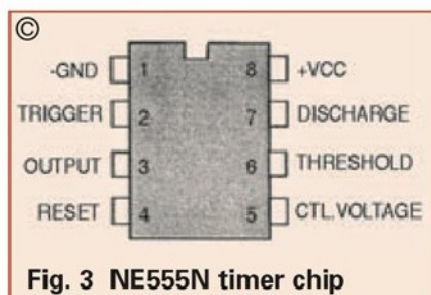
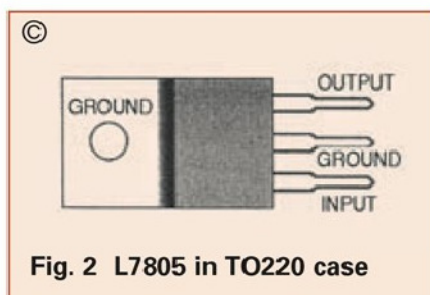
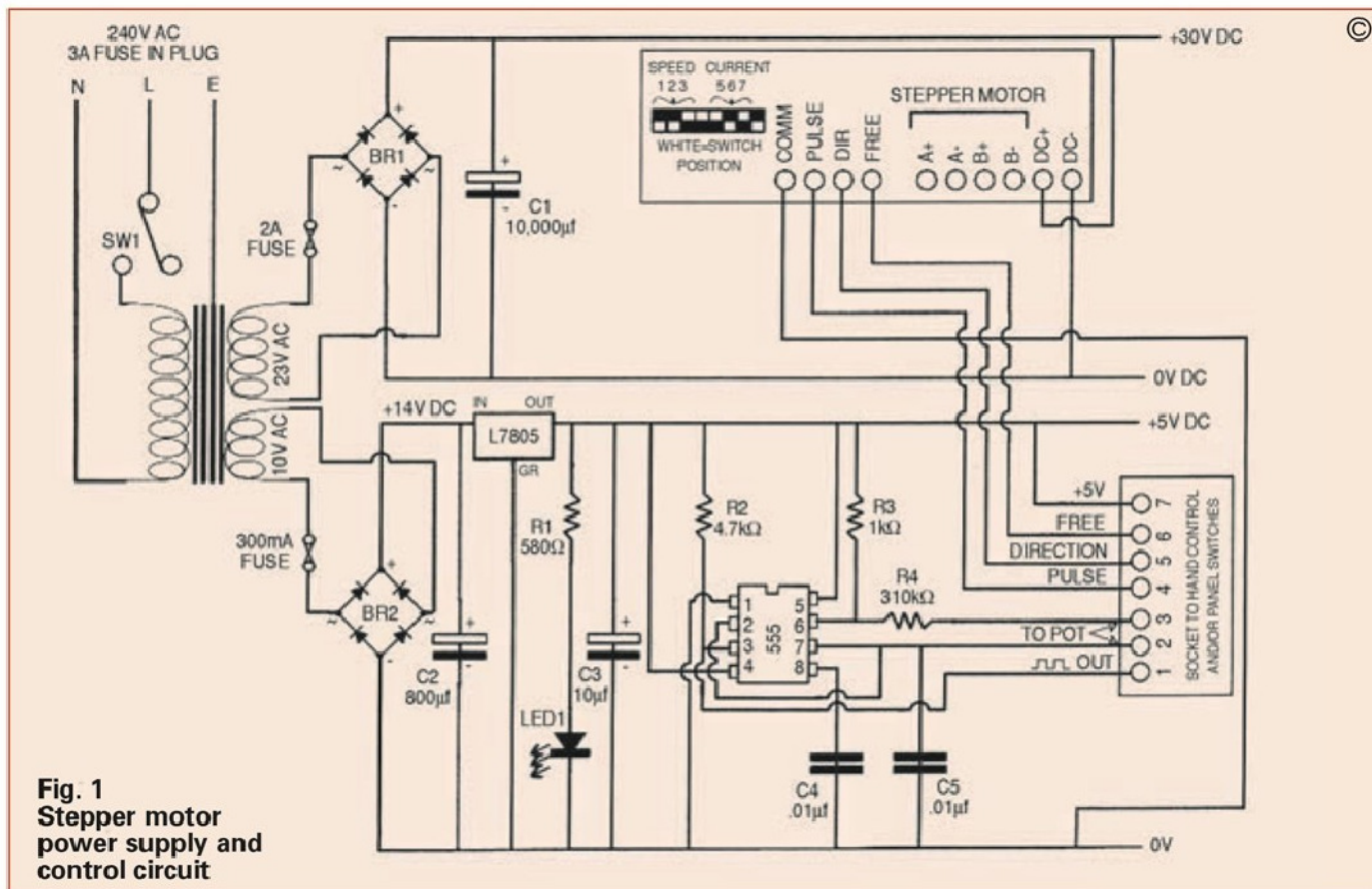
My oscillator was built onto a piece of Vero board, in the layout shown in **Fig 4** but it is a simple circuit and many methods of construction would be suitable. I mounted the voltage regulator onto the same board and fixed a strip connector to the board to serve as connection terminals for the power connections and oscillator output. Note

the configuration of the voltage regulator 7805 which is shown in a TO220 case. This chip can be purchased in various forms, but is usually supplied in TO220 configuration. If buying from Maplin the stock code is CH35Q. Once mounted on the circuit board you should bolt the regulator to a small heat sink with a little heat sink compound smeared on the joint to assist heat transfer. This heat sink could be made from a strip of aluminium sheet. Please note that this heat sink will be connected to your 0v line and therefore must obviously not touch the case or the positive lines.

Please use an 8 pin holder for the 555 chip. It makes soldering safer and easier and if you ever have to change the chip it makes it so much easier. A chip off the old block so to speak !!

On the circuit diagram **Fig 1**, I show R1 and LED1 as a way of indicating that the power is on. I actually used a mains neon indicator wired straight across the mains power switch instead. You can now buy 5v LED's with an integral current limiting resistor thus doing away with the need for R1 just put the LED between the +5 and 0v rails (Correct way round please).

The layout shown in **Fig 4** is shown from the "top" i.e. the component side of the board, but is obviously showing the copper strips on the underside of the board as if it were transparent. I have drawn the 555 chip and 7805 reg. transparent so as to show the breaks required in the copper strips beneath these components. I have a special hand tool for creating the breaks in the strips but careful drilling with either a drill ground to a shallow angle or a slot drill would be fine.



Once assembled, with the pot wired in temporarily, you can power up the board and see the nice square wave output between the negative and pulse terminals, if you are lucky enough to own an oscilloscope. Alternatively a good multi-meter should show about 2.5 volts between those terminals when set on ACv. Digital voltmeters don't always behave correctly when reading these square wave outputs.

Hand held control unit

A visit to Maplins (yes, my wife thinks that I really could take my holidays at Maplins) would secure all the components for the hand held unit (Fig 5). The cast aluminium case (110mm x 60mm x 30mm), switches, knob and

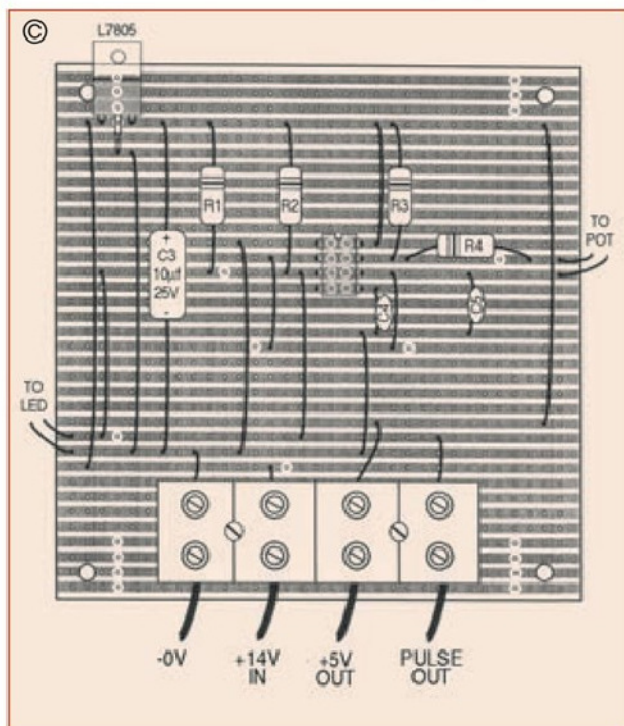
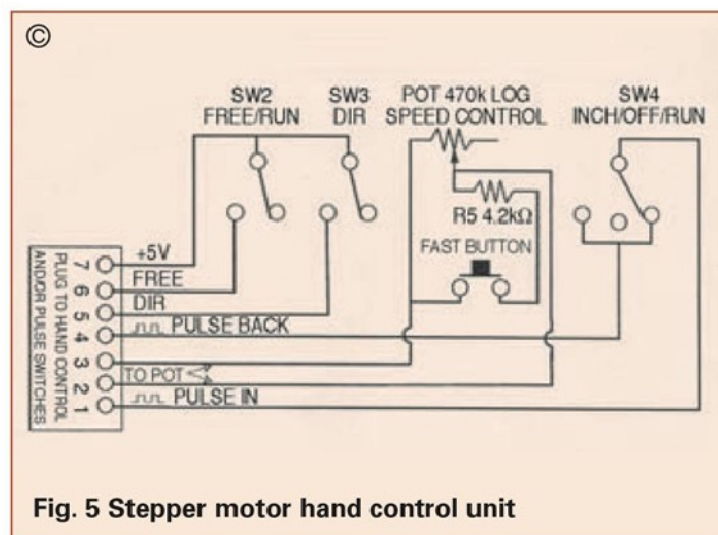


Fig. 4 Vero board layout (as viewed from above)



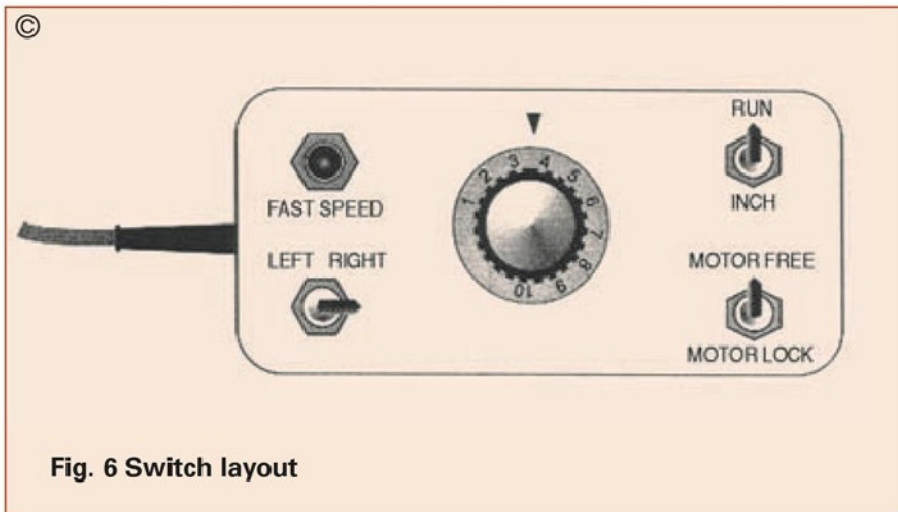


Fig. 6 Switch layout

cable outlet visible in the photo, all came from there, as did the 9 pin "D socket" to connect to the power supply box. Other suppliers are no doubt just as comprehensive. One switch deserves a special mention and that is the inch / run switch ref SW4. This was a miniature toggle switch from Maplin and in their catalogue appears to be referred to as "type C". The action is on - off - on and it is locking one way, non locking the other way, with centre off. Thus you can press one way for inch and the other way for the motor to stay on while you drink your coffee.

You will see from the photograph of the finished unit that I originally put all

the switches on the front of the main case. I found this to be most inconvenient and therefore changed the "free" switch to a 3 way 4 pole rotary switch which gives the three positions - "free, Panel Control, Hand Unit Control" - an unnecessary complication in my opinion.

Connecting the units

You will need to connect the stepper motor to the bi polar motor controller via a 3 amp 4core + earth / screen cable and a 4 or 5 pin plug. Mine was an ex W.D. one from the spares box.

To connect the hand-held unit to the power box, I used a "9 pin D Plug" as used on computer serial ports (Maplin again). Actually you are only using 7 wires plus earth/screen. For the cable I used a moulded plug and lead from an old modem and cut off one end to connect to the hand-held unit. It doesn't matter which pins you use for what so long as pin 1 from Fig 1 connects to pin 1 on Fig 5 etc. - if you see what I mean. Using an existing computer serial cable with a moulded plug saves a lot of fiddly soldering and looks neat. Most computer users seem to acquire many of these as they buy peripheral units, but if you can't purloin one, they can be bought from computer shops.

That is about it. Enjoy sitting about, watching your milling machine remove the metal while you enjoy that nice cup of coffee. But do remember to keep an eye on it won't you. Recently an American maker of Camper Vans was allegedly sued for not advising a purchaser the he couldn't leave the wheel of his camper to brew coffee in the back while it was travelling on the freeway under cruise control ! A sign of the times.

So let's be clear. - This unit will not stop the milling table running into your adjacent lathe, nor will it put sugar into your tea for you. It will however make milling much more enjoyable and vastly improve the surface finish that you achieve. I would be happy to answer telephone questions for any constructor who is stuck or puzzled.



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IN OUR NEXT ISSUE

Coming up in Issue No. 120 will be

The Business of Measuring

For the newcomer to the hobby, Bob Loader looks briefly at standards, then at some typical home workshop equipment.



Buying Engineering Stuff on Ebay

Mike Houghton offers advice for those new to E - commerce.



Renovating a Myford Super Seven Lathe

First of a series by Mike Thurgood describing an extensive rebuild.



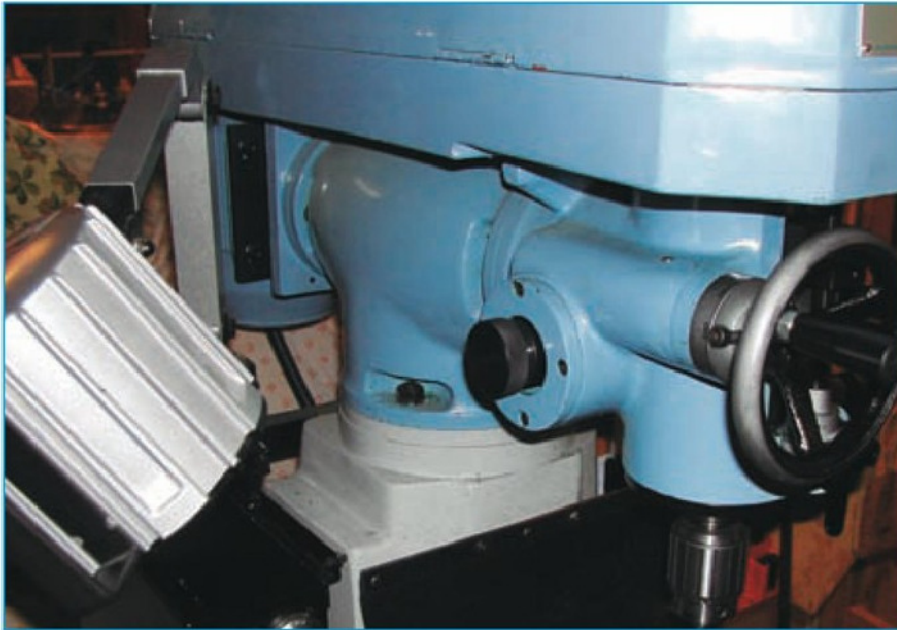
Taig/Peatol Mill CNC conversion (1)

Tony Jeffree describes the mechanical modifications.

Issue on sale 10th November 2006

(Contents may be subject to change)

MYFORD VM-E CNC RETROFIT 2



1. Existing layout for quill feed. Note the overhang of the belt guard.

In the last issue of MEW, (No 118) I described the application of ballscrews to the X and Y axes of the machine. In this concluding part, the conversion of the Z axis is considered.

Finding the best z axis approach

The Z axis was always going to be a bit more tricky than the X and Y feeds as there was no existing leadscrew to replace and I wanted to retain the option of using the lever operated drilling function. This latter is really useful for large diameter drills with Morse taper shanks or for co-ordinate drilling. **Photo 1** shows the quill arrangement. On this kind of vertical mill it is raised and lowered 90mm or so by a horizontally mounted gear which engages with rack teeth cut into the back of the quill. The gear is mounted on a shaft which carries the downfeed lever on the right hand end and a wheel on the left hand end which engages with a worm on the micro downfeed shaft. Clearly this worm and wheel must be capable of being disengaged so that the downfeed lever can work. This is done by an axial thrust, screwed collar on the left hand end of the shaft bringing the gear in and out of engagement. None of this immediately lent itself to a ballscrew drive.

Eventually I came up with three possibilities and I shall be interested to hear of others which people have devised:

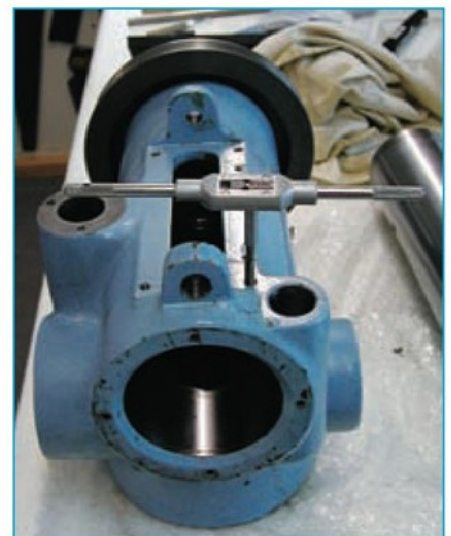
1. Retain the existing quill arrangement and fit the ballscrew to the knee thus raising and lowering the entire table assembly. This was quite attractive but for the loads involved and the difficulty of installing the stepper motor so that it would drive the screw. The only real option would be from below the machine bed and the Myford sits on a massive closed casting which I did not fancy hacking about for access.



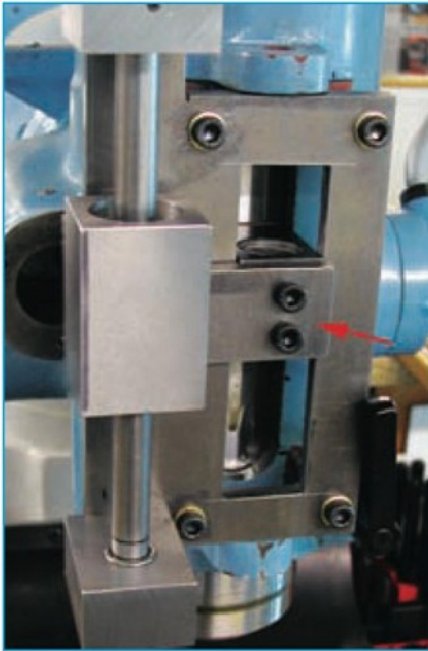
2. The Z axis mounting plate at an early stage, with quill in situ, and linking block in place.

In this, the second of two articles, Peter Edwards describes the addition of a ballscrew to the Z axis of this popular machine.

2. Fit a vertical ballscrew to the left of the quill casting and link the ball nut to a plate bored to a clamp fit on the quill nose. There was space to fit such a plate about 12mm thick without reducing the quill travel. It could be shaped a bit like the figure "8" with one loop clamped to the quill and the other (rather smaller) carrying a bush into which would fit a vertical shaft attached to the ballnut. Initially I liked this approach as it would be fairly straightforward. However, in order to fit the stepper motor directly to the leadscrew the latter would have to be displaced some way to the side of the quill casting in order to clear the spindle pulley housing. This in turn would make the "Figure 8" linking plate rather long, which would be intrinsically less rigid and might introduce backlash.
3. Use the existing block which is bolted to the front of the quill and carries the quill depth stop. This is a rigid mounting and by locating the ballscrew on the front left side of the head casting there would be room to mount the stepper motor in line with and above the screw while keeping the length of the link between ballnut



3. Tapping the holes for the pillars, paint not yet scraped from mating surfaces. To the right is the quill showing the register for the linking block.



4. Bearing blocks, ballnut housing and link plate. Removal of the two capscrews (arrow) isolates the screw feed and returns the quill to lever downfeed for drilling.

and quill as short and rigid as possible. It would also be a simple matter to unscrew a couple of bolts which would break the link between quill and ballnut thus returning the quill to lever feed mode.

Option 1 was soon ruled out from complexity and cost: it would have been a whopping stepper motor and driver as well as a 25mm ballscrew. Option 2 was the favourite for some time until I was considering how to fit one of the cheap Chinese DRO scales to the Z axis. The obvious way was to replace the existing depth stop and scale which use the block attached to the quill. When I investigated this it was revealed as a substantial attachment point to the quill and so the idea of the third approach developed quickly into the preferred solution.

Fitting the Z axis

The first problem was finding a way of mounting the ballscrew securely to the outside of the rough head casting such that it could be brought precisely parallel with



5. Top bearing housing (left) showing the spacing collar and grub screws used to locate it prior to fitting dowel pins. The bottom bearing housing (right) was bored to take the needle race as a light force fit.

the quill axis. Once again the accurate machining of the casting was in my favour. There is a flat on either side of the vertical slot on the front of the casting within which the quill linking block moves. Once the paint had been scraped off they were found to be machined surfaces which would take screwed pillars on which a plate could be mounted quite rigidly. This plate would then become the bed for mounting the ballscrew. **Photo 2** shows it at an early trial assembly stage. Between the last two sentences, however was some hefty work. I could have drilled tapping size holes for the mounting pillars with a pistol drill but I did not back myself to get them truly at right angles to the casting. So it was disassembly time again. Once the quill drive belts, intermediate pulley and casing had been removed and the quill feed dismantled, the quill was removed downwards using the table for support. The head was then unbolted from the flange on which it rotates. Once again the table and knee screw provide a useful means of support. The head casting was then transferred to the drilling machine for tapping size holes and **Photo 3** shows these being threaded. It turned out to be well worth the effort of dismantling the head as the progressive fitting of the various z axis components was much easier with the head resting horizontally on the bench.

The Z axis screw was mounted in two bearing blocks. The general layout is shown in **Photo 4** which also shows the

bite which had to be taken from the pulley housing. This was the only non-reversible modification which I had to make and the housing is reinforced by the stepper motor mounting plate which is shown. The top bearing is a pair of angular contact races mounted in a fabricated housing. I was keen to ensure that the axis of the bore for the races would be parallel to the mounting face and therefore decided to bore right through the block thus ensuring concentricity of both races. A turned collar was then located within the bore, halfway through the block, against which the two bearings abutted. The collar was initially secured by grub screws while the whole assembly was checked for alignment and then dowels were fitted. **Photo 5** shows the various components of the Z axis feedscrew mounting. The lower housing was bored to take a needle bearing from Arc Euro Trade's list. I chose one with fitted rubber seals to give some protection from swarf.

The feedscrew itself was modified in a similar manner to the other axes and details of my method are given below. **Photo 6** shows the top end of the screw with the extension shaft to take the bearings. The pin which reinforces the joint between screw and extension can be clearly seen. **Photo 7** shows the bearing block in place on the shaft.

The rather ugly rectangular outline of the bearing housings does serve a purpose. At least that's my story. They provided an easy way of mounting a swarf



6. The top end of the ballscrew showing the extension for locating the bearing and the coupling to the stepper motor.



7. Ballscrew and nut with top bearing in place. Note the PTFE sheet swarf shield screwed to the RH end of the bearing block.



8. All the Z axis parts in place, complete with swarf shield and DRO.

shield over the whole feedscrew assembly with the result shown in **Photo 8**. This shot also shows the location of the stepper motor vertically in line with the feed screw. The motor is mounted on a separate plate which rests on short pillars screwed to the aluminium reinforcement plate on the main pulley housing. This arrangement gives easy alignment of the motor and feed screw using a temporary collar with 6mm bore which fits over the top of the feedscrew and the motor shaft. Once that alignment has been set up the capscrews which hold the motor mounting plate to the pillars are tightened. The motor can then be removed from the plate and the temporary collar replaced with the Oldham



9. The setup used for grinding the hardened skin off the ends of the feedscrews. The wooden blocks in the foreground provide location. A wooden collar abuts the rest on the grinder and controls the length ground.

coupling. Realignment is ensured by the register on the motor endplate locating the recess machined in the mounting plate.

At this point I had a machine with three ballscrews and motors attached all of which gave less than 0.1mm backlash on any screw. I was confident that this figure would be reduced by careful adjustment of the bearings and ballscrews but it was an encouraging start. Trial cuts using handwheels temporarily fitted to the ends of the motor shafts gave almost effortless feed and a very smooth action (as long as

the motor leads were disconnected). So I was cautiously optimistic.

Machining the ballscrews

I had read about the difficulties which some people had encountered with machining the hardened ballscrews. Marchant Dice offer a machining service but I was reluctant to use that, not least because I suspected that there would be some on-the-job adjustment of the dimensions. So I went for two approaches. The tail end of each screw is supported in a light bearing which does no more than provide location. These bearings were mounted on extension shafts which I inserted into the appropriate end of the screw after carefully centring it in the lathe, drilling and boring. Loctite did the rest.

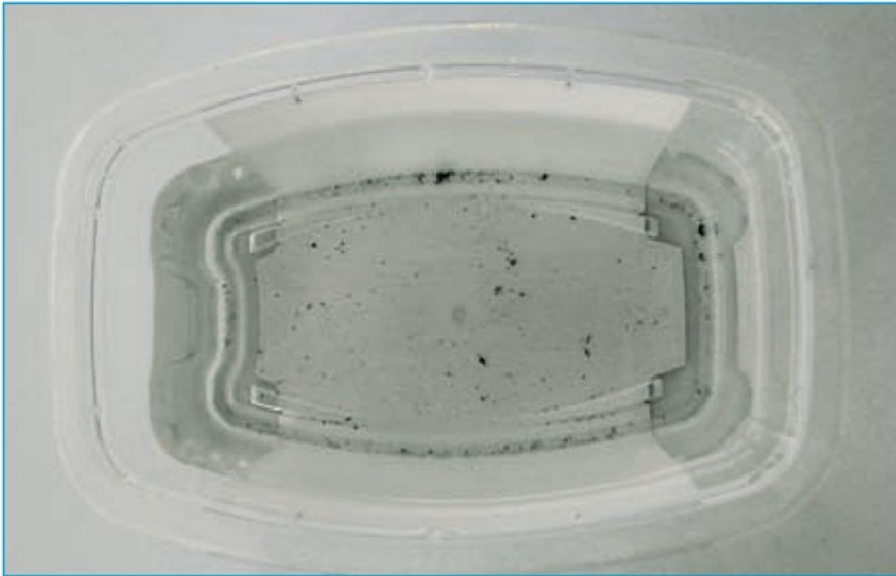
The other ends, however, take much more load and I preferred a design in which the ballscrew would locate into the bore of the extension shaft as being inherently stronger. The hardened skin of the shaft was specified as 1.00mm thick and it seemed that it should be possible to grind this away and then turn it with a carbide tool. My first approach was to mount a grinding head in the lathe toolpost and remove the skin in that way. But my grinding head and mounting were not sufficiently rigid. I had heard tales of people taking an angle grinder to the shaft to remove the skin but I doubted my skill in precision grinding in that way! The shafts are too costly to allow much experimentation. Finally I fixed up a support to hold the shaft parallel with the axis of my bench grinder and with the help of some wooden guides rotated the end of the shaft against the periphery of the wheel until it was reduced by about 1.5mm all round. **Photo 9**. In practice this was quick, easy and after a little trial and error reached a surface which my tipped lathe tools could handle without complaint. Interestingly, the depth of the hardness varied between the two lengths of ballscrew which I had bought. Cutting the screws to length, incidentally, was



10. Component parts of the ball loading jig.



11. Ball loading in process.



12. Illustrating the swarf and dirt washed out after just the trial assembly work.

achieved with a small angle grinder's cut-off wheel but I was impressed with the toughness of the "skin".

The screws were held in the lathe in a collet within which a split brass sleeve had been fitted. This was necessary because these are rolled ballscrews and the outside dimension did not match any of the 5C collets in my collection. By boring the brass collar in situ and marking it for repeated alignment with the collet I found the turned ends showed good concentricity with the ballscrew. This was checked by mounting the screw in one of the ballnuts and setting the ballnut with an indicator to run truly in a lathe chuck. The backlash adjustment in the ballnut was taken up and the indicator then placed against the fitted extension shaft to check runout.

The extensions were secured to the shafts by Loctite. That product's website gives a helpful guide to fitting for optimal strength. Nonetheless, I did not fancy the idea of the main extension, which carries the angular contact bearing, parting company with the ballscrew. So, being a "belt and braces" person, I fitted cross pins to that end of each shaft.

Go on - admit it

I have to come clean here and admit that in spite of all the warnings, I managed on one occasion to end up with a ballnut casing and a lot of steel balls rolling about the place. I suspect I am not alone in achieving this. At least I had taken the precaution of transferring the ballnut from its keeper shaft to the ballscrew over a container lined with some cloth so the worst did not happen. But I was faced with the question of getting 96 (that's right) 2.00mm balls back into the housing. If you should ever face the same situation with this particular design of ballnut you may find the following useful. Alternatively it may just give you a good chuckle.

I quickly realised that, unlike the ballnuts which have been described in Dick Stephen's articles, mine had four entirely separate rings with 24 balls circulating in each. The only way of replacing them would be from the end (I think). **Photo 10** shows a simple jig which helps with this. The large collar is machined with a close fitting recess into which the end of the



13. Showing the oil channels on the underside of the Y axis slide.

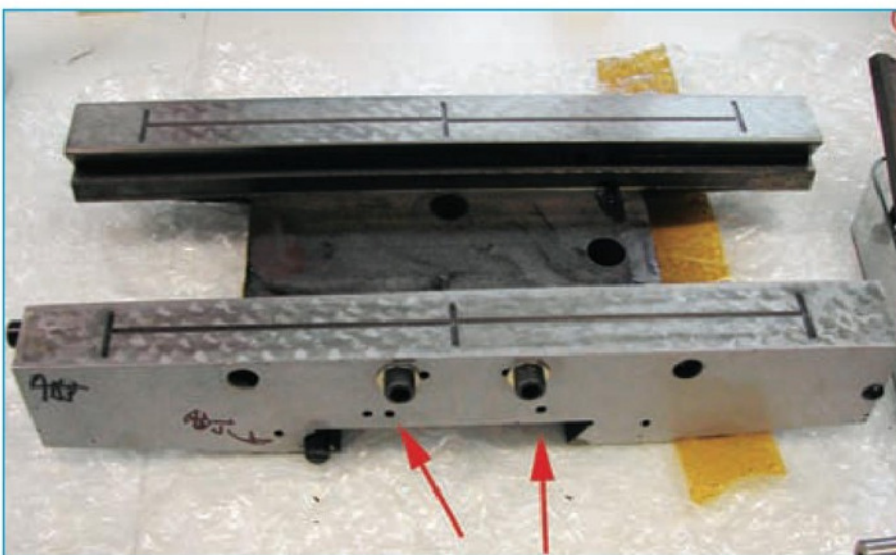
ballnut locates. The smaller hole through the collar is a sliding fit on the bar which is the same diameter as the keeper tube which comes with the ballnut. The end of the bar is turned down to be a close fit within the end of this keeper tube. The other end of the bar has a chamfer turned on it to encourage the balls to roll into the recesses in the nut. There is also a radial locking screw within the collar which allows the bar to be held in place. The wooden block just provides support for the collar and the hole drilled in it gives clearance for the bar to project below the collar. That is all rather wordy. **Photo 11** makes it clear, I hope. The ballnut is mounted in the recess in the collar; the bar is introduced to a depth such that balls dropped into the top of the nut will fall into the lowest groove but not right through the nut. A bit of trial and error will be needed to learn the best height for this. So do work over a container to catch the mistakes. 24 balls are gradually introduced and occasionally nudged into place with a clean toothpick. Once the whole ring is in place the assembly is lifted from the wooden block, the locking screw released and the bar raised carefully to the level appropriate for the second ring. Eventually all four rings are in place and you can start breathing again.

I did not plan to learn about this process but on reflection I now feel quite confident about dismantling the nuts at some future date when they need cleaning. Indeed, I did this voluntarily with the one nut I had used in all the machining and trial fitting of the three screws. It was salutary to see the amount of fine swarf which emerged in spite of the care I had taken to shield the nut. **Photo 12.**

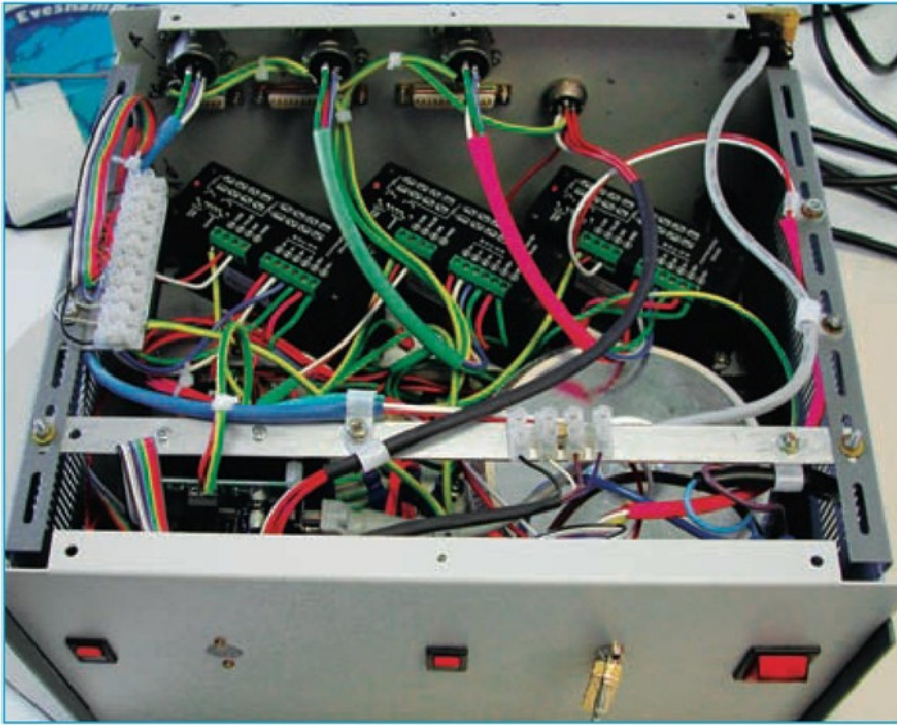
Two incidental improvements

I took the opportunity while the mill was dismantled to carry out a couple of small modifications.

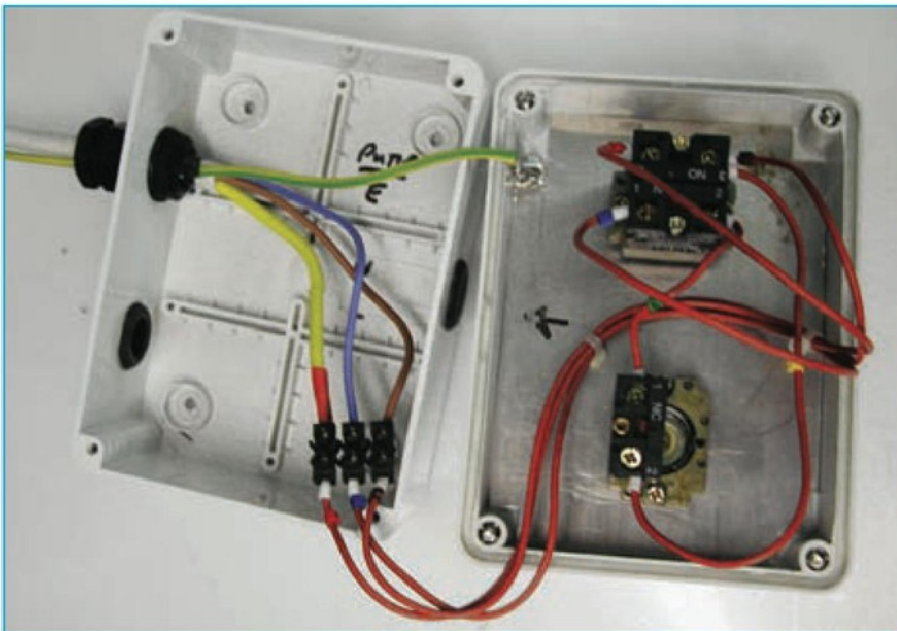
Photo 13 shows the underside of the y axis table with two oil distribution paths milled into the scraped surface. Unlike the



14. Red arrows indicate the holes drilled for lubrication.



15. Control box housing the stepper drivers (rear) and the second generation DeskCNC board mounted vertically front left below ribbon cable.



16. Interior view of new spindle control box.

similar oil paths elsewhere on the machine, however, there is no oilway to feed them. It seemed a sensible idea, therefore, while the table was on the bench to drill a pair of holes to provide for lubrication from outside. **Photo 14** shows these to which eventually oil nipples will be added.

The spindle control switches on the Myford are grouped on the top front of the control box situated to the left rear of the machine. I have never found this convenient for a right handed person. I therefore brought out the NVR switch and the emergency stop and mounted them in a box grouped with the other controls. **Photo 17.** They are mounted in a plastic box and I have stiffened the front mounting

panel with an aluminium plate as shown in **Photo 16.** This simple modification has removed a significant irritant in the day to day use of the machine.

Conclusion

I still have some work to do in order to have the manual drilling capability working to my satisfaction. The return spring on the original setup is a stiff wire coil. This has a varying rate which does not suit the new arrangement very well. I have some thoughts about using a flat coil clock spring in the space where the wheel was located for the micrometer downfeed of the quill. But that is still at the thinking stage.

I have completed the control side and now have a working cnc milling machine but that is only just the beginning as I learn how to get it to do what I want. The control setup **Photo 15** is pretty much as set out in Dick Stephen's article so I shall not repeat what is there. I have also taken a couple of Tony Jeffree's ideas from a later article for which I am very grateful.

The photographs show the absence of a top belt cover over the spindle drive pulleys. Before anyone needs to remind me about safety I should say that this is in production but was not ready for the camera. If you have read this far you will have realised that I am a self-taught practitioner who likes to try and solve problems in his own way. This probably causes those of you who have been well trained to wince at some of my approaches. I shall be grateful for any comments, which those more knowledgeable and experienced than I, choose to contribute. If anyone wishes to discuss what I have described in any more detail I can be contacted by email edwards@fullacott.plus.com.



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"X3-CNC Further Options." Article by Tony Jeffree MEW 113 March 2006

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01805 623486 www.marchantdice.com/

Arc Euro Trade 0116 269 5693
www.arceurotrade.co.uk/

Loctite www.loctite.com
Technical Data Sheet for Loctite 603



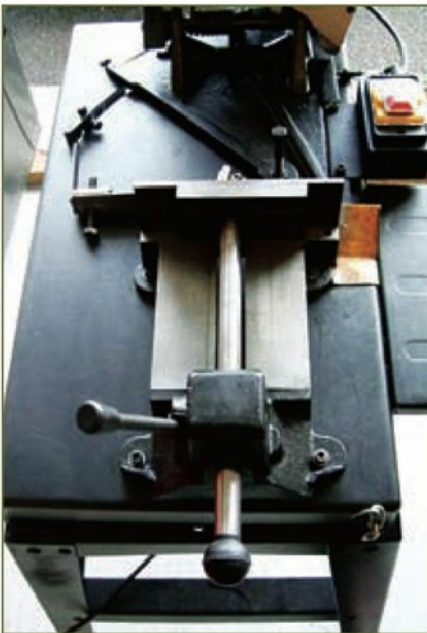
17. Nearing completion with controls conveniently grouped.

Background

To relieve the tedium and energy used in cutting off large section pieces of metal for projects, not to mention trying to keep to the marked line, I have invested in an economy Metal Cutting Band Saw. This is the bench top type that works only in the horizontal plane (it was the cheapest). It does however have three cutting speeds, is supplied with a metal stand and has an excellent quick action cam lock vice (Photo 1). This vice holds the work very well, (Photo2) but due to the clearance necessary to clear the blade guide, the moving jaw width (or lack of same) limits holding short stock (Photo 3). Work is held firmly by the edge of the jaw; provided a suitable distance piece is used at the other side of the jaw to keep it parallel.

REALLY SHORT WORK WITH A BAND SAW

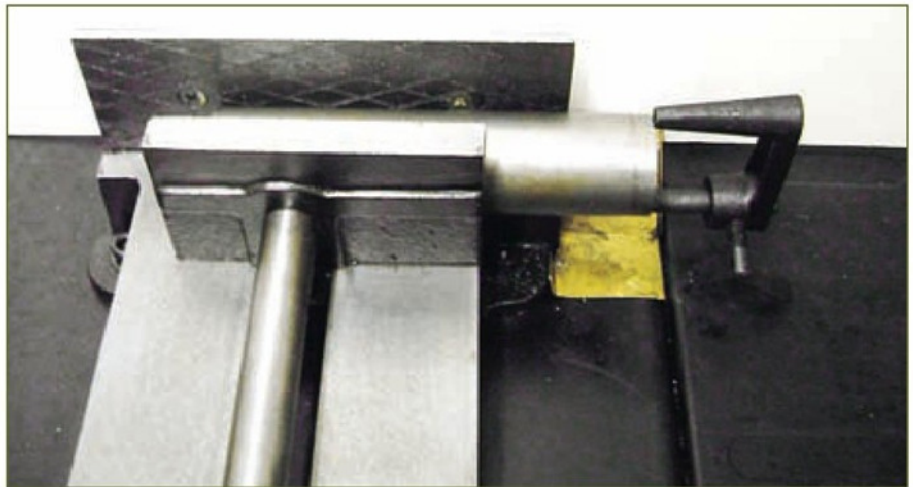
Bandsaws in standard trim are fine for cutting from long stock. Jim Whetren considers ways and means of handling small pieces.



1. The metal cutting bandsaw showing the quick action vice.

Adding angle

While pondering this situation, I tried using a piece of 1in. x $\frac{1}{2}$ in. equal angle the width of the fixed jaw, to hold the work at

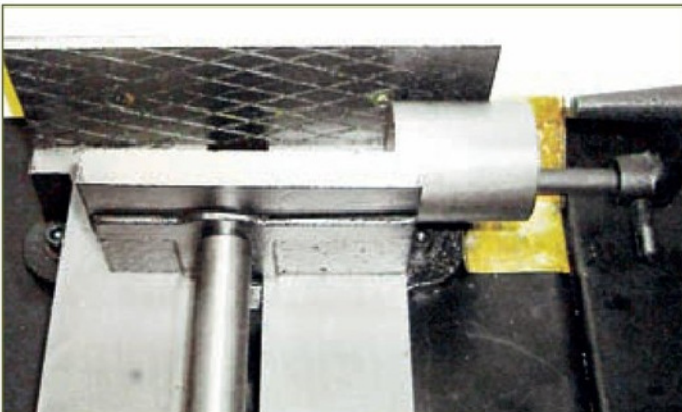


2. Long stock is held satisfactorily

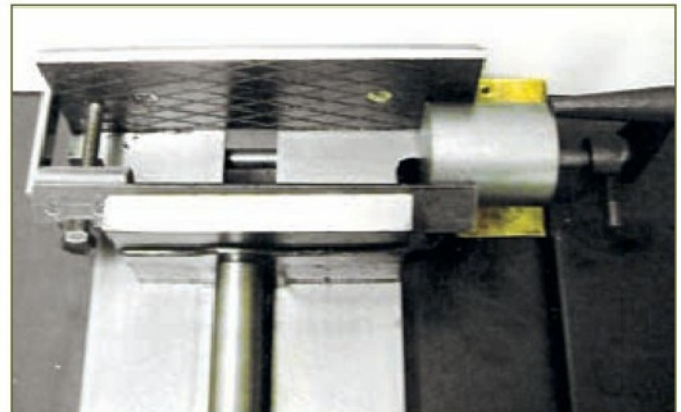
the extreme end of the fixed jaw. Angle was used as at the time I was playing with a piece of round bar and the angle provided a positive location against the bar (Photo 4). This was a resounding success, so I fixed a short length of 1in. square bar inside the angle, this supports an end stop and a jacking screw. Thus eliminating juggling with bits of packing and holding it all in place whilst tightening the vice.

I have since seen that one accepted method of addressing this problem is to

install a small vice attached to a wood or metal plate clamped in the main vice. I have tried various vices, but they would have to be too near the top of the main vice to enable them to be tightened, so I have stuck with the piece of angle. The only drawback found so far is that material smaller than about $\frac{1}{2}$ in. diameter or 1in. high, caused the angle to tilt forward and it would not grip. This was overcome by using a piece of scrap to bridge the two gripping edges of angle. As I could now securely hold less than $\frac{1}{2}$ in. diameter/thick,



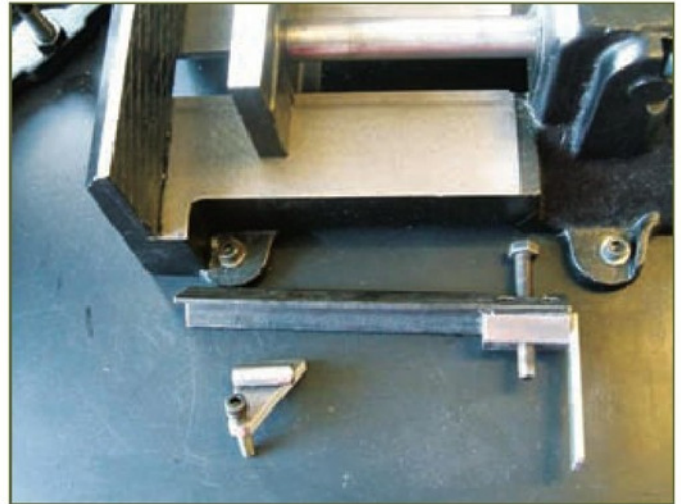
3. Shortest length which can be gripped in standard vice.



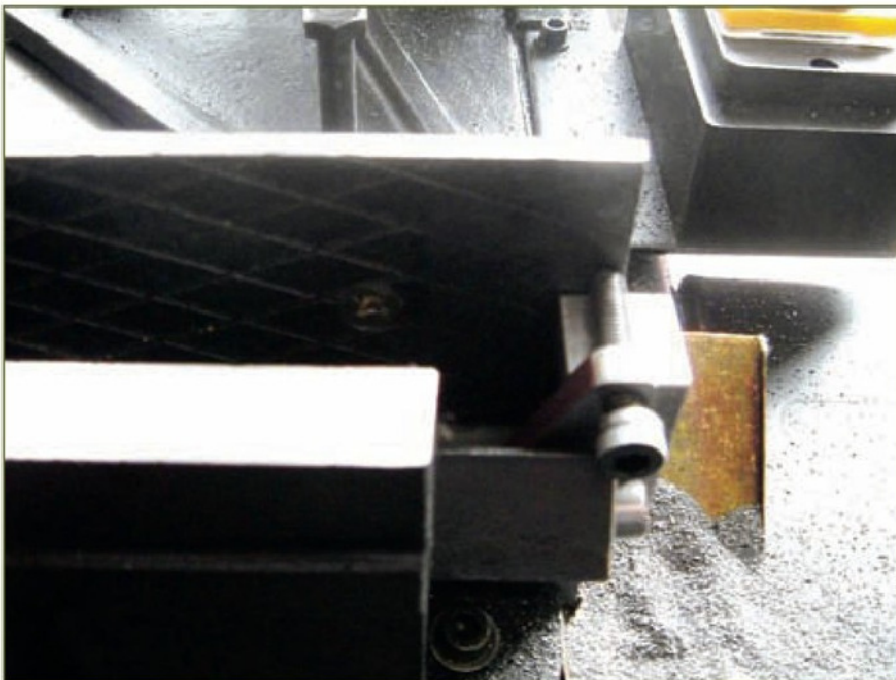
4. Length of angle with jacking screw gives added support.



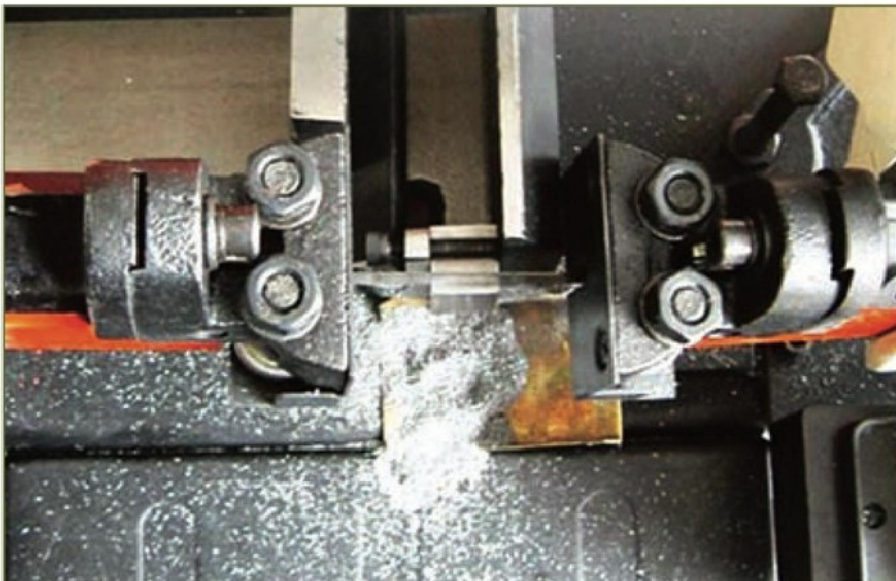
5. Showing the angle and insert.



6. The insert shown detached.



7. An embryo tool block.



8. Partway through.

(for the purposes of testing, even I can manage to hacksaw this size) I have made a permanent insert should the need arise. **Photos 5 and 6.**

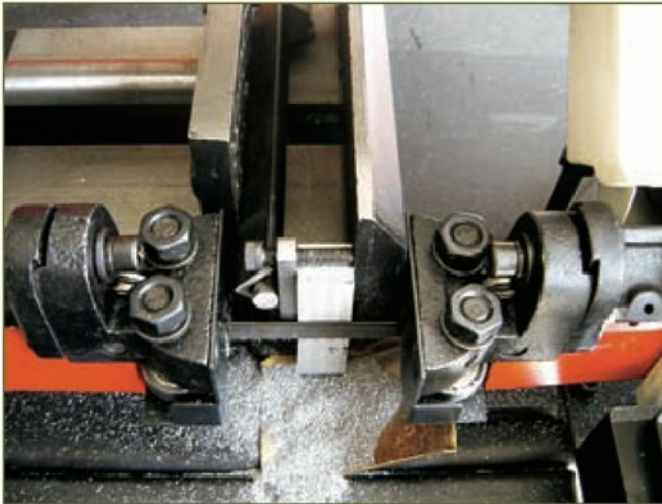
So, to put it all to the test: While making a QCTP for a Cowells Lathe I only had $\frac{3}{16}$ in. square for the tool blocks which were to be 19 x 16 mm. Although the excess could be machined off in a milling machine or lathe, why make swarf when you can save the scrap! It was decided to hold the pieces vertically using the angle and the insert, as shown in **Photo 7**. The piece was set vertical with a square and the vice tightened. The saw was started and gently lowered to start the cut and off it went. (**Photos 8, 9 and 10** show the progress) Another up side is that there is left a reasonable surface finish and the cut is quite square.

Sacrificial block

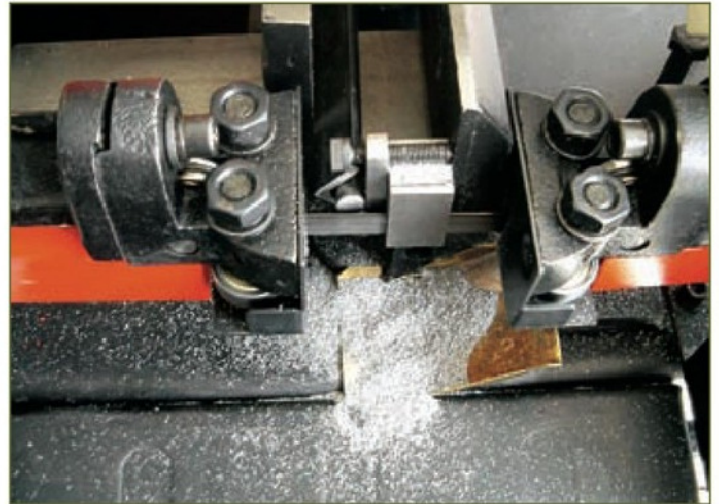
Whilst making this and a previous QC tool post for a larger Prazimat lathe, I pressed into service a sacrificial block I use on the milling machine. This is a steel block 95 x 75 x 50 mm, picked up in a scrap yard, already featuring the four counter-bored holes and the circle of six and the central $\frac{1}{8}$ BSF tapped holes. I added the other two other central counter-bored holes to suit the spacing of the milling table tee slots. The sacrificial bit is, in order to hold an awkward shaped item for machining and the existing tapped holes can't be used, there is no objection to drilling additional holes wherever required. The block can also be held in the milling vice.

So to make an angled cut with the band saw, the block worked fine for this too. The 30deg. angles were marked on the tool post, which was in turn mounted on the block with its own fastener system in an already present M5 tapped hole. The blade was lined up with the cut mark and the first side cut, the piece was rotated and the job completed, both sides automatically coming out equal. **Photos 11 and 12.**

To avoid having to make an extension to the saw arm stop to prevent the long drop at the end of the cut, I simply kept a casual eye on things and when almost through, lightly held the saw arm lifting handle so I was able to take the weight when the cut finished, lowering the arm on to its stop.



9. Almost there.



10. Completed cut with fair surface finish.

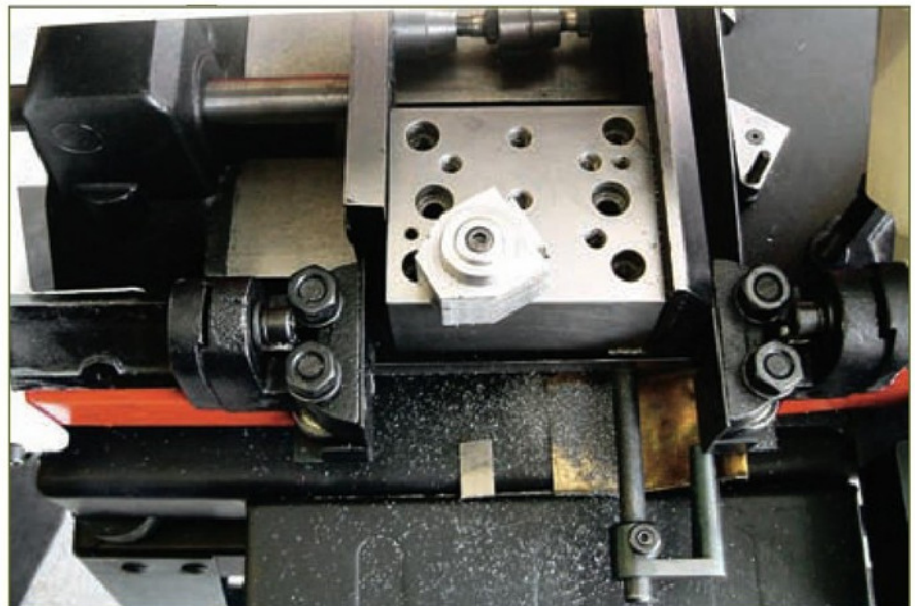
Further modification

The only further improvement to the saw I can envisage is to bring the entire vice closer to the blade. I did not relish the job of widening the longitudinal vice mounting slots in the quite thick table, so I compromised and went down two sizes with the mounting screws which has now brought the vice within 5mm of the blade (**Photo 13**). These slots would have been of more use if they were turned through 90deg, as I can see no point in having the ability to move the vice along the length of the blade.

Experience

This bandsaw is an excellent piece of kit, saving the arm power and producing accurate results. Also while about its business, you are free to get on with something interesting. On the health and safety front, while the saw should not be left unattended, I can see no objection to doing something else as long as you remain in the workspace. Some cuts can take 5 minutes or more to complete, and there is no point just standing there waiting for the automatic shut off to trip.

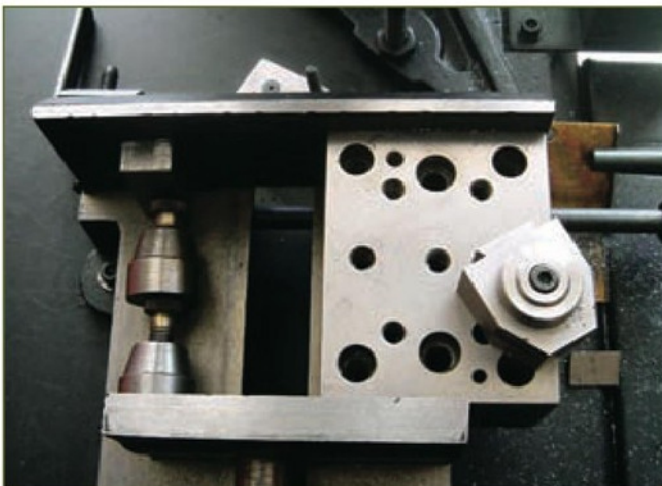
The unattended bit cannot be overstressed. I read recently where a user, I think in the US, went off for a short break and



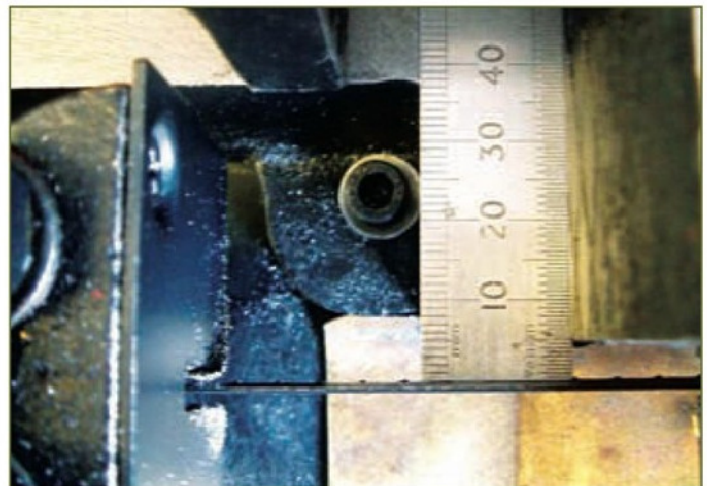
11. Setup for cutting toolpost

was delayed, only to return to the workshop to find smoke coming from the saw motor and melted plastic issuing forth. Apparently the saw had stalled at the end of the cut and the motor over heated before the current load finally tripped the circuit breaker.

I have not provided any measurements or sketches, as the device is dependent on the size of the saw vice and the dimensions of the materials used. I think the description and photographs are enough to convey the principles required.

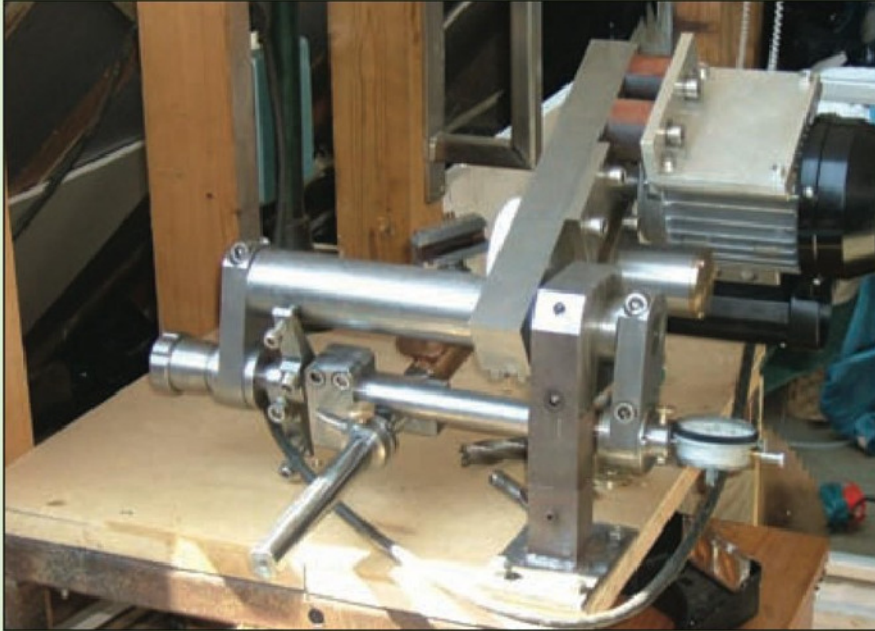


12. Both sides were automatically equal.



13. The vice is now within 5mm of the blade.

Scribe a Line



Robert Wallace writes:

Congratulations on a fine website and I also see that this month's magazine is up to its usual high standard. On that subject is it possible to pass on my comments on Mr J Winkel's article on his drill grinder featured in No's 108, 109 and 110. I thoroughly enjoyed making this grinder and found his drawings of an excellent quality. I have now sharpened all my old end mills but have yet to master the drill grinding attachment as there seem to be several ways to go about it. I would be interested to hear from anybody else who has made this device. I enclose a picture of the finished grinder.

Bob Margolis writes:

I have enormous respect for Harold Hall's experience and articles but I think that he's made a rare mistake in the article on the G H Thomas retracting toolholder. The dimples for gib strip adjusting screws are not a substitute for pinning, as a little experiment will verify. The screws do ride up the sides of the dimples as described in GHT's book. Pin the strips as described there (it must be done very carefully, even though it looks a simple idea) and they become a joy to adjust and they stay adjusted.

My Emco V10P has slides in good condition but the ease of adjustment and retention of that adjustment improved markedly after pinning. All my dovetail slides with gib strips are routinely pinned and I commend it. A length of 3mm silver steel and a 3mm hand reamer (not machine reamer – see GHT) will pin a workshop full of machines. GHT thought the modification worthwhile on his Myford.

Owners of Warco/Arc Euro/similar mini lathes should particularly note that replacing the gib strips with proper sized

ones (brass in my case) and pinning them transforms the slides.

You don't have to take my word (or GHT's) try it and see; do get the fits right for the pin, though.

Harold Hall replies

Having been an electrical engineer most of my working life only coming to metalworking just prior to my becoming editor of MEW my experience is therefore somewhat limited. Even so, I often feel that in this lies my greatest strength but also my greatest weakness. Strength in that I can look at subjects without preconceived ideas, weakness in that well proven methods are overlooked. However, in this case I did follow what appeared to me to be normal practice as evident from the four items in my workshop and which I had not found too difficult to adjust. Having said that, I do have a preference, all other things being equal, for screws having a hexagon socket or head. In this case the lever action makes minute adjustments so much easier to achieve than with a slotted screw and conventional screw driver.

Bob's letter though prompted me to look at the subject afresh and came to the conclusion that the most vital aspect of the set up was the condition of the end of the adjusting screw. This I felt should be properly machined, and most essential, concentric with its thread.

With that in mind I decided to dismantle one slide on each of the four items, a well respected lathe, two well made machines of European origin and a reasonably well made compound table that I use on my drilling machine.

The two European machines had a single vee groove across the gib strip into which one of the screws engaged the remaining screws just contacting the strips flat surface. All the screws having a pointed end. The major weakness of the method was that it would be essential the screw engaging the vee groove should be adjusted first, if done, then end float would be eliminated. The manual for the milling machine made this clear but not that for the lathe.

The compound table had a dimpled gib strip with poorly domed screws. As this is only used for positioning workpieces for drilling I have not paid much attention to adjusting the slides though suspect it would be a candidate for being modified in accordance with GHT's suggestion.

The other machine, a Myford series seven, had screws that had a short parallel portion and a very well machined domed end giving the impression that the two surfaces together with the thread had all been machined at the same setting ensuring concentricity. There were just two dimples in the gib strip into which the screws fitted very snugly the other two just contacted the strips flat surface. This arrangement works perfectly well, though I do not like the slotted screws.

As far as the retracting tool holder, I have looked at this again and feel the method I adopted was more than adequate. The slide has a good length to width ratio (3.5 : 1) and only a 4 mm movement, adjustment is not therefore crucial providing the slide is a very little on the tight side. In fact, I now feel that two rather than four gib strip screws would be perfectly acceptable.

I do believe therefore that G H Thomas's suggested method maybe a case of horses for courses, very worthwhile on some but unnecessary on others. Do any other readers have experience of the modification? For my part, should time surface, I will certainly give it a try on one of my lesser machines.

John Barnard writes

The motorcycle lift featured in 'On the Editors Bench' strikes me with two words 'BLOODY DANGEROUS'. In fact I can still hear my, now late, employer's words, on

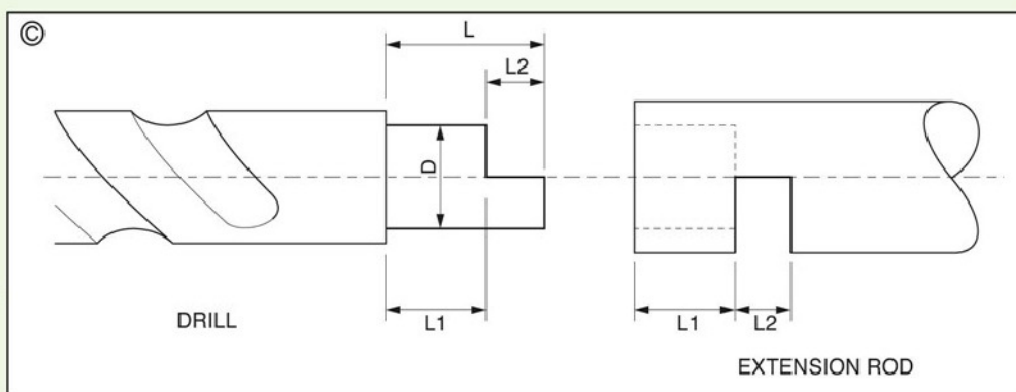
William Ray writes:

There have been some interesting letters in "Scribe a Line" recently, describing methods for deep hole drilling. Perhaps the "old hands" need reminding of the following method they used, and maybe the "young hands" will find it useful. Essentially, we can extend the length of a twist drill using a removable extension rod. The drill can be used in normal service after the deep hole process. Because we use the drill and materials to hand, it becomes a relatively quick and inexpensive method.

A standard HSS twist drill of the required diameter has the end of its shank turned down to a suitable diameter D and length L . A flat $L2$ is cut on the end level with the centreline. The extension rod is made from mild steel and is slightly smaller in diameter than the drill. The end of the rod is bored out to give a push fit with the drill shank diameter D and to a depth $L1$. A slot is cut across the extension rod, the width being $L2$ and the depth to the centreline. The slot is located at a distance $L1$ from the end face, and must break into the bored hole back face.

Specific dimensions are not given because they will vary with the size of drill being used. With a little practice, it soon becomes apparent that the wall thickness of the extension rod and the drill shank diameter need to be carefully considered.

The tool is improved by having a slope on the flat $L2$ to provide a tight fit between the faces engaging at the centreline. Also making the slot width wider than $L2$ will allow the use of a drift or similar tool to extract the drill.



noticing that I was working under a vehicle supported by just an hydraulic jack 'Where are your Steady Brackets, John'. by this, of course, he meant Axle Stands.

So, where are your Steady Brackets Dave? You must NEVER, NEVER rely solely on hydraulics to support a load, to do so is foolhardy as hydraulic components can and do fail, sometimes suddenly and without warning. Can you imagine the mess your arm would be in if the jack did fail suddenly and the limb was crushed between the longitudinals or the scissors and held there by the weight of the bike. Also, if the jack has failed how does one separate the frames to free the limb? Doesn't bear thinking about, does it?

To feature this lift design in an engineering magazine is doubly foolish as you are 'Leading Others Into Danger', surely not something a responsible editor should do. Remember, NEVER trust your safety to hydraulics. Always use a mechanical means of support to take the load off the hydraulic components.

Dave Fenner comments:

John is of course quite correct; the photo published in issue 117 showed the device in unfinished condition. The concluding words given in the BSA owners club descriptive notes are "The final part you should add is a bar across from the rear lever arm to the base which can be locked in position and is strong enough to support the total weight including motorcycle in case the jack's hydraulic seals fail". My own solution to this issue is to use an axle stand (I happen to have them) located between the upper and lower frames. This allows adjustment over a range of heights which has so far proved acceptable.

Interestingly, it appears that not all the commercially available equipment features such mechanical safety struts. Possibly

their expectation is that the operator will work above the table, not below it.

Peter G Shaw writes:

Ian Jefferies in his letter in Issue 117 comments negatively about the concept of using heaters attached to the lathe bed. As readers may remember from Issue 114, I reported that I had fitted two heaters to my lathe and that as a result I was no longer suffering from rust.

Although not mentioned in my letter, the effect of uneven heating did concern me, not so much because of stresses, but more because of uneven expansion leading to inaccuracies along the lathe bed. This was another reason why I fitted two such heaters. I have no idea whether or not any such inaccuracy has occurred.

In use, all of the lathe is noticeably warmer, including chucks, and is actually much more pleasant to handle because of it. I do have to say that there are two noticeably warm, but not hot, spots on the side of the bed where the heaters are located however the temperature is nothing like the 68°C that Mr. Jefferies suggests. It is also noticeable that the top surface of the bed upon which my saddle slides is very slightly warmer in the vicinity of the heaters. I have no idea what these temperatures are because although I could measure them, the heaters are switched off as being unnecessary during the summer months.

There is one additional point which I have discovered since my original letter, and that is that having obtained a plug in Mains Power Monitor, I have found that the two heaters are taking a combined total of 38W, rather different to the original 20W. This is, in fact, in accordance with the quoted specification for these devices. All in all, I am lead to consider that these devices may not be the best for my situation even though

they undoubtedly work and my lathe is now thankfully rust free.

Finally, Mr. Jefferies suggests that it is better to deal with the damp at source. I quite agree, but I happen to have to use a very basic garage which is attached to one side of the house. There is no insulation, the roof is single skin wood covered with felt, there are air gaps along the eaves and the ill-fitting up and over door allows rain water underneath it in bad weather. Not only that, but I recently discovered rain penetrating down the edge of the roof adjacent to the house wall, and that's after having had the house wall re-pointed, waterproofed and new flashing provided a few years ago. In this situation, individual cossetting of the machine tools is perhaps the only solution.

David Dunnet writes:

In your "On the Editor's Bench" of issue 113, you talked about condensation in your workshop and the dreaded rust. I have seen several lamentations on this subject in MEW and ME over the years as it seems to be a problem. The solution that I have used for quite a number of years is that which was contained in the assembly instructions for the 14 inch wood cutting bandsaw that I bought in September 1990.

The instructions read, and I quote "Remove the protective coating from the machined surfaces with a soft cloth moistened with kerosene. After cleaning, cover all unpainted surfaces with a good quality paste wax." I have always used the silicon automotive wax that I use on the car and I have found that provided it is done twice a year, or after a lot of use, I have no trouble with the dreaded rust.

I also use the wax on my lathe chucks, measuring sticks and other items of equipment that have a tendency to collect rust whilst not in regular use. Hope it helps.

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'Child' = 5-15yrs

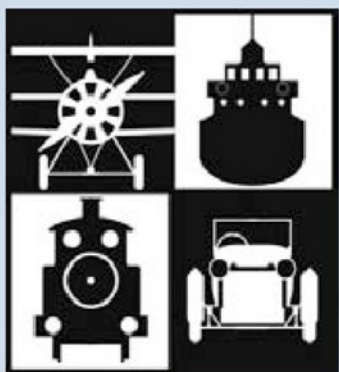
'Family' = 2 Adults and upto 3 children

Group tickets only available in advance

Ticket Hotline closes: 8th December 2006

*Free parking ticket available on first come, first served basis for advanced ticket bookers only.

TICKET HOTLINE: 01689 899 228/229



THE MODEL ENGINEER EXHIBITION

Please return completed form to:
Model Engineer Competition,
9 Tranmore Lane, Eggborough,
E. Yorkshire DN14 0PR

ENTRY NO.

OFFICE USE ONLY

CLASS	ENTRY NO.

ENTRY FORM - COMPETITION & LOAN MODELS

PERSONAL DETAILS (Please print)

Surname _____ Forename(s) _____ Age: _____

Address _____

_____ Post Code: _____

Home Tel No _____ Daytime Tel No _____

Model Club or Association _____

Have you entered before? (Y/N) _____

Do you purchase or subscribe to an Encanta Media Ltd magazine? (Y/N) _____

How many years have you been a modeller? _____

Mail Order Protection - please tick this box if you would prefer not to receive mail from other companies which may be of interest to you ☐

MODEL DETAILS – PLEASE TICK BOX IF MODEL IS FOR LOAN ☐

Entry Class (competition entries only) _____

Model Title (to be used for catalogue and display card) _____

Model Description _____

Model Scale _____ Length _____ Width _____ Height _____ Weight _____

Type of construction _____

Parts not made by you and commercial items _____

Have you supplied a photograph? (Y/N) _____

Are you supplying Judges Notes? (Y/N) _____

Value of Model (Encanta Media Ltd will not insure the model unless a value is entered) £ _____

Name and address of your local newspaper _____

TO HELP YOU GET THE BEST FROM THE MODEL ENGINEER EXHIBITION

These notes are written purely for guidance. Full information is contained in the Competitors' Information booklet which is sent to every entrant as part of the information package. If you have an item and are unsure as to the Class into which it should be entered, leave that section blank and we will take care of it. The Judges have the right to move any competition exhibit into another class if they feel that by doing so its chances of gaining higher marks or a more appropriate award are improved.

If the item is offered as a Loan exhibit please indicate this by writing Loan on the form in the box identifying the Class. Loan models are not judged but carry all other privileges associated with competition entries.

Part built models are particularly welcome in the Loan Section; visitors like to see work in progress, and entry does not preclude the item being entered in competition when completed.

The classes listed below are those associated with mainstream model engineering.

Club exhibits

Where a club is exhibiting, each model should be entered on a separate entry form and clearly identified as a club exhibit by entering Loan/Club in the class section box. This ensures that we have a full record of all models on display during the show and facilitates matters of administration and insurance.

Additional forms

If you do not wish to deface your copy of the magazine we are happy to receive photocopies of the entry form, one for each model. We will be pleased to send out extra forms if required, so if you know of a modeller who is not a reader of one of our magazines but who you think may wish to participate, please advise them to contact our Exhibitions Office, or simply photocopy the entry form for them.

The success of the show depends largely on the number of models on display. Your work could well be the stimulus which inspires someone else to start in the hobby. There can be no doubt that this event is our showcase on the world of modelling in all its aspects. Every modelling discipline needs more and more participants, and it is by displaying not only the crème-de-la-crème, but also examples of work of a more achievable standard, that people are encouraged to join into the wonderful world of modelling, in whatever aspect.

We look forward to seeing a sample of your work at the show!

Engineering Section

- A1 Hot air engines.
- A2 General engineering models (including stationary and marine engines).
- A3 Internal combustion engines.
- A4 Mechanical propelled road vehicles (including tractors).
- A5 Tools and workshop appliances.
- A6 Horological, scientific and optical apparatus.
- A7 General engineering exhibits – not covered by the above

Railway Section

- B1 Working steam locomotives 1" scale and over.
- B2 Working steam locomotives under 1" scale.
- B3 Locomotives of any scale, experimental, freelance or based on any published design and not necessarily replicas of full size prototypes, intended for track duties.
- B4 Scratchbuilt model locomotives of any scale, not covered by classes B1, B2, B3, including working models of non-steam, electrically or clockwork powered steam prototypes.
- B5 Scratchbuilt model locomotives gauge 1 (10mm scale) and under.
- B6 Kitbuilt model locomotives gauge 1 (10mm scale) and under.
- B7 Scratchbuilt rolling stock, gauge 1 (10mm scale) and under.
- B8 Kitbuilt rolling stock, gauge 1 (10mm scale) and under.
- B9 Passenger or goods rolling stock, above 1" scale.
- B10 Passenger or goods rolling stock, under 1" scale.
- B11 Railway buildings and lineside accessories to any recognised model railway scale.
- B12 Tramway vehicles.

Marine Models

- C1 Working scale models of powered vessels (from any period). Scale 1:1 to 1:48
- C2 Working scale models of powered vessels (from any period). Scale 1:49 to 1:384

- C3 Non-working scale models (from any period). Scale 1:1 to 1:48
- C4 Non-working scale models (from any period). Scale 1:49 to 1:384
- C5 Sailing ships and oared vessels of any period – working.
- C6 Sailing ships and oared vessels of any period – non-working.
- C7 Non-scale powered functional models including hydroplanes.
- C8 Miniatures. Length of hull not to exceed, 15in for 1:32 scale, 12in for 1:25 scale, 10in for 1:16 scale; 9in for 1:8 scale. No limit for smaller scales.
- C9 For any model boat built from a commercial kit. Before acceptance in this class the kit must have been readily available for at least 3 months prior to the opening date of the exhibition and at least 20 kits must have been sold either by mail order or through the retail trade.

Scale Aircraft Section

- D1 Scale radio control flying models
- D2 Scale flying control-line and free flight
- D3 Scale non-flying models, including kit and scratch-built
- D4 Scale flying radio controlled helicopters

Model Horse Drawn Vehicle Section

- G1 Carriages & other sprung vehicles. (Omnibuses, trade vans etc.) Wagons, carts and farm implements. Caravans.

Junior Section

- J1 For any type of model, mechanical or engineering work, by an under 14 year old.
- J2 For any type of model, mechanical or engineering work, by an under 16 year old.
- J3 For any type of model, mechanical or engineering work, by an under 18 year old.

All entries will be judged for standard of craftsmanship, regardless of the modelling discipline, i.e. a boat will not be competing against a military figure. Providing a model attains sufficient marks it will be awarded a gold, silver or bronze medal.

Model Vehicle Section

- K1 Non-working cars, including small commercial vehicles (e.g. Ford Transit) all scales down to 1/42.
- K2 Non-working trucks, articulated tractor and trailer units, plus other large commercial vehicles based on truck-type chassis, all scales down to 1/42.
- K3 Non-working motor bikes, including push bikes, all scales down to 1/42.
- K4 Non-working emergency vehicles, fire, police and ambulance, all scales down to 1/42.
- K5 Non-working vehicles including small commercial vehicles (e.g. Ford Transit) scale from 1/43 or smaller.
- K6 Any available body shells including Concours, in any scale or material, to be judged on appearance only.
- K7 Functional model cars/vehicles which must be able to move under its own power of any type. Can be either free-running, tethered radio controlled or slot car, but must represent a reasonable full size replica.

DUKE OF EDINBURGH CHALLENGE TROPHY

Rules and Particulars

1. The Duke of Edinburgh Challenge Trophy is awarded to the winner of the Championship Award at the Model Engineer Exhibition.
2. The trophy remains at all times the property of ENCANTA MEDIA LTD.
3. The name of the winner and the date of the year in which the award is made will be engraved on the trophy, which may remain, at the discretion of ENCANTA MEDIA LTD, in his/her possession until required for renovation and display at the following Model Engineer Exhibition.

4. Any piece of model engineering work will be eligible for this Championship Award after it has been awarded, at The Model Engineer Exhibition, a Gold or Silver medal by ENCANTA MEDIA LTD
5. No model may be entered more than once.
6. Entry shall be free. Competitors must state on the entry form:
 - (a) That exhibits are their own bona-fide work.
 - (b) Any parts or kits which were purchased or were not the outcome of their own work.
 - (c) That the model has not been structurally altered since winning the qualifying award.
7. ENCANTA MEDIA LTD may at their sole discretion vary the conditions of entry without notice.

COMPETITION RULES

1. Each entry shall be made separately on the official form and every question must be answered.
2. Competition Application Forms must be received by the stated closing date. LATE ENTRIES WILL ONLY BE ACCEPTED AT THE DISCRETION OF THE ORGANISERS.
3. Competitors must state on their form the following:
 - (a) Insured value of their model.
 - (b) The exhibit is their own work and property.
 - (c) Parts or kits purchased.
 - (d) Parts not the outcome of their own work.
 - (e) The origin of the design, in the case of a model that has been made by more than one person.

NOTE: Entry in the competition can only be made by one of the parties and only their work will be eligible for judging.

4. Models will be insured for the period during which they are in the custody of ENCANTA MEDIA LTD
5. A junior shall mean a person under 18 years of age on December 31st in the year of entry.
6. Past Gold and Silver medal award winners at any of the exhibitions promoted by ENCANTA MEDIA LTD are eligible to re-enter their model for the 'Duke of Edinburgh Challenge Trophy'. Past winners at any of the exhibitions promoted by ENCANTA MEDIA LTD will not be eligible for re-entry into the competition unless it has been substantially altered in any way.
7. ENCANTA MEDIA LTD reserve the right to:
 - (a) Transfer an entry to a more appropriate class.
 - (b) Describe and photograph any models entered for competition or display and to make use of any such photographs and descriptions in any way they may think fit.
 - (c) Refuse any entry or model on arrival at the exhibition and shall not be required to furnish a reason for doing so.
8. Entry into the competition sections is not permitted by:
 - (a) Professional model makers.
 - (b) Anyone who has a financial interest in the direct supply of materials and designs to the public.

NOTE: If unsure, please contact the Competition organisers prior to the show.

9. The judges' decision is final. All awards are at the discretion of the judges and no correspondence regarding the awards will be entered into.
10. Exhibitors must present their model receipt for all models collected at the end of the exhibition and sign as retrieved.
11. The signed release for each model must be presented to security staff when leaving the exhibition complex with display model(s) after the close of the exhibition.

IMPORTANT NOTE: PLEASE MAKE COPIES, INCLUDING PHOTOGRAPHS, OF ALL INFORMATION RELATING TO YOUR MODEL, AS ENCANTA MEDIA LTD WILL NOT ACCEPT LIABILITY FOR ANY LOSS.



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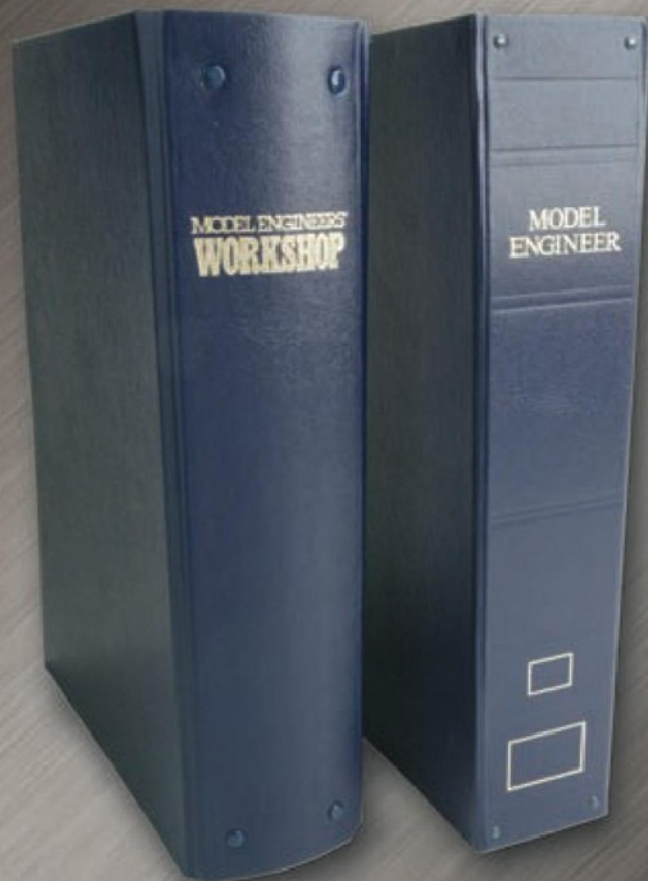
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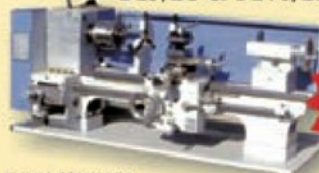
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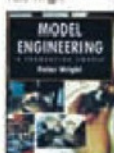
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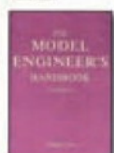
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C2	1/4 - 9/32 - 5/16 - 3/8 - 7/16 - 1/2 - 5/8	10.90	BRASS FLATS		
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BRASS ROUNDS			N5	1/4 x 3/8 - 1/2 - 3/4 - 1	30.70
E1	1/8 - 3/16 - 1/4 - 5/16 - 3/8 - 1/2	15.40	ALUMINIUM ROUND F/C		
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G2	1/4 - 9/32 - 5/16 - 3/8 - 7/16 - 1/2 - 5/8	31.25	S1	3/32 - 1/8 - 5/32 - 3/16 - 7/32 - 1/4 - 9/32 - 5/16 - 3/8 - 7/16 - 1/2	22.45
BRASS ANGLE			S2	3mm - 4mm - 5mm - 6mm - 7mm - 8mm - 9mm - 10mm - 12mm	19.50
H1	1/4 x 1/4 x 1/16	5/16 x 5/16 x 1/16	ALUMINIUM FLATS		
	3/8 x 3/8 x 1/16	1/2 x 1/2 x 1/16	R1	1/8 x 1/2 - 1/8 x 1 - 1/4 x 1/2 - 1/4 x 1 - 1/4 x 1 1/2 - 1/4 x 2	18.90
H2	5/16 x 5/16 x 1/16	3/8 x 3/8 x 1/16	R2	3/8 x 1/2 - 3/8 x 1 - 3/8 x 1 1/2	15.55
	1/2 x 1/2 x 1/8	3/4 x 3/4 x 1/8	R3	1/2 x 1 - 1/2 x 1 1/2 - 1/2 x 2	23.75
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5"G	Butch	0-6-0	3.1/2"G	Petrolea	2-4-0
5"G	Chub	0-4-0	3.1/2"G	Iris	0-6-0
5"G	Simplex	0-6-0	3.1/2"G	Doris	4-6-0
5"G	Springbok	4-6-0	3.1/2"G	Rainhill	0-2-2
5"G	King John	4-6-0	3.1/2"G	Heilan Lass.	4-6-2
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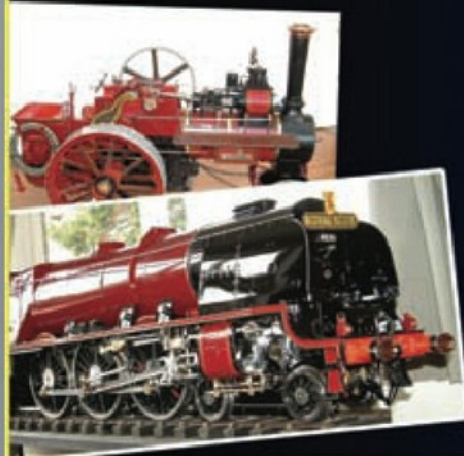
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1-13mm Drill Chuck & Arbor, Variable Speed, Milling Drawbar

Features

Dovetail Columns, Adjustable Depth Stop, Fine Feed Head Control, Geared Drive, Slideway Covers, Zero Setting Dials.

Specifications

Drilling Capacity	20mm
End Mill Capacity	16mm
Face Mill Capacity	63mm
Table Surface Size	180x600mm
Longitudinal Travel	350mm
Cross Travel	200mm
Max. Distance Spindle to Table	300mm
Spindle Taper	MT3
Spindle Speed	50-3000rpm
Motor	1000W
Weight	135Kg



Century Mill £895

Standard Accessories

Machine Work Light, Central Lubrication System, Machine Stand, Table Guard.

Features

Head Swivels 90 degrees, Head Tilts 45 degrees, One Shot Lubrication System, Interlocked Spindle Guard.

Specifications

Drilling Capacity	32mm
End Mill Capacity	25mm
Face Mill Capacity	75mm
Table Surface Size	156x745mm
Longitudinal Travel	365mm
Cross Travel	135mm
Max. Distance Spindle to Table	330mm
Spindle Taper	MT3 or R8
Spindle Speed	190-2100rpm
Motor	1.1Kw
Weight	410Kg



Shown with optional Powerfeed

626 Mill £1395

Features

Cut, Fold & Roll in one Machine, Slip Rolls Ground, Folder has Removable Fingers, Three Wire Grooves, Rigid Cast Iron Frame, Back Gauge.

Specifications

Shearing Thickness (Steel)	0.6mm
Bending Thickness	1mm
Bending Angle	90 deg
Rolling Thickness	1mm
Min. Rolling Diameter	30mm
Weight	45Kg



12" Multiformer £145

All prices include VAT & Delivery UK mainland only