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# MODEL ENGINEERS' WORKSHOP

THE PRACTICAL HOBBY MAGAZINE

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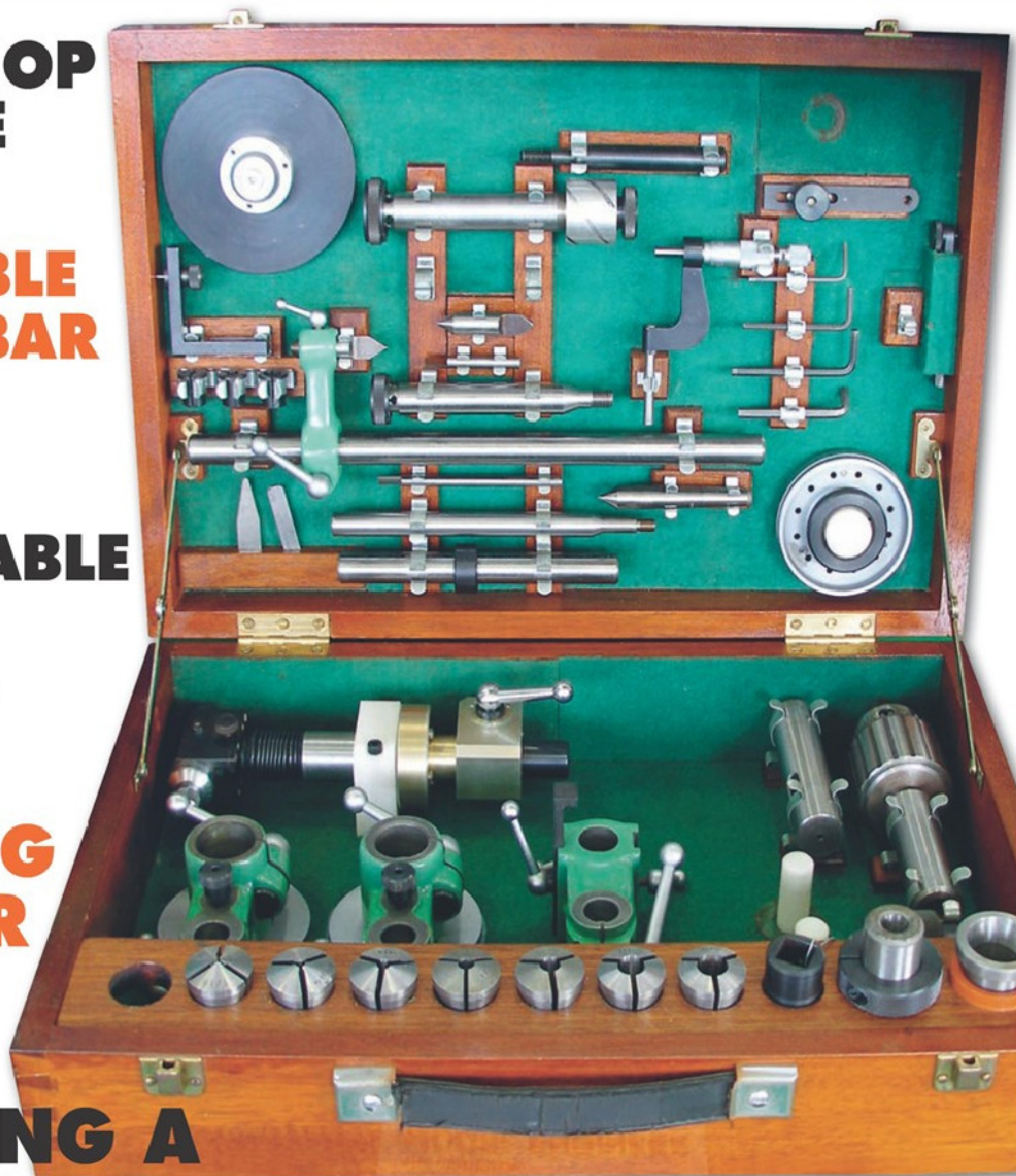
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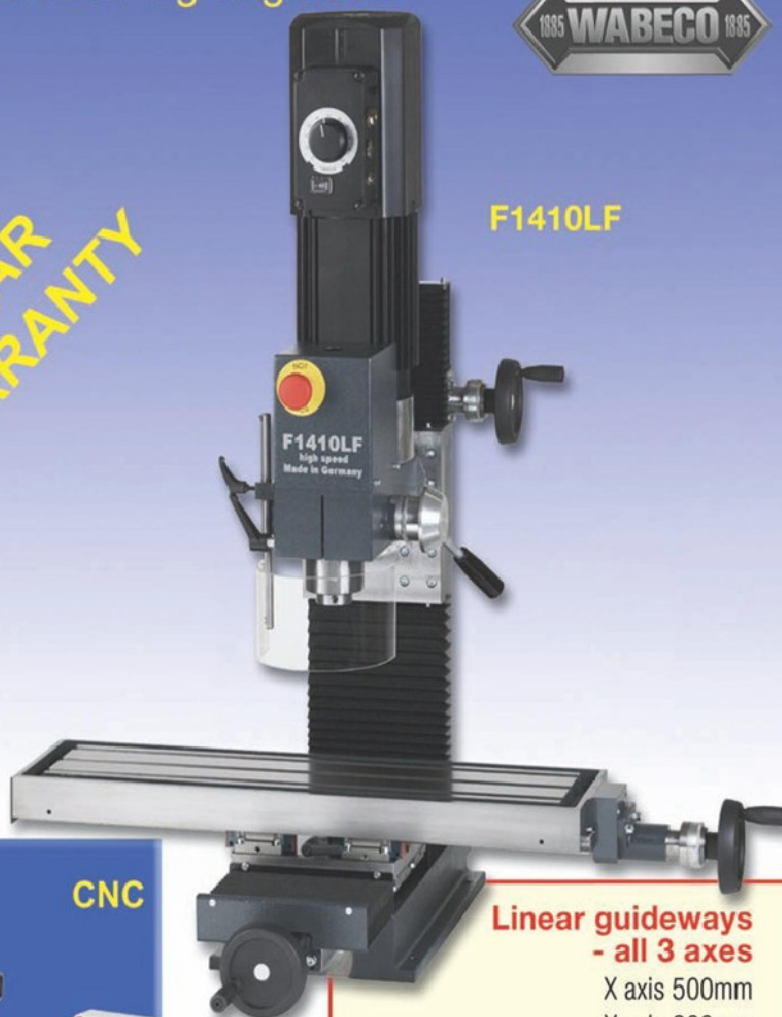


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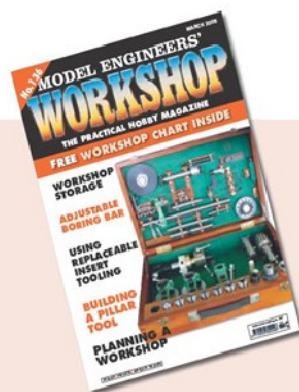
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### On the Cover

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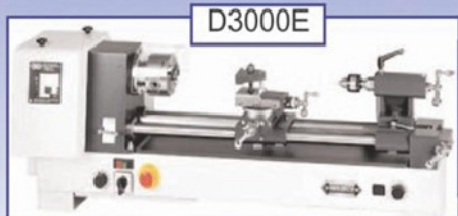
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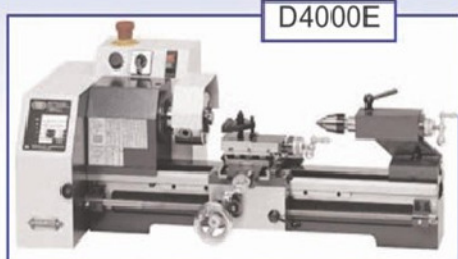
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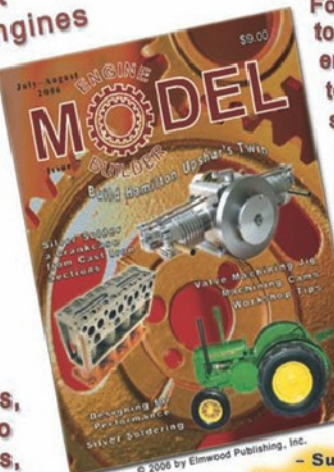
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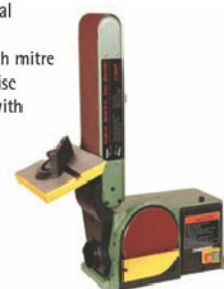
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David Clark

### Outrunner Electric Motors

There has been a very good positive response to this article. It is interesting that a totally different type of article finds a readership in MEW. It shows that a lot of readers are open to all sorts of different ideas and technology.

A couple of people have mentioned that they would like to know a bit more about how the controllers work. This is a bit outside the scope of MEW but I have printed a letter from John about using a servo tester for control rather than a radio control system. John has supplied a photo of the simple wiring of the ESC that I will put in the next issue of Scribe A Line and has also mentioned the use of batteries and why mains power units are not ideal. It is too late for this issue as the last thing that is done before going to print is 'On The Editor's Bench'. John has also agreed to write up his Mk2 CNC router and will take photos as construction takes place.

While thinking about this router, it occurred to me that you could use two or even three cutter heads to produce more than one component at a time. Obviously you would have a need for more than one of the same component. I believe there was a similar machine in industry years ago called a copy mill. It had three Bridgeport type heads and produced three identical components at the same time.

It is funny how thinking of one thing leads you to remember something from the past that is even more relevant to the future.

I also worked where they had big CNC mills for producing aerospace components. When I say big, the operator sat on the machine and went back and forth with the cutting heads and gantry. They produced lots of aluminium swarf. Several 50 gallon drums would be filled with swarf during every shift.

### New contributors

The response to my requests for new contributors has been tremendous. Several new contributors are already in print and several more have submitted articles that will be used in the near future. More contributors are still welcome. I am particularly short of articles on making specific small items of tooling. I have plenty of articles on dividing in the lathe and quite a few longer articles. Harold Hall still has more articles awaiting printing although by the August issue, Harold's filing box may be bare. This is one of

# ON THE EDITOR'S BENCH

the main reasons for requesting new contributors. Harold has single handedly written about ten pages in recent issues of MEW. I now am confident that we will have sufficient good material to fill the pages of MEW when Harold's articles have dried up.

I hope you will all give a warm welcome to David Piddington who has written a two part article about workshop organization. David has written for both Model Engineer and Engineering In Miniature in the past as well as designing tooling and locomotives. I hope to publish further contributions from David in the future.

### The Practical Engineer

The next issue sees the start of a new series called 'The Practical Engineer' I have not written the first article yet but now I have mentioned it in these pages, I will have to get on and do it. The first article will be about speeds and feeds and a quick rule of thumb to set a reasonable speed for the job in hand whether it is a milling cutter or a piece of metal in the lathe.

When I first got the Editor's position, I sat down and thought of ideas for articles. I managed to fill 3 pages of A4, one idea to a line so I doubt I will ever run out of ideas.

### Wind Farms

I know this may not be strictly of interest to MEW readers but I went to the nearest main shopping centre (Inverness) last Saturday, a round trip of 240 miles. Halfway there, the police pulled us over to one side of the road. They told the traffic queue that there was a wide load passing through and the holdup would not be for too long.

About 5 minutes later, two lorries passed with wind farm towers on them. I say on them but they were actually mounted between the lorry and the trailer. They appeared to be bolted on at the front and the back with no support underneath at all. They were huge and also quite long. I think they were half towers on each rather than a whole tower. Unfortunately I had left my camera on the computer desk as I had the battery on charge. It makes me wonder about the problems of machining something that large compared to the small items in our home workshops.

### Machining complicated components

I started out machining industrial sewing machine components, which as you can imagine were tiny. I have done larger components in the past up to about 4 metres long and also complicated components that take hours of CNC machining time. I have worked with engineers who could not get their head around a complicated drawing but the simple way to do this is to treat each component as a series of individual steps. A flat surface, a drilled hole, a turned diameter

etc. Break it down into steps and it becomes relatively easy. The more machining problems you solve, the easier you will find it is to solve further problems as they arise.

### British Seagull outboard motors

Expensive machinery does not necessarily mean a better component is produced. I remember many years ago, we were given a pair of castings for a two stroke crankcase for the new (then) British Seagull 170 outboard engine. We were asked to produce a finished crankcase in case the other suppliers could not produce the ones they were asked to do in the required time.

To cut a long story short, we produced a working crankcase that looked good as well by using knife and fork methods. The other company (who were a household name in the motorcycle industry) installed a brand new CNC machining centre to make these components and proceeded to make crankcases covered in four jaw chuck marks. These were rejected and our crankcase was built into a finished engine and was exhibited at the January boat show.

We later got the contract to produce the crankcases in large batches and ended up producing three different sizes of crankcases, the gearboxes, three sizes of cylinder heads, casing tubes, and lots of other bits. We did turn down the cylinder manufacturing contract. If you had seen the cast iron dust in the original cylinder machining shop, you would know why it was turned down. Perhaps I will continue this next month.

### Dates for your diary

**The 16mm Association National Garden Railway Show** will be at Stoneleigh Park, Warwickshire near Birmingham on Saturday 29th of March 2008. There will be lots of narrow gauge layouts on display, over 60 traders are expected and over 2000 people are expected to attend. [www.16mm.org.uk](http://www.16mm.org.uk)

**Myford Ltd** are holding their annual spring show on Thursday 17th April 2008 9am - 5pm, Friday 18th April 2008 9am - 5pm and Saturday 19th April 2008 9am - 4pm. Please see Trade Counter for more information.

**Large Scale Model Rail Exhibition** Saturday 12th and Sunday 13th April 2008 at the Warwickshire Exhibition Centre, Nr Leamington Spa on the Junction of the A425/B4455. For more details on entry to the show visit [www.largescalemodelrail.co.uk](http://www.largescalemodelrail.co.uk) or call 01926 614101. Opening Times are 10.00am - 5pm daily with last admission at 4pm.

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# THE METALWORKERS WORKSHOP 10

## Harold Hall introduces the Milling Machine, part 1

**U**nlike the lathe where the only major differences are size, quality and price, milling machines are much more variable in terms of design. The major difference is in the orientation of the cutter's spindle, vertical or horizontal. The vertical machine has similarities with a drilling machine and uses cutters called end mills, not that different to a twist drill but despite their name, 'end mills', they cut predominantly on their side. Horizontal mills use cutters called 'side and face cutters' being rather like a very substantial circular saw blade. **Photo 1** shows end mills on the left, a side and face cutter in the centre and on the right are examples of slot drills. Side and face cutters are mostly much wider than the one shown.

When it comes to choosing which type of machine to equip the workshop with, there really is only one answer, a vertical mill as for almost all milling operations, the vertical mill is by far the best option. With that decision having been made for you there are many versions of the vertical mill and the choice is far from easy. However, when it comes to how they are used, this will be virtually the same no matter which one is chosen and will be much simpler than the wide range of tasks undertaken on a lathe.



**Photo 2** A very well equipped Turret Mill from Warco. This is the VMC and is shown fitted with the optional digital readout and power feeds. The table size is 152 x 660mm.



**Photo 1** End mills, a side and face cutter and slot drills.

### Turret mills

At the top end of the range are the turret mills, **photo 2**. These are primarily industrial machines but at the lower end of the size range, they may fit into the home workshop budget for some. Their main feature, and a distinct advantage over others, is that the three axis, X, Y and Z, see **Sk. 1**, are all provided by means of dovetail slides moving the table. In non-technical terms this is left/right, towards/away and up/down. The part of the machine that provides the up/down movement (Z) is often referred to as the knee.

The head is similar to that of a drilling machine but built to a much higher standard and with a calibrated vertical quill feed and when added to the up/down table movement provides a wide range of cutter to table dimensions enabling tool changes without losing position. This will be discussed later in relation to the mill drill. In addition, the fine down feed can be

disabled and they can then be lever operated enabling drilling operations to be carried out. A major advantage of using the machine for drilling is that hole centres can be very accurately set without the need for marking out but by reference to the table's X and Y micrometer dials. Whilst at the more expensive end of home workshop mills, they are not necessarily the machines with the largest capacity. Some mill/drills have larger tables and traverse. Changing speed will either be by belt, gears, or by electronic control.

### Mill/Drills

The other machines are those where the table provides only the X and Y axis whilst the Z axis is provided by moving the head up and down and the spindle up and down within the head.

There is considerable variation in these machines but probably the most common are the so called mill/drills, **photo 3**. These have a head almost the equal of a drilling machine head but more robust and with a calibrated down feed in addition to the lever feed for drilling. A provision for locking the down feed in place whilst a cut is being taken is also provided. The head is mounted on a round column on which it moves up and down to provide the main adjustment for the distance between the head and table. On most there is no calibration on this provision and it is used only to roughly position the head with final positioning of the cutter being by means of the spindle's fine feed within the head. Whilst this works well for most tasks, it has one major weakness that may occasionally cause a problem.

For ease of explanation I will take the simple example of drilling a large hole. If attempting to drill a large hole but first using a short centre drill to establish its position, it will be found necessary to raise the head to fit the much longer drill. With the column being round, it is likely that the head will rotate a little on the column as it is raised. If this happens the drill will not align with the pre drilled centre. Similarly,



**Photo 3** The 'Eagle 25' Mill/Drill from Chester UK Ltd. This has a table size of 190 x 585mm.



if attempting to machine a complex part accurately at different levels relative to each other then any loss of position will make the process more difficult. Fortunately, for the vast majority of applications this problem will not exist, particularly if care is taken to avoid it by starting with the most suitable table to tool distance.

Within limits, the ability to rotate the head on the round column can be a benefit, as it will enable the cutter to reach parts of the table that would not be available with a fixed head. Again this will be an infrequent situation so is not a major consideration.

A variation on the original mill/drill format is to replace the round column with a dovetail slide so that register is maintained as the head is raised and lowered. Because of this, the up/down feed may be calibrated but often this is not done, the movement of the spindle within the head still providing this essential feature.

Like the turret mills, the mill/drills and their variants may have belt, geared or electronic speed control.

### Common Features Speed control

As already commented on, speed control can be provided by belt change, geared head, or electronic control. Machines using belts will be amongst the cheapest but the task of changing the position of the belts on the pulleys can be an unwelcome task prompting one to work at a less than ideal speed. Geared heads on the other hand provide simple and very quick speed change, whilst the drive is stationary of course, but are more expensive and can be noisy. Electronic control has advantages and disadvantages but as this is common to all machines, it was covered as a general subject in MEW 132, page 14.

### Speed ranges

Speed requirements follow the usual pattern, small cutters at high speed and large cutters at low speed. Unfortunately, having made your decision regarding the size and type of the machine for your workshop, there will not be a lot of scope for choosing the speeds you require. Even so, the speed ranges on most milling machines are reasonably adequate, certainly more so than is the situation with the lathe.

Whilst most work carried out on a milling machine, typically surfacing and making rebates, can all be carried out with the same size end mill, say 16mm, there will be times when smaller cutters will have to be used. This is most likely when slots, enclosed or otherwise, are being made. If these are small, say 3mm, then a speed in the order of 2000 rpm plus should be sought.

Using a 20mm end mill on steel a speed of 300 rpm would be ideal. However, it will be intermittent cuts using say a 50mm face cutter on cast iron that will demand lower speeds. For this, speeds as low as 100 rpm would be beneficial but at these speeds, robustness of the machine is an important factor.

As a very rough rule of thumb I would advise a speed range of 100 to 2000 rpm for a typical mill/drill. If you are limited to one of the lighter weight machines then a minimum speed of say 300 to 400 rpm should suffice as it will not be



**Photo 4** A digital display has been added to a mill/drill's down feed.

expected to carry out heavy-duty tasks. Small diameters will still be likely, perhaps more so, so the top speed of 2000 rpm is still preferable.

If you consider a machine with electronic control that quotes a speed range of say 0 - 2000 rpm, do be suspicious of the zero figure. It just maybe able, although I have my doubts, to run at a few rpm but at that speed, power available will be equally low and unable to do any useful work. Do ask at what minimum speed it will be able to function satisfactorily. It is often at the lower speeds where the most demands are placed on the machine.



**Photo 5** As Y axis stops are rarely available on machines as purchased, shop made stops, as those in the photograph are the only option.

### Rotating head

Some machines have the facility to rotate the head, that is clockwise/anticlockwise as you view the machine from the front, enabling the cutter to approach the table at an angle but just how useful this will be will depend on the machine's intended use. Even so, I suspect that even if available, for most it will rarely if ever be used, so is far from an essential provision. Having angled the head, getting it accurately back to the normal working position would be a similar problem to that described for setting a drilling machine tilting table. This alone would be a deterrent from using the head at an angle unless there was no other option.

### Calibrated X, Y and Z feeds

All three axes will have calibrated micrometer dials enabling the amount of feed to be accurately set. Early machines, and maybe still some at the economy end of the price range had fixed dials. With this, having made a cut, measured the result and determined the amount still needing to be removed, some mental arithmetic will be necessary to determine the dial reading required to achieve that depth of cut. If however the dial can be zeroed, it will be a case of zero the dial and then set on the depth of cut required. This is a highly desirable feature for the machine to possess.

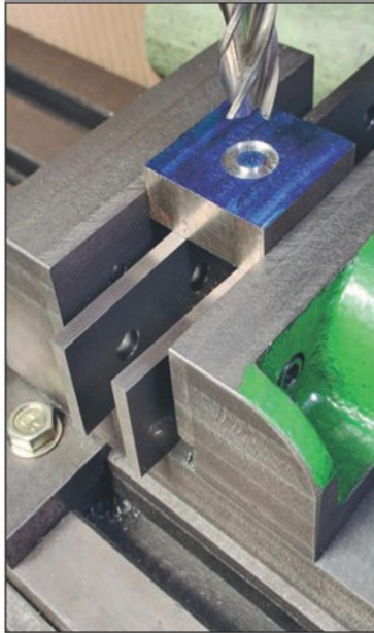
### Digital readouts

These are sometimes fitted for use in addition to the micrometer dials but the provision is presently only available on the more expensive and mostly industrial machines. Even here, it is frequently an option rather than a standard fitment. Equipment for adding this facility to existing machines is widely available but as there is no standard as far as machine design, there is therefore no standard method of fitting these. Because of this,



**Photo 6** Indexable milling cutters with round, diamond and triangular tips.





**Photo 7** This photo shows that it is impossible to plunge the normal end mill due to it not cutting to the cutters centre.

you will need to determine your own method should you decide to add them yourself. **Photo 4** shows one fitted to the down feed on a Mill/Drill. This was fitted because vibration caused the poorly balanced operating handle, and therefore the micrometer dial to rotate whilst a cut was being taken, making it difficult to place on another cut with any degree of certainty.

#### Traverse stops

These are very useful where an operation has to be carried out repeatedly over a given range, either on a single component or for batch production. A typical example being the need to machine a slot with closed ends that will

need the table to be traversed over the same distance each time the cutter is dropped deeper into the slot being made. Setting the table stops will make this operation so much easier than relying on reading the micrometer dials to establish the end positions at each pass.

These stops do appear to be standard on the average size Mill/Drill and larger but not on the smaller machines, which is a pity. Table stops for the Y axis are not normally provided, even on the more expensive machines. However, having to mill an enclosed recess to a depth of around 12mm I decided to fit Y axis stops of my own design as **photo 5** shows. Whilst useful, this gets far less use than the X axis stops, a provision that I consider to be all but essential. The photograph also shows the right hand X axis stop and the stop bar against which it contacts to stop the table.

Down feed (Z) stops are useful, typically when drilling blind holes to a given depth and like X axis stops these appear not to be included on most of the smaller machines but are standard from the average size mill/drill upwards. **Photo 4** shows a typical example to the right of the digital readout.

#### Power feed

This is another feature, limited to the X axis except for some very expensive machines, but even on the X axis it is still an extra in most cases and whilst far from an essential requirement it is a nice provision if you do a lot of work surfacing large areas. Be warned, the cost of one will be in the region of 1/3rd the cost of the complete mill. Also, if attempting to fit one to an existing machine, you may need to carry out some minor modifications to make this possible.

#### Drawbar

Unlike the drilling machine where the pressure on the end of the drill is attempting to push the taper of the chuck into its mating taper, this is not the case with a milling cutter chuck. As mentioned

previously, end mills cut mainly on their side and as a result, the spiral cutting edge attempts to draw the chuck from its taper. The intermittent cutting action also causes some vibration, which together with the spiral effect may remove the chuck from its socket, doing this with potentially serious results. To avoid this, the end of the chuck's taper is threaded into which a threaded bar is placed. This passes completely through the spindle and is tightened at the top so as to secure the chuck against the problem.

There are a number of standard thread sizes used, mainly metric on metric machines and imperial threads on imperial machines and as it tends to be linked to the size of the taper, there is not normally a problem. However, if you have a metric machine but decide to purchase an imperial cutter chuck to use with existing cutters, you may find the Morse taper will have an imperial thread. Fortunately, all is not lost, as the drawbar is removable and an imperial threaded bar can easily be made and fitted. Just one problem may exist with a larger machine, that is, they can be quite long and there may be insufficient headroom to allow the drawbar to be interchanged easily.

The attempt to withdraw the chuck from its taper due to the helix angle of the cutter's cutting edge will also attempt to draw the cutter from the chuck. This situation will be discussed later.

#### The spindle taper

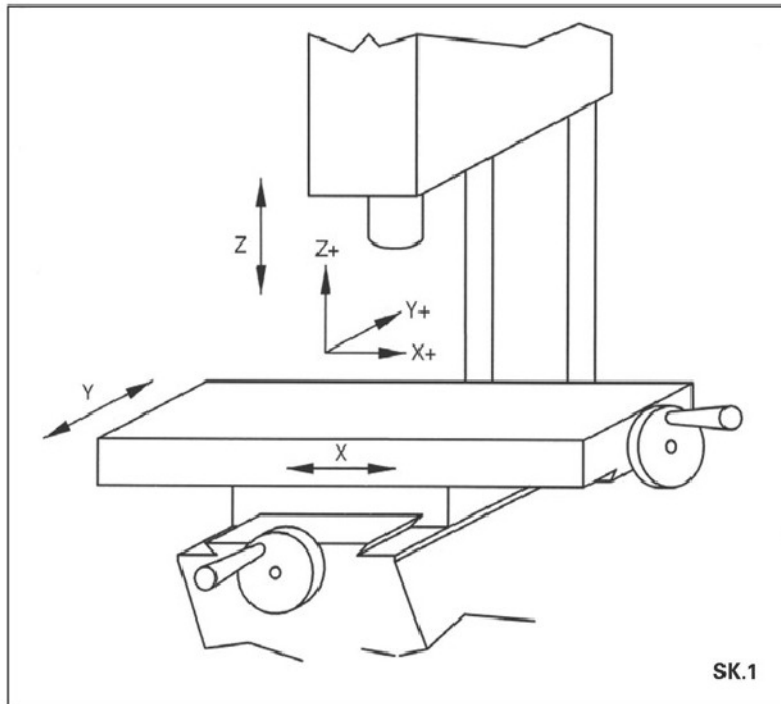
Whilst at one time there were other tapers in addition to the Morse tapers, these have all but been relegated to history, though you may come across them if you purchase an old second hand machine. Even here I think this mainly applied to tapers on lathes. Tapers have therefore become standardized on Morse tapers and a modern taper known as an R8 taper, though others are used on the larger industrial machines.

The R8 taper was mainly used on industrial machines but can now be found in larger size machines in the home



**Photo 8** Mini mills are can be plunged and are primarily used for milling closed end slots and open-ended grooves.





workshop. Whilst over the years Morse tapers have been made in a large number of sizes, just three are likely to be found in the home workshop, sizes two and three mostly but occasionally size one. The R8 taper is a single size device and is quite large, hence the reason for it only appearing on larger machines. See photo 22, MEW 134, page 13.

### Horizontal/Vertical attachments

These are available for a small number of industrial machines enabling say a vertical machine to be converted into a horizontal machine, and similarly, a horizontal machine into a vertical machine. A few very small industrial milling machines made in the past, but still relatively common second hand, did have this provision but other than that are unlikely to be found in the average home workshop.

### Accessories

Having obtained your milling machine, there are still wide ranges of accessories that can be added to it, a few being essential. Topping the list of essentials will be two items, the cutters and equally essential a chuck designed to hold these, as the drill chuck supplied with many mill/drills just will not do!

### The cutters

In very simple terms, cutters come in two types, those that include a shank by which they are held and others that are disk shaped and are held using the central hole.

### Cutters having shanks

These come in a very wide range of types and sizes but at the non-working end, the shank there are only three common types. Dealing first with the least common, there are those cutters that mount directly into the machine's taper, Morse or R8. These are not solid high-speed steel or carbide but cutters having a normal steel shank, maybe hardened, and with removable tips.

One piece solid cutters come with one of two parallel shank forms, plain shank or possibly with a flat for the use of a holding screw, or a threaded end. The thread is the same diameter as the shank and has a 20 threads per inch Whitworth form thread, even on metric size cutters. The benefits and disadvantages of these forms will be discussed later. Both types can be seen in photo 1.

### Indexable cutters

The removable tip cutters have tips that can be replaced when those fitted become blunt. The holders can only accept one particular size and shape of tip but can be fitted with tips made from different material grades and minor changes in detail, such as the radius between cutting edges. However, in the home workshop, a general-purpose tip will suit and will be the one supplied with the holder when purchased.

In most cases, each tip will have three of four cutting edges that can be moved to the next cutting position as the amount of use dictates and before a completely new tip is fitted. A few are fitted with round tips that can be rotated. Photo 6 shows some parallel shank cutters that I have myself permanently fitted into Morse taper shanks. Whilst shop made, they are essentially the same as those available commercially. Some have just two tips but versions having three or four are made in the larger sizes. A few smaller sizes, maybe with just a single tip, have parallel shanks for holding in a chuck.

Invariably the helix angle at the cutting edge is less than on the solid high-speed steel end mills, even negative on some. For a given diameter, this results in a greater load on the machine using it, as it tends to scrape the metal away rather than cut it. They are not therefore ideal for use on lightweight machines such as those smaller than the average mill/drill. They are particularly suitable for machining iron castings as they are less affected by the hard spots that may occur.

### Solid cutters

One piece cutters are most frequently made of high speed steel, but cutters made of carbide are also available. The latter are confined largely to industrial use. There are just two common forms of cutter as shown in photo 1, end mills (left) and slot drills (right and rear). The end mill is a general purpose cutter able to surface horizontal and vertical surfaces, machine steps and open ended grooves.

Close examination of the end of the end mill shows that the four cutting edges do not go to the centre, as there is a cavity in the middle. Because of this, the cutter cannot be plunged into a surface, as it will not cut to the centre as photo 7 illustrates. Because of this, when a closed end slot is required, a slot drill is used. This has one short edge and one long cutting edge that passes through the centre, enabling it to be plunged. This makes it possible to machine enclosed slots. Having made that point, a few end mills are now being made without the cavity and can therefore be plunged. Whether this will eventually become the standard only time will tell. They will however be more difficult to sharpen than those with the end cavity.

Photo 8 shows some smaller end mills with three cutting edges that are known as mini, or throw away, mills, throw away due to it not being intended that they should be sharpened. They can be plunged with their main purpose being to machine open-ended grooves and closed end slots. They are made with either a 6mm or  $\frac{1}{4}$ in. diameter shank and minimum sizes of 1.5mm- $\frac{1}{16}$ in. Ideally you will need a very high speed to use the smaller sizes, preferably at least 3000 rpm.

### What size cutter

In theory, only one size of end mill will be required as they are not intended to cut at their full width except maybe for very shallow surfacing. It is normal practice, not to exceed a width of cut of nominally  $\frac{1}{3}$ rd the cutter's diameter. Typically, this means 3mm using a 8mm diameter cutter or 5mm using a 16mm diameter cutter. To minimise the number of passes necessary to machine a given width, a larger diameter will obviously be beneficial. If therefore you have one of the smaller mills then two sizes of 8mm and 12mm would be a good starting point and for the average size mill/drill say 10mm and 16mm and if a large machine then 12mm and 20mm.

For me, more important than the sizes, is the quantity of each size. Sharpening end mills and slot drills is without doubt the most demanding sharpening task to be undertaken in the average home workshop. It takes an appreciable amount of time to set up, no matter what the equipment is that is available for the task. Because of this, it is a good idea to have a quantity of each size so that sharpening operations can be delayed until there are sufficient cutters needing sharpening to warrant setting up for the task. With this in mind, I would suggest a minimum of three of each size used. This will still be appropriate even if you have to use a commercial firm for your end mill sharpening requirements.

The situation with slot drills is more complex as a single drill will suffice for just one width of slot. Slots are often used in combination with a screw passing





**Photo 9** The four types of milling cutter that should only be purchased as a need arises. These are, left to right, T slot cutter, ball nosed end mill, rounding end mill and dovetail cutter.

through it to enable adjustment of position of one part with another. On this basis, the screw sizes likely to be used will set the sizes of the slot drills to be obtained. If metric sizes of screw, say M5, M6, M8 and M10 then slot drills of 5mm, 6mm 8mm and 10mm would be required. However, you may choose to purchase as and when required. Even in this case I would still recommend purchasing two of each size. I am suggesting two rather than three as slot drills are likely to get much less use than the end mills.

### Preferred shank

Whilst shanks can be had plain or threaded, my overwhelming preference is for the threaded form and would suggest that you adopt this format also. The reasons for this will be discussed when holding methods are considered.

### Other types of cutter

Whilst the above will certainly satisfy virtually all your milling requirements there are a few others that will possibly be necessary, **photo 9** showing four of them. Left is a T slot cutter that should the need arise, there is no alternative means of machining them. Another operation not easily done by other means is the machining of dovetails where a special dovetail cutter (right) will be necessary. Having said that there are no other means for machining T slots and dovetails, they can quite easily be machined using a shaper and with simple cutters. However, shaping machines are rarely found in the home workshop these days.

Another form of cutter is that with a curved end known as a ball end, (centre left). These are sometimes called slot drills and in other cases end mills. Whether there is a difference I do not know as they both normally have just two flutes. Obviously they can be used for milling grooves with a rounded bottom but with

care no doubt, also a step with a fillet between the horizontal and vertical surfaces. They are used in industry for machining complex surfaces using computer controlled machines.

Finally, as far as the home workshop is concerned, there are the rounding end mills (right of centre). These are used for producing an external radius between vertical and horizontal surfaces. However, as the need for these four types of cutter cannot be predicted, then it is a case of purchasing them as the need arises.

Like many items in the workshop, there are very many variations available, cutters being no exception. However, the cutters described above will be sufficient in all but the most exceptional cases, others being solely for use in the industrial world.

### Disk type cutters

These are primarily intended for use on horizontal milling machines but in the smaller sizes, they are perfectly at home on the vertical mill providing a suitable adapter is available. The adapter can either be one having a Morse or R8 taper for direct fitting or for smaller sizes, one with a parallel shank for use with the cutter chuck, **photo 10**.

Cutters of this type likely to find a use are limited with only two being common. These are slitting saws (left) and gear cutters (right).

Slitting saws come in two forms. Smaller sizes are flat with no set on their teeth and come in two pitches, fine and coarse. Fine being about a 3mm pitch and coarse about 8mm. They are made in a wide range of diameters and thicknesses but only two bore sizes are common,  $\frac{1}{2}$ in. and 1in. This limits the number of holding mandrels required. Heavy-duty slitting saws come in the form of a side and face cutter as seen in **photo 1**.

Gear cutters are likely to find a use in at least some home workshops though

probably not to the same extent as slitting saws. Unfortunately, even for a single gear tooth size, DP or MOD, the shape of the tooth varies depending on the number of teeth on the gear. In theory therefore, there is a different tooth shape for every number of teeth. However, as the difference is very small a compromise shape is adopted so that each cutter will cover a range as follows.

| Cutter Number | Number of Teeth Cut |         |
|---------------|---------------------|---------|
|               | Minimum             | Maximum |
| 1             | 135                 | Rack    |
| 2             | 55                  | 134     |
| 3             | 35                  | 54      |
| 4             | 26                  | 34      |
| 5             | 21                  | 25      |
| 6             | 17                  | 20      |
| 7             | 14                  | 16      |
| 8             | 12                  | 13      |
| 9             | 10                  | 11      |

The cutters are not sold in sets so it is possible to purchase them individually to meet your requirements. These are definitely only to be purchased as a need surfaces.

### Holding cutters

Apart from those that have their own taper shank, cutters will need some additional means to hold them in the machine and having the correct equipment for this is vital. Above, it was explained how the cutter's helix can attempt to draw it from its mating taper and, as a result, a draw bar is necessary. In the same way, the helix can attempt to draw a parallel shank cutter from the chuck holding it. Because of this, it is essential that the cutter be held in a suitable holder, as a drill chuck will most certainly not do.

Two methods of holding the cutters are employed, a simple holder or a collet chuck. The disadvantage of the holder is that it will only hold a single shank size and so typically four will be required, that is 6mm, 10mm, 12mm and 16mm, or imperial equivalents. With collet chucks now being more reasonably priced than in the past, purchasing four holders is hardly worthwhile.

Cutters come with either a plain shank (maybe with a flat for a screw if held in a holder) or with a threaded end. Whilst



**Photo 10** Disk type cutters mounted on adapters to enable them to be used on a vertical machine.





**Photo 11** An ER collet chuck with a Morse taper mount.

there are chucks specific for each type, the threaded shank cutters can be used in the chucks intended for plain shanks but if you do that you lose the benefit that the threaded shank provides. Starting then first with the threaded shank system.

The collets used in this case have a thread in the base to accept the thread on the shank but have a through hole so that the centre impression on the end of the cutter can engage with a centre point in the base of the chuck. This ensures that the end is central in the chuck body though there is another more important aspect of this provision.

The tapered end of the collet used in this system has a large angle and because of this is unable to convert efficiently the turning force of the closing ring into a sufficient gripping force. However, if when taking a cut the cutter rotates a little in the collet it will not screw the cutter further into the chuck in view of it already being firmly in contact with the centre point in the base. The result therefore is to jack the collet forward into its closing ring increasing the grip of the cutter. This alone will not prevent the cutter from rotating further as the increased friction between cutter and centre point, and more importantly, between the thread on the cutter and the thread in the collet all contribute to the cutter not turning further.

With this method, the axial position of the cutter cannot change whatever load is placed onto it, as it will always remain firmly against the centre in the base. This is the major advantage with this type of milling cutter chuck and is the reason for its popularity. If wishing to use mini mills for machining narrow width slots, as these do not have a threaded shank, an adapter must be made or purchased for use with this type of chuck. A major advantage of this form of chuck is that they do not need a spanner to tighten them. Finger tight is sufficient though a spanner may be required to undo them after use if a heavy cut has been taken.

For a collet solely to grip the cutter, it must have a small internal angle to convert the rotation of the closing ring into a grip sufficient to hold the cutter. Collets that meet these requirements have over

recent years become more readily available and have to a small extent diminished the advantage of the collets above. Even so, they do not have the absolute certainty that the system using threaded shanks has.

Whilst there are a number of plain collets that meet this requirement, the ER range is now by far the most prominent but is not solely intended for holding cutters. Because of this they were discussed in detail in MEW 134, page 14, where they were considered in terms of their use on the lathe.

When using this form of chuck, **photo 11** to hold a cutter, it is essential that it is fully tightened else the cutter will gradually work out of the collet as it is traversed along the workpiece causing the cut to deepen. Anyone who has attempted to use a drill chuck will almost certainly have experienced this situation.

Other forms of collet are the ones that fit directly into the machine's taper. Morse or R8 collets use the drawbar to pull the collet into the taper enabling it to grip the

cutter's shank. These, like the ER collets, may allow the cutter to be withdrawn if not fully tightened. They do have an advantage as with the cutter being held much closer to the machine's taper, the set up is more rigid than using a chuck that projects. This may allow a heavier cut to be taken but possibly more important, a better finish may result. They do also create a greater maximum cutter to table dimension that may on rare occasions be beneficial, especially on smaller machines.

Now having described the types available, my advice would be to obtain a milling cutter chuck that is made specifically for threaded shank cutters, as this will totally eliminate the possibility of the cutter being withdrawn from the collet as machining progresses.

### Boring head

For the want of a better place to include this device I have included it within the section of holders for cutters. Its major difference to other tool holders is that the position of the cutter within the holder is adjustable. This enables it to bore holes over a range of diameters and by adjusting the tool between passes, the diameter of the hole can be gradually increased until the size required is achieved.

The head has a fine feed with a calibrated dial for precise setting but as this has a limited range there are a number of positions that the tool can be fitted to suit the diameter to be bored.

**Photo 12** shows a typical version but a nice feature of this actual set is that it is supplied with both number 2 and 3 Morse tapers. As a result, it is suitable for both my milling machine and my lathe.

Boring heads are far from essential in the majority of workshops. Because of this, it is best left to see how the workshop's range of activities develops before a purchase is made. Should this become necessary, choice is not difficult as there is very little difference between the versions available.

With the machines and the required cutters and cutter holders having been discussed, in the next issue we will cover the very wide range of accessories available for use on the milling machine.



**Photo 12** A boring head with numbers 2 and 3 Morse taper shanks.



# The C3 Mini Lathe 4

Dave Fenner modifies the handwheels and makes a sub table for the vertical slide

In the previous article, I commented briefly on parting off and noted that I just do not attempt this with a conventional front mounted tool. It may be possible to add a rear toolpost to the Mini Lathe, or consider another approach, but that is an exercise for another day. For now I will continue to either saw off in the machine or remove the work to the bench vice or bandsaw. Sawing work off in the chuck carries the risk of damaging the bed with the saw blade, so a quick exercise is to make a guard/cover, which can be put in place to ensure that the saw does not contact the bed.

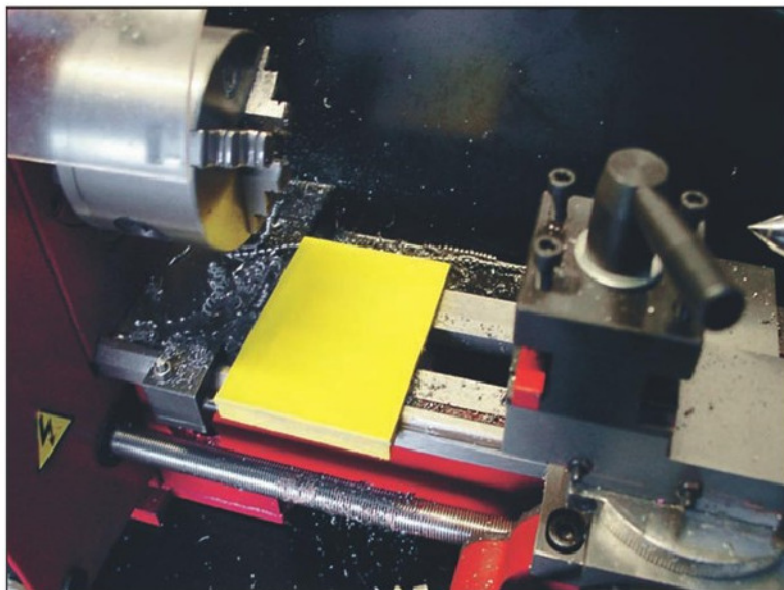
Various arrangements may be considered. I have chosen a simple assembly of three pieces of wood, cut, sanded and glued. Another eminently suitable alternative might be a piece of sheet metal, folded into a shallow "U". The machine bed measures about 83mm across, so aim to have a millimetre or so clearance. On width, I opted for about 75mm. and the finished gadget is shown in **photo 1**.

## Milling in the Lathe

For many purchasers, the C3 may represent the first significant foray into the world of the home metalworking workshop. It is therefore likely that while owners may also possess a small vertical bench drill, milling facilities are not yet to hand. It is not so many years ago that small mills were something of a rarity and pretty expensive; it was therefore commonplace to undertake small scale milling work in the lathe.



**Photo 2** The vertical slide for the C3 lathe as supplied by Arc Euro Trade.



**Photo 1** A bed protector made from MDF.

One of the accessories offered by Arc for use with the C3 is a Vertical Slide, which can be fitted in place of the tool post. The slide, **photo 2** carries clamping screws, which may be used for securing work, which can then be milled in the lathe. It might also be used as a variable height toolpost for turning work and in this guise could allow larger than normal turning tools to be employed. Before introducing work with this unit, I believe it will be useful to consider, in the first instance, a modification to the lathe, and in the second the construction of a simple accessory to use with the vertical slide. The modification will improve the accuracy and convenience when undertaking such work and consists of the addition of a graduated handwheel for the leadscrew. With one of these fitted, the halfnuts may be closed (change gears being disengaged) and the saddle moved along the bed with a high degree of precision. Arc supply chrome handwheels which may be used to upgrade the black plastic standard items, so the exercise has been executed using one of these for the leadscrew and then a further two to replace the plastic wheels on the tailstock and the apron. Converting fully to these chromed cast wheels gives a marked increase in the feel of quality when working with the machine.

## Modification

In standard form, the right hand end of the leadscrew terminates flush with the associated bearing so to accommodate the handwheel, an extension is required, the details being given in **Fig 1**. It is located in a hole drilled 8mm diameter, slightly more than 25mm deep, and is retained by Loctite. Adding the extension also presents the opportunity to provide a more sophisticated form of leadscrew end float adjustment. This is achieved by having two nuts running on an M12 x 1 thread.

## Nuts

It makes sense to have a nut or tapped part to use as a thread gauge when screwcutting. Having chosen M12 x 1 to give a fine degree of adjustment, the first part of the process is to make the nuts. Start by sawing off a couple of slices of 19mm AF hex bar, one about 9mm thick, the other about 13mm. Each is faced in the three-jaw chuck, **photo 3** then drilled through 11mm and tapped. As can be seen from **photo 4**, the tap was held in a tailstock chuck, and the machine run slowly in low gear, while the tailstock was pushed gently towards the work. The variable speed and reverse facility then made it easy to run back at higher speed saving a little time. **Figs 2a** and **2b** give the details of these parts

## Extension shaft

As I had pushed ahead with the project in advance of receiving the handwheel, one or two slight differences may be discerned between the drawing and the photo. Specifically, handwheels are supplied with a bore of 8mm diameter and it makes sense to work to this. The length varies a little between wheels; one should be selected and the shaft made to suit. The drawing shows 25mm at each end, and this should suffice.

A length of 12mm diameter free cutting mild steel bar is faced to a length of 70mm and centred at each end. With about 30mm protruding from the chuck, the first 8mm section is turned to a thou or so undersize, **photo 5**.

The second 8mm diameter is handled in a similar way and centred. The work is then chucked leaving perhaps 10mm clearance between the chuck and the 12mm section. This clearance will ease the screwcutting operation. (It may though be seen from **photo 6** that I handled the operations in a different order and so cut a relief groove for the threading tool to run





Photo 3 Facing the hexagon material.



Photo 4 Tapping a nut under power.



Photo 5 Turning the first section of the extension shaft.

into. It can also be seen that a 10mm diameter had been adopted in advance of examining the chrome handwheels). Here, added support for the work is given by the tailstock, again using the multi centre kit.

Setting up the change wheel train is straightforward; the details are as per the table given with the machine. There are two schools of thought on screwcutting. The first believes that the topslide should be swung round to half the thread angle so that the tool is fed in parallel to one flank of the thread and cuts only on one edge. As this would reduce the cutting load, it would be particularly applicable to lightweight machines such as the C3. When using this technique, it is important to remember that the overall amount of infeed will be increased due to the angle. For a metric thread of 1mm pitch, the depth of thread is 0.613mm, so feeding in at 30 degrees would increase this figure by a factor of  $1/\cos 30$  deg to 0.708mm.

The second line of thinking is probably held predominantly by those with a background in industrial machining. Here the top slide is left in its normal position, (presumably to save time) and feed movements made mainly radially with the cross slide, but with axial changes using the top slide. Because, for some of the time, the tool may be cutting on both edges, the loads on the machine are correspondingly higher. It may have been slightly unfair to choose this method on such a relatively small machine, but it passed with flying colours.

Here the variable speed and forward/reverse control proved a great advantage in that the cut could be taken slowly forward, then stopped as the tool moved into fresh air. The cross slide was then backed out to bring the tool clear of the job before switching to reverse and dialling up a higher speed to return. Note that after closing the half nuts to start the thread cutting process, they remain closed until completion. I took an initial series of cuts, feeding in 0.1mm each time and intermittently moving the topslide across by a similar amount. (It is possible to work with a combined feed of 0.1mm on the

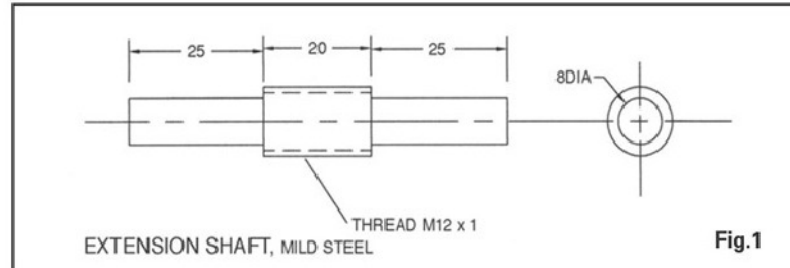


Fig.1

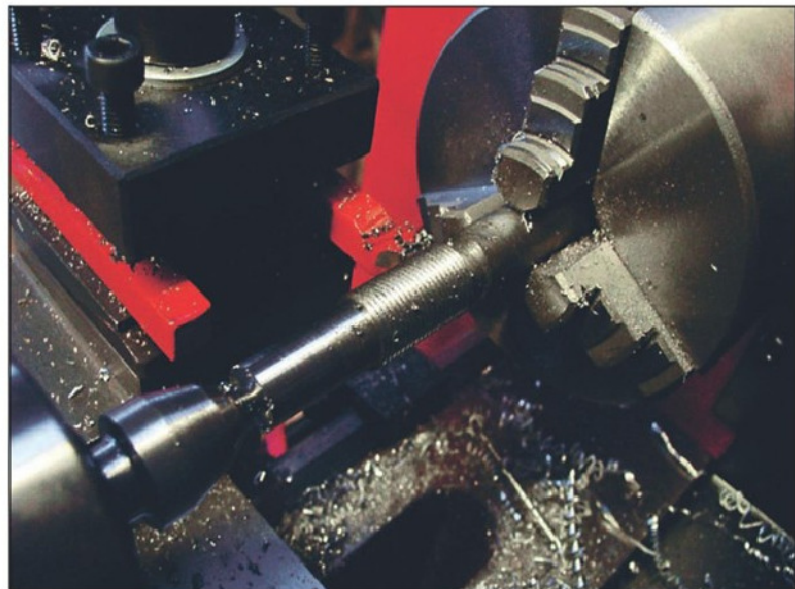


Photo 6 Screwcutting the shaft.

cross slide and 0.05mm – topslide which will give nearly the same effect as setting the topslide over to 30 degrees).

Once the radial infeed passed 0.5mm, the increment was reduced to 0.05mm and the size checked with a nut after each cut. This process was continued until it became possible to run the nut smoothly along the length of the thread. If you have a suitable thread chaser/file, then this can

be used in combination with the screwcutting process to give a bit of rounding to the thread crests.

### Leadscrew Handwheel

The 80mm dia. spoked chrome handwheels supplied by Arc (stock number 084- 14-00080) are ideal for this application and matching handles are also available. As noted above, these wheels may also be used as an "upgrade" for both the tailstock and apron to replace the standard plastic items. As supplied, these wheels feature a plain diameter of roughly 29mm by 16mm in length and this makes an ideal location for a graduated indexable micrometer dial collar. Three of these wheels were obtained together with M6 handles. This approach would allow a micrometer collar to be added to the tailstock wheel, and an "approximately" graduated wheel to the apron.

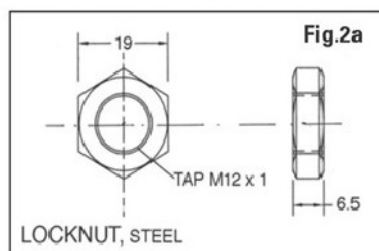


Fig.2a

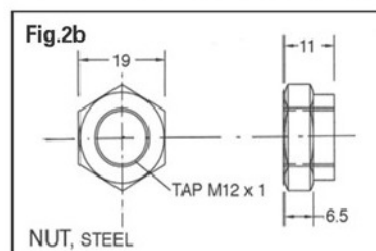


Fig.2b





**Photo 7** An extended centre drill reaches places others cannot.

For this first wheel, I chose to arrange a position for the retaining grub screw located axially between this plain diameter and the wheel rim. To do this required a bit of careful positioning and the use of an extended centre drill, as shown in **photo 7**, (A standard centre drill Loctited into an extension rod). It occurred to me later that the retaining screw may actually be positioned along the plain diameter, provided an access hole is drilled in the collar, to allow access for an Allen key to the clamping screw.

An indexable collar needs a bit of friction to ensure that it retains its setting but can still be moved without undue force. The first experiment used heavy grease between the collar and wheel and this simple approach may be suitable depending on the consistency of your



**Photo 10** The changewheel has been marked to indicate the teeth to be used.



**Photo 11** A vee tool has been mounted on its side to cut the divisions.



**Photo 8** The handwheel with a graduated collar and friction rivet.

chosen grease. The solution actually adopted employs a blind hole drilled radially, containing a small spring which pushes a shortened rivet outwards to contact the inner diameter of the collar. The parts are shown in **photo 8**. In the case of the leadscrew wheel, all of the components in contact rotate together, so the need for friction is not so great. Other methods of introducing the friction effect may include turning a groove in the wheel to accommodate either an O ring or short bent spring as on the existing cross slide and topslide dials.

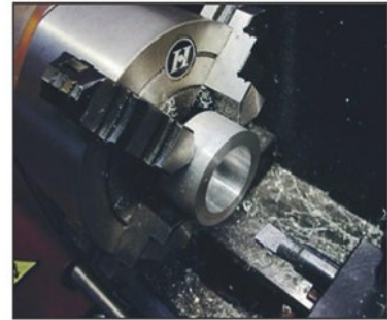
### Graduated collar

Before proceeding to make the collar **Fig 3**, first measure carefully the plain diameter of the new wheel. The three wheels used here showed a diameter variation of roughly a millimetre and about the same on length so collars are made to match each wheel. The aim is to have the collar slide easily over the wheel and be a few thou less in thickness than the length of the shoulder.

A slice of 38mm diameter aluminium was faced both ends, a millimetre or so over length, then drilled through 12mm. Using the wheel as a gauge, the interior was then bored out, **photo 9** to give an easy shake free fit. It was then measured for length and the amount to be machined off checked by reference to the handwheel. The work was then chucked with sufficient material protruding and squared up by pushing gently into the chuck with the tool.

*For those not familiar with this method of aligning blanks, first lightly grip the work in the chuck, and set the saddle stop so that the tool is a few thou clear of the job. Then with number one jaw horizontal and towards you, move the saddle up to the stop and wind in the topslide to contact the work then another 5 thou, gently pushing the work into the chuck. Back off, rotate the spindle to bring No2 jaw into position and again bring the saddle towards the chuck. Repeat for jaw 3, (and 4 if using a four jaw chuck). If at any of the stages, the tool did not contact the work, then advance the topslide a further 5 thou. and repeat the process.*

The work was then faced back to the



**Photo 9** Boring the collar.

required length.

To apply the graduations, the collar was held by its internal diameter in the three-jaw chuck and the headstock indexing device, featured in a previous article, was fitted, utilising the 60 tooth change wheel. The pitch of the leadscrew (on the metric machine) is 1.5mm, so I opted to apply fifteen divisions with longer markings at 0, 5 and 10. As a preliminary measure, white Tippex marking fluid was used to identify those teeth on the change wheel, which would be used, **photo 10**.

To cut the division marks, a vee tool was set in the tool post, but at 90 degrees to its normal position, **photo 11**. The saddle stop was set so that the tool travel would be checked partway along the work, fine adjustment then being made by the topslide.

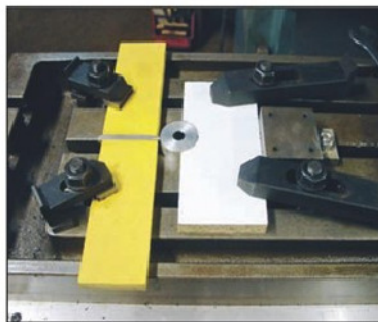
The three major long marks were tackled first. The spindle was rotated and latched into the first of the Tippexed major division teeth. The tool was moved in to contact the work, the saddle moved clear, the tool moved in five thou, then the saddle moved up to the stop to make the first cut. It was then moved clear and the tool advanced in a further five thou for a second bite, deepening the graduation. After the two other major divisions had been similarly completed, the topslide was wound back a few millimetres to give shorter lines for the other positions.

The final operation on this part was to add the stamped numerals. In the past I have applied number punches free hand with variable results. While there have been designs published for robust metal jigs, it is an operation which has not arisen sufficiently frequently for me to consider making such an accessory worthwhile. I therefore sought an easy method of aligning punch and work to give a reasonably tidy result. My number punches measure close to 0.250in, square in cross section, so three pieces of MDF glued together sufficed to make a punch guide, **photo 12** while the workpiece was successfully located in a semicircular recess sawn in a piece of chipboard. These two items were clamped down, **photo 13** to the table on a large mill, but the same



**Photo 12** Three pieces of MDF serve as a punch guide.





**Photo 13** The punch guide and work holder are clamped to a mill table.

system might equally be held down on a convenient bench. Just aim to have the punch axis aligned with the centre of the work. One minor point worth noting is that the number 'one' has less line length than the others and hence needs less "oomph" with the hammer.

### Leadscrew modification

First remove the leadscrew as described in the first of this series of articles, then all that is required is to drill the right hand end 8mm diameter by 25mm deep, so that the extension shaft may be inserted and retained with Loctite. To avoid the possibility of damage to the surface of the screw, I opted to grip the work using the ER32 collet chuck, **photo 14**. Again, this is an accessory available from Arc. A detail view of the particular collet and closing ring is given in **photo 15**. If you choose to use a conventional chuck, then protect the work by placing thin aluminium or copper between it and the jaws. Once the drilling work is completed, the extension shaft may be fitted. It was found that the Loctite trapped air in the cavity, which pushed the extension out. Placing the components in the lathe, **photo 16** and applying pressure with the tailstock overcame this.

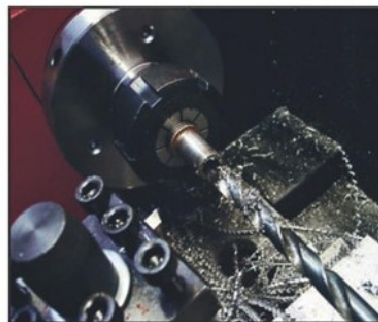
### Assembly

The leadscrew was refitted to the machine, then the two locknuts were added. These were then adjusted to give free rotation with minimal end float. The handwheel and collar were then added. A bracket was then made from 20g sheet steel on which the static fiducial line was marked by gently applying a junior hacksaw. As can be seen in **photo 17**, the cut lines have been filled (black on the aluminium, white on black painted steel). The paint used was the acrylic supplied in tubes for artists, smeared round with a finger, working into the grooves, then rubbed off after allowing to partially dry.

### Tailstock and apron handwheels

The exercise here was then substantially similar to that for the leadscrew, except for the following design points:

- 1 A 22g brass disc was made, seen near completed and placed in position in **photo 18**. It is clamped between the handwheel and the shoulder on the screw and retains the collar on the handwheel. It rotates with it, preventing the collar from contacting the static part of the assembly. Such contact might upset the setting.
- 2 The divisions are as for the leadscrew, but the numerals progress in the



**Photo 14** A collet chuck is used to grip the leadscrew.

opposite direction.  
3 A second collar was made mainly for appearance that fits over the black static thrust block and is Loctited in place. A single fiducial line was marked, again using the Junior saw, although, with the benefit of hindsight, this would be better done in the same way as the wheel collars.

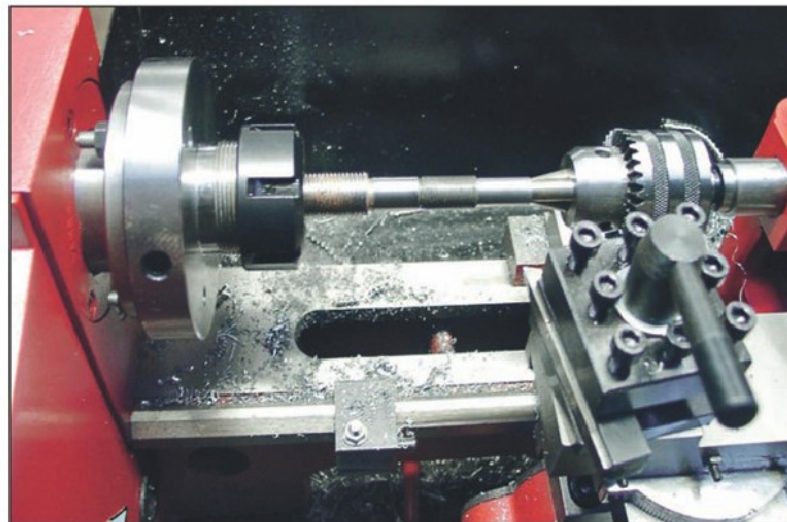
This arrangement shown in **photo 19** would now allow holes to be drilled to depth using the 0.1mm divisions, or perhaps



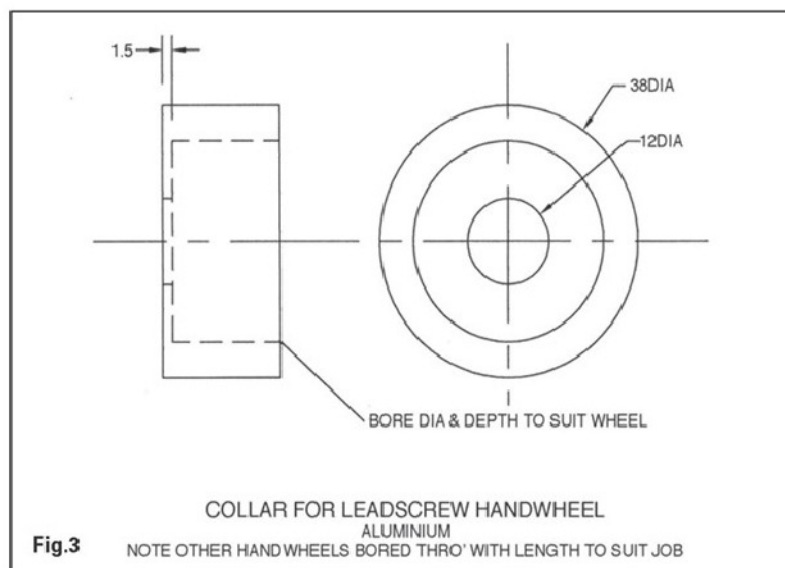
**Photo 15** A detail view of an ER32 collet and closing ring.

judged by eye to even greater accuracy.

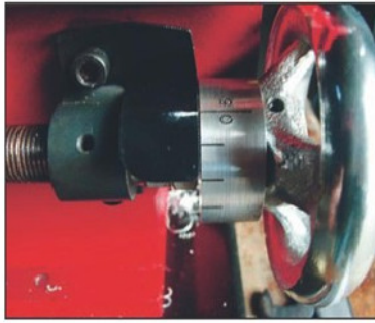
The tailstock wheel needs to be clamped up by its retaining screw, so its thickness was reduced to that of the original plastic, less the thickness of the brass disc. This was done in two operations. First the wheel was gripped in the three-jaw chuck and the rear counterbored about three millimetres, then it was located on the faceplate, **photo 20** to allow material to be removed at the opposite end. In this case the exercise to drill and tap the position



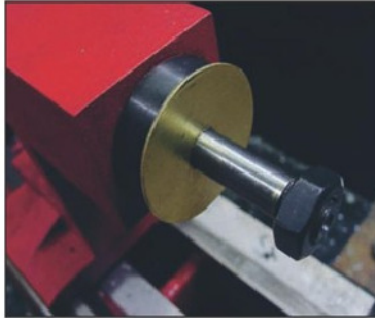
**Photo 16** Pressure is applied to the extension shaft by using the tailstock.



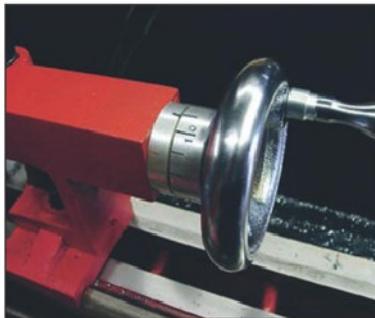




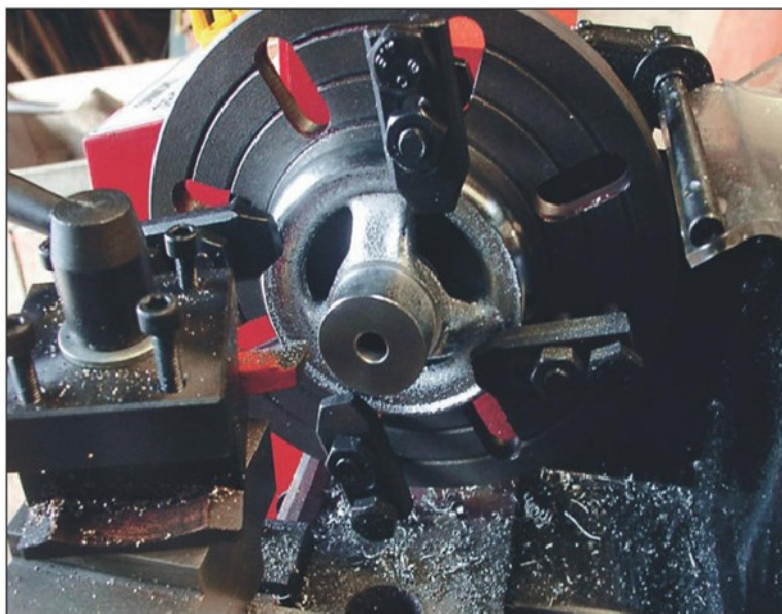
**Photo 17** The leadscrew handwheel assembly fitted.



**Photo 18** Brass disc for tailstock wheel.



**Photo 19** Tailstock wheel assembly with the new static collar fitted.



**Photo 20** Handwheel mounted on the faceplate.

for the grubscrew was exactly as before.

In the case of the apron, it was found that one turn of the wheel moved the saddle by approximately 19.2mm. It was felt that for rough turning to length, this might be approximated to 20mm. A collar was thus made carrying twenty minor divisions and numerals corresponding to majors at 0, 5, 10 and 15. This collar was retained with Loctite, and may be seen in **photo 21**.

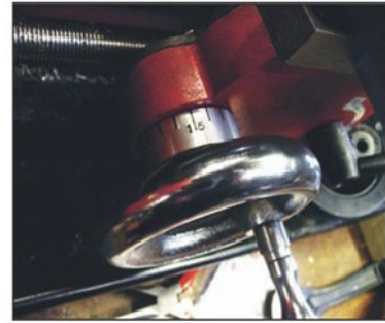
In an earlier article, it was noted that on the apron wheel, the grubscrew engages in a drilled recess. It is therefore worth ensuring that the position is duplicated on the replacement wheel to ensure that the screw engages in the same way.

### And now to milling

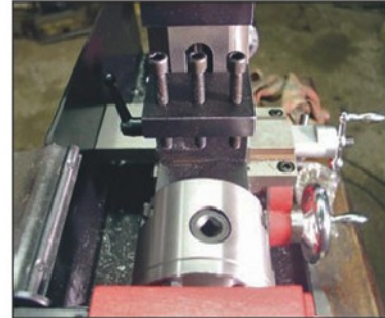
The vertical slide attachment was shown earlier off the machine in **photo 2** and may be seen mounted in the 90degree position in **photo 22**. As supplied, it gives a good robust mounting allowing some 90mm of vertical movement. However it attaches in place of the toolpost and this position compromises the convenience in use. The cross slide travel is some 70mm and thus milling work may be accomplished over a notional table area of 70 x 90mm, but as can be seen in **photo 22**, when the cross slide is run inwards (limited by contact with the rear splashback), the centreline of the spindle is only partway across the clamping section. As an immediate and simple solution to this, I propose a form of sub table, which may be clamped in the "Vice", extending across to provide a useable miniature milling table. Added accessories for use with the table are a number of small clamps and a short length of bright mild steel angle used as a miniature angle plate. Other clamping arrangements may be made to suit the requirements of specific jobs.

### Sub table

This is made from two components, shown in **photo 23** and **Figs 4 & 5**. These are assembled with M5 x 20 Allen screws. The table surface was cut from a piece of 1/4in. aluminium plate and finished to a



**Photo 21** Apron handwheel fitted with a graduated collar.



**Photo 22** Relative positions of spindle and vertical slide at one extreme of travel.

rectangle of some 120mm by 110mm. As can be seen from the photo, the surface features a grid formation of rows of M5 tapped holes into which the clamps may be fastened. If you decide to construct something similar, you may of course choose a different pattern, or even leave the surface blank and simply add holes as necessary to suit the requirements of particular jobs.

The table stub (by which it is clamped into the vertical slide) is a piece of 30mm by 20mm BMS cut to 120mm in length. Note that this size may be varied to suit material to hand. For future convenience in aligning work horizontally or vertically on the table, it is worth making sure that on assembly, the clamping stub is parallel with the top/bottom edges.

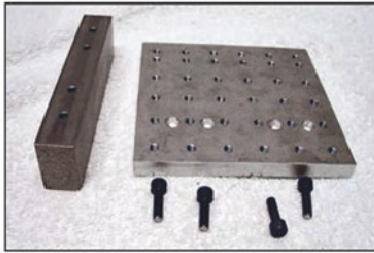
### Clamps

The material used here was an offcut of 25mm by 6mm black steel flat bar. This allowed the holes to be marked out and drilled/tapped, **photo 24** then the clamps to be cut off crosswise. Feel free to work with other raw material that may be to hand. A strip of say 10mm x 6mm or even 8mm x 5mm would work equally well except that the individual pieces would be cut off lengthwise. For convenience in manufacture, it is often easier to hold a larger part than a smaller, hence my choice to drill and tap the holes before cutting off the individual pieces. The intermediate spots that can be seen in the photo were used to guide the position for sawing. **Photo 25** shows a selection of the clamps with the small angle plate made from bright steel angle.

### In use

**Photo 26** shows the sub table fitted to the vertical slide, with a length of aluminium secured to the table by a couple of clamps. It is now possible to utilise the full travel





**Photo 23** Two components form the sub table.



**Photo 24** One piece of flat bar has been drilled to create five small clamps.

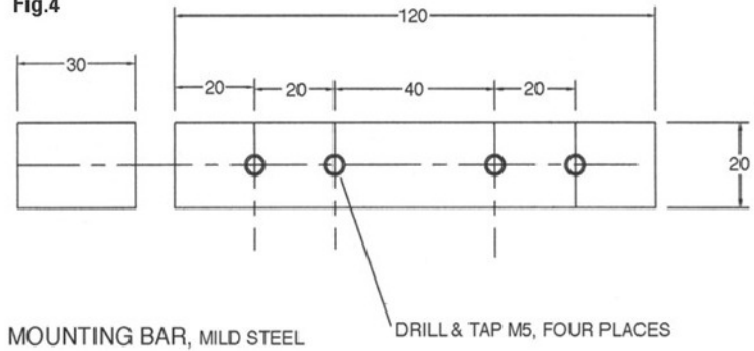


**Photo 25** Clamps have been cut off, tidied up, and fitted with screws.

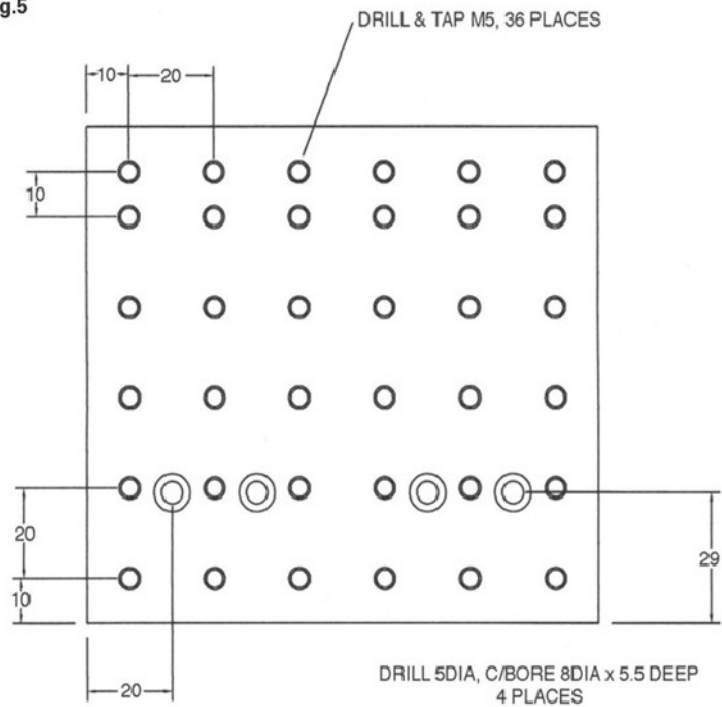
of the cross slide along with that of the vertical slide, to perform light drilling operations, such as spotting the positions of holes. Due to the interrupted cutting action of a milling cutter, milling places great demands on a machine in terms of rigidity if excessive vibration is to be avoided. The next article will consider methods of improving the rigidity to an extent that will permit effective milling work and will also return to the topic of parting off. **Photo 27** shows an overall view of the milling table set up on the lathe ready for use.



**Fig.4**

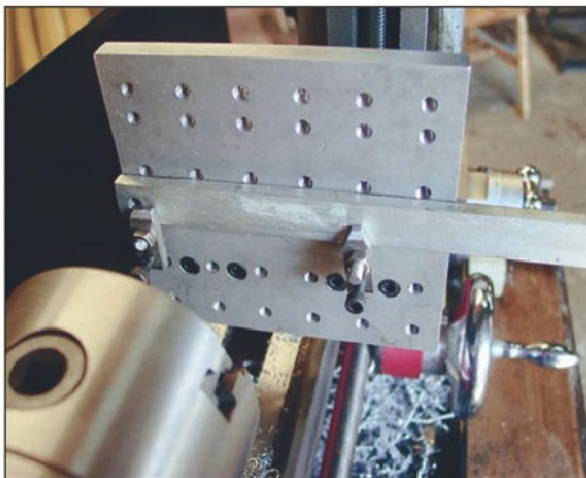


**Fig.5**

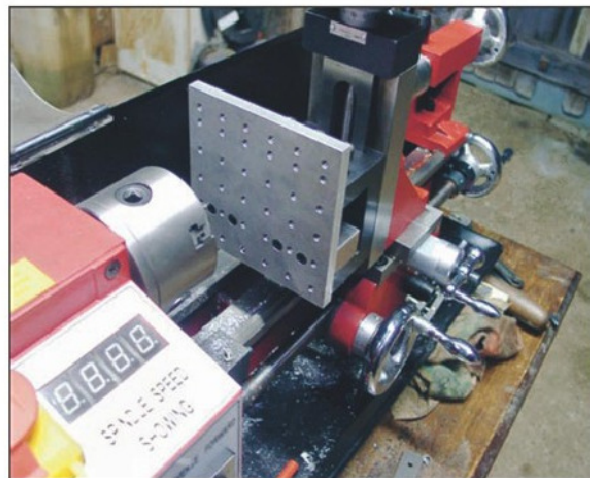


**TABLE PLATE**

9.5mm ALUMINIUM OR STEELPLATE, 120mm x 110mm



**Photo 26** Two clamps used to hold a length of aluminium to the table.



**Photo 27** The milling sub table set up ready to go.





# REVISING WORKS STORAGE part ①

## David Piddington puts his workshop (and affairs) in order

In June 2004, my long-standing friend Frank Hunt, who I had known almost from when I joined the Birmingham Society of Model Engineers in 1968, died suddenly. Those of you that have read "Engineering in Miniature's" April issue in Volume 27 (2006) will have some idea of Frank's magnificent modelling. Frank was a bachelor from a very small family having, after his parents had passed on, only a sister, a brother-in-law and a nephew, none of whom had any interest in his hobby.

He had reached retiring age but preferred to work on for nearly three years because, it is believed now, he was not happy in his own company. He had not made a Will and so his sister relied on his friends to sort out his modelling affairs.

His 12 feet by 20 feet workshop was a sort of "Aladdin's Cave" packed from floor to roof and end to end with model engineering paraphernalia as was much of his house. Frank probably knew where most of his possessions were. To his friends, John and Tony and myself, attempting to identify castings, tools and materials, his system, or lack thereof, gave considerable, though not insurmountable problems.

I decided that I could not leave my own executor in that unenviable position for, assuming I could live another twenty-five years to the age of ninety-one, not an unreasonable assumption as my dad lived



Photo 1 Ready to wind out cable reel.

to eighty nine as did his mother. Her sister reached ninety-four, my maternal grandparents both reached mid eighties and my mother attained one hundred and two years less eight days. My executor brother-in-law would, at my demise, be at an advanced age too.

### Getting organized

Significant changes in my own workshop would continue a process started many years ago in allotting spaces, drawers, shelves and containers for specific items. Recently it became possible to put all information onto a computer, produce an inventory and from that an updateable hard copy index enabling me to locate items that I had forgotten where I had put them provided I could also remember what I had named them. This will also help my executor.

My garage – one in the middle of a row of nineteen – is not attached to the house

and on the far side of a rear access road. However as these late 1960s facilities are no longer suitable for modern cars that are (a) too large and long to manoeuvre into and out of, and (b) too wide to get out of once inside the garage anyway, there is infrequent traffic.

It is about 40 yards from the nearest wall of my home on the outside of which I mounted an external waterproof socket with an inside-the-house circuit breaker. To reach that I have a cable reel fixed to an internal garage wall and run out a cable to the socket. With minimal traffic use, it is fairly safe to leave the lead out but only while working there.

On completion of work, it is wound back onto its reel as in photo 1. There are three projecting handles on the reel for winding the drum on and so it is impossible to leave the plugs in permanently which explains the improvised rear hook for their out-of-use retention. Ideally, a contractor electrician would put in a buried cable to a dedicated fuse/switch board but this would be very expensive for the occasional use I give it. I also fitted internal lighting and have my off-hand grinder, 'Burgess' Bandsaw and belt sander in addition to the motorcycle – I have never owned a car anyway – and other paraphernalia for both interests.

### Belt sander

The belt sander deserves some comment, as it is probable many readers may have been tempted to purchase one. Mine is the "Clarke" (also sold under other trade names) vertical + horizontal



Photo 2 'Clarke' sander with replaced belt guard support.



Photo 3 'Clarke' sander with new table support.



Photo 4 'Clarke' sander showing underneath air access hole.



# KSHOP

but it has inbuilt weaknesses. Intended for 4in. x 36in. abrasive belts, it has a substantial hollow base iron casting and motor housing from which, the motor shaft protrudes to fit the drive belt on one side and a sanding disc on the other. The pivoting sanding belt arm is a substantial steel plate fabrication with rollers at each end, one of which has a tracking adjustment and a tensioning device. Obviously, to replace the sanding belts, it has to be supported on one side only achieved with a combined bearing housing and drive-belt guard made from a die casting which has draft angled sides to release it from its mould. The hole to accept the bottom belt spindle bearing housing is tapered for the same reason but the steel housing itself was machined parallel and seems to have been roughly hand filed to fit the taper. It is then secured with a cross-bolt through two lugs, one each side of a clamping gap.

The belt arm does not need to be exactly vertical when in that mode as the table is also attached to the assembly and can be adjusted to a true 90Deg. to the belt or at an angle to it. I had used my machine for some time and felt that a slight tightening of the clamp would improve matters. BIG MISTAKE! One of the lugs broke off revealing a poor quality metal beneath the smart blue paint. What to do next? Two options came to mind. Firstly obtain, if possible, a spare new component, or fabricate a new one but only because a replacement would be from the same poor quality metal. I chose steel fabrication with a brass two-piece cover and achieved success.

## A better table

While reassembling the worktable, also a die casting, I noted a small fragment of metal fall to the floor. Yes, another poor quality item! I decided there and then to fabricate a better table from steel and the result may be seen in **photo 2**, where it will be noted, I achieved an additional support at the right hand side still leaving access for the sanding belt replacement. I had already decided to use the machine in vertical mode only and would not require the angled table facility except on rare occasions, nor would I be using the sanding disc at the right hand side.

When using a belt sander in the vertical mode, it is important to put a bent guard - visible at the top of this picture, over the upper roller. Not all the particles of dust drop off at the bottom; some carry up and over from the back of the belt. It is vital that if you are a spectacle wearer and when you are sanding metal, to deflect these particles downwards for if you do not, being hot they will imbed themselves into your expensive plastic lenses. If you are not a spectacle wearer then you will also find out the hard way very quickly that these still-hot bits actually enjoy going into your eyes! Hospitals' A&E departments prefer not having to remove them surgically even though their staff are paid to do it! I should point out that safety goggles or



Photo 5 Tap and die storage drawer and tray.



Photo 6 Tee bolts, clamps, nuts, washers etc.

visors are readily available and should be worn on processes like this but . . . ? Do we? In the home environment it is the operator's choice, but readers, please consider your personal health, safety and well being.

Things went well for some weeks as I was mainly sanding MDF for purposes that will be explained later. One day there was a blue flash and a loud 'BANG' and a quiet hush descended on proceedings for at least five seconds until the air went blue again with my (unprintable here) comments. To my shame I have a 'Masters' degree in the "Workshop Obscene" language learned while an engineering apprentice and with which, in such times of stress, I get some practice.

Anyway, after I had cooled down, I removed the motor to find it very dusty with an apparent burn inside the windings

probably caused by heat from dust build-up. I took it along to a local electrician who advised me that "Clarke motors are not very good" and that "It'll cost you more than a new machine to rewind anyway." I had a further think and wondered if I could adapt a better motor if I had one, either inside or on top of the base casting, but I didn't have such a motor. My dear centenarian mum provided the finance for a new machine. I added my modifications and then gave the carcass of the older one to an electrician friend who wanted to use it when suitably re-motored.

## Restricted access

I then sought out means of excluding dust from the motor as can be seen in **photos 2 & 3** by completely blocking up all external access holes. Having decided not to use the side sanding disc, the disc itself has





**Photo 7 'Clarke' box exhibition display.**

van on its inner face which I hoped would stir up air currents inside the base housing and additionally, I carved a big hole underneath the machine as can be seen in **photo 4**. I am now very careful not to let it run for more than a few minutes at a time to avoid overheating and have had no further problems of that sort.

In regard to storage of tools and equipment, I had already made a series of drawers to fit under the drilling and milling bench. I used large drawers from an old office desk and made an additional storage area for two, three and a half inch gauge locomotives awaiting completion. On the other side of the shop are a series of shallow shelves for bar materials stock, though the computer and printer, which had to go on a stout shelf below the window bench, now restrict access to

these. The scanner is hung underneath this same bench in its dedicated drawer.

I am very spoiled by having in my small home, one of four in a block of maisonettes, an indoor ground floor room 11 ½ feet by 7 ½ feet and as my hobby workshop was installed before my wife 'arrived' it was a 'fait accompli'. Everything I do in regard to hobby and other interests (well almost everything) the quart - everything that is solely mine - has to go into this 'pint pot' though I did get dispensation recently to transfer my library to the spare bedroom when our daughter fled the nest. The remainder of the home is now 'ours'.

Further workshop adjustments have been made as required, though the biggest upheaval was to fit in a computer, printer, scanner etc. Tool storage had also



**Photo 8 'Clarke' box with unfinished tray partitions.**

commenced two decades ago and **photo 5** shows my original arrangement for taps and dies, being two shallow compartmented trays, one above the other, number two in the drawer stack. I now continued this theme very successfully for most of my collection of tools and am particularly pleased with the double tray arrangement inside a lower drawer for my tee bolts and their clamps, washers and nuts in **photo 6**. It is now so easy to extract the required bolts and then replace them quickly and tidily.

### The larger tools

Larger accessories such as my rotary table, described in "Engineering in Miniature" volumes 10 and 11, with its additional but separate parts, required 'special' treatment and I searched for many weeks for something suitable and robust. Eventually I found a galvanised steel tool chest with a hinged lid in my local "Machine Mart" store, 550mm (21 ½in.) long by 223mm (8 ¾in.) wide and 219mm (8 ½in.) deep realising that the rotary table would just fit into the vertical side's height. I bought one and lined the inside with close fitting sheets of 6mm MDF - which is where the belt sander came into use. Incidentally, it is advisable to wear a facemask when working MDF as its particles are extremely fine and could be harmful to your lungs. The bottom is fitted first to be a close push fit into the box. The long sides are fitted next, again made to a close push fit.

I should mention that the lid has a close-down latch and is lockable which I didn't really need for my purposes but as the boxes didn't come without this feature ... I did note later however to punch an identification character - starting at "A" - into the latch and on to both of the keys; this system was repeated on subsequent boxes. The lock and the hinge straps on the back are secured with "Pop" rivets which project inside the box by about ¾in. I found that once the side liners had been 'sized', I could G-clamp them over the rivets leaving depressions where the rivets protruded and then drill clearance holes on these marks. I found that the rivets are not in precise positions, so each liner has to be dedicated and marked with its outside next to the rivets.

Having achieved this, the end boards are then fitted, again to a push fit. You may find that the end metal skin has bowed outwards. Bend it in by hand until reasonably in contact with the MDF. Apply a bead of adhesive ('EvoStik' Wood Adhesive is probably the best) along the bottom of both sides and put these in first. Allow time for the glue to set. Then put in the ends, again with adhesive, lightly clamping to the metal outer skin, so that the ends will push the glue into the joint. After about 15 minutes, carefully run a bead of adhesive around the corners of all internal joints leaving a small fillet. Most of this will soak into the joint and any dry excess may be scraped away later.

The fillet of adhesive should also be given to all inserted partitions, as I find that this strengthens the assembly, especially where no other fixings are used. It is impractical to insert screws from underneath the chest through the MDF base into the extra partitions as it will be necessary to slide the boxes across a floor at times. You will not be applying side



strains to any of these parts by lifting and replacing your accessories vertically in and out of their compartments. Should one become detached, it is easy to replace in the same manner.

That completed, I then arranged accessories inside, the rotary table first and glued blocks of 6mm and 12mm to partition the inside. I was also able to include the George Thomas mandrel dividing unit plus George's universal division plate head, which I can use on either accessory. There are also two internal trays, one inside the other, supported on additional internal blocks of 12mm MDF. You also need imagination to plan well in advance where parts will be positioned.

A digital image of a more complex layout will be an advantage so you can remember the positioning when fitting spacer blocks. The prototype box was entered in the 2005 Midlands Model Engineering Exhibition in the display section and at the same venue on the Birmingham SME club stand in 2006, where I hope many readers will have seen it as **photo 7**. Other than the basic box, I am not giving dimensions so that readers can 'do their own thing' in regard to storage. My aim in the exhibition display was solely to give my IDEA to others, as I am so pleased with the result.

### More storage

Having achieved success with the prototype, I bought another chest, repeated the process and as in **photo 8**, store the Myford vertical slide which has been modified to a base-only swivel (see Model Engineer volume 147 issue 3665) and the Myford dividing head, both of which belonged to the late Alfred J Reeves who died in 1968, purchased from his estate along with other tools including a Myford Super 7 lathe. The top tray has since been filled with various between-centre boring bars. The smaller inner tray accepts my larger capacity three point steady.

I now have five of these chests, all treated similarly, which have excellently fulfilled my needs. They fit beneath my lathe's bench, and those used most often are on the floor to slide out as required. **Photo 9** shows these with a gap, still to be filled, on the upper shelf.

For tray bottoms, I find that 6mm plywood is a better option and combine glue with panel pins to secure the sides. I use 15mm pins, bought from my local B&Q store, which have an average shank diameter of 1mm though it states 1.25mm on the last packet purchased. They are a light push fit into drilled number 55 holes in MDF. Pre-drill the tray bottom at, say, 2 to 3-inch centres and at half the side thickness. Clamp a straight edge to the drill table to set this measurement. Then do a 'dummy assembly' with clamps and pre-drill the holes into the MDF taking great care that the total drilled hole depth is LESS than the total pin length by about 1/8in. This 'extra' length will bite the pin into the MDF and secure it without splitting leaving adhesive on the joint to give the necessary strength. If your drill's chuck is deep enough, then set the drill to protrude by the required length and use the chuck jaws as the depth gauge or otherwise shorten the drill's shank



**Photo 9** 'Clarke' boxes underneath lathe bench.



**Photo 10** Faceplates stored flat with extended jaws.

appropriately. I acquired one of the modern 12-volt cordless electric drills for this and other uses.

Apply adhesive to the side's edge, put in a couple of the pins to locate, hammer them home and then insert all the others to complete. Wipe away excess adhesive from the outside and ensure that there is a small fillet of adhesive all around the inside contact corners as already mentioned. After the adhesive has set and when the tray is complete, it can be put back to the belt sander and the sides 'trued up' to a fine finish and the corners bevelled off lightly. Having an indoor workshop free from condensation, none of my storage has needed paint or varnish. If you do intend to varnish, then it is

probable that additional preparation will be required to remove dried adhesive from the flat areas. Cabinetmakers among you will cringe at these rough and ready methods, but I am not intending to exhibit my workshop, nor indeed give it any lasting antiquity value, just to use it effectively and efficiently.

There are always snags of course. MDF itself is a super material BUT it splits if screws or pins are inserted on the edges without care and preparation. Inserting pins has already been covered but for screws, approach the job as above, pre-drilling with a suitable sized tapping drill just as you would for metal. The actual tapping drill is best found by experiment on some scrap pieces. The



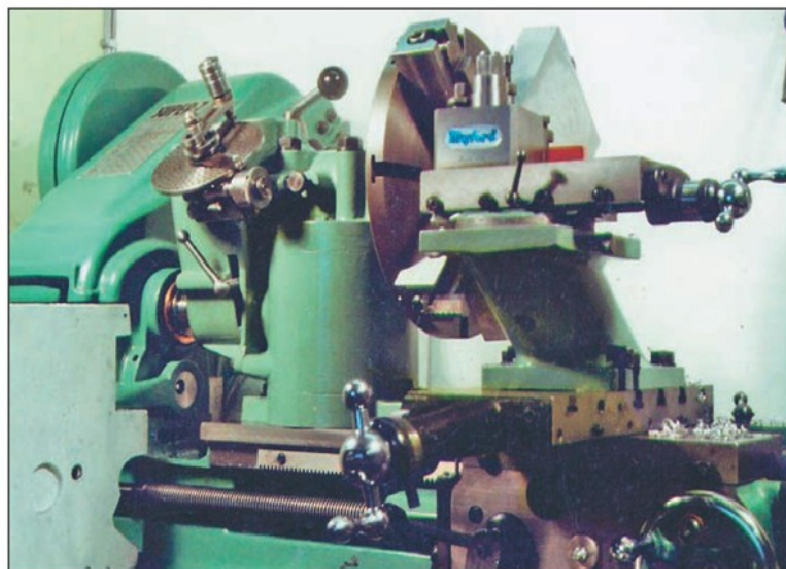
essential requirement in this process is to firmly support both sides of the MDF for more than the full depth of the hole. A toolmakers clamp by itself is one way, or use a couple of strips of  $\frac{1}{8}$ in. minimum thickness of steel each side with a "G" clamp. The selected screw is then driven full depth into the hole, removed, and then reinserted on final assembly with adhesive to complete the joint seal face to face. I have successfully joined parts into the edge of 12mm MDF in this way without splitting using the following sizes:

| Screw size                                    | Tapping drill      | Clearance drill |
|-----------------------------------------------|--------------------|-----------------|
| 3.5mm x 30mm<br>(No. 6 x 1 $\frac{1}{8}$ in.) | $\frac{3}{16}$ in. | No. 29          |
| 4mm x 40mm<br>(No. 8 x 1 $\frac{1}{8}$ in.)   | $\frac{1}{8}$ in.  | No. 18          |

My Myford and Tee slot faceplates were too large to fit into the chests, as was my "Spindle Raiser", also described in "Engineering in Miniature" volume 14, which included the tee-slot extended chuck jaws seen at the top of the dedicated storage container **photo 10**. The steel rings that may be seen on the upper shelf are used behind the faceplates or catch plate to allow a small recess between the front face



**Photo 11 Spindle Raiser, boxed.**



**Photo 12 Spindle Raiser machining a block too large for the bed's gap.**

of the plate and the spindle when required, or when you have made your own fixture and the spindle protrudes from it. An end on view of the boxed Spindle Raiser is shown in **photo 11**.

Digressing briefly from 'storage' matters, all the major castings for this attachment were machined on the standard Myford Series 7 lathe for which it was designed and, for readers' interest **photo 12** shows the complete unit on my lathe, set up to machine a block of aluminium too large to clear in the gap under normal conditions. For anyone interested in making one, I described it in "Engineering in Miniature" Volumes 13 and 14.

The adapted dividing head is from the drawing board of the late George Thomas' and was added so that, for example, rivet holes in the wheel rims of traction engine models up to 14in. diameter could be divided out exactly. The design and patterns for the "Spindle Raiser" are now copyright of Reeves 2000 with whom I no longer have any connection. At this point may I say I have no similar connection with Messrs "Machine Mart" or Messrs "B & Q" except as a customer.

### 1950's storage

One item of furniture I had acquired just after I had moved into my new home in 1968 was a 1950s period television cabinet from those halcyon days when TV was an intrusion and needed to be shut away out of sight when not in use. This cabinet had doors on the front for doing just that, a central compartment for the tube, and upper and lower internal shelves accessible only from the back for "the works". I used it as a base for my "Martin Cleeve" bench drill (see Model Engineer Volume 133 from April 1967) but later incorporated it as a mid-support for the 'quiet bench' next to a partition wall on the other side of which is my neighbours lounge.

Perhaps I should stress here that my whole shop is 'quiet' between the hours of 10pm and 9am except on occasions when I know the neighbours are 'out'. In the four decades since then I have only had two complaints one of which I countered with "Well, you were noisy weeks ago well



**Photo 13 Cabinet for "Worden" tool grinder.**

after 11.30pm!" The other was electrical interference on a TV and I proved it wasn't me. I believe this is not a bad record. Former Model Engineer Editor Ted Jolliffe visited me in 1988 and his report was published in that magazine, Volume 160, 20th May issue.

### Worden grinder

Anyway, returning to that TV cabinet. During the reorganising programme, I decided to give it a better use. I am in the process of making the 'Worden' tool grinder and realised this would neatly fit inside after removing most of the 'ornamental' front boards. **Photo 13** shows the final result after I had removed the right hand door, inverted it and attached it to the outer edge of the left hand one, this left room under the lip of the bench to fit a small strip light. The only real snag is that I have to crouch or kneel to sharpen tools.

The "Worden" itself is mounted on a sliding panel of 12mm MDF and I found that my local B&Q stocked a selection of metal and plastic sections and extrusions including some 12mm (inside) aluminium channel, which I bought. I had already strengthened the internal plywood base, drilled across the channel so I could screw this down with countersink heads inside and made the sliding panel to fit smoothly.

The "Worden" is not fastened to the slide, just located and kept there by gravity. You will have noted from the picture that I made and fitted two drawers above and one below but I hit a major snag with the latter. For reasons unexplained, the bottom of the cabinet sloped and so the aperture into which I was fitting a drawer was deeper at the front.

As almost everyone knows, drawers do not like anything other than parallel-sided holes to fit into but using more of the aluminium channel and a side extension of the drawer's bottom it can now be withdrawn from its hole without falling on the floor. Unfortunately the cabinet was securely fastened into the bench assembly so I could not remove it to work from the front and back at the same time. I later made yet another drawer to fit into the void beneath the cabinet next to the floor so that the one immediately above it will be used for "Worden" accessories.



# TAPPING INTO SCRAPYARD RESOURCES

## Background

Tapping small holes true is always a bit of a challenge, especially with very small taps. I have seen a device advertised to assist with such operations; I believe it was called a 'Tap Tru'. At about the same time, 'Model Engineer' was running a series of articles on the George Thomas Tapping & Staking Tool, later to become 'The Universal Pillar Tool'.

This interested me, as the device could be utilised for additional operations besides tapping threads. At the time, I had no idea that there was a kit of parts available to construct such a tool.

## Finding the material

I had been given a length of 1in. dia. black bar, which turned out to be stainless steel. Although this material can be challenging to machine with some types, I decided to use this as the main pillar. A visit was made to a scrapyard, when at that time you could mooch around picking up bits of really useful stuff.

On a recent visit to a local yard, I was told it would be too dangerous to enter for safety reasons and I had to go away. This was odd, as when this yard was in the nearby city of Wells, I found some lengths of useful bar in a corner, up to about 16mm dia. which I bought. These were too long to go in the boot, so when I mentioned this to the owner, he pointed to a huge machine; which had a hollow 'V' shaped punch, and told me to cut them in half. There was no guard, fence, stops or hold down fitted. With some trepidation I placed a piece on the table, pressed the pedal and the machine bit out a triangular lump in the middle like it was cooked spaghetti, with no lifting of the ends whatsoever. Times are changing.

I found two short pieces of 1 1/2in. x 1 1/2in. aluminium offcuts which would serve for the two arms and one of the cast iron crowned pulleys I had been given by a friend would make a suitable base, so I had the essentials to make a start.

## The pillar

This just involved sawing off a length of the bar and facing each end to bring it to 16 in. long. This was followed by cleaning the black coating off the surface.

## The arms

The two pieces of aluminium were squared off to length and the hole centres marked as

## Jim Whetren makes a pillar tool

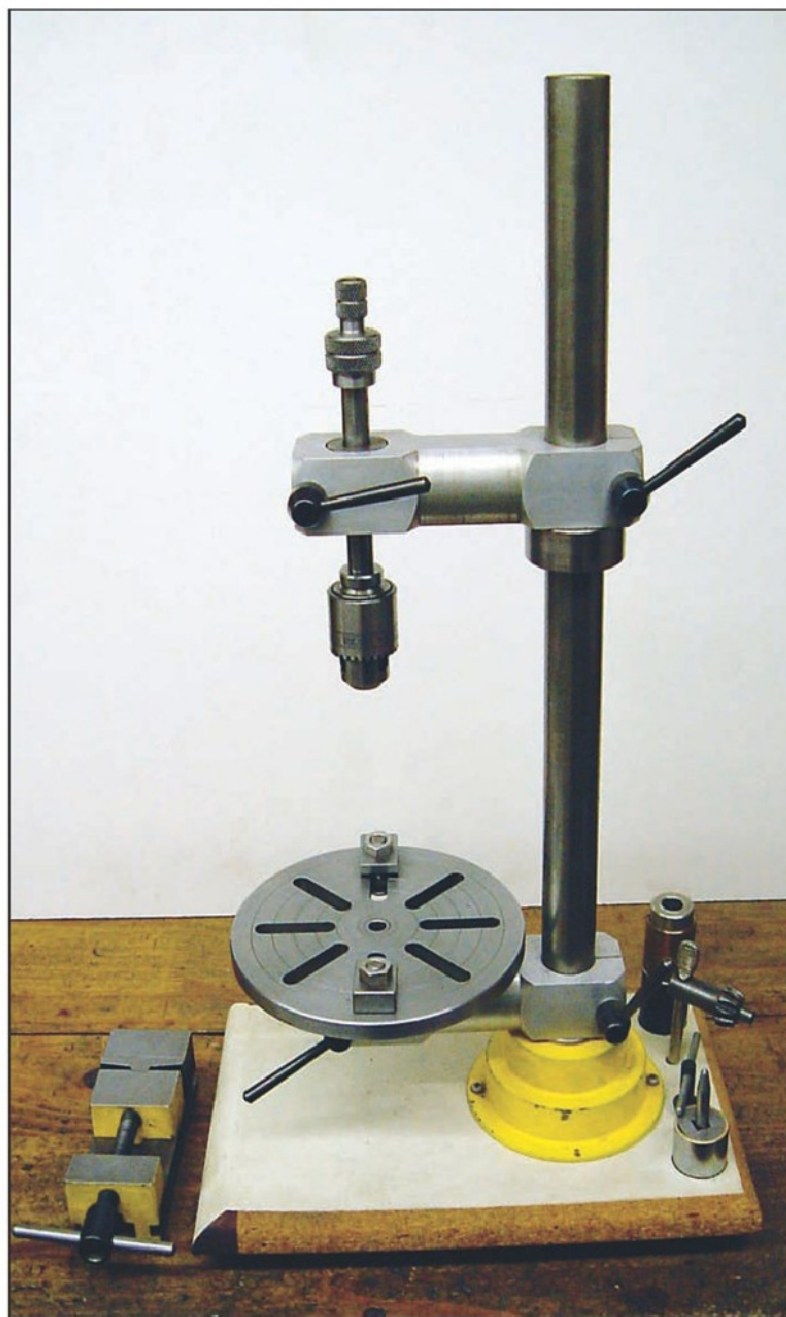


Photo 1 The finished staking tool.



in the sketch, **Fig. 1**. Having the Drummond lathe at the time, with its large faceplate and gap bed, I was able to drill and bore the first hole in each piece. The finished bores were located on a close fitting peg on the faceplate to ensure equal distance between each bore and the second holes were drilled and bored. The chamfers and wasting in the centre was just for improved appearance and was machined between centres prior to drilling the clamping bolt holes and slitting the ends.

Now knowing better, I would opt for the split cotter method of locking the arms as

in **Fig. 2** and **Fig. 3**. Without the Drummond's advantage, the holes could be finish bored with a lathe or mill using a small boring head, still locating the second bore with a peg in the first, or boring both pieces clamped together.

### The base

The pulley was bored to accept the pillar and drilled and tapped for a clamping screw. The largest step was removed from the pulley to leave a small flange, allowing just enough room to drill clearance for two round head wood screws to secure it to the wooden base, **photo 1**.

### The large tool holder

The collar on the spindle locks on to the bar with the knurled screw to hold the tap clear for final adjustments. The 10mm Jacobs No.32 chuck was reclaimed scrap. When I found it, it was just one lump of rust. Having learned the secret for dismantling with the aid of some salvaged ball-race outer rings and a 6in. vice, the chuck was pulled apart and

given a good clean and lubrication. The tightening sleeve was re-blackened and the highlights polished before reassembly, **photo 2**.

Be warned! I thought I would give the same treatment to an old Rohm chuck, but did not realise that they use a different script and 'killed' the chuck. Whereas the Jacobs system has the sleeve and gear in one piece pressed onto the split nut from the front, Rohm in their wisdom have the sleeve pressed onto the combined gear ring/nut, which is split. Therefore they separate by pressing the sleeve in the opposite direction. Why do we find out such things as this and hidden screws or pins after something breaks? However, I then learned how to bore to an interference fit and made a new knurled tightening sleeve, restoring the chuck to a serviceable state.

### The normal tool holder

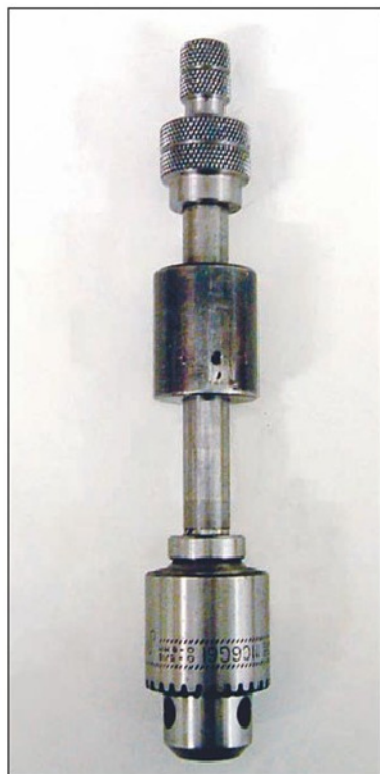
The two step, knurled turning knob allows a sensitive touch with small taps; the smallest I have used is 10BA, and a bit more torque for the larger ones. The bearing piece contains a tapped hole, housing a steel ball and spring that are compressed with the grub screw, holding the spindle in any position whilst still allowing free rotation, **photo 3**. The Jacobs Multi-Craft chuck was formerly used on a Tinker grinding jig as it held up to 8mm, but was much smaller than a 30B 8mm chuck, **photo 4**.



**Photo 2** The No. 32 large Jacobs chuck.



**Photo 4** The Jacobs No. 30B compared with the Multicraft chuck.



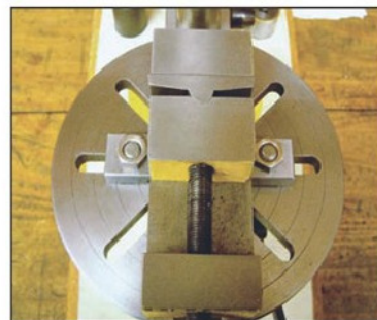
**Photo 3** The small chuck, note the two knurled knobs.



**Photo 5** The No 1 Morse taper holder.



**Photo 6** My collection of reamers.



**Photo 7** The vice mounted on the table.





**Photo 8** Cutting the mounting lugs off the vice.

### The 1 Morse taper holder

This holder was made to accommodate a number of No 1 MT reamers that I have, although only two of them appear to be machine reamers. It has the normal slot for inserting a drift to remove the reamer, **photo 5**. I often use these reamers, as some of the smaller ones are better than my hand reamers and this is my only 1/2 in. reamer, **photo 6**.

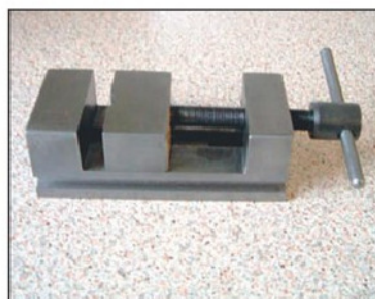
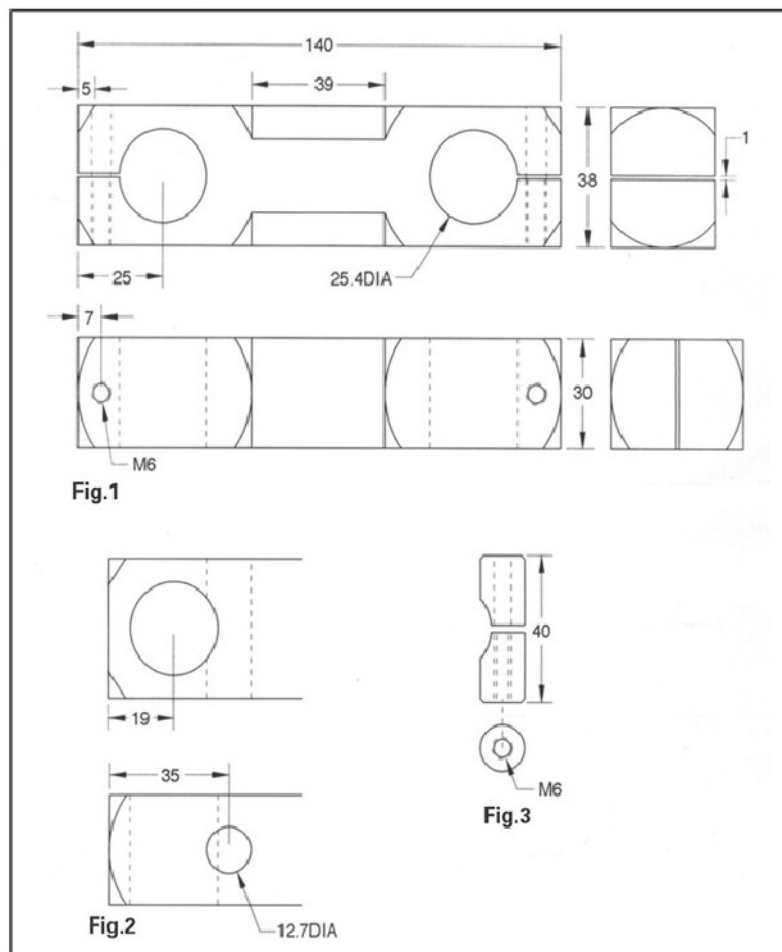
### The table and the vice

The slotted table was made from a disc of mild steel 3/4 in. thick, threaded onto a spigot, which is clamped in the arm. It houses a vice I use on a Myford swivelling vertical slide on the Drummond, and looks very similar to the Myford vice, **photo 7**.

Following Harold Hall's advice, the clamping flanges were since removed with a slitting saw, **photo 8** and clamping slots milled down the sides, **photo 9**. Also a longer jaw plate was fitted, **photo 10**.

I have a small Brown & Sharpe vice with alternative jaws, which snap onto the tightening screw, **photo 11**. I don't know the purpose of the 'hourglass' jaw, but it does form a suitable finger grip to hold the vice with a clamped item. The tommy-bar is retained with a close fitting spring, which keeps it in position and stops it from falling out, **photo 12**. I drilled the end of the modified vice, and adopted the same retention method which works well, **photo 13**.

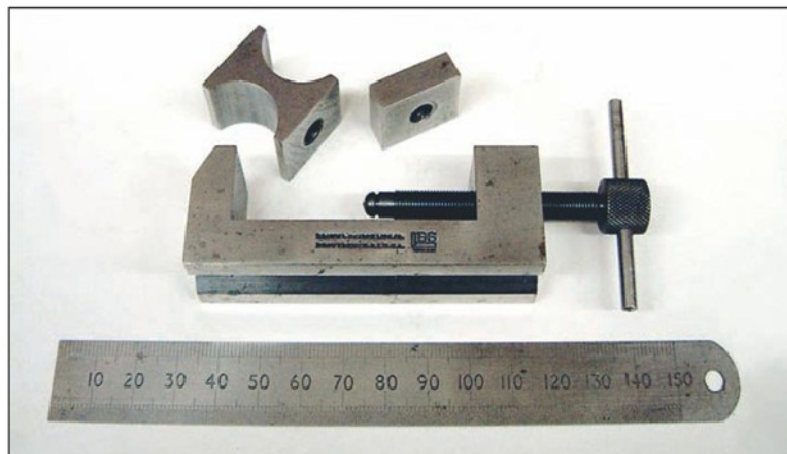
The vice is secured to the table with two small clamps and reduced height nuts to bring them below the vice bed, **photo 14**.



**Photo 9** The modified vice with side clamping slots.



**Photo 10** The underside of the vice showing longer jaw plate.

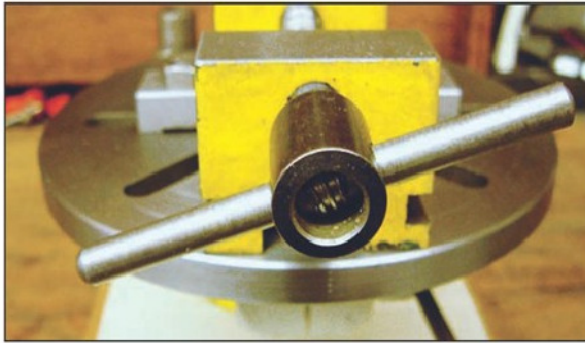


**Photo 11** The Brown And Sharpe vice.



**Photo 12** The tommy bar is retained by a spring.

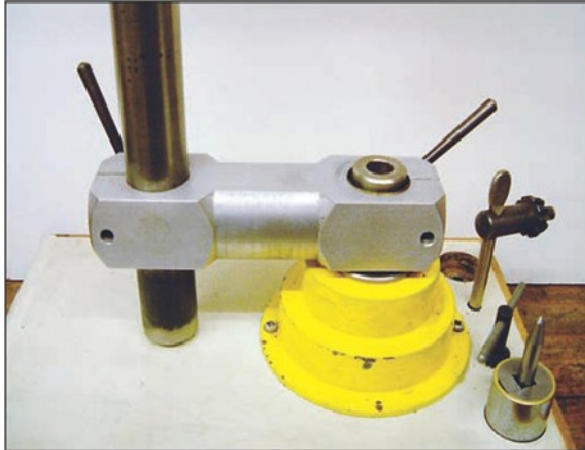




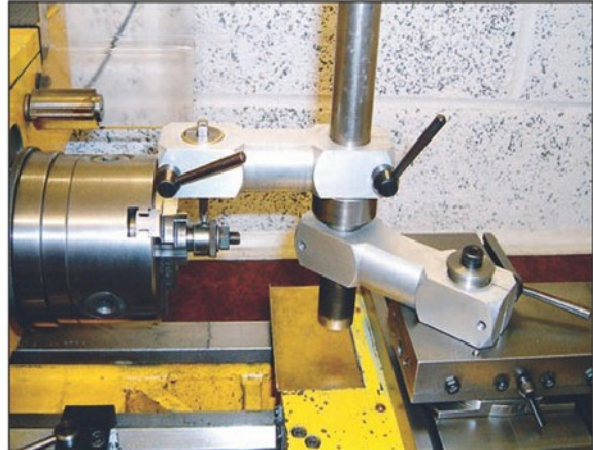
**Photo 13** The other vice also has a spring on the tommy bar.



**Photo 14** The clamps are small and unobtrusive.



**Photo 15** The special anvil is better suited to absorb the striking force.



**Photo 16** Using a clamping pillar to mount the tool on the lathe.

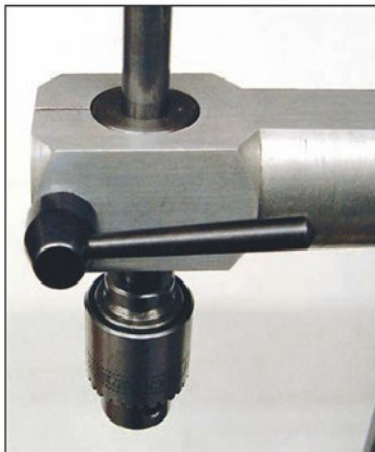
### Number stamping

This was dealt with in MEW issue 135.

### Heavy hitting

Although I have not had cause to use it yet, there is a short piece of the pillar bar containing a reamed hole to receive various anvils. This replaces the table in the lower arm and is fitted into the base, placing the striking force directly onto the more solid base, **photo 15**.

If a similar piece were drilled clearance for a T bolt or tool-post stud, then this would allow mounting the unit on the cross slide or top slide of the lathe to stamp numbers on dials in situ held in the lathe chuck, **photo 16**.



**Photo 17** Neat taper pin handles are used.

### Fasteners

M8 coach bolts are used to secure the vice and the angle plate to the table, thus locking down the vice becomes one-handed. See MEW issue 135.

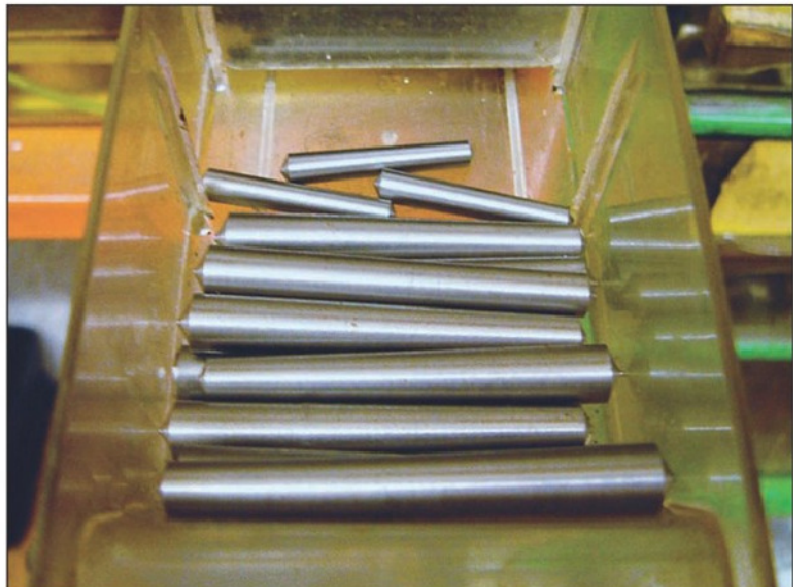
### The locking handles

There are smarter ways of doing this, but I had a stock of taper pins, and these make reasonable looking handles, also they were instantly available, **photo 17**. This

stock has now been exhausted and I cannot find another supply.

As I find a regular use for two sizes of these pins, I have found a way of batch producing them with just two cuts, turn the taper, part off, - pin made, **photo 18**.

Although not as neat and tidy as the 'official' one, I have found this easily made workshop accessory to be most useful on many occasions.



**Photo 18** Taper pins are machined as a batch.



# INSERT TOOLS

## part 1

Mike Houghton takes a look at replaceable tip tooling Materials.

**R**eplaceable tip tooling could well find uses in the Home Workshop. A visit to any of the many UK Model Engineering Exhibitions will reveal a burgeoning array of 'carbide' replaceable tip tooling for drilling, turning, milling, boring and even tapping operations, sized to suit the smaller machine tools that most of us operate.

Clearly, most of these products were not developed for our Home Workshop use. They are a spin-off of development trends that have been at work in commercial manufacturing for a number of years. With lower cost, tougher and more exotic materials being worked at higher speeds, higher power input machining along with CNC control, they have and will drive industry forward.

Industry likes the idea of having a consistent supply of accurately dimensioned inserts made from reproducible materials that don't need to be re-sharpened as this does away with having to employ an in-house toolmaker and to be able to throw the insert away after its cutting edges become blunt. In modern practice, inserts can now be easily recycled for their exotic metals content, particularly Tungsten and Cobalt. Current value of clean used carbide inserts is said to be around £10/kg.

My experience of using insert tooling over the years has been very patchy. Some things work brilliantly and others are a failure for apparently no good reason. Talking to other Home Workshop users, they generally have a similar experience, so it can't just be me! Oh and we don't like the throw away tooling concept, but that's another issue!

As we will see, "carbide" tooling is an area where we just cannot make our own (roll our own) inserts, it's technically too difficult. Home workshop manufacture or modification of commercial tool holders is possible, however. Hopefully these articles will make the choice of inserts and tool holders for a particular job a bit easier. This introduction uses some chemical symbols.

### So why carbide?

To explain why Carbides seem to be appearing in the Model Engineers' Workshop as a hard metal of choice, it's worth considering how we got to this point and consider the alternatives, their pro's and con's.

### Carbon tool steels

I'm sure we all turn our hands to a little tool making at one time or another for that special form cutter, D bit, broach or whatever. The starting material is likely to be a tool steel that can be worked soft then hardened by heating and quenching into water or oil and finally tempered and sharpened.

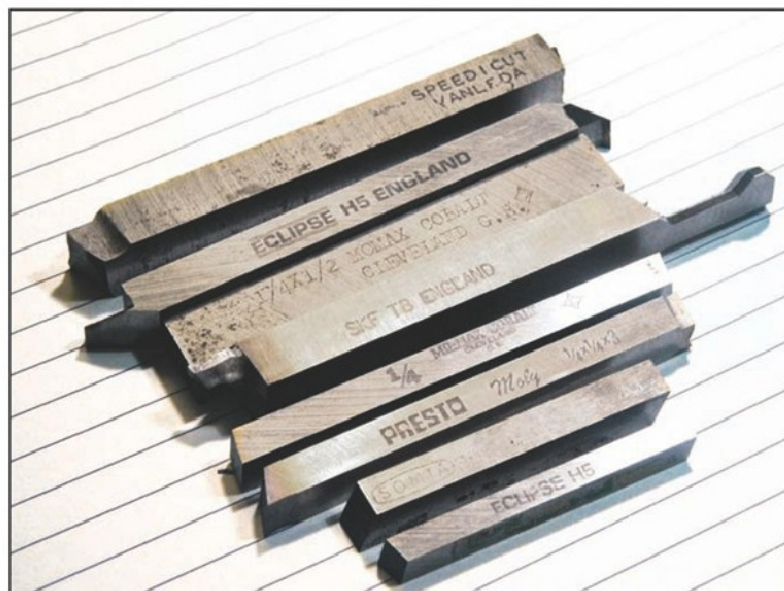


Photo 1 HSS Tool Blanks.

The excellent little book by Tubal Cain (Tom D. Walshaw) Ref. 1 on the Hardening, Tempering and Heat Treatment of tool steels contains lots of information on the iron/carbon phase diagram and the effects of the carbon content and heat treatment of steels from near zero to about 1.4% carbon. It's a good, practical, how to book, with a bonus; the metallurgy is explained better than I could, so I won't attempt to even summarise its contents here. Incidentally, you will read that Iron Carbide (cementite, Fe<sub>3</sub>C) is an important component in the iron/carbon phase diagram. There will be much more on Carbides later.

The author gives scant consideration to "High Speed Steel tooling" and does not mention "carbide" tooling at all. He probably didn't think they had any part to play in our workshops with small and "unstable" machines.

Our carbon tool steel cutters will take an excellent sharp edge but don't stay sharp

where they are a commodity. See Ref. 2. Particularly useful is the High Speed Steel Smart Guide, which is available on the net and in paper form. See Ref. 3.

High speed steels belong to the Fe-C-X multi-component alloy system, that is Iron, Carbon and X where X represents chromium Cr, tungsten W, molybdenum Mo, vanadium V, and/or cobalt Co. Generally, the X component is present in excess of 7%, along with more than 0.60% carbon(C).

The impression given by most advertisers and manufacturers/importers supplying the Home Workshop market is that there is just one grade of High Speed Steel. Imported tooling is often just marked HSS or sometimes just HS.

In fact there are many internationally recognised grades of HSS and they are not all the same, far from it. The table below shows 3 of many grades that a good quality toolmaker may employ as his feed rod material for the manufacture of drills, reamers, taps and dies etc.

| Grade | C   | Cr | W   | Mo  | V   | Co | Rockwell c Hardness |
|-------|-----|----|-----|-----|-----|----|---------------------|
| M2    | 0.9 | 4  | 6   | 5   | 2   | -  | 63-65               |
| M35   | 0.9 | 4  | 6   | 5   | 2   | 5  | 64-66               |
| M42   | 1.1 | 4  | 1.5 | 9.5 | 1.2 | 8  | 66-68.5             |

for long if they are used on tough materials or are run at high speeds. High speeds create heat and heat rapidly tempers and softens a carbon tool steel tool bit.

### High Speed Steels

So what about High Speed Steel? There is a HSS Manufacturers Forum and a lot of information about the composition of these cutting tool steels is freely available on the Internet. HSS tool steels seem to have become standardised almost to the point

HSS in its annealed state is quite soft and easy to machine and this is the form our toolmaker will start with. The Rockwell C Hardness range shown is what could be achieved after hardening and tempering by a competent manufacturer. The fact that a tool says HSS is no guarantee that it's been shaped, hardened, sharpened and tempered and possibly coated correctly.

The grade number shown in my table is AISI. (US) but equivalents are available in other National standards. All the grades





**Photo 2 HSS tool grades.**

above are from the Molybdenum series or M series. A similar, Tungsten, T series also exists. More on these compositions and many others are given in **Ref. 4**, if you are interested.

M2 is the standard HSS and is used where toughness is important, together with a good standard of wear resistance and red-hot hardness. Compositions like these in the table didn't just arrive out of the blue, but were the results of countless hours of metallurgist's development time. Each element in the alloy mixes above brings its own special properties. E.g. Vanadium forms very hard carbides; cobalt improves heat resistance. Also the cost and availability of each element is not equivalent, and the composition is therefore something of a balancing act. All HSS contain Carbon and this will be visible after suitable sample preparation under a high magnification microscope as M6C or MC carbides. More on carbides again later.

The lathe tools I inherited with my old Myford ML7 were all made from chunks of HSS welded to a carbon steel shank. This arrangement was economical in the use of costly HSS and allowed the hardest grades of HSS with up to 11% Co to be used.

If you look up ground solid HSS tool bits for grinding into lathe tools in a comprehensive tool catalogue such as J&L Industrial, **Ref. 5** you will find that M2 is again the standard but with 5 to 8% cobalt or 10 to 11% as tougher grades.

If you are like me and never turn away a gift of a tool bit, your collection will probably contain round and square blanks with all manner of markings that don't seem to relate to the above HSS types, see **photo 1**.

I find that you can detect a difference in the tool bits when you grind them. Those with higher Cobalt and Molybdenum contents seem to produce a redder spark



**Photo 3 HSS powder grades.**

and grind more slowly on a standard white or blue wheel. In my photo, fast cutting has burnt some of the bits. See the brown marks on some.

By this point you should be realising that Toughness, Hot Hardness and Wear Resistance are key factors in high performance cutting steels.

### So what are Carbides?

Carbide is simply a chemical compound of a metal and carbon. Older readers will remember carbide lamps on early cars where water was dripped onto calcium carbide. CaC<sub>2</sub>, acetylene gas was produced and burnt in the lamp. Acetylene for welding is still made in a similar way. Calcium carbide is a grey hard brittle material with a very high melting point, 2300 deg C and is produced in an electric arc furnace from carbon and lime. Note: our carbide tooling inserts don't react with water like Calcium Carbide!

Silicon carbide, SiC, is made in a similar way from sand and carbon in an electric arc furnace and is used by us all as an abrasive in wet and dry abrasive paper and green grinding wheels for carbide. Again it has a very high melting point, 2730 deg C and remains hard when hot. Most carbides remain very hard almost right up to their melting point. Cast iron melts at about 1370 deg C by comparison so we are talking about exceptional refractory materials.

The other carbides of interest as tool inserts are all high melting, very high density and very hard. Importantly, they all maintain their hardness when heated over 1000C.

Tungsten Carbide, WC has a melting point of 2870 deg C, a density of 15.8 and a Mohr hardness of 9.

We are all familiar with the tungsten filament electric light bulb. Tungsten is the highest melting point metal at 3422C and the powder metallurgy techniques developed to make Tungsten wires for light bulbs and early radio valves (bright emitters) in the early 1900's are still the basis of methods used today to make inserts. The extremely high melting point of tungsten metal necessitated the development of new production methods. Very finely ball milled tungsten oxide powder can be reduced to the metal with hydrogen, at a temperature below the metal's melting point, to yield a powdered metal. This powdered tungsten metal can then be converted to powdered carbide by reacting it with carbon, the starting point for insert manufacture. Incidentally, the requirement to draw fine tungsten wires for filaments lead to the production of tungsten carbide for drawing dies in the 1920's in Germany. The original inventing company rapidly became a part of Krupp and still trades today as Widia, but it's now a part of Kennametal. Widia, in German, derives from "as hard as diamond"

### Hardness

The first thing we all do after hardening a piece of carbon tool steel is to see if it will scratch glass or if a file will not scratch it. Mohr devised his scale of hardness for minerals in 1812. He assigned an arbitrary scale with values from 1 to 10 based on the ability of minerals to scratch each other. Diamond was given 10 as nothing scratched it and it scratched everything presented to it. Talc was given 1 as everything scratched it. Glass and hardened steel are about 5.5 on

the Mohr scale.

Absolute hardness, measured by pressing a diamond into the test piece in a sclerometer, gives a similar ranking but a more realistic measurement of hardness. Using this measurement, Diamond is 4x the hardness of aluminium oxide, Al<sub>2</sub>O<sub>3</sub> (corundum).

### Toughness

Hard tools tend to be brittle and snap (fracture) rather than bend. Hardened HSS tool bits and drills can be broken if the going gets really tough. They usually fail by fracturing. We have all shortened HSS tool bits by grinding a small vee in one side, clamped the bit in a vice, covered it with a cloth and hit it with a big hammer! Crude but effective. The crack propagates from the vee. (Please wear safety specs when you attempt this)

So, one way of defining toughness is "resistance to fracture when stressed". Tough materials can stand sudden loading and intermittent cutting. The Izod can measure toughness or Charpy swinging hammer tests and measures the quantity of energy the test specimen can absorb.

### So how tough and how hard?

**Chart 1** shows the relative hardness and toughness of a number of hard materials used for cutting tools and tool inserts. The data has been taken from a number of sources and is intended to be comparative, not exact. My chart contains many abbreviations which I shall clarify as I describe their applications to tooling.

### CS, Carbon tool steels

These are the toughest and probably the cheapest materials on my chart. They can be sharpened to a very sharp edge but lose hardness rapidly when worked hard. Examples might be En24/25/26, En31, O-1, Silver steel, Gauge plate etc. Temperatures above 200C will cause loss of hardness.

### HSS, High Speed Steels

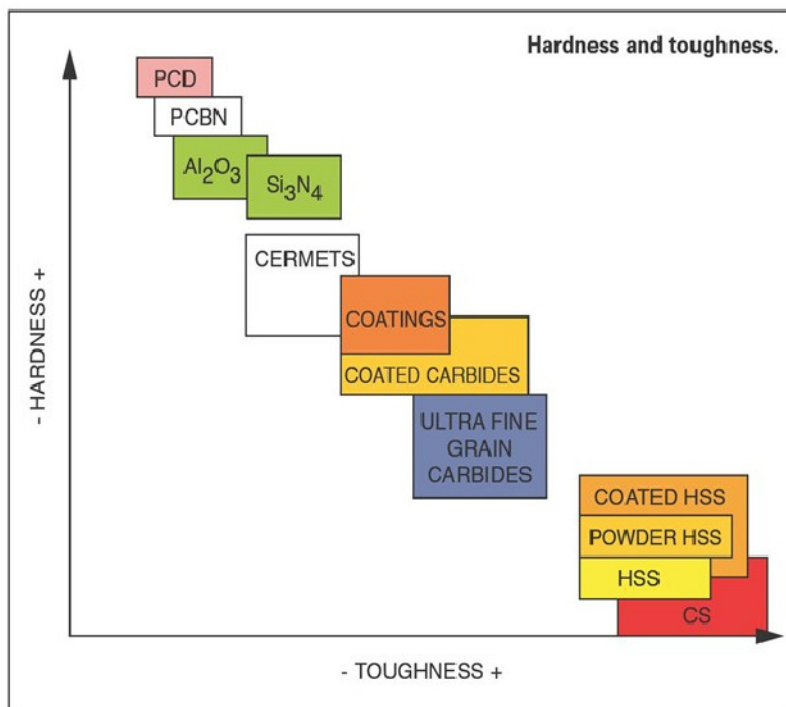
These have the benefit of improved hardness at higher temperature with little loss of toughness. They can be sharpened by grinding and lapping to very sharp edges. The compositions of typical HSS alloys were given earlier. HSS is difficult to harden and requires more than one tempering cycle. Unfortunately the hardening and tempering of HSS is not possible in a Home Workshop.

HSS is starting to lose its hardness at about 650C. The marking of the grade of HSS used to make the tool, even amongst reputable manufacturers, is quite infrequent. I had to search through quite a lot of tools to find those shown in **photo 2**. The tool at the top, a core drill, is marked HSS but M2 on the box. The 10mm threaded shank milling cutter at



**Photo 4 Brazed carbide lathe tooling.**





the bottom is clearly marked M42 and the drill in the centre is marked HSS-E. A more modern nomenclature used by some quality manufacturers is HSCo-8, i.e. HSS with 8% Cobalt.

### Powdered HSS

These are relatively newer products that adopt manufacturing advances made originally with carbides. Amazingly, HSS can be powdered by atomising liquid HSS with an inert gas, nitrogen, and cooling the droplets before they can condense back to a liquid. HSS powders are pressed under vacuum and heated to fuse the binder. The result is a very fine grain HSS containing no voids that can then be processed as normal HSS. The material also has the advantage of many fewer and smaller micro slag inclusions than a standard HSS, giving better tool edges.

This material is 2 to 3 times more expensive than HSS and is unlikely to show any dramatic performance benefit on relatively low-powered unstable machine tools that inhabit our workshops. If you know differently, let me know. Tools made of this material are sometimes marked HHS-E or even HHS-E-PM, but each manufacturer seems to have his own ideas on this point.

**Photo 3** Shows a screwed shank, 8% Co HSS-E end mill. The manufacturer Presto has a good website for further information about HSS grades that they use. **Ref. 6.** Erasteel claim to be the largest producer of HSS, see **Ref. 7** for their website.

### Ultra Fine Grain Carbides

These materials are made by vacuum pressing powders made from WC and a binder, usually cobalt and subsequently heating the formed shape to cause the binder to fuse and wet all the carbide particles surfaces. The result is a void free composite material that looks like a metal but is actually made of carbide grains embedded in the cobalt binder and is a metal matrix composite, sometimes called cemented carbide. There are several

methods of carrying out the pressing and fusing process. HIP, Hot Iso Static pressing at up to 1400C and 30,000psi is often used.

Greenwood Tools, **Ref. 8** uses the rather neat analogy of road surfacing material that is made of hard stone coated with asphalt binder. The stone provides the wear resistance and the asphalt acts as a shock absorber. The sintered insert shapes may be further processed, if they are complex, by grinding with a diamond wheel on a 5-axis CNC grinder. The cemented carbide production process actually produces very little waste material.

The composition of the "carbide" is adjusted according to the use it will be put to, e.g. Carbides intended for rock drilling, wire drawing or woodworking are different from those we might find in a lathe turning insert. Higher levels of Cobalt binder make the insert more shock resistant but reduce the hardness.

Inserts for turning or milling are micro grain (Sub micron particle size) with perhaps 6% Co. For inserts that have to be brazed, like carbide tips for saw blades, milling cutters and lathe tools, more cobalt binder helps the braze to stick to the insert. **Photo 4** shows a variety of rather tired, brazed carbide lathe tooling.

Brazed insert milling, turning and boring cutters are still available and are quite inexpensive. The steel backing and the brazed bond provide shock resistance for the hard but brittle carbide. These carbide tipped brazed tools lasted for ages because you could re-sharpen the carbide tip on a "green grit" wheel. Notice that some of these lathe tools ISO style markings and grade descriptions, P30 and P40. The tips for brazing are still available. **Photo 5** shows a selection of old but unused brazing tips from my collection.

In use, the major failure of these brazed inserts was unequal thermal expansion of the steel tool, the brazed joint and the carbide tip.

Readers may have noted the comparatively recent and rapid appearance of "solid carbide" drills, saws, burs and milling cutters, see **photo 6**. From the top

there is a solid carbide combined drill and countersink with a whistle notch shank. Below that is a 16mm end mill made from P40 grade solid carbide. Below that is a 6.8mm solid carbide, coated drill, again made from P40 and finally a 3mm solid carbide inverted cone burr.

These are all made from micro grain WC produced as described above. They are immediately recognisable by their very high density, roughly twice that of HSS. Carbide rod is produced by extruding the mixed binder and carbide powder and sintering. The hardness and wear resistance of carbides increase with decreasing grain size.

### Mixed carbides and carbonitrides

Many commercial carbide grades don't just contain TC and a cobalt binder. Other metal carbides are often incorporated in the mix to adjust the properties, **Ref. 9**. It is said that the use of impure hydrogen in processing TC and TiC introduced ammonia into the process resulting in the inadvertent, if uncontrolled, introduction of TiN, titanium nitride. Nice story and probably some truth in it.

Despite all this production technology and the high price of tungsten metal, I have seen bulk (commercial) prices for small pressed and sintered carbide saw blade inserts for brazing at below 20p each!

### Coatings

Examination of HSS drills and cutters in the above photos shows them to be available in a variety of surface finishes. Some are gold, some simply polished and others black. Simply polishing the tool after sharpening to give a bright smooth surface can lead to problems with some metals sticking to the tool flutes. **Photo 7** shows an M6 uncoated HSS end mill with aluminium alloy fragments welded to the tool just in front of the cutting edges. When drilling deep holes, you can encounter similar problems.

Swarf evacuation from the cutting point also leads to a lot of erosion (wear) damage to the cutter. One way to avoid this welding and wear is to add a non-metallic surface coating with a low coefficient of friction and low thermal conductivity to the tool surface. HSS is often steam tempered to yield the familiar blue-black colour. This is an oxide layer that resists welding and also absorbs oil, adding some corrosion resistance. Of course once the tool is re-sharpened, the coating is removed from the cutting edge but it still provides a useful slippery surface to the flutes.

Considerably more sophisticated coatings are now available to tool manufacturers. The golden colour on the drill in **photo 2** does not extend right down the shank and this is a sure sign that the Titanium nitride coating, TiN (not Tin or TIN please advertisers), has been applied in a high vacuum PVD (Physical Vapour Deposition) finishing plant. Titanium Nitride is one of about 10 coatings of very high hardness, considerably harder than straight TC, that can be applied at very low pressures (10-4 to 10-6 torr) and 200 to 500C using plasma. These coatings can be applied to HSS, HSS-E, carbide inserts and cermets. **Ref. 10** is the website of a well known manufacturer of PVD coating plant.

Hardened and sharpened HSS Tools or





Photo 5 Carbide tips for brazing.



Photo 6 Solid Carbide tooling.

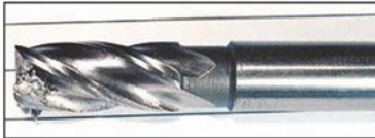


Photo 7 Alloy welded to M6 end mill.

carbide inserts to be coated have to be immaculately surface cleaned before batch PVD treatment. Many tool re-conditioners are now equipped with PVD plant that can restore coatings after regrounding.

PVD tool coatings are extremely thin layers, you won't be able to measure them with a mike' and often have characteristic colours. Strictly, they are ceramic coatings.

First generation tool coatings (1980's) were metal Nitrides of Ti, gold colour, Chromium, Cr, looks like chrome plating, and Zirconium, Zr, green gold. They are all harder than any HSS or carbide grade. Their disadvantages are their comparatively low, 500C, decomposition temperature that makes high speed dry machining a bit problematic.

Introducing a second metal, Aluminium, Al to the coatings gives coating colours of black to bronze depending on the metal ratio. TiAlN is a more thermally stable 800C and is protected from oxidation by an Aluminium oxide layer on the outside. More recently, multi layered coatings have become available, again applied by PVD and delivering extreme hardness (over 3000 Vickers) and improved toughness. The PVD process is very versatile and can be used to apply all sorts of surface coatings. For instance, low friction MoS2 coatings that have a lower coefficient of friction than PTFE. Think NASA and lubrication in Space and you should get the picture.

Chemical Vapour Deposition, CVD, is a process widely used in the electronics industry. Basically, a chemical vapour reacts with the heated substrate (insert) surface and chemically bonds to it. The CVD process can be used to make synthetic diamonds. CVD is not really

applicable to HSS tooling as the coating temperature is high enough to soften the HSS but it is used to coat some grades of Carbide inserts that are much more thermally stable than HSS.

### Cermets

A Cermet is a composite material formed from a ceramic and a metal. The metal is used as a binder for oxide, boride, carbide, or alumina. Cemented TC is strictly a Cermet but is usually described as a class in its own right. The Cermet binder metals are usually Cobalt, Nickel or Molybdenum.

Cermets are being used instead of tungsten carbide in saws and other brazed tools due to their superior wear and corrosion properties. TiCN, TiC, TiN and similar, can be brazed like tungsten carbide if properly prepared, however they require special handling during grinding.

Hence we are seeing materials developed as coatings in the PVD process being used in cermets in their own right. The methods used to make Carbides, described above, can be applied to other Cermets and all the major insert manufacturers offer Cermet grades for very high speed machining of difficult materials. If any reader has experience of turning or milling with exotic Cermets in a home workshop, please step forward and tell us all what happened and share your knowledge.

### Si3N4, Silicon Nitride

On first inspection, the prospects for the use of Silicon Nitride in engineering materials looks problematic. The material will not sinter and heating to 1850C causes the compound to dissociate back to silicon and Nitrogen. However ways have been found to reaction sinter Silicon Nitride powders and produce hard metals with some exotic properties. This is maybe one for the future?

### Al2O3, Aluminium Oxide, Alumina.

Ceramic or "cemented oxide" tools are made primarily from alumina and can contain additions of titanium, magnesium, chromium or zirconium oxides or silicon-carbide grains that are distributed homogeneously throughout the alumina matrix to improve toughness. They are made by powder pressing and sintering as described above. Cemented oxides are relatively brittle and require highly rigid and vibration-free machines and setups. They are chemically stable and have such high thermal stability that they can be used dry and at high speeds. They are said to be good for dry machining of exceptionally hard metals. They are unlikely to find use in home shops? Let me know if you know otherwise.

### PCBN, Polycrystalline Cubic Boron Nitride

Next to diamond in hardness, PCBN wheels have been used for some time to sharpen HSS and other tooling by grinding. Boron Nitride is insoluble in iron, nickel and related alloys, unlike diamond. Insert tooling tipped with CBN is available and used for the very high speed machining of cast iron, (Disk brakes).

### PCD. Polycrystalline Diamond.

Natural diamond is "pure" crystalline carbon and has been used for turning and wire drawing. Diamond is the hardest

material available and yet diamonds can be used to polish diamonds, probably because diamond shows cleavage planes. Diamond has a thermal conductivity much higher than silver or copper but has a number of disadvantages in addition to its brittleness. Heated to 1100C, it slowly converts to graphite. Heated to 850C in oxygen/air it will burn to CO2 and heated with iron it is rapidly absorbed by the iron. Hence diamond grinding wheels should not be used on ferrous alloys if there is any risk of high temperatures being created.

Polycrystalline diamond is made synthetically from carbon (dirt cheap) under extremes of pressure and temperature. You may already have some of these synthetic diamonds on diamond files and plates or grinding pastes in your workshop. The diamonds on files always seem to me to have been secured in place on the support by electroplating, but maybe I'm wrong and one of our readers' can correct me?

Certainly diamond has a very high electrical conductivity, which would aid electroplating.

The concentration of diamond on a file is much higher than a ceramic tile cutting saw where the diamond particles look as if they have been smeared into the metal surface.

In diamond sharpening wheels, which are extensively used for carbide tooling, the diamond particles are usually embedded in a tough rubber (resin) bond. The prices of these diamond files, plates and wheels have come within our scope in recent years. I find fine diamond files and plates excellent for hand sharpening HSS tool bits.

In polycrystalline diamond tool inserts, the diamond is sintered with a cobalt binder as described for carbide inserts. They are used commercially for the high speed machining of tough aluminium alloys.

### Health & safety

I am obliged to state the obvious. Many of the inserts described are brittle and can shatter. Wear safety specs. Grinding of carbide inserts can cause dust that you should not be breathing. See the manufacturers Safety Data Sheets. (MSDS's.)

In the next article, I will concentrate on the ISO classification of materials and tooling inserts made of HSS and sintered Carbide, coated or uncoated.

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# Vice Squad Clampdown

Jim Whetren restrains his work

## Background

Some years ago, a work colleague acquired a fire damaged 'Startrite' drilling machine from his local garage, which he found to be oversize for his intended use. I was fortunate in that he agreed to swap it for my smaller budget imported drill, leaving me with the task of replacing smoke damaged label plates and melted plastic ball handles.

I have found my new acquisition to be ideally suited to my use. It is equipped with a No.2 Morse taper spindle and an epicyclic gearbox, giving a range of 10 speeds from 95 to 3830 RPM. The gearbox provides an instant speed change from drilling speed to a reduced speed for countersinking etc. Also in the neutral position, the spindle is completely free to rotate allowing tapping to be carried out in situ without disturbing the work.

I have since made some minor alterations and additions to the machine and found a different way to secure the vice to the table.

## Table Support

The table is clamped to the pillar with a handle operating on split cotters, which is effective in locking the table position, but there is no support under the table, so with a vice and work-piece in place, there is quite a bit of weight to support with one hand whilst the table is positioned correctly to commence drilling.

The head of the drill is free to rotate and be positioned anywhere upon the pillar, again it is locked with a handle and cotters. There is an aluminium split collar clamped to the pillar under the head to prevent it suddenly dropping during any adjustment, **photo 1**. Once the height has been set and found satisfactory, there is not really a need to move the head again.



**Photo 1** The head support clamp as supplied.

All the parts were removed from the pillar and the split collar replaced first. The nut on the pinch bolt was replaced with a handle operated nut to allow instant release of the collar, **photo 2**. The table was replaced and a new head safety stop made from strip material secured with an extended nut to give better access, **photo 3**.

## Vice Clamping Bar

The table has two slots running from front to back, **photo 4** that are at just the right spacing to accommodate a 'Nippy' vice, **photo 5**. This is a good quality item with angled ways to support the jaw keep plate which is finely adjusted with a screw and jacking screws allowing lift free movement, **photo 6**. The jaws are 83mm



**Photo 2** The head support clamp with added handle.



wide opening to 40mm with 'V' grooves everywhere. They have hardened step jaws with a capacity of 47mm. Although the 'Vs' allow round work to be held securely and provide drill clearance with narrow pieces, the hardened top jaws can mark the work if packing is not used.

A piece of  $\frac{3}{4}$ in. x  $\frac{3}{4}$ in. flat bar was cut off to span the table slots by 19mm each side, and drilled 10mm for the vice securing bolts and tapped M10 in the centre for the clamping handle.

A piece of  $\frac{3}{4}$ in. x  $\frac{3}{4}$ in. flat was cut off to the same length and clamped to the thicker piece to drill through M4 tapping size at 30mm from each end and to spot through the outer fixing holes. This bar acts as a stop piece for the clamping



**Photo 3** The safety clamp.



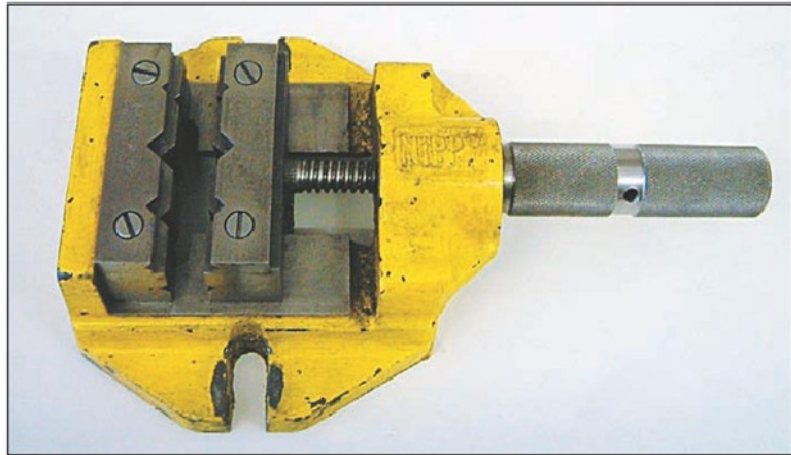


**Photo 4 The drill table**

screw, it's necessary due to the central hole in the table. The thinner piece is tapped M4 and the 10mm clearance holes drilled. The other piece is drilled M4 clearance and counterbored for two pan head screws to keep the pieces aligned with a gap of about 3mm **photo 7**.

Although not my first choice for a handle, it was made as in the photo to be in keeping with the factory fitted items. A piece of 10mm dia. rod is threaded for about 25mm at one end and the piece screwed into the clamp to lock the vice to the table. The bend location is marked so that the handle will point to the front in the locked position, giving an arc of movement in front of the table when in use. After the bend was put on at about 70deg., a plastic ball knob was fitted onto the end, again as used for the other handles, **photo 8**.

When first made, the clamp was tapped M10 for hex. bolts to secure the vice, but as there is a need to remove the vice to clamp work directly onto the table, or use a different vice, swarf collected in the threads made bolt replacement difficult, as they are only tightened by hand to take up clearance, the locking



**Photo 5 A nippy vice.**

being done with the handle.

Two knurled peg bolts were made as replacements, **photo 9** and two slots and stop pins provided in the clamp bar so the new bolts could be inserted and given half a turn clockwise to lock them in place and the handle used as previously. The tops of the knurled knobs were marked on the pin side to allow easy engagement with the retaining slot, **photo 10**. The fitted view is shown in **photo 11**.

No specific measurements are given due to the variation of tables and vices likely to be used, but the pictures should illustrate the requirements. However, when deciding on the free space between the clamping bars and the placing of the peg in the vice bolts, there should be enough movement to accommodate the variations in the thickness of the clamping flanges of the vices intended to be used.

### More Capacity

Although a well made item adequate for the majority of drilling jobs, the Nippy vice does fall short somewhat on the jaw capacity, so a wider opening vice is also required.

On a visit to B&Q I saw a budget vice on offer for £6, which appeared to be a

bit 'cheap', **photo 12**. On examination, it was quite well made, with the same jacking screw arrangement to allow fine setting of the jaw movement, **photo 13**. The vice was branded 'Rexon' with a jaw width of 98mm, opening to 90mm with 98mm available in the jaw steps, so the vice was purchased.

The slots in the base were slightly wider spaced than those in the drill table, but with the bolts being 10mm dia. and both vice and table slots being about 12mm wide, the clamping system could still be used, **photo 14**.

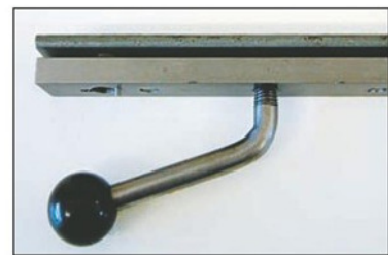
The only work needed on the vice was to clamp it to the table of the mill with the jaws fully tightened, and run a 6mm end mill along the stepped area to even up the bottoms of the steps.

### Recycling

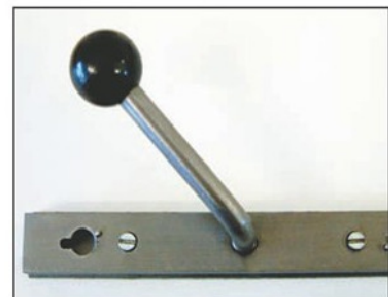
In order to secure work directly to the table, I modified an old 'Mole' wrench, **photo 15** which will lock from nothing to 75mm, **photo 16**. I know these clamps are available in the shops, but I had a redundant pair of grips, and the money can be used for something that can't be made.



**Photo 6 Adjustable jaw adjusters.**



**Photo 7 The vice clamp.**



**Photo 8 Another view of the vice clamp.**





Photo 9 Peg bolts.

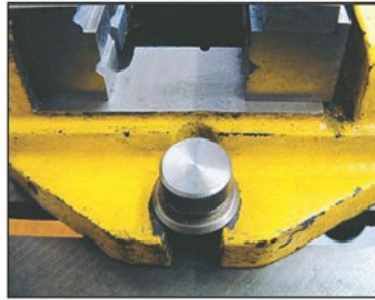


Photo 10 Peg bolt located in Nippy vice.

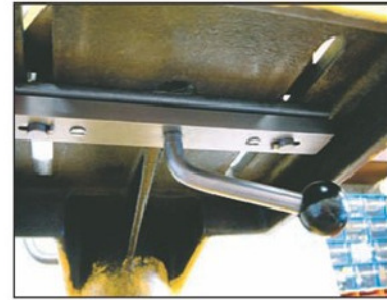


Photo 11 The clamp locked underneath the table.

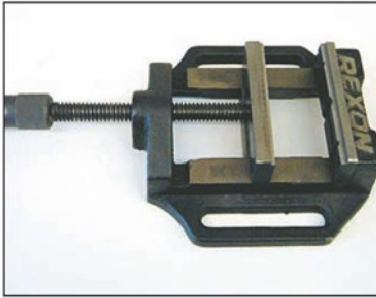


Photo 12 The Rexon vice.

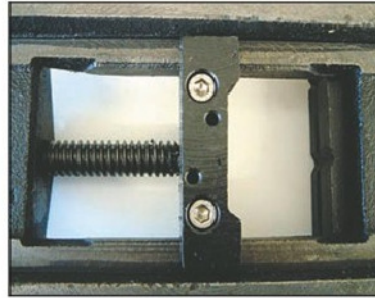


Photo 13 The Rexon jaw adjusters.

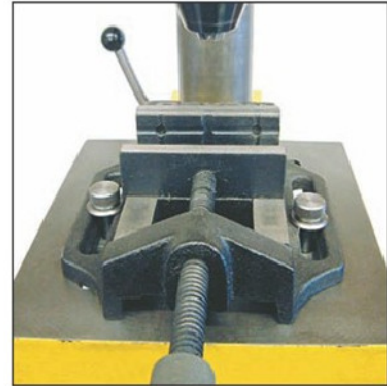


Photo 14 The Rexon vice fitted to the drill

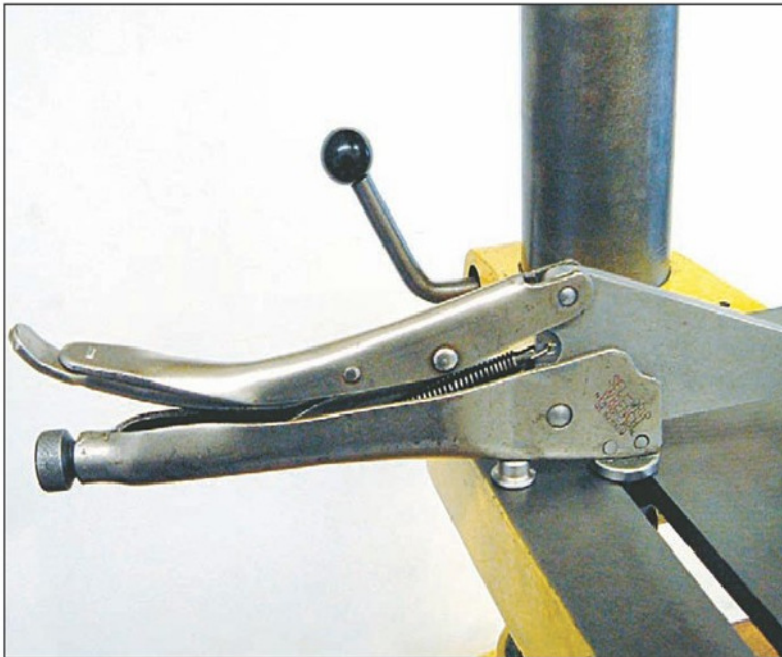


Photo 15 A Mole wrench clamp.

### Depth Stop

The drill uses the lock nuts on a flat-sided stud method of limiting the drilling depth, **photo 17** which does not get the required amount of use due to the fiddle involved in the setting. To make life easier, a new collar was made with a hole drilled and filed to match the oval shape of the stud, **photo 18** and secured with a knurled screw, which happened to be lying in a drawer. Now the required depth can be instantly set, **photo 19**.

### Depth Indication

Having a means of easily setting the depth, there is no means provided to indicate the depth. The capstan

was removed and the three handles dismantled to allow the machining of a boss on the casting, **photo 20** to accept a calibrated friction dial with three pieces of watch spring to provide the friction **photos 21 & 22**.

The odd choice of material is due to the only piece available at the right diameter was an old three step round belt pulley in the scrap box. The maximum travel was measured and found to be 90mm with the stop removed, so a 90 tooth change wheel was used to graduate the collar. A small shaped plate was attached next to the collar with a screw to carry the fiducial line, **photo 23**. One complete revolution is 90 mm travel but only 80 divisions were

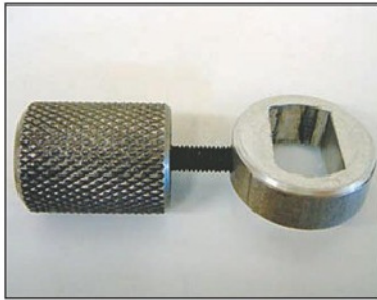


Photo 16 The maximum capacity of the Mole wrench.

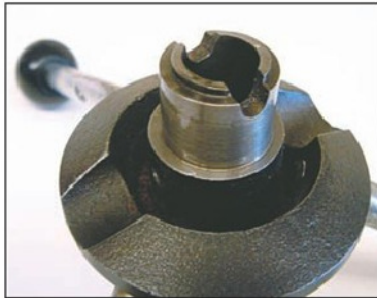


Photo 17 The added screw stop.





**Photo 18** The screw stop.



**Photo 20** The turned boss.

engraved on the dial, as the dial travel is limited to 80mm. That left a gap of 10 divisions, which can be seen in **photo 23**.

In use the drill bit is lowered to touch the work and the dial set to zero and either the drilling commenced to the required depth indication on the dial, or with the work moved clear, the drill lowered to the required indicated depth and the stop locked in place. The work is returned to the correct position and the hole drilled to the stop.

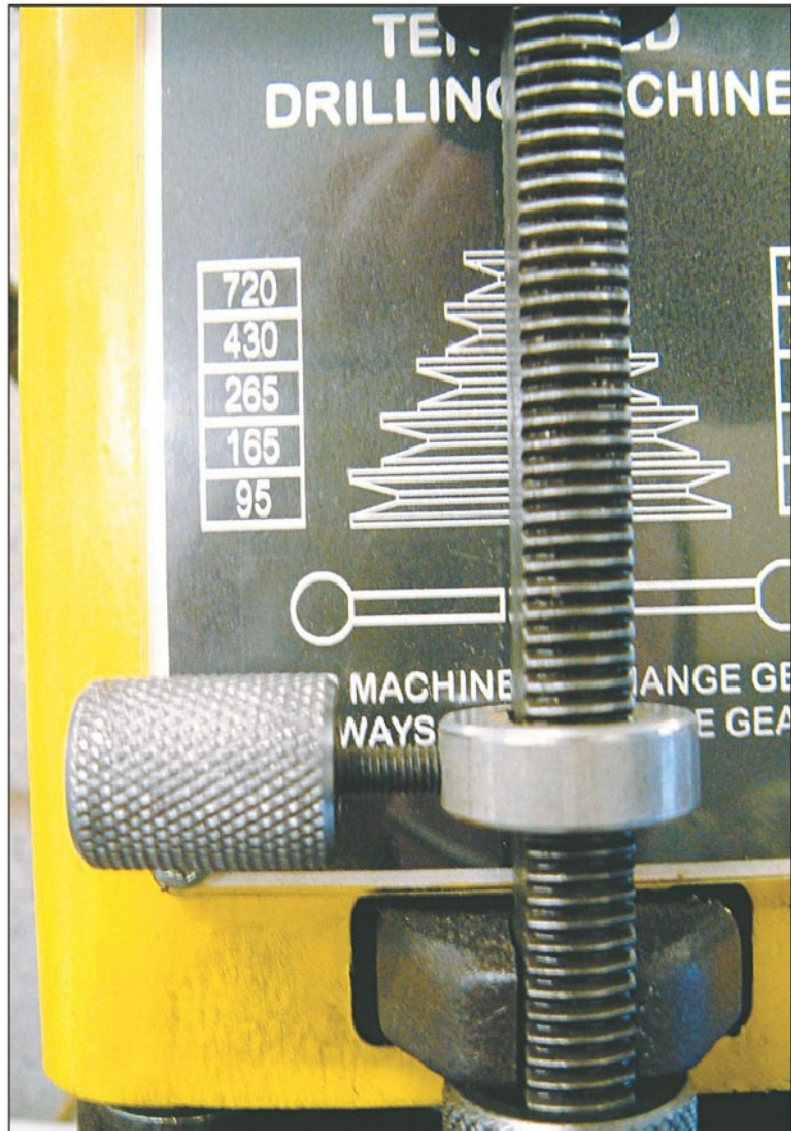
### Drilling Safely

There is no doubt that all work should be firmly secured for drilling, perhaps with the exception of a very small hole in a very large work piece. Human nature being what it is, if the securing of the work involves any form of fiddling, using the right spanner etc. then the fiddling will probably be avoided and the operation carried out without it.

Because the vice clamp bar arrangement is so easily and instantly locked after the vice has been slid into the appropriate position, then ALL drilling operations are carried out with the work held in a vice and with the vice locked



**Photo 21** The dial.



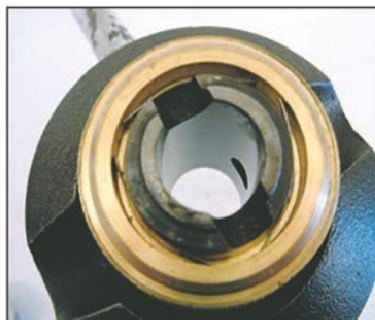
**Photo 19** The stop set in place.

down on the table.

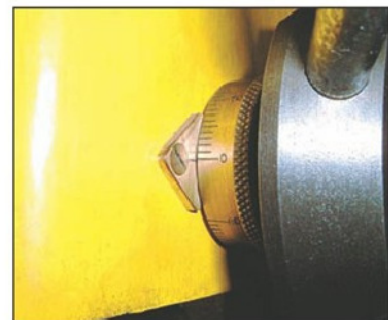
Although what has been described relates to a Startrite drilling machine, any machine without the benefit of a rack rise and fall to the table will be made easier to use with a collar fitted under the table, allowing it to rotate about the pillar without the fear of it suddenly dropping, or the risk of hitting the drill bit when lifting it together with the weight of the vice and the work-piece.

The vice locking system will apply to any

through slotted drill table with the exception of tables which rotate around a boss on the attachment arm. However in the case of rotating tables, the clamp bar could be split and the pieces joined with a U shaped bracket, with a larger bearing piece for the locking handle which would bear on the base of the central boss. If the vice used had slotted clamping flanges, then the lock screw bearing piece would not need to move very far from the central position on the boss.



**Photo 22** The friction springs in place.



**Photo 23** The added depth collar.



# SOME THOUGHTS ABOUT THE 12TH LONDON MODEL ENGINEERING EXHIBITION by "Richmond"

**B**eing used to spending 4 hours in the car and driving 210 miles to work at a remote office, the prospect of driving to London for a "fun" day at the exhibition wasn't daunting, especially with my friend Harry's company to look forward to, rather than the radio or CD player.

The 12th London Model Engineering Exhibition held at Alexandra Palace boasts being the largest Model Engineering and Modelling Exhibition in the south. I am not so sure about the Model Engineering part being correct, but more of that later. We visited on Friday, having assumed that most people would be at work. We were obviously wrong! Having press passes we managed to avoid the long queues to get in at 11am, and this despite the exhibition already having been open for an hour as we were delayed on the dreaded North Circular (A406).

The venue itself is impressive, with the large exhibition hall dominated at one end by the organ stand (currently under repair) and the large ornate stained glass window at the other end, **photo 1**. A third of the hall was taken up with demonstration areas for model flying, tanks, the miniature railway, and hovercraft, with club and trade stands occupying the rest of the space. Rest areas were provided at either end of the hall adjacent to the loos and close to the refreshment stands. There were also 30 minute queues for food and drink.

Normally, at shows, I do a quick scout around to see what tools and tooling are on display before returning to spend more time on each item found. However, so little was in evidence on the club stands that the quick scout around took a lot longer than usual due to having to look in all the nooks and crannies trying to find something. There also didn't appear to be a competition table. Maybe because the theme of the show was modelling in

general as well as Model Engineering, people thought that tools and tooling were not of interest to the paying public?

Of course, the usual trade stands were in evidence and were swamped with people 3 deep buying the "show specials". Surprisingly, despite London's reputation for high prices, they appeared to both of us to be very competitive (we do have to keep up the Yorkshireman's reputation for frugality you know), but we both "splashed the cash" on some much needed workshop basics.

The most striking thing about the show was that being indoors, there were no "live steam" displays, except for the gauge 1 and miniature railway. With the large grounds available this was a surprise. The RC aircraft models, tanks and hovercraft were all battery powered, and there were some impressive flying displays.

Bob Symes, of TV fame was also in attendance and despite his advancing years seemed very sprightly. He is still involved in TV and produces voiceovers for many railways films. He even has his own YouTube channel, <http://www.youtube.com/bobsymes>

OK, more about the club stands. These were many and consisted mainly of locos, with some outstanding models on display. Many of the members were also present to discuss the models with the visitors. It is a shame though that there wasn't more tooling on display, but I can imagine that the majority of layman visitors would prefer to see the end product, as opposed to the tools that made them. Having said that, transporting locos around to exhibitions does show dedication to the clubs as well as the hobby, so all power to those that displayed at the exhibition.

Of interest to those that make locos will be the Large Radius Milling Attachment, **photo 2** exhibited by Peter Pardington of Ickenham



**Photo 1**

and District MES. This device is capable of radiuses in excess of 15in. In use, the device is fixed to the mill table, and the peg on the right is clocked true to the spindle of the mill, before final clamping down. The table is then indexed along by the radius required and the work clamped in place. Milling can then take place.

Also by Mr Pardington is the Tapping and Staking tool to the George Thomas design, **photo 3**. Although this piece closely follows the original design, it does differ in terms of the motor, where it drives the spindle direct as opposed to the original, which was driven via adjustable jockey pulleys.

Moving to the Romford MES stand I met Roy Nixon who specialises in restoring "classic" tools. On display were an Myford ML1, **photo 4**, an Adept No 2 shaper, **photo 5** and a Cowells Shaper. He tells me that this is but a small part of the collection. The eagle eyed amongst you will notice that one of the top slides is cracked. Roy has a close match replacement sitting next to it in the photo,



**Photo 2**



**Photo 3**





Photo 4

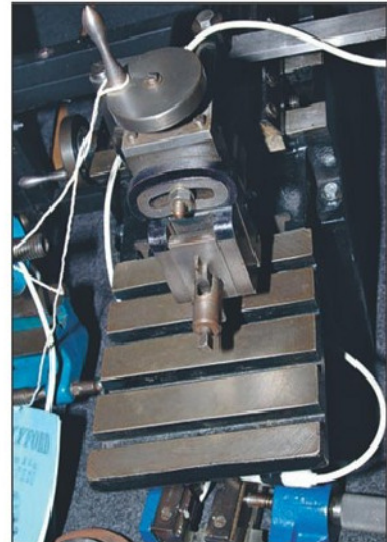


Photo 5

but is keen to get the original if possible and he is always looking out for parts, so please contact him via the club. **Photo 6** shows the Cowells prior to restoration. Unfortunately, this scribe failed to take a picture of the finished article, the excuse being that SWMBO called my mobile at an inopportune moment – my penance was to buy the beer once we got home!

Tonbridge MES had an excellent display of tools, **photo 7**, comprising a Spotting Tool, Finger Tool, Ball Turning Attachment, Graduating Tool and a Thin Piece Travelling Steady amongst other things. All excellently finished, they are a credit to the unknown maker(s).

Given that this show had a Model Engineering and Modelling theme it was interesting to see some of the other traders not normally present at an ME show. One trader selling Airfix kits brought back some good memories from my childhood, and I was nearly tempted to buy "Bismarck".

Overall, we enjoyed the show, but felt that it wasn't of the scale of Ascot and didn't appear to have the outdoor "live steam" displays, hence my contention that it might not be the largest ME show in the south. Travelling for about 9 hours for a day at the show, in hindsight, is a long time in the car, and perhaps we should have broken things up with a night in the "smoke". Would we do it again? Maybe.

In some ways I am biased in that I don't just want to see locos at ME exhibitions, I want to see Sterling Engines, Traction Engines in steam and watch IC engines running. I like the workshop demonstrations and chatting to people about hints and tips about how to produce the finished product in a timely yet fun manner, yet with a quality finish. Maybe that is why I like tools and tooling so much. If you can get that part right, it makes the hobby and the production of models so much more fun. Some people see this aspect of the hobby as a means to an end, I don't. So please, if you exhibit at model exhibitions bring along the tooling as well as the model. Share the knowledge, and the tips of successful model building.

Comments and criticisms are welcome.

You can contact via e-mail me at: [richmond@richmonddr.karoo.co.uk](mailto:richmond@richmonddr.karoo.co.uk)

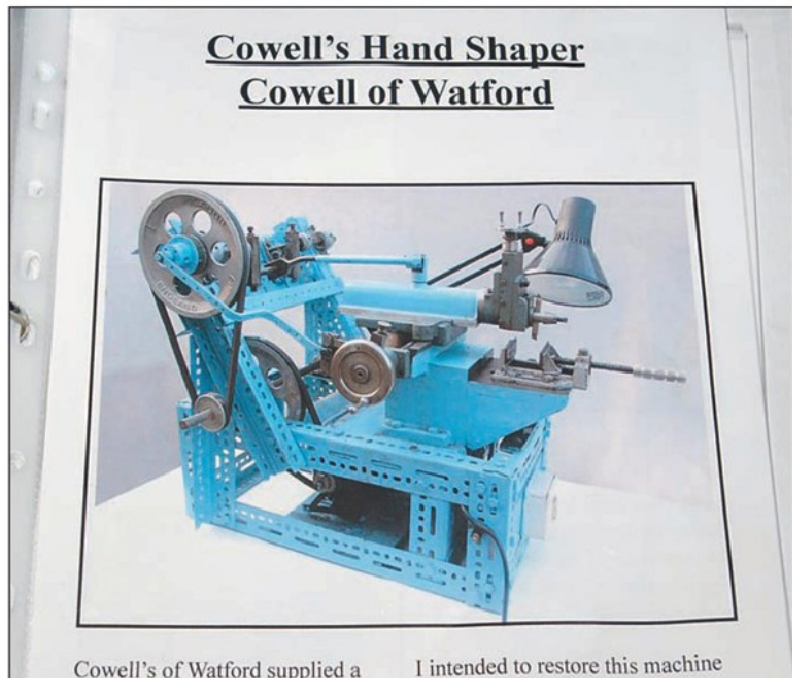


Photo 6

Cowell's of Watford supplied a

I intended to restore this machine



Photo 7



# A BETWEEN CENTRES BORING BAR WITH FINE ADJUSTMENT

Paul Murton tackles a boring job

## Background

This project came about from a need to line bore some bearing housings for an alternative energy project I am planning using the stepper motor from a New Zealand designed Fisher & Paykel smart drive washing machine. New Zealand fully metricated in the 1960's so all the dimensions are in mm except where related to the 1/2in. high speed steel tool bit used. The boring bar is designed to bore holes from about 40mm up to 80mm diameter, **photo 1**. For smaller holes the dimensions can be scaled down and a smaller tool bit used. You can make the bar any length to suit your particular purposes. I made mine 400mm long with the position of the cutter off centre about 50mm towards the tailstock end. The basic design of the adjusting mechanism can also be used for a collet mounted boring head for the mill.

## The bar

A 400mm long piece of 32mm dia. mild steel bar was faced and centre drilled on both ends. The bar was placed in the milling vice as shown with the area to be drilled for the cutter overhanging the vice by about 30mm. Centre the length of steel in the vice then offset the table 1mm away from you, see **Fig. 1**.

Firstly mill a flat on the bar at the adjusting screw location to start the centre drill then drill 5mm right through the bar. Open this out with a 7.8mm drill to a depth of about 22mm then finish with an 8mm end mill to a depth of 24mm. Without removing the bar from the vice, traverse the table along 9mm to the tool holder location. Drill a 12mm hole then bore it out to 18mm. The two holes will overlap so a 12mm drill is about as big as you can go without the drill running off too much, **photo 2**.

Slacken the vice and rotate the bar through 180 degrees. Move the table 2mm towards you to allow for the offset. Place a piece of 5mm silver steel or equivalent in the milling chuck and centre the 5mm dia hole in the bar with it. Tighten the vice and the bar should be accurately located under the centre of the arbor. Mill a flat on the bar as shown in the drawing. Transfer the bar to the lathe and reduce the ends to 25mm diameter.

## The tool holder, Fig. 2

There is some accurate machining required here so take care. To make the threaded half hole, I used a piece of 32mm



Photo 1 The finished boring bar.

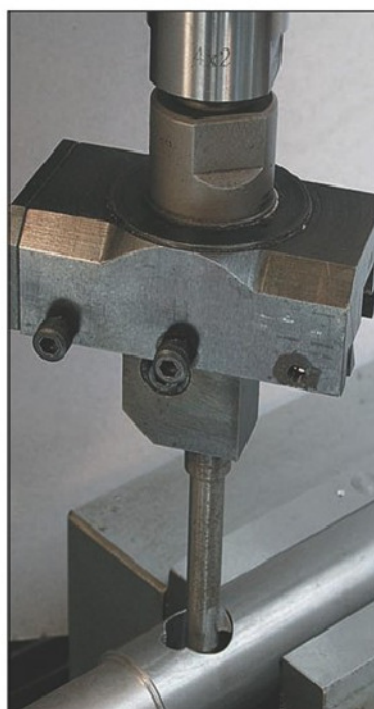
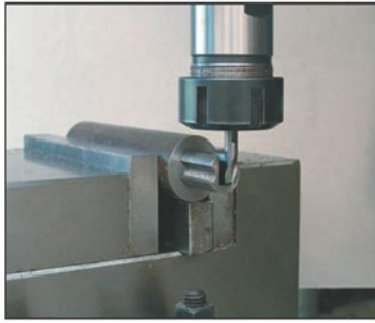


Photo 2 Boring the hole for the tool holder.



Photo 3 Drilling and tapping the offset hole.





**Photo 4** Milling the slot in the tool holder.



**Photo 5** Engraving the divisions on the dial.



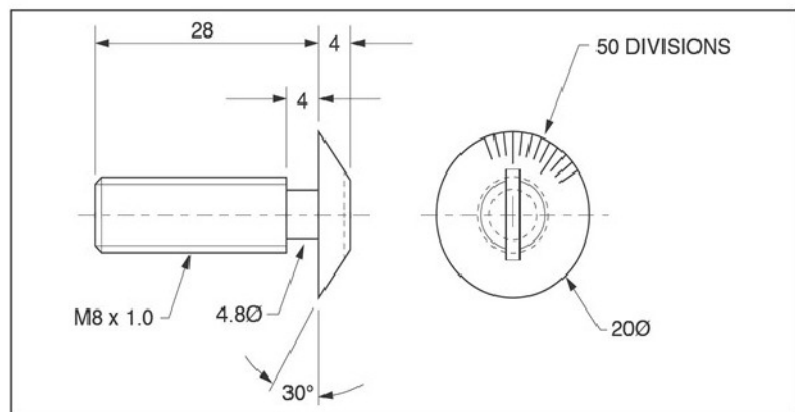
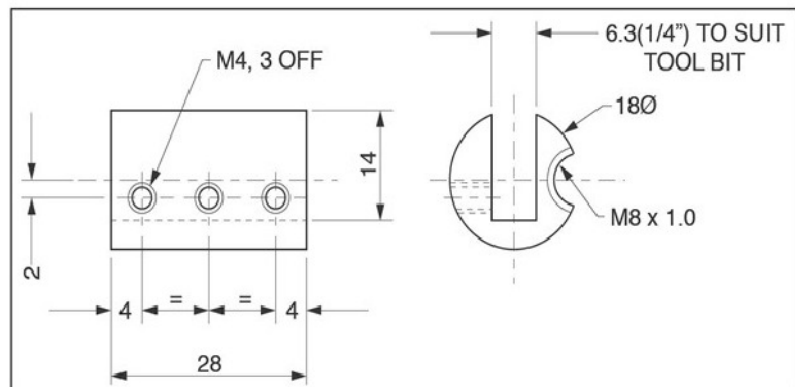
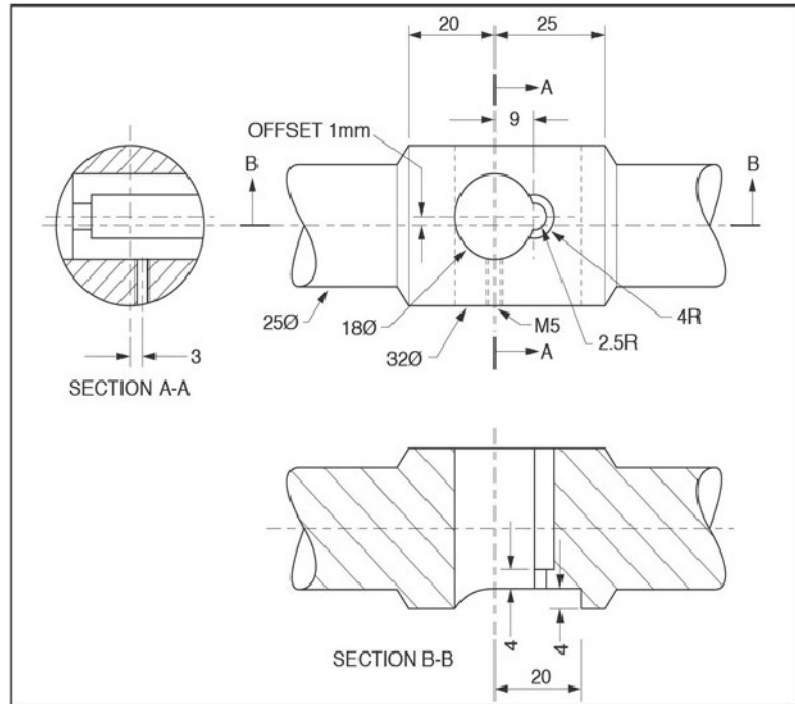
**Photo 6** The three parts of the boring bar.

dia x 100mm long piece of tool steel. Grip this work piece in the three-jaw chuck and skim the surface to true it up. Transfer the chuck to the rotary table on the mill and centre it under the arbor. Offset it by 9mm then drill and tap the 8mm x 1mm pitch thread to a depth of about 30mm, **Fig. 2**. Ideally a left hand threaded tap should be used here so that you turn the dial clockwise to advance the cutter, **photo 3**.

If you don't have a rotary table you could use a vee block in the vice on the mill. Transfer the work back to the lathe and turn the diameter down to 18mm to be a sliding fit in the boring bar. This will expose the half thread. Because the finished holder is difficult to hold in a vice without crushing, it is necessary to machine the slot for the tool bit while it is still attached to its parent bar. Make sure that the slot is at right angles to the threaded half hole, **photo 4**. Transfer the job back to the lathe and part it off. Drill and tap the three 4mm holes for holding the tool bit. Harden and temper the holder if tool steel has been used.

### The dial

This is a straightforward turning job. Clamp a piece of 20mm mild steel bar in the three jaw chuck and machine the threaded end to the dimensions shown. Part off and reverse the job in the chuck using sheet copper to protect the thread. A collet chuck would be ideal here.



Face off and shape the 30Deg. angle of the dial. I indexed and inscribed the dial while it was still set up using the rotary table locked into the headstock spindle, **photo 5**. Divide into 50 divisions making every fifth division 4mm long with the in between ones 2mm. This makes each small division amount to a movement of the tool bit of 0.02mm and every large division 0.1mm. The screwdriver slot was cut using a small slitting saw and the cut was made more towards one side to provide a zero reference point, **Fig. 3**.

**Photo 6** shows the three parts that make up the boring bar.

### Using the boring bar

Set the tool bit into the holder so that it protrudes the minimum amount required to start the hole size you are boring. Assemble the holder into the bar and set it back as far as possible. This leaves about 12mm of adjustment available. When making fine adjustments, take up the backlash before undoing the locking screw and moving the cutter.



# LAYING OUT A WORKSHOP

Michael Green makes room

**W**hen I first saw the letter in MEW 133 asking about laying out workshops, like the editor I thought that I was bound to have that information as I've been doing layouts in factories (off and on) for the last 20 years. Looking through some of the handbooks I have, I was surprised to find that only one of them mentioned clearance distances around machines and then only in passing. Having failed in this respect, it was time to fall back on plan 'B' – trying to formulate rules based on my practical knowledge. I realised that there are some slight differences between industrial practice and what would be done in the home workshop, but these are not significant.

To start with, there are two questions that must be answered before any serious layout work can be done. These are –

- What is it that is to be made, and
- What equipment is going to be used to do this?

Simple questions, but they cut to the heart of the matter. For example, in the home situation a clock-making workshop will be quite different from that of a large-scale traction engine enthusiast. That is not to say that things can't change. It is important not to be afraid to change a layout if needs change. I had significant changes in layout when my mill arrived and then again when I got a shaper.

Once you have an idea of the type of equipment that you want in your workspace, you can make a start. Sizes are needed. There are several that might be applicable. Some of these might have to be a guess although there are brochures out there for most things and if you find someone who has a similar piece of equipment they may be able to provide some dimensions.

## Footprint and extended dimensions

For a start there is a footprint dimension. This is the space on the floor that the machine is in contact with. If you have to get concrete pads poured this is the one that influences those. Then there is the area of the machine that is projected onto the floor in plan view. Most machines take up more space than their footprint – this includes parts that overhang the footprint, such as slides, drip trays, motors and control handles. This is the one that is normally used for layout purposes. The final variation is an extended plan view, where the machine at its maximum extents is used. This includes slides at the full extent of their travels (in all directions), access doors open and any other condition that may cause the machine to use 'extra' space over a plan view. This is used in a layout plan for things that can change shape a lot. For example, I would use a normal plan view for lathes and drill presses but an extended one for a mill.

Normal industrial practice is to allow 600mm (2ft) around a machine for access, although I have also seen the figure of 850mm (2ft 10in.). 600mm is the dimension that is mandated as a minimum in Australian standards for access. This



**Photo 1** Use storage under the vice and drill press (Vertical thinking). The extra weight keeps the stand in one place more easily. The small drawer among other things holds vice soft jaws and the drill drift. (The grey thing under the drill table is a swarf catching device).

space is sufficient for a normal sized person to move past. Here the home workshop has an advantage over industry because at home this figure can be reduced if desired. Summarising these constraints,

## CONSTRAINTS

### INDUSTRY

- Occupational Health and Safety Standards
- Multiple Workers
- Preferences of others in the organisation

### HOME WORKSHOP

- Space
- Money
- Tooling is in the same area

As well as having to conform to OH&S standards, in an industrial situation personal preferences are more difficult to take into account and others (such as managers or a layout department) may also have overriding demands about how things should be done. However, in the home situation most of us are constrained by limited space, limited money and usually everything is in that space (that is, there is no tool crib to park little used tooling in). Every rose has its thorns.

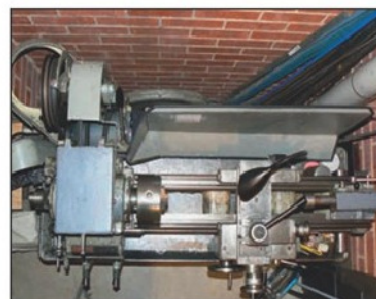
Whatever the number chosen, it should be allowed on all sides of the machine that access is required. For example, access is rarely required to the back of a drill press. While I have said that industry is constrained by OH&S rules, the home workshop should still be planned to be safe. This may mean the obvious – things like keeping small children out to the less obvious – such as that wooden floors should be avoided in welding areas. For a

home workshop, safety is also looking to the future. Although I can lift stupidly heavy items now, I'm looking at some lifting equipment so that when I'm older and wiser I have other options available to me.

While collecting sizes and work envelopes for equipment, you also need a plan of the space available. If you have a CAD package this is ideal, but a plan on paper is perfectly useable. Pick a scale that allows reasonable detail without being unwieldy. I can remember the boards in a factory layout area (before computers) being 6'x12', but this is a little excessive for a home workshop. On the plan of the space should be power, lighting and access points (doors, windows). Draw the equipment to the same scale and then shuffle things around. Another thing to be drawn is a person in plan view – a scale representation of the user, normally with arms out (with elbows to the sides) to simulate a 'worker'.

A few 'rules' (designed to be broken) that may help –

- Consider putting non used sides of equipment against a wall, remembering that while some sides may not need person access, access may still be needed for material.
- Zone your equipment where possible – for example, put the drill press near your lathe so you can share drill bits. Locate a welding set near the Oxy set. This makes it easier to locate common equipment and facilities
- Consider putting fixed (immovable) objects next to walls, while more portable items can be on wheels or trolleys. In a home workshop with only one user these can be stored in access ways and moved elsewhere when that particular machine needs to be reached.
- Think vertically – what can be stored under or over other things? Can benches made to support small equipment (say a bench grinder) have cupboards or drawers underneath to keep other things safely?
- Remember to incorporate storage into the plan. A friend of mine once



**Photo 2** An overhead view of the lathe. (Non used sides are against the wall). The tailstock just touches the wall when its clamp cannot grip the bed. The headstock door clears the bench next to the lathe and the belt cover just clears the wall. There is a gap of 300mm (12in.) behind the lathe that gives limited access if needed.





**Photo 3** Storage on storage on storage, (storage in the plan). Flat surfaces tend to accumulate 'stuff', so use them for planned storage to avoid clutter. (Alternatively, a car plant I worked in fitted sloping tops to lockers to avoid the clutter)

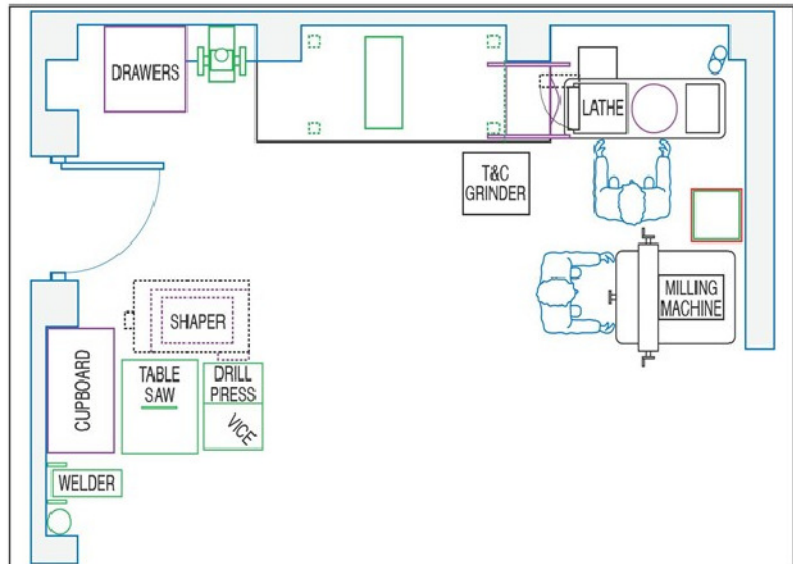


**Photo 4** Zoning – Above the welder are the rods and other welding small tools, gas and filler rods are to the left, helmet and gas torch stored to the right. The blue frame is a folding welding table with a detachable top. This is the edge of 'my space' so there is also a bike hanging from the roof.

commented that getting a mill was the cheap part. The tooling for it would double the cost of the exercise (and double the amount of space that the whole thing would require). He was wrong as I estimate that the cost and space is significantly more than that.

The CAD printout is of my workshop – half a garage. This was the last layout I did for this workspace and demonstrates the gist of the article. Note that some layers are off to reduce clutter (lights and power for example). Starting with me standing in front of the mill, it can be seen I have no problems with getting to it. Behind on my left is a T&C grinder (work in progress) that is on a wheeled trolley, so it can be moved to where it is convenient.

To the left of the mill is the lathe, where my clone is standing on the business side of things. He looks uncomfortable as he has a mill handle in his back, but usually I crank the table over so that it is not a problem. (In an industrial setting this would not work as multiple people may be using both pieces of equipment at the same time). When I'm finished for the day I crank the table towards the lathe so it is



**Photo 5** The mill in its stowed position, (storing in machine access way). The slide intrudes into the lathe operating space, but as a single person workshop, that does not matter. The tape measure on top says 300mm (12in.) between the two. Just on the edge of frame you can see the roller door for vehicle access. Behind the mill there is a surface table on a stand. Access is similar to that for the lathe.

not such a big target for the car.

The dotted purple circle in the middle of the lathe is a rubbish bin stored between the lathe stand columns. On the left end of the lathe is a door for changing gears. I've drawn it open to show clearance. It actually opens over the end of the main bench but the heights work in my favour. Headstock access for long stock is over the bench, but I rarely have stock over a metre long and usually much shorter.

The shaper has a variety of dotted lines, as the footprint is smaller than the plan view, which in turn is smaller than the full extent of possible travels. The purple rectangle against the wall is a set of metal shelving, while the purple square by the bench grinder is a set of metal drawers.



**Photo 6** Shaper controls are accessed from the aisle way (machine operation from aisle ways) – a no-no in an industrial setting but all right at home. V belt changes are made from a space behind the drill press.

The bench the drill press is on also has storage under it. Industrially, a lot of the things in these areas would be in a tool crib elsewhere but in a home workshop it's there with you. The table saw is on wheels so that the shelves can be accessed when needed. The welder is also on wheels so it can be better positioned when needed.

A good layout is not difficult to develop, and certainly makes working in a space a lot less frustrating. Even established workshops can do with a re-layout if their purpose has changed. For a hobbyist there is also a tendency to improve a workshop by slow accumulation, so thinking about the layout every so often is not a bad idea. If ever you have thoughts about how awkward it is to get to something while in the middle of a task then workshop layout is something to consider and working things out on paper is certainly easier than trial and error with large lumps of Cast Iron.



# MAKING SOLID SWARF!

John Slater combines trepanning and parting off.

**P**eople I meet (once they become aware that I've a private workshop) often ask, "What do you make?" My usual response is: swarf! Some of it curly and some of it in small pieces!

Seriously, I get a deal of satisfaction just from making swarf and by that I mean deploying methods and processes with some skill and knowledge to make things. (I do know how sad this makes me sound! But I hope you will bear with me or at least indulge me).

## Beginners/ improvers

When for instance operating a lathe, you know when the method and process are going well because you can feel it, see it and hear it, almost as if the machine tool is speaking to you. (Beginners/Improvers keep at it! It will eventually come. At first it felt as though I was wrestling with the tools and processes).

A case in point happened recently. Whilst making a new lathe accessory, I had to produce a shoulder as shown in Fig. 1. Yes, I could just as easily have turned all that material to nice long curly swarf but I thought I'd have a bit of fun and try trepanning and parting off to leave me a solid ring of material that might be of use later, possibly as a die for forming a boiler tube plate or a smokebox door, it's also easier to clean up as "solid" swarf!

No doubt some of you view parting off with trepanation. I did too at one time, however, reading round the subject and trying the methods and ideas of the likes



Photo 1: The trepanning tool.

of Tubal Cain, George Thomas, Duplex and Martin Cleeve it became apparent to me that there were some vital parameters needed for success, namely; rigidity, optimum cutting tool geometry, optimum feed and speed (cutting conditions) coupled with some bravery.

These same parameters are actually vital for most metal cutting processes. Parting off is particularly hazardous because of the broad cutting edge of the tool, which tends to promote large cutting forces, instability and vibration. The latter two effects then lead to chatter and the inevitable seizure and breakage of the tool. The processes of parting off and trepanning are very similar in action and nature. The broad cutting tool is a necessary part of both processes and is also concerned with the rigidity issue above.



Photo 2: The trepanning tool, the cutting tip.

## Ancient and worn

These days, the process of parting off presents few problems to me. How did I get to this haughty point? Well, my first lathe was a very ancient and worn Myford ML4. Parting off on that machine was a real problem. Owing to a basic lack of rigidity in the worn machine no matter how I adjusted it, parting off from the front tool post was not on but parting off was just possible with a Duplex style rear tool post. Optimum tool geometry was definitely a problem with my hand grinding of parting tools. I always seemed to get them too thin, too much relief or just too weak to be any good. So no matter how much a hero I thought myself or how skilled in maintaining a constant feed rate, parting off was a big problem best solved with a hacksaw!

Then I was fortunate enough to be able to obtain a reconditioned (as good as new) Super 7. The rigidity issue disappeared completely and my skills turning the handles proved more than adequate for parting off from the front tool post. I'd invested in quick-change tooling when I had the ML4 and transferred this over to the S7. I was about to embark on the manufacture of a George Thomas style rear tool post when at an exhibition I saw and immediately purchased the Myford Dixon rear tool post and tool holders for carbide tipped parting tools. This combination of the S7 and the rear tool post and Industrial quality parting tools complete with optimum cutting tool geometry built in, put parting off into the "every day processes" category.

## The sound of the swarf

I found that by looking at the swarf, listening to the sound of the machine, feeling for the cutting forces through the cross slide feed handle and listening to the sound of the cutting action enabled me to maintain the optimum cutting conditions even when deploying parting tips with cutting widths of 3mm. The cutting sound by the way is very much like the sound of frying bacon and when all the parameters are correct, there feels and sounds little



Photo 3: Setting the radius.



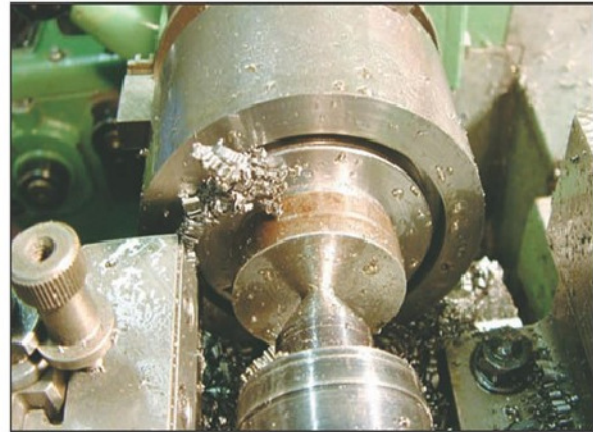


**Photo 4: Trepanning: Nearing the full depth**

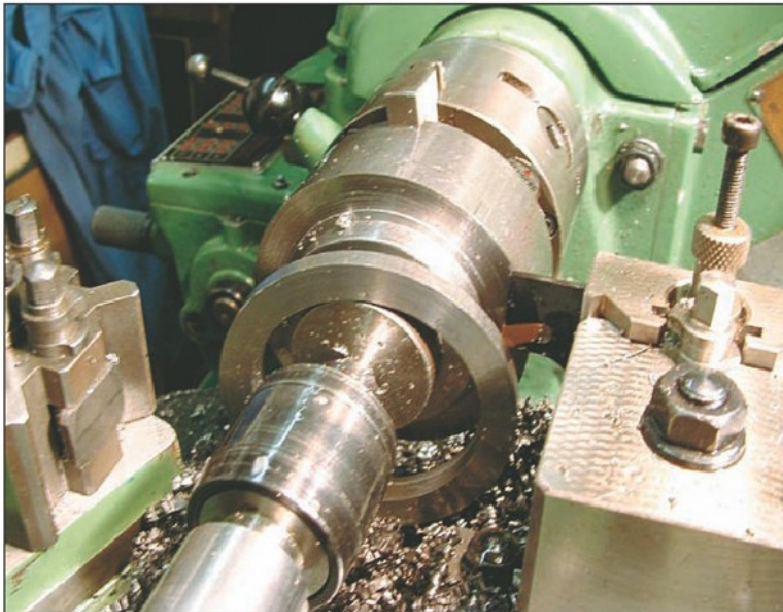
strain on the machine, the chips come off in a constant stream and it really does feel good! (Very sad I know). I also use Shell Garia H neat cutting oil that is dripped onto the workpiece from a hand held plastic bottle with a folding spout (actually

a recycled Milton bottle from my son's infancy 28 years ago!).

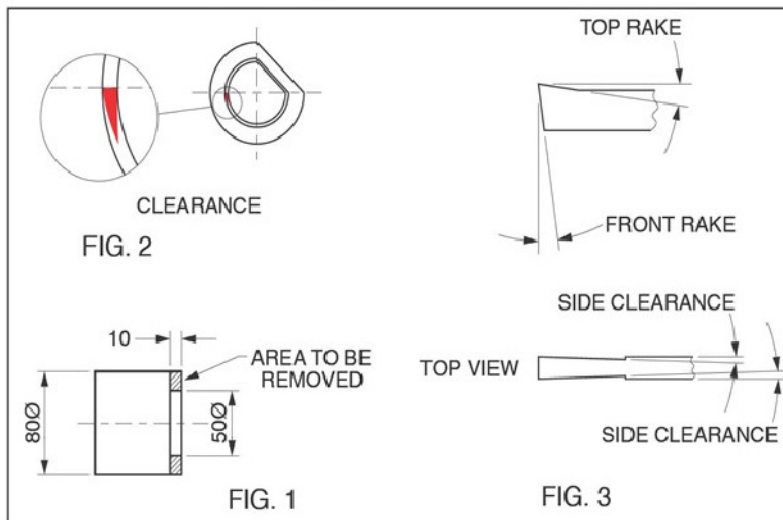
The trick of it appears to be not to force the feed but feel for it by applying as constant a force as you can and by maintaining the force at a level that will



**Photo 5: The swarf produced by trepanning.**



**Photo 6: The end of the parting off operation.**



enable the tool to cut without rubbing or crowding the tool. All this sounds as if you need three hands and multiple sensors but I assure you, with the correct set up it's much easier to do than write about!

If you haven't tried parting off using a rear tool post and throw away tips I recommend you do. Get Mr Myford to demonstrate them to you at one of the exhibitions and I'm sure you too will be convinced.

All well and good I hear you say, but where does this get us with trepanning? Well, to remove the material as shown in Fig. 1, two cuts are needed, one taken from the front face of the 80mm diameter bar in the form of a groove, (Trepanning) and one parting cut taken radially a little way along the bar. The parting cut is relatively easy to do. For the face groove, a specially shaped tool is required that has a broad cutting edge, is long enough to reach to the bottom of the groove and that has top rake and front and side clearance yet is strong enough to withstand the cutting forces and the rough handling by the operator.

I used to be in a similar position of not being able to offhand grind a suitable tool for trepanning as I was with parting off, basically always finishing up with a tool that was too weak for the job and wasting a great deal of high speed tool steel along the way. Having solved the parting off problem with the carbide inserts and the rear Dixon tool post, the standard Dixon parting tool used from the top slide was somewhat surplus until I hit on the idea of grinding the trepanning tool from the parting tool blade.

Producing the top and front rake is fairly easily achieved with offhand methods. As for the side clearance, as can be seen from Fig. 2, only the side of the tool that produces the largest diameter of the face groove needs to be ground to give clearance. The existing straight side of the parting tool automatically provides the required clearance on the inner side of the face groove.

The shape of the tool is indicated in Fig. 3 and the actual tool I used is shown in photo 1 with a close up of the business end shown in photo 2. The curved side to the parting blade was ground freehand by holding the blade in its Dixon holder and rolling it freehand across the face of a shallow cup wheel on the bench grinder. The idea is to produce a curve of a smaller radius than the groove to be cut without reducing the depth of the parting blade too much. The deeper the tool the stronger it will be. Some practise may be needed to achieve the required shape and



the use of some aids in the form of simple sketches of the face groove similar to Fig. 2 used to check on the progress of the tool grinding. It is also important to make the tool long enough to be able to produce the groove depth needed without being any longer (weaker) than necessary.

Once ground up correctly, the tool needs setting exactly on centre height and at an appropriate radius, in this case a shade over 50mm (2in.) was needed to allow for a final clean up after the trepanning. Photo 3 shows how I set the tool using a rule and half centre in the tailstock for reference. The exact radius is not critical just so long as it leaves a diameter large enough to clean up with out being too large.

Once the tool is set, cutting can begin but only after making sure that the workpiece is secure in the chuck. You don't want a large item like this to work its way out of the chuck so just to be sure, use tailstock support too. Photo 4 shows my set up with the trepanning at an advanced stage.

Set the lathe speed in middle back gear and to begin the cut, move the tool into contact with the workpiece using the saddle hand wheel and gently increase the pressure and the tool should then begin to cut. Keep the pressure steady and listen to the noise that the machine and cutting action are generating and feel the cutting force. Try to maintain things gently, cutting without forcing the pace. The resultant cutting sound should also be that of frying bacon. The swarf should be coming off as a ribbon and be thrown clear of the groove by the top rake. The swarf should also have the crinkly characteristic as can be seen in photo 5.

Adding coolant will also help the



Photo 7: What's left: The ring produced by Trepanning and Parting off.

cutting process. In my experience, it is best to keep the cut going but it is also important that the swarf does not jamb in the groove. If it starts to build up, withdraw from the cut, stop the lathe and clear away the swarf before beginning again. Continue until the full depth is reached, then part off the ring to complete the job. I maintained tailstock support during parting off as can be seen in photo 6.

#### Solid swarf

Photo 7 illustrates the 'solid' swarf produced by the trepanning and parting off operations. The useful (?) ring of material is destined for the 'come in handy' box.

The next time you have a deal of material to shift, consider using trepanning and parting off and hopefully the tips and clues above might help. Don't forget the other benefit of having less curly swarf to clean up!

## IN OUR NEXT ISSUE

Coming up in Issue 137 will be



**The Stent Tool And Cutter Grinder**  
Charles Woodward describes his modifications to this versatile tool



**New series**  
Rebuilding a Myford lathe.  
Part one, a visit to Myford's for a regrind.



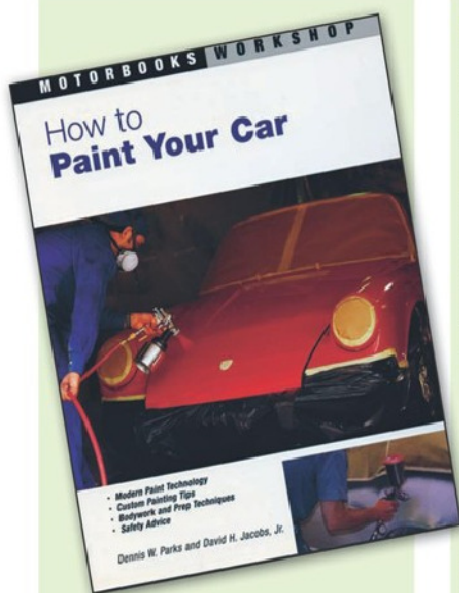
**Diary Of A CNC Convert**  
Dave Senior converts a mill to CNC

**ISSUE ON SALE 20 MARCH 2008**

*(Contents may be subject to change)*



# FIRESIDE I



## How To Paint Your Car Dennis W Parks and David H Jacobs Jr.

This excellent book starts off with how to determine the type of paint on your car. Older cars were painted with either enamel or lacquer prior to modern high tech polyurethane paints. The 3 types are incompatible with each other so you must use the same type of paint as originally used.

On a complete paint job, 95 percent of the work is preparation the only 5 percent of the time is devoted to the painting. Paint chemistry, thinners and additives are all covered in detail as are supporting products.

Tools, materials and safety are examined in detail including the selection of compressors and spray guns.

Although about painting, there are a few pages devoted to removing dents and minor repairs to the metalwork that should be done before final painting. Preparation is covered in detail including all the stages of sanding, applying primer and sealing.

There is a complete chapter about how to mask your car to avoid overspray.

Paint application notes are quite comprehensive and there is a 2 page chart on repairing imperfections and problem solving. Hopefully, after reading this book, you won't find any problems.

Finally, there is a chapter on painting flames, pinstriping etc.

## Performance welding handbook

Richard Finch

Firstly, this book is about welding, not car repair. It starts with a comprehensive guide to TIG welding, Mig welding and gas welding.

There is a comprehensive chapter on shopping for welding equipment. It covers all types of welders, accessories and also mentions plasma cutters. The latter are great fun to use, sparks flying everywhere.

Fitting and cleaning of the parts to be welded is discussed next, it explains how and why the fit should be well done. Preparation of different types of components is shown in the photos.

Next up is the construction and use of jigs to hold the components in alignment while they are being welded. A simple way to design a welding jig is given although this is only relevant where there is more than one component

being welded.

Welding of steel tube is covered in detail and this may be useful to the car chassis builders out there.

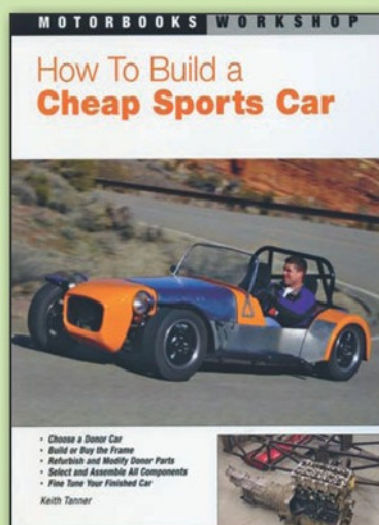
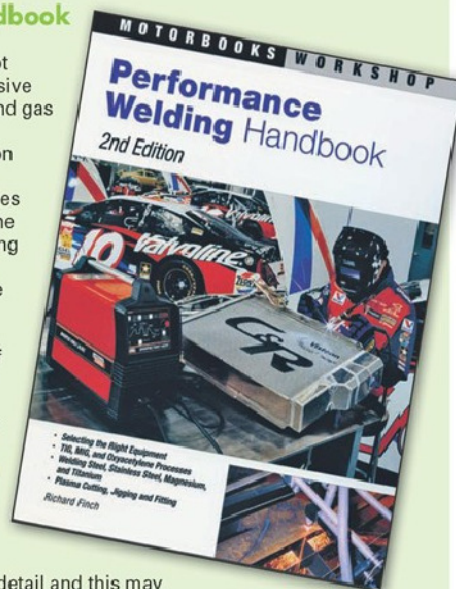
TIG welding in a vacuum chamber is discussed but this is unlikely be available in the amateurs workshop. Tig welding of aluminium and magnesium is shown in detail with the aluminium information being particularly comprehensive.

Mig welding of steel and stainless steel is also well covered with the emphasis being on tubes rather than sheet metal.

MIG welding of aluminium and magnesium is up next. Apparently two of the most popular aluminium alloys used are not weldable. This bit of information is probably worth the cost of the book alone if you are into welding aluminium. No, I am not going to tell you the specification of the two alloys, buy the book if you want to find out. Apparently MIG welding of aluminium is between 10 and fifteen times faster than TIG welding in this application.

Gas welding of steels and stainless steels has a chapter of its own. Quite a few welds are shown in this chapter and a lot of useful information is imparted. Gas welding of aluminium is next although this is not as comprehensive as previous chapters.

There is a short chapter on plasma cutting and then the last chapter is about welding shop safety and is a 'must read'.



## How To Build A Cheap Sports Car Keith Tanner

This book is in sections rather than the more usual chapters. This makes it a bit difficult to find information quickly. You need to look at the index first. It starts with finding a donor car and moves almost immediately into putting the car together. This book is much more of an overview compared with some of the books I have reviewed. Most of the information is there if you look for it. The car itself appears comparable to the similar English version you see so often being driven around on sunny summer days.



# READING

## How To Paint Flames

Bruce Caldwell

Chapter 1 is all about design and inspiration. There are lots of coloured photos of 'flames' on full size cars and also a photo of flames on model diecast toys.

Marking and masking out are comprehensively covered, followed by surface preparation. Tools, compressors, airbrushes and spray guns are discussed together with respirators.

Airbrush basics are dealt with and then comes the chapter on paint. Paints and catalysts are dealt with as well as custom colours.

Chapter 7 shows how to layout traditional flames using 3M masking tape for the outline, then filling in the blanks with a wider tape. This is a long chapter and it goes deeply into producing the layout, the cleaning and the final painting of the flames.

Next, wall of fire flames. These are totally different from the standard flames, they look like the car is actually on fire rather than being a representative of a flame like the traditional variety.

Realistic flames have a separate chapter but in my opinion, they look like a smaller version of the wall of fire flames.

A simpler and cheaper method of applying flames is the one shot method. This is done with masking tape and an ordinary foam roller. It is so simple that even I could do it.

Ghost flames are flames that are very subtle. They tend to be visible in bright sunlight but are almost invisible in dull light or after dark.

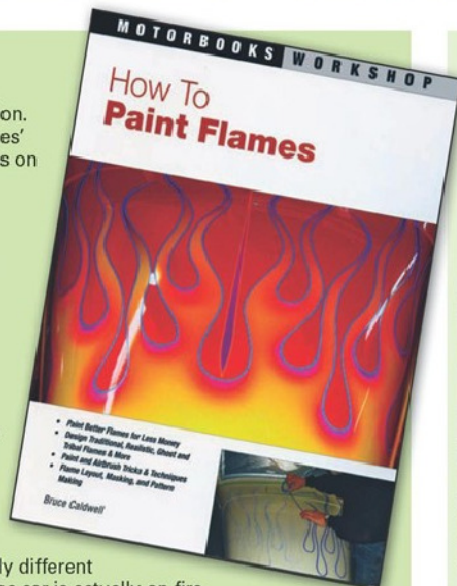
Pinstripe flames are basically just the outline of flames in paint, applied with a longhaired brush.

Rip flames are produced by using the rough edge of the masking tape. They don't really look like flames at all.

Tribal flames are sort of non-traditional flames. They are usually of a blend of different types and people tend to associate them more with tattoos than traditional flames.

Masking out and painting are as for traditional flames, it is just the design that is different.

Special effects cover a lot of different ground. Some of these designs look very smart. The final chapter covers clear finishing and final polishing.



## How To Build A Cheap Hot Rod

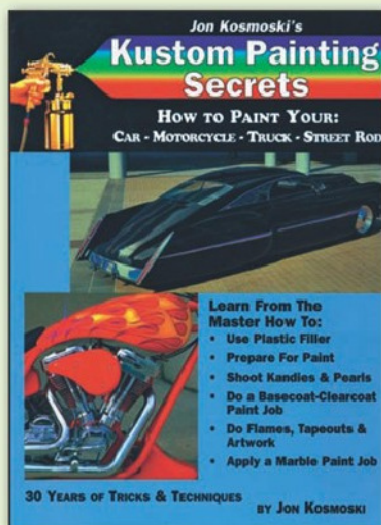
Dennis W Parks

Build it in your mind. What you want versus what you can afford. It is better to build an affordable project rather than start one that you can't afford to complete. Check the car's value first before chopping it about. It may be worth enough to pay for that hot rod. You need to decide which parts are to be fitted, budgeting the money so you don't run out or can't afford to continue for a while.

Next chapter is all about where to buy the parts, swap meet, Internet or other. Don't forget to add in shipping costs as well. There are 3 main types of chassis depending on your abilities and the depth of your pockets. They are; use the original chassis; use a reproduction chassis or use a custom chassis. Details of steering and suspension are touched on and painting of wheels is covered in detail. Lots more information is given for chassis construction and assembly.

Steel bodies are touched on but the main choice of bodywork appears to be fibreglass. Mounting the body on the chassis is covered in detail, as is the fitting of lights to the body. The body section is far more comprehensive than a short review will indicate. Engine and drive train is dealt with in a few pages with the recommendation that a new engine is best if you can afford it.

Chapter 6 is about additional systems. Fuel tank construction is dealt with in great detail, followed by the cooling system. Steering, gauges and electrical are next and finally covered are the painting, the upholstery and the glass.

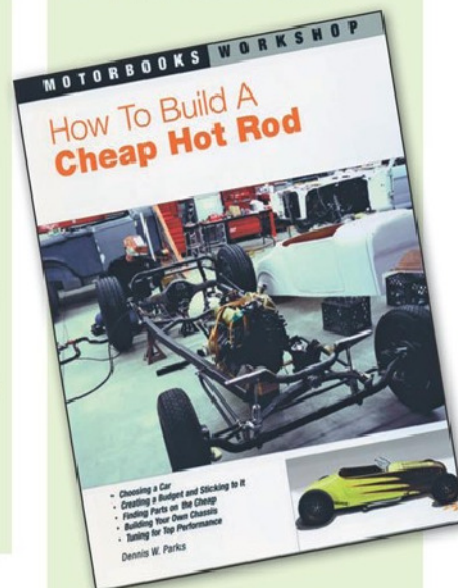


## Kustom Painting Secrets

Jon Kosmoski

The author has 30 years of tricks and techniques to give to you.

How to set up a shop covers all the requirements (including legal ones) for setting up a spray shop. Spray guns are then covered in detail. Preparation for paint is covered including rubbing down, different types of primer, and how to prepare fibreglass. Next is dirt, the final frontier. Dirt is the enemy of a quality paint job. Its control is important. Paint coats and then sealer are covered in reasonable detail. Basic painting is covered before moving on to Kandy type paints. Graphics are demonstrated from marking out to final painting. Pinstriping is covered and the book finishes with a few pages on flames etc.



All six books are available from Grantham Book Services, Isaac way, Alma Park Ind. Estate, Grantham, NG31 9SD Tel: 01476 541000



# 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 we consider may be of interest to our readers.

## Machine Mart are offering their new 40th edition catalogue free to all readers of MEW

It's that time again, Machine Mart are getting ready to launch their new Spring - Summer catalogue for 2008. With a launch date of February 14th, Valentines Day, you are going to love it. It's the biggest yet with over 400 pages and 890 new products and slashed prices.

The 40th edition features extra products across all categories with lots more big brand products at rock bottom prices, making



the latest catalogue a real 'must have'.

With over 25 years' experience, Machine Mart is Britain's biggest specialist supplier of tools and machinery so whether you're Trade or DIY, Builder or Mechanic, Local Authority or Industry you're sure to find everything you need to get the job done at the keenest price possible.

Over 4 million satisfied customers have enjoyed Machine Mart's unrivalled customer service, technical help and after sales support.

Get your FREE Machine Mart catalogue NOW by calling them on 0845 450 1855, go online at [www.machinemart.co.uk](http://www.machinemart.co.uk) or you can visit any of their 53 superstores nationwide.

## Artist Blacksmithing DVD by Peter Parkinson. Running time is 154 minutes

Artist Blacksmithing shows the fundamental techniques of working with hot iron (and steel) and suggests how these techniques can be used creatively in designs.

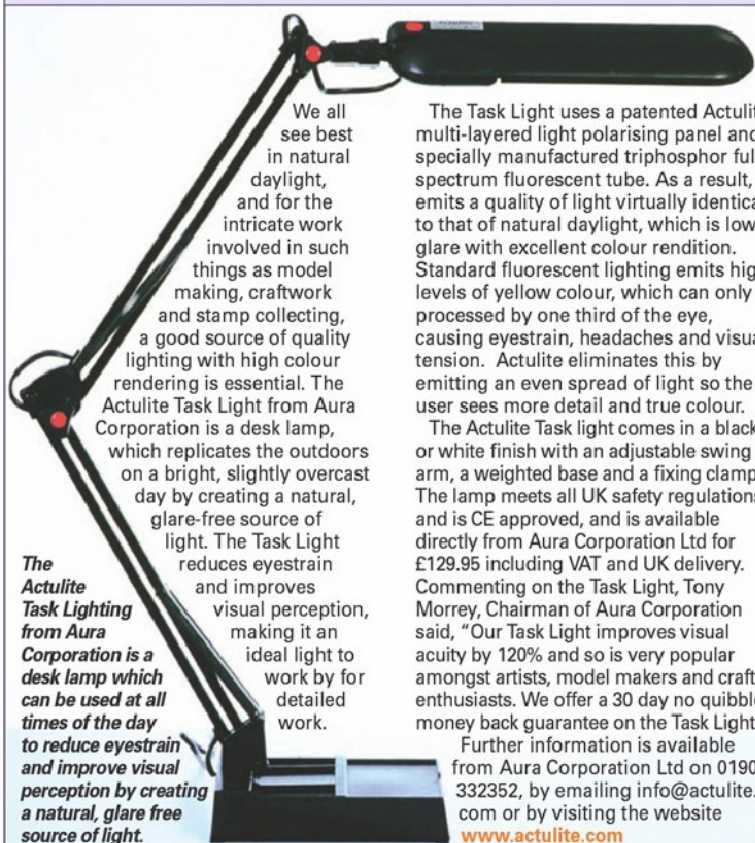
Set in Peter's own workshop, it is a rare opportunity to see a leading blacksmith in action. With the roar of the forge, the dancing of the flames and the glow of hot metal, the two and a half hour long DVD captures the romance and magic of using fire to transform metal.

Peter Parkinson is an inspiration to blacksmiths. His enthusiasm for the craft alongside his recognized talent makes him an exceptional tutor. In this double DVD, he brings his own insights to the craft while explaining the processes and pitfalls.

Artist Blacksmithing is available price £29.99 from:

The Crowood Press,  
The Stable Block,  
Crowood Lane, Ramsbury,  
Marlborough,  
Wiltshire SN8 2HR  
Tel: 01672 520320  
Fax: 01672 520280  
Email: [enquiries@crowood.com](mailto:enquiries@crowood.com)

## The Actulite Task Light



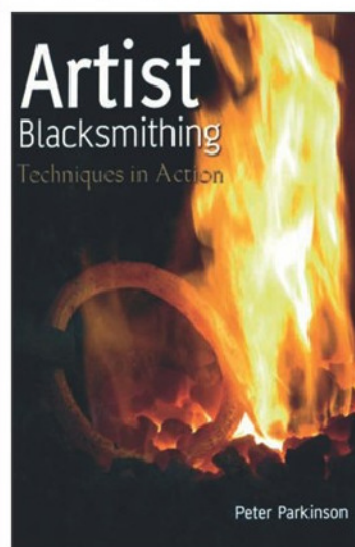
*The Actulite Task Lighting from Aura Corporation is a desk lamp which can be used at all times of the day to reduce eyestrain and improve visual perception by creating a natural, glare free source of light.*

We all see best in natural daylight, and for the intricate work involved in such things as model making, craftwork and stamp collecting, a good source of quality lighting with high colour rendering is essential. The Actulite Task Light from Aura Corporation is a desk lamp, which replicates the outdoors on a bright, slightly overcast day by creating a natural, glare-free source of light. The Task Light reduces eyestrain and improves visual perception, making it an ideal light to work by for detailed work.

The Task Light uses a patented Actulite multi-layered light polarising panel and a specially manufactured triphosphor full spectrum fluorescent tube. As a result, it emits a quality of light virtually identical to that of natural daylight, which is low glare with excellent colour rendition. Standard fluorescent lighting emits high levels of yellow colour, which can only be processed by one third of the eye, causing eyestrain, headaches and visual tension. Actulite eliminates this by emitting an even spread of light so the user sees more detail and true colour.

The Actulite Task light comes in a black or white finish with an adjustable swing arm, a weighted base and a fixing clamp. The lamp meets all UK safety regulations and is CE approved, and is available directly from Aura Corporation Ltd for £129.95 including VAT and UK delivery. Commenting on the Task Light, Tony Morrey, Chairman of Aura Corporation said, "Our Task Light improves visual acuity by 120% and so is very popular amongst artists, model makers and craft enthusiasts. We offer a 30 day no quibble money back guarantee on the Task Lights."

Further information is available from Aura Corporation Ltd on 01902 332352, by emailing [info@actulite.com](mailto:info@actulite.com) or by visiting the website [www.actulite.com](http://www.actulite.com)





## Myford Spring Open Day

Myford Ltd are holding their annual spring show on Thursday 17th April 2008 9am - 5pm, Friday 18th April 2008 9am - 5pm and Saturday 19th April 2008 9am - 4pm

The Show is aimed, in particular, at Myford users who have interests in model engineering related subjects or the reconditioning, maintenance and running of veteran, vintage and classic motorcycles.

Myford will be running, on a daily basis, both turning and milling demonstrations on a variety of motorcycle components.

Many readers may well have a Myford in their workshop, and some no doubt may need some T.L.C. There will be three fitters, Terry, Darren and Brian, running useful demonstrations on how to service your Myford and make the most of it.

Ivan Law and Harry Paviour, who both are Chief Judges in the Model Engineering World, have between them a wealth of experience in workshop practices, which they will be happy to share with you.

Also, for the first time will be D.A.G.

Brown. Derek Brown is well known in the Model Engineering World, especially for his work and articles covering metric conversion of the Myford Quick Change Gearbox and his articles on building a 7 1/4in. Manning Wardle engine.

S.M.E.E representatives will have a display with working models.

You will be able to see the full range of new Myford machines and accessories, together with a large selection of reconditioned machines, all rebuilt to a very high specification and covered by one year's warranty. Also on display will be an excellent selection of general preowned workshop equipment.

As usual, there will be some excellent 'Show Offers' on new lathes, which will include some high value accessories. Nearly all the new equipment, whether it is a machine, accessory or spare part, will be subject to special offers only available to those attending the Show. New Myford spares and accessories will be available at reduced prices to save you the VAT.

Myford are always willing to consider and quote against taking your existing Myford Lathe in part exchange against a

new model. Take along photographs of your machine on the day.

Malcolm and Chris will be available to talk to you about all the above.

There will be free parking, tea and biscuits and a free £250 prize draw to all attending.

If you arrive in a classic car or on a classic motorcycle, you will get entry into a further free £250 prize draw.

During the run up to the show, the second-hand showrooms will be closed from Monday 7th April until the show opening on 17th April 2008.

This show is aimed at Myford users with a general interest in Model Engineering and Horology, and for those who have a particular bent for restoring, maintaining and running Veteran Vintage, Classic Motor Cycles, Cars, old Lawnmowers and Stationary Engines etc.

The general theme will be how to make the most of your Myford and to simply have an enjoyable day out.

Myford, Wilmot Lane, Chilwell Road, Beeston, Nottingham, NG9 1ER.

Tel: +44 (0)115 925 4222 Fax: +44 (0)115 943 1299 Email: sales@myford.com

[www.myford.com](http://www.myford.com)

## Arrand Flat Standing Toolmakers Clamps and catalogue

Trevor Drabble wrote to me regarding the style of clamp shown in issue 135, page 16, photo 2 of Harold Hall's article "Toolmakers Clamps", to tell me such a product is available commercially from Arrand. Arrand have supplied a catalogue and one page supplement that does list this style of clamp. The clamp is 3in. long and has a maximum opening of 1 3/8in. From the photograph, they look to be made to a very high standard.

Arrand also list a rivet shortener in the supplement that will cut a wide range of small rivets (max 5/16in. Dia.) to a minimum length of 1/4in. using the bench vice as a press. Arrand produce a wide range of taper tooling, various tipped tools and face milling cutters. First are right and left turning and facing tools and also tipped boring bars. Then there are two sizes of face milling cutters.

Screwed shank end mills with a single inserted tip are listed in two shank sizes. Brazed (3 different sets) and replaceable insert boring bars are supplied. Clamps, T bolts and nuts are available in several sizes and blank T strips are available for the Myford and Emco Maximat 11 and are stock items, other sizes are available to order. Two sizes of between centres boring bars are supplied with adjustable carbide tipped inserts.

Several sizes of boring heads are available. I had a small Arrand boring head that had a M14 x 1mm thread on a Unimat 3 some years ago and it was a very nicely made item. There are over 25 different types of shank available so there is sure to be one available to suit your machine.

A radius turning attachment is available that takes one of the boring heads to do spherical turning. This is similar to the

method described in MEW recently. A spring loaded 4 jaw-chuck centraliser is listed. With the use of a dial indicator, this useful item helps to locate a centre pop when using a 4 jaw-chuck.

A high speed counterbalanced flycutter is available in three different sizes together with a wide range of shank types. Imperial and metric end mill holders are supplied in 1, 2 and 3 Morse and also R8 tapers.

ER16 collet chucks in 2 and 3 Morse taper are fitted with an adjustable back stop to stop tools moving backwards under cutting pressure. An ER25 collet holder for direct mounting onto the Myford nose spindle will take collets up to 16mm. It is also available for backplate fitting.

Stub arbors and long milling arbors

are made to take 1in. bore milling cutters. Standard size face mill arbors are listed for 16mm, 22mm and 27mm bore cutters.

A little hand tapper consisting of a small chuck on a 2 or 3Morse taper and a tommy bar looks a very useful item.

Drill chuck arbors are listed in various tapers to take all sorts of different drill chucks. Blank end arbors can be supplied to make your own tooling. Various tapers to convert to two Morse adaptors are supplied. Drawbars for various Myford and Boxford lathes are supplied and also available are Morse taper (from 1 to 5 Morse) and parallel test bars. A 2in. diameter x 4 3/4in. long cylindrical square would be a welcome addition to the Workshop.

Arrand also supply a very useful milling

spindle that is ideal for clockmakers. It is a substantial size and has ball races fitted. Soft leather belting is also listed.

Finally we come to lathe tailstock tooling. Listed are a tailstock die holder, a tailstock tap holder and a quick-change tool holder with a wide range of adaptors. This is a very comprehensive catalogue of Morse taper tooling and should be on every Model Engineers bookshelf.

Arrand, The Forge, Krossington, Nr. Oakham, Leicestershire, LE15 8LN  
Tel/Fax: 01664 454566.





# Scribe a Line

Please send your letters to Scribe A Line (or Readers' Tips), The Editor Model Engineers' Workshop, Magicalia Publishing Ltd., Berwick House, 8-10 Knoll Rise, Orpington, Kent, BR6 0EL or e-mail to [david.clark@magicalia.com](mailto:david.clark@magicalia.com) and you will have the chance to win a book. Please remember to include your name and address with the letter and also in the email. I normally answer letters where necessary but a lot just get put in a letter tray (after reading them) ready to insert in Scribe A Line so please be patient. Emails are normally answered very quickly although please allow at least 12 hours for reply. I have a copy of a book from the Workshop Practice range to give to the writer of the best letter (the editors decision is final) and also another book for the best readers' tip in each issue. If you would like to purchase a copy of any book in the Workshop Practice series, please e-mail [customer.services@magicalia.com](mailto:customer.services@magicalia.com) for prices or visit [www.myhobbystore.com](http://www.myhobbystore.com)

Peter Titterton receives a Workshop Practise book for his timely warning and Hans Muller receives one for his excellent tip on workshop storage. Most books have been sent out to the winners but I think there are a couple outstanding. If you have won a book and not received it, please contact me. I have been given permission to give the car and motorbike books that have been reviewed as prizes as well so if you don't want a Workshop Practice book, now is your chance to win something different. First come first served so get writing today.

## Thread cutting in MEW issue 134

If I may I'd like to add some comments to the article in issue 134 by Harold Hall on thread cutting.

I'd like to begin by acknowledging Harold's massive continuing contribution to those of us who have and are interested in home workshops. My comments are not intended as a criticism in any way. I generally find myself in agreement with the information and sentiments expressed in the article. I do have a "however" and this is with reference to the use of a sharp pointed tool for producing a thread.

Harold rightly says that the result is a smaller core diameter and (therefore) weakening of the component and then adds that the effect is minimal and is more a theoretical than actual problem. This may be true for the majority of the work carried out in home workshops but the sharp pointed tool will leave a sharp groove in the work, which is likely to start cracks forming in the root of the thread which will lead to premature failure of the screw thread in those applications subjected to cyclical loading. The sharp groove acts by concentrating the stress carried by the component into a small area promoting the propagation of the crack, further reducing the effective core area and hence failure. Poor surface finish of the thread will also contribute to the promotion of cracking.

The key is the nature of the loading. In lots of cases, screw threads are not subject to cyclical loads but there are classical examples such as cylinder head and con rod fasteners that are. Given that the readership of MEW is diverse and that some are engaged in the repair and restoration of automotive artefacts and production of miniature gas turbines, I feel that a note of caution to do better than a sharp pointed tool in the case of cyclical loading is worth adding.

John A Slater by email

## "On The Editor's Bench" Issue 132 Future Articles.

I have just re-read your piece on the above mentioned. Unlike yourself I only spent about 15 years in engineering, however

unlike yourself I can screw cut, I was more successful at this than I was at using a Coventry Die head. I would like to see if it is at all possible to print an articles on tap making especially what size to make it.

The reason for this is that I am a great believer in finishing a thread off with either a tap or die. I am at the moment making backplates for various chucks for my lathe (Engineer's Tool Room BL1224), which has a 2 1/4 in. x 8 TPI Whit form thread and I would rather finish this off with a tap than make a dummy mandrel nose. I have to say I have made taps in the past when I was working as a turner but I was always given a size to work to and this is not my forte. I can make them but due to a rather inadequate education' working these thing out for myself is, shall we say, a non-runner. I do also feel that quite a few of your readers would also be interested in articles of this nature.

Eric Parker by email

## The editor replies

*If anyone would like to write an article about making taps in the home workshop including calculating the correct size, please contact me.*

## ER collets - Metalworking series

I have recently received MEW issue 134 and have seen that there is an article by Harold Hall concerning the lathe as well as work and tool holding.

I see that there is a basic mistake with regard to the use and misuse of type E, ES and ESX type collets. There is also a type ESTX which are made to hold the Clarkson Threaded types of cutters. The basic mistake is that the 'E' range of collets are for tool and cutter holding only. The following quote is taken from the Schaublin collet catalogue, after all, as manufacturers, they should know.

EX/ESX Group 75, cone collets. These are used to hold the shanks of tools and are not suitable to hold bar material.

The type E and EX collets have only six slits lengthwise and are more accurate as they are made for one diameter only. The ES and ESX collets have twelve slits lengthwise and will span 1mm for

## Star Letter

## Modification to Warco headstock cover - a warning

Having just read the star

letter by Nigel Walton in your January edition of MEW

re a modification to the headstock cover on a Warco lathe, I would point out that my Chester version of the lathe (Craftsman) has a safety cut out switch under that cover to stop the main motor switching on with the cover hinged open. If the cover is slid back, this switch will not operate with possibly serious consequences!

Keep up the good work with the mag it has a varied mix of articles and makes an interesting read. Re CAD you have had a couple of articles on the subject but I have not been able to get going with CAD.

A step by step guide to a few simple example drawings may get me started. I realise that there are many different drawing packages to use but I have downloaded a couple of free types to try but I have not had much success!

Peter Titterton by email

dimensions above 3 mm, those for less than 3mm will only span 0.5mm.

Most work holding collets have a draw bar, so are not suitable for second operation work where the workpiece is removed between operations. For this type of work, the type F collet is used as it is of the 'dead length' type, where the nose of the collet remains stationary and the closing mechanism is inside the nose of the lathe headstock. Such a system is the Myford lever operated collet head.

Another type of collet not mentioned is the Burnerd multisize 'E' type collets as I have fitted to my Colchester lathe. Here there are just twelve collets to cover the range of 1/8 in. to 1 1/2 in., so each collet covers about 1/8 in. span. While these collets are much more accurate than the normal chucks, the highest accuracy is achieved with type 'W' collets fitted to Schaublin lathes.

I hope the above is of some use to



readers who use or will use collets for their work holding.

Philip T Bellamy from Switzerland

### The editor replies

Harold did not mention specific types of ER collets in his article. I have been in industry for over 35 years and did not realise there was a difference in the available ER collets, other than the quality of manufacture. In the introduction to metalworking series, it is more of an overview than a detailed narrative. It is nice that there are readers who are more knowledgeable than the rest of us. Perhaps Mr Bellamy would write us an article on the correct selection and use of all types of collets, particularly the ER ones.

### Sawdust in motors

I note that you have printed, in issue 133, a reply to my letter in issue 129. My original concern was that an open frame motor was suggested as suitable, by virtue of the fact that the author used this type of motor, for use in a machine that has a large quantity of air born wood particles. The very nature of these particles means that they are inflammable.

I am not and have never claimed to be an expert on electric motors but I worked for many years repairing amongst other things electric lawnmowers. My experience with the motors has been that even grass cuttings will ignite inside an electric motor. The most unusual occurrence I came across was when a customer purchased a replacement motor for one of the hover mowers. He came back the following week complaining that the motor had burnt out and he wanted it replaced. The customer was given a replacement motor and the burnt out unit was dispatched to the manufacturer with a guarantee claim. The manufacturer refused the claim because they found saw dust inside the motor, which had actually set on fire and burnt the insulation. It turned out that the customer had used the motor to power a homemade saw bench. The lawnmower motors are open frame type but they are enclosed in plastic shrouding and the air



### Unidentified lathe

I committed the ultimate sin and sold my 11" Harrison eight years ago on the basis that it would not fit into the new garage when we moved to the smaller house. My needs are simple -- spacers, bushes, pins and making up special tools for M/cycle restoration. Four years ago I bought an unidentified lathe, it was missing the changewheels and needed some work. It has served well despite its limitations. Now that I have more time, I want to restore it, so identification would be a big help. It is approx 24in. between centres, 5in. centre height and has a serial number on the bed casting between the slides at the tailstock end - L/1489/51. The pulleys are made from a resin or plastic material, as are the belt and gear guards. I have spent the last two years scouring the pages of M.E.W. for a picture, I have searched E-Bay for the same, I have shown the photos at steam fairs and auto jumbles to no avail, even Myford's man wasn't sure, he thought it could be a Flatbed Drummond or a "copy". So any help you or your readers can give would be much appreciated. MEW is a great magazine, very informative and well put together.

Mick Morritt by Email

is filtered. So my original comments still stand, use the correct type of motor for the application. If in doubt take professional advice. I do not want to get into a prolonged discussion with this. Perhaps if another reader with suitable knowledge and experience could give a definitive answer to the problem then all readers would know what type of motor should be used.

Les Pitt. By email

May I suggest that any reader who intends to build this drive has a good look at <http://www.sdp-si.com/D260/PDF/part1.pdf> paying special attention to Sections 7 and 8

Michael Gilligan by email

### Unimat 3 toothed drive

I was very impressed by Maurice Rhodes' design in MEW 134 ... A Toothed Belt Drive for the Unimat 3, but I was worried by his mention of a slight rise in noise level.

I suspect that some of this may be attributable to the over simplified tooth profile on his 40 tooth wheel, which is also likely to increase the rate of wear.

### Outrunner motor article

That was an interesting article from John Rutter in Issue 135 - If I'm correct outrunner motors are a sort of inside out induction motor, (a rotating field appears to be created by the ESC inside a conducting rotor with very low aerodynamic drag). However, John gave us no information at all about the ESC and its connections. Could he or another expert be persuaded to rectify this for a future issue perhaps? This sort of motor would appear to be well suited to a CNC engraver.

### Model Engineers' Workshop Data Book

Special Interest model books have provisionally agreed to publish both my Data Book and The Metalworkers Workshop series, though the latter not until the series is well finished.

The Data Book will follow closely to that originally published in MEW but with some omissions, additions and of course some corrections. It is with possible additions and corrections in mind that I wondered if you could publish the following in Scribe a Line.

Long term readers of Model Engineers' Workshop will remember the Data book published during 1994 to 2000. Some who were unable to collect the whole book have queried if it would ever be published in book form. I am pleased to say that this is now underway and is the reason for my writing.

The book will follow closely that already published with a few omissions of items I feel of relatively limited interest. I am keen that the book should be as correct as is possible and wondered if any readers have spotted technical errors that I am not aware of.

The following are errors that I already know about. Owners of the original data book may like to update their copy should they have not already spotted them.

Page B23. The 114 dimension should be 104 though I will now quote imperial dimensions, as this is how the taper originated.

Page D4 The last three values should read 0.73, 0.82 and 1.02,

the last value being correct as printed.

Page K19 The formula stating 8 over 25.4 should read 25.4 over 8. from this point though the resulting calculations are correct.

Whilst not an error, I am rearranging the order of the inch/metric conversions on the tapping drill size charts to make them easier to use. The charts will still give the resulting depth of thread and the effect on this of increasing or decreasing the drill size.

I am also expanding the section on dividing (E1) to include details for dividing heads having a ratio of 40:1 which is now very common, also other dividing plate numbers.

There will of course be many other changes of a minor nature. Should any reader feel that some other topic should now be covered I will be pleased to consider any suggestions. With this in mind, do take into account that the data in the book is what I would call hard and fast. For that reason, such details as cutting speeds and feeds that depend on so many variables, machine rigidity, etc., are not appropriate to the book.

Reader's wishing to make suggestions can contact me via E-mail at [databook@homews.waitrose.com](mailto:databook@homews.waitrose.com). This is a temporary address that I will keep open for about two months. Thanking readers in advance.

Harold Hall by email



### John Rutter replies

When using my motors for CNC, I simply use a servo tester. Mine came from SM Services [http://www.smservices.net/acatalog/Test\\_Units.html](http://www.smservices.net/acatalog/Test_Units.html) many years ago but anyone with a bit of electronic experience could knock one up. I think they use a 555 timer circuit to vary pulses around the 1.5ms centre mark (1 - 2ms I believe) but for a few quid I couldn't be bothered to mess about. Robotbirds [http://robotbirds.com/catalog/product\\_info.php?cPath=37&products\\_id=595](http://robotbirds.com/catalog/product_info.php?cPath=37&products_id=595) do one that's a couple of quid cheaper than SM's and can control 2 servos at once, (quite why I don't know) which my son bought and seems happy with. They simply plug into the lead that would go to "throttle" on the ESC (electronic speed controller). ESC's are very cheap these days, certainly not worth the bother of making one. They'd probably cost more in parts than the Chinese knock them out for.

### Foundries for one offs and small batches

On a slightly different tack, the production of items from castings is always of interest, but not many of us have either the nerve or the space to build and operate our own mini-foundry, especially for cast-iron. Would it be possible to attempt to compile a list of foundries who are willing to cast small runs or one-offs from shop-built patterns?

Nigel Parkinson by email

### The editor replies

If you know of any foundry that will produce small quantities and one offs from home made patterns at a reasonable price, please let me know and I will print them in MEW. Please let the foundry know that you are submitting them for inclusion before doing so.

### MEW 133 cover, Dave Fenner's daughter and jewelry

I have just got your Christmas issue (late but we are a long way away in Canada). I took a look at the cover and my first reaction was -Where is this magazine heading? Then I realized that the girl is Dave Fenner's daughter. I have never had the privilege of having a daughter (two sons) and I find it charming that she is showing an interest in her father's activities. She is a pretty girl and I am sure she is into lots of the things young girls are into, fashion make-up and looking good and the cover is a nice confluence of his interests and hers.

This brings me to a related topic I have been meaning to write to you about. I often try to think of things to make in my shop as gifts. When I was in to woodworking, I made my wife some turned bowls. My best metalworking effort to date was a jewelry box for my son's girlfriend (picture attached). I would really like to see some ideas for gifts to make for the non-gear heads in my life. I even would like to see an article (or articles) on jewelry making. I find I can do all the tasks, but I sometimes lack inspiration. Maybe Dave's daughter can give us old guys some ideas.

Peter McKelvey, PEng by email



### The editor replies

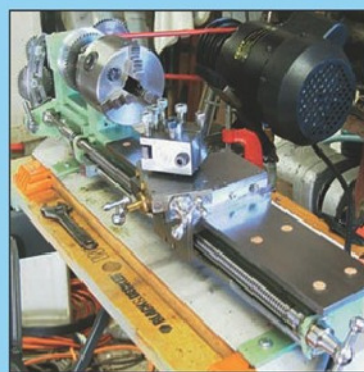
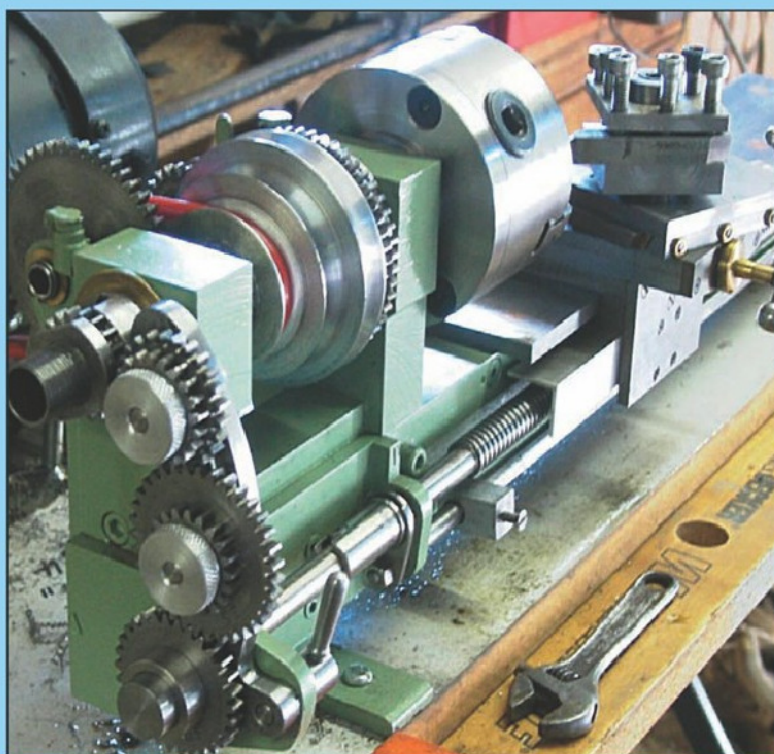
Jewelry making as such is a bit outside the scope of MEW but if anyone would like to write an article or two on some of the metal working processes involved that might help readers' with other interests, I would consider publishing them.

### A power feed to the cross slide

I recently picked up the January copy of MEW in W.H. Smith. It was the first time I had read it for many years. I had a subscription to the magazine in the first year it was produced, whenever that was, but I didn't receive a reminder when the year was up and the subscription lapsed and I then had more pressing matters to absorb my free time. I enjoyed the January issue and thought I would like to read the previous month's articles so I phoned the back issues department

and ordered it. It arrived the next day, exceptional service! I have taken out a new subscription.

I particularly enjoyed the lathe articles by Harold Hall but I was surprised that he did not rate the provision of a powered cross slide more highly. Machining flat surfaces is surely one of the lathes main uses and skimming say a 2x4 inch or larger plate is tedious and difficult to achieve a good standard of finish without powered cross feed. Of course I recognise that many smaller lathes do not have this feature but it is



### Len Mason's baby lathe

In response to David V. Atkins question in Scribe a Line October 2007 regarding anyone building Len Mason's Baby Lathe, the answer is yes. I have just finished building one after retiring. So far I am thrilled with the results and the performance of this machine. I would be happy to correspond with anyone who is making one and explain a few mods that I have made to it. I have included two pictures of it almost complete if anyone is interested. Best wishes with the magazine,

David Porter by email  
dfporter5@hotmail.com



Best  
Tip

## Workshop storage - Space saving

Occasionally, I buy a copy of the Model Engineers' Workshop (quite expensive in the Netherlands, about £ 5.60, a lot of money for an OAP...).

In the August issue I saw the interesting article about 'The Metalworkers' Workshop'; I increased the wall space for my hand tools by mounting hinged 3/4in. plywood boards on the walls over the workbench; this increases my wall space three-fold.

In addition, I made a mobile tool trolley using the same principle; I use it while working outside on my classic motorcycles (British, of course...).

The verticals are 2in.x 3in., which allows for a double row of hand tools between the wall and the rear of the plywood panel. The hinges are of the 'drop-on' type. The spanners are marked by a dab of paint: metric = blue, BS = yellow and AF = red. Special ones are marked in green.

The bike is my daughters' 1966 Triumph 3TA (former Dutch Army) that I modified to 500cc, electronic ignition and better front brake. My preferred bike is a 1942 BSA WDM20; for that story, have a look at <http://www.bbc.co.uk/ww2peopleswar/stories/74/a2006074.shtml>

Hans Muller by email from the Netherlands



one that is well worth aspiring to, perhaps even more if one doesn't have milling facilities. It is a facility that I would not be without. I spent a good deal of my apprenticeship using Harrison and Boxford lathes and that is why I jumped at the chance of a second hand 9in. South Bend when one was advertised several years ago, (this is of course what the 4 1/2in. Boxford was cloned from). Made in 1940, it is still the pride of my workshop.

Tony Reid by email

## The editor replies

*Cad will be looked at in the near future. Readers' can download Dolphin Cad for free from <http://www.dolphin.zenwebhosting.com> and use it for as long as they like at no charge. Dolphin Cad will be used in the new CNC series starting in a couple of months.*

## Skip diving

I usually poke my nose in the skips outside of the shops when they are being re-fitted and it is amazing what is thrown away. I

got some really good 12 volt transformer which had been used to power those quartz Halogen lights and even better some overhead lights. These lights are mounted on parallel chrome rods; the rods are about 2 metres long and are energised via the transformer. The shop can move the lamps along to where ever they need a display, very handy in the workshop above a machine. Lots of good benches, cabinets and cable turn up as well, storing them all is the problem.

Ted Fletcher by email

## Screwcutting

Regarding the previous correspondence about screwcutting, please find a quick & dirty photo of an ER16 insert cutting a 2 BA thread onto a soft iron rivet.

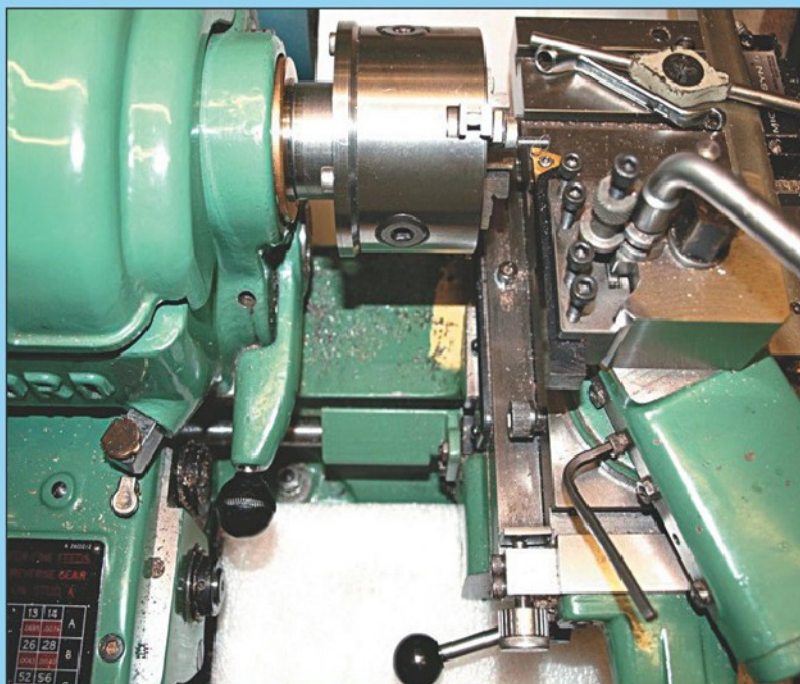
Topslide is set-over at half the angle. At the bottom of the photo you can just see the cross slide calibrated stop which allows retraction of the cross slide and quick reset to within 0.001in., which I can then check for greater accuracy on the DRO (0.0002in. usually!).

As the Myford is inverter controlled, I can use the clutch to disconnect the drive, then withdraw the crossslide, switch directly to reverse and drop the clutch back in. During reverse traverse, I change the topslide cut setting, lock the topslide and as the insert clears the right hand end, revert to forward by just switching and without de-clutching and reset the cross slide for the next cutting pass, all one continuous movement!!!

Ken Willson by email

## Editors comment

You could always use old CD's between cutters if you run out of the plastic disks.









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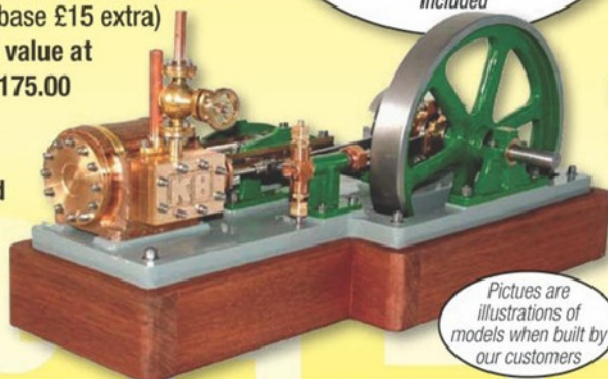




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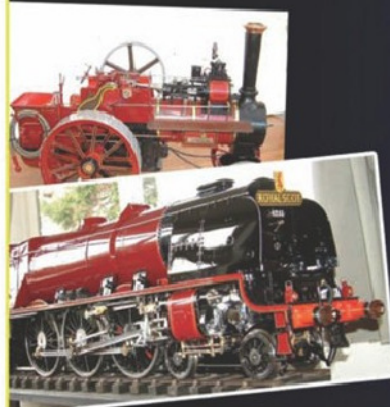
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Boxford CUD 5" centre height precision lathe



Hayes Diemaster milling machine - sure quality!



CMZ 40" rolls (brand new)



SIP 39" high, 16 speed, 2MT 5/8", rack table NEW



Colchester Chipmaster (240 volts)



Gabro 2ft box and pan folder

**COMING IN WE HAVE:**  
Boxford collets + drawbar £175,  
Boxford dividing head complete + plates £825,  
Boxford vertical slides from £345,  
Colchester Chipmaster £1250,  
Harrison vertical mill £1625,  
Harrison M250 lathe, gear cutters, broaches,  
New Leyton 50" rolls,  
Marlow vertical mill £950,  
Micrometers boxed from £10,  
Rapid hacksaw £145,  
Denford Micromill  
Sharp milling machine,  
Blacksmith dollies.



Harrison pedestal grinder



Tom Senior 'E' type milling machine, extremely rare in this condition



Harrison Graduate wood lathe



Raglan 5" lathe + gearbox and variable speed



Boxford 1130 5 1/2" x 30" + stand



Colchester Student, gearbox + gap



Eagle Model 3 + magnetic chuck



Bridgeport slotting head



Milling/Drilling ground X-Y table

### Also:

- Myford Fixed steady £90
- Myford travelling steady £40
- Colchester Bantam travelling steady £45
- Viceroy fixed steady £125
- Baty 0-1" (calibration certificate) NEW £30
- Baty 0-25mm (calibration certificate) New £30
- Micrometer 11"-12" M & W £55
- Micrometer 12"-18" M & W £120
- CEJ metric slips (as new) £245
- Engineers flat's £125 each
- Harrison (lathe) jig boring table £175
- Boxford (lathe) jig boring table £145
- Burnerd 3 jaw chuck for Graduate wood lathe £70
- Draw sets (9 and 15 draws) metre high £65 each
- Meddings EMG tool grinder £475
- Marlow vertical mill (3MT) £950
- Viceroy vertical mill (30INT) from £495
- Super Brown cut-off-saw £345
- Pedrazzoli Aluminium cut-off-saw £345
- Viceroy sharpedge 10" wheel £150
- Clarke Strongarm 1 ton (fold up) crane £125
- Epco 1 ton quality engine crane £245
- Clarke profile router 145 £175
- RJH Gerbil 2020 vacuum plastic cutting mch. £275
- Clarke 812V vacuum forming machine £345
- Draper WTL 100 wood lathe £100
- Multico K3 mortiser £475
- Startrite 145 sawbench £395
- Startrite 275 sawbench + sliding table £1950
- Startrite TA1250 sawbench + bells & whistles £2250
- Startrite 14-S-5 bandsaw £595
- Black & Decker radial saw £345
- Minor finisher 4" wide/ bench type £145
- Scripta (Graphograph) bench engraver + type £245
- Oxford 110amp oil cooled welder £90
- Jones and Shipman No.2 arbor press £175
- Hearths (small pedestal model) £70
- Flamefast DS220 hearth £245
- Holbeck-Leba oven £145
- Crompton 240 volt Myford motors NEW £155
- G & C 2hp 240 volts 1420 revs £120 each
- Brook 3hp 240 volts 2850 revs motor £120

PLEASE PHONE 0208 300 9070 TO CHECK AVAILABILITY OR TO OBTAIN OUR LIST

DISTANCE NO PROBLEM!

DEFINITELY WORTH A VISIT

ALL PRICES EXCLUSIVE OF VAT

**Just a small selection of our current stock photographed!**



# The UK's No.1 Machine Tool Specialists

**CHESTER U.K.**  
LIMITED  
MACHINE AND TOOLING  
SPECIALISTS  
www.chesteruk.net

**DBTVS**



**£475**

**Features**  
Digital Spindle Speed Readout • Hardened and Ground Vee Bedways • Offset Tailstock • Variable Spindle Speed • Metric & Imperial Thread Cutting • Longitudinal Power Feed • Cast Iron Construction

Distance between Centres 300mm  
Swing 180mm  
Motor 700w

Shown with optional stand

**H110 BANDSAW**



**£159**

**Features**  
Max Cutting Capacity @ 90°  
Max Cutting Capacity @ 45°  
Blade Speed  
Motor  
Power  
Blade Size  
Packing Size  
Stock Code

Round 110mm Square 100x150mm  
Round 100mm Square 85 x 65mm  
20,30,50mm/min  
550w  
240v/48  
1640 x 685 x 13mm  
965 x 410 x 500mm  
SAW-SAW-H110

**626 MILL**



**£1450**

**Features**  
1.5HP Motor • Metric or Imperial Machines • MT3 or R8 Spindle Taper • Head Swivels 90 degrees • Head Tilts 45 degrees • One Shot Lubrication System

**Standard Accessories**  
Machine Work light • Central Lubrication System • Machine Stand • Table Guard • Drawbar • Manual & Parts list

**Including Power Feed**

Face Mill Capacity 75mm  
Table Size 156x745mm  
Motor 1.5hp

**COBRA MILL**



**£239**

**Features**  
Variable Speed  
Angled milling Head  
Adjustable Gb Strips  
Quill Fine Feed

**Standard Accessories**  
Drill Chuck  
Spanners  
Drawbar  
Allen Keys

**Specifications**  
End Mill Capacity 10mm  
Table 145 x 40mm  
Speeds Variable 100-2000rpm  
Spindle Taper MT2  
Weight 25kgs  
Size 480 x 380 x 680mm

**CHAMPION 16 V MILLING MACHINE**



**£575**

**Features**  
Variable Spindle Speed • Dovetail Column • Digital Quill Depth Readout • Column Guideway Covers • Tilting Head • Large Table Size • Wide Spindle Speed Range

**Standard Accessories**  
Drill Chuck • Drill Chuck Arbor • Chuck Guard • Drawbar • Manual & Parts list

Face Mill Capacity 50mm  
Table Size 500x140mm  
Motor 600w

Shown with optional stand

**CENTURION MACHINE CENTRE**



**£1095**

**Features**  
Powered Crossfeed • 2 Motors • 28mm Spindle Bore • Large Milling Table • Taper Roller Bearings

**Standard Accessories**  
3-Jaw Chuck • Drill Chuck • Steel Centres • Change Gears • Lathe Tools • Vice

**Specification**  
Centre Height 210mm  
Centre Distance 500mm  
Spindle Bore 28mm  
Drilling Capacity 25mm  
End Mill Capacity 28mm  
Size 1570 x 490 x 955mm  
Weight 250kgs  
Motor 3/4hp

**COMET LATHE**



**£595**

**Features**  
Hardened & Ground Bedways • Camlock Spindle Mount • Large Spindle Bore • Footbrake • Precision Taper Roller Bearings • Double Vee Bedway • Removable Swart Tray

**Standard Accessories**  
Machine Work light • Central Lubrication System • Machine Stand • Table Guard • Drawbar • Manual & Parts list

**Including Power Feed**

Face Mill Capacity 75mm  
Table Size 156x745mm  
Motor 1.5hp

**100mm 3-Jaw Chuck**



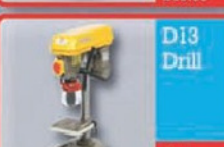
**£41.12**

**80mm 4-Jaw Chuck**



**£39.00**

**100mm 4-Jaw Chuck**



**£49.00**

**VType Vice 5"**



**£49**

**100mm Rotary Table**



**£99.00**

**130mm Self-Centring 4-Jaw Chuck**



**£75.00**

**Boring Tool Set MT2 MT3**



**£59.00**

**D13 Drill**



**£49**

**8" Vernier Caliper**



**£15**

**MT3 Imp/Met Posi Lock Collet Set**



**£80.00**

**Hobby Coolant System**



**£59.95**

**Machine Angle Level**



**£65**

**5" Bench Hand Shears**



**£55.23**

**6" Bench Hand Shears**



**£60.00**

**Magnifying Lamp**



**£35**

**Collet Chuck 125mm ER32**



**£35.00**

**Collet Chuck 125mm ER40**



**£39.00**

**Imperial Micrometer Set**



**£35**

**Slip Rolls**



12" £99 / 16" £109  
20" £199

**T1 Quick Change Toolpost and 8 Holders**



**£115**

**Toolbox 6 drawer**



Self Reversing Slides  
**£60.00**

**Lifting Crane 1 Ton**



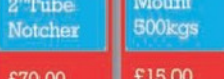
**£130.00**

**2" Tube Notcher**



**£70.00**

**Machine Mount 500kgs**



**£15.00**

**Box & Pan Folders**



12" £199 / 24" £299

All prices include VAT. Delivery included UK mainland - excluding certain Scottish postcodes

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