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# MODEL ENGINEERS' WORKSHOP

THE PRACTICAL HOBBY MAGAZINE

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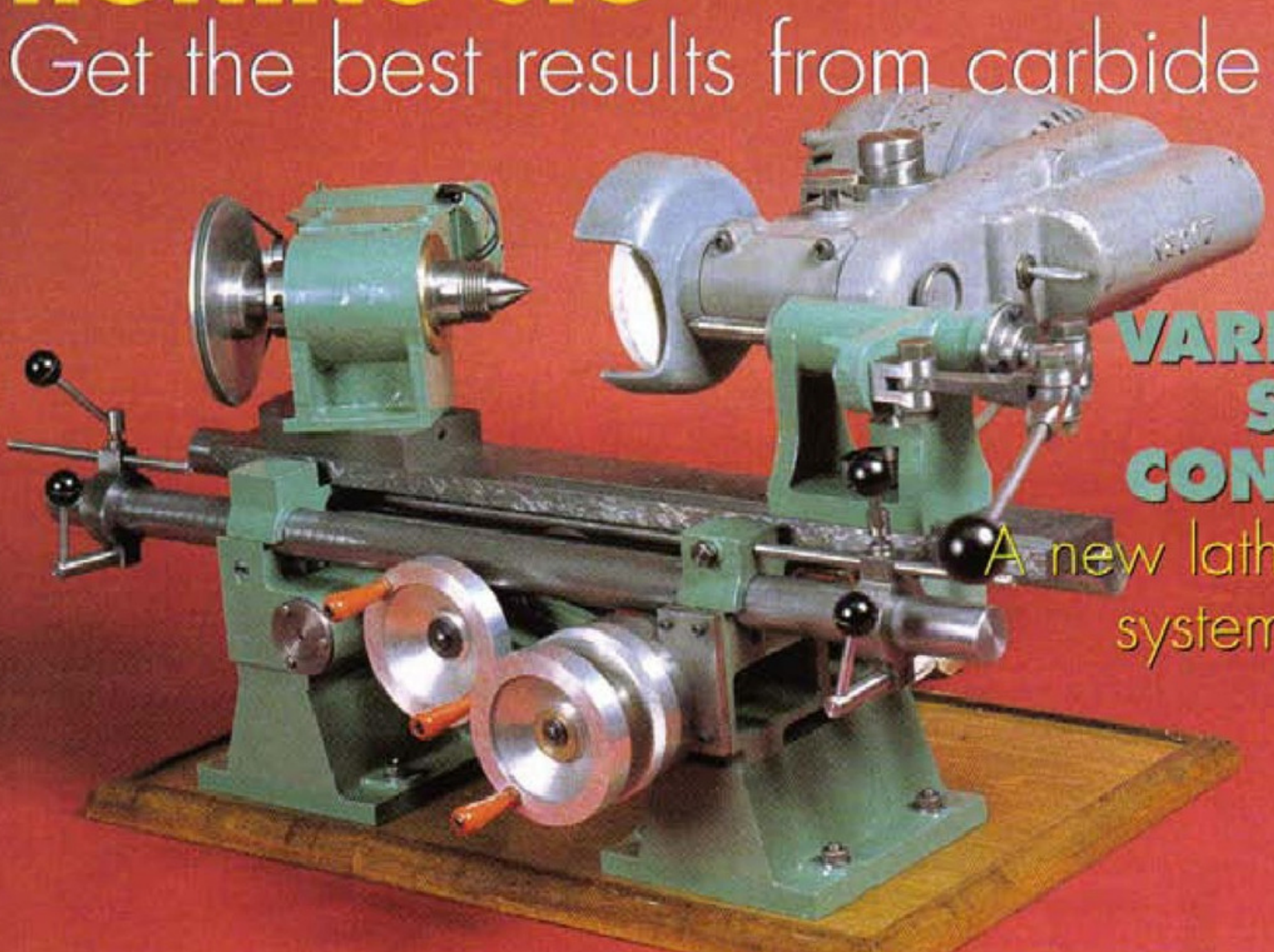

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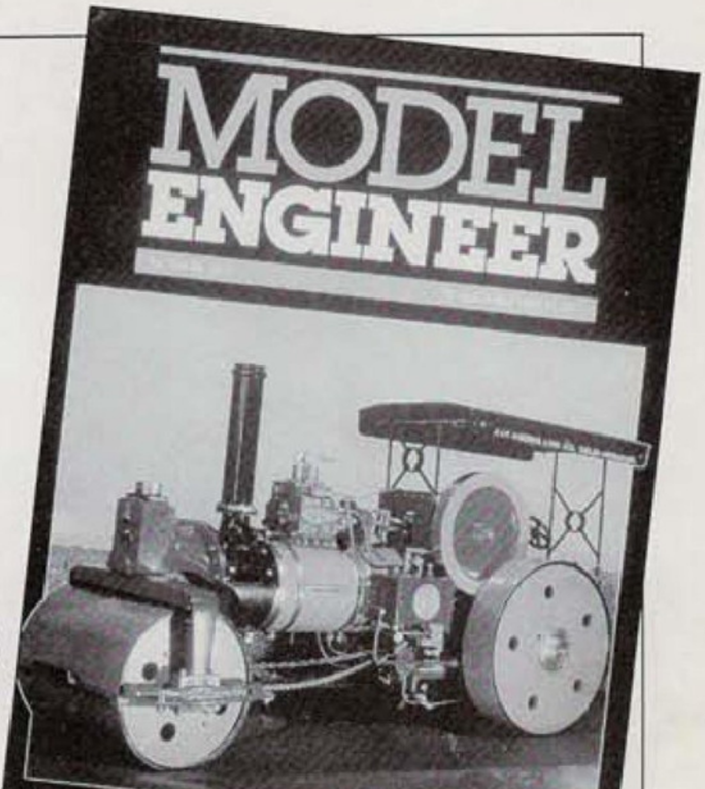

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BORING & FACING HEAD
POSITIVE WHEEL QUARTERING
GREEN ARROW


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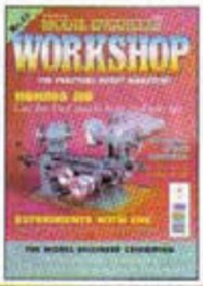
**Issue No. 69**

**Editor: Geoff Sheppard**
**Nexus Special Interests, Nexus House, Azalea Drive, Swanley, Kent BR8 8HU tel. 01322 660070 fax. 01322 667633**



## On the cover

*This prototype cylindrical grinder, designed by Ivan Law, was seen on the stand of the Society of Model and Experimental Engineers at the last Alexandra Park International Model Show. Ivan will again be the Chief Judge at the revived Model Engineer Exhibition which will be held at Sandown Park.*


***Indicators come in a variety of types and sizes, as described by Bob Loader in his article which starts on page 46***



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**EDITORIAL**

**Editor**
Geoff Sheppard

**Editorial Administrator**
Sarah White

**PRODUCTION**

**Designer**
Carol Philpott

**Copy Control Manager**
Lucy McGeough

**Printed By**
St. Ives plc (Andover)

**Origination by**
Derek Croxson Ltd

**SALES**

**Sales Executive**
Mark Pinkney

**MANAGEMENT**

**Group Managing Director**
Tony DeBell

**Divisional Managing Editor**
Dawn Frosdick-Hopley

**Divisional Sales Manager**
Roy Kemp

**Newstrade Sales Manager**
David Pagendam

If you experience problems obtaining your copy of Model Engineers' Workshop you can e-mail Nexus Special Interests at copy.sales@nexusmedia.com
Alternatively, write to Daniel Webb, Newstrade Executive, Nexus Media Ltd, Nexus House, Azalea Drive, Swanley, Kent BR8 8HU or call him on 01322 660070 ext. 2115.

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# ON THE EDITOR'S BENCH

My first task this month is to bring news of two of our trade suppliers, some good and some not so good, so let's deal with the bad news first. During September the old established and well respected firm of A. J. Reeves & Co. (Birmingham) Ltd. went into voluntary liquidation. This is a severe blow to the model engineering world as they were stockists of many items which are difficult to obtain in small quantities at a sensible price from other sources. They also own the copyright on a number of model designs and have the necessary patterns from which to supply castings and it would be a great loss if these were to disappear or be scattered to the four winds.

By the time this issue is published a meeting of creditors should have taken place and a Liquidator appointed. I have had an opportunity to speak to a representative of the organisation which is advising the company in the interim period and he assures me that the value of the drawings and patterns is well understood and that strenuous efforts will be made to keep these items together. Fortunately there has already been a significant number of expressions of interest in purchasing the business.

This must be a traumatic time for all the team at Reeves and the news has caused a great deal of distress to their many customers. This is not some large, anonymous commercial organisation which is in difficulties. The Reeves directors and a number of their staff are active model engineers, members of local clubs and personal friends of many participants in our hobby. We send them our best wishes and hope that matters are resolved with the least pain to all concerned. In the meantime if any reader has outstanding business with the company and is unable to make contact, I suggest that they write to the Liquidator, care of the Marston Green address.

The second piece of news is that, after 12 years in the business, Terry and Sylvia Gausden of Maidstone Engineering Services (Sales) have decided to retire, but this time there are no uncertainties over the future of their business as it has been acquired by Maxitrak of Staplehurst, Kent. Readers may recall that just about two years ago Terry and Sylvia left their Hedley Street premises for more spacious accommodation at Larkstore Park, Staplehurst, close to Maxitrak's premises. The decision to seek more space came as no surprise to anyone who had visited the old shop as we always wondered how they managed in such cramped conditions. There was one advantage, though, as customers who may have entered the shop as complete strangers often left as firm friends! It was impossible to ignore each other as it was necessary to manoeuvre delicately past one another to reach the goods on display. A visit to my old friend Will Mowll at Canterbury was never complete without a run to the Maidstone shop where, over the years, we acquired some useful bits and pieces.

Maidstone Engineering Services (MES) will continue to supply both trade and retail customers and Terry will continue as the initial point of contact and will co-manage the business during the change-over. Consequent upon the acquisition will be a merger of the MES trade/retail counter with the Maxitrak showroom and a move to yet larger premises at 5 Larkstore Park (i.e. next door). Maxitrak wish to assure all customers that there will be no interruption to the mail order service during the period of relocation, but all correspondence should now be addressed to Maidstone Engineering Services, 5 Larkstore Place, Staplehurst, Kent TN12 0QY, telephone and fax numbers remaining unchanged. Plans are well advanced to improve and increase the product ranges offered by both companies and now there will be more space in which to display them. MES will continue to display its range of materials at exhibitions, on a combined stand with the Maxitrak range of road and rail locomotive kits and ready to run models.

I'm sure that all readers will join me in wishing Terry and Sylvia a long, healthy and happy retirement. I am certain that it will be an active one and I feel that we have not seen the last of them around the hobby. We thank them both for all their help over the years.

## Engineering courses

Following my note regarding model engineering evening classes and similar courses, reader Tony Stewart has suggested that anyone in the London area seeking a course should have a look at the website at www.floodlight.co.uk. Floodlight is the official guide to courses in London, both full-and part-time, run by public sector colleges, universities and adult education centres. A quick look at their course finder index reveals such subjects as mechanical engineering, clock making and repair, motor car and motor cycle maintenance and welding. There is a facility for refining searches by adding additional keywords, so it would appear to be worthwhile spending a little time looking at this site.

I have not been able to spend much time doing further research, but I suspect that there may be similar sites covering other areas of the country. If anyone is aware of any others, I am prepared to pass on the message.

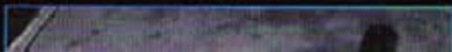
## Searching for a bevel gear

Back in June I wrote about the horse gin which had been donated by the Combe Mill Society to our local National Trust house for display in an original setting. This has now been moved to Dyrham Park, where we have had an opportunity to assess the work required to bring it to operational condition. We were aware that some parts had gone missing, the unit having been partially stripped many years ago, seemingly by professional conservators, on the farm where it was originally used to drive a water pump. Apparently, soon after work was started, a change of local government responsibilities left the device 'ownerless'. Despite a search by the Combe Mill team, even using a metal detector to see if anything had become buried, a few vital parts are missing, including one main support casting and a number of items from the gear train. One of my volunteer colleagues has fabricated a replacement for the casting and this has now been fitted, allowing us to take measurements prior to designing some new components. The difficult one will be the small bevel gear which meshes with the 36in. diameter 71 tooth main drive gear. As far as we can ascertain, the smaller gear contained only twelve teeth and had a diameter at the larger end of around $6\frac{1}{2}$in., a length of some $2\frac{3}{4}$in. and a very shallow taper. The construction of the unit makes it difficult to measure the 'theoretical' dimensions such as the back cone angle, and after consulting our gear expert, Ivan Law, I decided that a bit of trial and error with thin plywood gear slices would allow us to see if our estimates were anywhere near the mark. A CAD program has been invaluable here and we are progressing towards establishing the shape of a pattern from which a gear could be cast. In the meantime, if anyone comes across a gear or a pattern which matches the above specification, I would be pleased to hear, as it could save a lot of time and effort. Using an existing gear as a pattern would be a feasible proposition as the duty involved is not terribly arduous. Incidentally, we have already been promised the loan of horse if we wish to demonstrate use of the gin when we get it operational.

It was pleasing to have the opportunity to visit Combe Mill during their September open day to thank Richard Brown and his colleagues for their efforts in recovering the horse gin and to admire their beam engine and the extensive collection of engineering and agricultural memorablia which they have assembled. In addition to the engine collection being in steam, demonstrations of other skills were in progress and it was possible for visitors (suitably attired) to try their hand at the blacksmiths craft, making simple items such as pokers and toasting forks. The whole atmosphere was busy and welcoming, with stewards on hand to deal with queries. A most worthwhile visit, highly recommended.

# THOSE CONFOUNDED CHIPS

**Philip Amos discusses the care of threaded lathe chucks and the mandrel nose**



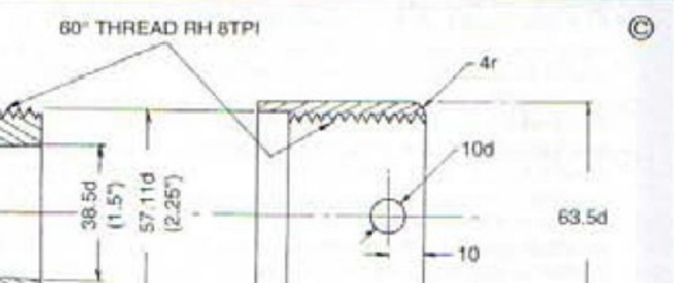
*1. Brushes and extension rod*

It is a necessary consequence of lathe operation that much swarf is produced, either in the form of long spirals of material, or a plethora of small chips. Broken fragments of the spirals, as well as chips, find their way into the interstices around the chuck jaws and also on to the mandrel/backplate threads when mounting or removing the chuck. In both cases they cause problems for the operator

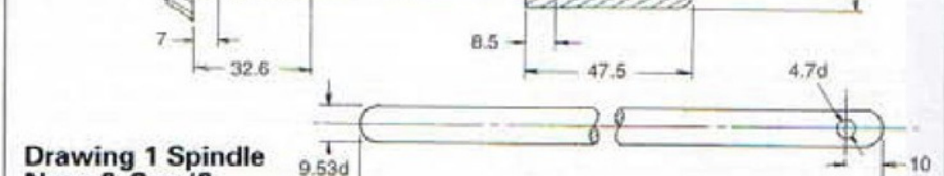
## Mandrel

The form of a threaded lathe mandrel also includes a parallel unthreaded portion and a square shoulder which accurately locate the chuck coaxial with the mandrel. A typical example, with measurements taken from my own lathe is shown on **Drawing 1**. Chips on these surfaces interfere with this accuracy. Chips on the mandrel nose thread or in the matching backplate thread can cause difficulty in screwing the chuck on and off the mandrel; in a worst case it gets stuck in position.

The mandrel nose should be carefully brushed free of chips before attempting to mount the chuck. This is quite easy to effect as the thread is readily accessible. It is worthwhile at the same time running a brush through the mandrel bore to clear chips from that location lest they later migrate into the chuck.



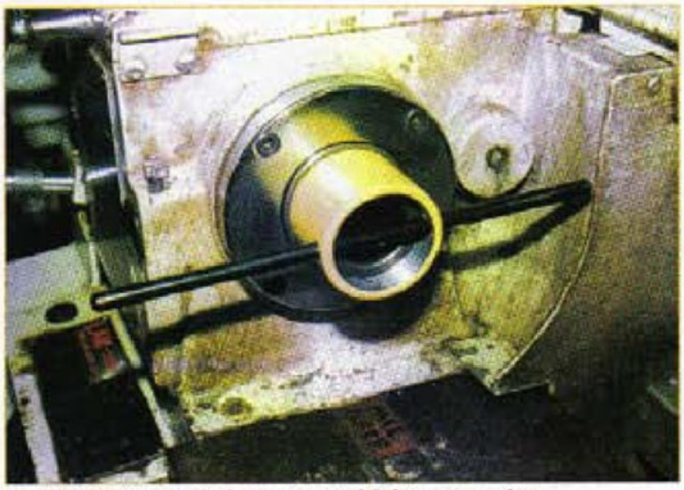

**Drawing 1 Spindle Nose & Cap (& Tommy Bar)**




**Drawing 2 Chuck "Height" Blocks**

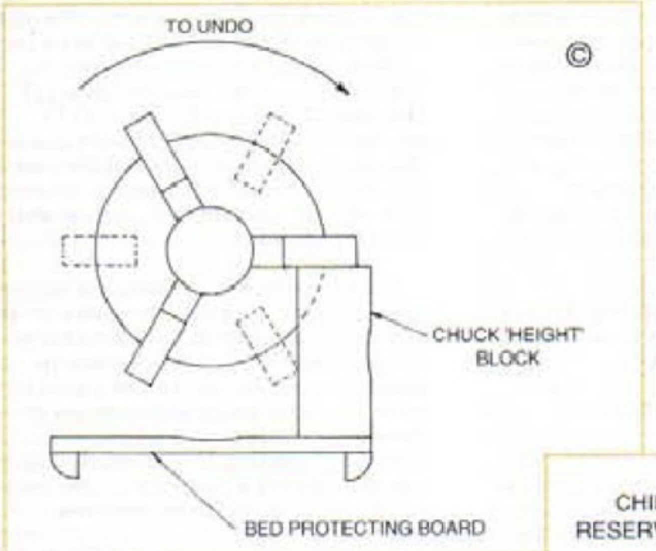
Of course, if a centre is to be fitted in the mandrel nose taper it must be cleaned free of chips before this is done.

A bottle brush as shown in **Photo. 1** is a good device to clear both the threads and the bore. In the latter case I extend its handle by using a piece of wooden rod (broomstick) with a slot in one end into which the loop on the end of the bottle brush fits. This wooden rod also serves as a knockout for the headstock centre and sleeve.

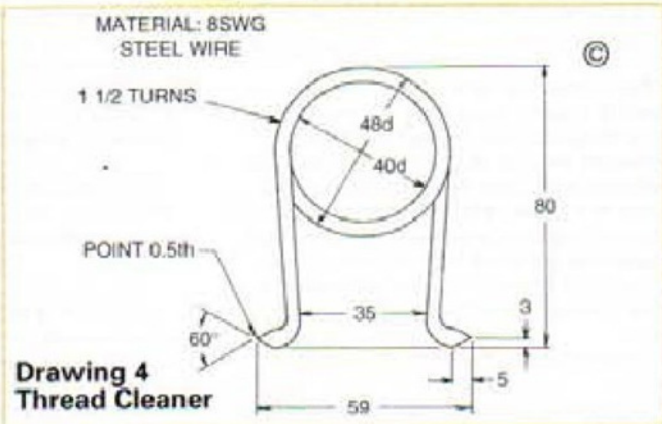


*2. The lathe mandrel nose cap with its tommy bar*

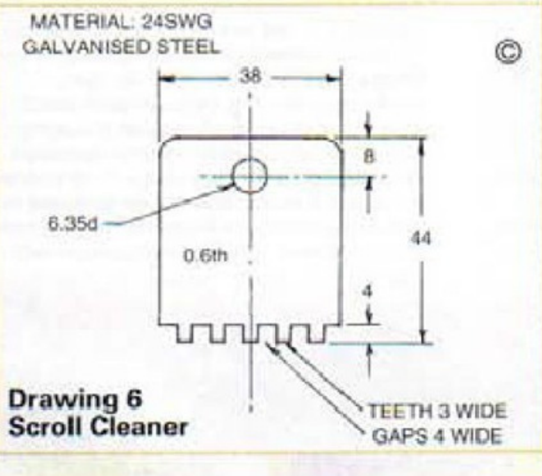
*3. The home-made wire tool being used to clean the backplate threads*



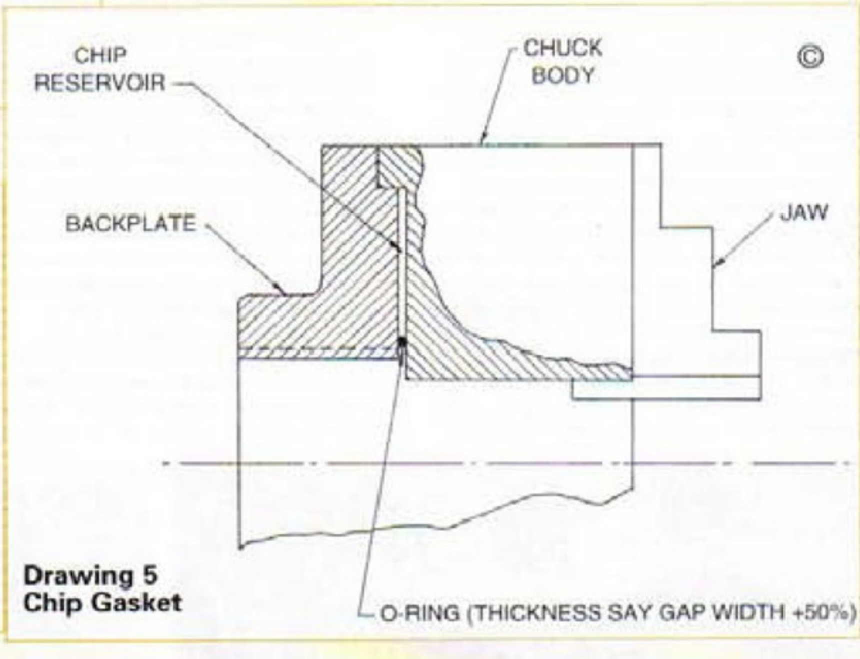

**Drawing 3**
**Chuck Loosening**




**Drawing 4**
**Thread Cleaner**




**Drawing 6**
**Scroll Cleaner**




**Drawing 5**
**Chip Gasket**

# Chuck Mounting

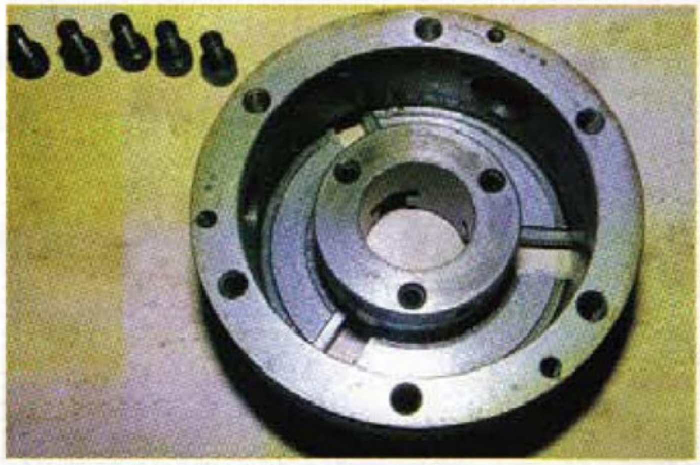
1. The chuck is a fairly heavy piece of equipment which has to be carefully manoeuvred into position to screw on to the mandrel nose. It is essential not to start to cross thread it during this process. Thus it is a great help if its weight can be carried on a support of some kind while engaging the threads.

A bed protecting board is a normal article to find in a home workshop to avoid damaging the ways by a chuck accidentally falling on to them. Combined with suitably shaped blocks of wood, the protecting board can present the chuck to the mandrel nose at the correct height and supporting the chuck weight.

In my case there are two 'height' blocks to cater for the self-centring and the independent jaw chucks. Further, a small excavation in the protecting board itself caters for the faceplate - **see Drawing 2.**

2. When the chuck is being screwed on to the mandrel nose it should be done up firmly. It must NEVER be run on under power as this will almost certainly tighten it to an extent where it is impossible to remove. Any temptation to 'spin' the chuck on by hand must also be resisted for the same reason.

*4. An 'O'-ring is attached to backplate with adhesive*



*5. A chuck body with its backplate attachment screws*

The chuck must be firmly bedded against the shoulder of the spindle nose before the power is turned on, otherwise the same effect as running on under power will occur.

3. There can also be a problem if the chuck is insufficiently tight, because if the lathe is run at a high speed and switched off before any cutting has taken place, the inertia of the chuck may cause it to slow down at a lesser rate than the mandrel. This will lead to it starting to unscrew and possibly to come off the mandrel, to fall on to the lathe bed, and perhaps bounce on to the floor (and maybe the operator's foot).

I once had this happen and resolved

(i) never to start the lathe after screwing on the chuck at other than its slowest direct speed and

(ii) to have handy a piece of timber to use between the bed and the chuck periphery as a brake if such became necessary.

While most spindles can be reversed (by reversing the motor), operating on the workpiece in this mode can also run the chuck off the mandrel nose - so should not be attempted. Modern lathes with camlock attachment of chucks do not, of course, suffer from this problem, and can happily operate in either direction. It is usually quite satisfactory to run the spindle in reverse if not applying load to the workpiece - as for example in running back the carriage with the split nut still engaged when cutting metric threads on an Imperial calibrated lathe.

At times I have contemplated putting tapped holes radially through the chuck backplates to allow the insertion of brass grubscrews to clamp to the parallel section of the mandrel nose. However I decided against this modification as

(i) it probably would not give a sufficiently positive hold to allow secure reverse direction working on the job in hand and

(ii) knowing of the possibility of chuck run-off allows precautions to be taken to avoid this occurrence and

(iii) it avoids possible effects on accuracy of mounting.

4. What happens if the chuck does get stuck against the mandrel nose shoulder? Most workshop texts tell you to put the lathe into back gear leaving the spindle pulley locked to the back gear; place a piece of timber between the jaws of the chuck; then apply undoing force.

Well, about a year after I bought my lathe, I had the chuck stuck and went through this procedure. The result was two broken teeth on the back gear. Fortunately I was able to get a replacement gear from the manufacturer, but it was a difficult and tedious business to carry out the substitution of the new gear for the old. So my advice is don't do it.

Instead I now use one of the chuck 'height' blocks on its end as a stop for an extended chuck jaw while rapidly turning the countershaft pulley by hand. The block length is such that when standing on the protecting board it exactly engages the jaw in the horizontal position - **see Drawing 3**. You can get 1/6 to 1/4 of a revolution of the chuck before the jaw hits depending how far you extend the jaws. To date this system has worked (fingers crossed) and there are only belts to slip not teeth to break.

5. Sometimes it is necessary to operate the lathe without chuck or faceplate on the mandrel nose. This exposes the nose to possible damage, and the operator to possible injury. To avoid these a steel cover has been machined as shown in **Drawing 1**. This screws on and completely envelops the mandrel nose. It has two holes to allow a transverse bar to be used to undo it if necessary **(see Photo. 2)**.

# Chuck Backplate

Access to the threads in the chuck backplate is not as easy, but a device as shown in **Drawing 4**, and in use in **Photo. 3** is recommended in many workshop texts e.g. References 1 and 2. Mine is made of fencing wire, the ends of the coil being heated and then flattened, and afterwards filed to shape to match the backplate threads. If it can be screwed into the chuck backplate from the bottom when the chuck jaws face upwards, chips will

*6. The internal components of a chuck - the scroll seen from the bevel gear side, the central location casting with its attachment screws and the three pinions with their securing pins*

*7. The scroll and pinions assembled*

drop out by gravity. But it works fairly well when the chuck is on its side, with assistance from a (tooth) brush. I have a magnetised scriber - useful also to remove steel chips.

When the backplate is positioned in the register at the back of the chuck, there is a small gap which forms a convenient receptacle for chips. These can later migrate to the chuck jaws and cause problems - see **Drawing 5**. Hence there is an advantage in preventing their getting into this gap in the first place. For some years I have used a 'worm' of Plasticene, placed around the central chuck hole, which is then squashed between chuck and backplate on assembly, sealing the entrance to this gap. Recently however I have been trying the arrangement shown in **Photo. 4**, where an 'O'-ring is put in this position, being initially attached to the backplate with a few drops of polyurethane adhesive. It is expected that this arrangement will be an improvement on the Plasticene as the chips could invade the soft surface of that material.

## Chuck care

Tubal Cain in his various writings e.g. Reference 2, stated that he completely dismantled his chucks regularly for cleaning and re-oiling. This certainly allows complete removal of chips, but once a year should be often enough for this process. In between times, a lesser dismantling can give good results.

**Photos. 5, 6, 7 & 8** show the internal arrangements of a typical self-centring chuck. Two sets of jaws are provided; one set to grasp the workpiece externally and the other set internally. The latter is more generally used as it can also externally grasp smaller diameter workpieces. The jaws have teeth on their rear surfaces which engage with spiral grooves in a scroll inside the chuck body. It will be noted that the teeth are not of uniform thickness as they have to continue engagement with differing radius curves on the scroll by virtue of its spiral form - **see Photo. 9.**

On the back of the scroll is a bevel gear which is driven by any of three bevel pinions which are held in place by threaded pins running axially in the chuck body, and which pass through grooves in the pinion bodies. A shaped casting encloses the back of the chuck body and it is secured with three socket head capscrews. I fill these with putty **(Photo. 8)** to prevent chips accumulating therein.

The backplate closely fits a register in the rear of the chuck body and is attached to the body with six socket head capscrews. It is essential when dismantling the chuck to mark the parts (permanently if possible) to ensure they are reassembled in exactly the same place. The backplate is usually a close fit in the chuck body register and it is necessary to split them apart with a blade inserted into the joint e.g. a wood chisel lightly tapped in. Before reassembly, all parts should be lightly oiled.

*8. After assembly, the location casting holes have been puttied*

The main problem at intermediate cleanings is to get rid of chips in the ways of the chuck jaws and from the scroll of the self centring chuck, so firstly remove the jaws which can be completely cleared of chips. Next clean chips from the ways, and for this a splayed bristle toothbrush is most useful - **see Photo. 1**. A brush in this condition may dismay the family dentist but it is just the thing for this job.

To clean chips from the scroll a 'comb' as shown in **Drawing 6 and Photo. 10** is helpful. With the chuck on its side and the comb in a slot facing downwards, the scroll is turned with the chuck key in the direction which moves the jaws (and so also the comb) outwards. The comb collects the chips from the scroll and they either fall out under gravity or can be wiped off. Again the magnetised scriber is useful.

Making the comb from something like sheet galvanised steel is just a case of marking out, then sawing with a junior hacksaw and filing to fit. However, getting the actual dimensions of the scroll 'teeth' is not so easy. Probably this job is best tackled when the chuck is having its annual dismantling and cleaning. Even so, measurement of the teeth is difficult as the jaws of the vernier calliper will not go in between them and the curvature of the scroll makes the use of gauge blocks inappropriate. Drill shanks are one approach to gauging the gaps, and the insides of a long set of dividers can be use as a sort of substitute for outside callipers. Anyway, it seems worthwhile going to some trouble to make the comb as it greatly facilitates clearance of chips from the scroll.

## Storage

When not in use, chucks should be parked jaws down, as this allows chips to fall out of, rather than into the jaw guides. My chucks live on a shelf below the lathe drip tray, and when parked have their backplate boss and hole covered with old coffee tin lids, which prevent swarf or chips from current operations finding their way into the chuck interiors.

## Conclusion

The provision of barriers to chips inside the chuck/backplate gap will reduce the nuisance of a chip supply feeding back into the chuck jaws.

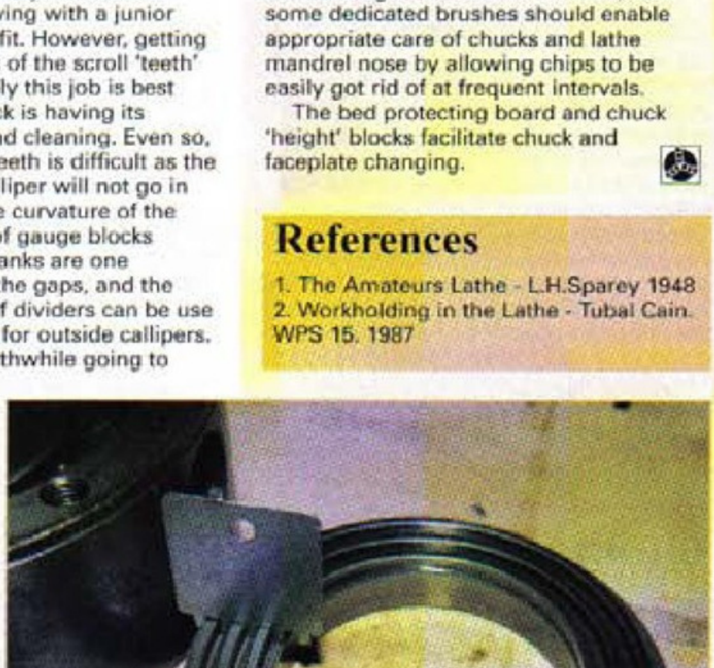
The availability of the two special tools for cleaning threads and the scroll, and some dedicated brushes should enable appropriate care of chucks and lathe mandrel nose by allowing chips to be easily got rid of at frequent intervals.

The bed protecting board and chuck 'height' blocks facilitate chuck and faceplate changing.

## References

1. The Amateurs Lathe - L.H.Sparey 1948
2. Workholding in the Lathe - Tubal Cain. WPS 15. 1987

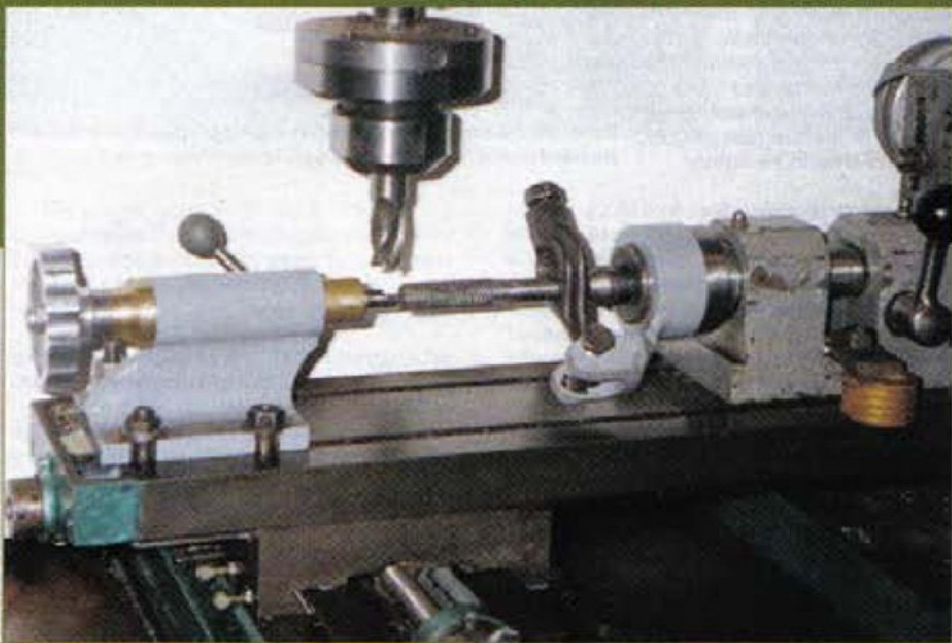
*9. A set of inside grasping jaws*



*10. The cleaning comb engaged with the scroll*

# MILLING BETWEEN CENTRES

**Having completed the tailstock described in Issue 68, Norman Hurst addressed the problem of aligning workpieces in the indexing unit**



*1. Milling between centres showing both the new tailstock and the carrier in use*

## The Alignment Problem

When I had made the tailstock for use with my indexing device, I already had a another milling job in mind on which I could use the new item. This new job entailed longitudinal milling, parallel to the X-axis of the table, a situation which is likely to be the case for most jobs using a tailstock; e.g. cutting flats, hexagons, keyways and splines. On attempting to set my job up however, I suddenly realised that it wasn't straightforward. The indexing head seemed to be going at one angle and the tailstock at another, making the set-up a sort of 'S' or 'Z' figure. I knew that the height to centre line (the vertical plane) was correct on both items, so the difficulty lay in the horizontal plane only.

## The solution (1)

I decided that the answer to this difficulty would be to fit locating keys under the bases of the two items. These could touch the edge of the machine table - in the same manner as the guiding pins on a scribing block - or engage in the tee slots. I concluded that the latter alternative would be more positive, so that was the method I adopted. However, because work would sometimes be carried out in a direction other than longitudinally, the keys would need to be removable.

As I have only two 5/16in. slots on my table (**see Photo. 1**) and because of the comparatively small size of the tailstock base, I was quite restricted as to where these keys could be fitted. Due to the shape of my indexing head base however, I soon realised that it had to have its key in the far slot, i.e. the one furthest from the operator. This - in turn - determined the location of the key on the tailstock. Two small keys could have been fitted on the tailstock base, but I decided that a single long one would be preferable.

Because of the holding-down positions on its base, the tailstock had to straddle the tee slots, with its centre line aligned with the table's centre line. This established the exact position of the tailstock key and became the starting point for the alignment and key fitting. I decided to make the longest possible key and position it between two holding-down slots (Photo. 1 in last issue); bearing in mind that there needed to be clearance with the tee bolt heads, hence the ends of the key are about 5mm from the edges of the slots (**Fig. 1**).

In order to align the tailstock with the indexing head, I used two 1/2in. diameter steel bars - each about 4in long - and a dial test indicator. One bar would be mounted in the tailstock and the other in the indexing head.

## Manufacture (1)

One of the 1/2in. bars was first mounted in the lathe and adjusted to run true. A No. 1 (male) Morse taper was then turned at one end, then the bar removed from the lathe and its Morse taper end firmly fitted into the barrel. With the tailstock resting on a surface plate and with the use of the dial indicator, the upper side of the bar was checked, this proving to be parallel with the surface plate.

After the vertical sides of the far tee slot were lightly filed to remove any burrs, a key for the tailstock was made from a piece of mild steel, approximately 5/16in. x 3/8in. x 13/16in., the sides being filed to make it a close (but not a sliding) fit in the tee slot. It was essential that the faces of the key be kept at 90 deg. to ensure that it was square to the base when fitted. Three holes were drilled in the key, two for locating pins or dowels and one for a securing screw, these being positioned along the centre-line of the key, but with the screw hole drilled off-set from the mid point (Fig. 1), thus ensuring that it could only be fitted one way around. Having decided to use 1/8in. diameter locating pins and an M4 cap screw with each key, I drilled the locating pin holes with a No. 31 drill and the screw hole with a 4mm drill; i.e. no clearance on the screw at this stage. The tailstock was then positioned on the machine table to be as close as possible to the final alignment. Measurements from the edge of the tee slot were carefully taken (to use as a reference) and the position was marked on the base where the screw hole was to be drilled tapping size and then tapped M4.

The tailstock key was secured into position using a flat headed screw, but as no pins had yet been fitted, the key could be twisted around, pivoting on the screw. The latter was tightened to the point where the key could not be moved by hand, but was not yet fully secured. The assembly was then placed into position on the machine table with the key in the tee slot. Before taking the next step, a check made to ensure that the screw head was clear of the tee slot bottom, this being the reason why the flat headed screw was used.

Although the key itself was in its final position, the tailstock was not. Its alignment was achieved by again using the dial indicator, but this time horizontally mounted, with the plunger against the side of the 1/2in. bar. By moving the table from side to side, the error in the alignment was clearly shown. This set-up is similar to the one in **Photo. 2**, but without the holding-down bolts. The end of the tailstock was then gently tapped, so that the tailstock swivelled around on the screw and key until the indicator reading was constant. The set-up was then lifted out, care being taken not to displace the key position. Without disturbing the screw, a clamp was fitted at one end of the key, securing it to the base; the idea being to prevent any movement then, using the key as a jig, a hole was then made in the base with the No. 31 drill. The key was removed and the small hole in the base opened out with a 3.2mm drill. A pin was then cut to length (about 15mm) and fitted in the key - in the same hole as used for the base drilling. At this stage, I have assumed that the constructor does not have a 1/8in reamer and drilling will be the method used. The fitting of the pins will depend on their actual diameters and whether the drills cut exactly to their size.

With the pin fitted, the key was secured to the base - this time with the screw tightened. The assembly was again mounted in position and another alignment check made with the indicator. It should - of course - have been true, but it wasn't! I assume that small movements and inaccuracies had crept in during clamping, drilling or in fitting the pin. I had foreseen that something may go wrong and that was one reason why I drilled a 4mm hole with no clearance. From the indicator readings, I knew which way the tailstock had to go to correct the error and this could be done by altering the location of the screw - relative to the key. Using a round Swiss file, the screw hole in the key was elongated sideways to accommodate the revised set-up. Another trial was run, but this time the tailstock would be swivelling on the pin. Again the assembly was tapped until the reading was constant then, having satisfied myself that the set-up was now correct, I removed the key and opened up the hole with a No. 18 drill in order to give it some clearance. I counterbored the underside of the screw hole to take the M4 cap screw head. As previously described, the screw hole had been 'drawn over' to one side and this caused the counterbore to break through on that side of the key. This can just be seen in Photo. 1. The diameter of an M4 cap screw head is 7mm and my counterbore tool is 8.1mm diameter, so it was not a surprise that this happened. The key was again fitted, but this time with its own cap screw, which was not fully tightened - as with the previous trials. When this had been aligned, it was carefully removed and clamped then the second pin hole drilled. On fitting this pin and opening up its clearance hole with the 3.2mm drill, I found that the key was difficult to push into position, so the holes were opened out with a No. 30 drill. The key was then lightly filed along one side to give a sliding fit in the tee slot before it was finally was fitted and secured and the tailstock bolted down, in readiness for lining up with the indexing head.

A slightly different method was used with the indexing head. The second 1/2in. bar (bar 2) was held in the 4in. chuck (Photo. 2). Using the dial indicator, bar 2 was checked to confirm that it was rotating true in the chuck. The assembly was then brought up to within a millimetre or so of the tailstock bar (similar to Photo. 2 but not bolted down) and the approximate position of the key securing screw was marked, both on the machine table and on the indexing head base. The indexing head was then moved away, ready for the next step. The key was made to be a push fit in the tee slot, and placed in the slot in the position already marked. A piece of packing was placed under the key to enable its top surface to be just below, but parallel with, the surface of the table. Because I didn't have the restrictions previously encountered, this key was made longer (1 3/4in.). The reader should note that it is advantageous to make either key as long as possible, thus reducing the extent of any errors that may occur. The indexing head was next moved back into position, but this time the aligning process was carried out. Using the dial indicator, bar 2 was aligned with the tailstock bar, in a 'trial and error' manner, by shifting the indexing head and then moving the table back and forth, similar to the method adopted previously. The unit was then temporarily bolted down to ensure accuracy in the next operation.

A centre (Slocombe) drill was mounted in the drill chuck and aligned with the centre line of the tee slot. The machine table was then wound along until the centre drill was over the proposed screw hole mark and a small hole drilled, this being followed through with the M4 tapping size drill. The base was drilled right through and the key (in the slot underneath) spotted. The indexing head was again removed and the key extracted from the slot so that a 4mm hole could be drilled through at the spotted position. The key was secured to the base with the M4 flat headed screw and partially tightened, all as previous, so that the assembly could be put back in position and tapped around until bar 2 showed a constant reading. It was found that the ends of the two bars were not quite in line, so this fault was again corrected by elongating the 4mm hole, as was done previously. When I was satisfied with the positioning of the indexing head, the elongated hole was drilled through with the No. 18 drill and then counterbored.

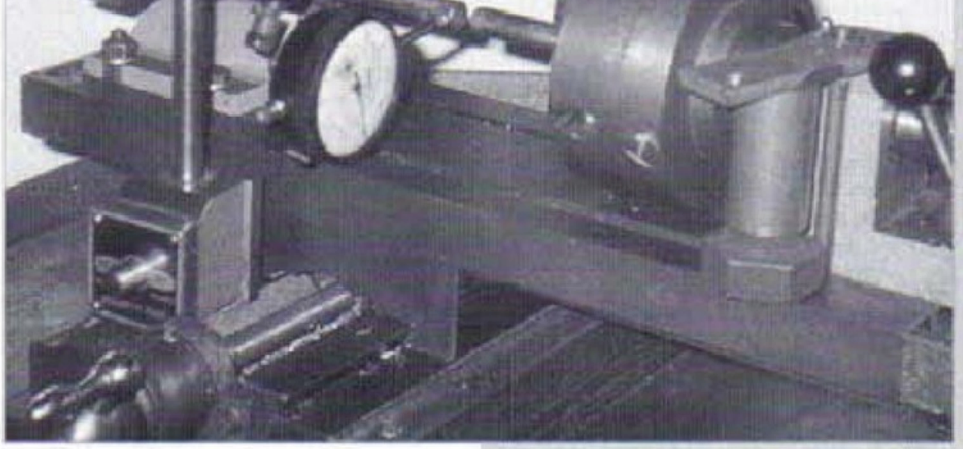
Two dowel holes had already been drilled in the key and a similar procedure of aligning, clamping, drilling and fitting pins was used as was employed when fitting the tailstock key. The final result was an acceptable reading on the dial indicator when the table was wound over the full length of about 5 inches. The sides of the key were then eased with the file to give a sliding fit - again, all as done previously.

In retrospect, I realise that I could have aligned the two items and fitted the keys in a different manner. Instead of using the two short bars, I should have used one long bar; one end being left plain and the other with the Morse taper, as previous. The plain end of the bar would be mounted in the chuck and adjusted to run true. The tapered end would then be pushed into the tailstock, connecting the three components as one unit. Using the dial indicator, the whole unit would then be aligned - using the tailstock and the tee slot as the starting points - and then clamped to the table. Three holes would be drilled in the tailstock base by lining up with the slot centre line, similarly to the method I used to drill the M4 tapping hole in the indexing head. Without disturbing the set-up, the screw hole would then be drilled in the indexing unit base.

Instead of drilling and immediately fitting a dowel in each key, I would now tap the base M3 and have a 3mm hole in the key. This would give a secure temporary fixing, but would also leave scope to adjust the position slightly before opening out to the full 1/8in. pin diameter. I would also use a temporary M3 securing screw in the M4 position. This would also allow provision for adjusting the hole before opening out to the full size. Hopefully however, with the new aligning method these adjustments would not be necessary.

## The Work Holding Problem

On the first milling job that I did with the new set-up, I held the work in the chuck, but whilst carrying out the work, I realised that although I had already centred both



*2. Checking the alignment of the two units*

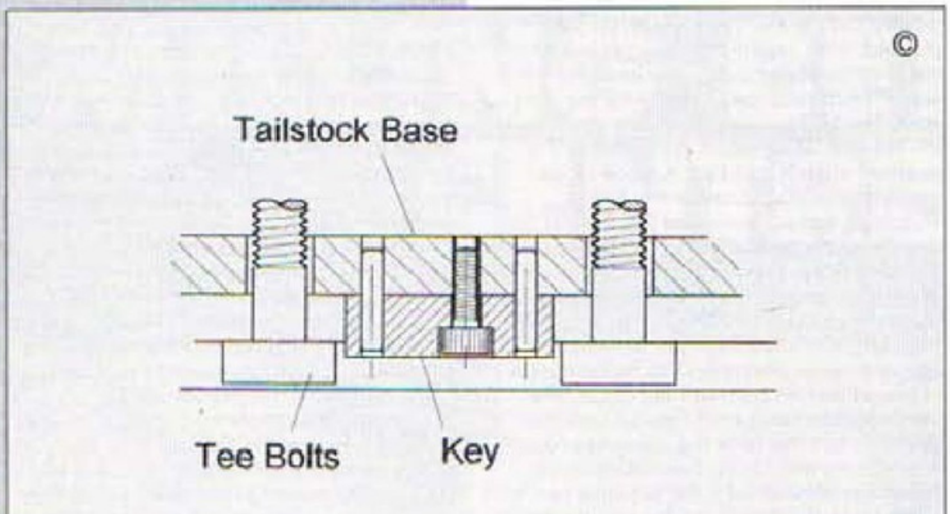



Fig. 1

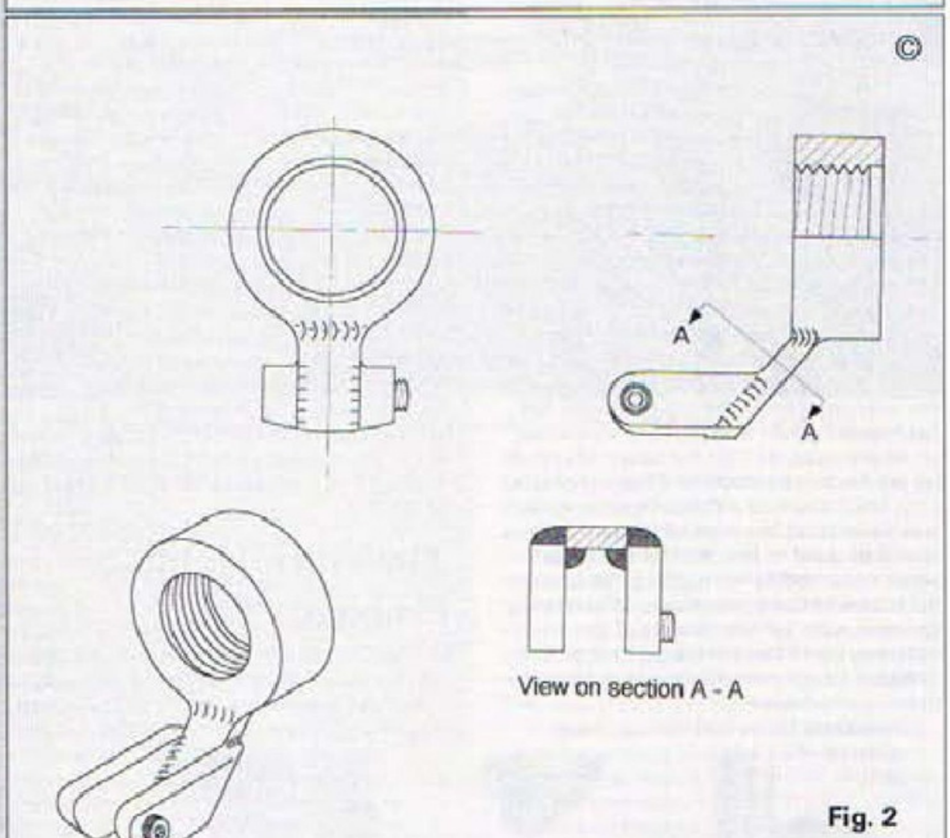



Fig. 2

ends of the work piece, I was only using one centre. This seemed to me to be an odd way of going about such a task and I wondered if there would be a method where I could make use of the two centres and thus avoid having to get the work running true in the chuck.

Work between centres in the lathe is invariably driven by a carrier and a catch plate. Work in a milling machine however, mounted between a tailstock and a dividing head, is not being driven in the same manner and has to be firmly secured to the dividing head. There are 'catch plates' for dividing heads, but (a) I don't have one, (b) They require a bent carrier and I don't have one of these either, and (c) I don't think that they would be suitable for my size of work. I therefore decided to make an item specifically for use with my indexing head.

## The solution (2)

I have a small lathe carrier of 18mm diameter capacity, which I decided would normally be suitable for my milling operations. I then needed a type of catch plate onto which the carrier would be locked. On small equipment such as used in the home workshop, the conventional method of securing a catch plate is by screwing it onto the nose of the lathe or dividing head. My indexing head has a screwed nose of 1½in. diameter x 8 tpi and I felt that this size would be suitable for the new item. Because it would not be driving in the normal sense of the word, but would be clamping the work, I am calling it a catch clamp. I decided that it would take the form of a screwed ring or collar with a fork welded on, this fork to include a screw, which would be the clamping part of the unit.

## Manufacture (2)

The chuck was removed from the indexing unit and my shortest No. 2 Morse taper centre was put in its place. This centre became the datum to which other measurements would be referred. I secured the carrier to my partially machined work piece, in the position that it would eventually be required and located the work in its centre, as if I was mounting it for milling. The dimension between the carrier and the nose was then noted, which in this case was 63mm. This distance would eventually determine the position of the clamp screw.

A steel ring 53mm diameter x 23mm long was turned, drilled, bored and an internal thread cut to suit the threaded nose of the indexing unit. This ring was then screwed on to the nose and another check dimension taken, using the centre and the work piece. This confirmed the dimension of 40mm. A piece of mild steel 6 x 16 x 35mm long was welded to the edge of the ring at an angle of about 40 deg., in a 'pan handle' configuration (**Fig 2**). Two steel 'fork' side plates, each 9 x 15 x 40mm maximum length were cut to shape and welded onto the pan handle using the welding procedure shown in the sectional view in Fig 2. Comparatively thick sides and heavy welds were used for the fork, as it must act in the same way as a G clamp and the sides must therefore not be forced apart when its screw is tightened.

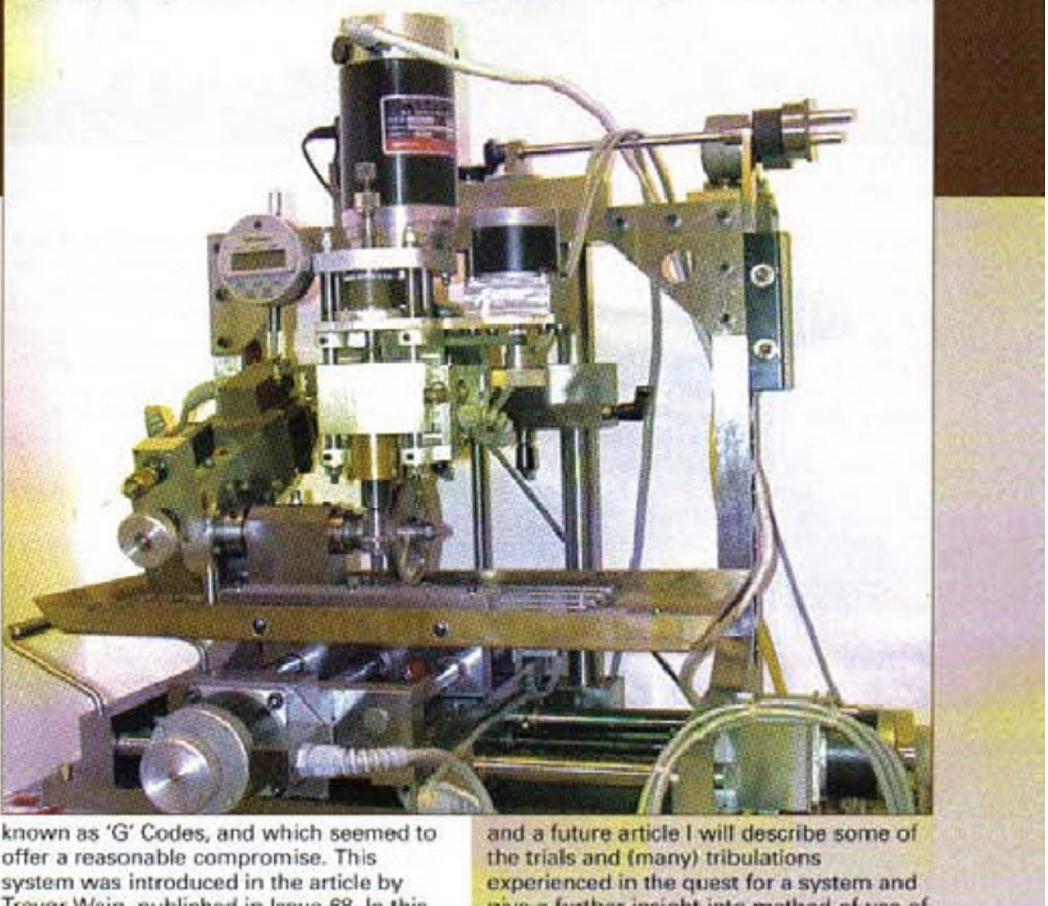
The unit was then screwed onto the lathe nose and the underside of the forks machined to give the curved finish as shown in Fig 2. In this instance, the height to the centre line on the indexing unit was 2.100in., so I made the finished dimension from the bottom of the fork to the lathe centre line at 2.05 inches. After turning, this dimension was checked by stopping the work on the far side of the lathe, i.e. the side opposite to the tool and then measuring between the machined surface and the tool itself. In this case the dimension was therefore twice 2.05in, i.e. 4.10 inches.

The work was then removed from the lathe and the position for the clamping screw marked, this being 40mm from the end of the ring, in order to be in full contact with the carrier foot . The hole was drilled and tapped M8. In Photo. 1, hexagon headed set screws are shown, both on the carrier and on the fork clamp, these being kept as short as possible in order to maintain clearance with the machine bed. However, they have now both been changed for grub screws as the length (within reason) is less critical.

In Photo. 1, I am cutting the flutes on a one-off special tap, the thread of which had already been cut on the lathe - between centres. Without disturbing the carrier or the lathe set-up, the work had then been transferred from the lathe to the milling machine and the flutes cut. The work was finally returned to the lathe and, again without disturbing the settings, a light cut taken along the threads to remove the burrs from the milling operation. I believe that this method is particularly well suited for work that needs to be accurately set-up and subsequently transferred to carry out different machining operations.

# FURTHER EXPERIMENTS WITH CNC

**Peter Rawlinson describes his quest for an alternative control system for his CNC milling machine**

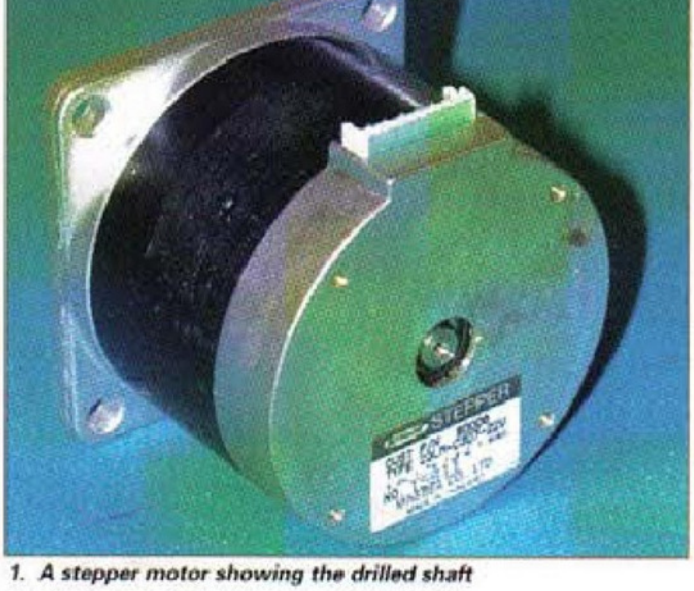


In Issues 52 to 56 of this magazine, I described the building and use of my CNC milling machine which uses the HPGL system (see Note 1) in conjunction with the 'Compucut' software and hardware supplied by Richard Bartlett and advertised in these pages. Subsequently I decided to look into the possibility of using other systems of CNC control which use alternative methods of programming the instruction to the machine.

I therefore looked at a number of commercial systems but found most to be highly complex and to cost much more than the average amateur would wish to spend, both for the necessary hardware and for the software (the program). I did not consider them to be warranted, particularly in view of the limited use to which we are likely to put them.

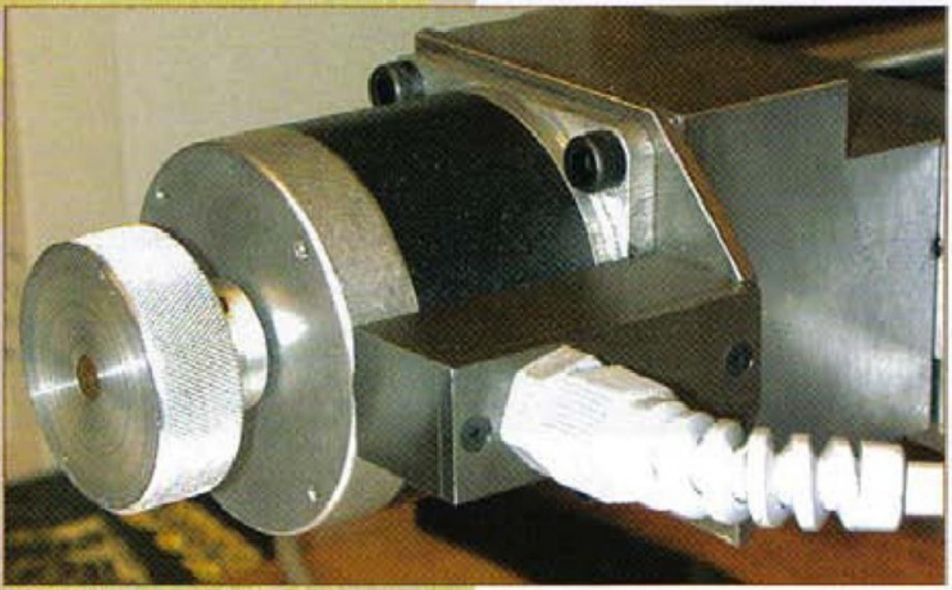
It would seem that the programs, in the main, are written for individual control systems and for specific machines. I did contact a software company in Wales who explained that theirs were designed on this basis and were not likely to be of much help.

I therefore started looking at the industry standard which uses a system known as 'G' Codes, and which seemed to offer a reasonable compromise. This system was introduced in the article by Trevor Wain, published in Issue 68. In this and a future article I will describe some of the trials and (many) tribulations experienced in the quest for a system and give a further insight into method of use of



*1. A stepper motor showing the drilled shaft*

*2. The new knob Loctited into position*



*3. The motor mounted in position on the machine. The neat plug and socket arrangement keeps the cable tidy*

the 'G' and 'M' code system with its simpler programming methods, this without the use of a computer aided drawing (CAD) package. I will include details of the equipment that I have used, together with instructions for building a control system using standard parts, interconnected using a series of special printed circuit boards. In previous articles I have discussed the manufacture of PCBs, but will now cover the making of double sided boards, not so difficult a task as it may seem, especially if a dedicated circuit is used.

Variations associated with Unipolar and Bipolar systems will be described, together with a simple set of hardware that can, with the addition of a computer and the appropriate software, give a cheaper solution for the Unipolar.

Throughout all this, it is important that the reader must realise that I am self-taught and that I am sure that there are many readers out there who could give us all many tips and share their experiences. I know that the Editor would welcome any follow-up articles from other sources.

## The search

There are numerous companies which supply the hardware and software for these systems, so it was necessary to acquire and evaluate a large amount of data. It was here, for the first time, that I used the Internet for this type of activity, and found it simple once the coded addresses for these companies were known. I was able to 'download' all the information from a single company in about 10 minutes. At the 'local' rate for telephone calls, the cost amounted to no more than 10 pence, even though this was from the USA. A stamp for a letter would have been 64 pence and, of course, the information could be printed off to be read at leisure. More importantly, it was available immediately.

The company that I chose eventually is called Microkinetics who are located at Kennesaw, Georgia (full address at the end of the article).

From this company I decided to purchase their 'MillMaster Pro G-Code Interpreter' plus the hardware to go with it - the 'OptiStep Plus-PC' together with their 'Break out Board' which allows a screw terminal connection to the other equipment. In the end this latter part was not used as a special PCB was produced to do the same job and also act as a 'master' link to all the other driver and relay boards.

## Hardware modifications

While discussing hardware, it is probably a convenient point to mention some changes I have made to my CNC milling machine. I have now connected my stepper motors at a one to one ratio with the lead screws. It seemed a pity to have to do this through a precision toothed belt drive in order to be able to retain manual adjustment of the table position, so I decided to see if a hand wheel could be fitted to the rear of the motors. I am using Model Motors Direct Type 23 stepper motors, and my idea (or rather that of friend Ray Jolley) was to drill a hole in the back of the motor shaft and to Loctite an extension shaft in place. As the main shaft was $^1/_4$in. dia., it was decided to fit an extension shaft of 4mm. dia., so the motor was drilled and reamed 4mm x 16mm deep, and a silver steel shaft prepared. A knob was also made and Loctited to the extension shaft, and then came the crucial job of Loctiting the extension shaft into the main shaft, all this without getting Loctite into the ball bearings.

It was here that I remembered the way the girl was poisoned in the James Bond film "You Only Live Twice", by letting the liquid run down a string, so I used a piece of 24 SWG wire, carefully running the adhesive down into the 4mm reamed hole. A little was also put on the extension shaft and the knob placed on the table, shaft up, then the motor offered to the shaft and carefully pushed down until fully home. In this way any excess adhesive ran away from the bearing.

Due to the depth the extension is set into the main shaft it is immensely strong and I feel there should be no trouble in the future with it coming loose. There should also be no worries about the strength of the main shaft as it is not in bending and the torque that is transmitted when machining is acting only on the other end of the shaft. I have now completed four of these modifications and all seems to be well. The photographs show them in place. A flexible coupling of the Oldham type is incorporated between the motor and its leadscrew this, with its sliding centre section, being very suitable.

As the motors I am using are fitted with a plug and socket connection for the six wires, a very tidy arrangement was possible, eliminating any necessity for taping the wires up.

## 'G' & 'M' Codes

Trevor Wain gave us an insight into the history of CNC machining and introduced the 'G' and 'M' code system. To re-cap, the 'G' codes are the basic commands for the control of the machine movements, whereas the 'M' (or 'Miscellaneous') codes control the such things as cutter spindle motor, coolant and the various chucks, tool changes and the like. Some are unassigned and may be used for other functions. Many of the 'G' codes have a one-off function, whereas others have a 'latched-on' function and must be 'turned off' by a second complimentary code, the latter being referred to as 'Modal'.

The system, dating back to the early 1970s became the industry standard throughout America, The UK and mainland Europe and was covered by a variety of National and International Standards for use on the growing range of sophisticated machines. In Appendix A I have included an example of one of these lists of codes (probably superseded by now), Table A covering the 'G' codes and Table B the 'M' codes. Although the list is comprehensive, it will not usually be incorporated fully by the designers of software as they will select only those codes that are thought to be appropriate for the type of machine the program is intended for. Indeed out of the 99 codes in each list, some 37 of the 'G' codes and 57 of the 'M' codes are unassigned, these being available to manufacturers to suit their programs.

**TABLE 1**

**Abbreviations**

| | |
|---|---|
| X | X axis Either + or - |
| Y | Y axis Either + or - |
| Z | Z axis Either + or - |
| A | Rotary axis |
| V | Rotary table speed of rotation |
| D | Dwell (in seconds) To allow checking etc. |
| T | Tool Numbers (1, 2, 3, 4, 5, 6 etc.) |
| F | Feed Rate (Start at F10 to F500 dependent on material etc.). - put into the command line |
| I | Distance - centre to arc (more later) |
| J | Distance - centre to arc " |
| Q# | Number of passes |
| K | Depth of cut in multiple passes |
| S | Spindle speed |
| * | Multiplies two variables |

**TABLE 2**

## 'G' Code function descriptions for MillMaster Pro

| | |
|---|---|
| G00 | Rapid Move only, position to position, in a straight line<br>*Example G00 X0.2 Y-0.2* |
| G01 | Cuts a straight path at any angle if X & Y are appropriate<br>*Example G01 X2.2 Y2 F20 (Feed rate)* |
| G02 | This is used to cut a circular path in a clockwise direction. The last move must be to the start of circle. After the G02 code, the end point of the arc is entered in 'X & Y' co-ordinates, then the 'I & J' dimensions followed by a feed rate again.<br>*Example. G02 X.5 Y2 J1 F10* |
| G03 | This code is used in exactly the same way as G02, but cuts counter-clockwise<br>*Example. G03 X3 Y2 J1 F10*<br>Note:- As I understand it, a circle has to be split into 4 quadrants and each 90 deg. quadrant must have its own line in the program as each line will only give a maximum of 90 deg. |
| G04 | This will put a delay in the program<br>*Example. G04 D20*<br>(This gives a pause of 20seconds) |
| G17 | Selects 'X-Y' plane |
| G18 | Selects 'X-Z' plane |
| G19 | Selects 'Y-Z' plane |
| G25 | Program run to carry on at start of a sub routine. Some Modal states are saved and restored on completion of sub routine. These include G90/91, G74/75 and current program line.<br>*Example. G25 #Groove*<br>Runs "Groove" Subroutine in current file.<br>G25 #Subs.Groove<br>Runs the "Groove" Subroutine in file SUBS.CNC in current directory |
| G26 | Conditional Branch. Causes program to jump to specified Label<br>*Example. G26 I1 #Holeset*<br>Will jump to #Holeset when input is a logical zero. |
| G27 | Unconditional Branch. Causes program to jump to specified Label<br>*Example. G27 #Holeset* |
| G28 | Used to set a variable to a desired value. It should be made up of letters and numbers only and enclosed in brackets. Once defined it may be used in later blocks in place of numerical constants<br>*Example. G28 (Depth) = .5*<br>*(Sets depth to .5)*<br>G91 (Incremental<br>G01 X-(Depth) F10 (Cut into material)<br>G00 X(Depth) (Rapid travel out of material) |
| G70 | Sets the Imperial program format. This overrides the selection in the 'Material Size/Set-up' Window<br>*Example. G70* |
| G71 | As above but metric |
| G74 | Selects single quadrant arc programming (Default)<br>(I, J & K parameters must be positive<br>*Example. G74* |
| G75 | Selects multiple quadrant arc programming. (In other words a 'full' circle)<br>(I, J & K parameters may be positive or negative)<br>*Example. G75* |
| G79 | Multi pass canned cycle**. Mill in one direction only using Q# passes or K depth of pass. Includes X, Y co-ordinates<br>*Example. G00 X2*<br>*G79 X3 Y1 Z.2 Q4*<br>Mills a channel 0.2in. deep in 4 passes. |
| G80 | Cancels any canned cycle. Must be used after each canned cycle |
| G81 | Drilled canned cycle. Parameters include X, Y & Z depth<br>*Example. G81 X.5 Y.5 Z.15*<br>Drills a hole 0.15in. deep in single pass |
| G82 | Spot face canned cycle. Parameters include X, Y, & Z depth return at feed rate<br>*Example. G82 X.5 Y.5 Z.2 D.5*<br>Spot faces 0.2in. deep and dwell 0.5 seconds |
| G83 | Deep hole drilling canned cycle. Parameters include X, Y & Z Depth and either Q# number of passes or K depth per pass<br>*Example. G83 X.5 Y.5 Z1 Q4*<br>Drills hole 1in. deep in 4 passes |
| G85 | Boring canned cycle. Parameters include X, Y & Z depth return stroke at feed rate<br>*Example. G85 X.5 Y.5 Z.2*<br>Will bore 0.2in. deep |
| G87 | Deep drill canned cycle with chip breaker (Woodpecker). Parameters include X, Y & Z, either Q# passes or K depth of stroke (Retracts 0.05in. after each cut)<br>*Example. G87 X.5 Y.5 Z1 Q4*<br>*or (both equivalent)*<br>*G87 X.5 Y.5 Z1 K.25*<br>Drills hole 1in. deep in 4 passes (Woodpecker) |
| G89 | Boring canned cycle with dwell. Parameters include X, Y, Z & dwell time<br>*Example. G89 X.5 Y.5 Z.2 D.5*<br>*Bores 0.2in. deep, wait 0.5 seconds andreturn at feed rate* |
| G90 | Sets absolute programming from zero point (is Modal and therefore requires cancelling). Default is incremental. Cancel using G91 |
| G91 | Sets incremental mode (or relative). Always from last tool position |
| G92 | Initial start point, but can be used to step and repeat a set of commands at a new position |
| G95 | Chains to another program. Include this command at the end of a part program*** file and it will automatically load and continue machining the specified program. Any code placed after this command will not be executed<br>*Example. G95 #Test*<br>*Will load and machine Test.CNC out of the current directory at the end of the current file* |

** A 'canned cycle' is a form of sub-routine or 'repetitive machining sequence'. It consists of a small programme which is embedded, details having to be added to the program, but the machine recognises it from the 'G' code.

***The term 'part programming' does not refer to a part or section of a program but to the item that is to be machined.

# Microkinetics System

This leads conveniently to the next topic, the variation on the basic theme used within the Microkinetics MillMaster Pro system which I have now adapted to my machine. Table 1 lists the abbreviations used, while Table 2 covers the 'G' codes and Table 3 the 'M' codes.

# Programming

The 'G' code system is simpler to programme than other systems I have encountered and there are advantages as most variations can be carried out in the centre of a stopped program. It is even possible to modify the program in the middle of machining a component and the variation can be entered into the computer before the program is recommenced at the finish point. It is also possible to alter the parameters at any time during the cycle. Individual cutter movements can also have their own speed of feed set for that line of program or left at the default setting for all movements.

## TABLE 3

### 'M' Code function descriptions for MillMaster Pro

| | |
|---|---|
| M00 | Temporary stop. Operation will recommence by pressing <Enter> |
| M02 | End of program stop |
| M03 | This operates Output No. 1. Cutter motor clockwise |
| M04 | This operates Output No. 5. Cutter motor anticlockwise |
| M05 | Turns off M03 or M05 |
| M06 | Selects the tool *Example. M06 T2 Selects tool No. 2* |
| M08 | This operates Output No. 2. Coolant? |
| M09 | Turns off Output No. 2. Coolant? |
| M10 | This operates Output No. 3. Vacuum or Auxiliary? |
| M11 | Turns off Output No. 3. Vacuum or Auxiliary |
| M12 | This operates Output No. 4. Auxiliary? |
| M13 | Turns off Output No. 4. Auxiliary? |
| M17 | Must be used at the end of a sub-routine. Restores G90/91 & G74/75 and continues the program after the subroutine line. |
| M25 | Homes the Z, Y & X axes in that order |
| M39 | This operates Output No. 6. Chuck? |
| M40 | Turns off Output No. 6. Chuck? |
| M97 | Pauses program until logical zero is detected at specified input *Example. M97 I2* Will wait for Input No. 2 to become logical zero before continuing program execution |
| M99 | Restarts the program from the beginning |

The system allows the leadscrew and the number of steps per rev. of the motor to be independent of the decision of whether Imperial or metric dimensioning is required. It is, by default, Imperial, but by adding the code G71 can be made metric in an individual program, and it would also seem that individual lines could be made Imperial or metric if required (this would seem to be a good way of getting in a muddle, to say the least!).

The programming of radii is simple and consists of defining the finish point X & Y and a radius in I or J. This threw me, but it seems that if the curve is to go 'Horizontal & Up' then J is used and if 'Vertical & Across' then I is used. As mentioned before, a circle is split into four quadrants so remember that four lines of program are needed if greater than 270 deg is required, but there is a separate code for the full circle, which can be done in one line of code.

## Worked examples

I have found little in the way of text about this subject and although the system is in current use, the British Standard has now been withdrawn. One book that I have found is mentioned at the end of the article, but personally I like worked examples as I find them easier to understand. I am therefore including a few simple programs to illustrate some of the principles. I am indebted to Chris, a friend of my son, who is a tool maker and to a machinist Phil Guess, with whom I used to work, for their help in this endeavour.

## Circular quadrants

Figures 1 and 2 illustrate how circular arcs are buit up of quadrants or part quadrants to make any angle that is required. Figure 1 shows the two quadrants, and Figure 2 shows one and a part quadrant. A program for generating these is shown in Table 4.

It is only necessary to calculate the angular position in X and Y co-ordinates of the end location and to put these into the required positions in the program. Alternatively these can be drawn in CAD to save the calculations.

## TABLE 4 - Circular Quadrants

Figures 1 and 2 cover the following program for circular quadrants.

| | | | | | |
|---|---|---|---|---|---|
| G90 | | | | | Absolute |
| G71 | | | | | Metric |
| G92 | X0 | Y0 | | Z1 | Start position |
| M06 | | | T3 | | Tool number |
| M03 | | | | | Start spindle |
| G00 | X30 | Y5 | | | Start position of quadrant |
| G01 | | | | Z-2 | Lower cutter |
| G02 | X5 | Y30 | J25 | | Finish Position and Radius J Lower Quadrant |
| G02 | X30 | Y55 | I25 | | Finish Position and Radius I Upper Quadrant |
| G00 | | | | Z1 | |
| G00 | X0 | Y0 | | | |
| M02 | | | | | |

The last quadrant that I wish to explain in detail is the one that does not start and finish on the X, Y or Z axes. This is a little more complex and again requires that a few calculations are carried out to obtain the necessary data. It is shown in Figure 3, the calculations being as follows:-

X = 25.00 cos 30 deg. - 25.00 cos 75 deg.
= 21.65 - 6.47 = 15.18

Y = 25.00 sin 75 deg. - 25.00 sin 30 deg.
= 24.15 - 12.50 = 11.65

I (in X axis) = 25.00 cos 75 deg. = 6.47

J (in Y axis) = 25.00 sin 75 deg. = 24.15

The program required to produce the curve shown in Figure 3 is given in Table 5 and introduces the G03 code for an anti-clockwise cutting path.

## Sub-routines

We now come to the use of sub-routines, code G25. This allows a separate program to be written and stored in the normal memory file. It can then be called up and placed in the main program at any and as many places as is required. It can specify a group of holes, a recess, a groove or any machining that is of a repetitive nature. This program is written exactly as normal but should be in Incremental and not Absolute and should end in the return code M17 which then returns the 'reading' to the main program, which will then carry

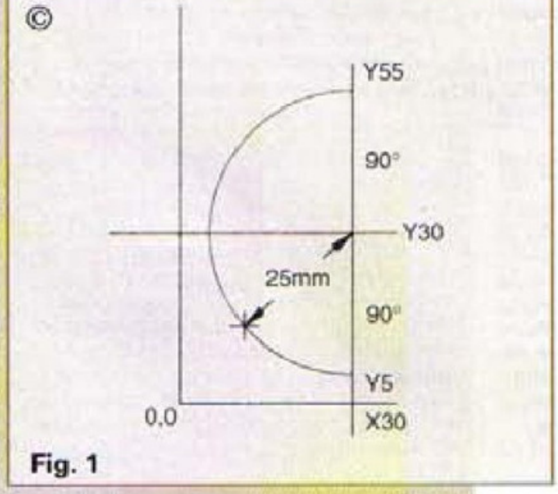



Fig. 1

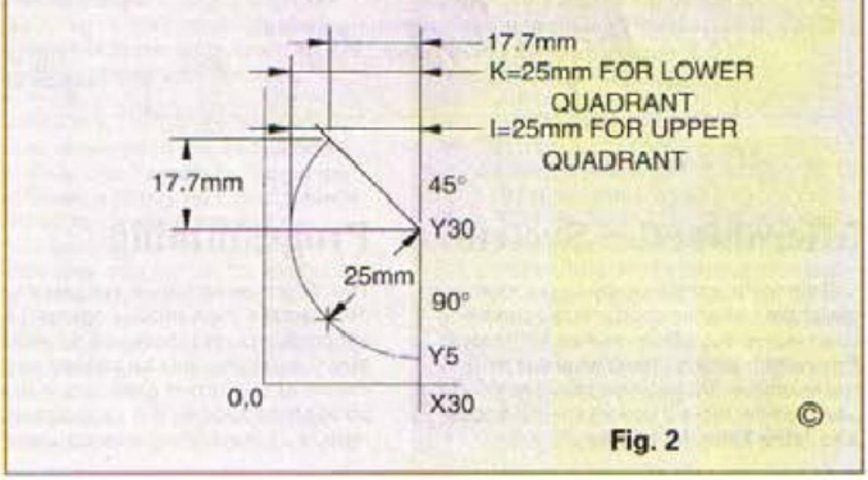



Fig. 2

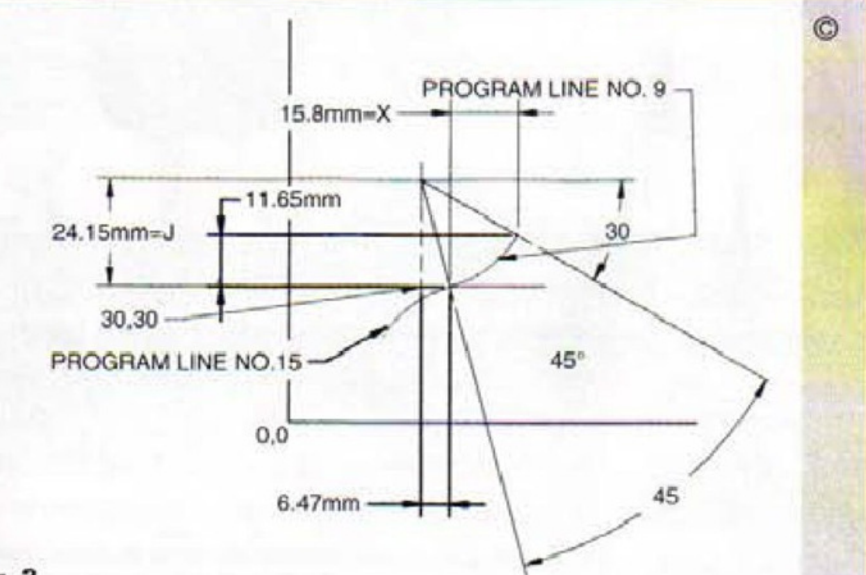



**Fig. 3**

## TABLE 5

This program introduces the G03 code for an anti-clockwise cutting path.

| | | | | | | |
|---|---|---|---|---|---|---|
| N01 | G90 | | | | | |
| N02 | G71 | | | | | |
| N03 | G92 | X0 | Y0 | | Z1 | |
| N04 | M06 | | | T3 | | |
| N05 | M03 | | | | | |
| N06 | G00 | X30 | Y30 | | | |
| N07 | G01 | | | | Z-2 | |
| N08 | G91 | | | | | |
| N09 | G03 | X15.18 | Y11.65 | | I6.47 | J24.15 |
| N10 | G90 | | | | | |
| N11 | G00 | | | | Z1 | |
| N12 | G00 | X0 | Y0 | | | |
| N13 | G00 | X30 | Y30 | | | |
| N14 | G01 | | | | Z-2 | |
| N15 | G03 | X-15.18 | Y-11.65 | | I-6.47 | J-24.15 |
| N16 | G90 | | | | | |
| N17 | G00 | | | | Z1 | |
| N18 | G00 | X0 | Y0 | | | |
| N19 | M02 | | | | | |

This gives the curves shown in Fig. 3.

on until it gets to the next G25 or the end of the program.
A sub-routine program which will instruct the drilling of three holes in line is listed in Table 6.
By repeating this sub-routine at the appropriate points in a more comprehensive program, a number of similar rows of holes can be made to form a pattern. Table 7 illustrates this.

These sub-routines can be as large as necessary and of course, the bigger they are, the greater the savings in time and the shorter the main program. They can be stored for future use, perhaps on floppy discs and called into programs as and when required.

I have used names for my programs but as a large number are likely to be stored eventually, I think it will be wise to use a numbering system. Program name lengths are severely restricted due to the original programs having been written in DOS (Disc Operating System), used to run the basic computer.

This is not supposed to be a manual, but is to give some ideas of the programming steps involved. The straight movements are simple, just requiring X and Y co-ordinates. Various combinations can be used, and contouring can be carried out on any two axes. With a little thought and control of the fourth axis, some three-dimensional sculpting is possible. A variety of other canned cycles are catered for, which I am sure will come in handy in the future. One thing I have found most useful is the 'jog' command on all four axes, which I also believe can be fitted with a joy stick.

The system should give easier use and as it is set up Dimensionally instead then it will be easier to use it must be borne in mind that there is no cutter size compensation and this must be allowed for during the programming.

As stated before, I am happy to answer any questions, but by phone only please on 01233 712158. If you wish to notify me of a particular question before hand, then I can be e-mailed at piprawli61@aol.com or faxed at the above number.

## TABLE 6

A sub-routine program for drilling three holes
This is saved as I1#Holes.CNC

| | | | | | |
|---|---|---|---|---|---|
| N01 | G91 | | | | Incremental |
| N02 | G81 | X10 | Y0 | Z-2 | Canned Cycle |
| N03 | G80 | | | | Finish |
| N04 | G81 | X10 | Y0 | Z-2 | Canned Cycle |
| N05 | G80 | | | | Finish |
| N06 | G81 | X10 | Y0 | Z-2 | Canned Cycle |
| N07 | G80 | | | | Finish |
| N08 | M17 | | | | Return |
| N09 | G90 | | | | Absolute |

Will produce this hole pattern:- O O O

## TABLE 7

This next program is called Holes CNC, and to call it up, we start up the main program in the following way:-

| | | | | | |
|---|---|---|---|---|---|
| N01 | G90 | | | | Absolute |
| N02 | G71 | | | | Metric |
| N03 | G92 | X0 | Y0 | Z1 | Start position |
| N04 | M06 | | | T3 | Tool Number |
| N05 | M03 | | | | Start Cutter |
| N06 | G01 | X30 | Y30 | | Move to position |
| N07 | G91 | | | | Incremental |
| N08 | G25 | I1#Holes | | | Drill 3 holes |
| N09 | G90 | | | | Absolute |
| N010 | G01 | X30 | Y20 | | Move to new position 10mm below first hole |
| N011 | G91 | | | | Incremental |
| N012 | G25 | I1#Holes | | | Drill 3 holes |
| N013 | G90 | | | | Absolute |
| N014 | G01 | X30 | Y10 | | Move to new position below first hole in the second row |
| N015 | G91 | | | | Incremental |
| N016 | G25 | I1#Holes | | | Drill 3 holes |
| N017 | G90 | | | | Absolute |
| N018 | G00 | X0 | Y0 | Z1 | Return to home |
| N019 | M02 | | | | End program |

This will give the following pattern of holes:-

O O O
O O O
O O O

# APPENDIX 1 Standard Codes

## TABLE A

### 'G' Codes

| Code Number | Function | Modal* |
|---|---|---|
| G00 | Rapid positioning, point to point | (M) |
| G01 | Linear positioning at controlled feed rate | (M) |
| G02 | Circular interpolation Clockwise-two dimensional | (M) |
| G03 | Circular interpolation A/clockwise-two dimensional | (M) |
| G04 | Dwell for programmed duration | |
| G05 | Unassigned Electronics Industries Association (EIA) code - may be used as hold (Cancelled by operator) | |
| G06 | Parabolic interpolation | (M) |
| G07 | Unassigned EIA code | |
| G08 | Programmed slide acceleration | |
| G09 | Programmed slide deceleration | |
| G10 to G12 | Unassigned EIA codes sometimes used for machine lock and unlock devices | |
| G13 to G16 | Axis selection | (M) |
| G17 | XY Plane selection | (M) |
| G18 | ZX plane selection | (M) |
| G19 | YZ plane selection | (M) |
| G20 | Unassigned EIA code | |
| G21 to G23 | Unassigned EIA code sometimes used for nonstop blended interpolation movements | |
| G24 | Unassigned EIA code | |
| G25 to G29 | Permanently unassigned Available for individual use | |
| G30 to G32 | Unassigned EIA code | |
| G33 | Thread cutting, constant lead | (M) |
| G34 | Thread cutting, increasing lead | (M) |
| G35 | Thread cutting, decreasing lead | (M) |
| G36 to G39 | Permanently unassigned Available for individual use | |
| G40 | Cutter compensation/offset, cancel | (M) |
| G41 | Cutter compensation, left | (M) |
| G42 | Cutter compensation, right | (M) |
| G43 | Cutter offset inside corner | (M) |
| G44 | Cutter offset outside corner | (M) |
| G45 to G49 | Unassigned EIA code | |
| G50 | Reserved for adaptive control | |
| G51 | Cutter compensation +/0 | |
| G52 | Cutter compensation -/0 | |
| G53 | Linear shift cancel | (M) |
| G54 | Linear shift X | (M) |
| G55 | Linear shift Y | (M) |
| G56 | Linear shift Z | (M) |
| G57 | Linear shift XY | (M) |
| G58 | Linear shift XZ | (M) |
| G59 | Linear shift YZ | (M) |
| G60 to G69 | Unassigned EIA codes | |
| G70 | Imperial programming | (M) |
| G71 | Metric programming | (M) |
| G72 | Circular interpolation-Clockwise (3 dimensional) | (M) |
| G73 | Circular interpolation-A/Clockwise (3 dimensional) | (M) |
| G74 | Cancel multiquadrant circular interpolation | (M) |
| G75 | Multiquadrant circular interpolation | (M) |
| G76 to G79 | Unassigned EIA code | |
| G80 | Fixed cycle cancel | (M) |
| G81 to G89 | Fixed cycles 1 to 9 | (M) |
| G90 | Absolute dimension input | (M) |
| G91 | Incremental dimension input | (M) |
| G92 | Preload registers | |
| G93 | Inverse time feedrate (V/D) | (M) |
| G94 | Inches (millimetres) per minute feedrate | (M) |
| G95 | Inches (millimetres) per revolution feedrate | (M) |
| G96 | Constant surface speed, feet (metres) per minute | (M) |
| G97 | Revolutions per minute | (M) |
| G98 -G99 | Unassigned EIA code | |

*Function retained until cancelled or superseded by subsequent command of same letter

## TABLE B

### M Codes

| Code | Function | Modal' |
|---|---|---|
| M00 | Program stop | |
| M01 | Optional stop | |
| M02 | End of program | |
| M03 | Spindle on clockwise | (M) |
| M04 | Spindle on anticlockwise | (M) |
| M05 | Spindle off | (M) |
| M06 | Toolchange | (M) |
| M07 | Coolant 2 on | (M) |
| M08 | Coolant 1 on | (M) |
| M09 | Coolant off | (M) |
| M10 | Clamp | (M) |
| M11 | Unclamp | (M) |
| M12 | Synchronization code | (M) |
| M13 | Spindle on clockwise, coolant on | (M) |
| M14 | Spindle on anticlockwise, coolant on | (M) |
| M15 | Motion in the positive direction | |
| M16 | Motion in the negative direction | |
| M17 - M18 | Unassigned EIA code | |
| M19 | Oriented spindle stop | (M) |
| M20 to M29 | Permanently unassigned. Available for individual use | |
| M30 | End of tape/data | (M) |
| M31 | Interlock bypass | (M) |
| M32 to M35 | Unassigned EIA code | |
| M36 to M39 | Permanently unassigned Available for individual use | |
| M40 to M46 | Gear changes if used, otherwise unassigned | (M) |
| M47 | Return to program start | |
| M48 | Cancel M49 | (M) |
| M49 | Feed/speed bypass override | (M) |
| M50-M57 | Unassigned EIA code | |
| M58 | Cancel M59 | (M) |
| M59 | Bypass constant surface speed updating(M) | |
| M60 to M89 | Unassigned EIA code | |
| M90-M99 | Reserved for user | |

* Function retained until cancelled or superseded by subsequent command of same letter

***Supplier:-***
***Microkinetics Corporation, 2117-A Barret Park Drive, Kennesaw GA 30144 USA. Tel. 770-422-7845, Fax. 770-422-7854,***
***e-mail. http://www.microkinetics.com***

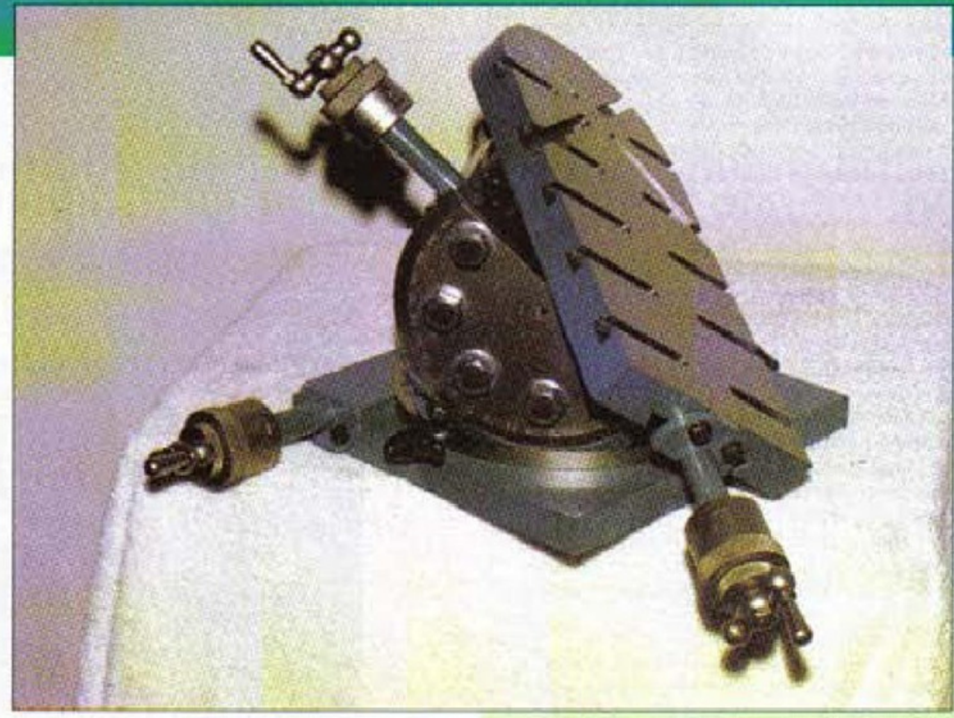
Reference book:-
'An introduction to CNC Machining and programming', David Gibbs & Thomas M Crandell, Industrial Press Inc. 200 Madison Ave. New York.

### Note 1:-HPGL

This is the abbreviation for 'Hewlett Packard Graphics Language' and was originally designed for use with their plotters. It does not have the more complex systems that are available to dedicated CNC programs, so it is necessary to draw out the simplest of curves and then to edit them to the exact requirements. You may remember that my original articles on the CNC mill covered this.

# A TILTING COMPOUND TABLE

In this second article, Geoff Allen gives some hints on machining the first batch of major castings



## Machining flat surfaces

I have found it a good idea to mount a rough casting on a birch ply base for initial machining. When creating the complete flat surface of any casting it is essential not to induce distortion by clamping, so I have decided it is best to mount each casting on ground strips of hardened and tempered steel (I use 12mm x 20mm x 150mm pieces of CO1) placed under it with the edge of the strip just proud of the bottom of the casting. This bridges the T slots in the table of my miller and allows secure clamping, with any repositioning of the clamps on the surface not causing bowing or depression of the casting.

This applies especially to the top of casting No. 10 (Drawing 1, shown here) and bases of castings No. 6 (Drawing 4) and No. 9 (Drawing 31, both to be seen in a later article).

I found that if the castings were secured centrally and at two corners, the other unclamped side could be cut then, as machining progressed to the centre, the two centre clamps moved to the machined corners. When the original corner clamps were approached, they could be moved to the centre of the work, thus completing the whole surface in one pass, without moving the piece.

All other surfaces except those mentioned above can be machined at one pass.

## Procedures

Now, a few suggestions on the sequence to be used when machining individual castings:-

### 1. Casting No. 10 (Drawing 1)

Machine the base and top flat using a large milling cutter or fly cutter to give a clean surface, near to dimension, checking to make sure that the bottom surface is less than 10mm above the unmachined surface of the central recess.

If possible, surface grind both surfaces to true parallelism and flatness. Hand scraping is a possible alternative, but a lot of work is likely to be involved.

### 2. Casting No. 9 (Drawing 2)

Mount in the lathe using a 4-jaw chuck, holding it by the rectangular section which will form the dovetail slide. Due to the draw on the castings, it may be necessary to dress square the ends and sides of this section in the milling machine, to provide a good grip in the chuck jaws. Machine the periphery and face the underside to form the centre spigot and the outer annular band, taking care to achieve accuracy of depth and diameter and to create a good finish. There may be an opportunity to correct dimensional errors later, but better to get it right now. The most important aspect here is quality of finish.

Drill a central hole through the casting using the largest possible drill (using pilot drills as necessary) and bore out to the diameter shown.

### 3. Casting No. 7 (Drawing 3)

3.1 Mount in the 4-jaw chuck with the top surface outermost. Again it may be necessary to machine the edges of the into four jaw chuck - (machine edges straight if necessary to facilitate grip). Centralise and check square.

3.2. Drill and ream a central 5mm diameter hole through the casting (this is not shown on the drawing).

3.3. Face off the top of the raised section, seeking a good quality finish.

3.4. Turn the recess in the centre to match up with the spigot on Casting No. 9. Ensure that the recess has a depth greater than the height of the spigot and that the one is a close running fit in the other. If the two do not fit snugly together (i.e. there is any lateral movement), then the accuracy of the unit will be compromised. It will either mean starting again with at least one new casting or carrying out a difficult salvage.

In order to spread the loads over the greatest possible area, I spent time in getting all the mating surfaces bedding together, with contact both on the top surfaces and at the bottom of the recess. I did this by initially making the recess over depth, as mentioned, then machining the top surface carefully, frequently checking with engineers' blue until the bedding was even. Some may think that this was over doing things a trifle, but whatever your approach, make sure that there is good contact with the top surface as this has the larger bearing area.

3.5. Remove the casting from the lathe and mount top down on the miller, using packing strips as suggested. Ensure that the casting is as near square as possible to the line to be milled for the dovetails.

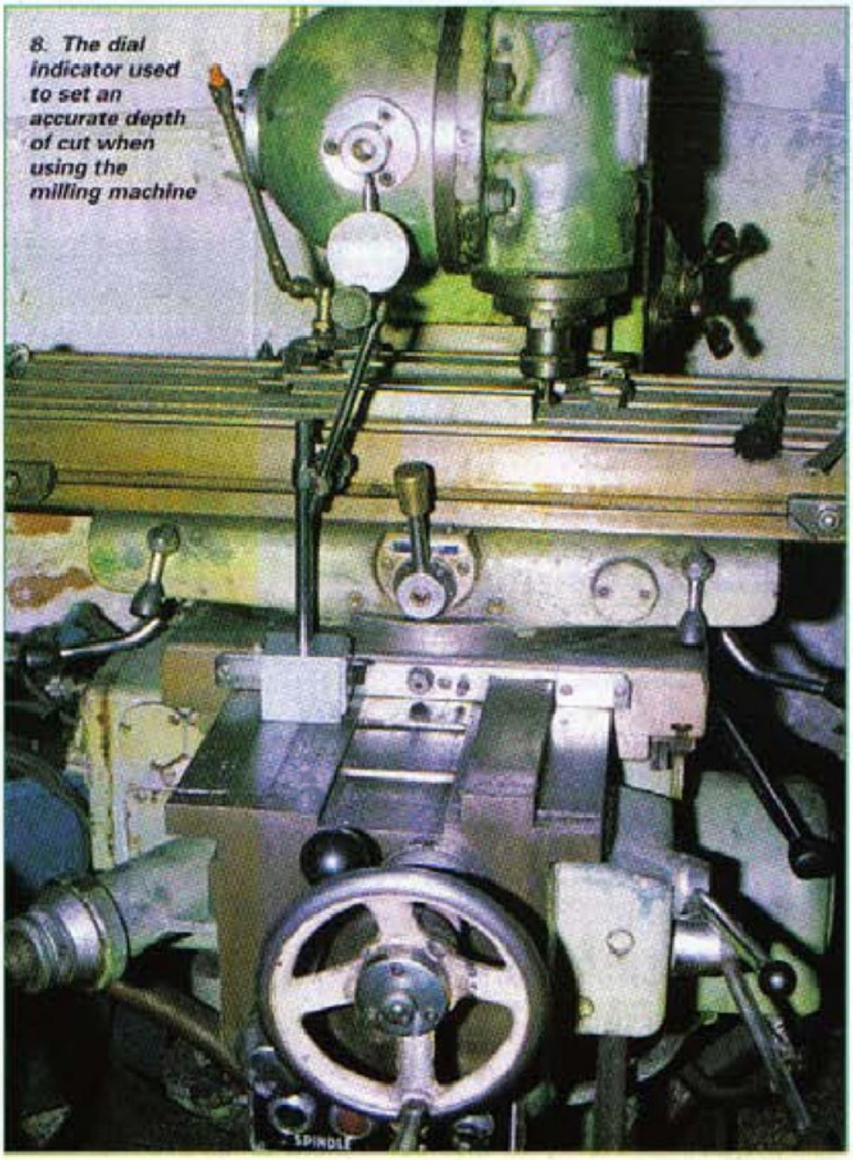
3.6. Clamp by the corners and machine off the top surface to be less than 10mm above the lower surface and approximately to correct depth relative to the previously machined face. I used the dovetail cutter to do this as I have found that if the machine head has any slack in the bearings, this type of cutter will be drawn down when machining the dovetails. By using the same tool to machine all surfaces on this side, dimensional errors can be reduced. This feature is especially true of any quill fed machine and can lead to considerable inaccuracy. In this case it may be better to reverse the order of machining to achieve the accuracy required. Obviously the dovetail cutter must be mounted in a well locked chuck (Clarkson or similar) to eliminate movement.

When this face is finished, carefully clamp the piece centrally over this raised machined area and remove the corner clamps. With the tool clear of the work, raise the table (or lower the cutter) exactly 10mm and lock firmly in place. This is best achieved using a dial gauge mounted between the table and the milling head, judging relative movement by means of the gauge **(Photo. 8)**. Take care when locking slides or quill as this often moves things by a 'thou' or so. If this happens simply make an appropriate allowance on the gauge reading. I have found that using the table calibrations is not accurate enough to achieve the required result.

When satisfied that everything is in the correct position, use the cutter to remove the necessary material in a continuous pass, taking such cuts as the machine will tolerate. It may be better to machine each surface progressively to achieve the dovetail dimension required and to ensure it is central in the piece. Again, slight inaccuracy here could be corrected later.

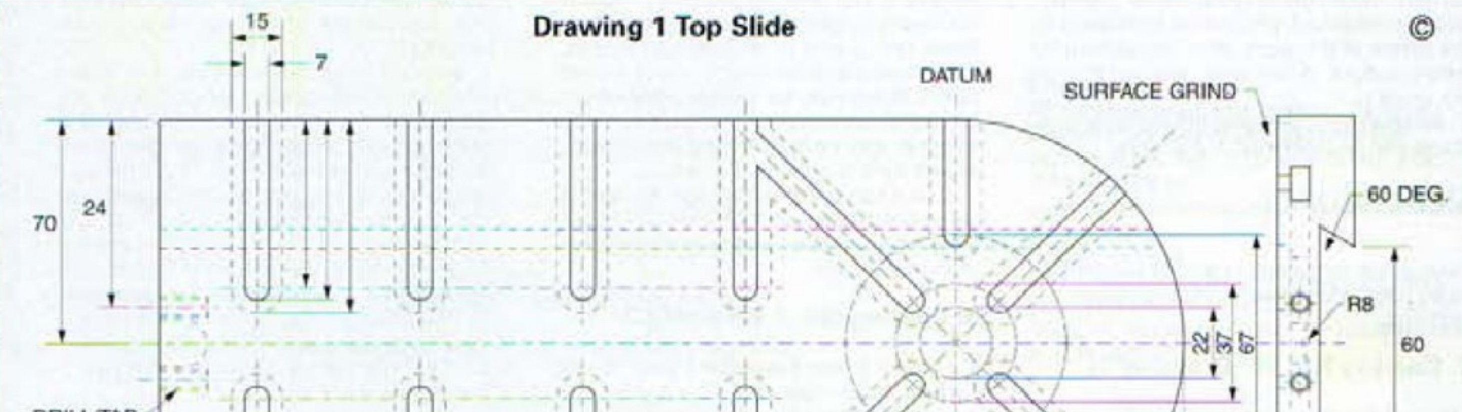
Finish should be to a high standard, taking a very fine final cut on each dovetail face, ensuring that they are exactly parallel.

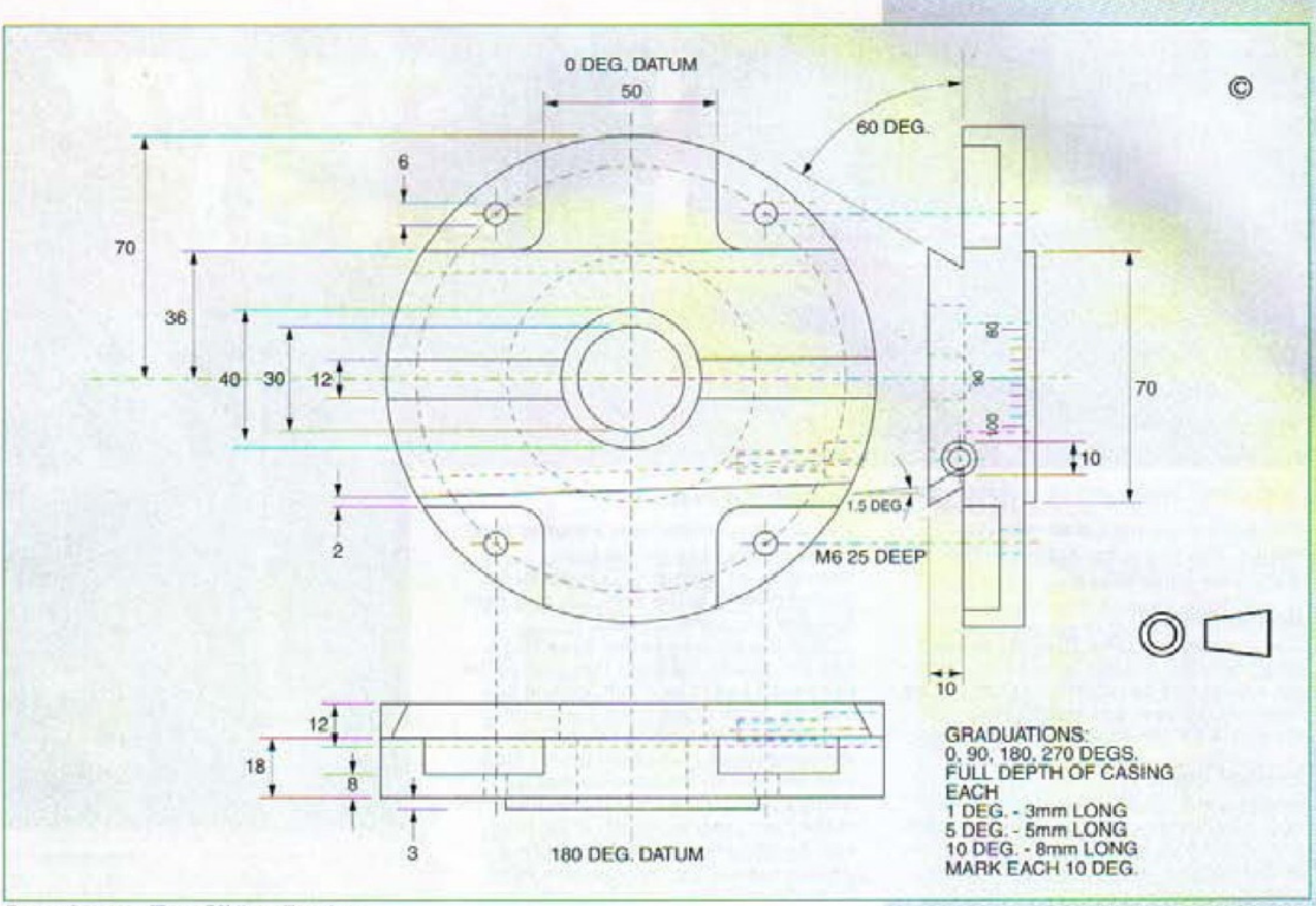
3.7. Reclamp without moving the component and square off one end with a parallel cutter, using the other table axis to give a true 90 deg. relationship with the dovetails. this casting can now be removed from the milling machine miller table.



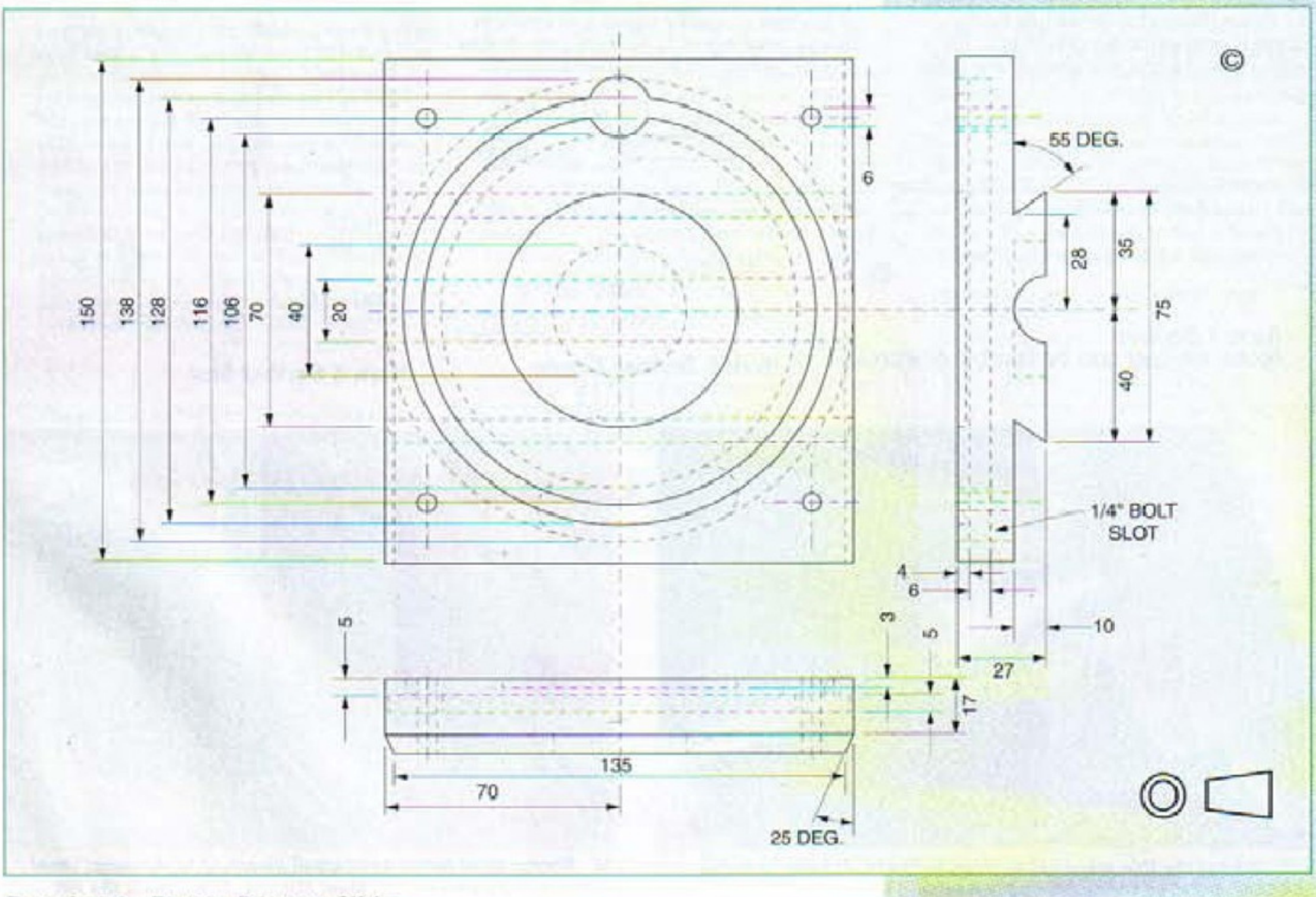
*8. The dial indicator used to set an accurate depth of cut when using the milling machine*

**Drawing 1 Top Slide**






**Drawing 2 Top Slide - Rotary**




**Drawing 3 Rotary Bottom Slide**

# Lathe projects for beginners (3)

**With this article we complete the first project in the series. Harold Hall gives detailed instructions on machining the remaining components of the mini surface gauge**

## The scriber assembly

The remaining parts are all relatively simple, with only a few hints required about their manufacture.

### Screw (Item 2)

This is a standard M6 x 25 hexagon head screw with just a single hole drilled into it. For appearance sake, the top surface of the head can be faced and re-chamfered and the end of the thread similarly improved.

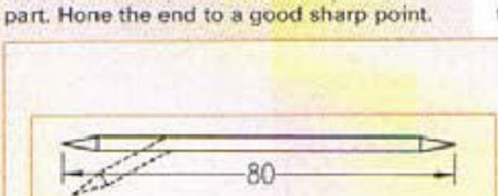
### Scriber (Item 1)

Made from 3mm silver steel, the pointed end is fashioned on the grinder. To harden, just hold the tip in the flame until the end 3mm becomes red hot (colour of boiled carrots) viewed in good but not bright light, keeping it in the flame for a few seconds to retain colour and then quench in water. Having hardened just the tip there should be no need to temper the part. Hone the end to a good sharp point.

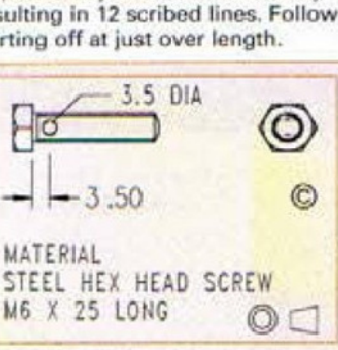
### Scriber nut (Item 4)

This would normally have a knurled head, but as this task has not yet been discussed, an alternative is suggested. Having made it in this way, you may even find that you prefer it - I did.

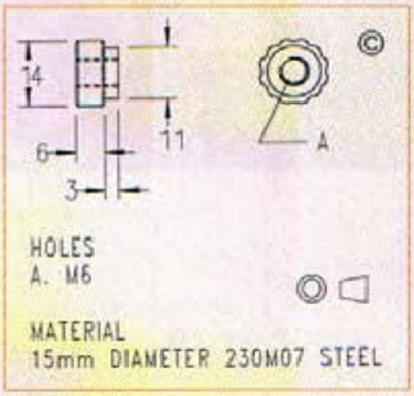
With the material in the 3-jaw chuck turn the smaller diameter then plunge the parting-off tool in by about 3mm at just over the width of the head. Centre drill, drill and tap M6, tapping being done manually rather than under power. Now, with any tool on the top slide that will scribe a line, proceed as follows. Place one of the three jaws horizontal at the front and, by traversing the saddle, scribe a deep line using the tool you have fitted. Bring the next jaw to the horizontal and repeat, similarly for the third jaw. Repeat the process with the three jaws horizontal at the rear, vertically above and vertically below, resulting in 12 scribed lines. Follow this by parting off at just over length.



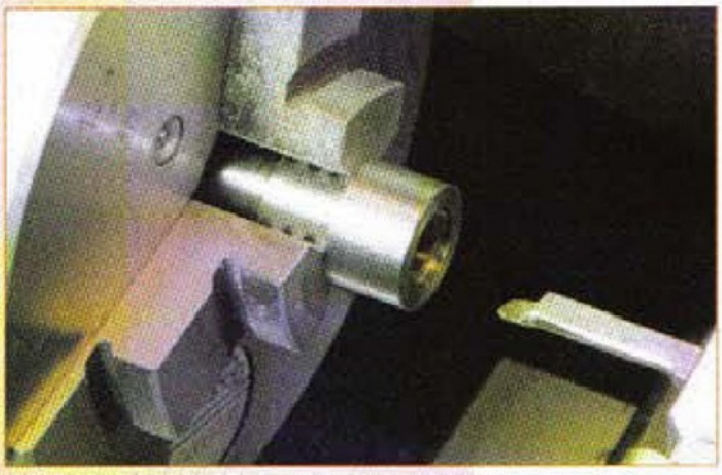

**Item 1 Scriber**
**Note: Scriber can be bent if preferred**




**Item 2 Scriber Screw**

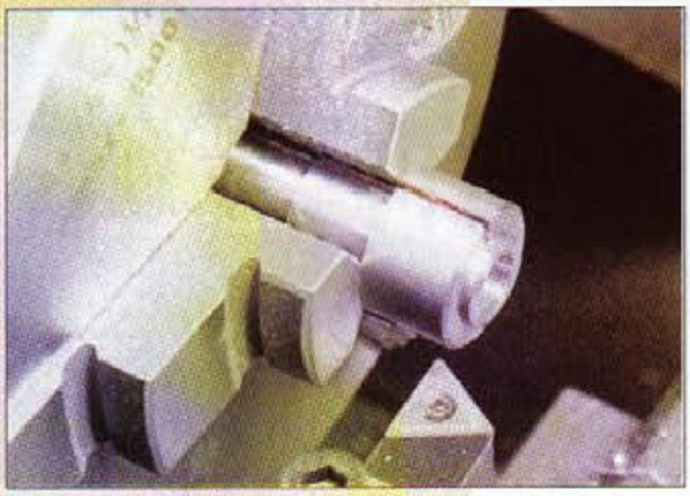



**Item 4 Scriber Nut**

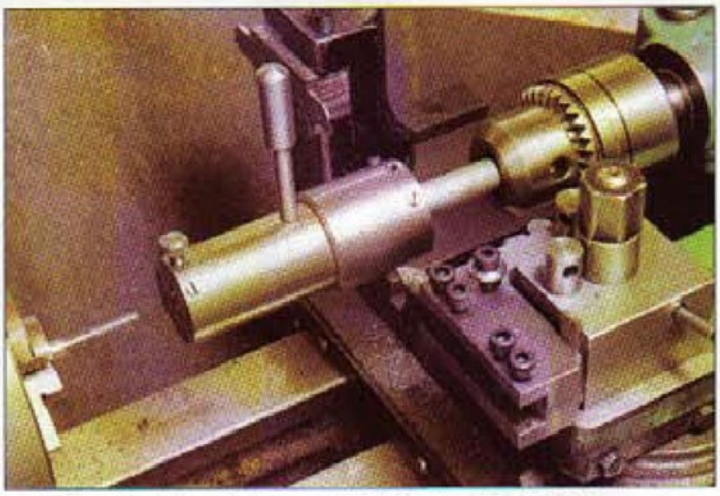


*15. Boring the thin piece collet (seen in Photo. 3) prior to being slotted and used for machining a washer*

*16. Boring tools made from small pieces of High Speed Steel which are gripped in mild steel holders. The one on the left would be suitable for boring the collet*



*17. Using the thin piece collet to hold a washer whilst being machined to the thickness required*



*18. Threading the adjuster stud with its two thread sizes*

With the part held in a vice and using a small round file, about 3 to 4mm diameter, file a groove in the head at each scribed line, making each groove about 2mm wide. This can be seen in Photo. 3 (issue 67) though not as clearly as I would have liked. Return the part to the chuck, holding it on the reduced diameter, and skim over the outer diameter to clean up the filed edges. Face and chamfer the outer end. Grip a length of M6 studding in the chuck and fit the nut to this, the other way round, enabling the other edge of the head to be chamfered.

### Scriber clamp washer (Item 3)

Place a piece of 10mm dia. steel in the chuck, face the end, centre drill, drill and part off at about 2.5mm thick. The ultimate thickness of the washer is quite critical, so as to ensure that it is the washer that clamps the scriber and not the inside of the hole on the clamping screw. This feature has been incorporated to create a deliberate need to work on thin parts. You may feel what is being proposed is rather over involved, but the small collet specified here is to be used a number of times through the series, being needed for operations where there is very little alternative, so do not be tempted to bypass the operation.

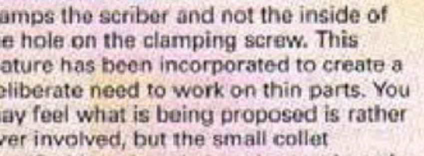
## Thin piece collet (SK4)

The answer to the problems of working on thin pieces is to use a dedicated piece chuck (Ref. 5), but these can be a sizeable project to make. A simple alternative is possible where concentricity is not over-important. The collet suggested is intended to be held in the 3- or 4-jaw chuck, so no other item is required, other than the plug that makes it possible to machine the end for use with other diameters, larger or smaller. After completion of the initial task, the end can be opened up to accommodate a larger diameter, or the head reduced in length and bored to a smaller diameter. In this first instance, the collet will be bored prior to being slotted **(Photo. 15)**, but subsequently the plug has to be fitted to prevent the collet closing whilst held for re-boring.

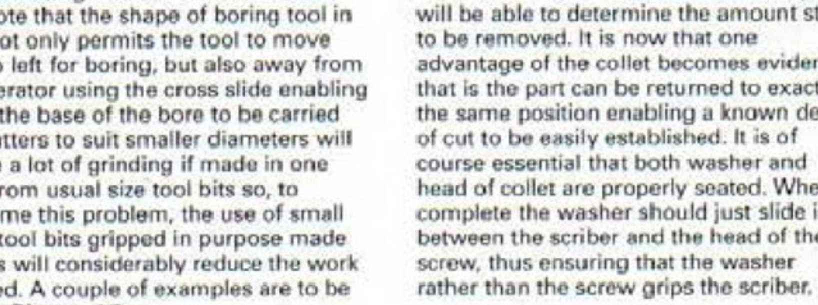
Boring, to be covered more fully at a later date, is much more complex than outside diameter turning, especially at smaller diameters. Shaping the tool is all important to gain the clearance between it and bore being made as shown in **SK5**. Take note that the shape of boring tool in Sk. 5 not only permits the tool to move right to left for boring, but also away from the operator using the cross slide enabling facing the base of the bore to be carried out. Cutters to suit smaller diameters will require a lot of grinding if made in one piece from usual size tool bits so, to overcome this problem, the use of small round tool bits gripped in purpose made holders will considerably reduce the work involved. A couple of examples are to be seen in **Photo. 16**.

Having bored the end of the collet to be close fit on the washer it can be slotted using a hack saw. Remove any burrs, especially those in the bore, and return the collet to the chuck, then grip the washer, ensuring it is properly located on the base of the bore and that the rear of the collet head is located against the jaws of the chuck **(Photo. 17)**.

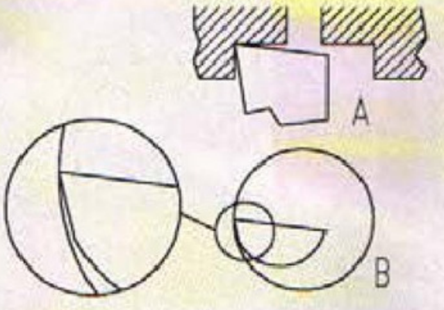
Place the scriber through the hole in the screw and, using feeler gauges, determine the distance between the scriber and the inside of the head. Lock the saddle and, using the top slide to place a light cut, face the washer using the cross-slide. Do not move the top slide but remove the washer and measure its thickness. From this you will be able to determine the amount still to be removed. It is now that one advantage of the collet becomes evident, that is the part can be returned to exactly the same position enabling a known depth of cut to be easily established. It is of course essential that both washer and head of collet are properly seated. When complete the washer should just slide in between the scriber and the head of the screw, thus ensuring that the washer rather than the screw grips the scriber.




**Item 3 Scriber Clamp Washer**



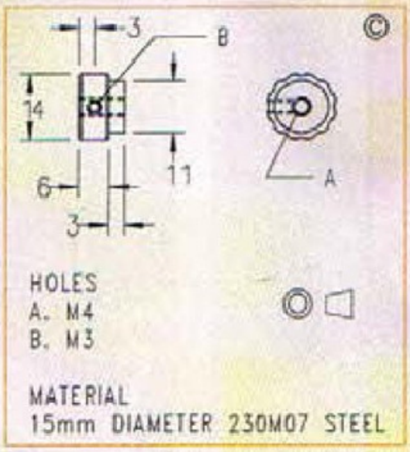

**SK4 Thin Piece Collet**



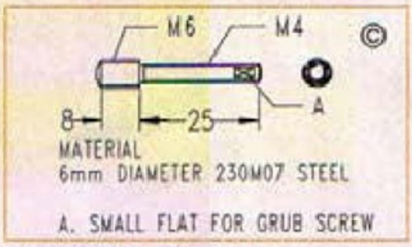

A. FOR BLIND OR SEMI BLIND HOLES END OF BORING TOOL MUST BE SHAPED TO CLEAR END OF BORE.

B. BORING TOOL MUST HAVE SUFFICIENT CLEARANCE WITH INSIDE OF THE BORE, SETTING THE TOOL ABOVE CENTRE MAY HELP IN EXTREEM CASES.

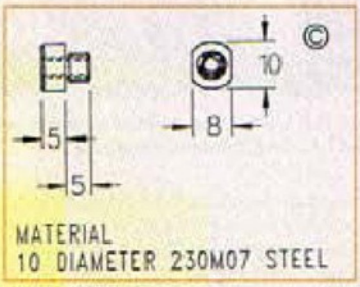
**SK5 Boring Tool Form**




**Item 6 Adjuster Nut**




**Item 7 Adjuster Stud**




**Item 8 Bush**

# Adjuster assembly

### Adjuster nut (Item 6)

This is a virtually a repeat of item 4, though the through hole is M4 and it has the addition of hole B (M3).

### Adjuster Stud (Item 7)

Chuck a piece of 6mm steel, set the speed to around 2000 rpm and turn down to 4mm over 25mm length. If your lathe does not run at so high a speed, and many do not, use the highest speed available. Using threading dies on the lathe is another subject yet to be given an airing, but being a simple task, you should be able to give it a try. **Photo. 18** shows the set-up, but if you do not have a tailstock die holder, do not go out and purchase one, as this will be a construction item in the series. In this case, remove the component to the vice and make the threads using a hand held die stock. Concentricity of the threads is, though, of importance and making them a little on the slack side will help, the reason for this becoming obvious when the assembly stage is reached.

### Bush (Item 8)

Chuck a length of 10mm diameter steel, drill and tap M4, turn down the end to 6mm diameter and thread M6 and part off. Return to the chuck, holding it very carefully on the M6 thread - it will not eventually be seen, so any small mark on the thread will be of no consequence - face and chamfer the end. If you wish you can mill the flats, but for such a small operation, improve you hand work skills and file them.

# Assembly

With all the parts now having been completed there remains only their assembly, which is a little more complex than probably you anticipate. The scriber assembly is straightforward and needs no explanation, but this is not so for the adjuster mechanism. Study the assembly drawing and the individual parts and you will become aware that the difference between the pitch of the M6 thread and the M4 thread are being used to control the gap between top and bottom halves of the base, as created by the saw cut. With M6 having a pitch of 1mm and M4 a pitch of 0.7mm, the resulting differential is a pitch of 0.3mm. Not only does this make turning the screw to effect an adjustment easier, of greater importance is that it can also jack open the slot as well as closing it, thereby increasing the adjustment range.

One feature of the mechanism is that, as the gap is opened and closed, the axis of the two inside threads become misaligned, and this probably limits the range over which adjustment can be achieved. Making the threads on the adjuster stud (7) on the small side, as suggested above, limits the effect of the misaligned axis.

To assemble, run the bush down the adjuster stud leaving some 3mm gap between the bush and the M6 threaded portion. Also run down an M4 locking nut. Now using an M6 screw as a gauge, check that the two M6 threads are on the same pitch. If, for example, you find an error of half a pitch, it would be easy to fall into the trap of thinking that you had to turn the bush just half a turn. This is not so, as the differential effect will make it necessary to turn the bush by much more. This can result in the M6 portion on the stud and the bush itself being further apart than expected. As it is almost impossible to control the relative positions of the two threads on the stud and similarly those on the bush it is similarly impossible to control how this assembly turns out.

Having aligned the two M6 threads lock them in this position using the fitted lock nut and screw them, as a pair, into the base using an 8mm spanner to lock the bush in place. Remove the lock nut and fit the adjuster nut, securing this with an M3 grub screw. At this point attempt to adjust the gauge but if you left the web, as dimensioned, at 2mm thick it will probably be hard to turn. Using the hacksaw on the accessible side of the web, gradually reduce the thickness until adjustment becomes easy. Do take note though that, as the gap is opened or closed, the threads become misaligned and so become stiff to operate. This is really beyond the intended range for the adjustment, so do not continue to thin the web or else you may end up with two pieces.

# Final comment

With the gauge now complete and ready for use, I do hope that you will find it useful. As you will see, I have made use of it for marking out items later in the series. In the next issue we will be dealing with two items that outwardly are much more simple, one of which is really a most essential part of any turner's tool box. Of even more importance is that, as a result of making the item, future turning operations will be much more satisfying. I am referring to the task of setting up the lathe to turn parallel. This is much more crucial than is often portrayed, as there is no point in making a part within say +/- 0.002mm (0.0001in.) of the required diameter if, over the length of the part, there is an out-of-parallel amount of 0.01mm. If you own a lathe which you know does not turn parallel and you cannot see any adjustment to overcome this, do not give up. You will be pleased to know there is almost certainly something that can be done to correct it and it is not complex. All will be revealed in the next issue.

# References


4. "Thin Piece Chuck" M.E.W. Issue 4 page 57
"Thin Workholding" M.E.W. Issue 8 page 36

# LIFE WITH A PLANING MACHINE

Jack Frazer of Ballymena, Northern Ireland relates the story of the rescue of a scrapped planing machine of unknown make and describes a subsequent programme of modifications

The small planer which is the subject of these notes was discovered in a derelict condition in a scrap yard. It presented a discouraging spectacle, lying on its side and covered with rust and dirt. Nevertheless, it appeared to have possibilities, and after the transfer of a modest sum I was able to bear it homewards with some satisfaction tempered with apprehension as to what I had let myself in for!

The first job was to dismantle, clean and paint, and re-erect roughly on a pair of legs welded up from some scrap channel to enable an assessment of its potential to be made. When this had been done, I found myself the now satisfied possessor of the basic components of quite a substantial planer with a table 24in. x 9in. actuated by rack and pinion giving an effective travel of 21inches. The rack and pinion were in good condition as were the screws and cross shaft for the lifting gear for the cross-slide, and the cross-slide carriage and traversing screw itself. Missing were the tool slide and clapper box, parts of the self-act mechanism for the cross-slide and the capstan necessary to move the table. The whole appeared to have suffered more from abuse than usage. There was no evidence of maker's name, the only identifying mark being a serial number stamped on the table.

Some little time was spent in adjusting and fitting the various components to achieve correct operation of the table and cross-slide, and to ensure that the supporting angle brackets for the latter were true and square with the table. At this stage a capstan head was made, equipped with four bars, so that the table could be traversed, then the missing parts (mainly linkage pins and tappets) for the self-act mechanism made. None of this presented any major problem, and little difficulty was encountered in adjusting gibs and slides so that both table and cross carriage operated sweetly and without play **(Photo. 1)**.

Attention was then turned to the missing tool slide, and after much cogitation, I decided to base the design for this on the topslide of a William Muir Traversing Mandrel lathe, which I believe to be of about the same vintage as the planer. This lathe, which is perhaps worthy of a mention in its own right, was discovered in, and rescued some years previously from, a local garage where its bed was being used as an anvil!

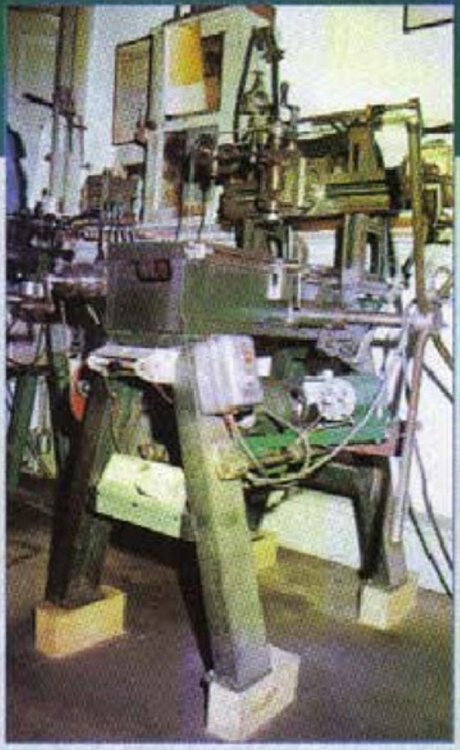
After a lot of sketching and cardboard engineering, patterns were prepared for the base and slide, and castings obtained from a local foundry. Most of the machining on these was done on the aforementioned Muir lathe, which tackled the largish castings with equanimity, despite the fact that it is not fitted with back-gearing. The combination of a carbide tipped tool and slowest speed (about 60 rpm) enabled the $^5/_{16}$in. round leather driving belt to overcome all obstacles. As I had no reliable means of machining the slideways, I had to seek outside assistance with this part of the job. The leadscrew, nut, and all other small parts were 'in house' work and carried out on my 4in. Round Bed Drummond.

One major mistake was made at this stage, this being that the housing for the clapper was made integral with the slide, and thus no provision was made for relieving the tool on a vertical cut. I have frequently regretted this, and some day will make the necessary modification to enable the tool box to be slewed in the orthodox manner, independently of the tool slide.

With this completed it was possible to put the machine to work: for some years it was successfully operated in this form, and I was enabled to carry out normal planing and keyway cutting operations, for which I previously had no facilities.

## Adding a milling capability

At the same time, it became apparent that the machine was capable of further development, in that, if a milling spindle were to be substituted for the clapper box and a suitable drive thereto arranged, its scope would be considerably enlarged. Accordingly, after the usual session with pencil and paper, a sketch was prepared, a pattern produced, and a casting obtained for the body of such a spindle. This was machined to be a neat fit in the clapper box, in which it is secured by four counterbored screws, and bored out to accept a $^3/_4$in. dia. spindle with ball thrust races top and bottom. The spindle was ground and the body honed out to provide a good running fit: no trouble has been experienced with the steel/cast iron combination as a bearing. A cup and wick oiler was provided to ensure adequate lubrication and the spindle bored out with a No. 1 Morse Taper at the nose to accept end mills and cutters which are secured therein by a $^1/_4$in. draw bolt through the spindle.

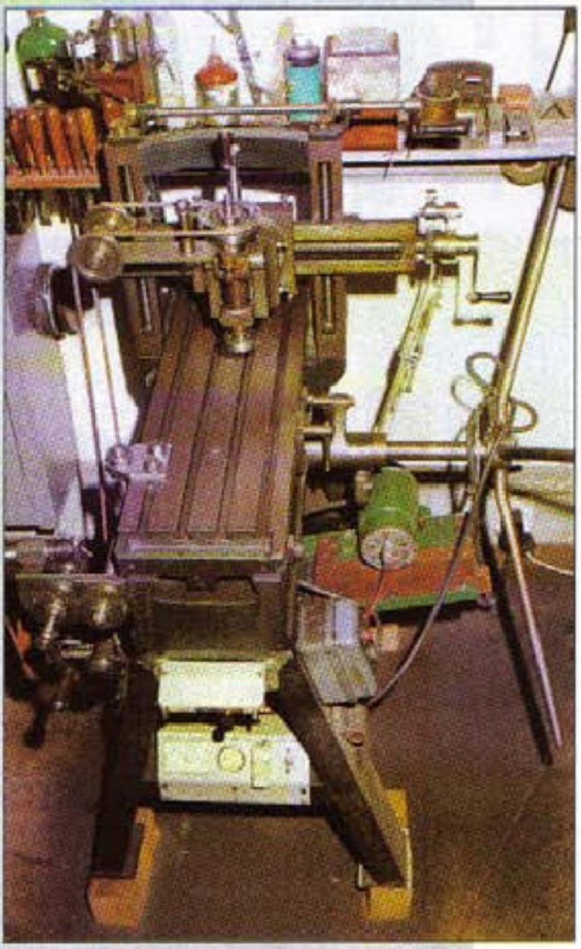


*1. The planing machine mounted on its new legs and with the replacement capstan fitted*

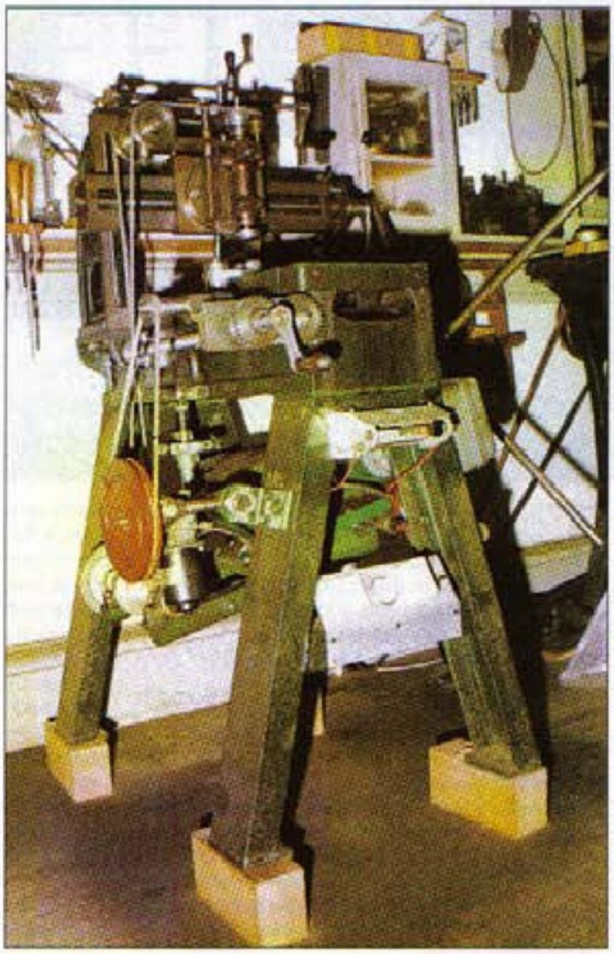
The top end of the spindle was machined to take a 'V' pulley or a Drummond change wheel, either of which can be secured to the spindle by means of a collar locked thereto and fitted with the usual Drummond peg and hole fixing and lock nut.

On the top of the spindle body was secured an outrigger, cut from boiler plate, which, on its outer end, carried an assembly with two guide pulleys and, on its inboard end, a pin at the correct centre distance from the spindle to accommodate change wheels giving a 2:1 reduction (20T and 40T wheels were used). Thus the spindle can be driven either directly or, by mating the pulley with a 20T wheel on the pin, through the 40T wheel on the spindle, at half speed **(Photo. 2)**.

Attention was then turned to the provision of a drive, and this was achieved by mounting, on a pivot bar spanning the legs of the machine, a hinged sub-frame constructed from angle section and carrying a $^1/_4$ HP single phase motor and countershaft. The whole was set up so that the centre line of the countershaft was vertically in line with the outside diameters of the guide pulleys with the horizontal tool slide carriage in the mid position of its travel. On the countershaft was mounted a three-step 'V' pulley (the blank for which was cast from old piston metal in a tobacco tin!) to provide drive through the



2. In this view the milling spindle and its drive can be clearly seen



3. The new table leadscrew is attached to the bed, with the drive assemblies for both this and the milling spindle fitted between the legs

guide pulleys to the milling spindle.

The position of the hinged sub-frame and countershaft relative to that of the jockey pulleys was defined by a right- and left-hand bottle screw strut with a hand wheel, so that the belt could be tensioned to accommodate any change in overall centre distance caused by the traversing of the cross-slide carriage or by vertical adjustment either of the cross beam or the tool slide itself. Occasionally has it been found necessary to alter the length of the 1/4in. round leather driving belt to accommodate unusual work.

This additional gear proved very successful and, with the provision of a handful of home-made slot drills, cutters and fly cutters with No. 1 Morse taper shanks, the range of the machine was considerably extended.

## A self-act feed for the table

One major defect still remained, this being that the only method of moving the table with the work on it was still the four bar capstan operated by hand. Not only was it extremely difficult to achieve a constant rate of feed, but when machining a 1/8in. keyway a moment's inattention could result in a broken cutter. What was required was some form of self-act feed for the table.

After consideration, I decided to make up a leadscrew which could be fixed to the side of the planer body, to be coupled as required via a nut and hanger bolted to the table of the machine. This could readily be disconnected when the machine was required in its planing role.

This leadscrew which is some 22in. long x 3/4in. OD x 8 tpi is mounted on the side of the machine in two bushed bearings, made from cuttings of angle section with bosses brazed in. It extends past the front of the machine and, on its outer end, carries one of a pair of gears with a graduated ring. The similar mating gear is carried on a short shaft working in a sleeve. On the front end of this shaft is fitted the operating handle which is thus brought clear of the table when the latter is at maximum forward extension (**Photo. 3**). On the inner end of this shaft is a loose gear (rescued from a superannuated gear box) which can be locked to the shaft by a slipping clutch incorporating a capstan headed nut. Thus this second gear can either drive the leadscrew or run free on its shaft.

To drive this second gear, a worm of the correct pitch was turned up and mounted on a short shaft in a long sleeve bearing set at the appropriate angle to mesh with the gear. On the outer end of this short shaft was fitted a pulley which took drive, via a spring curtain rod belt and a tortuous system of guide pulleys, from a pulley on the end of the countershaft.

In this form the machine was used for a number of years, but increasing dissatisfaction was felt with the spring belt drive, which not only provided a single traverse speed without a change of pulley, but was always breaking or coming off the pulleys at the most inconvenient moments, thus wasting not only time but putting a severe strain on my patience!

A solution presented itself in the form of a 12V permanent magnet field windscreen wiper motor from a Citroen car. Suitably modified to accept a pulley in place of the wiper crank assembly and energised by a 12 volt dynamo from a Ferguson tractor (driven from the main motor by 'V' belt), it is controlled by a variable field resistance for the dynamo made from an electric stove fire bar. This arrangement provides a secure drive and a turn-down in traverse speed of somewhere over 3:1, having replaced the original arrangement very satisfactorily. I admit that the Ferguson dynamo is somewhat 'over the top', but when time is available I will pension it off and replace by an appropriate transformer and rectifier.

This system works well and has revolutionised the machine in its plano-miller capacity. One can now set up for a considerable job, put the whole in motion and enjoy the sight of the equipment getting on with the work.

Although the machine is entirely satisfactory in so far as the maker's (whoever he was) original intentions are concerned, I make no claim that it is in any way a substitute for a vertical milling machine. It does however provide a 'facility' which I would sadly miss; not only that, but it has provided me with an interesting project which has given much satisfaction over quite a few years.

## Future developments

What remains to be done? Well, there is always the question of doing away with the hard work of the planing operation itself, and I find myself considering the possibilities of some form of Ward Leonard drive to the pinion and rack. As the years creep on, the prospect of the capstan becomes increasingly unattractive, and in due course, a solution to this problem will, no doubt, be found.

# INDEX FOR ISSUES 57 TO 68 OF M.E.W.

**The information contained in this index supplements that published in Issue 57 and brings the information upto date to Issue 68. As mentioned on page 36, a computer generated index available for those who have suitable equipment on which to run the software**

## SUBJECT INDEX

This section is arranged by Subject, listing Articles, Quick Tips, and letters to Scribe a Line. The key to the letters in the second and seventh columns is given at the end of the table. Columns five and six, e.g. 57 58 refer to the particular issue and page number.

## KEY TO THE SYMBOLS USED IN THE ABOVE SECTION OF THE INDEX

Column 2
C = Construction, P = Process, M = Miscellaneous

Column 7
A = Article, T = Trade, L = Letter, Q = Quick Tip, S = Subjects

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## MODEL ENGINEERS'WORKSHOP PUBLICATION DATES

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**It should be noted that Issues 1 to 6 were never formally numbered and that Issues 7 to 11, although numbered, did not carry these on their covers.**

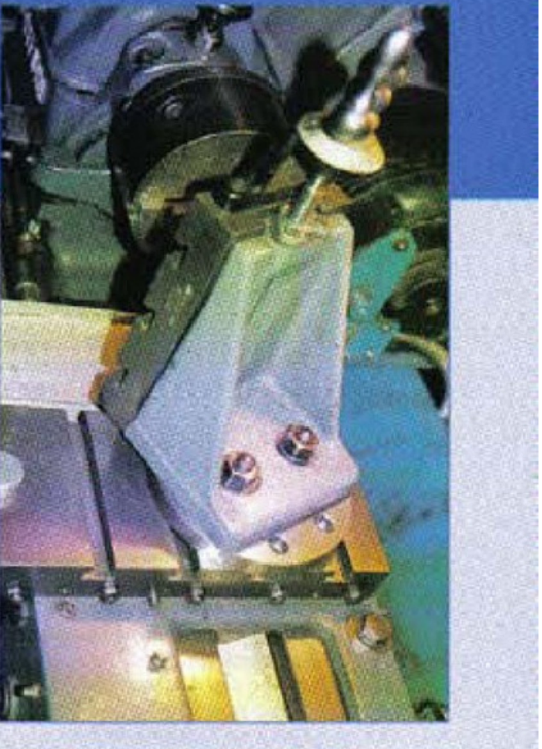
## MODEL ENGINEERS'WORKSHOP COMPUTERISED INDEX

The computerised index for M.E.W. continues to be available and, as the number of published issues of the magazine increases, it becomes a more valuable tool.
The current version contains an index to all issues up to No. 68 and includes references to all articles, Quick Tips, letters and to trade items having long term interest. A feature of the index is that it includes embedded subjects, items within an article but whose subject differs from the main object of that article.
The index is sorted by areas of interest: turning, welding, computer etc., but this can be over-ridden by the user so that it can be sorted by other criteria such as the author or chronologically. Search and print facilities are available, as is the ability for the user to to edit and update the index for him or herself. For those not wishing to carry out this exercise, updates are issued every six issues. however, all updates contain the index from Issue 1, so if an update is missed, later updates will cover the missing information.
The system, whilst not requiring Windows will run on a Windows based system, any 386 standard machine or higher being adequare. The supplied disks now also include the Lathe Changewheel Calculation program which was previously sold separately. This calculates every possible combination from the user's list of changewheels (well over 10000 for 13 changewheels).
The computerised index now costs £10, which includes post and packing within the UK. For non UK orders, please add £2.

***The index can be purchased from CAHW Systems, 23 Fieldway, Berkhamsted, Herts. HP4 2NX by post only. Please make cheques payable to CAHW Systems***

# A ROTATABLE VERTICAL SLIDE MOUNT

**Simple adapters can frequently increase the versatility of workshop equipment dramatically. Paul Boothby describes such a device which is capable of being made in an hour or so**



This project is one of those Saturday morning jobs, intended for all those (un)fortunate souls who possess a vertical slide but wish they had a universal one!

The device is essentially a 4in. diameter disk on which a vertical slide may be clamped in any position about a vertical axis to the boring table of the lathe. Although proportioned for the Myford 7 Series lathes and the matching accessory (**Figure 1**), the principle can be used for any similar combination with appropriate adjustment to the quoted dimensions.

A series of eight mounting holes on a 3$^1/_8$in. pitch circle, plus a ninth hole in the centre permits the mount to be set up across three slots on the boring table in any 45/90 deg. position. The vertical slide then bolts on to the mount using a pair of shouldered slots in the shape of 90 deg. arcs, thus increasing the movement of the slide to 360 deg.

## Material

The material requirement is simply a 4in. diameter x $^3/_8$in. thick mild steel blank, faced on both sides.

## Accessories required

To machine this item, the lathe will need to be equipped with a 4-jaw chuck.

The availability of a dividing head or a rotary table can be rated as highly desirable, fitted with either a 6in. diameter (maximum) face plate or a driver plate, suitably drilled (see below).

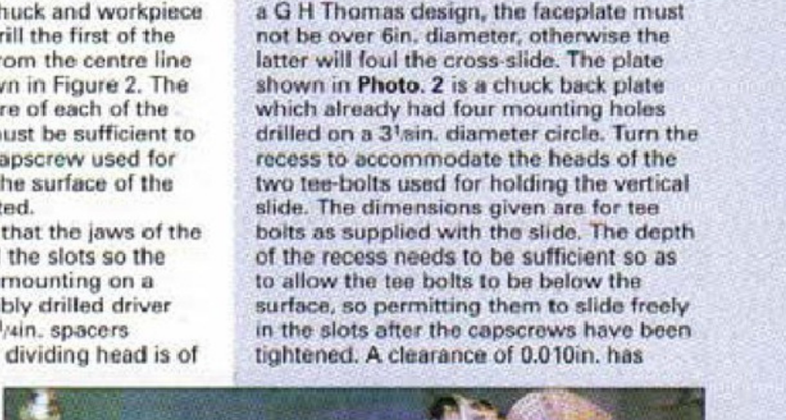
## Construction

Much of the work is straightforward and hence there is little need for comment. The drilling and counterboring of the eight holes is best achieved by holding the work in a 4-jaw chuck fitted to a dividing head or rotary table as shown in **Photo. 1** and **Figure 2**. If a 3-jaw chuck is used, it will be impossible to drill all holes clean through the workpiece without hitting at least one of the chuck jaws. Indeed, in the absence of either a dividing head or rotary table, there is nothing preventing the drilling of the mounting holes being performed by hand and the cutting of the slots by chain drilling and filing.

Commence by drilling and counterboring the central mounting hole and then transfer the chuck and workpiece to the dividing head. Drill the first of the eight holes 22$^1/_2$ deg. from the centre line of a chuck jaw, as shown in Figure 2. The depth of the counterbore of each of the nine mounting holes must be sufficient to allow the head of the capscrew used for clamping to be below the surface of the work. 0.01in. is suggested.

Figure 2 also shows that the jaws of the four-jaw chuck will foul the slots so the work piece will need remounting on a small faceplate or suitably drilled driver plate for milling using $^1/_4$in. spacers between the two. If the dividing head is of a G H Thomas design, the faceplate must not be over 6in. diameter, otherwise the latter will foul the cross-slide. The plate shown in **Photo. 2** is a chuck back plate which already had four mounting holes drilled on a 3$^1/_8$in. diameter circle. Turn the recess to accommodate the heads of the two tee-bolts used for holding the vertical slide. The dimensions given are for tee bolts as supplied with the slide. The depth of the recess needs to be sufficient so as to allow the tee bolts to be below the surface, so permitting them to slide freely in the slots after the capscrews have been tightened. A clearance of 0.010in. has

*1. Drilling and counterboring the eight mounting holes*



*2. Milling the second of the two slots*

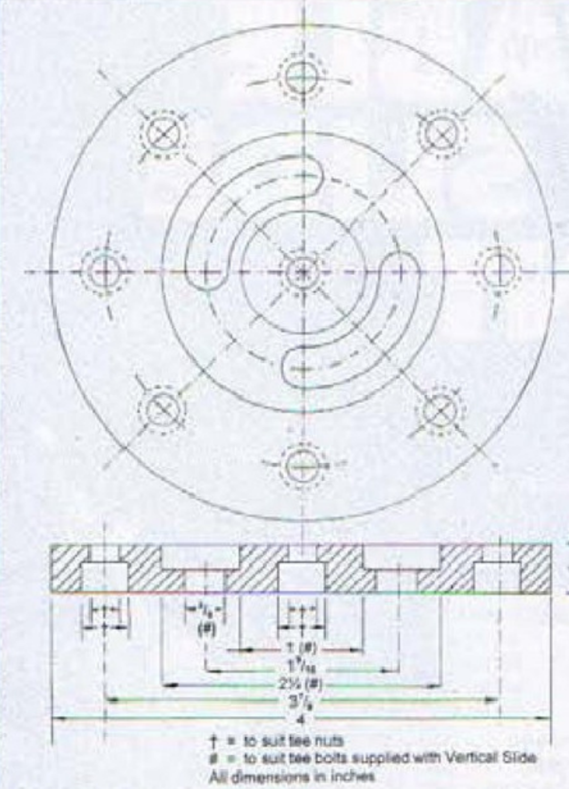



**Fig. 1 Vertical Slide Mount**

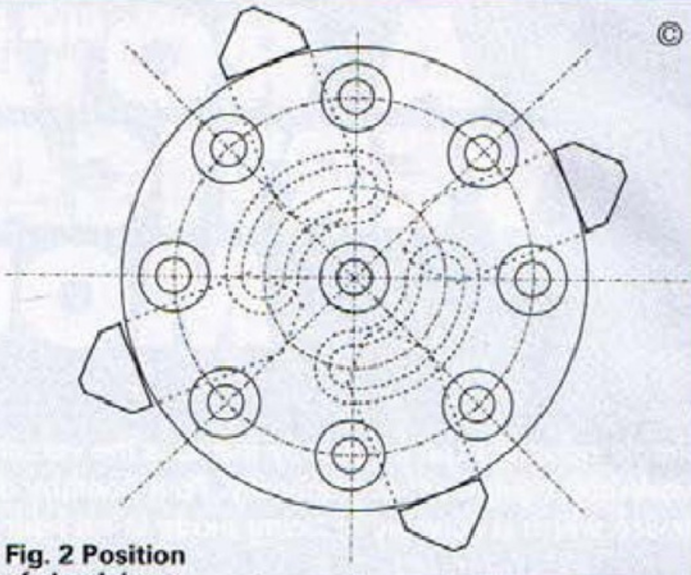



**Fig. 2 Position of chuck jaws when drilling outer holes. The slots have not yet been milled.**

proved satisfactory. If a dividing head is to be used for milling the slots, transfer the work still mounted on the driver plate/faceplate. Great care will be needed because a dividing head is not designed for such heavy work. Note that the slots will not be symmetrical in the recess, but slightly offset toward the centre of the clamp. The easiest way to minimize transverse forces associated with milling is as follows:-

1. Drill a pilot hole at the centre of the end radius of the slot and open out to about ¼in. diameter.

2. Open out to the final size with a mill or slot drill.

3. Withdraw the mill and advance the work by 6 deg. (in this case, one revolution of the dividing worm)

4. Repeat operations 2 and 3 another 14 times.

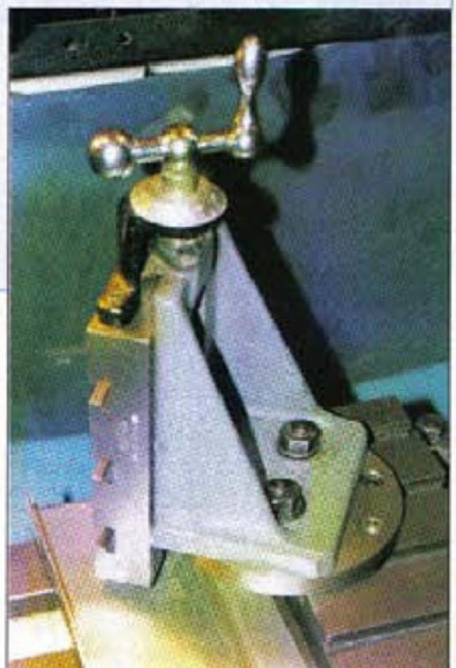
5. Advance the work 90 deg. and repeat operations 1 to 4.

6. Complete milling each slot in turn, removing the cusps left behind from operations 2 & 3.

Remember that dividing heads should be rotated in one direction only (clockwise).

## Afterthoughts

As soon as the mount was used, an unforeseen advantage appeared: it was possible to fit the mount on the boring table so that the vertical slide overhung the swarf tray mounting flat (**Photo. 3**) and this allowed the slide to have a further ½in. of travel. Stability in this set-up was achieved by bolting the mount to the boring table using four tee nuts and capscrews, arranged as shown in **Photo. 4**.



*3. With the mount positioned at the extreme left of the side of the boring table, the vertical slide can descend below the top surface*

*4. The underside of the mount showing the location of the tee nuts to achieve the set-up shown in Photo. 3*

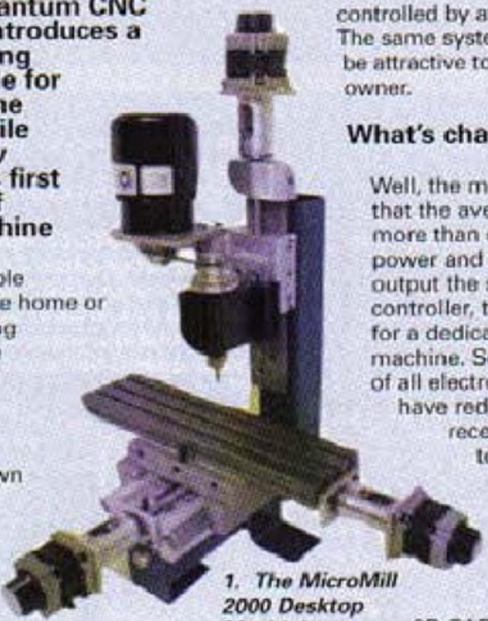
*5. The mount positioned centrally*

# 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**

## Affordable CNC milling for the home or light manufacturing workshop

**Jeremy Gough, Managing Director of Quantum CNC (Europe) Ltd introduces a new CNC milling system suitable for use in the home workshop, while reader Andrew Knox gives his first impressions of using the machine**



*1. The MicroMill 2000 Desktop Machining System*

To supply affordable CNC milling for the home or light manufacturing workshop was the objective I set for the company Quantum CNC (Europe) Ltd after research had shown me that the time had come when such an objective could be achieved. I have personally been closely associated with CNC (computerised numerical control), since its inception into industry in the early 1970's, replacing the old paper tape NC machines that had been in use up to that time. Over the years we have seen major advances in computer control, axis drive technology and the design of machine tools, to the point where they can be used in an automatic mode over many hours of unattended operation. We are now even able to see total 'lights out' production. The cost of this technology has always been high and until very recently has been totally out of the reach of either the home workshop enthusiast or the small light manufacturing workshop owner. The ability to achieve a return on such an investment has been difficult, but I had repeatedly heard of the frustrations of smaller companies, explaining how they were either having to sub-contract or find ways of trying to get round the limitations of their existing equipment.

Earlier this year I felt that there had been sufficient technological advances to change the situation allowing us to be able to make available to this market all the features of full-sized industrial equipment in a convenient desktop sized machine controlled by an ordinary domestic PC. The same system would also be likely to be attractive to the home workshop owner.

### What's changed?

Well, the most significant change is that the average home PC now has more than enough computing power and speed of operation to output the signals for an axis drive controller, thus eliminating the need for a dedicated computer to drive a machine. Secondly, as with the price of all electronic items, the costs have reduced considerably over recent years, make it realistic to produce a system for use on small desk-top sized machines. Another spin off of the powerful home computer is that extremely capable 2 or 3D CAD (computer aided drawing) and CAM (computer aided manufacturing or machining) software packages are well within the reach of the non industrial user.

### So what do you call affordable?

The MicroMill 2000 CNC desktop Machining System offered by Quantum CNC **(Photo. 1)**, is available in a full 3 axis format for under £1,800 + VAT, complete with a choice of operating software designed to meet the needs of every type of 2, 2.5 or 3D machining application. If necessary, add to this a sophisticated CAD/CAM package and you still have change left from a total expenditure (including VAT, of £3,000.

### Well what can I do on such machines?

The possibilities are almost only limited by your imagination. Every day I uncover a new application for the machine, from simple two dimensional shapes to very complex three dimensional sculptured forms in aluminium, steel, brass, copper, wood, plastics and glass. Applications in model making **(Photo. 2)**, jewellery design and die making, prototyping new products, mould making **(Photo. 3)**, artistic engraving **(Photo. 4)**, medical, educational, metallographic engraving of photo images and many, many more.

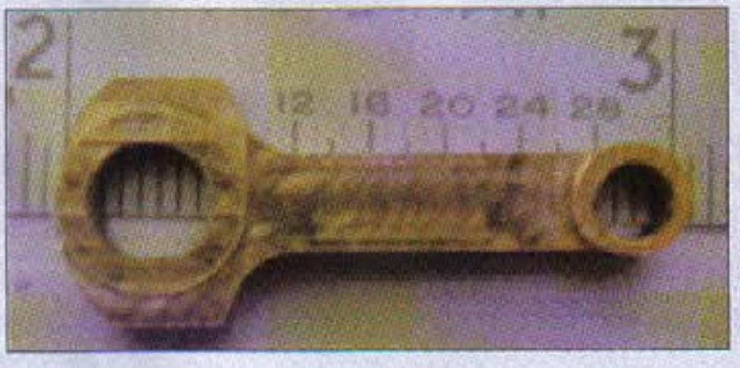
### Optional equipment

With optional equipment such as a fourth (rotary) axis **(Photo. 5)** we can open up the application possibilities further, as is the case with the digitiser option **(Photo. 6)**, where 'reverse engineering' from existing components becomes possible.

### Programming technique overview

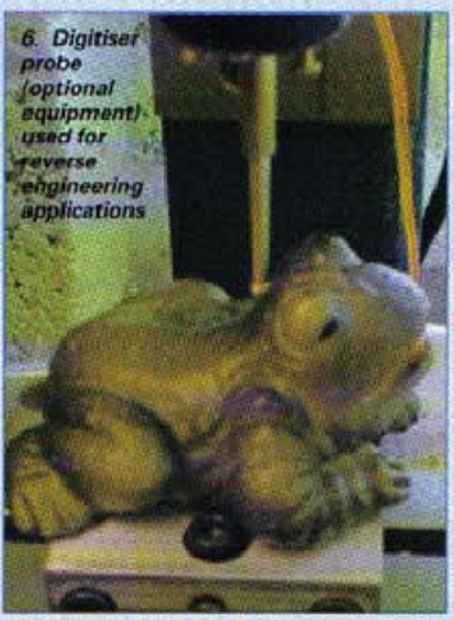
With all of the applications mentioned above, the type of programming (that is to say the way the machine is commanded to carry out the machining instructions) falls into just two categories. Firstly, for relatively simple shapes, where accuracy is important we, can ask the cutter to follow a line drawing that can be imported from a CAD package such as Turbocad, or alternatively imported from software like Corel Draw, where there could be many flowing arcs that would be difficult to computer generate. The latter is particularly useful for artistic engraving applications.

Secondly we can provide the machining instructions by 'G' code programming, a technique described elsewhere in this magazine. This is required for the more complex applications and, although this might appear somewhat daunting for the

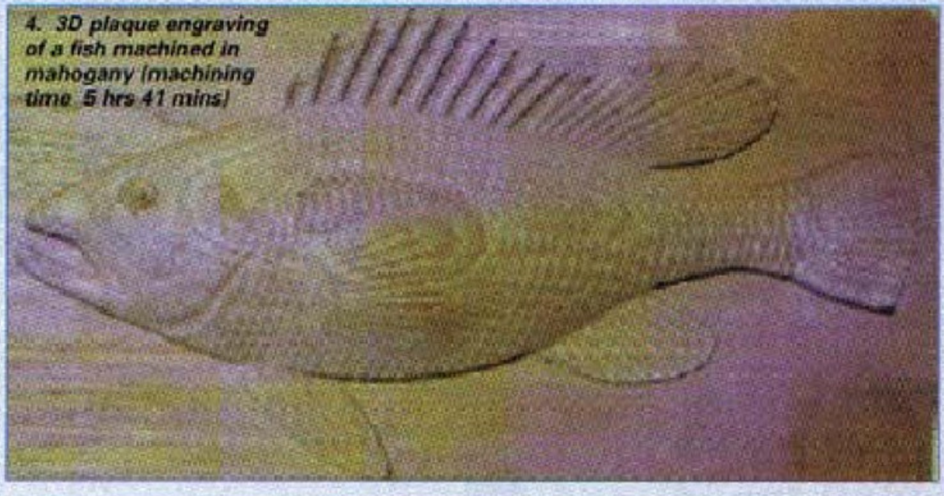



*2. Minature aero-engine conrod drawn & programmed using Dolphin CAD/CAM (machining time 11 mins)*

*3. 3D cameo mould programmed using MillWizard by Delcam (machining time 6 hrs 49 mins)*



6. Digitiser probe (optional equipment) used for reverse engineering applications



4. 3D plaque engraving of a fish machined in mahogany (machining time 5 hrs 41 mins)

*7. Rhino head cut in 6mm polycarbonate. Modelled using Rhino CAD and programmed using MillWizard from Delcam.*

inexperienced CNC machine programmer / operator, many Windows operating CAD /CAM packages now available for 2, 2.5D applications (Dolphin CAD/CAM for instance), make this task relatively straightforward.

For the machining of 3D sculptured shapes developed by solid modelling techniques, software such as MillWizard by Delcam provides extremely easy to use programme generation

## A Users view

***Andrew Knox installed his machine in mid July of this year, and reports progress to date:-***

After reading a number of reviews and looking at e-groups on the Web, the Micromill 2000 seemed to be the machine for me to go for. It was stated as being more robust, and having larger screws and bearing surfaces than similar equipment available, and has been specified with 200 ounce-inch stepper motors, so should have much less chance of missing steps when driving hard or fast.

Having ordered from Quantum CNC, its delivery came as a pleasant surprise. I was expecting to receive the boxes, and have to set it up myself, but Jeremy drove it over, assembled the machine, squared up the milling column, and left the machine ready to use.

Wanting it to perform its best, I entered into the parameter setting table program (which is used to match the user's PC to the axis drive controller of the machine) to see if I could tweak the performance further. My recommendation would be to take this very gently as the range of parameter settings is quite sensitive and each one can have a knock-on effect on others. It is possible though, to adjust such things as the jog rate (the speed of movement of the slide ways during set-up of a machining operation), the rapid traverse rate (the slide way speed when moving the cutter between cutting operations) and the acceleration and deceleration rate of the slides to and from their programmed speeds. by fine tuning these parameters it is possible to match precisely the output of your PC with the drive controller to ensure that the programmed feed rates match the actual feed rates achieved.

Here is a picture of a Rhino milled in 6mm polycarbonate **(Photo. 7)** It was taken from the 3D logo file of the NURBS software package of the same name, exported as an STL, imported into MillWizard and processed to *.TAP files. This was then machined via MAXNC DLX. Best spindle speed with 2-3mm cutter seemed to be 2900 rpm, as 4300 rpm caused the 'chips' to weld into fern like curls (and sometimes stick to the workpiece). A step over distance of 0.15mm seems to give an acceptable surface finish. Not bad for a first go. Hope to get on to cutting Titanium soon! My main use will be for cases for watches and small electronic instrument cases.

E-mail andrew.s.knox@btinternet.com

***Quantum CNC (Europe) Ltd., Wall End House, Moor Lane, Coleorton, Leicestershire LE67 8FQ Tel. 01530 834376 Fax. 01530 834369 E-mail: sales@quantumcnc.co.uk Web site www.quantumcnc.co.uk***

5. Fourth axis rotary table (optional equipment)

| MACHINE SPECIFICATION | Imperial | Metric Equivalent |
|---|---|---|
| X-Axis Travel | 9in. | 229mm |
| Y-Axis Travel | 5.5in. | 140mm |
| Table size (with 3 T slots) | 15 3/4 x 3 1/2 | 400 x 89mm |
| Spindle speed range | 1,100 - 10,500 rpm | |
| Tool mounting | Collet chuck (30 deg. included taper) | |
| Main spindle motor | 1/8 HP (Optional 1/3 HP) | 0.093 KW |
| Feed motors | Open Loop Stepper Motors | |
| Torque | 200 oz.-in. | |
| Machine size Height | 26in. | 660mm |
| Width | 22in. | 559mm |
| Depth | 21in. | 533mm |
| Mass of machine | 65lb. | 29.5 Kg |
| Machine Resolution | 0.000125in. | 0.003mm |
| Machine Repeatability | 0.0005in. | 0.013mm |

| MACHINE CONSTRUCTION | | |
|---|---|---|
| Column & Bed | Rigid square tubular steel | |
| Table | Hard anodised aluminium | |
| Cross-slide & Z slide | Hard anodised aluminium | |
| Sliding ways | Precision ground steel | |
| Leadscrews | 0.5in. | 12.7mm diameter |

# A VARIABLE SPEED CONTROL FOR A MYFORD ML7

## Tony Jeffree relates his experiences with a Newton Tesla speed control package

I recently acquired a second-hand Myford ML7 which had been used for a number of years in a commercial engineering workshop since new, so was in need of a comprehensive 'spring clean' before being put into active service. While cleaning it up and re-painting it in 'original' Myford grey, acquiring a stand and drip tray, and so on, I spent a bit of time considering what to do about the drive system. The lathe had been fitted with a 3-phase, 2-speed motor; and as my cellar is only supplied with domestic single phase mains, I was clearly going to need to change something, either the supply or the motor or both.

My other lathe and mill (a Peatol lathe and a Taig desktop CNC mill) are both fitted with DC motors and variable speed control units. Having got used to the luxury of variable speed and the relative infrequency of belt changes that it brings, I was keen to include this feature on the Myford. However, the DC motor route didn't look too promising, as I had no ready supply of suitably powerful motors or control units. As a compromise, I initially considered sticking to the 2-speed motor approach; either using a static converter to generate a 3-phase supply, or acquiring a single-phase 2-speed motor.

A bit of research seemed to offer the following options for generating a 3-phase supply:-

- Buy (or build) a static converter. These make use of passive electrical components (essentially capacitors and chokes) to create an artificial 3-phase supply from a single phase supply. However, they can only generate a 240V 3-phase supply from the UK mains unless you go in for step-up transformers.
- Buy (or build) a rotary phase converter. In its simplest form, this is a three phase motor, rigged to operate from a single phase supply by means of suitable start and run capacitors; you take the 3-phase 'supply' from the terminals of the motor to power the equipment in use. Jim Cox's book "Electric Motors in the Home Workshop" (one of the Workshop Practice series) gives details of how this can be achieved, along with even simpler approaches that use a single 'run' capacitor to start 3-phase motors. However, generating a higher output voltage than the supply voltage is again problematic with this approach.
- Buy a 'Variable Frequency Drive' or VFD. These are solid-state devices that can generate a 3-phase supply from single phase, and are capable of also varying the frequency of the three phase AC output. These generally only generate the same output voltage as the supply voltage; however, the ability to change the AC frequency opens up the possibility of creating a variable speed drive with a 3-phase motor that can be wired for 240V operation (most modern 3-phase motors can be 'star' wired for use with the normal 400V 3-phase supply available in the UK, or 'delta' wired for use with a 240V 3-phase supply).

All of the options so far seemed to rule out use of the original 2-speed motor, as these are generally not dual voltage motors, and therefore cannot be driven from the output of the kinds of 3-phase phase converter I was contemplating. The alternative seemed to be to replace the motor with a 3-phase motor capable of being driven from a 240V supply, or revert to using a single phase motor.

At this point, two things happened in relatively quick succession. First, I discovered a source of ex-Myford stock, 2-speed, single phase motors as fitted to their Tri-Leva variant of the ML7, and bought one, thinking that this would provide a compromise solution - a 2-speed drive, and none of the hassle of creating a 3-phase supply for it. Then, a few days later, a company called Newton Tesla put a full-page colour advert in Model Engineers' Workshop announcing their speed control packages for Myford lathes.

## Early discussions

The advert sounded interesting - a complete package consisting of a fully configured controller and a new 3-phase motor, that would fit the ML7 with the minimum of trouble. I phoned the company to get more details.


*1. The Newton Tesla control unit fits conveniently to the front of the Myford cabinet stand*

George Newton was extremely helpful, if not a little embarrassed. They had not expected the advert to appear in the magazine quite so quickly, and at that point, they had not finalised the design of the housing or decided exactly what features would be available. He indicated the general outline - it would consist of a metal housing that would attach to the front of the ML7 cabinet stand, containing a Mitsubishi variable frequency drive and ancillary mains filter (to prevent noise from the VFD being fed back into the domestic supply), would offer some pre-set speeds along with a 'jog' control and reversing switch, and a potentiometer to give fully variable speed. Full details to follow in a couple of weeks once they had finished the artwork and the design of the housing.

I discussed the particular requirements I had - for example, I was quite keen to retain the one major advantage of the 2-speed motor, that it doubles the overall speed range of the ML7. The 'standard' package that they were contemplating would generate an AC supply frequency range of between 5 Hz and 60 Hz (thus offering a 20% speed increase over a standard UK spec ML7); I suggested that a range of 5-120 Hz would be more like what I was after, which would translate into a motor speed range of very slow to about 3500 rpm, and delivering a top spindle speed of around 2000 rpm. He indicated that it would be possible to produce a variant of the standard package with this modification. Myford recommend the original non-hardened ML7 spindle and white metal bearings should not be used at speeds greater than 1000 rpm, something of which I was already aware, so I was planning to upgrade to a new hardened spindle and bronze bearings to cope with the higher speed operation.

All this sounded very promising, so I resolved to wait and see what the final specification looked like.

# The package

The final specification, when it arrived a couple of weeks later, looked pretty good:-

- Reversing switch;
- Jog control, allowing rotation of the spindle at extremely low speeds, e.g., for clocking in a part in the 4-jaw chuck;
- Three fixed speed settings, giving motor speeds of 750, 1500 and 1800 rpm (i.e., 50%, 100% and 120% of the normal motor speeds using a UK supply);
- A fully variable speed setting, giving potentiometer speed control over the 150-1800 RPM range;
- Start, stop and emergency stop switches;
- New Brook Crompton 3-phase motor;
- All pre-wired, with a plug-and-socket connector for the motor to allow the motor to be unplugged while fitting it to the motor plate;
- The VFD 'trained' to the characteristics of the motor, to ensure optimal torque output;
- LEDs to indicate power and overload.

Three power levels are offered - 1/2 HP, 3/4 HP and 1 HP. I decided that 1/2 HP (model ML370) would be fine for my ML7, and ordered one, with the requested modification to the frequency range of the VFD output.

# Fitting and setting up

The package duly arrived a week or so later - one large box containing the motor, plus the control unit heavily protected by bubble wrap. Fitting it to the machine could not have been easier; mark and drill four fixing holes for the control unit just to the left of the opening on the front of the cabinet stand, fix it with four nuts and bolts, fit the motor to the motor mount on the back of the lathe, fit the pulley and align it, plug the pre-wired motor cable into the bottom of the control unit, and finally plug the mains lead into the mains supply. Half an hour or so from opening the boxes, and the unit is operational. The unit can be seen fitted in position in **Photo. 1**.

Using the controller is also very easy. **Photo. 2** shows the layout of the control panel, which takes up the top surface of the controller unit. The emergency stop button, at the bottom left of the panel, is of the 'twist to release' type - this needs to be released before the unit will power on. The rotary switch at the top right corner of the panel selects JOG or RUN mode; in JOG mode, you have to keep your finger on the start button for the motor to run (or more accurately, crawl).

In RUN mode, a second rotary switch, marked PRESET SPEEDS, determines what speed setting is used; three positions select the three fixed speeds of 750, 1500 and 1800 rpm, the fourth position selects the fully variable speed, using the MOTOR SPEED potentiometer setting to determine the actual motor speed. Pressing START in RUN mode causes the motor to ramp up to the selected speed. You can instantly switch between the motor speed settings with the motor running, with no ill effects - the controller simply ramps the output frequency up or down to the newly selected speed.

The reversing switch, marked FWD and REV, is only taken notice of at the point that you press the run button. Changing from FWD to REV with the motor running has no effect whatsoever; however, if you then press the START button, the motor speed ramps down to a stop, then ramps back up in the reverse direction - very smooth indeed!

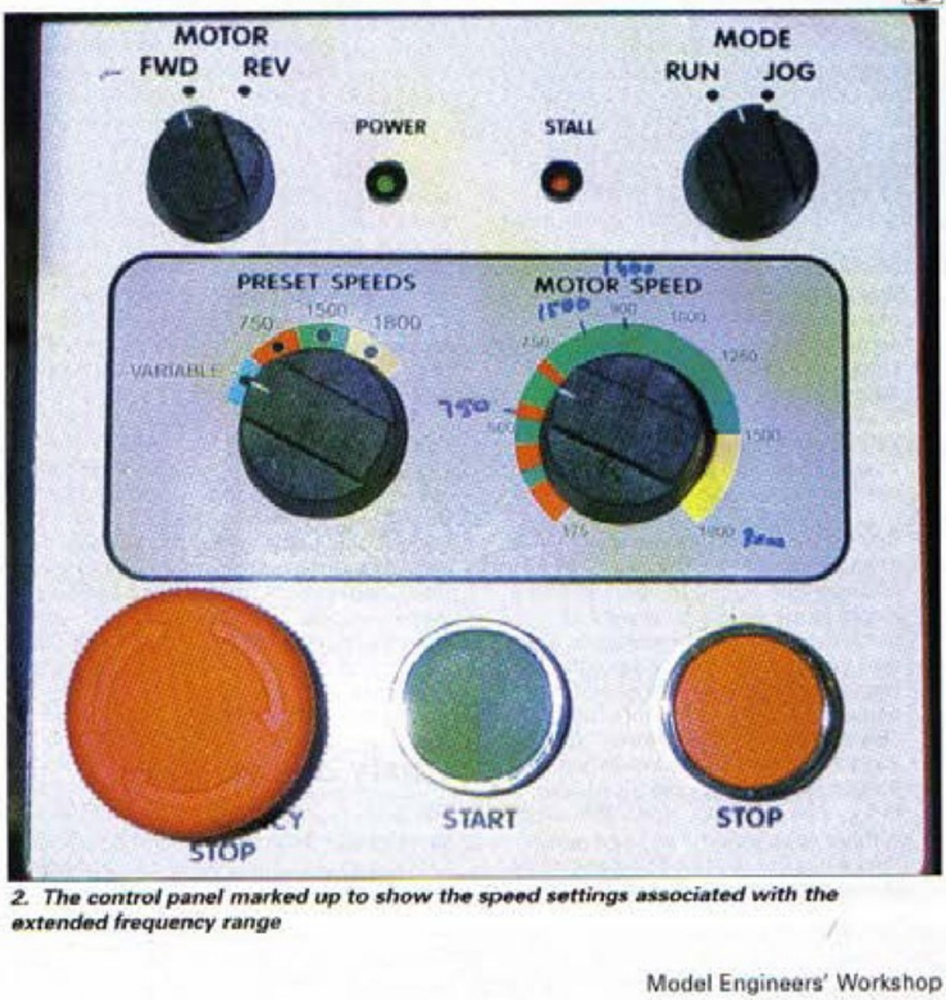
With the standard Newton Tesla specification, the result is an overall spindle speed range on an ML7 of 3.5 - 760 rpm, using the 1 7/8in. motor pulley that Myford fitted as standard. With my requested variant, doubling the maximum output frequency of the VFD, and with the optional 2.5in. motor pulley fitted, I get an overall spindle speed range of 5 - 2000 rpm. This works out extremely well - if the belt is fitted to the middle pulley on the headstock, the variable speed range is 27-655 rpm; very close to the entire speed range of a standard ML7, but without the need to change pulleys or fiddle with the back gearing. The table below shows the theoretical speed ranges available to me for each of the six speed settings of the lathe; the first row is for max. speed, no back gearing, the second is max. speed with back gearing engaged, and so on. The columns marked MIN and MAX show the spindle speed with the variable speed potentiometer set to minimum and maximum positions, and the other three columns show the preset speeds.

| MIN | S1 | S2 | S3 | MAX |
|---|---|---|---|---|
| 87 | 435 | 870 | 1044 | 2088 |
| 49 | 244 | 487 | 584 | 1169 |
| 27 | 137 | 273 | 328 | 655 |
| 15 | 76 | 152 | 182 | 365 |
| 8 | 42 | 84 | 101 | 202 |
| 5 | 24 | 47 | 56 | 113 |

# Problems?

Well actually, there weren't any problems of any significance. The mains lead could have benefited from an extra metre of length, but I fixed this by attaching an extension lead and 4-socket strip to the side of the cabinet (see Photo 1), which will come in handy when I fit some work lights to the cabinet later on. The artwork for the controller shows everything in terms of motor RPM; for my taste, percentages of 'normal' motor speed would have been more useful. And of course, as I had chosen a higher variable speed range, the calibration of the potentiometer scale is not meaningful on my machine and I have had to add my own extra marks.

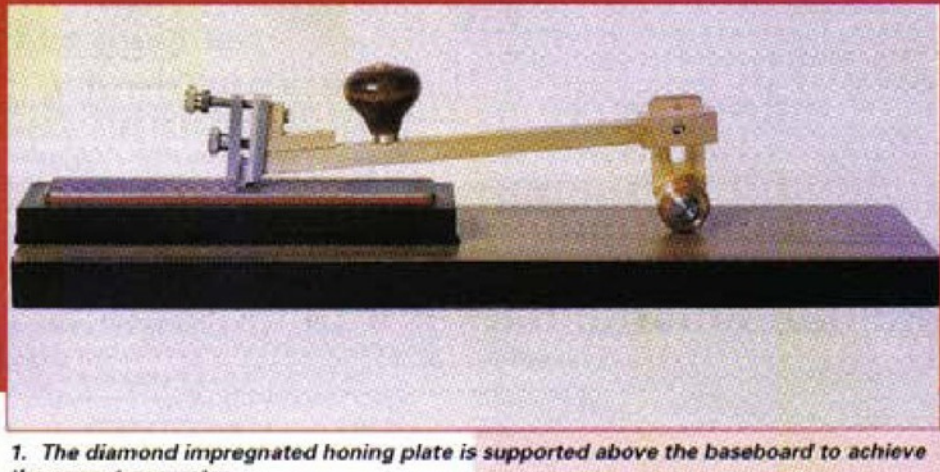
All in all, an extremely easy system to install, which works very well indeed.




*2. The control panel marked up to show the speed settings associated with the extended frequency range*

# HONING JIG FOR CARBIDE LATHE TOOL TIPS

**Tungsten carbide lathe tools, particularly those of the replaceable tip type are rapidly becoming an essential part of the home workshop inventory. Derek Winks describes a simply made jig which will help achieve their optimum performance**



*1. The diamond impregnated honing plate is supported above the baseboard to achieve the correct geometry*

Lathe tools with replaceable carbide tips are now readily available to the model engineer and have considerable advantages, especially for machining castings which will quickly blunt steel tools. They are intended to be disposable, but most will stand several careful sharpenings. Also, some are not particularly sharp as supplied. I have found the cutting performance of these to be much improved by diamond honing.

This simple jig was made to facilitate sharpening while retaining the correct clearance angle. Tungsten carbide is, of course, very hard and the best abrasive for sharpening it is diamond. The whetstone I used is made by Diamond Machining Technology Inc. in the USA, who supply them in many shapes, sizes and grades. I used type WMF, fine grade (colour coded red), which incorporates an area of unperforated diamond coating, a feature necessary for sharpening the tip radius which would otherwise catch in the perforations. The dimensions are 110 x 22mm. It is quite expensive (about £25) but can be used for many other sharpening purposes. It should be lubricated with water only, not oil, detailed instructions for use and maintenance being supplied with the packaging. Two suppliers are listed at the end of this article and there may be similar suitable products by other makers, but I have no further information at present.

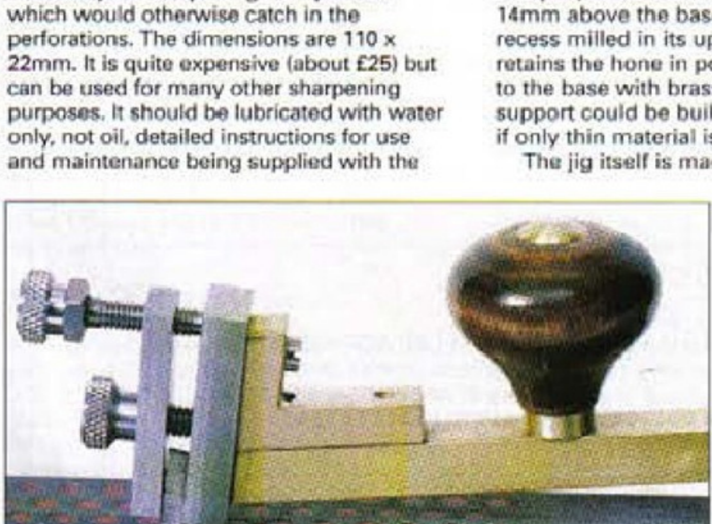
## Construction

The general arrangement is shown in **Photo. 1**, the baseboard being approx. 260 x 80mm and made of a material with a hard flat surface for the guide wheel to roll on. I used a piece of plastic faced chipboard of the type used for shelves and worktops, the edges of which were sanded smooth and painted. The hone is mounted on the end of the base on a support made of a hard plastic material such as Nylon or Perspex, which raises its surface to about 14mm above the base The support has a recess milled in its upper surface which retains the hone in position and is attached to the base with brass screws. This support could be built up of several layers if only thin material is available.

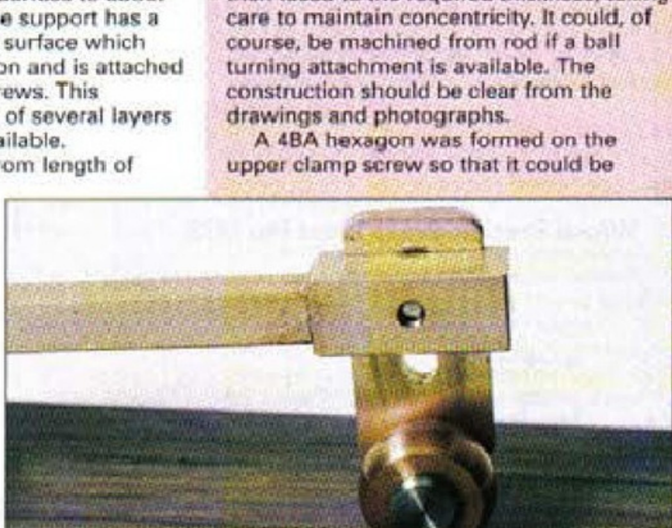
The jig itself is made from length of 1/4in. square brass bar, at one end of which is a clamp to hold the tip to be sharpened while the other end carries an adjustable guide wheel. The periphery of this wheel is made spherical, so that the jig can be rocked sideways without significantly altering the honing angle, a feature which is necessary for sharpening the tip radius. A wooden knob is added for easier handling. **Photo. 2** shows the clamp and **Photos. 3 and 4** the guide wheel.

Neither materials nor dimensions are critical, as long as the basic geometry is maintained, so the constructor could use whatever is available. I used a 5/8in. bronze ball for the wheel as I happened to have one to hand. This was drilled and reamed then faced to the required thickness, taking care to maintain concentricity. It could, of course, be machined from rod if a ball turning attachment is available. The construction should be clear from the drawings and photographs.

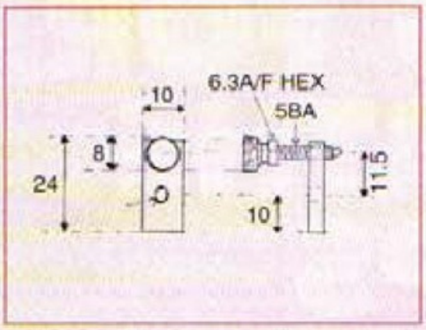
A 4BA hexagon was formed on the upper clamp screw so that it could be



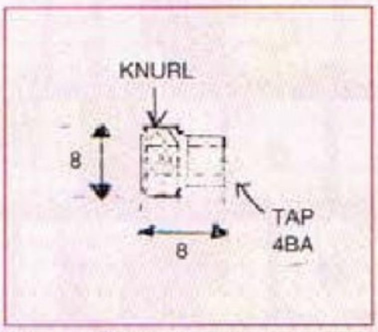
*2. The tip being sharpened must be securely clamped during the operation*



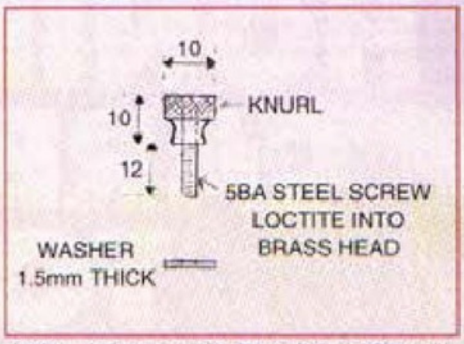
*3. The guide wheel is barrel shaped to allow the device to be rotated in order to sharpen a radiused tip*



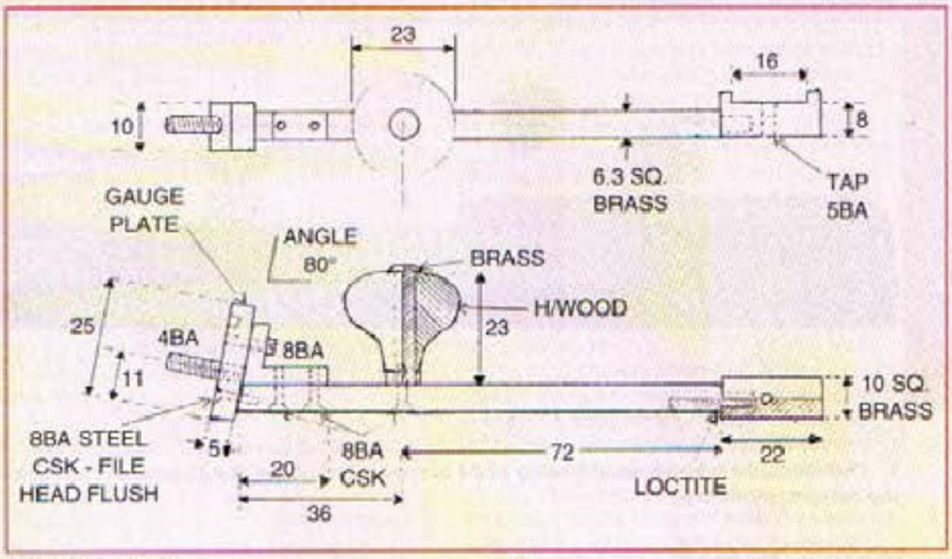

**Clamp Gauge Plate Screw M/S**




**Clamp Nut M/S**

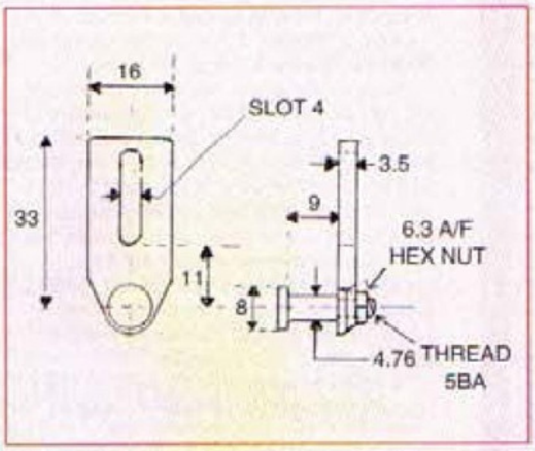



**Wheel Assembly Retaining Screw**

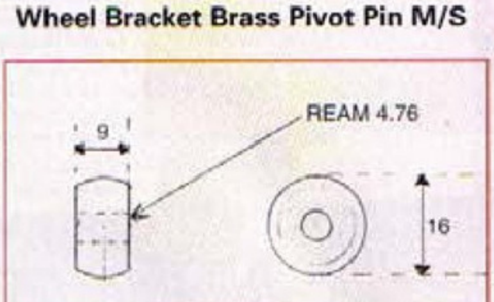



**Jig Assembly**

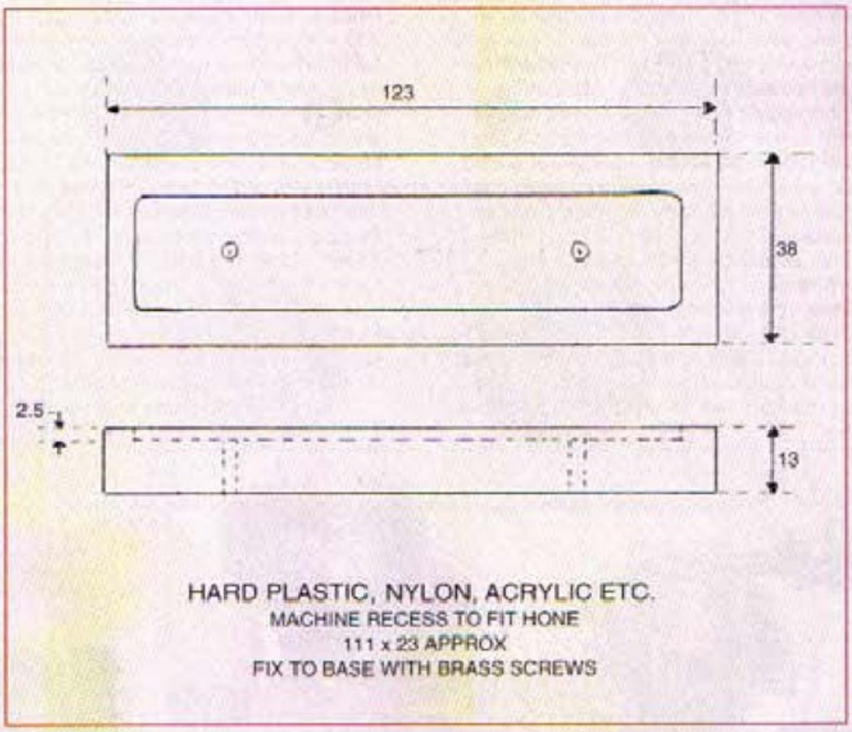





**Wheel Bracket Brass Pivot Pin M/S**



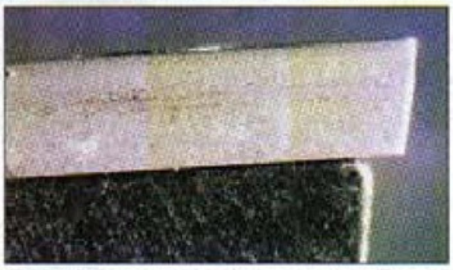

**Wheel Brass or Bronze**




**Hone Support**

*4. Tip clearance angles can be adjusted by altering the height of the arm*

*5. The grip adopted while tool edge is moved to and fro over the hone.*
*Tip: radii are produced by rocking the unit*



*6. The edge shape on a newly-acquired tip*

*7. A few minutes treatment in the jig has effected a considerable improvement*

tightened with a spanner, but I have found that finger tightness is normally sufficient.

## The jig in use

The tip to be sharpened is inserted into the clamp with its edge parallel to the bottom of the clamp, protruding 2-3mm below it, then the upper screw tightened firmly. The height of the guide wheel is adjusted to give the required clearance angle. If the bar of the jig is parallel to the base, the clearance angle will be 10 deg., any required variation from this being estimated by eye. It would be possible to graduate the wheel slide in degrees if considered necessary, but I have not done this. The honing action is started after moistening the surface with water, using the whole area to equalise wear. Heavy pressure is not necessary nor desirable, especially when the hone is new. I have found it best to hold the device as shown in **Photo. 5**. Slight pressure from the heel of the hand holds the wheel in contact with the baseboard while the cutting pressure is applied with the index finger. Frequent checking with a magnifying glass shows when a clean sharp edge is obtained. After sharpening two adjacent edges, the tip is reset in the clamp with the point protruding to carefully sharpen the tip radius. As mentioned, this is done on the continuous diamond surface at the end of the hone, using light pressure and rocking the jig sideways to form the radius. Go gently, as it is easy to round it off too much.

**Photo. 6** shows a magnified view of a carbide tip as supplied, while **Photo. 7** shows the edge after honing; the improved cutting edge is evident.

**Suppliers**

*The specified DMT whetstone is listed by Axminster Power Tool Centre, Chard St., Axminster, Devon EX13 SW. and Simbles, The Broadway, Queens Rd., Watford, Herts. WD1 2LA.*

THE MODEL ENGINEER Exhibition & Competition

# THE 70th MODEL ENGINEER EXHIBITION NEWS UPDATE

Arrangements for the 70th Model Engineer Exhibition are now being finalised and we can confirm that support from the trade has exceeded expectations, to the extent that additional exhibition space has had to be booked. This has had the beneficial effect that more space has become available for Club and Society stands. At the time of writing these notes there are just five trade stand spaces remaining unbooked, so if anyone is interested they should contact Mark Pinkney at the Swanley office without delay.

## Win a Unimat lathe

A Free Prize Draw sponsored by Chronos Limited of St. Albans has as its prize a Unimat Millennium lathe, the mail order value of which is £299 including VAT. All that entrants have to do is to collect and complete an entry form and post it in the box on the Chronos stand at Sandown Park. The winning entry will be drawn at 4.00 p.m. on Monday 1st. January 2001.

## M.E. Exhibition website

The Model Engineer Exhibition website is now up and running at http://www.modelengineering.co.uk/exhibition. This is updated regularly and brings the latest news and now includes the facility of advance booking tickets on line.

This is just one of the methods of advance booking, the others being via the Credit Call Hotline (01858 438897), by fax, quoting a Credit Card number (01858 461739) or by post. Orders will be taken up to 8th. December and tickets will be despatched by 15th. December.

## Getting to Sandown Park

With the provision of 3000 free parking spaces and good road access, exhibitors and visitors travelling by car should find little difficulty. Sandown Park Racecourse and Exhibition Centre are located on the A307 London to Portsmouth road. If approaching from the direction of Central London, take the A3 and exit for Esher on the A309. From all other directions, join the M25 and exit at Junction 10 to follow the A3 towards London. Turn off for Esher on the A244. The route to Sandown Park is signposted.

Trains run from London Waterloo to Esher at half hourly intervals, the journey time being 21 minutes. A free bus service for rail ticket holders will run from Esher station to the exhibition, timed to connect with the trains. A return bus service will also be available.

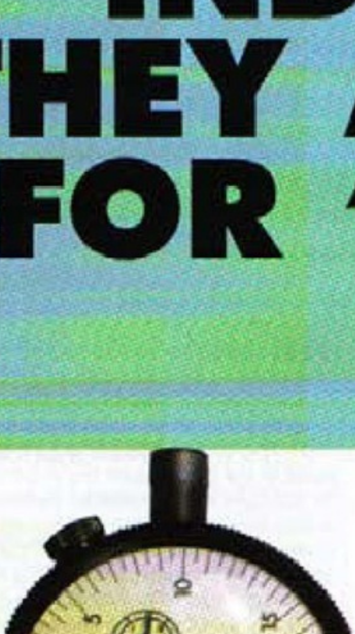
## Competition and Loan entries

Details of the competition sections and an entry form for these and for loan exhibits are again included, on pages 58 and 59 of this issues. Entries are already being received and the organising team is always pleased to be aware of the items which will be arriving (and particularly their size and weight!) in good time to make the necessary arrangements. Please let us have your completed forms as soon as possible.

The 70th. Model Engineer Exhibition will take place at Sandown Park Exhibition Centre between the 29th December 2000 and 1st January 2001.

# INDICATORS - THEY AREN'T JUST FOR 'CLOCKING'

One of the more versatile devices to be found in any workshop is the indicator. Bob Loader surveys some of the mechanical types available and suggests a variety of uses



*1. A dial indicator with the stylus removed and a probe fitted*

Mention the word 'clocking', to an engineering craftsman or woman and two things will come to mind. Those who own cars may think of the habit of ungodly dealers who 'clock' back the mileage of used cars by a few thousand miles. More often though, the word will bring visions of a round component to be set true in a 4-jawed chuck.

This is not the only setting operation to need doing in a workshop and even the smallest will benefit from having an indicator of some sort to make life easier.

## Three useful indicators

Of the three, the ones most used are the dial indicator and the dial test indicator, with a very simple one called a 'tell-tale' indicator. **Figs. 1, 3 & 4**, show the three types. There is an even simpler way of setting, a round workpiece true in a lathe which needs nothing more than a pencil.

## The pencil method

To do this, the toolpost is moved in until it is about a finger's breadth from the work, the machine is turned on and a pencil held against the toolpost and gradually moved in till it just touches the work. The mark it makes will be the highest spot and the chuck jaws can be adjusted until the mark gets longer. When the mark is consistent all the way round, the work will be true within a few hundredths of a millimetre. For most jobs it will be true enough, but for better accuracy an indicator must be used. This method can also find the high spots which may have developed in a 3-jawed chuck. Not all of them run true and they can often be corrected by shimming one or two of the jaws, but it needs a bit of fiddling about with various thicknesses of shim between jaws and work. There are plenty of shims about the house, cooking foil is 0.0005in., cigarette paper, the red or green, is 0.0015in., 80 gram typing paper just under 0.004in. and so on.

## Setting work in a 4-jawed chuck

A word or two about this won't be out of place. I used to have trouble with it when I was an apprentice and it was one of those things which apprentice masters and instructors used to skip over. Advice used to vary from "You aren't holding your mouth right" to "Clear off and come back when its running true"!

Eventually, I worked out my own way, based on the dictum "Don't tighten too much too soon". First the work is set somewhere near by using the setting rings on the chuck face, then the pencil method is used to get it a bit closer. Putting the indicator to it at this stage will frighten the unwary because it will wobble furiously.

When it has been 'pencilled' closer still, the indicator can be used to pick up the high spot. If the opposite jaw (or jaws) is slackened a little and the high one gently just eased up to finger tight, the job is well under way. As long as the tightening is done gently, the error will gradually reduce. When it is only a matter of a few hundredths of a millimetre or whatever, there will still be enough movement in the jaws to get the last little bit out without undoing the opposites.

This way of setting should avoid having to slip a three foot length of scaffold tube over the chuck key to get the last few divisions out. I hope this will be of some use to those who have the same trouble which I used to have. So much for method, time to think about the various indicators.

## Dial indicator

This is the one **(Photo. 1)**, which has a large clock-like face. The plunger will move a long way, usually 1/2in. or 10mm. The pointer will indicate thousandths if Imperial, and hundredths if metric and often the divisions are sub-divided so that

*2. The dial indicator with attachments, used for lining up a milling table*

*3. The dial indicator with attachments, used for checking a bore*

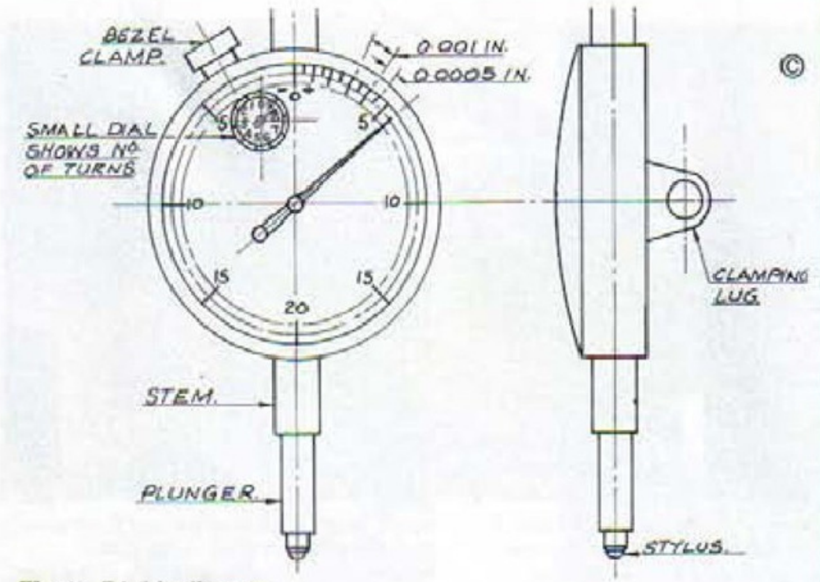



**Fig. 1 Dial Indicator**

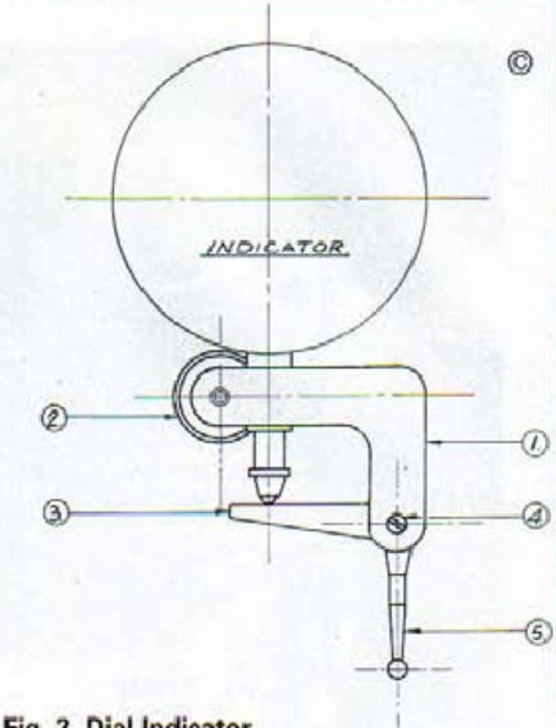



**Fig. 2 Dial Indicator Accessories**

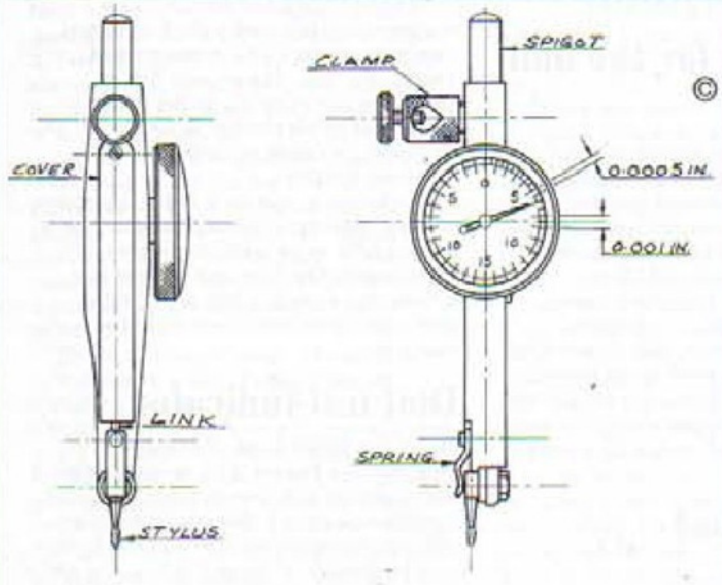



**Fig. 3 Dial Test Indicator**

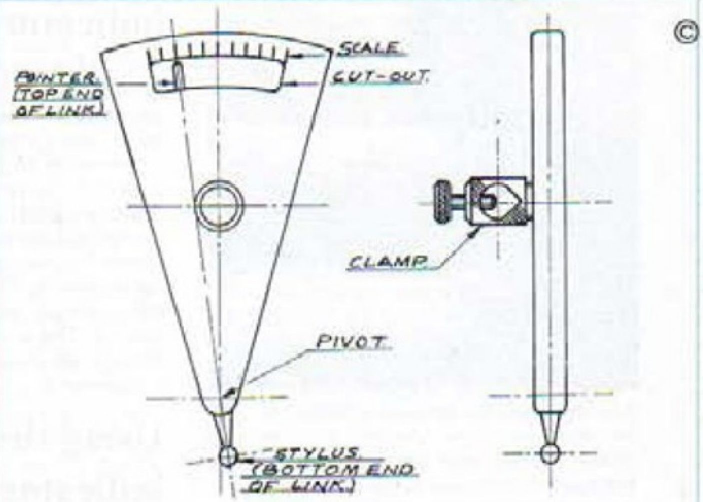
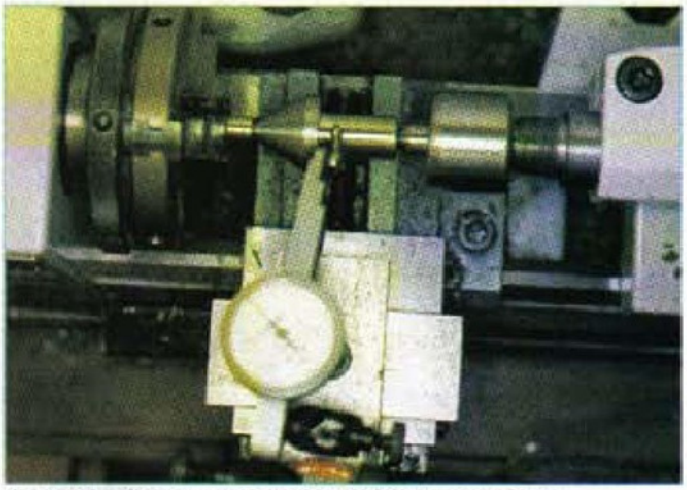
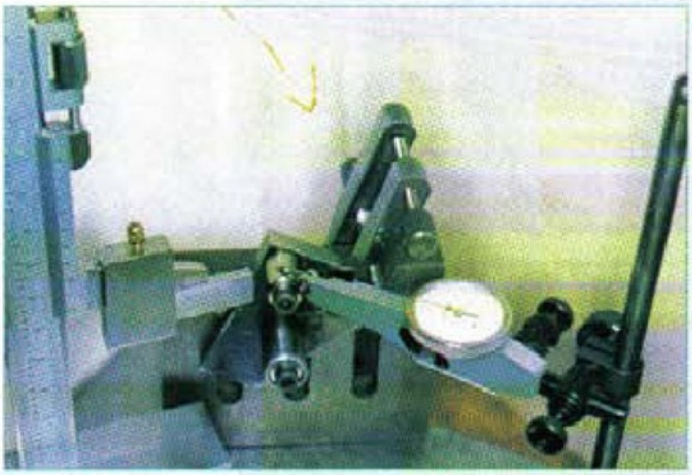


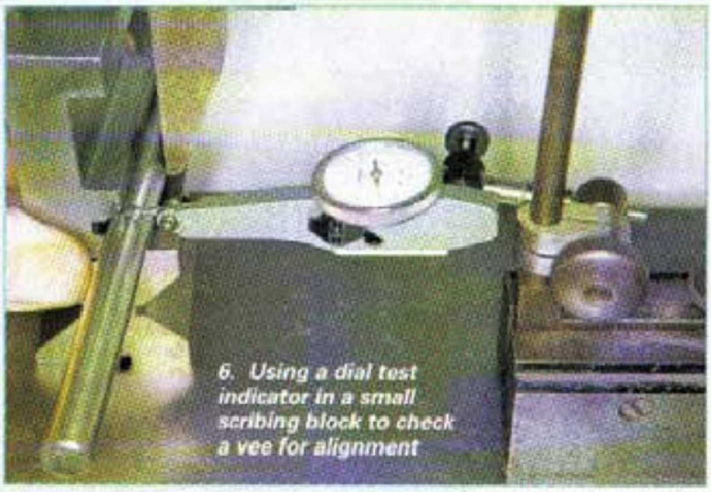

**Fig. 4 'Tell-Tale' Indicator**



*4. A dial test indicator checking a job for concentricity*



*5. The dial test indicator used with a vernier height gauge to check the height of a button*



*6. Using a dial test indicator in a small scribing block to check a vee for alignment*

*7. Checking an edge for parallelism*

*8. Lining up a milling table with a dial test indicator*

an even finer degree of accuracy is indicated. On some there will be a smaller dial which will show the number of turns the main pointer has done. The bezel will rotate and lock in any position - useful for setting to zero.

The mechanism consists of a plunger operating a rack and pinion, the latter connected to gearing which turns both the main pointer and the small one, if fitted. It is very accurately made and can be used for measuring as well as checking and lining up. The one in Photo. 1 has a probe fitted to where the stylus goes, and as the thread is 6BA, it is easy to make probes or other attachments.

Apart from the usual things an indicator is used for, it is very good when the work is outside the range of a smaller instrument, like setting an eccentric.

## Accessories for the dial indicator

The usefulness of the instrument is increased a lot if a few bits and pieces are made. **Figure 2** shows a few of them. The complete set, with some information on their manufacture was shown in the first issue of M.E.W. (Summer 1990). The important ones shown in Figure 2. are (1) a bracket which fits over the stem and is locked by the screw (2). The bracket is reamed to take a pin (4), which forms a pivot for the arm (3). The arm changes the movement through 90 degrees. A stylus (5) screws into the arm.

## Using the dial indicator

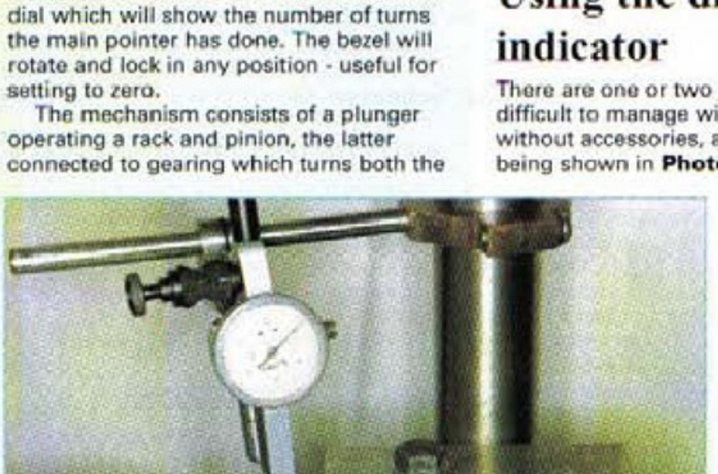
There are one or two jobs which are difficult to manage with the indicator without accessories, a couple of examples being shown in **Photos. 2 and 3**. These would be a non-starter without the extras. Its main virtues are the range it can measure over and the accuracy of the movement. There is a lug on the back of the casing for fastening to holders and fixtures or a magnetic base. Some dial indicators are an almost permanent fixture on many machines where they are used in conjunction with bed stops to establish datums and co-ordinate dimensions.

The one shown in Photo. 1. has a movement which goes from 0 to 20 and back to 0, giving a total movement of 0.040in. per turn. The smaller dial is numbered from 0 to 10, so the total movement of the plunger is 0.400in. to an accuracy of 0.001in. or, using the half divisions, 0.0005in.

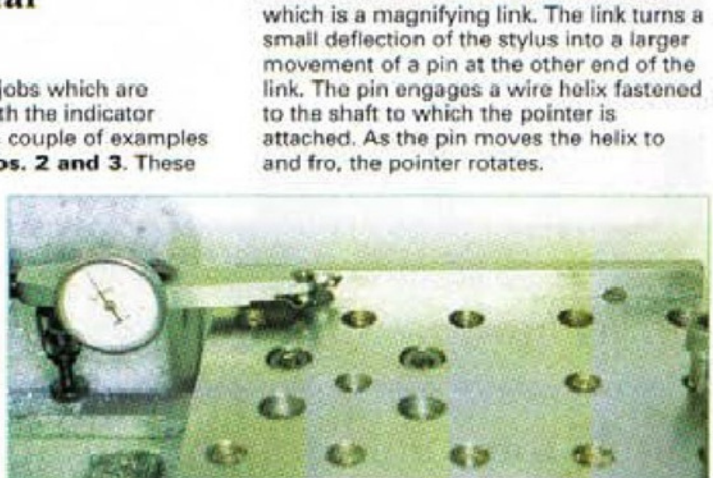
The indicator shown in Fig. 1 is just one of many different sizes and ranges. Some have special large dials, some are built into gadgets like thickness gauges and cylinder bore gauges, the only limit to their uses being the ingenuity of the designer.

## Dial test indicator

This is the little brother of the dial indicator, see **Figure 3** for an illustration. It has a smaller movement, about 1½ turns, a smaller dial and a different mechanism which is a magnifying link. The link turns a small deflection of the stylus into a larger movement of a pin at the other end of the link. The pin engages a wire helix fastened to the shaft to which the pointer is attached. As the pin moves the helix to and fro, the pointer rotates.

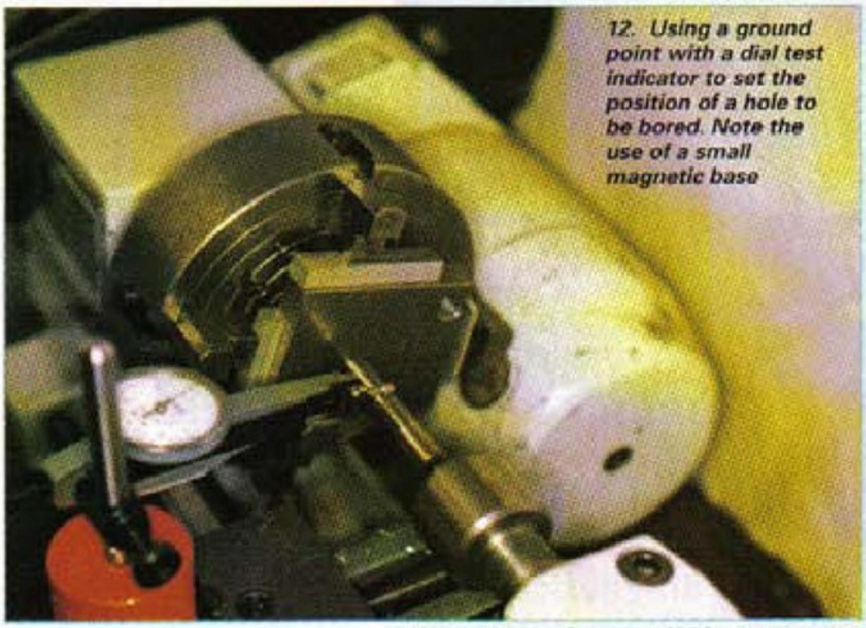


*9. Setting a work piece straight on the milling table*



*10. A different way of setting a fence straight by holding the indicator in the lathe chuck by the spigot*

***11. Setting a small angle plate at right angles to the lathe axis***



***12. Using a ground point with a dial test indicator to set the position of a hole to be bored. Note the use of a small magnetic base***

The dial is divided into the same units as the dial indicator. The direction of the stylus can be reversed by a lever on the side of the instrument and it is held in place by a sprung serrated washer, so that it can be clicked into different angles. On some of them, the stylus can be unscrewed and different ones fitted, like extra long ones for reaching into bores.

My favourite is the Verdict type C, the one shown in the photos. It is an extremely versatile instrument which can be held in a scribing block or magnetic base and is ideal for the small, or not so small workshop. I have no connection with the company, other than being a very satisfied user.

There are many ways of using it and there is a set of attachments which comes with it, allowing it to be fitted to many different holders. It also has a dovetail machined into the underside of the body. The stylus is pear shaped so that it can be used at an angle without the problems caused by cosine error, something which can be disregarded unless it is being used for direct and very accurate measuring.

## Using the dial test indicator

The dial on the type C is graduated movement of 0.030in. Each of the 30 divisions is 0.001in. and they are sub-divided so that 0.0005in. can be read. Not that the units matter much - the indicator could be graduated in sparrow's knee caps - it would make no practical difference because it is usually used to indicate a variation.

There are many uses, from the simplest **(Photo. 4)**, checking that a component is running true, to a more complex one **(Photo. 5)**, where it is being used with a height gauge to check the height of a button by comparing the measurements. Note how easy it is to use it with a small scribing block. This is also the case in **Photo. 6**, where the check is to see if a machined vee is straight and true. A test bar is clamped in the vee and a reading taken at each end by passing the indicator over the bar and zeroing at the highest point. If the reading is the same at each end, the vee is true. Like the dial indicator, the bezel can be rotated and is made so that the movement is stiff enough not to need locking.

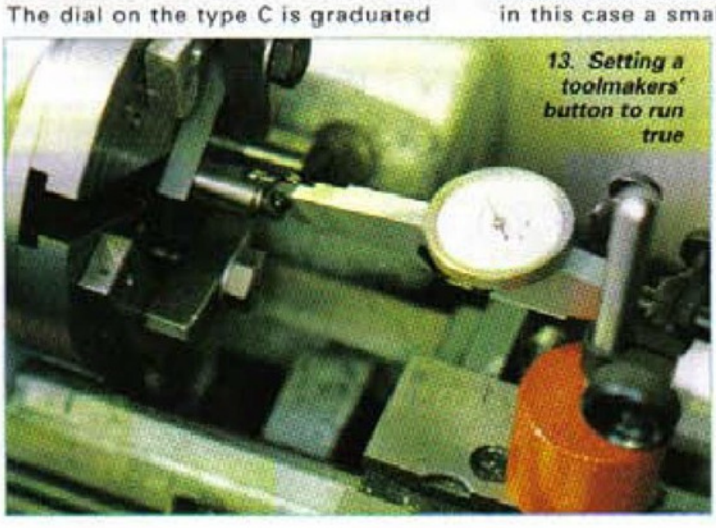
A variation of this method is shown in **Photo. 7**. The block is passed along under the indicator to check if the edge is parallel. It is an easy way of checking, as long as there is an accurate datum surface, in this case a small surface plate.

## Setting for milling work

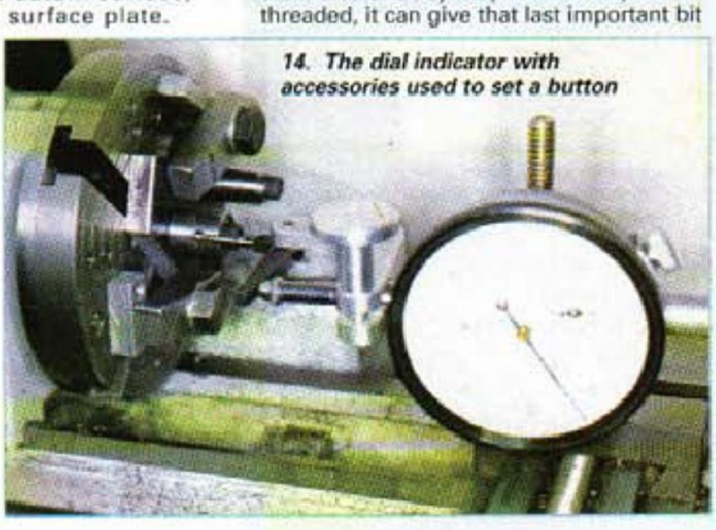
Using a dial test indicator is a very convenient way of setting up for milling operations. With its small stylus and compact design, it fits in nicely for work like that in **Photo. 8**, where the fence is being set straight by winding the saddle to and fro with the stylus just registering on the fence. It is good practice to have a small reading on the indicator, just enough to do the job. For this example, the indicator is fastened to a fitting made from the lower end of a connecting rod, which just happened to fit the pillar at the back of the lathe. **Photo. 9** shows a better view of the fitting, also the clamping screw on the side of the indicator. In this photo a block is being set ready to mill a slot, the block being part of a small fabricated vice.

Another way of setting the fence (and a slightly quicker one) is to hold the indicator by its spigot in a chuck **(Photo. 10)**, making sure that the lathe spindle is locked or that it is in a very low speed setting, so that the indicator doesn't move.

I also use the dial test indicator to set up my small angle plate **(Photo. 11)**. The indicator is clamped to a 1/4in. bar which is held in the scribing block clamp, which is clamped to a short length of bar in the drill chuck. Luckily, it isn't as complicated as it sounds. Because the clamp on the side of the indicator body is split and finely threaded, it can give that last important bit



***13. Setting a toolmakers' button to run true***



***14. The dial indicator with accessories used to set a button***

*15. An improvised set-up for checking alignment of a vee*

of adjustment and as it is sprung, it stays put. It must not, of course, be undone too far. The angle plate is checked by winding the cross-slide to and fro.

## Using a magnetic base

A very useful extra for the small indicator is a small magnetic base. It comes with its own pillar, universal clamp and keeper which should always be on when the base isn't being used. **Photo. 12** shows it in use for holding the indicator while it is positioning a centre punch mark. The magnet holds securely on the cross-slide and the indicator is used to true the ground point, which is under slight compression between the work and the tailstock centre. The point is one I ground to a 60 deg. included angle, concentric with the centre hole at the other end. It does what I need it to, but could be longer. **Photo. 13** is of a similar operation, but this time it is a toolmakers' button being set. For comparison, **Photo. 14** shows the same job done with a dial indicator and accessories.

**Photo. 15** is another lining-up operation, checking that the block which has a vee in the underside, is parallel from top surface to vee. The clamp off my scribing block was used to hold the indicator with a 1/4in. bolt screwed into a tee nut in the cross slide. The same operation can be made easier by using the magnetic base, **Photo. 16**, to hold the indicator.

The base can be clamped to any ferrous part of the machine. **Photo. 17** shows it clamped against the front of the cross-slide. The rectangular bar had to be set parallel with the movement of the engraving point held in the tool post.

The main virtue of this magnetic base is the small size and ease of use. The clamp is interchangeable with the one on my scribing block, as seen in **Photo. 18**, where it is used to set the height measured by the height gauge and compare it with the height of the toolmakers' button **(Photo. 19)**.

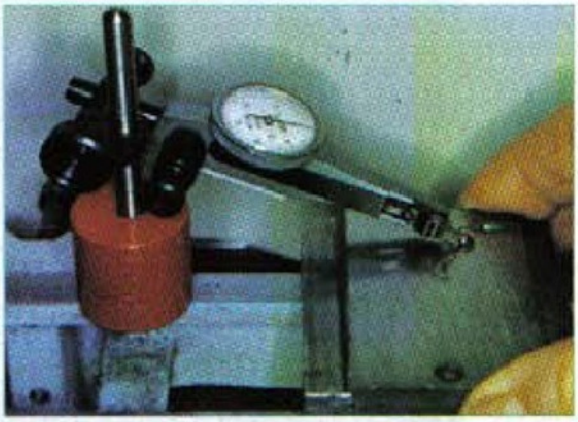
As with the dial indicator, there are lots of different makes of dial test indicator, some with larger dials, some with larger movements and some with jewelled bearings, but the principle is the same - a magnifying linkage.

## Tell-tale indicator

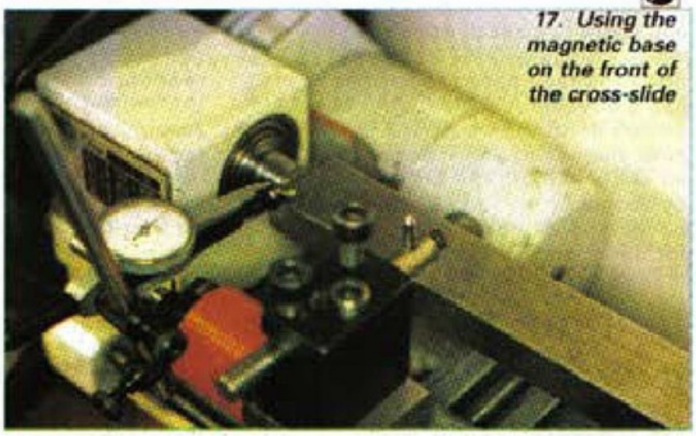
This one is a very simple version of the dial test indicator. It has no helix to convert the movement to that of a pointer on a dial and is just a magnifying link built into a triangular body **(Figure 4)**The indicating arm shows as a pointer moving in a cut-out in the top of the instrument. The cut-out has a few graduations each side of a zero mark and the movement is limited. Its main use is for setting work true when the error is quite small. Although the mechanism is simple and the movement small, it is a reasonable alternative to other indicators when they have been borrowed or mislaid. I have often used one when there was nothing else in the stores to use for a setting or lining up job. Because of its simple construction, it is not a difficult project to make and would be a welcome addition to a tool kit.

Whether the name, 'tell-tale' is the correct one, I am not sure. Perhaps not, but that is what I have always known it as. They are made by several makers, Lufkin is one which comes to mind, so is the name Ideal. There are a number of different designs, but most of them are similar to the one shown in **Figure 4**, looking like a piece of Brie cheese which someone has nibbled the pointed end off. Some have the divisions numbered, some are left for the user to guess at. When using an indicator of any sort, I like to think in divisions and not numbers because it is variations which are shown.

With an indicator of some sort, there is always an answer to problems of lining up, setting square and setting true. Those I have described are a few of the most common ones, but there are many more and the more an indicator is used, the more uses will be found. A workshop is not really complete without one.

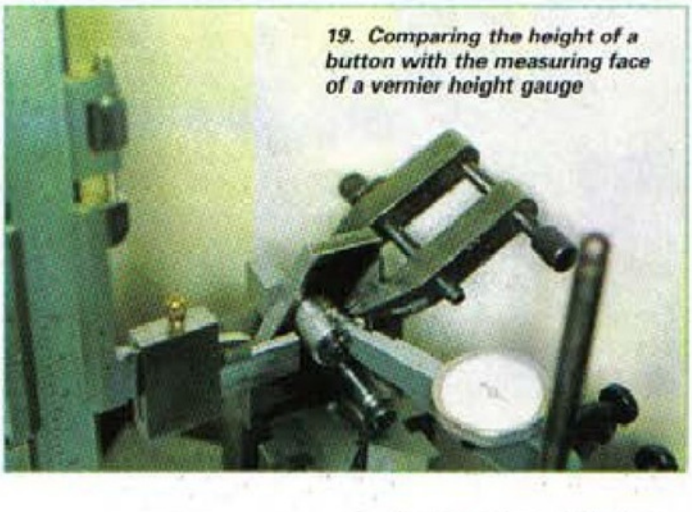


*16. Another alignment check using the magnetic base on the lathe bed*



*17. Using the magnetic base on the front of the cross-slide*

*18. Making use of the clamping gear from the magnetic base, on a small scribing block, to measure the height of a button*



*19. Comparing the height of a button with the measuring face of a vernier height gauge*

# A MILLING CHUCK ADAPTER FOR A HUFFAM CENTRE LOCATOR

Derek Oxley has devised this simple aid to accurate work setting

*2. The modified locator in use, held in a SKF milling chuck*

When transferring a partly machined item from the lathe to a dividing head and tailstock under the vertical mill/drill for slotting or grooving, it will require accurate positioning relative to one or more datum faces. The required co-ordinates can be picked up with a Huffam centre locator which has interchangeable stems, either ball ended or of cylindrical form. It has a body diameter of approx. 25/64in. and is necessarily held in a drill chuck, closed up finger tight.

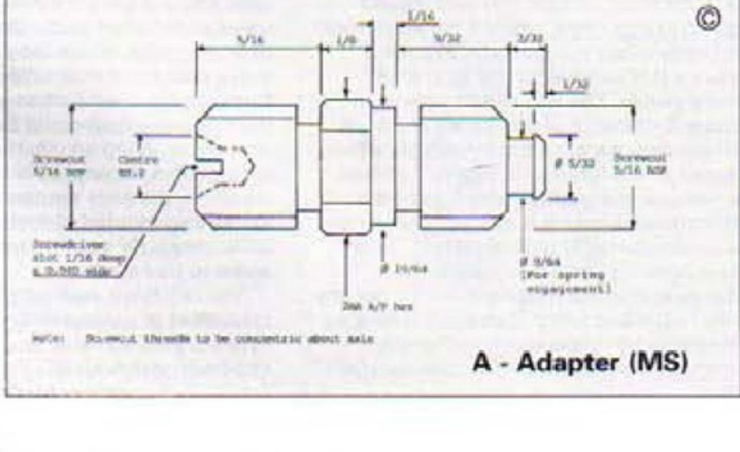
In order to then replace the drill chuck by a milling chuck, it is usually necessary to raise the head of the machine by some 4 to 5in. to effect the exchange and then to lower it again by a similar amount. On my machine of Taiwanese origin (and, no doubt, many others) that operation virtually guarantees that the previously established co-ordinates will not be truly held.

Instead of attempting to modify the substantial machine column and/or its lifting/lowering rack, I chose to adapt the locator to suit the milling chuck, by a method requiring no permanent modification, and requiring only the manufacture of two small parts, details of which are shown on **Sketches A and B and Photo 1**.

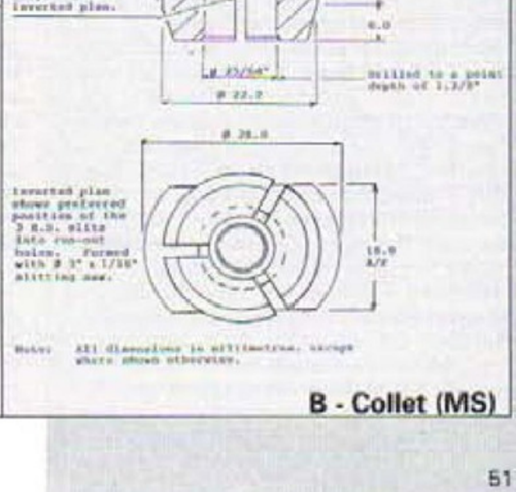
*1. The 25/64in. bore collet and adapter plug*

After temporarily removing the knurled rim spring retaining plug from the locator it is replaced by the double ended adapter, and the whole entered into the special bore sized collet. This is secured in the milling chuck in the usual way, but omitting the final tweak with the special spanner. Fingers gripping the knurled portion of the locator body and screwing up tight against the chuck centre pin closes the collet about the body of the locator equivalent to finger tightness in a drill chuck. **Photo. 2** shows a typical installation.

The design of the special bore sized collet is compatible with milling chucks by SKF/Dormer of type R8 Fastloc Small and by Clarkson type 2MT 'S' Autolock. It has been successfully used with both for more than 6 years.




**A - Adapter (MS)**




**B - Collet (MS)**

# ELECTROMAGNETIC DEVICES Part 4

**Permanent magnets are incorporated in many of the devices which we encounter every day. In this article, Tony Claridge covers the theory, the materials from which they are made and describes a few applications**

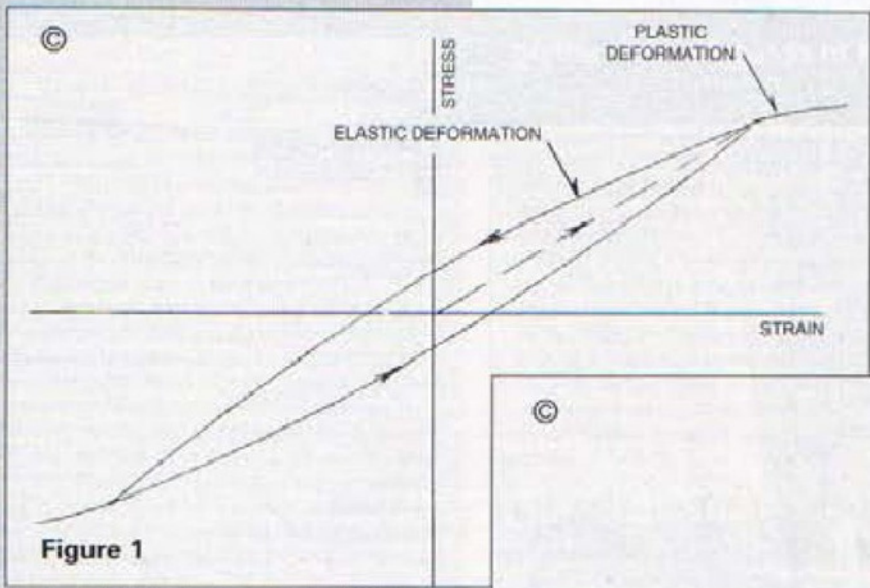


**Figure 1**

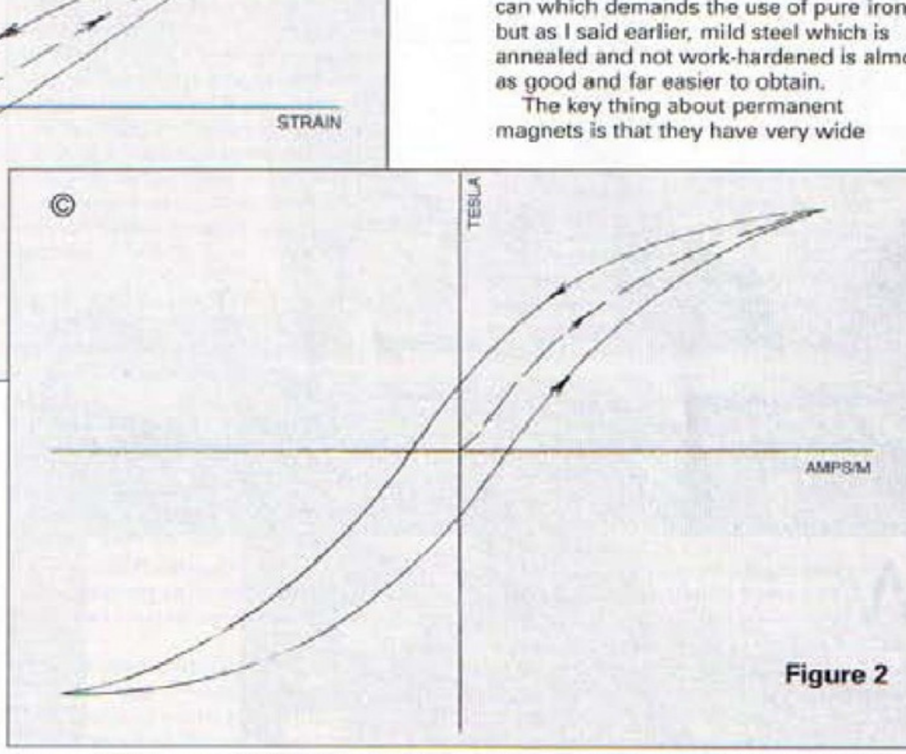


**Figure 2**

When you look at all the trouble involved in using a coil to establish a magnetic field, the idea of doing the same thing with a permanent magnet seems irresistible. But, as I said in the last instalment, you can't switch a magnet off, and this can be very inconvenient. Nevertheless, permanent magnets are very useful, so we need to know how to use them.

Earlier in this series we referred to the residual magnetism which occurs in all but the purest iron. In permanent magnets this residual magnetism is the most important characteristic. In order to understand permanent magnets we have to look at the all-important B/H curves which we touched upon earlier.

You will probably have encountered stress/strain curves for materials, and will know that when the stress is reducing, the strain does not follow exactly the relationship that applies when stress is on the increase. **Figure 1** is an example of what I mean. The arrows show the direction of change, and the strain, that is the dimensional change, can be seen clearly. So long as the strain is reversible, this is called the region of elastic stress, but if the stress is made high enough, then we enter the region of plastic deformation, where the material is permanently deformed, and does not return to. its original shape. Incidentally, the difference between the up and the down lines encloses an area which represents the energy lost in the process, called the hysteresis loss. In the stress/strain world this appears as heat. I have exaggerated the extent of the hysteresis to make the principle easier to see.

The reason behind this bit of revision is that permanent magnets have similar characteristics, and we can understand their workings more easily if we start from the stress/strain comparison. **Figure 2** shows a B/H curve with the loop effect clearly visible. The B/H curves shown in **Figure 3** of Part 2 of this series show just a single line, because the hysteresis effect is small so we ignored it. Figure 2 shows the residual magnetism which occurs in all but magnetically soft material. You can see the resemblance to a stress/strain curve. There is no equivalent to plastic deformation in the magnetic world, but the same hysteresis effect is present, and also appears as heat. It is again called the hysteresis loss, and this will crop up again when we deal with alternating fields later on.

Figure 2 also shows the residual magnetic flux which is still present when the exciting current in the coil is switched off. This is the property which makes electromagnets stick on when the current is removed. It is getting this as small as we can which demands the use of pure iron, but as I said earlier, mild steel which is annealed and not work-hardened is almost as good and far easier to obtain.

The key thing about permanent magnets is that they have very wide hysteresis loops. Therefore they retain most of their magnetism after the magnetising coil is de-energised. This is illustrated in Figure 3. The value of flux density which remains after the current is switched off is shown in the figure. It is called the remanent value of B, and usually identified as $B_r$. On the horizontal axis, the point where the characteristic curve cuts the line is called the coercive force, and is identified as Hc . In theory, the magnetic field could be forced down to zero by applying an electric current to provide this amount of H to the magnetic circuit. In practice, permanent magnets are too strong-minded to respond to this, and other methods must be used. We will come to these later.

You will have realised that the important properties of permanent magnets are concentrated into this 'top left-hand' quadrant of the hysteresis loop, and the exact shape of the curve in this quadrant is almost the only information which we need to use magnets effectively. A selection of curves for typical materials appears in **Figure 4**. In the last quarter century there have been huge advances in permanent magnet materials, mostly directed towards getting more 'magnetism' per unit amount of material, and also towards shaping the properties towards what best suits a particular application.

## How magnets work

Even though in our work it may be a matter of making use of whatever magnets we can get hold of, it is useful to understand why the material properties are important. Let us start by considering a ring magnet which is magnetised in a circumferential direction. After it has been driven into saturation (this means having an applied MMF sufficient to force the value as high as it will go, as indicated in Figure 3), the field will settle at the remanent flux density, as also marked in Figure 3. In practice, however, all useful applications require some access to the field produced by the magnet. A more typical assembly is that shown in **Figure 5**, where the aim is to set up a field across a small gap.

You will know from Part 2 of this series that we need a supply of MMF to set up the flux around the magnetic circuit. Forgetting leakage flux for the present (it would be a substantial factor in a practical design), we have to get some MMF from somewhere. It can only come from the permanent magnet! What happens is this: The MMF needed is provided by the working point of the permanent magnet sliding down the curve to some intermediate point. At the equilibrium point, where we have reached stability, the MMF needed to drive the flux through the iron and the air gap is derived by the magnet's working point moving down the curve until there is enough MMF to set up the field in the gap. At the same time the flux density in the magnet is falling.

To keep this concept simple, I have left out any consideration of the size of the magnet. As you would expect, the longer the permanent magnet, the greater the coercive force available. Also the greater its cross-sectional area, the higher is the total amount of flux (not flux density) which is obtained. A little later we will work out an example, which will, I hope, make things less incomprehensible. (I know just how you feel - I can still remember how I felt when I first met all this nearly fifty years ago).

But first we need to look at the different permanent magnet materials which are in use today. The old, hard steel (usually tungsten alloyed) magnets are now extinct, though you may find some if you dismantle 1930's loudspeakers or old magnetos.

Among modern magnets there are several families, according to the needs of different applications. First to appear were the Alnico group (there are many proprietary names for these). As the name suggests, they are alloys of aluminium, nickel and cobalt with around 50% of iron. Various grades exist, with some having enhanced properties in one direction.

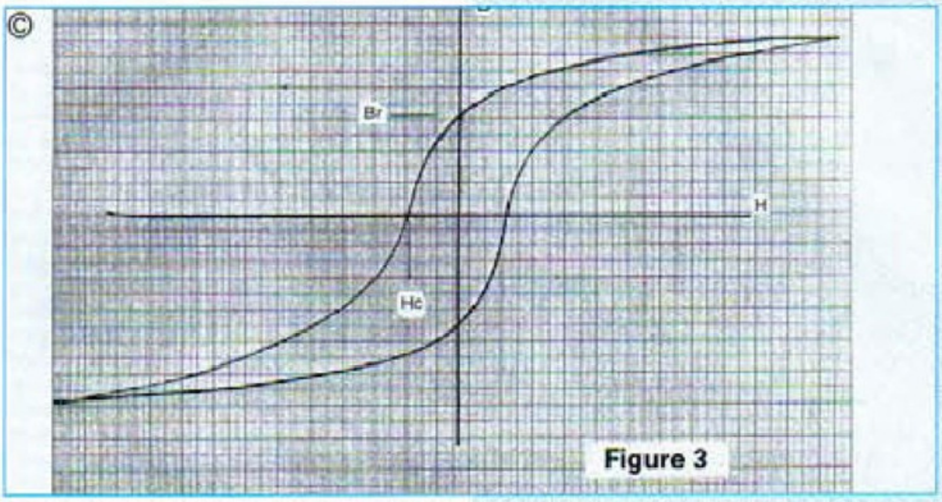


Figure 3

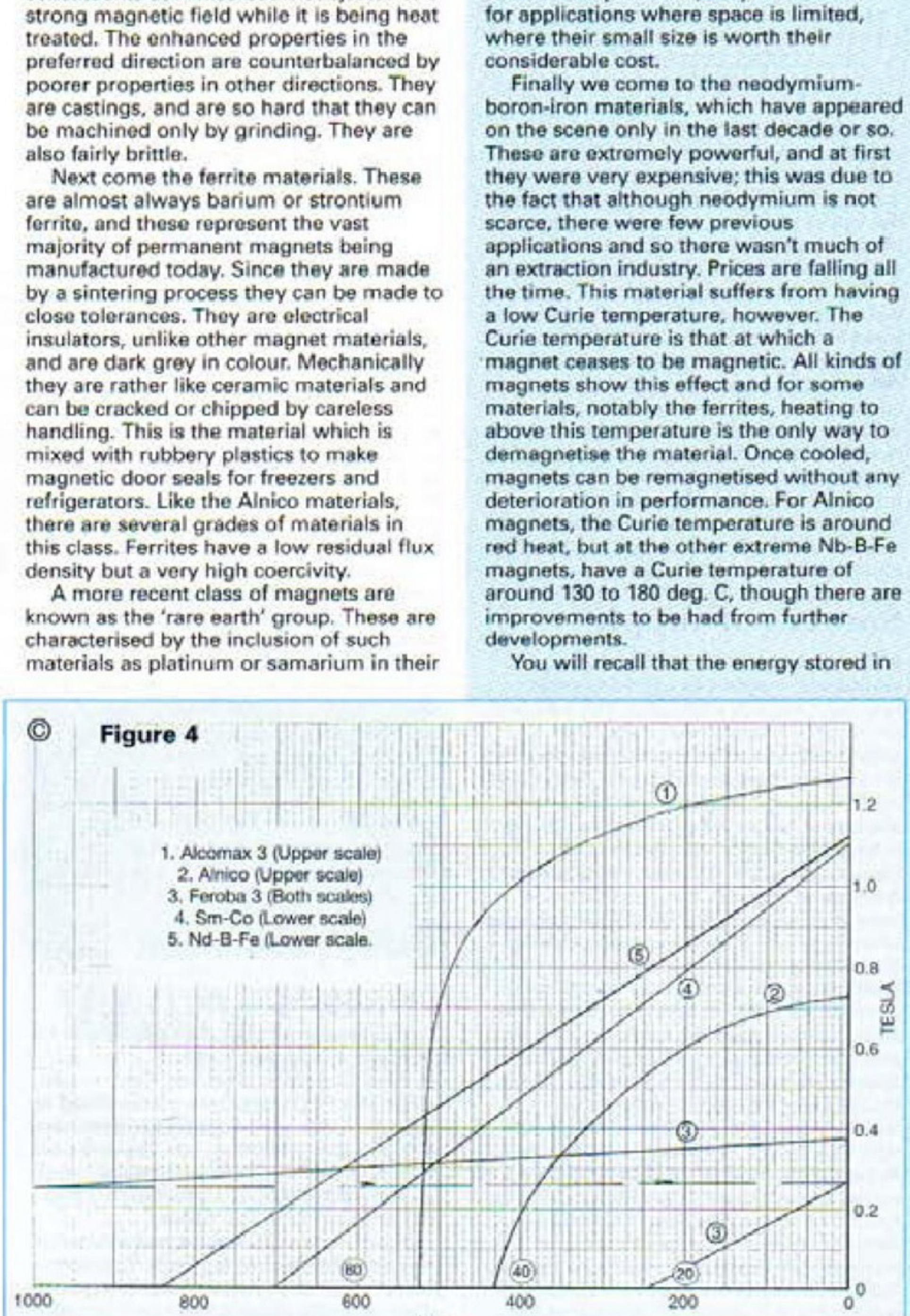
Figure 4 shows a curve for Alnico, and also for Alcomax, which has the same constituents as Alnico but is subjected to a strong magnetic field while it is being heat treated. The enhanced properties in the preferred direction are counterbalanced by poorer properties in other directions. They are castings, and are so hard that they can be machined only by grinding. They are also fairly brittle.

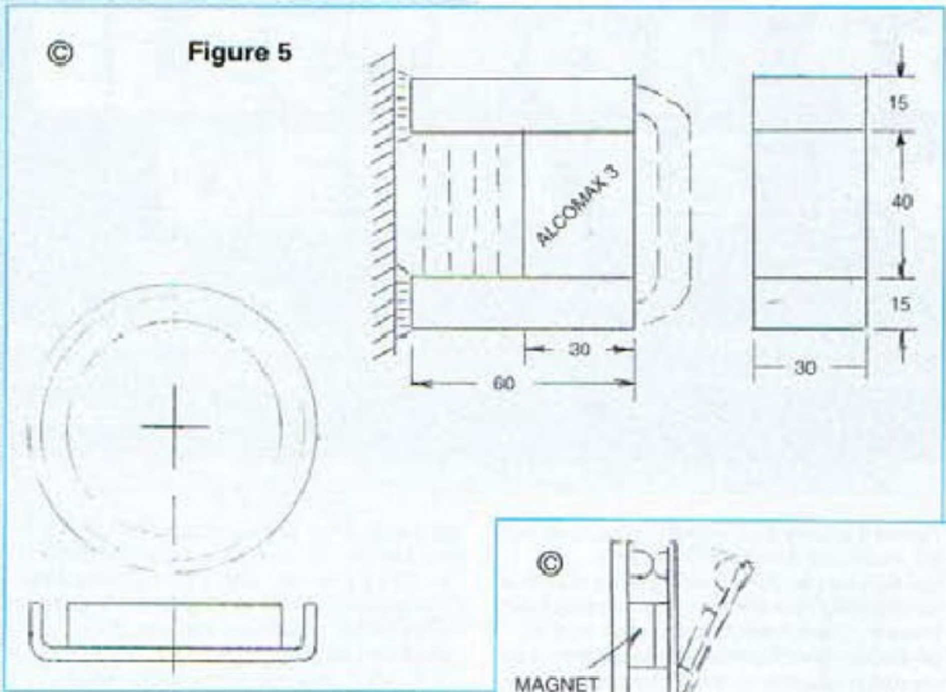
Next come the ferrite materials. These are almost always barium or strontium ferrite, and these represent the vast majority of permanent magnets being manufactured today. Since they are made by a sintering process they can be made to close tolerances. They are electrical insulators, unlike other magnet materials, and are dark grey in colour. Mechanically they are rather like ceramic materials and can be cracked or chipped by careless handling. This is the material which is mixed with rubbery plastics to make magnetic door seals for freezers and refrigerators. Like the Alnico materials, there are several grades of materials in this class. Ferrites have a low residual flux density but a very high coercivity.

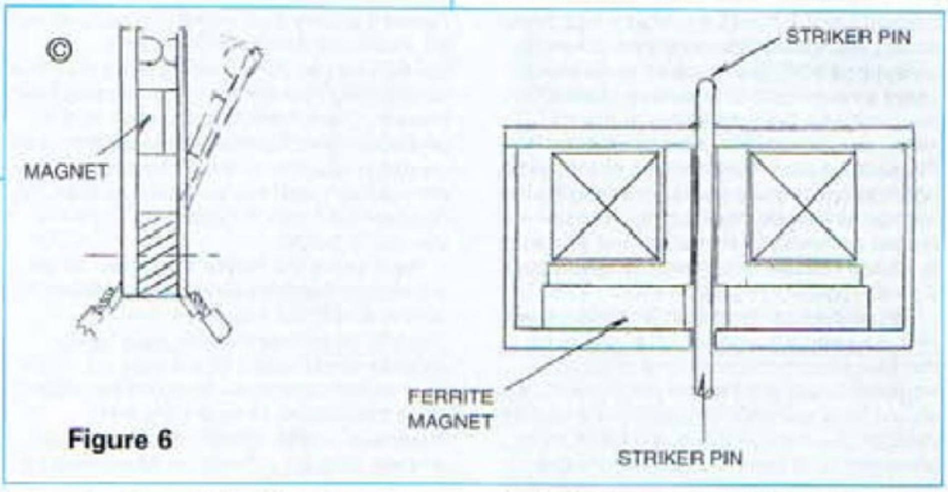
A more recent class of magnets are known as the 'rare earth' group. These are characterised by the inclusion of such materials as platinum or samarium in their makeup. They are consequently rather expensive, but as less material is needed to fulfil a requirement, they are attractive for applications where space is limited, where their small size is worth their considerable cost.

Finally we come to the neodymium-boron-iron materials, which have appeared on the scene only in the last decade or so. These are extremely powerful, and at first they were very expensive; this was due to the fact that although neodymium is not scarce, there were few previous applications and so there wasn't much of an extraction industry. Prices are falling all the time. This material suffers from having a low Curie temperature, however. The Curie temperature is that at which a magnet ceases to be magnetic. All kinds of magnets show this effect and for some materials, notably the ferrites, heating to above this temperature is the only way to demagnetise the material. Once cooled, magnets can be remagnetised without any deterioration in performance. For Alnico magnets, the Curie temperature is around red heat, but at the other extreme Nb-B-Fe magnets, have a Curie temperature of around 130 to 180 deg. C, though there are improvements to be had from further developments.

You will recall that the energy stored in






a magnetic field is the sum of the product of B and H in every part of the field. This allows us to get an indication of the best working point of a magnet. We multiply the values of B and H as we travel down the characteristic curve. Where the curve meets the vertical axis, H is zero so the energy is zero. Similarly it is zero where the curve cuts the horizontal axis. Between these limits, the energy rise to a peak. It can be thought of as being represented by the area of a rectangle whose top left-hand corner is at a point on the curve, and which is bounded by the vertical and horizontal axes. Working at this point provides the most useful field that the magnet can deliver. This piece of information is maybe more detailed than most readers will wish to use, but a better understanding sometimes helps.

## Sources of supply

Although it is possible to buy new permanent magnets in relatively small numbers, there are other sources which are much cheaper (free!) if you are prepared to cannibalise scrap components. Small magnets are used in telephones and in old moving coil voltmeters and ammeters. Larger, ring-shaped magnets, magnetised axially, are used in loudspeakers, but the most useful source I have come across is scrap magnetrons from microwave ovens. These are replaced when their power declines due to falling cathode emission, and the repair shops just throw them in the scrap bin. They are ours for the price of a drink, or free for the asking. Mostly they are made by Toshiba, and each contains two ferrite magnets measuring 56mm OD x 19mm ID x 12mm thick. There is a modest amount of butchery required to extract the magnets, with saw and chisel (if you have one, an angle grinder is ideal), but the magnets are exceptionally powerful and well worth the trouble of dismantling the magnetron. Incidentally, if you are interested, it is rewarding to take the copper body from the middle of the magnetron and cut it in two across a diameter. A magnetron can be perceived as a kind of electric motor, and I will describe how it works when we come to deal with motors later in this series. It was invented at Birmingham University in 1940 by Randall and Boot, and was the vital element in the development of centimetric radar.

Boxes of mostly broken magnets are sometimes on sale on the 'surplus' trade stands at our shows, though curiously I have done best at the Classic Motorcycle Show which is held at Stafford in April each year. Prices are usually so much a pound, with the buyer picking from a jumbled box-full. There is at least one manufacturer, Eclipse Magnetics Ltd. who supplies new magnets in a wide range of materials and shapes, though subject to a £25.00 minimum order charge. I have found their catalogue very informative, and would recommend it to any serious experimenter.

## Using permanent magnets

There are vast numbers of applications for permanent magnets, and only a few can be described here; However, if any reader would like help in designing something for a specific purpose, I shall be happy to deal with enquiries via the editor. There is a lot of know-how in permanent magnet applications, and it is impracticable to go into great detail in this series.

By way of an illustration, we will look at the magnet shown in Figure 5. This is the kind of assembly we might put together to attach a textile or cardboard screen over the car windscreen to protect it from frost or strong sunlight. The dimensions are shown on the figure. We will assume that the magnet is Alcomax 3. I have not shown how the magnet and its pole pieces are joined.

The first point to consider is that most permanent magnet systems suffer from leakage to a surprising extent. The main leakage paths are shown as dotted lines on the figure. In anticipation of this effect, the permanent magnet is made with a cross-sectional area twice as large as that of the pole pieces. To start with, this allowance is a guess. To get a feel for the amount of flux leakage we can start from the fact that the MMF in the working pole faces is the same as that which is developed along the main leakage path (the one shown on the figure). The flux density in the two paths is inversely proportional to the paths' lengths. With the two gaps on the poles in series adding up to 5mm, while that on the main leakage path is 40mm, it follows that the leakage flux density is only one eighth of that in the pole pieces. However, the cross-sectional area of the leakage path is about 50 x 30mm, i.e. 1500 square millimetres (remember that the leakage flux bulges outwards wherever it can), while the useful flux path area is only 15 x 30, or 450 square millimetres.

The leakage flux is estimated from these figures to be about 40% of the useful flux, since the leakage flux density, though only an eighth of that of the pole faces flows over a cross-sectional area which is over three times as large.

Having estimated the leakage flux as a proportion of the useful flux, we have to jump to trial and error for the next step. We will start with a guess that the value of B in the working air gap is 0.7 tesla. We can then calculate the attractive force for the two poles from the formula we gave in an earlier instalment:-

$$\text{Force} = 0.0406 \times B^2 \times A \text{ Kg}$$

$$= 0.0406 \times 0.49 \times 900$$

$$= 23.4 \text{ Kg}$$

The working point of the magnet is obtained by starting from the 0.7 tesla of the air gap and dividing this by two because the magnet's area is twice that of the air gap, and then multiplying this by 1.4 because of the amount of leakage which we estimated above. Thus we arrive at roughly 0.5 tesla. From Figure 4 we can read H for Alcomax 3 as 52 KA/m and with the magnet being 40mm long, this gives us

$$52000 \times 0.04 = 2080$$

Assuming that this is all applied to the air gap, we get:-

$$B = \mu_0$$

and remembering that H = MMF divided by the length over which it applies, we arrive at:-

$$B = \frac{4 \times \pi \times 2080}{10 \times 0.005} = 0.52 \text{ tesla.}$$

So 0.7 wasn't a bad guess, but if we were interested in a closer estimate it would be necessary to try another figure and do the calculations again.

To add to the uncertainty, we have assumed that the steel to which the magnet assembly is attached is thick enough not to constrain the amount of flux. You will see that it is rarely worthwhile to do more than very rough estimates of the performance of magnets in this kind of application.

With the advent of ferrite magnets, which you will recall from Figure 4 have very high coercivity, the disc shape shown in Figure 5 is frequently used for the kind of application we have just looked at, but it is really only suitable for sticking to a fairly flat surface.

**Figure 6** shows some other applications for permanent magnets. One which is widely used is to give a snap action to the overheating protection device which is often fitted to electrical appliances such as fan heaters. These usually use a bimetal strip (a flat strip made with two layers of different metals which are bonded together and which have different thermal expansions) When the temperature rises, the strip bends and this movement is used to pull a pair of contacts apart and so shut down the machine. However, electrical contacts burn away if they are separated only slowly (as well as the arc causing radio interference). The cure is to add a small magnet which tries to keep the contacts together, but eventually lets them separate when the force exerted by the bimetal strip is more than the magnet can overcome. Once the gap between the magnet and the metal it is holding on to separate, the holding force falls to a negligible level and the switch contacts separate so quickly that the circuit is broken 'instantaneously'.

Yet another application is for what is called a polarised relay. In this device the magnetic field which operates the relay is provided by a combination of a permanent magnet and a coil. The design is made such that the magnet alone cannot operate the relay, and the relay responds only when the coil is energised. This has two benefits; firstly the relay operates only when the current is in the correct direction, and secondly the relay can be made to operate with a very small current. This comes about because, as you will recall, the force developed by an electromagnet is proportional to the square of the flux density. It follows that the addition of a small amount to the flux density can result in a large increase in the force. The idea is that a permanent magnet furnishes nearly enough flux to operate the relay, and a small additional contribution is enough to make it respond.

Finally we come to the opposite application of this principle in a device which I designed about twenty years ago. It is also shown in Figure 6. The requirement was to hold a spring-driven striker pin against the force of a 'cocked' spring until it was to be released by an electrical signal consisting of the discharge of a 10 microfarad capacitor charged to about 30 volts. This is a very small signal to control a striker force of around 2 Kg, being only 0.0045 joules.

The principle was to use a ferrite magnet in a holding arrangement similar to that which we discussed earlier, but then to divert or suppress the field for long enough for the armature, and hence the striker, to be, released. Discharging the capacitor into the coil did the trick perfectly. This was one of the more satisfying jobs in my consulting days. As well as cutting the cost of the mechanism by a factor of five, its reliability was a order of magnitude higher than that of its predecessor.

In the next instalment we will make a start on magnetic devices which use alternating currents. To do this we need to understand the nature of 'AC', and easy ways to represent sinusoidal waveforms, so we will start with a little theory (but not too much!).

*Supplier:- Eclipse Magnetics Ltd. Vulcan Road Sheffield S9 IEW Telephone: 0114 2250610*

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- A quantity of new, boxed end mills and slot drills, HSS, Clarkson etc. Various sizes, mostly 1/2in. dia. or below. £2.50 each. Tel. 01327 351274 (Northants)

- Mitutoyo vernier caliper, boxed, 300mm 160-127. £45 Tel. 01672 563552 (Wiltshire)

- M.E.W. Back numbers Issues 1 to 68 good condition, with Data Sheets. Best offer. Tel. 01524 822885 (Lancaster)

- Rotary Forward and Reverse switch. OK for single phase motors £15. Single phase motor starter with 240 volt coils and No-volt release £12. Prefer buyers to test and collect, otherwise to arrange collection. Tel. 01723 362537 (Scarborough)

- Boxford accessories:- Curved wooden rack with 9 of original 12 lathe tools £20. Original fitted steel case for 'Little Giant' toolpost grinder £10, both in good condition. Also Sigma pneumatic comparator £15. New Dormer HSS No. 9 taper pin reamers £2 (boxed). Tel. Malcolm Leafe on 01924 460864 (West Yorkshire). (Please leave name/number if machine answers)

## WANTED

- For Pools bench miller (1950 vintage), illustration or diagram showing the countershaft and motor assembly. Tony Birkinshaw, 219 Teagues Crescent, Telford TF2 6RA Tel. 01952 617856

- Information on how to use an engraving cutter grinder. Believed to be Taylor Hobson and quite old. Cash waiting for a photocopy of the handbook. Tony Moss, 43 Windsor Gardens, Bedligton, Northumberland NE22 5SY Tel./Fax. 01670 823232

- Royal Oak Grinder (R-O Tool and Cutter Grinder) Can you please help with information about the above machine? I would especially like information on the 'Universal Form Relieving Attachment' and the pile of accessories which accompany it. As a T&C grinder it does a good job, but I would like to use the full facilities of the relieving attachment.
The machine table has a 30in. x 8in. working area and a tool head centre height of 8in. It probably dates from the WWII era, made by R. O. Manufacturing Co., Madison Heights, Michigan USA. The electrical control unit for the relieving head was made by Edon Industrial Products of "Royal Oak, Michigan". Possibly a reader from the area could help.
Please phone or fax Malcolm Leafe on +44 (0) 1924 460864

- M.E.W. Back issue, No. 58 (June 1999). M. J. Mussett, Ashby Hall Farm, Ashby, Lowestoft, Suffolk NR32 5QU Tel. 01493 488436

## Sources of soft iron and some thoughts on bush retention

### From Frank W. Adams, Sheffield

Perhaps the following observations relating to items in Issue 67 of M.E.W. may be of interest.

**Materials for electromagnets (Page 58)**
A ready source of soft iron for making electromagnets (which is better than mild steel as it exhibits less remanence) is the cores of old Post Office Type 3000 relays. These are readily available in this country on the surplus market, and I feel sure that the same can be said for Canada. Other similar relays can yield cores up to some ½in. diameter by some 3 to 4in. long.

For making smaller electromagnetic devices, soft iron wire (uncoated with plastic) is still used by florists for binding and bunching flowers, and should be available from florist's suppliers. Such wire was commonly used in the earlier part of the last century for making small transformers. These were not very efficient because they did not have a closed magnetic circuit and were known as 'hedgehog' transformers. They consisted of a long bundle of iron wires formed into a core. Suitable primary and secondary windings were put onto the central part of the bundle and the free wire ends bent over and looped back radially so that, as far as possible, the ends of the wires were in close proximity to each other and touching if possible. The writer made several of these for providing low voltage supplies and, whilst they were not very elegant, none-the-less they worked and were useful. The test applied in those days for suitable soft iron wire was to hold a length of the wire in both hands and start to bend over the two thumbs. Soft iron wire bends very slightly then 'kinks' suddenly. The effect is quite noticeable and characteristic.

**Securing a bush (Page 57)**
I do not claim to be any expert on this topic, but I would have thought that the answer is fairly obvious, and a parallel example springs to mind. If you are joining two spindles or shafts with a coupling or fixing a knob to a shaft, there is commonly a residual degree of play and freedom of movement. Securing the coupling to the shaft/spindle with two screws in line will still permit movement about a single plane if there is any play whatsoever in the system.

To obviate this, it is necessary to restrict play in a second plane. With lightweight mechanisms, couplings and knobs this is commonly done by securing with two screws at 90 deg. apart or thereabouts or, in the case of more robust mechanisms with three screws at approximately 120 degrees. I assume that the same thinking applies in Mr. Sutton's case although I would assume that with press-fit bushes it would not matter, the criterion being whether or not there is any play in the system.

## Electro-magnetic V-blocks

### From Mike Brown, Ponteland, Newcastle Upon Tyne

I found Peter Rawlinson's recent article on his electro-magnetic V-block of great interest, but have some concerns over safety with the coil supplied from a battery charger as described.
If the coil supply depends upon mains electricity, the workpiece may be released during a dip or complete failure of that supply. Consideration needs to be given to what happens next; will the electro-magnet maintain its grip on the workpiece until the tool comes to a halt?
Probably the most reliable supply would be provided from a battery or a mains supply with floating battery back up, combined with simple, substantial and workmanlike wiring to the coil. The battery itself must be reliable and it's probably not a job for a battery no longer fit for the car. If a mains or floating battery arrangement is used, it could be arranged so that the machine supply is taken via the mains feed to the coil (an auxiliary socket either on the charger or fed from the same plug?). Operation of the 'wrong switch' will then remove the power to the machine as well as the workholding supply.

## Protecting a brass finish

### From Dr. W. B. Amos, Cambridge

Can anyone tell me how to varnish brass? In my experience, proprietary varnishes do not give an enduring protection against tarnish, no matter how carefully the surface is prepared. Yet brass musical instruments and antique microscopes stay shiny, apparently indefinitely. I have heard that epoxy sprays are now used, but I have not been able to find where to purchase them, or whether an oven is required to polymerise the coating. This problem must have presented itself to many modellers and horologists.

## Brown & Sharp Dividing Heads

### From Dave Sobel, Closter, New Jersey

With reference to the letter (Issue 67) from Dr. G. Walsh, the standard ratio for Brown & Sharp dividing heads was 1:40. I have four old catalogues from 1910 and they are all the same. I think his dividing head was rebuilt at some time as the spindles were bored to No. 9 Brown & Sharp taper, threaded 2in. x 6 tpi. The worm plates always had 24 holes as this number is divisible by 2, 4, 6, 8 and 12, whereas 20 is only divisible by 2, 4, 5 and 10.

Speaking of oddities, many years ago I purchased at a sale at Litton Industries a bench micrometer thimble, 4in. diameter, graduated to 360, left hand thread. Every turn covers $^1/_{16}$in. If anyone can tell me the purpose, I would be very glad.

## Headstock dividing

### From Ted Wale, Porters Lake, Nova Scotia

In Issue 67 of M.E.W. there is an interesting article by Raymond McMahon on adding a direct dividing attachment to a Myford dividing head. I agree with him on the usefulness of this facility but the thing that I cannot understand is why lathe manufacturers do not make this a standard feature of every one that they design.

For the lathe designer this is an easy thing to do. Virtually all lathes have a bull wheel ( as it is often called). This is the large narrow gear immediately inside the bearing next to the nose spindle. It is used to accommodate the drive peg which applies the drive to the nose spindle in normal gear and the same drive peg is withdrawn when back gear is used. There is nothing to prevent the drilling of holes on the circumference of this wheel and providing a simple locating indent. Even my old Atlas lathe has this facility and it has been very useful over the years except that the indent is a poor cheap design and requires an elastic band to make it work properly.

For those of us who already have a lathe without this facility, rather than making an adapter to go onto the dividing head, which is itself another piece of equipment to add to the lathe for special work, I suggest that a jig be made to hold a portable drill and, with the aid of the dividing head, that suitable blind holes be drilled in the bull wheel with a centre drill. Once this is done the lathe is immediately ready at any time to do the direct dividing job.

The obvious number of holes is 60 (or even 120 if the lathe is large enough) as this number allows for whole numbers of degrees to be indexed. However it is often not realised that this number allows for many other divisions as 12 is a factor of 60 and 12 is a very versatile number itself. I won't go into all the applications but one example suffices. To divide a circle into 5 just count round in twelves($5 \times 12 = 60$). The factors of 60 are 2, 2, 3, 5, which in various combinations give many possible divisions of a circular piece.

Come on, lathe manufacturers, think about this.

Turning now to Peter Dawes letter in Scribe a Line and the centre drills with the concave taper, these are still available. I buy them when needed, our supplier here in Canada being Doall Tools Ltd 10 Meridian Road, Rexdale, Ontario, M9W 2Z8, Telephone #1-800-923-6255. The centre drill type concerned is Style D400R and is shown on Page B44 of their catalogue. There surely is an agent for Doall in Australia.

## The Urwick triangular key

### From Brian Padgett, Clifton, Bedford

I was fascinated to read David Machin's article in Issue 67 of his re-discovery of the triangular key method for accurate angular location of a sliding sleeve on a circular column, invented by the late David Urwick.

I visited David at his home near Taunton in the early 1980s, before he died and he demonstrated this keyway on his Universal lathe which combined the functions of a lathe, milling machine and boring machine in one piece of equipment. The lathe tailstock was mounted on a cantilever from the top of of a vertical circular column, whilst the bed of the lathe carrying the carriage and toolpost were cantilevered from a sleeve on the vertical column in which the vee shaped keyway was used for precise alignment of the head with the tailstock. In this way he had created a lathe with adjustable centre height - an extremely valuable feature which I have never seen repeated.

He had licensed the idea to a manufacturer several years before and it was incorporated in the 'Labourmill' which was used in some workshops aboard ships, but I don't believe that he ever received any royalties for this. His Universal lathe was covered in Model Engineer many years ago.

A feature of the locking screw which tightens the vee key in position in its slot, as demonstrated to me by David Urwick, was the force multiplication which could be obtained by using a 45 deg. (or less) angle key, since the key could be locked by only light finger pressure on the wing bolt which he used. I suspect that David Machin has sacrificed some of this advantage by using a 60 deg. vee on his Dore Westbury column.

Incidentally, David Urwick, who lived in Malta for many years before moving to Taunton, developed over a dozen small Stirling engines which were in different configurations, and I remember his articles on them in M. E. He believed that the secret for performance lay in the effectiveness of the recuperator. I wonder if James Rizzo, also of Malta, owes anything to David's work?

## Radiused centre drills

### From Hans-Ulrich Dussel, Wuppertal, Germany

With regard to the letter from Peter Dawes, I might be able to supply a piece of helpful information. The centre drills Mr. Dawes is looking for are specified in Germany as 'Radius Centre Drills DIN 333 Form R' and I am sure they can also be found in some international standard. The current catalogues of both Sartorius and Hahn & Kolb both offer them in a variety of diameters as standard stock products. Although I do not know if Mr. Dawes has access to these suppliers, at least he will know what to ask for.

## An effective abrasive

### From B. Bach, Longfield, Kent

I would like to comment on two items in M.E.W. Nos. 66 and 67.

In No. 66 there is an article about a 'Wire Brush Substitute' and I would like to suggest another approach. I had to de-scale some angle iron, but the use of wire brushes proved ineffective. It was not possible to get into the corner using a grindstone and hand cleaning with abrasive was laborious. My solution was to use 'Garryflex' bonded rubber abrasive blocks which are available in four grades. I used the coarsest, 36 grit (wine coloured), the size being 80 x 50 x 20mm.

Using them by hand was again rather slow, but I cut discs from them, 50mm diameter, drilled a 6mm hole in the centre and put them on M6 screws. Used in an electric drill at about 2000 rpm, the very quickly removed rust and scale down to bare metal. Although they wore very rapidly, they are cheap and effective, but it is unfortunate that the makers do not supply them in larger sizes. For more delicate work, the finer grades could be used.

My second comment refers to the article by Philip Amos in Issue 67. He suggests the use of a bar held in the toolpost to provide some side support for a drill. The very next day after reading the article, I had the problem of re-positioning a wrongly drilled hole. It was only 2-3mm out of position and could be drilled larger. By holding the article in a 4-jaw chuck and using a steady bar, I was able to re-drill exactly where I wanted the hole. Thank you Philip!

# IN OUR NEXT ISSUE

## Coming up in Issue No. 70 will be

### A MACHINE TABLE WORK CLAMP

An aid to safe and accurate drilling described by Dyson Watkins

Devon reader Loris Goring relates some of the lessons learned from setting up a model engineering workshop

### A 'LIVE' CENTRE

Alan Aldrige offers a rotating centre with interchangeable ends

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*(Contents may be changed)*