

No. 108

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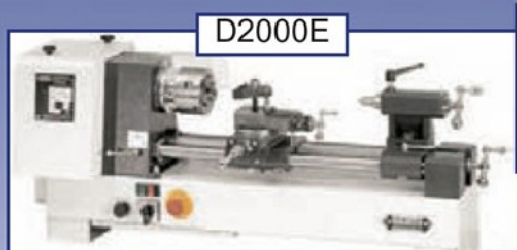
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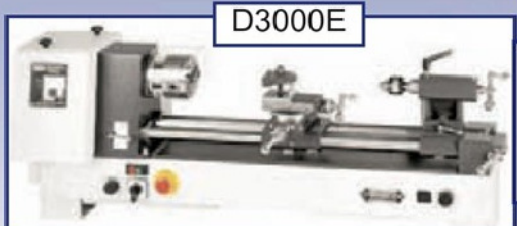
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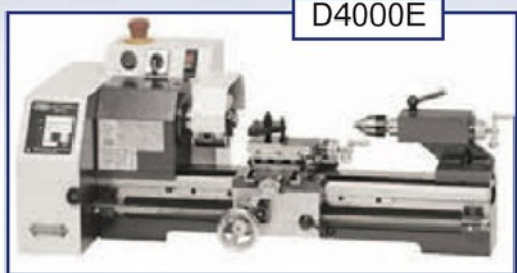
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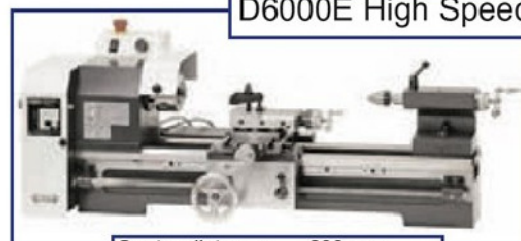
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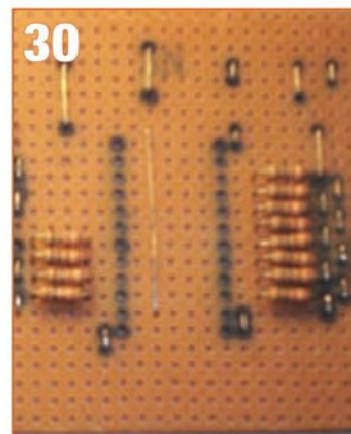
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*An unmodified Stent tool and cutter grinder built by Alex. Gray.
Giles Parkes discusses his changes on page 28*

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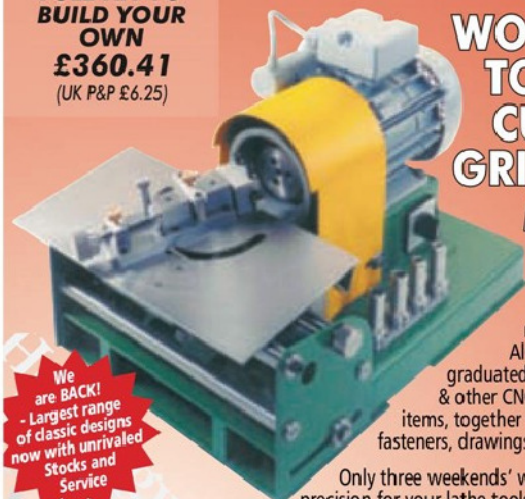
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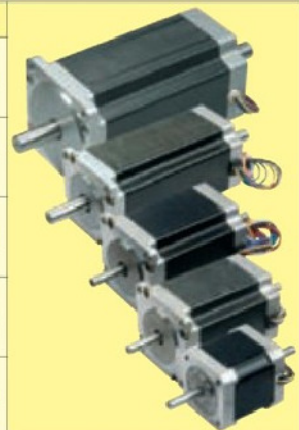
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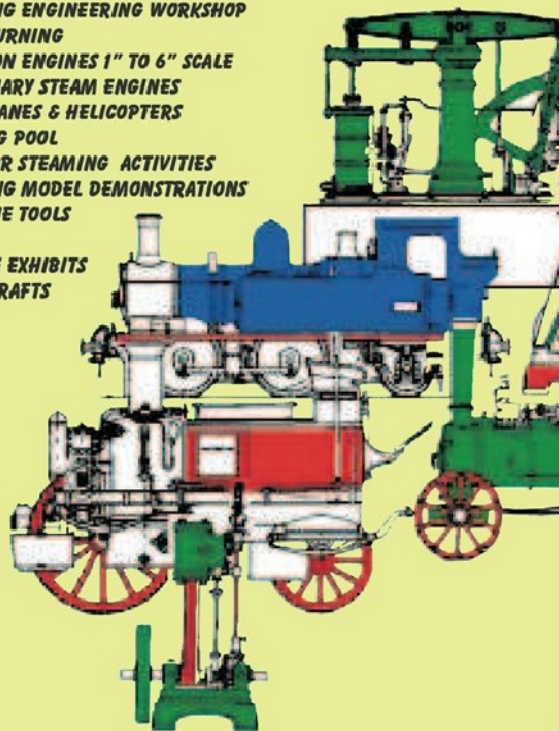
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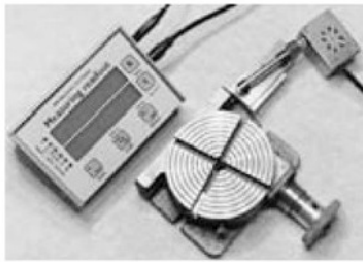
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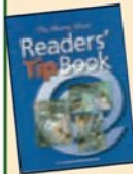
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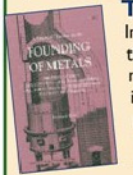
The majority of this B & W film was shot during the summer of 1955 and shows the manufacture of crown scythe blades at Issac Nash's Belbroughton works, near Kidderminster, including the working of their last water-powered tilt hammer. It may only be 15 minutes long, but this film is a fascinating record of a manufacturing process which had changed little over 100s of years but which is now, needless to say, long gone. Highly recommended!



The Design and Use of Instruments and Accurate Mechanism • 1934 • Whitehead •

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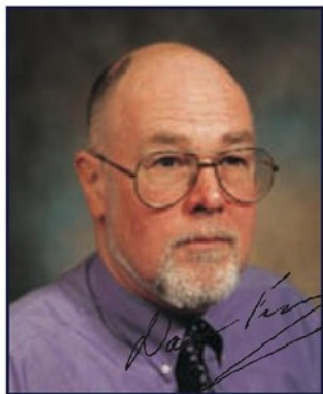
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Three Phase from Single Phase

Reader Ron Jeffrey kindly sent me extracts from a book published many years ago by Brook Motors. An artificial three phase system is described which bears similarities to those described by Ted Wale (Scribe a Line Issue 103), and Ted Fletcher (Scribe a Line Issue 106). Brook refer to the use of a "Pilot" motor, and note that "when a three phase A.C. motor is connected to a single phase supply, whether running lightly or on load, a rotating magnetic field is formed which, cutting its own conductors, spaced electrically at 120degrees, generates the near equivalent of a true three phase system, the third leg being previously used as the starting winding.

In order to neutralise the impedance drop of the windings, a condenser of suitable capacity is connected between this third phase and one of the single phase lines acting as a rigid phase converter and passing a fixed amount of power to the three phase supply. In the same way, all the remaining motors in the plant, which are standard three phase, use auxiliary condensers connected across the same pair of phases as the pilot motor.

Where a complete installation, including pilot motor, is required, we recommend that the pilot motor should be a separate unit, running light, and bearing no mechanical load. Its rating should be 15 to 20 per cent of the total load, and as great as the H.P. of the largest load motor. The remaining motors on this system will be standard three phase machines, and capable of giving their full three phase rated output with the addition of a condenser between the same two lines as the condenser on the pilot motor."

The illustration in the book shows a star connection, but it could presumably be reconfigured for delta. This would seem to confirm that the general idea was well accepted back around 1906.

Bull wheel tooth count

One of the endearing features of the Myford Super 7 is that the back gear bull wheel has 60 teeth unlike the ML7, which had 65. Reader Ron Hallam got in touch to point out that, on his relatively new big bore Super 7B Plus, the bull wheel has 67

ON THE EDITOR'S BENCH

teeth. It seems that all those aeons ago when the Super 7 was being designed, the "60" number arose from the gear design calculations rather than being chosen because it forms a useful division feature. With the Super 7B Plus, history has in a way repeated itself, and design calculations yielded a bull wheel of 67 teeth. A number of machines have been manufactured to this standard. Myford have however responded to customer comment that bull wheel division is a desirable feature, and the design has now been changed to a 60 tooth gear. Due to the different belt drive arrangements, the Connoisseur lathe has featured a 60 gear since its introduction.

In the workshop

I was presented this week with yet another case of automotive "designed in obsolescence". Our daughter arrived home saying that one of her windscreen wipers had stopped. The car is a Fiat Punto, which has covered just 49000 miles. Examination showed that the driver's side linkage had come adrift. It's one of these part spherical joints which is "clicked" together at manufacture, but unfortunately is able to unclick easily once a little wear takes place. The dealer's solution is a complete new motor/linkage assembly at a cost of over £110.00. My fix was to make a sheet metal bracket, shaped to fit over the joint, screwed and glued in place so that the linkage is held in position. A second bracket has been fitted to the passenger side.

Matchmaker - The Saga Continues

The two larger size 34 stepper motors from Arc Euro Trade, have been fitted to the X and Y axes, each being coupled directly to the relevant leadscrew. It is interesting to compare these new size 34 motors with the earlier size 42's. It does really emphasise the development in such motors over the years in that the new smaller variety actually delivers higher torque. A Z axis trial using an old size 42 motor coupled to an API driver did not prove successful, as the driver tended to trip out. Whether this was a fault associated with this particular (second hand) unit, or whether these drivers do not like the older (very low resistance motors, is not known. So it was back to plan A using the biggest of the size 23 motors, again from AET. To compensate for the lower level of torque, this one was arranged to drive through 3:1 reduction toothed belt drive, using the XL type, 0.2in. pitch x 3/4in. wide. This is easily able to



X axis directly driven by size 34 motor.

accelerate the mass of the quill and cutter assembly upwards, albeit to a reduced speed compared to the original.

A fourth axis drive is now under construction, this time using a smaller size 23 motor, salvaged from an industrial scrap heap. It is actually of Sanyo Denki manufacture and has been fitted with a 12 tooth HTD pulley. Undoubtedly the neatest approach to fitting a stepper drive to a rotary table is to use a machined adaptor such as are available from DivisionMaster and Engineer's Tool Room. However I anticipate that my Vertex table will migrate regularly between the VMC (manual operation) mill, and the Matchmaker (CNC). I therefore propose to fit a 48 tooth pulley permanently behind the hand wheel, and have the stepper motor on its own bracket, bolted separately to the mill table. The belt can then be slipped on and the motor positioned for suitable tension. It may also be possible to arrange for the same motor to drive the universal dividing head via the shaft normally used for table gear drive.

Dates for your Diary

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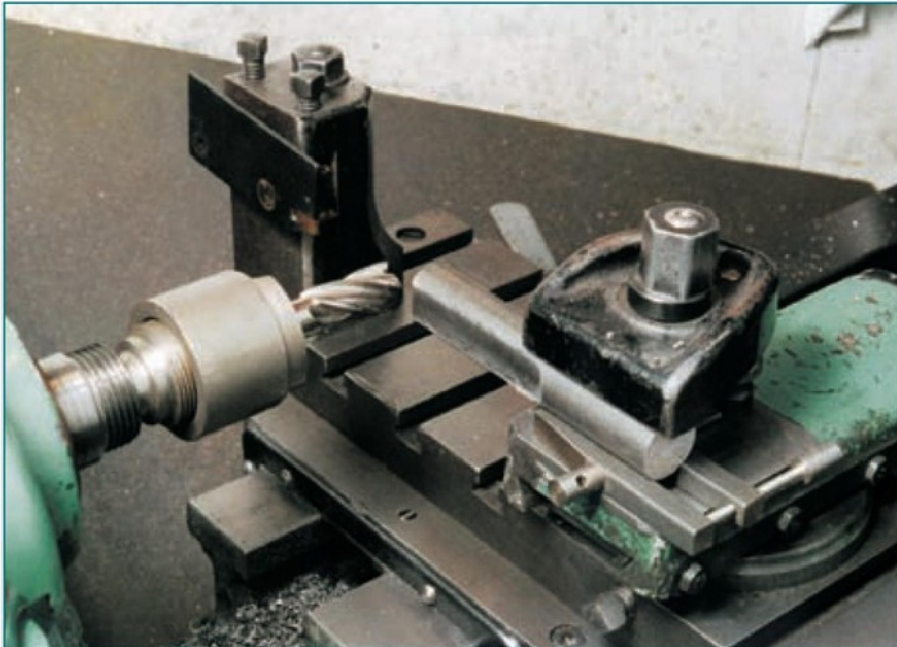
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23rd to 25th September, (subject to confirmation)

Midlands Model Engineering Exhibition

14th - 19th October
Leamington Spa (formerly Donington)

THE LATHE ONLY WORKSHOP 1



1. Milling without special equipment, other than a cutter chuck.

The first of a new series from Harold Hall which will illustrate how much can be achieved with limited equipment.

Cutter chucks

Whilst milling can be carried out with just a lathe as supplied, typically milling the flat in **Photo 1**, some additional items are really essential for more advanced work. Absolutely essential is a milling cutter chuck, as using a drill chuck, or the three jaw chuck, is a very risky approach. The problem is that the helix angle of the cutter attempts to, and very frequently does, draw the cutter from chuck even with a very light cut. My preference is to use the type of collet chuck where the threaded end of the cutter shank is screwed into a matching thread in the base of the collet. With this method the cutter remains in the same relative position to the workpiece even if the cutter rotates as the end of the cutter is in contact with the base of the collet housing. Because of this, it does not run the cutter into the chuck but pulls the collet forward tightening it further as a result.

Collets having a very gradual taper, typically the ER series or those based on a Morse taper, are also used with plain shank cutters and are capable of a substantial grip. They do not though have the absolute certainty of holding the cutter's position in use. Chucks having a Morse taper shank, or similar, must be held in place with a draw bar, passing back through the machine's spindle. This is because the cutter's helix can draw it from its mating taper with potentially disastrous consequences.

Cutters are made with a number of standard shank sizes and in the home workshop this will normally mean (for metric) 6 mm, 8 mm, 10 mm and 12 mm. Sixteen millimetre may also find a use so it is worth acquiring a chuck that will cope with that size if funds will run to it. Twelve millimetre collets will take cutters up to 14 mm and 16 mm collets up to 20 mm. Imperial sizes are $\frac{1}{8}$ in, $\frac{3}{16}$ in, $\frac{1}{4}$ in, $\frac{5}{16}$ in and $\frac{3}{8}$ in with similarly oversize cutters.

Vertical slide

The major problem with milling in the lathe is the requirement for a third axis. This is usually overcome by the addition of a vertical slide as shown in **Photo 2**, and when milling with the cutter mounted in the lathe's spindle this device is essential for other than the simplest task. Another approach is to use an overhead milling spindle that is supplied as an accessory by

An introduction

It was in the late 1940's, then in my mid teens, that I first became aware of the hobby of model engineering. The occasional purchase of the *Model Engineer* magazine and a couple of visits to the *Model Engineer* Exhibition in London and my interest in metalwork was firmly established. An old Myford ML4 was obtained but quickly replaced by a new ML7. Equipping the workshop beyond this was though limited to the absolutely essential small tools.

A drilling machine was though desirable and I set about making a Cowells of Watford machine, doing this entirely on the ML7. This was though the limit of my workshop activity until a few months prior to my becoming editor of *MEW*. However, I did in those early days discover that making workshop equipment and engineering models was invariably carried out with just limited equipment, milling machines being a rarity. Making the drilling machine gave me my first experience of using just a lathe.

It was not until the 1970's and the introduction of the Mill/Drill that the milling machine began to be much more common. Even in *MEW* issue 7 (1991) it was found that only 45% of the respondents to a survey had a vertical milling machine and only a very small number a horizontal mill. The milling machine was though high on the list of probable major purchases for the future. Even so, there are still a large number of workshops using a lathe for both turning and milling. These no doubt fall loosely into three categories, lack of finance, lack of space, or a newcomer to the hobby who has made their first purchase of a lathe and will no doubt want to wait awhile before purchasing a milling machine. There may well be a fourth, others who simply do not have sufficient time available for major workshop activities and cannot therefore justify obtaining a milling machine on these terms. The projects in this series will be of particular interest to such readers, as none will take more than 25 hours to construct.

This series is therefore primarily for the benefit of the lathe only workshop owner and includes items made solely by this method, though most will also be of interest to the owner of a fully equipped workshop. Even here the occasional milling or boring operation on the lathe rather than the mill can be preferable. Also, the series is not intended purely for beginners and assumes very largely that the reader is conversant with milling practices. However, as is my usual approach I do go into a fair amount of detail, with this introduction to the series particularly having the newcomer to the format in mind. If you consider yourself an absolute beginner, then reading up my beginner's articles starting in issue 10 or the project's series starting in issue 84 should be helpful. If finding the back numbers proves difficult, then there are books available on the subject, particularly in the Workshop Practice series.



2. A vertical slide is essential for most milling on the lathe.

some lathe manufacturers. With this fitted the result is the equivalent of mini vertical milling machine and is largely outside the scope of this series.

Tee slotted cross slide

For most readers the lathe will already be available and will, or will not, be fitted with a tee slotted cross slide. If on the other hand you are reading this with a view to starting up a new workshop then do purchase a lathe with a tee slotted cross slide, if you intend undertaking milling work on the machine. Even if it is intended that a milling machine will also be acquired at some later stage, some milling and particularly boring operations are still more conveniently done on the lathe. Also power feed to the cross slide will be a distinct advantage as this will ease the task of multiple passes necessary due to the light weight nature of the set up.

If an existing lathe does not have a tee slotted cross slide a vertical slide can often be fitted using the same fixings as those used for the top slide, as can an auxiliary table such as that in **Photo 3**. However, you may not feel inclined to make a tee slotted add on table in which case a simple plate drilled and tapped with a large number of holes would be an alternative. Again this could use the top slide fixings.

Machine vice

Small vices are available but frequently only have two holes or short slots for fixing them to the machine table. This, coupled to the limited tee slots on a vertical slide gives very little scope for getting the workpiece into a suitable position for machining. Vices that have the facility for varying the fixing position are therefore of considerable benefit.

Unfortunately, there are only two types having this facility that are commonly available. First, there are the economy

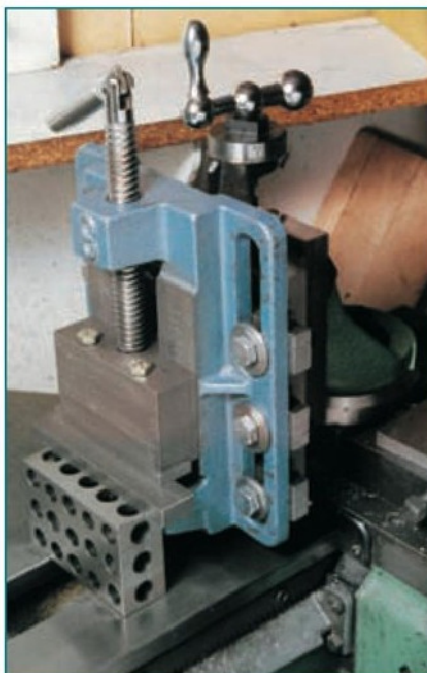


3. A tee slotted table for adding to a cross slide where tee slots are not provided.

drilling vices, **Photo 4**. These though are totally inadequate for milling without some modification, a longer moving jaw, and some re-machining to improve accuracy (Ref. 1), a task not easily done within the limitations of using a vertical slide. Even with that done they are too wide for the average vertical slide and bars need adding to the vertical slide to provide fixings for the vice as seen in the photograph. Having done that though they perform the required task quite well. A considerable improvement, but much more expensive, are the toolmaker's vices, as seen in **Photo 5**. The method of mounting these make them ideal for the purpose. Both photographs show how these vices can be set with their jaws accurately horizontal and, if initially done with the fixings loose, also at the correct height on the slide for the task in hand.

Workpiece clamps

It is inevitable that as you take on more projects that you will find the need for more and more clamps and support members. Having served their initial purpose do not scrap them as many will find further use. **Photo 6** shows three examples. A strip of steel (1) has been slid into the lower tee slot, this will have a



4. and 5. The method of clamping these two vices onto the slide allow their position on the slide to be easily adjusted.

multitude of uses as you will see through the series. For accuracy, it should be a light push fit in the slot. In this case it is supporting the workpiece prior to fitting the clamp (2, left) and the additional support (3, top). When a workpiece and or the vertical slide are too small to make it possible to fit more than a single clamp, supports as in the photo should be considered essential.

Limited capacity

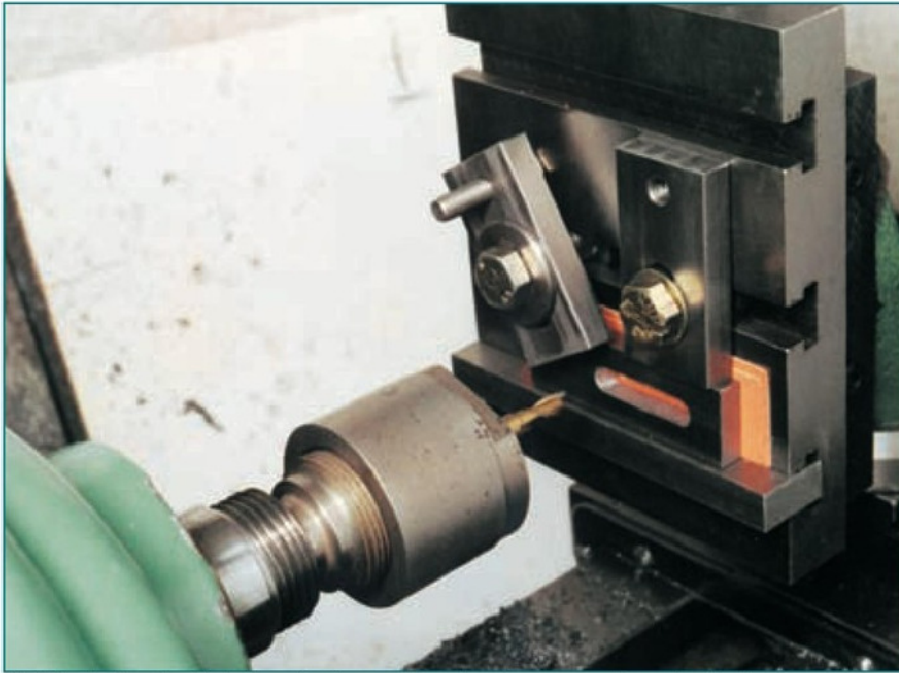
Aside from the need to take relatively light cuts, the main, and probably only real, problem with milling on the lathe is its inability to cope with large items, due to the small area of the slides and their limited travel. Throughout the series though I will attempt to illustrate how the set up can be used to its limit. Readers with ready access to back numbers may like to get an early indication of the methods used by looking at my article in issues 21 and 22 in which the Hart grinding rest was made using the lathe only. Unfortunately, this particular device is no longer available.

Unless working in a large scale, the owner of a typical vertical mill or its mill/drill equivalent will rarely have to give the capacity of the machine a second thought, even the smallest being more than adequate for the majority of the tasks undertaken. However, this will invariably be the first consideration before obtaining kits/materials for lathe only projects.

Drilling machine

I have referred to the series being for the lathe only workshop but do assume a drilling machine will also be available. If not, a lathe can be pressed into service for carrying out drilling operations. Typically, a taper shank with thread to match the lathe's faceplate enables it to be fitted onto the tailstock, which is then used to feed the workpiece, giving, in essence, a form of horizontal drilling machine.





6. A typical method of clamping two parts using two supports and a single clamp.

Cutters

End mills are used mainly for three purposes, surfacing, cutting steps and cutting grooves. Surfacing and cutting steps can be carried out with the same size cutter and 12mm would be a good general purpose size. Grooves will though need a wider range of sizes but a smaller end mill can be used to cut and widen a groove so you do not need a cutter for each width. In any case slot drills can be used for the purpose. However, end mills (which do not have one cutting edge which extends across the centreline) cannot easily be used for enclosed slots as they cannot be plunged, so slot drills are a necessity here. Enclosed slots are frequently for adjustment with screws passing through them, so if we say M5, M6 and M8, 5mm, 6mm and 8mm slot drills will be required. Actually, having cut a slot using a slot drill, an end mill can be used to open it up if necessary.

Equally important to sizes required is the number of end mills of each size necessary,

I would say a minimum of three unless you have access to a tool and cutter grinder when I would say two. My three consist of one in pristine condition for surfacing and general work on free cutting mild steel (230M07), one used cutter for general purpose mild steel (typically 070M20) and cast iron castings and one new one in reserve. I find that slot drills get less use so settle for just one of each size.

The size and travel restrictions of the vertical slide will sometimes create difficulty in mounting the component to enable access to the surface requiring machining. A long series end mill, say 12mm diameter, may get you out of an otherwise impossible situation. It will not get a lot of use so just one will suffice.

Sharpening end mills requires specialised equipment and few home workshops are that well equipped, so it will be a question of locating a local industrial tool and cutter grinding service. However, it will not be economic to sharpen one at a time, this being my reason for suggesting three of each size.

Sharpening just the end cutting edges will though be a good half way measure and is a relatively simple process. Equipment for doing this will feature in the next issue.

Replaceable tip milling cutters are available in many forms. Smaller ones can have plain shanks with larger versions either plain or taper shanks. Some economy plain shank cutters in larger sizes, say 1in., have unhardened shanks around $\frac{3}{16}$ in. diameter and can with safety be held in the three jaw chuck, those in **Photo 7** being a typical example, (Ref. 2). Even at these larger shank diameters, I would be hesitant to use hardened shanks in my three jaw but perhaps I am being unduly cautious. Morse taper shank cutters are available but not with much choice and tend to be expensive. Also, if they do not include a drawbar feature then it is possible for them to become loose.

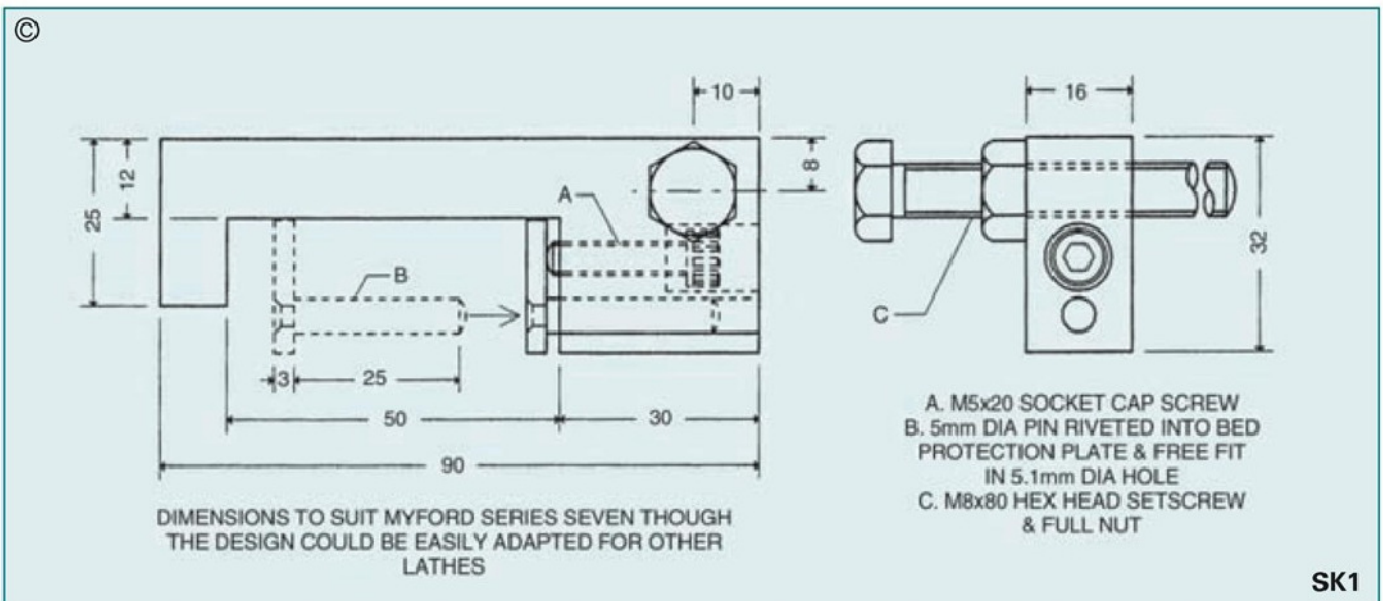
Many tipped tools do not have an appreciable helix, often even negative, **Photo 8**, so there is no force generated which attempts to withdraw the cutter from the chuck holding it. However, the lack of a normal helix, also a normal rake, **Photo 9**, results in higher cutting forces, which in turn makes them demand a more robust machine and have therefore limited use in the lathe; more about that later.

Saddle stop

I really do believe that a saddle stop is all but essential for milling on the lathe and should you not have one then making one should be the first step before proceeding further. **Sk. 1** shows a simple design for a flat bed lathe. Stops for the cross slide, going forward and back would also be helpful, but I managed without them, which is far from the case where the saddle stop is concerned.

The milling process

First stage for most operations will be to mount the vertical slide; a relatively simple task but one which needs doing with care. The essential requirements are that its face must be accurately parallel with the cross slide traverse. **Photo 10** shows how this is done aided by a DTI as the cross slide is traversed, the engineer's square will not of course be there for this operation. The





7. Three economy tipped tools that will be very useful for machining cast iron. However, the lack of a positive helix places more load on the lightweight cross slide/vertical slide set up. Rate of metal removal is therefore limited.

square in the photograph illustrates how, should you have a swivelling slide, the slide is set accurately vertical after mounting. Whilst a swivelling slide will be calibrated in degrees that will be adequate for much of the work where angles are involved they should not be used for setting the slide square or parallel to the cross slide axis. Also, do not bypass this stage if the immediate task to be carried out is not critical; the next one maybe and you may forget that the slide has not been accurately set.

Next stage is to mount the workpiece for machining and is the most demanding aspect of working with a vertical slide. As a general rule I can only stress that the workpiece must be securely fixed using sufficient clamps and supporting pieces to achieve this aim. The examples through this series will show that this is not always easy. For a further example at this stage, **Photo 11** is a variation on the arrangement in **photograph 6**. However, the supporting piece on the left also acts as a stop so that a number of parts can easily be finished to the same length.

A suitable cutter also has to be chosen and this is probably more crucial than is the case when working on a robust vertical milling machine. For this reason I have chosen to go into some detail as this should help with the understanding and therefore the choice of cutter. Consider an end mill being used to produce a narrow (W) and shallow (D) step on the edge of a piece of material as illustrated in **Sk 2/1**. From this it can be seen that the thickness of cut is dependent on the feed rate and not the width of the step being cut. **Sk 2/2** shows that for a wider step the thickness does not change appreciably only the duration (A) of the cut increases. It can be seen that in both cases the cut starts very thin and increases towards the amount of feed per tooth, (FR) Therefore, within limits, the width of the step will not greatly effect the load presented to the machine. If though the depth of the step is increased, **Sk 2/3**, the amount cut will increase accordingly, comparing a surface skim of $\frac{1}{16}$ in. with a definite step of $\frac{1}{16}$ in. the load on the machine will increase approximately eight times.

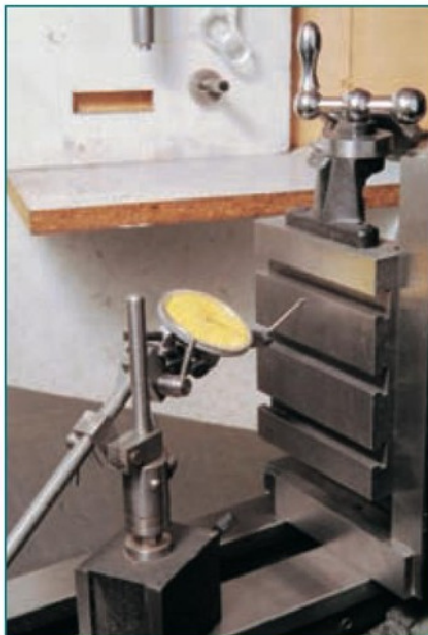


8. Helix angle of a tipped tool and conventional end mill compared.

Considering further increase in width, as this approaches half the diameter of the cutter other factors come into play, a subject that is beyond the scope of this article. As a result, when cutting steps, even if this is very shallow for surfacing, width of cut is best limited to no more than one third of the cutter's diameter. This though is not a hard and fast rule as cutting at the full diameter will be necessary when machining a groove. In this case and when using a slot drill depth of cut will need to be kept low.

Sketch two shows us that the end mill only cuts at the tip of the end teeth and not across its full width. That though is dependent on the end teeth not being convex and to ensure this it the case they are always sharpened very slightly (about one degree) concave. More about that in a later issue.

Another factor that will affect the load on the machine is the state of the cutting edge. Handling a brand new HSS cutter it will soon be realised that the cutting edges are almost razor sharp and must be treated with caution. Typically holding them with a piece of cloth or leather when



10. It is essential to accurately set the vertical slide parallel to the cross feed using a DTI and upright using a square off the lathe's bed. Do not rely on the slides angular calibrations.



9. Rake of a tipped tool and conventional end mill compared.

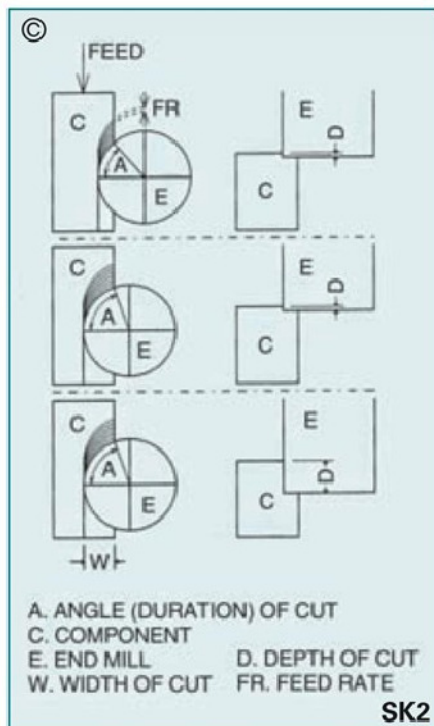
screwing them into a collet. However, after some use, or even misuse, the edge will be found to have lost its razor sharpness and obviously this will lead to an increase in cutting forces and tax the rigidity of the set up.

Of considerably more importance is the tipped tool's lack of positive helix and rake as illustrated by **photograph 8** that will dramatically increase the loading. For this reason their use in a light lathe should be limited to use with cast iron where a hard spot on the initial surface of a casting could do serious damage to a HSS tool. Ideally, the tool should be used for surfacing using the end of the tool with depth of cut being kept to a minimum, that is, just sufficient to remove the surface skin.

If however, you find it necessary to surface a casting using the side of the cutter it will be necessary to be patient and step the cutter down the face in very small increments, say about 1mm and make multiple passes. Once the casting's skin has been removed it will be OK to use your HSS cutters allowing you to speed up operations considerably. Having made that



11. Similar to the set up in Photo 6 but the second support is mounted at the end of the workpiece for accurately machining a batch of parts to the same length.

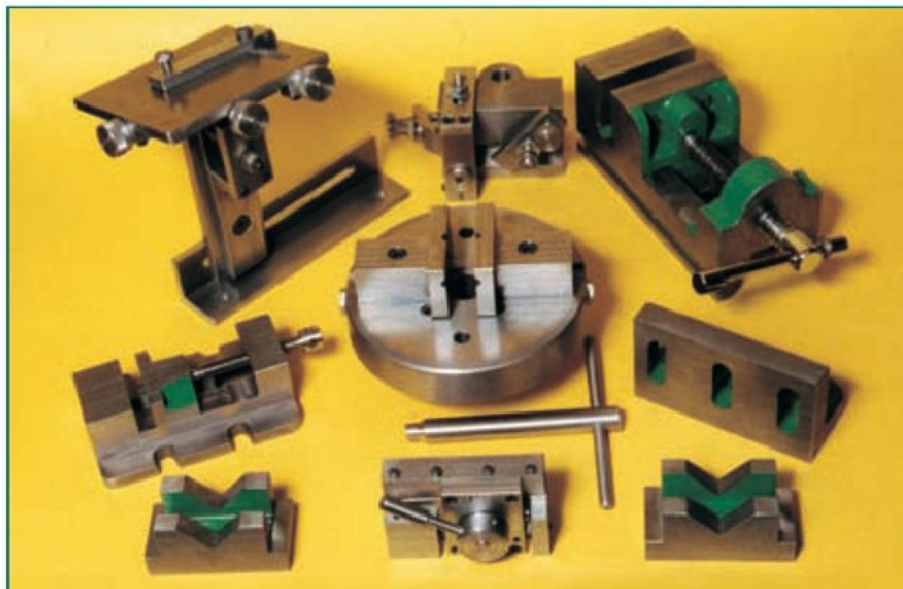


recommendation, if the casting is machining easily then take a chance and use an HSS end mill from the start when machining a side face, though an older one rather than one in pristine condition.

Some brief comments worth bearing in mind!

For maximum rigidity, ALWAYS lock the two axes not being traversed when making a cut. Also, remember that the helix angle of an end mill can, if being used to cut an appreciable depth, draw the saddle forward if not locked or hard against a stop. The result is then a progressively deepening cut, as the workpiece is traversed, either by the cross or vertical slide. Releasing an axis can result in a very small movement of the workpiece and may cause a machining mark if the cutter is rotating. Always ensure the cutter is away from the workpiece if rotating when releasing a slide.

Having set up a part for machining check that the amount of traverse



12. The items that will feature in the series.

available will enable the required machining to be completed fully before commencing the task.

Slides in the horizontal mode are always pushed or pulled along using their leadscrews. However, for the vertical slide this is not always the case, in particular if carrying a large vice and or workpiece. In this case the slide can fall under its own weight causing errors in reading the slides dials. This will be especially so if it is a borderline case, sometimes being pushed, sometimes falling. Ideally, the slide should be set stiff enough for this to not happen. However, it may then be uncomfortably stiff to operate when fitted with a very light component. You must be aware of this problem if working to tight tolerances. Ideally, you should adjust the slide to cope with the weight of the assembly fitted onto it.

Fitting the vertical slide to the cross slide can sometimes very marginally distort the cross slide causing it to stiffen up. You may therefore find it necessary to change the cross slide adjustments between milling and turning.

The limited space between headstock and vertical slide makes it all too easy to catch your knuckles on the end mill in the chuck whilst making adjustments to, or measuring, the assembly on the slide. Always move the saddle as far from the headstock as is possible in these situations

and cover the cutter with a few layers of cloth. This will reduce dramatically the cost of sticking plasters!

The series to come

In the next issue a grinding rest is described built from stock materials which will allow accurate sharpening of lathe tools and milling cutters. This is seen top left of **Photo 12** which also shows the remainder of the items that will feature in the series. These are, left to right, back to front. Grinding rest, Cross drilling jig, Modified drilling vice, Small vice, Two jaw chuck, Angle plate, Matched pair of vee blocks and a retractable tool holder, as used for screw cutting. Having now completed all the items for the series I am fully aware how versatile the "Lathe Only" format is. Having just a lathe is no bar to having an interesting hobby, or to being able to undertake quite involved projects.

References

1. From Drilling to Milling Vice *MEW*, issue 23, page 50.
2. **Chronos Ltd.** Unit 14 Dukeminster Trading Estate, Church Street, Dunstable, Beds, LU5 4HU Tel. 01582 471900. Fax 01582 471920. E-mail sales@chronos.ltd.uk. Website www.chronos.ltd.uk

QUICK TIPS FROM PETER FOYLE

To measure the concentricity of a cross drilled hole in a bar.

Mount a piece of rod the same diameter as the drilled hole, in the lathe chuck. Set a square ended tool in the tool rest, (square end to the lathe centre line), and hang the drilled bar on the chuck mounted rod.

Using the cross slide micrometer, wind the tool in so that the square end touches the side of the bar and record the reading. Back off the tool, rotate the bar 180 degrees on the rod, and advance the tool again, record the new reading. If the hole is drilled dead centre, the readings will be the same. If the readings

are different, half the difference equals the "off centre" of the hole to the bar.

To countersink cross holes on the inside of a channel section

The easiest way is to countersink the holes before bending the section, but when it is only feasible to do this after the section is bent, proceed as follows:

A tool must be produced in two parts. The shaft should be of suitable length and no larger than the holes it must pass through. It should also have a short thread on the end. Fitted to this is the cutter, a short length of silver steel, of length to fit between the walls of the

section, the diameter of the required chamfer, and chamfered on one end. If chamfering brass, all that is required is a number diametral sawcuts across the chamfer to give a number of cutting edges. There is no need to back them off or even heat treat the steel. For steel, a little more attention would be required to achieve both form and hardness. Finally a thread is tapped to suit the shaft. In operation, the cutter is placed in rough position, and the shaft entered through the opposite hole, then screwed into the cutter. The shaft can then be gripped in a drill chuck, and pressure brought to bear.

Using the Boring Heads

When using either Boring Head there are some general points to consider:

All boring tools by their nature of long overhang have a high degree of spring. This is often evident during use and it is necessary to repeat some cuts without altering the settings towards the finishing size or prior to taking a measurement. Therefore always use the shortest, largest tool diameter possible to maximise stiffness. Incidentally, this spring can be used to advantage in taking small cuts to final size.

In contradiction to the previous statement, the tool must have sufficient clearance to the bore to prevent the trapping and compaction of the swarf. It is normal to consider that the business end should, if possible, not be greater than 80% of the bore diameter. Occasionally I have found it necessary to ignore this rule for very small holes, but this should be done with due care.

It is often recommended to set the cutting edge above the centre line. This has the advantageous effect of increasing the clearance below the cutting edge which can be useful for small holes, but has the negative effect of reducing the carefully ground top rake (more on this below). I avoid this where possible. Another point to note is that the dial graduations will not read precisely if the tool is not cutting on the centre line because of geometry effects. This can be ignored for large diameters, but does become more important for small diameters.

Changing the effective tool height is possible by rotating the cutter (which of course does have an effect on the top rake). For a reasonably large diameter it is normally accurate enough done by eye. If you need more precision try levelling the head and measuring as per normal turning methods. GHT once showed us how to make eccentric collets to adjust a boring tool height, the principle of which could be adapted to this.

Boring cutting speeds are technically the same as those for normal turning in the lathe. Unfortunately a less rigid tool is more likely to chatter and you must be mindful of the out of balance forces created by an off centre lump of steel, so drop the speed to avoid any bearing or accuracy problems. Discarding any spring effects of the tool and assuming the cutting is generated by rotating the boring head (as opposed to rotating the workpiece), it simply cannot produce tapered or bell mouthed holes. It must produce parallel bores which is, to say the least, useful. It is sensible to lock the slide during cutting, so get into the habit of cut, unlock, adjust, lock, cut. With both heads, adjustment, clamping and locking procedures require the use of Allen keys which I have, admittedly, not tried to rationalise.

Remember that 0.01 mm movement on the slide is 0.02 mm on the bore diameter. I stamped the units of measurement on the side of the Body to ensure I always remembered. A boring head can be useful for other applications, such as flycutting with a short tool with the cutting face at the front, or for taper turning by holding a



1. Heavy Duty Head in use on Mill

TWO HEADS BETTER THAN ONE?



In this final instalment, Will Bells covers operational and tooling aspects of the boring heads.

centre instead of setting the tailstock over, although I doubt that I will ever use mine for the latter.

Cutting tool options

A number of different tool options can be used with either of the boring heads, some of which are shown in **diagram 2**, with details of tool tips being given in **diagram 3**.

Firstly there are a number of proprietary round shank boring tools, both HSS and TC tipped which will fit. One thing to watch with any tools which have soft shanks is that the area which is held can be damaged by the grub screws. I would suggest you grind some relief on the shank in this area to ensure that removal is not affected if damage occurs. This is the reason for the shape of the bars shown in the drawings. Similarly, any grub screws with flat front faces need either to be hard or need a reasonable chamfer to avoid

burring the leading edges and therefore preventing removal. The boring tool location diameters have been developed around standard available metric tools, but of course could be modified to suit individual requirements. Adapter collets are suggested for different tool sizes, which could be turned slightly eccentric to allow height adjustment if desired as mentioned above.

Secondly, you can make your own from either silver steel rod, hardened at the end or grind from HSS. The silver steel option gives an easily made quick tool which can be made for a specific job, but more care must be taken in use and sharpening compared to HSS. The biggest problem with silver steel is that it will reduce its hardness at quite low temperatures. This is a problem when sharpening and even when turning. As a consequence it needs to cut at around half the speed of HSS. I generally avoid using silver steel tools



2. Home constructed bar using carbide tip.



3. Heavy duty head shown with rule to illustrate scale.

where I can, although I do have a few made up. To harden, heat the end of the formed tool to a bright cherry red – be careful not to overheat the edge as it is likely to become over brittle. Quench in tepid water to harden. If the tool is for brass, I hone to a sharp edge and use hard. If the tool is to be used with ferrous metals, the tool is best tempered before honing and using to avoid chipping. To temper, polish the end with fine emery cloth and very gently reheat the shank until the tip is dark yellow then quench. Sounds easy, but I'm colour blind, which does make things difficult on occasions!

Thirdly, the user can make bars to suit carbide tips - an example of which is shown in **photo 2** and was used for much of the roughing work on the Quorn bores. Last, but certainly not least, is the boring bar with HSS bits, which is my preferred option whenever possible. Two designs are shown in **diagram 2**, one which can be used for the majority of occasions, and one which is ideal for screw cutting. These should be made in different lengths to suit

the range required. Of course, one can modify to suit ones specific needs. If it is necessary to break HSS bits to use in the bar, grind a nick where you want to break it, hold in the vice and hit with a hammer. For safety's sake, wear glasses and cover with a cloth prior to hitting.

Specifically for the Heavy Duty Boring Head, I have included a drawing for an Extension Arm (**item 15**). This fits into the side tool hole, as shown in **diagram 4** and allows the use of the standard boring bars and tools. This provides up to 250mm diameter, but of course the rigidity is reduced, so use with care.

Cutting tool geometry

As mentioned above, in theory all the rules which apply to normal turning apply to boring. Unfortunately we have, in effect, that which we try desperately hard to avoid, a huge tool overhang, and this forces some modifications to the methods.

Top rake

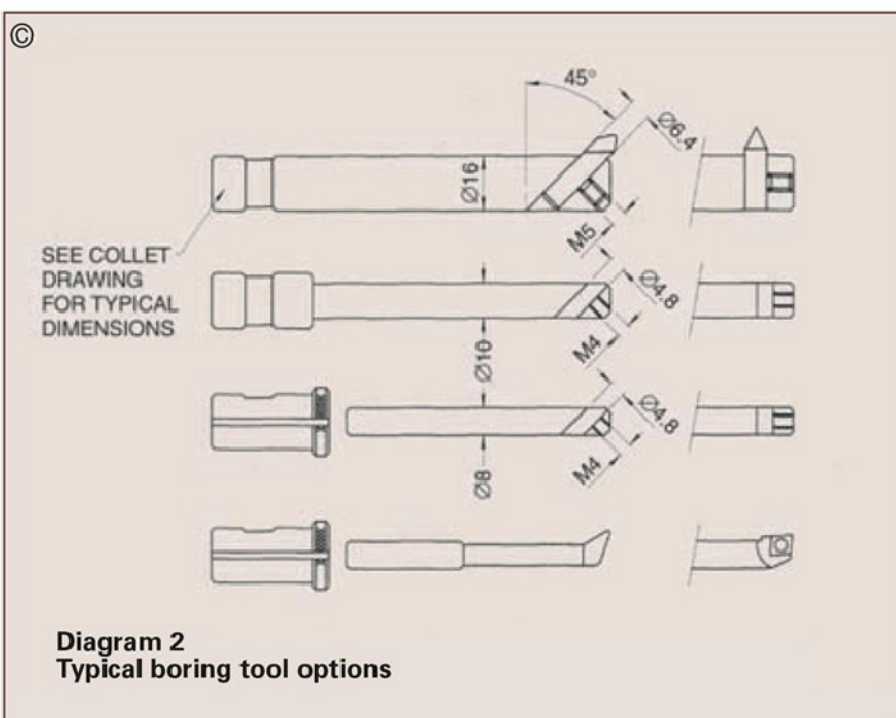
In any cutting tool, the top rake angle, by which I mean the resultant of the side and back rake angles, has a big effect on cutting performance. Theory has it that going from a positive rake (as shown in **diagram 3**) to a negative rake increases the power used in cutting, but increases the strength of the cutting edge. This changes and increases the forces on the cutting tool and in particular has the effect of increasing the tendency to push the tool away from the cutting surface. Because cemented carbides are extremely hard, but brittle, the top rake is frequently designed to be zero or negative which helps prevent the tip chipping. For materials such as brass or gun metal, zero rake is needed to prevent digging in. But this is not good news for our slender piece of stick with a tool attached to its end.

Lead angle and tip radius

The second important aspect to consider is the lead angle, which is the angle at which the front of the tool approaches the cutting face. In the normal roughing tool, we give the leading face an angle, which has the effect of preventing digging in when taking deep cuts (because the chips are wider but thinner). Unfortunately, the payback is that this causes the tool to again be pushed away from the work and increases the tendency for chatter. A big tip radius compared to the depth of cut has a similar end result.

Practical recommendations

With HSS and silver steel tools for general purpose use, I always keep a sharp cutting edge, put on top rake and try to set at centre height at the expense of limited tool life. For brass I use zero top rake. If you are lucky enough to have an indexable carbide insert set up, they provide a nice easy tooling solution and are near essential for dealing with iron castings. It is unlikely however that we



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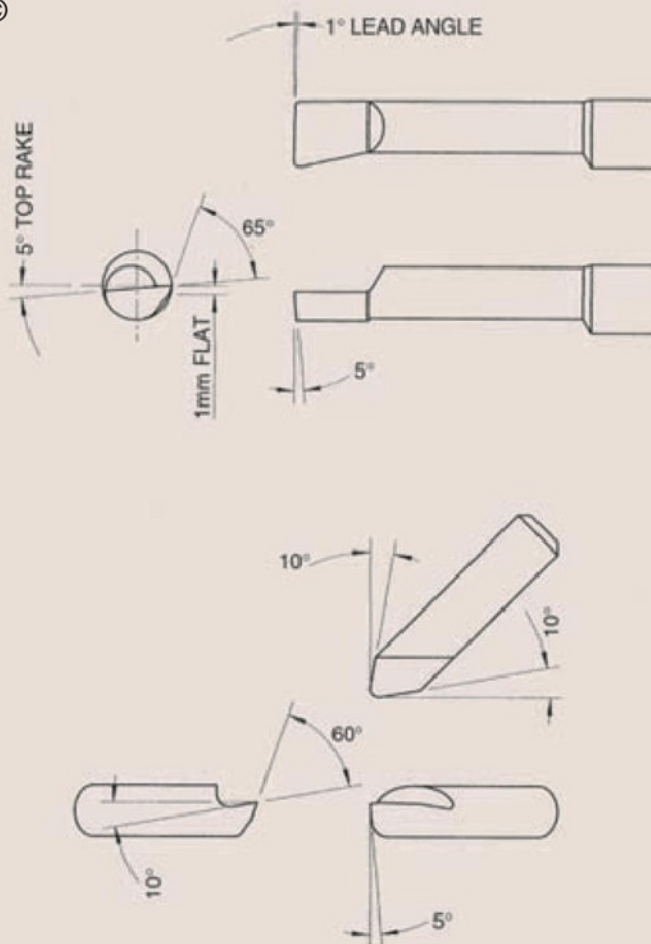


Diagram 3
Typical tool shapes



will approach a rigid enough set up to take advantage of the cutting. The home concocted bar shown in the **photo 2** with the carbide insert has had, naughtily, back rake and bottom clearance ground, which has worked in practice. The reduction in edge strength is, I suspect, quite academic for work of this class.

With a boring head, the cuts practically are unlikely to be particularly deep, so I never use a roughing tool design. For general work I use the shape as per **diagram 3**, basically keeping the front face flat or slightly acute and keeping as big a radius as the work will allow. 0.5mm seems about right.

If a flat bottomed hole is required then a tool with a front face ground with a clearance angle is definitely needed. The tip radius should suit the job, but be careful as if the cut is bigger than the tip radius this sort of tool can act opposite to the roughing design and want to dig into the surface.

Bottom clearance should be ground to prevent scraping the tool against the work surface. I use a small angled cutting edge to keep some strength, but grind the rest away in a radial shape, again as in **diagram 3**.



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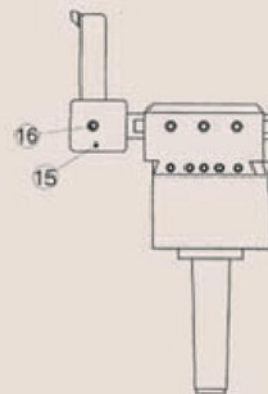
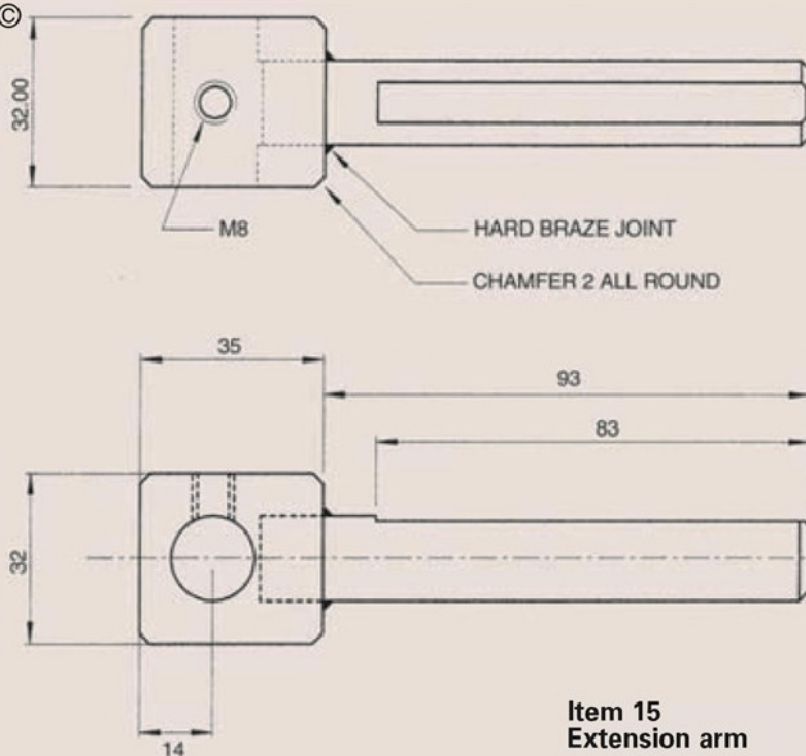


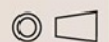
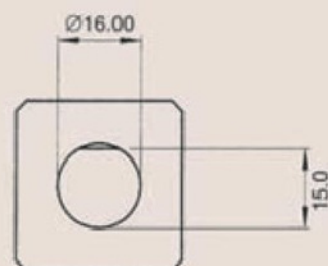
Diagram 4
Typical use with extension bar

©



Item 15
Extension arm

MAT'L: FCMS



SHEET METAL ETCHING 1

Introduction

Some manufacturing techniques move quickly from industry to the home workshop, depending mainly on how useful they are for one-off or small scale applications, how much they cost in equipment, tooling or materials and how steep their learning curve is. Within my own area of interest, (scale model ships), glass/resin fabrication became a widely used technique very quickly and resin casting was adopted as quickly as the availability of improved mould making and casting materials allowed. However, though PCB etching is fairly widely practised, metal etching has been slow to be adopted, although is now an effective technique for the amateur.

Sheet metal etching or, to use the more descriptive American term, chemical milling, is widely used industrially for bulk production of small parts, including model components. Its model applications, though, are generally commercially produced etchings for kit or accessory producers who require multiple items. It is rarely used by modelmakers needing parts for a single model and even more rarely do they do their own etching at home. In the main, kit parts and model components take advantage of the ability of metal etching to produce small and delicate items (Victorian wrought ironwork in small scales, for example, or the handwheels and ring gunsights in **photo 1**) or its ability to cut out multiple identical parts. However, metal etching is a lot more versatile than that.

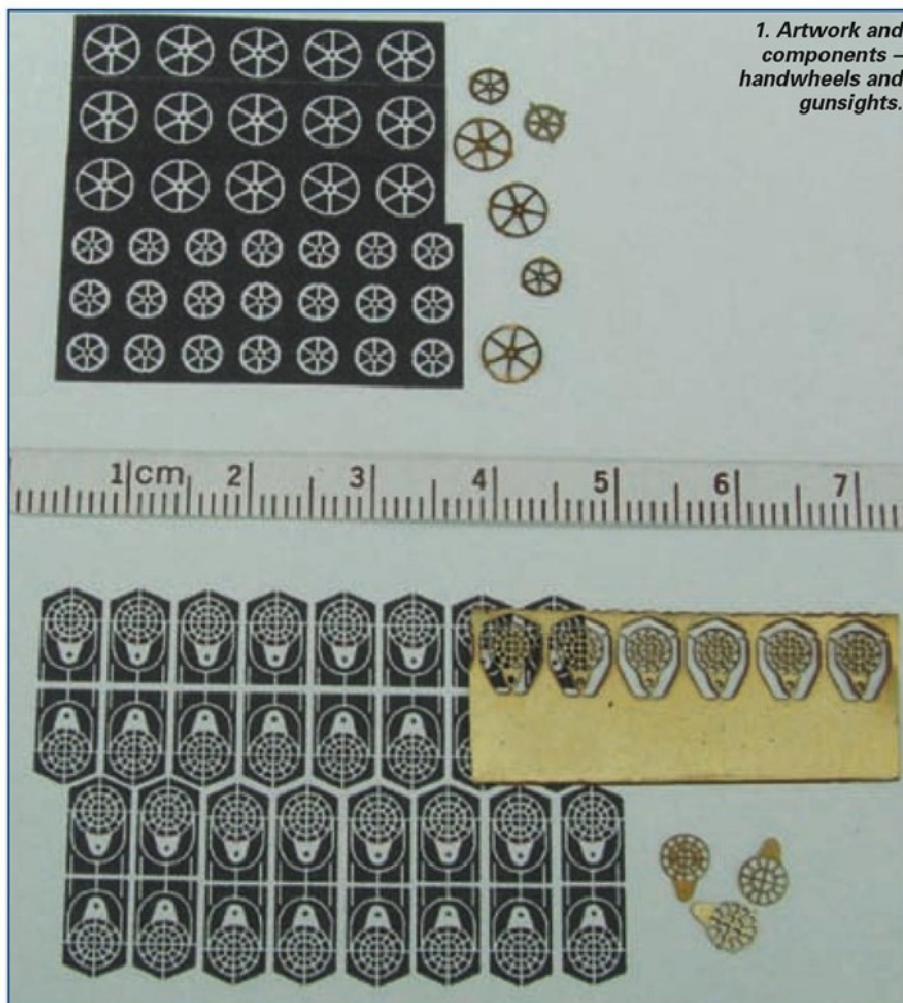
John Purvis discusses a technique which is invaluable for the production of delicate parts.

and an anchor etching before it was folded.

Half etching can be used to make patterns for casting, as well as surface detail. The gun components in **photo 4** are folded patterns. The patterns in **photo 5** are examples of half etching of thicker sheet and were for a gun elevating quadrant, the toothed outer rim of which is also in half etched brass. The finished castings can also be seen assembled in the same photograph.

Half etching of thicker metal will also produce badges or nameplates (**photo 6**) in this case subsequently nickel plated. Half etching of thin sheet, with or without full cut outs, can be used for decorative artwork, model vent and radiator grilles, rivet detail, and areas of brickwork, tiling, planking or chequerplate (also **photo 6**) – the list might not be endless but it is fairly long. Even the basic ability of etching to produce multiple, identical parts isn't of use only for commercial production; there can be a need for multiple components on a single model. For example, the zareba around some warship gun mounts is, in effect, a low wall of armour plate to protect the gun crews. It is constructed from heavy plate (15lbs./ sq. ft.) and needs a large number of support brackets. These are closely spaced so that any differences between them would be very obvious. Of course, multiple sheet metal parts can be made by soldering several thicknesses together and filing them to shape as a block but, as those of you who have tried it will know, this is not really practicable for more than about twelve items. On the model shown there are 94 zareba brackets (**photo 7**), which would have been difficult to make, and to make identical, other than by metal etching.

Most of the etched items shown are model ship components, since this happens to be my main interest, but metal etching has applications in many other fields. In clock making, for example, "engraved" faces and filigree hands, however ornate, should present no problems. Frames could be etched from heavier gauge material and, in a CAD design, the bearing holes could be placed very accurately, undersize for subsequent reaming. Though the technique is unlikely to be precise enough to make finished gearwheels, as the etched edge of the teeth will have a small ridge (shown in **Drawing 1**, due to the manner in which etching takes place), it could certainly produce "part machined" blanks for finishing. The range of applications in railway and road vehicle modelling, to



1. Artwork and components – handwheels and gunsights.

Applications

Etching on one side only will show surface detail, or provide fold lines which ensure precise edges and corners on three

dimensional components, as shown by the depth charge racks and plough anchor in **photos 2 and 3**, and also in **photo 12**. **Photo 3** includes the transparent mask used for copying the image onto the metal

2. Three dimensional assembly from two dimensional components.



judge by the wide variety of kits and etched parts commercially available, must be enormous.

In addition to all of this, very little special equipment is needed and the cost of it is not high in comparison with most workshop equipment, particularly if you make it yourself. The materials are relatively inexpensive and the techniques are no more complicated than those of, say, resin casting. A range of materials can be etched but the most suitable for home use are copper alloys; brasses, bronzes, nickel silvers etc. It is technically possible to etch other materials, such as stainless steels, but this is less straightforward in the home workshop. Fortunately some nickel silver alloys (e.g. NS106) are sufficiently "silver" in appearance to be a close enough match for most applications where stainless steel or polished aluminium needs to be represented.

Historic difficulties

You might think that a technique as useful as this would have been very widely adopted, so why hasn't it? Probably because until fairly recently, it has been difficult to produce consistent results, comparable with commercial products, due to limitations on the materials and methods available to the amateur. This, in turn, has perhaps made it appear complex and a little daunting. In practice, like many things, it is much easier than it appears before you have tried it. In fact, metal etching is merely an extension of PCB production, with a few added twists.

PCB etching is relatively straightforward and masking can be by a wide range of methods. Of these the most practicable

system for double sided sheet metal is photoresist. The PCB photoresists available were, initially, aerosol sprays and, more recently, precoated board and, as those of you who have used it will know, the precoated board has simplified PCB etching considerably.

Of these two, only the aerosol sprays have been applicable to home metal etching and this has been the main method used by those who have written on the subject in the past and in my own initial work. However, while it is possible to produce usable metal etched parts using resist sprays it is difficult, the results are very variable and the reject rate high.

The one advantage of spray photoresist is that it allows the use of odd pieces of sheet but there are several disadvantages. It is essential to clean the sheet very thoroughly and to apply a coat of even thickness, without trapped dust, air or moisture. This is reasonably practicable on a single sided PCB where some variation in developing and etch rate due to varying coating thickness is acceptable. However, to achieve the required standard of coating on both sides of a metal sheet, and of identical thickness on both sides, is much more difficult, particularly as variations in etch rate cause bigger problems than for PCBs.

Current industrial practice

The answer to the problem lies in industrial practice, where the photoresist is applied by the etching company, either by dip coating or by hot rolling a photosensitive film onto the sheet. Either method provides a completely even and

3. Transparent mask shown with formed plough anchor.

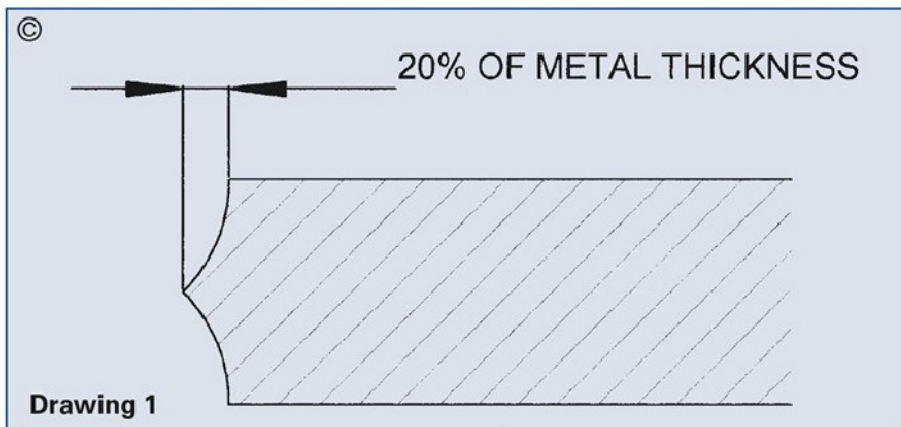


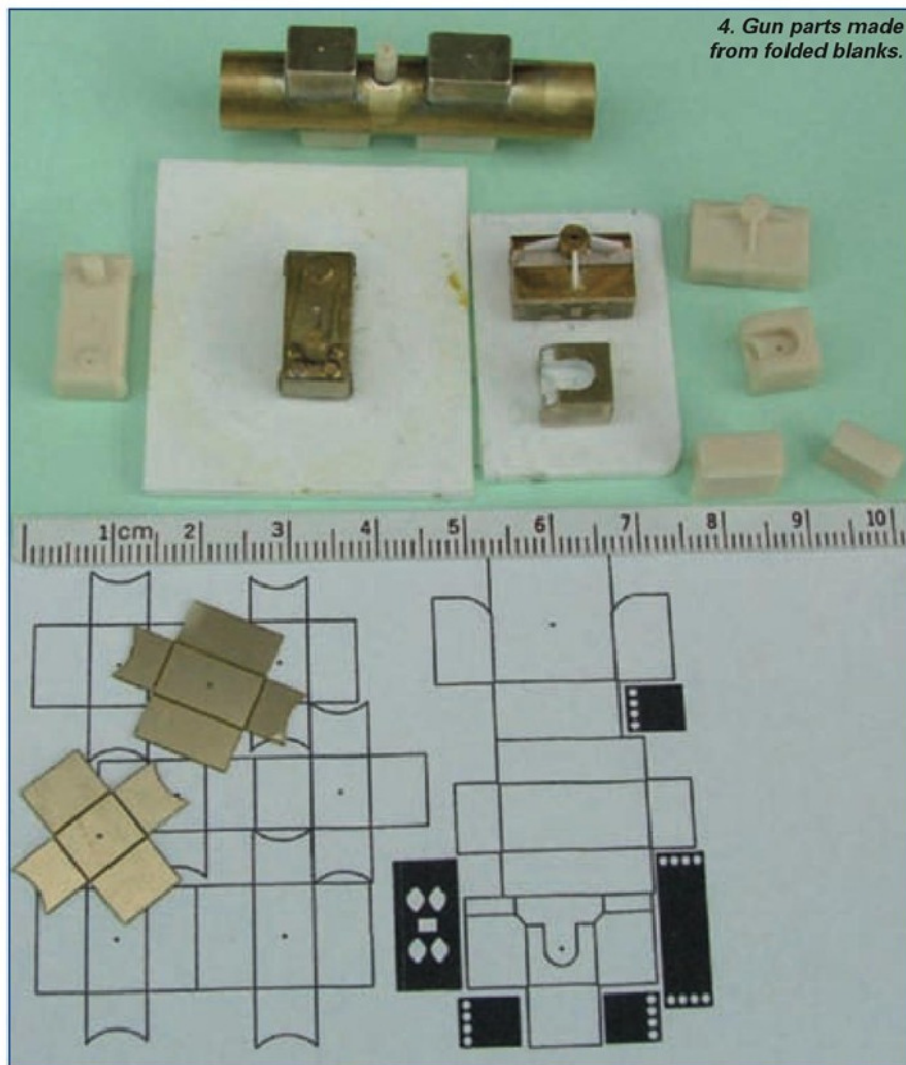
uniform coating, which is ideal. In industry, developing and etching are usually by spraying at a controlled temperature, allowing tight control, and the closer that you can get to that at home the better though, fortunately, high precision isn't essential. One other aspect of commercial practice is the accuracy of the design work. While computer design is not essential for home etching, and I'll describe other methods, it is easier, faster and more accurate and it cuts the cost of making masks. I can now claim that, by using precoated sheet and computer design (and by taking some care with the processing) my reject rate is nil. Apart, that is, from mistakes, second thoughts and the odd spot of carelessness and incompetence.

DIY or outsourcing

Having, I hope, persuaded you that metal etching is one of mankind's greater advances since the development of sliced bread, I'll try to give details of how to do it and what you will need. However, before doing so, I ought to deal with an alternative approach. You might well wonder why it is worth doing your own etching at all, when there are companies to do it for you. The standard sheet size used commercially is 12in. x 18in., about 300mm. x 450mm. If you are able to fill this area in one go (as you might if you need a large number of items, or if they are large items) and/or you are likely to want several sheets, then commercial etching is a possible cost effective approach. I have been in this position only once.

Fairly recently my club produced a "limited edition" semi-kit for a 1/4th scale boat, the "Swordsman", which is the modern successor to the Fairey "Huntsman". The metalwork for this filled a standard sheet, part of which is shown in **photo 8**. We needed an initial fourteen sheets, with a possible future requirement for more, and were able to produce a design which limited the work needing to be done by the etching company and therefore kept the tooling cost to the minimum. Otherwise, commercial production would have been too costly for components for a single model. Since, in this case, the etching was to be done commercially we opted for 0.5mm. stainless steel. The company was able to supply this in a high polish, which is ideal for the models but made it very difficult to photograph (**photo 8** is, in fact, a scan).





4. Gun parts made from folded blanks.

that I rarely need to etch a sheet larger than about 180mm. x 130mm. Also, I sometimes get it wrong, or have a better idea, and need to do it again. Furthermore, it is easier to etch smaller sheets.

Similarity to PCB work

The stages in the production of etched sheet metal broadly correspond to those for etching PCBs. The drawing forms the basis of the etch design from which the transparent masks are produced. These masks are then used to transfer the mask design to the precoated metal in a UV light box. The metal is then etched and, finally, the mask is stripped off.

Though some of the work involved is similar to procedures, which have been described for PCBs by other contributors in the past, there are aspects of them which are particular to metal etching so, at the risk of repetition, I shall still describe the systems that work for me. This will also include solutions to problems that might arise, and odd tips, in the hope of providing a practical guide which will give good results and save you from some of the mistakes that I made along the way. However, I don't claim that the methods described are necessarily the only ones, or even the best ones, and I would be glad to hear of any better ideas.

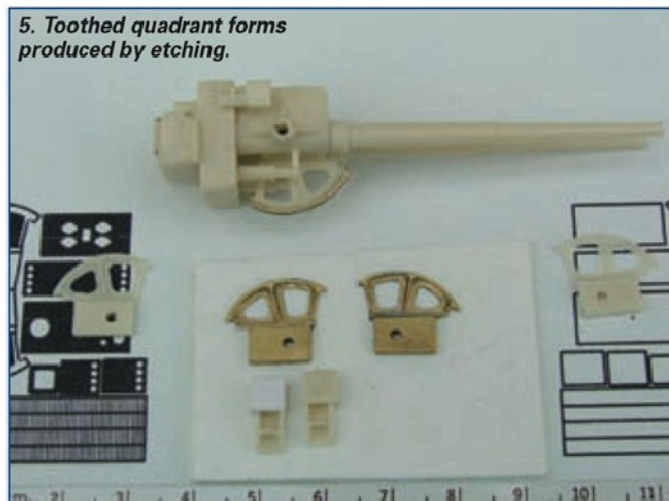
Design and artwork production

The object is to produce two "mirror image" drawings to form the basis for the transparent masks. This can be done manually or by the use of Computer Aided Design software. For the moment I'll deal with the manual method and leave until later, the computer alternative, which offers advantages to those who want to use it. Another factor affecting design is the type of resist to be used. Spray resists, like precoated PCBs, are positive, so that the areas protected from the light during exposure will be retained, with the unmasked areas etched away. The film photoresists used for metal are negative, so that the black lines on the mask are the lines which will be etched. This is a slightly more "user friendly" arrangement in that the masks are copies of the drawings, and also don't normally have large areas of

If you decide on professional etching and pass your drawing to an etching company it will produce the transparent mask tooling and supply you with a finished etched metal sheet in the material and thickness of your choice. For one-off items or small quantities, though, this has a few drawbacks. The first is the cost. Each etched sheet will be marginally cheaper than if you etch it yourself as the basic material cost will be about the same but there will be no developer or etchant to buy. However, assuming that your final drawing is entirely suitable as a basis for the tooling production (and you would need a bit of

experience of the specific design requirements for that) the tooling cost will be several times the cost of the etched sheet, typically at least £60, and might well be considerably more if the etching firm has any work to do on your drawings.

Another consideration is that, to get the most for your money, your design must fill a complete metal sheet and you will have no margin for error or second thoughts, as any modification of the design would involve retooling and hence added cost. For me this is a major factor since I need components only for the part of the model that I happen to be working on at the time and have found



5. Toothed quadrant forms produced by etching.

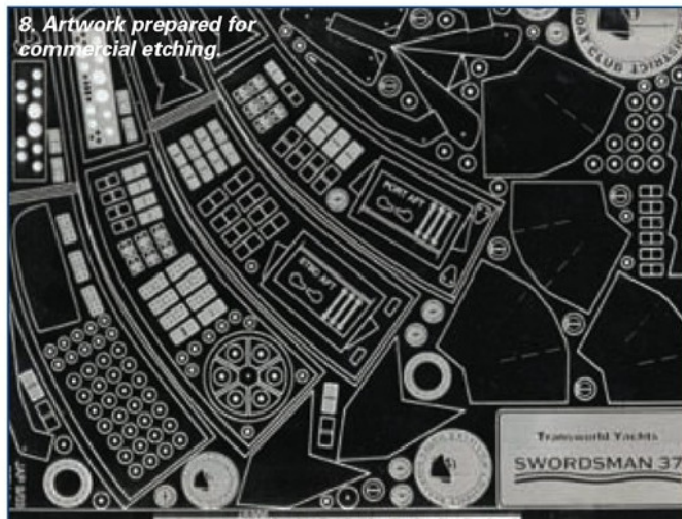


6. Nameplates produced from thicker material.

7. Just some of the 94 zareba brackets.



8. Artwork prepared for commercial etching.



black, which can cause printing problems.

The following notes are based on the use of precoated sheet. The required etch design should be drawn with all lines included, whether they are cut lines, which will appear on both sides of the image, or fold lines and surface detail, which will ultimately be on one side only. Areas where half the thickness is to be removed will be solid black.

There are some ground rules for preparing the artwork. The first is that lines intended to be "cut lines" (etching completely through the metal), and fold lines (which are to be etched on one side only) must be at least as wide as the thickness of the metal, though some surface detail markings may be finer. Lines marking surface detail can appear clumsy, if they are the full width of the metal thickness and it is usually better to make them about 0.125 to 0.2 mm. irrespective of the metal thickness. Surface detail and/or fold lines can be included on both sides, provided that they do not interact. For example, a fold line on one side that crosses a surface detail line on the other will result in a pinhole at the crossing point, or if one side is etched in chequer plate then a fold line on the other side will produce a "dotted" cut line.

To control the line width you will need to use special pens. I know of three types that are suitable (photo 9). There are the traditional, adjustable width drafting pens, reservoir pens of the type used with "UNO" stencils, possibly the best known of which are by "Rotring", and the fine fibre tip pens made by "Pilot", among

others. Of these, the fibre tip pens are rather easier to use, cheaper and more readily available. Both of the fixed types are made for a range of line widths and any will do the job. Lines must be drawn on the outside of the required area so that if a 20mm. square is to be produced then the 20mm. must be the distance between the inner edges of the lines. Thus, if the line width were 1mm. the actual distance between the line centres would be 21mm. It's rather like sawing on the waste side of a line so that the kerf doesn't reduce the finished size. Conversely, if the 20mm. square is to be cut out of a component to leave a 20mm. square hole then the lines will need to be on the inside of the hole, at 19mm. centres. The same principle will apply to circles and curves, which must have their radii adjusted to suit the line width. This doesn't apply to fold and detail lines to be etched through only half of the sheet thickness, which are drawn at the true line position.

The etching companies' design recommendations provide for hole diameters (finished size) to be not be less than one and a quarter times sheet thickness to ensure that they etch all the way through. However, this isn't of serious concern to us as a blank hole can easily be drilled out. Slightly larger holes, of any shape, can be drawn as black discs, squares or whatever so that the material etches away completely. However, this practice should be limited to holes up to about 3mm. diameter (or equivalent area) as it wastes etchant. Larger openings are better done as cutouts. To make drawing

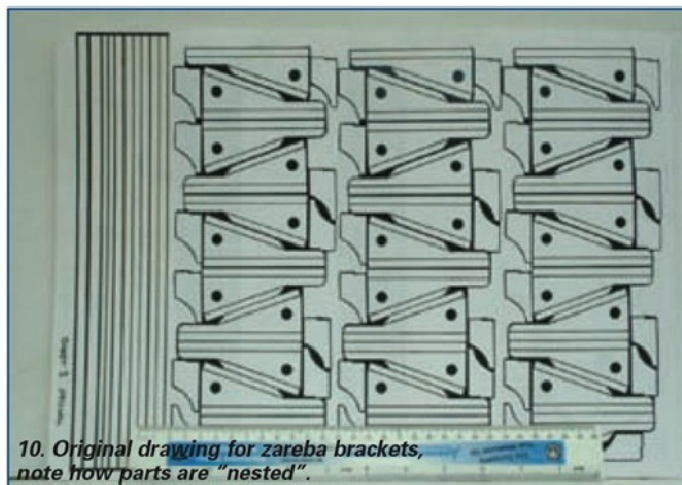
easier and more accurate it may be up to four times the required finished size and subsequently reduced in the copying stage of the drawings, which will be needed anyway. The reason for setting a limit of four times is to suit most copiers. As those who have had drawings rescaled will know, any modern copier will enlarge or reduce on a percentage basis, but this can lead to inaccuracy, particularly if multiple copying is needed to achieve a particular size, when errors can become cumulative. Apart from this facility many machines will also multiply or divide by two or four in a single shot operation, and this is often more accurate. It would be worth finding out what the capabilities of your local copy shop's machines are before starting and then choosing your scale accordingly, but bear in mind that the final reduced drawing will need to fit on an A4 sheet. It might seem an obvious reminder but remember also to multiply the line thickness when drawing oversize.

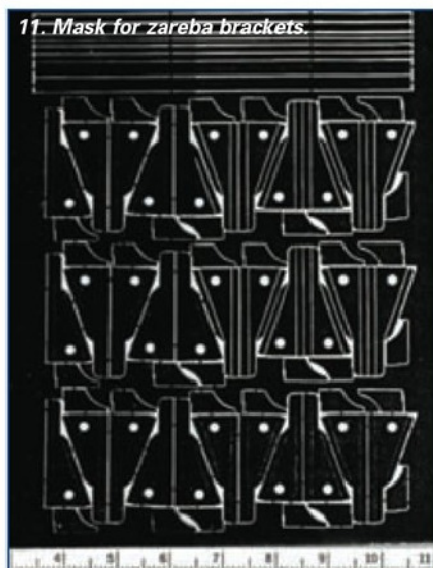
Photos 10 and 11 show the original drawing and the mask for the zareba brackets seen in photo 7. The drawing was four times finished size and the photographs show the advantage of working at a larger scale as relatively crude initial work has been greatly improved by the reduction. To make the photo 10 clearer a piece of white paper has been slipped halfway in between the two transparent masks to show up the etch lines which appear only in the upper mask. These examples show masks for positive photoresist made from hand drawn designs. No examples of hand

9. Several types of suitable draughting pen.



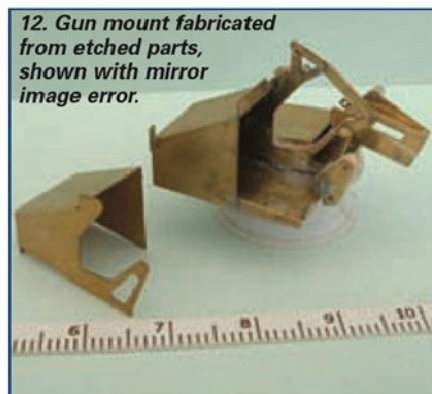
10. Original drawing for zareba brackets, note how parts are "nested".





drawn negative resist masks are shown because I had changed to computer design before starting to use negative resists. However, initial drawings for both positive and negative resists are exactly the same.

The completed drawing now goes to the copy shop to be reduced to finished size and have two copies made, one of which must be reversed to a mirror image. All of the surface lines and detail not required on side one can now be blanked out with a white correction pen or, if larger areas are to be removed, with pieces of white adhesive label stuck on. At this stage the drawing does not need to be elegant as long as it is accurate. Side two is then treated in the same way. Now bridges, or tabs, across the cut lines must be put in to prevent the components falling out when etched. If there is a face side to the design, perhaps the upper or outer side of the components, then put the tabs on the reverse side. This is again done with the correcting pen and the line width of half thickness tabs should be at least one and a half times the metal thickness. The number required is a matter of judgement depending on the size and shape of each component. As an example, a 20mm. square would probably need only one tab in the centre of each side, while a 20 x 30mm. rectangle would be safer with two on each of the long sides. It's not critical, but err on the side of generosity until you get the feel of the work. It would be better to have a little more work to do in separating the components than to have them falling out of the sheet. Unless the sheet is to be



subject to further work after etching (polishing or electroplating, for example) these bridges need not be more than half the metal thickness, and can be added on one side only. If further work is to be done on thin sheet then the tabs can be full thickness (and will need to have been added before the last copying operation in order to appear on both sides). For heavier gauges it will probably be sufficient simply to increase the number of half thickness tabs.

Your drawings are now the patterns for the transparent masks and must go back to the copy shop to be transferred onto overhead projector transparent film. Tell the shop what you propose to do with the films and ask for a quality setting that will give the maximum black density. For negative resist masks this is particularly important if there are areas of black where surface detail requires it to be half etched, as in a nameplate, for example. It would be important for all positive resist masks as these will always contain large areas of black. If you wanted transparent masks for use with positive resist you would need only to ask for the work to be inverted at the transparency printing stage, giving clear lines on a black background. If the drawings are small enough there is no reason why you shouldn't put them both on a single A4 transparency, provided that there is a margin of about 30mm. around each.

Having described the basic procedure, there are a few refinements which need to be covered. It is common to need a number of identical components, and it is more economic to avoid leaving too much unused space between components being etched. **Photo 10** shows how the brackets have been repeated and "nested" to make the best use of space. This was done by making a number of copies of the original enlarged drawing of the bracket and then

cutting and pasting to produce the multiple drawing. To get the multiple copies ask the copy shop to "step and repeat" to fill the A4 sheet. It is also unnecessary to have each component separated by unused metal. As **photo 10** also shows, the cut line at the edge of a component can be made common with that of the next one. This is slightly more difficult to achieve manually than by computer design but it is still practicable. Another space and material saving technique is to paste drawings of small items in the spaces in and between larger components. All of this is done, of course, at the initial enlarged drawing stage.

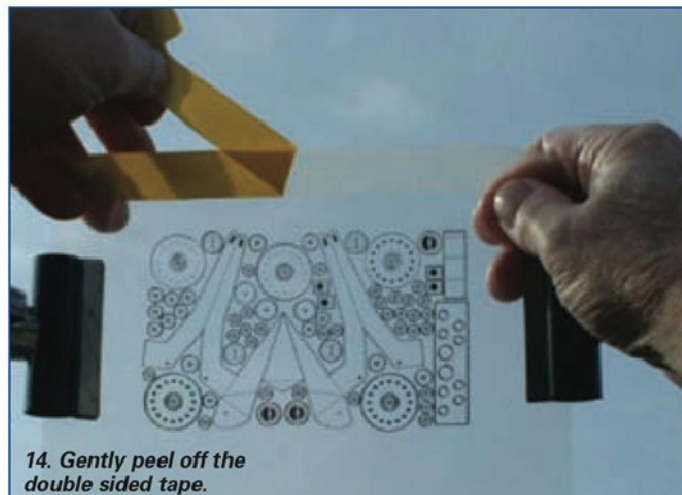
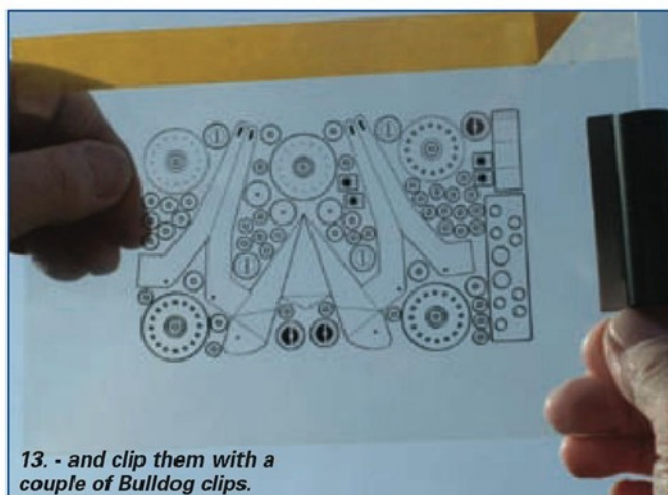
When the transparent masks are used the printed side is placed against the photosensitive coating of the metal sheet to minimise distortion, which means that lettering used on nameplates would be reversed when etched. However, this can easily be avoided. When blanking the words on one of the two sheets retain the reversed lettering so that, when the transparent mask is made, it will read the right way around when viewed from the unprinted side.

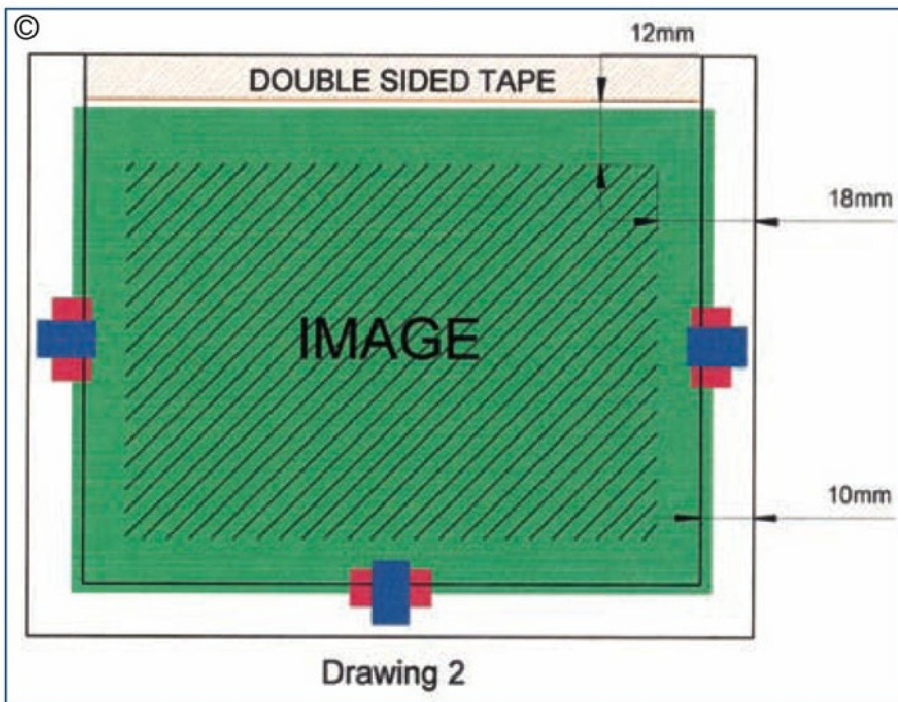
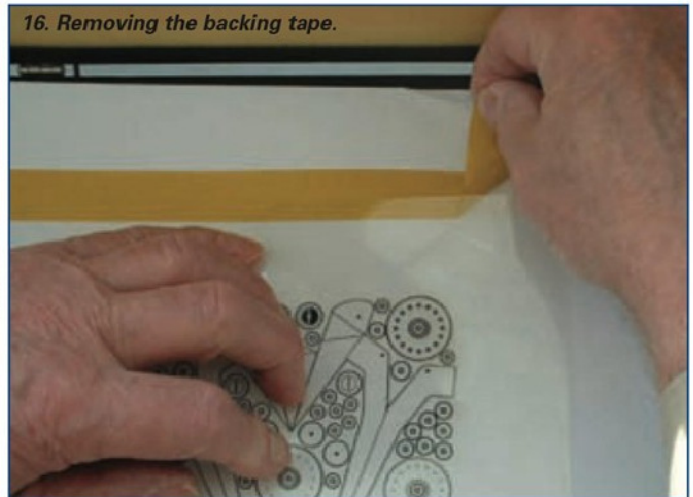
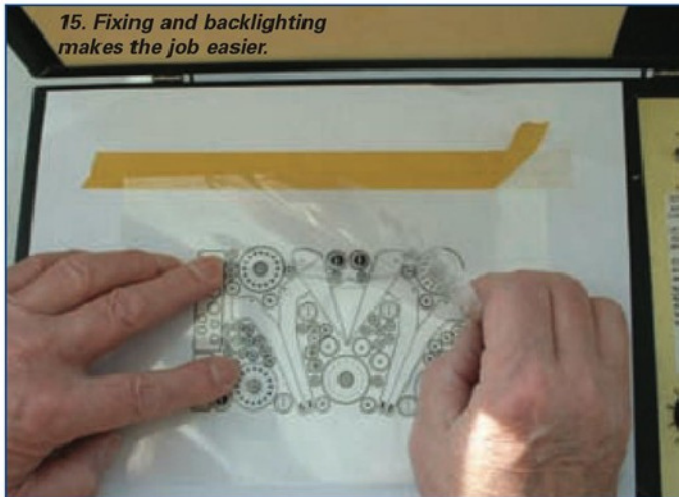
A variation of this technique must be used in producing right and left handed parts when care is needed to blank the lines on the correct sides to give the properly handed component. To illustrate how easy it is to get this wrong, **photo 12** shows an etched part of a twin 20mm. gun mount, which is a mirror image of the required item, compared with the correct component. As it happens, this particular mistake was made in a computer design, leaving me with even less excuse.

Making the masks

The two transparent masks must now be joined and must be accurately in registration. This is easier than it appears and is shown in the photographs. First place a strip of double sided adhesive tape along one of the long edges of one of the transparencies, on the printed side, and fold a corner of the paper backing tape back to make it easier to grip. This tape should be the thin type, not foam plastic mounting tape. It should be about 12mm. away from the edge of the image for metal up to about 0.3mm thick (more for thicker sheets) and the edges of the masks should be about 18mm from the image on the other three sides (**Drawing 2**).

Now place the second transparency on the first with the printed sides together





and manoeuvre it to line up the images. This can be done by holding the two sheets up to the light. When the images are accurately aligned, hold the sheets with one hand and clip them with a couple of bulldog paper clips (**photo 13**). The remaining backing paper strip can then be gently peeled off the double sided tape and the job is done (**photo 14**). With practice you will find that you can hold the sheets together with one hand while removing the paper with the other, without needing the bulldog clips.

There is an alternative method using a light box, which can be the UV exposure box if it is made to include separate fluorescent tubes. Commercially made UV boxes do not normally double as light boxes but it is easy to build in a couple of light tubes when making an exposure box and this will be described later. For this method lay a sheet of thin paper on the glass screen with a transparency on it, printed side uppermost. When applying the adhesive tape let it overlap the edge of the transparency to stick it to the paper and turn back the corner of the backing tape as before. Having the lower transparency fixed to the paper in this way makes it

much easier to keep it still when adjusting the second transparency over it and the backlighting also makes the job easier (**photo 15**). Having the transparencies laid flat on the glass also allows them to be held in position more easily when removing the backing tape (**photo 16**). Finally, simply cut the paper and tape around the edge of the joined transparencies. Either method is

completely practicable but using the light box is slightly easier.

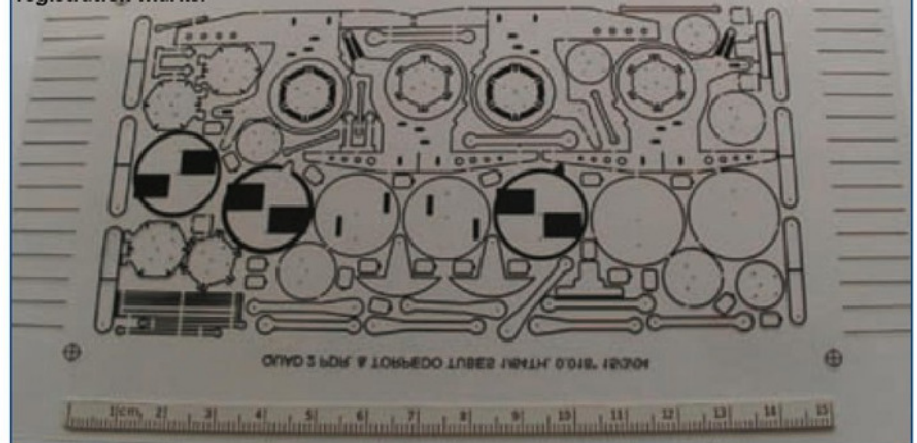
The thickness of the double sided tape (about 0.125mm.) gives adequate separation between the masks for metal up to about 0.3mm thick, and two layers of the tape will be sufficient for metal up to 0.5mm. For thicker metal it will probably be advisable to add a strip of a suitable thickness of card to the double sided tape, with a second layer of tape to attach the upper mask, to increase the separation. If this is done then it will be useful to make the masks a little larger and include some registration markings around the design to show outside the metal sheet. These will allow you to check that the masks for the two sides remain properly aligned. They can be seen on the set of masks for negative photoresist in **photo 17**. These are for 0.5mm. sheet, which is why the lines are wider than those on the transparencies shown in other photographs.

I have covered joining the transparencies in some detail only because it might appear to be more difficult than it is. One transparency should be cut down to be about 10mm. smaller on each of the three free edges, as shown in **Drawing 2**, which can be done before joining if you find this easier.

In the next issue of MEW, the second part of this article will deal first with the exposure, developing, and etching processes. Also covered will be the equipment required, and how this production technique may be assisted by the application of computer aided draughting.



17. Set of masks showing registration marks.



TAILSTOCK OFF CENTRE TOOL

The origin

I must start by saying that I cannot claim any originality for this simple device, as, if I recall correctly, it is based on something published about fifteen to twenty years ago in Model Engineer. Unfortunately, as I do not have the backnumbers, I cannot give credit to the author concerned. The accessory is useful in that it allows the tailstock to be left undisturbed in its accurate datum position on the centreline when long shallow tapers are to be turned. (Of course this tool is also invaluable as it has a wider range of adjustment than is normally available on the standard tailstock).

The tool

The tool itself is mounted on a standard No.2 or 3 Morse taper arbor which is modified with an M16 thread which is screw cut on the end. This is also equipped with a draw bar tapping on the rear end to allow the tool to be fitted tight into the tail stock to save any possibility of the tool turning during the machining of a tapered part.

It is simple to make and does not warrant the machining of a dove tail slide as the tool is clamped solidly in place during any future machining sequence. However if you are careful to achieve a good sliding fit, then this will help to ease the setting up.

Details are given for a small selection of spherical centres, which should ideally be polished and hardened. If you do not wish to get involved in ball turning, then centres of a bit less than the standard 60degree could be used. It must of course be remembered that in use, the work will be running out of line with the tailstock, and hence the spherical centre is a preferred arrangement.

Peter Rawlinson describes a time saving accessory for machining slow tapers



1. Completed off centre device with spherical centres and alternative arbors, in case.

Machining

The Main Body is made from 30mm x 40mm bright mild steel and finished with a smooth cut in and on the slide recess (To obviate the large amount of material to be removed during the hand "rounding" of the slide block a small diameter end mill may be used instead of the 18mm shown). Having a reasonably heavy duty mill, I tend towards the "Hewn from solid" approach, however it should also be perfectly acceptable to construct this component as a bolted assembly of two parts thus cutting down on the volume of swarf.

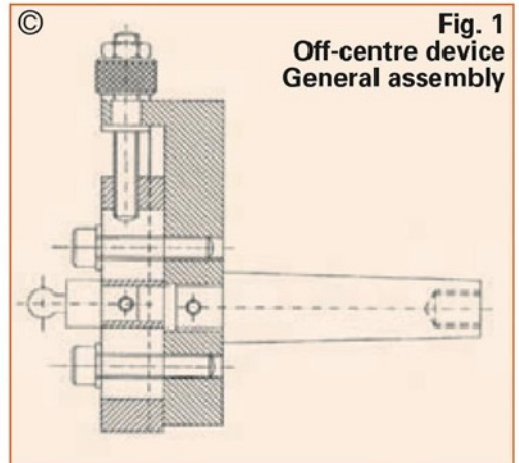
During this set up, the body part may be drilled and tapped to create the threads for the arbor location, and for the M8 clamping bolts. This guarantees

the tool will be parallel to the lathe cross slide. Next, the 10mm dia hole is drilled and may be reamed, although extreme accuracy is not necessary, as the thread in the slide block will align the screwed shaft.

The slide block is slotted to allow adjustment and incorporates the M8 tapping for the adjuster shaft. The block requires to be a good sliding fit in the main body component so that the setting up is simplified. A good sliding fit will help the accurate setting up.

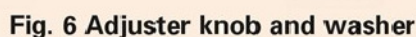
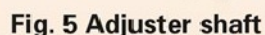
The location hole for the spherical centres should be accurately finished and to this end I drilled, bored, and reamed it at the same time as the adjustment slots were milled. This operation could also be carried out in the lathe by mounting the completed tool in the tailstock and holding the drills and reamer in the lathe chuck.

2. Slide block removed, showing slide groove and adjuster shaft.





When assembled, the arbor is screwed into the main body and locked with an M6 grub screw which bears on a very short brass "spacer". This is manufactured in the following way and its purpose is to avoid any damage to the Arbor M16 thread. The tapping size for an M6 thread is 5mm dia. and thus we use a short length (say 5mm) of 5mm dia brass. The brass piece is put into the tapped hole and backed up with the grub screw. The grub screw is then used to push the brass piece into the hole until it partially protrudes into the M16 tapping. The M16 tap is then screwed into the tapping hole, cutting into the end of the brass. This process is repeated, driving the brass further in and recutting with the tap, until the full depth of the M16 thread is visible on the end of



the brass. (Once the thread is cut, this component will fit only one way, so caution should be exercised or the part could be marked in some way so that it can be replaced correctly).

This will save any damage to the thread and will allow the arbor to be re-used on other tooling.

Back to the machining

The adjuster shaft could be made up from a piece of studding and by Loctiting (or soft soldering) a small screwed thrust bush into position, however I carefully cut the thread using a "Herbert" die box, which I found quite adequate for the purpose. In my amateur workshop, I do not expect this tool to be used on a regular basis and I therefore

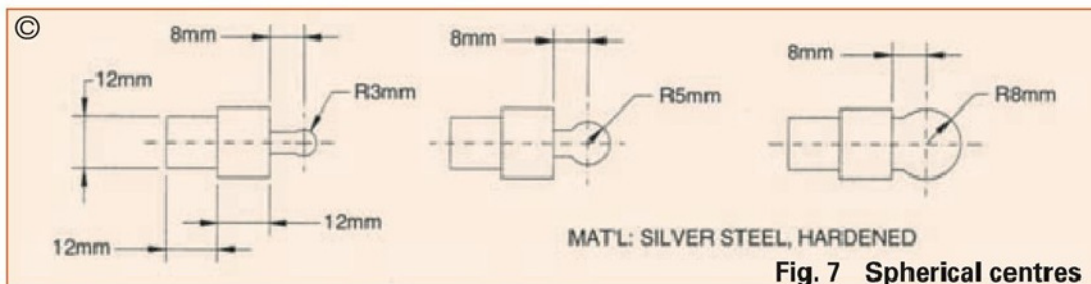


Fig. 7 Spherical centres

feel that there is no justification in hardening this part. However if other readers wish to carry this out, then I suggest the use of a piece of silver steel 16mm dia. and then machine completely from solid.

The adjuster knob is from steel and should be knurled for grip. A standard lock nut is used to lock this in position after adjusting to remove any noticeable play.

Three special heavy duty washers are required. The first of these is for the outer thrust flange and might be machined from brass or bronze. The other two will be located under the cap heads of the clamp screws.

Assembly is straight forward and needs no particular comment.

In use

Again it is simple to use but I have found that in certain applications that there is insufficient space for the both the device and the tool post. In such cases if the taper is short enough, I revert to using the top slide in conjunction with the removable

power feed that was described in *MEW* issue 105. To gain extra clearance, it may be useful to make up a longer spherical centre just for that "awkward" job.

The vertical column of my "Congrieve" clock is but one use of this tool, which I have also used to turn the middle column of a beam engine. However the connecting rod for the "Wyvern" engine could not be machined with it because of clearance. With hindsight, even this could have been carried out using a longer spherical centre.



CAUTIONARY NOTE

If the reader should make one of these, then a couple of little tips that may prove worthwhile are: firstly, fit the tool and make sure that it is tight in the Morse taper, preferably retained with a draw bar, and secondly, always adjust the centre towards you. This way, if it should slip in the taper, the weight of the work will rotate the job downwards and away from the tool).

STENT MODIFICATIONS

Background

I built a Stent Tool and Cutter grinder many years ago and have used it extensively for sharpening four facet drills and many different cutters including hobs. The precision achieved must be dependent on the application of the cutter to the grinding wheel and this I found left something to be desired. The problem appeared to be lack of smoothness in the travel of the dovetail slide holding the tool holder; I stripped and reassembled this on several occasions but with little improvement. Because the application of the cutter to the wheel was controlled by the lever operated slide I found it somewhat insensitive and my thoughts returned to the Quorn where the passage of the cutter over the wheel is controlled by hand movement. It then occurred to me that part of the problem with the Stent slide was due to the large overhang of the slide when working on the left of the wheel, which was mounted on the left of the vertical column in accordance with the drawings. The overhang produced a cantilever strain on the dovetail slide, which was in part the cause of the lack of smoothness and difficulty in adjustment of the gib.

Turnaround

I had just finished building a Quorn when I visited the Model Engineers' Exhibition at Alexandra Palace and there I saw a Stent with modifications, which would solve my problem. The vertical column was rotated one hundred and eighty degrees and the wheel was on the right of the column: this brought it in line with the middle of the

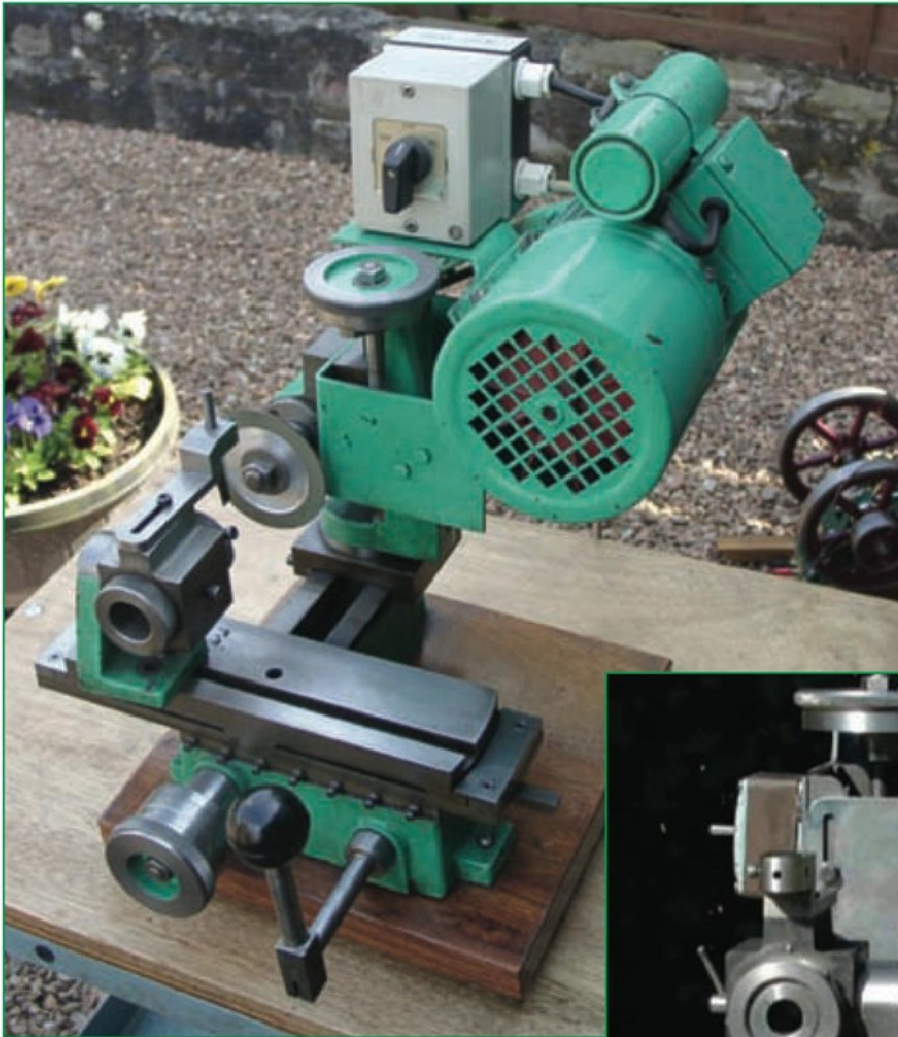
base of the dovetail slide thus eliminating the cantilever problem when working on the left of the wheel. I regret that I failed to make a note of the name of the exhibitor or the Club stand and efforts to trace them have been unfruitful. It is not, therefore, possible to give appropriate credit to the originator.

I returned home thinking that it would be a simple matter just to rotate the

Giles Parkes describes improvements to this popular tool and grinder

vertical column one hundred and eighty degrees on my Stent, but this of course meant that the grinding wheel was at the back and the pulley at the front! Since the Stent spindle housing has built in bearings, a different size at each end, this presented a problem and I needed a mirror image spindle. Having just built the Quorn, I was aware that the spindle is separate from its housing and can be turned end for end with no trouble. I therefore decided to build a separate spindle and housing to fit in place of the Stent spindle housing and I scaled up the Quorn spindle to take a 15mm central spindle with appropriate larger angular contact bearings.

The same mirror image problem applied to the motor, but this was just a matter of turning it over end to end; however when I mounted the motor to the left of the vertical column the weight of the



1. Unmodified Stent showing overhang
(courtesy A. S. Gray)

2. Face on view, showing
new relative positions.

motor tended to unbalance the machine. I therefore mounted the motor to the rear of the vertical column and this involved only making a suitable bracket for the purpose.

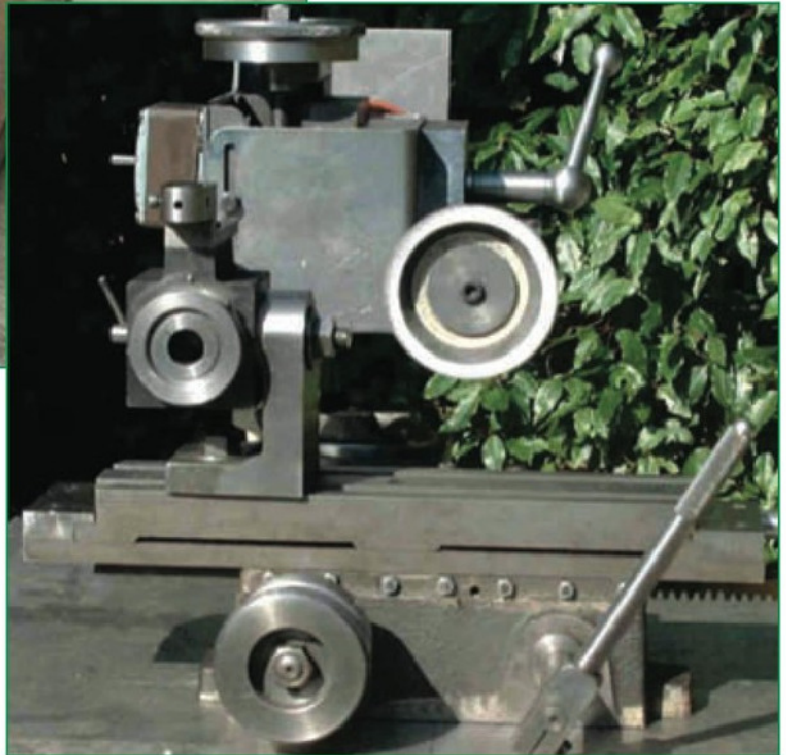
No formal drawings were prepared for the exercise, but it is anticipated that the description and photographs will convey sufficient information for anyone who has

already built the machine to undertake a similar modification.

Operation

Most of my use of the Stent is with a cup wheel or saucer wheel: if I have to use an ordinary wheel in the conventional way and feed the work across the circumference I still have the problem of the wheel being on the left of the main base slide and so the cantilever problem again. With the separate spindle housing I can always turn the spindle end for end to bring the wheel to the middle of the slide, and of course turn the motor over to match. I can't see that I will need to do this very often.

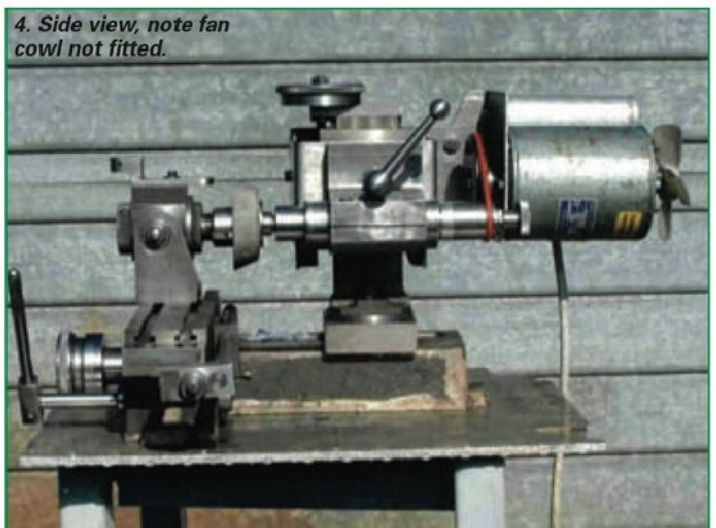
The new position of the cup wheel over the middle of the dovetail slide makes the application of the cutter to the wheel much more smooth and the traverse much easier; the toolholder is over the dovetail base when working on either the right or left of the wheel and no overhang: perhaps I now have a redundant Quorn!



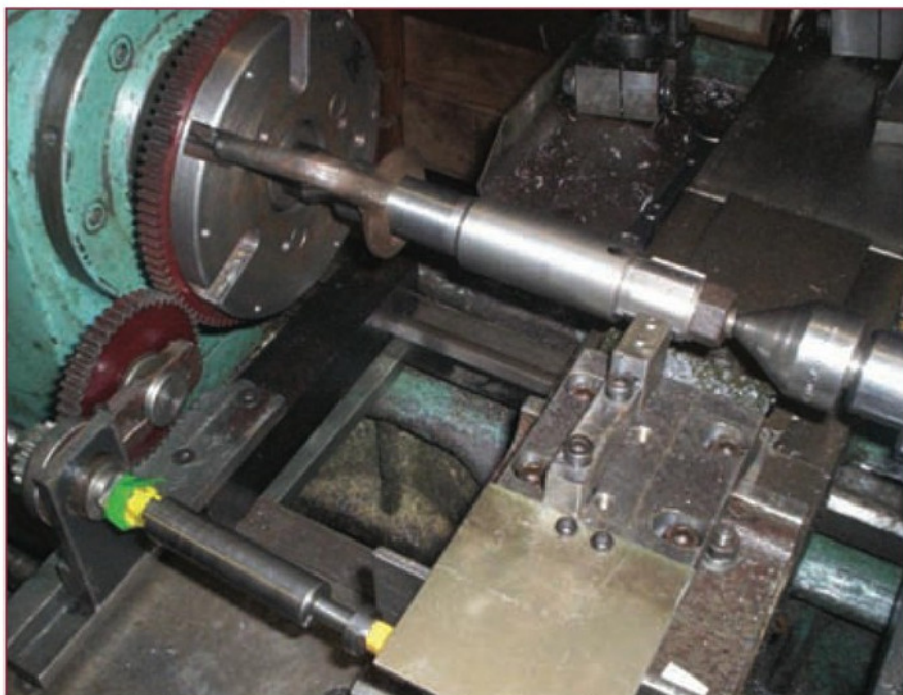
3. Three quarter view.



4. Side view, note fan
cowl not fitted.



GEAR HOBBIING WITHOUT CHANGE GEARS



1. Cutting a hob using the method described by Giles Parks

Background

It all started way back in the early 1990's while watching the Norton Racing Team at Cadwell Park on their Wankel powered machines. I decided to have a go at making a Wankel engine. After many trials and tribulations I successfully made two, a single and a twin chambered. Both ran but were difficult to control, so I decided to make a half size Norton engine. I needed some means of accurately cutting the internal gear teeth on the rotors and the fixed gear pinions.

The gear size to be used was 32DP which is also the same DP as the gear train on my lathe. Two gears were bought from "Hinchcliffe Gears" which enabled me to make a 32DP hob using the method described by Dr Giles Parks in *M.E.W.* No. 57 – April 1999 (photo 1). To be able to hob gears it is necessary to synchronise the gear blank to the hob. As in screw-cutting, it is normally achieved mechanically by a gear train. To cut different numbers of teeth the gear train has to be altered, hence, as with a lathe, you need a good stock of change wheels. If instead of a gear train a stepper motor was used to synchronously rotate the gear blank, life would be easier.

Electronic alternative

Stepper motors work by pulse inputs, typically 200 pulses per revolution, but I thought this was too coarse to cut gears. A 20 to 1 worm and wheel gearbox was added so the new ratio would be 200 pulses x 20 = 4000 pulses required for 1 revolution of gearbox output shaft. Having sorted out the gear blank drive, some means of synchronising it to the hob needs to be arranged. This was achieved by fitting an encoder to the hob mandrel. Encoders give a fixed number of pulses

per revolution: - 200, 400, 500, 800, 1000, 1024 pulses per revolution are some of the encoders available. The one I used was 500 pulses per revolution so an 8 to 1 tooth belt drive was used.

Thus having 4000 pulses per revolution output from the hob and the gear blank requiring 4000 pulses per revolution the hob and gear blank were synchronised 1 to 1. To be able to cut different numbers of teeth a divide by "N" divider was used. This particular unit is capable of dividing by "2", "4", "5", "8" or "10" depending on what is selected. Divide by "2" was selected. If a gear with 30 teeth was required the divider would be set $30/2 =$

Brian Thompson describes his electronic synchronisation system.

15. A gear with 31 teeth would be $31/2 = 15 \text{ r } 1$ the 1 remainder was set by an odd/even switch. In theory any number of teeth from 2 to 999 could be cut just by changing the number switches.

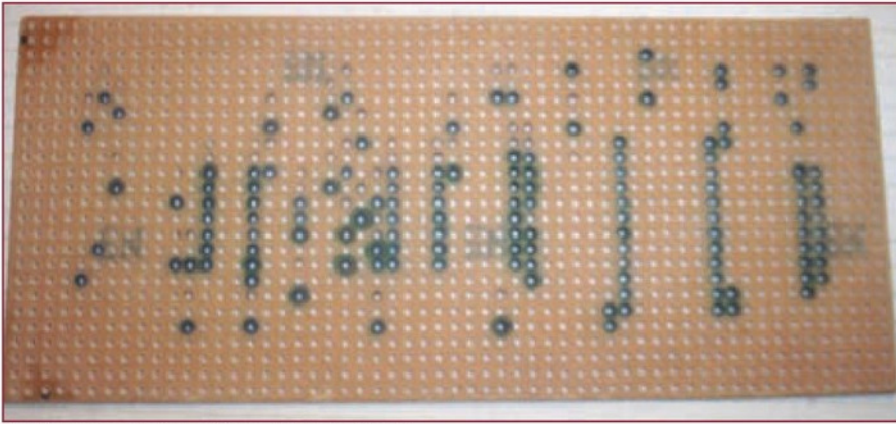
Heavy duty and Mark II Versions

Since cutting all the gears for my C.V.A. lathe, John Stevenson from Nottingham was very interested in the unit, which was displayed at Donington *Model Engineers' Exhibition*. John bought a proto divider unit, coupled it to a stepper motor and gear box with a hollow output shaft and an encoder with 1024 pulses per revolution which required a 1.953125 to 1 drive to give 4000 pulses per revolution a tooth belt drive with 64 x 125 toothed wheels. The unit was set up on a "Victoria" universal miller (very robust setup) and successfully cut gears he required. He then ventured to cut worm wheels, helical and crossed gears, all of which meshed very well. He was also in contact with a fellow enthusiast in America – Don Foreman, an electronics engineer who designed a multiplier unit for the encoder, so instead of 1024 pulses per revolution it gave 4 times = 4096 pulses per revolution.

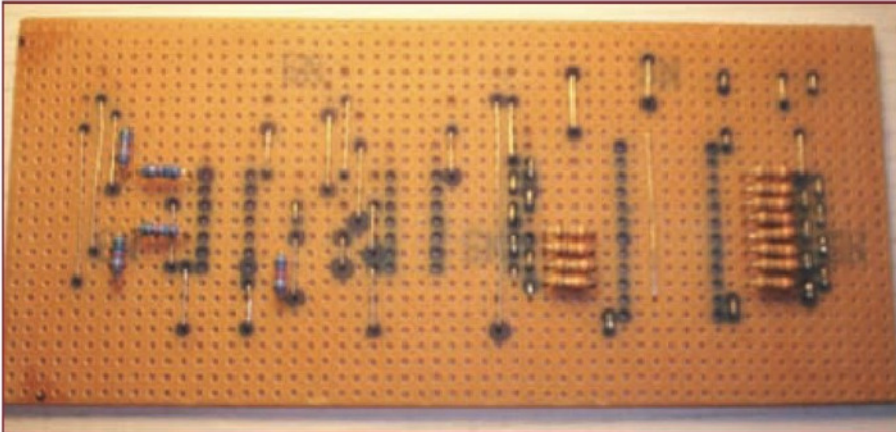
John and I then decided that if we doubled the output of the encoder from 4000 pulses per revolution to 8000, the odd/even switch would not be required and the number of teeth required on the gear blank would be selected by the number switches (no dividing required). Encoders come with 2 or 3 channel outputs, channels 1 and 2 usually are in quadrature, i.e.: one, a $\frac{1}{4}$ cycle behind the



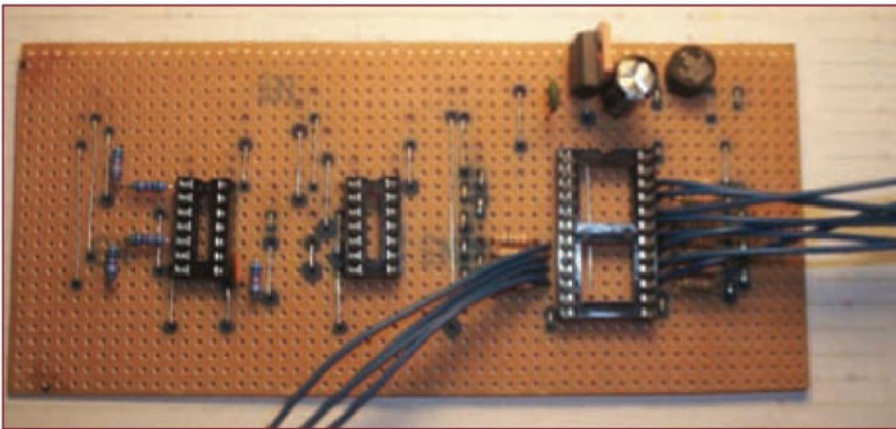
2. Hobbing a gear electronically, the encoder drive belt is visible.



3. Component side of board marked out.



4. Board fitted with links and resistors.



5. Wires, I.C. sockets, and other components have been added.

other. The third channel usually gives 1 pulse per revolution. Don Foreman's circuit multiplies channels 1 and 2 by 2 giving 4096 pulses per revolution.

Vero board version

The divider board described is based on an encoder giving 2000 pulses per revolution whether it be an encoder which gives 2000

Test procedure

With 9 volts A.C supply to the board a few tests can be made before inserting the I.C.'s.

Voltage Regulator

Test between
Pin 2- and Pin 3+ = 5 volts

MC14584

Test between
Pin 7- and Pin 1+ }
Pin 3+ } = 5 volts
Pin 5+ }
Pin 14+ }

CD4070

Test between
Pin 7- and Pin 14+ = 5 volts

HEF 4059

Test between
Pin 12- and { Pin 11 }
{ Pin 13 }
{ Pin 14 } = 5 volts
{ Pin 24 }

Pin 12- and 7 }
8 }
9 }
10 }
15 }
16 }
17 } Zero Volts WITH ALL
18 } No. SWITCHES AT "0"
19 }
20 }
21 }
22 }

pulses per revolution or tooth belt driven to give 2000 pulses per revolution of the cutting mandrel. A block diagram is shown in Fig 1. The first board I made was an etched circuit which also had a low power stepper motor driver included on it. For muddled engineers not wanting to do down the etched circuit board way I've done the circuit on 0.1in. pitch Vero Board, 53 holes long and 22 holes wide. I had never used Vero Board before so it was rather a steep learning curve, but this should make it easier for those who do not have circuit board etching facilities. It was all initially worked out on graph paper. Don't worry it's similar to painting by numbers! The schematic circuit diagram is given as Fig 2.

Board construction

Clean the copper strips with fine wire wool or Scotchbrite. Working from the

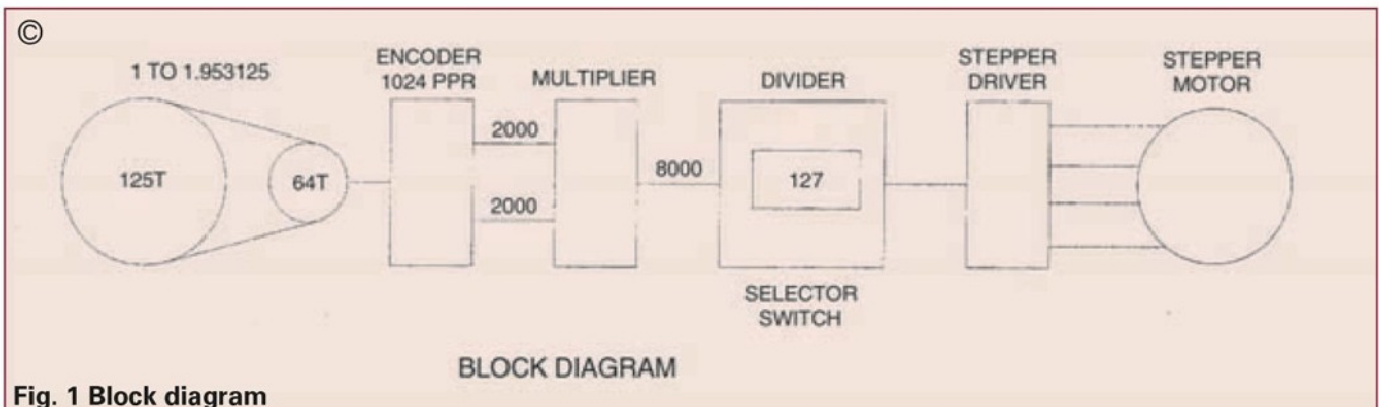
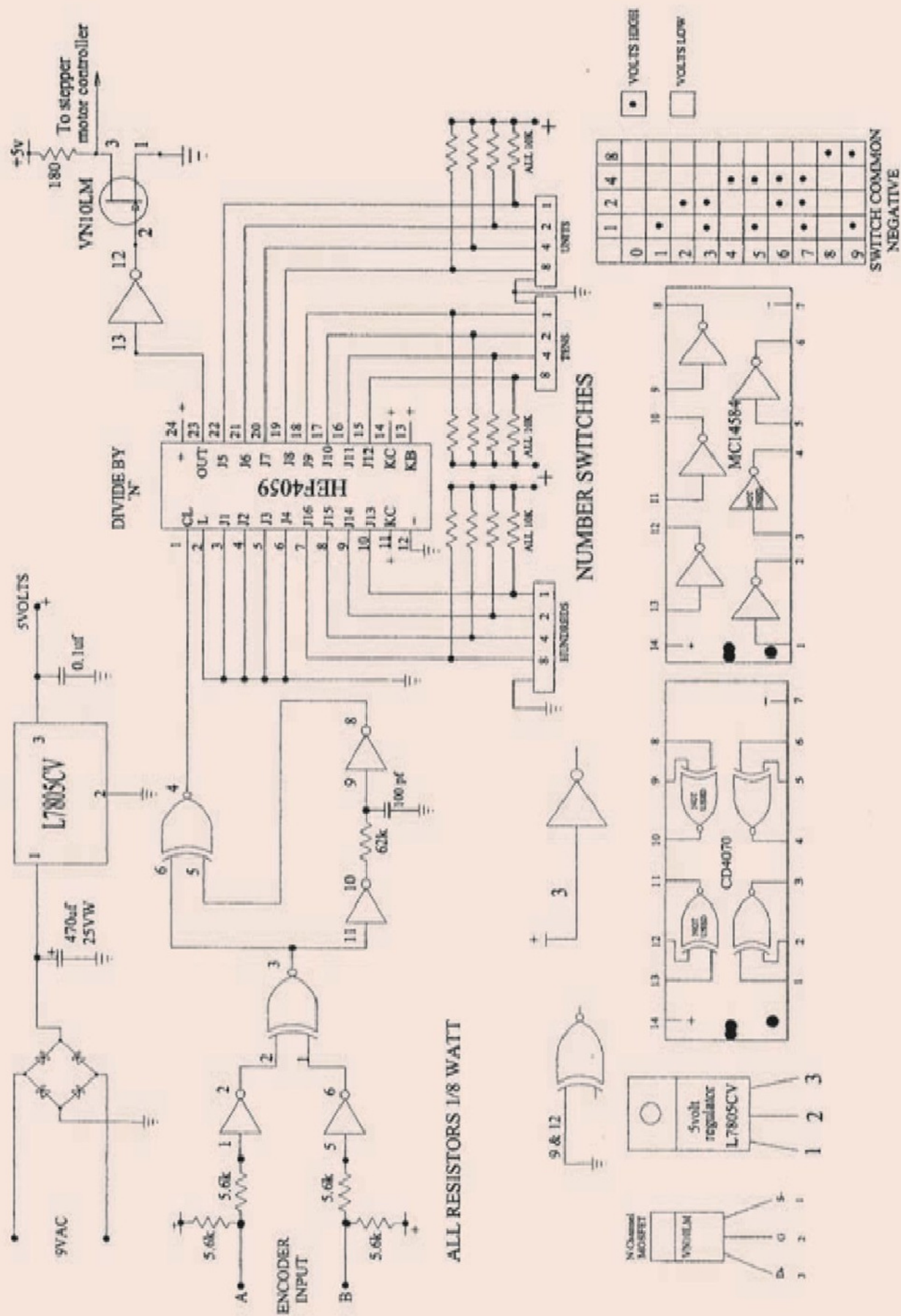
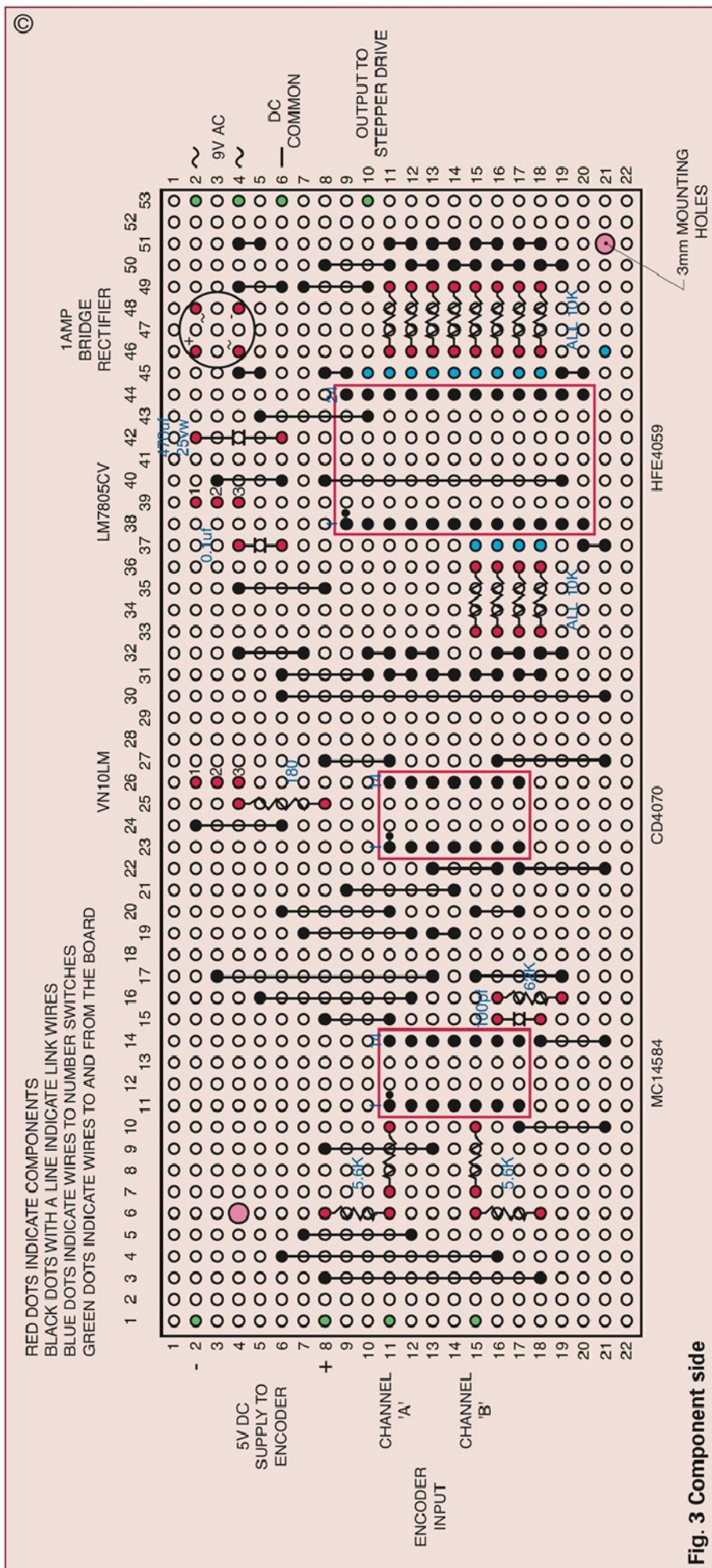


Fig. 1 Block diagram





“component side” drawing (**Fig 3**), mark the holes on the board with a marker pen where the link wires go (**Photo 3**), solder the lines in, mark for the resistors and solder them in (**Photo 4**), next the 13 wires which go to the divider switches, finally the remaining components (**Photo 5**).

Refer to the "strip side" drawing (Fig 4) for the detail on cutting the copper strips. I used a 1/16 in. drill in a small hand held chuck. A magnifying glass is handy for weary eyes; one of the cuts I made had left a very thin sliver of copper uncut. Consequently the board didn't work, fortunately when the fault was found and cleared it worked perfectly. The number switches are marked 1-2-4-8-C as are the wire connections on the schematic drawing. Common is linked to all three switches. I used sockets for the I.C. chips so static tests could be done without the chips in the circuit.

Accuracy and options

The speed at which hobbing can be accomplished depends on the stepper motor response at high stepping frequencies. This is particularly the case when low tooth numbers are selected.

The photos show hobs made of EN8 used to cutting gears, and also fly cutters of silver steel used to cut a daisy wheel and count wheel for Dr Woodward's Gearless Clock which was serialised in M.E. It must be noted that you still have to set the helix angle on the table for fly cutters just as with hobs, and when grinding fly cutters, they will require a clearance angle slightly greater than the helix angle.

I made an encoder disc in $\frac{1}{8}$ clear acrylic 3in. diameter with 500 slots, the cutter being just 0.010in. wide and taking only 0.002in. cuts per revolution. Several cuts were needed to get a depth of 10 to 12 thous which were then filled with blackboard paint. The disc was then set up on a test rig and run at 1000 revolutions per minute. Checked on a 'scope, the output was found to be almost jitter free.

Gearbox ratios other than 20 to 1 can be used.

i.e.:
15 to 1 would be
 $200 \times 15 = 3000$ pulses per
revolution

$$200 \times 10 = 2000 \text{ pulses per revolution}$$

but the hob cuts would be coarser.

Use of higher ratio gearboxes is uncharted territory, and may well reduce the speed at which the hob can be run.

Conclusion

It has been a very satisfying project which has shed a whole new light on gear cutting, whether it be a daisy wheel for a clock or a helical gear for a power drive. Now back to model making.

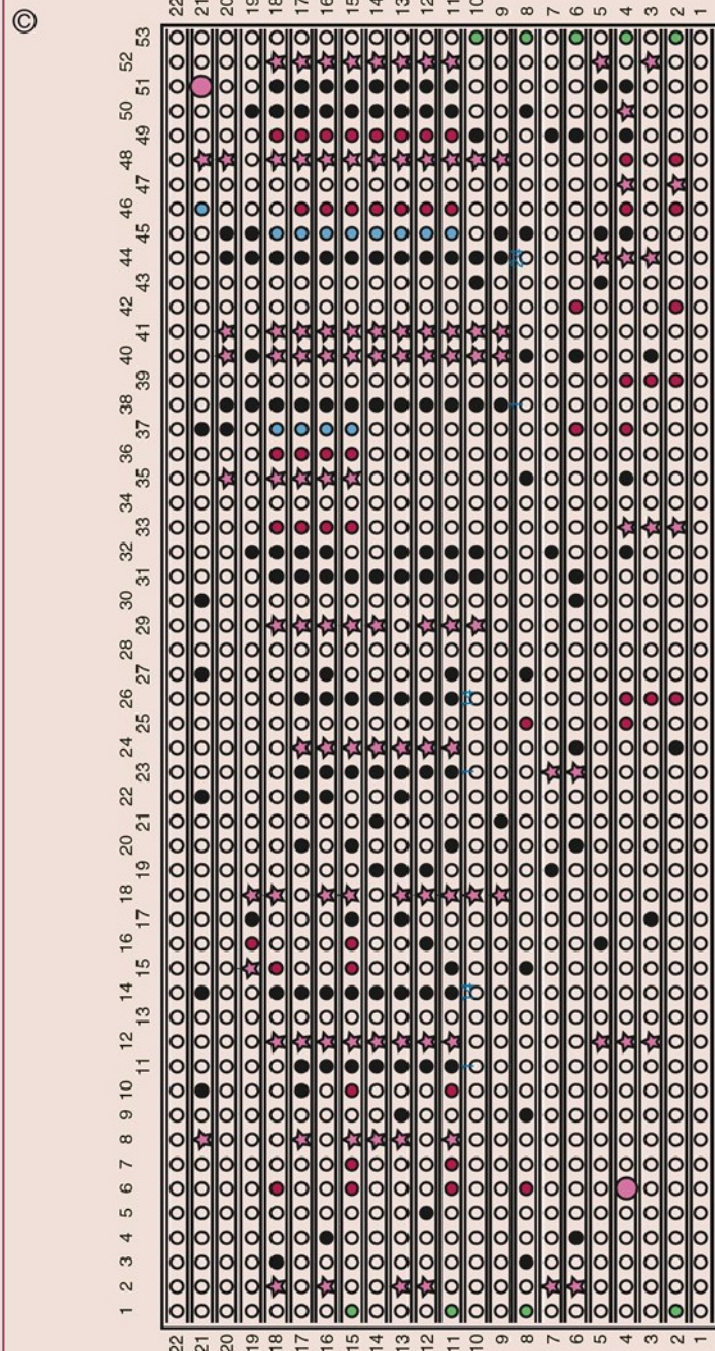
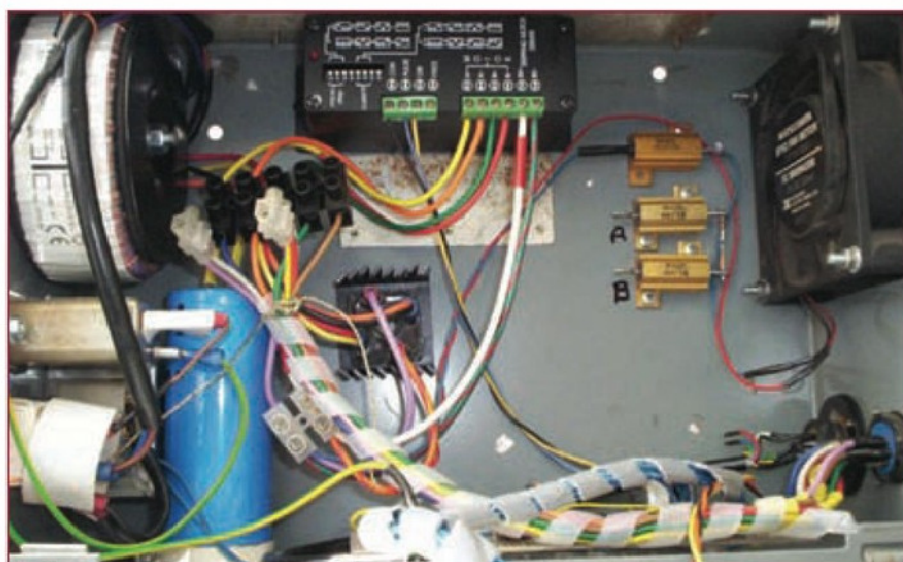


Fig. 4 Strip side



6. Enclosure houses board together with power supply and stepper driver.

Suppliers

FARNELL

Canal Road

Leeds

LS12 2TU

Tel: 08701 200 200

12 - 10k	1/8 w -	514-263
4 - 5.6k	1/8 w -	514-202
1 - 180 R	1/8 w -	513-842
1 - 62k	1/8 w -	514-457
1 - 470 μ f	25vw -	920-551
1 - 0.1 μ f	-	146-227
1 - 100 pf	-	237-048

1 - CD4070	573-796
1 - MC14584	639-310
1 - HEF4059	385-402
1 - VN10LM	352-720
1 - L7805CV	412-764
1 - 1 AMP BRIDGE REC	330-7906

1 - 24 PIN I.C. SOCKETS	35-0758
2 - 14 PIN I.C. SOCKETS	355-0705
1 - VERO BOARD	451-058
3 - No. SWITCHES	149-188
1 - RH SIDE PLATE	149-192
1 - LH SIDE PLATE	149-191
2 - SPACERS	149-193

M.G.C. SYSTEMS

Newgate Lane

Power Transmission House

Radcliffe Road

MANSFIELD

Nottinghamshire

NG18 2QH

Tel: 01623 635150

20 to 1 Gearbox

H.P.C. GEARS

Unit 14 Foxwood Industrial Park

Foxwood Road

CHESTERFIELD

Derbyshire

S41 9RN

Tel: 01246 268080

Toothed Belt Drive For The Encoder

Arc Euro Trade

10 Archdale Street

Syston

Leicester

LE7 1NA

Tel. 0116 269 5693

Stepper Motor Driver



7. A selection of components and the cutters used to create them.

MACHINE VICE FOR THE MYFORD

Dyson Watkins describes an easily made accessory for better work holding.

Background

I have for years struggled with the various work holding problems that have cropped up, where a decent vice, particularly a small one which would fit easily on the vertical slide, would have been a blessing. I did make a 'temporary' clamping arrangement that was a long way from being satisfactory, but it did the job. I visited a number of model engineering exhibitions and hunted around the trade stands for one of the vices made by Myford, but was informed that the Myford item was then out of production, and furthermore if I did manage to come across one, then it would probably cost me an arm and a leg. (I later learned that, while the earlier Myford item had indeed been discontinued, an improved version had been introduced as their part number 78217.) I therefore decided at long last, to modify this 'temporary' arrangement into a piece of equipment worth using. I should state at the outset, that had a slightly longer piece of material been available from which to make the body, and then I would have increased the capacity by a little more. The vice has however ended up at its present length, which is still a useful size. The most serious problem with the original lash up was that the sliding jaw lacked squareness of movement although sometimes this was a mixed blessing because when holding material, which was slightly tapered, the jaw would simply align itself to the work on clamping. The jaw would however end up out of square in the vertical plane. The new version has a tenon and a bottom plate, which now imposes constraints on the jaw movement, keeping all things square. Additionally, a retaining plate has been added to the back of the sliding jaw to keep it in engagement with the end of the screw. Those readers owning a mill should have no difficulty in making this little item, but it is also quite likely that being in possession of a mill would mean that they would not need this vice, their need for machining, using a vertical slide, being rather remote. It would however make a nice little gift for a not quite as well equipped friend! The project is well within the capacity of the Myford lathe and the text is aimed at the Myford owner.

The body

For this I used a piece of steel measuring 1.625 x 2.00 x 3.625 inches, as shown in Fig 1. It might be possible to produce this as a bolted assembly of three parts, but I feel that the "hewn from solid" approach makes for greater rigidity. Check the material for sectional squareness and initially choose the flattest side for the

bottom. Set up in the four-jaw chuck and lightly true up the surface, which will be the datum for further work. All other surfaces will be either parallel or square to this. Next mark out the hole positions for the four securing bolts and drill through from the newly machined bottom using the drilling machine. Then turn the block over and drill the counter bores to their finished depths. The block can now be mounted on



1. Completed vice mounted on vertical slide.

the vertical slide using these fixing holes for machining away the waste material. (Much of this waste can in fact be removed by turning in the four-jaw chuck, which will ease the milling work considerably.) Make sure to set up the vertical slide using a dial indicator so that the block when mounted will be accurately positioned relative to its bottom face. Complete milling of the gap, taking extra care to produce a good finish on the bottom of the gap (which forms a sliding surface) and the inside of the fixed jaw. An important point when milling, is to clamp up any slides that don't need to move during machining. Another point is to avoid "climb" milling on the lathe, because most lathes do not have the provision of backlash eliminators.



2. Machining the slot and tracks for the sliding jaw.



3. Milling the tenon on the moving jaw.

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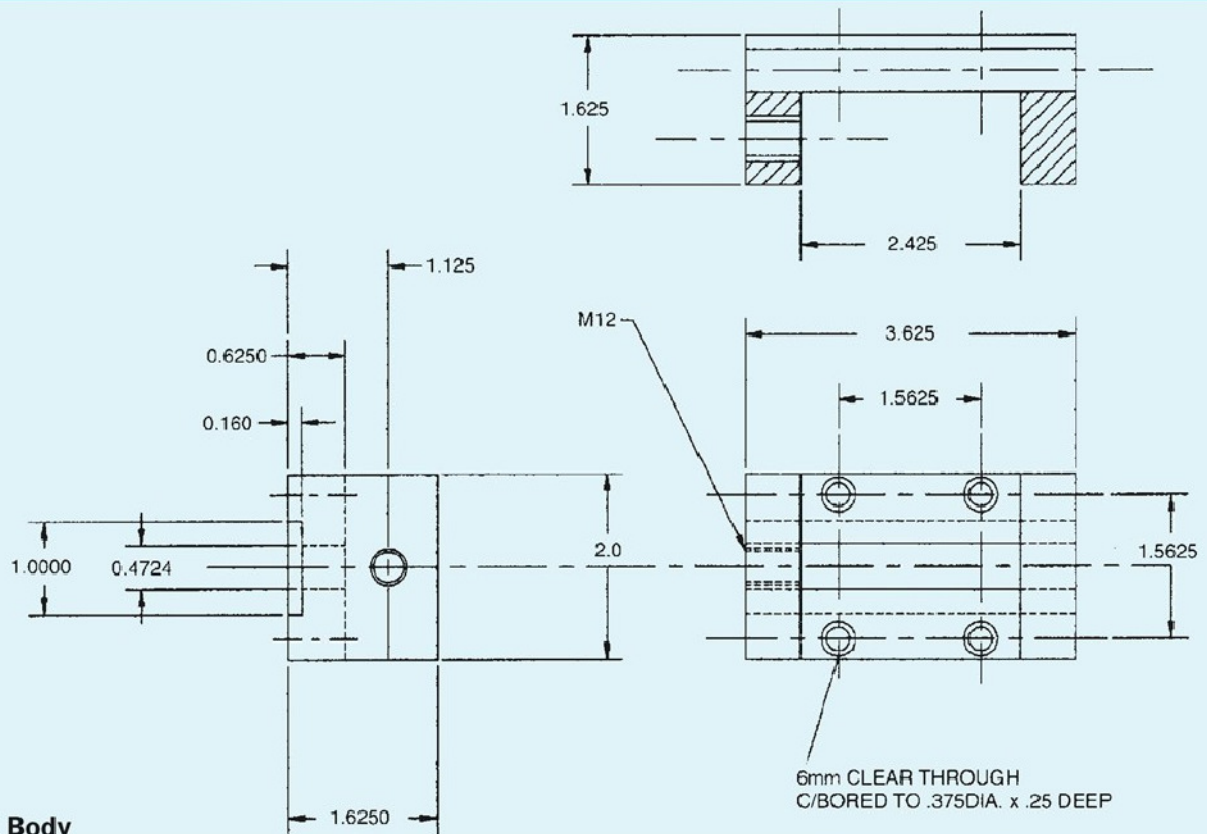


Fig. 1 Body

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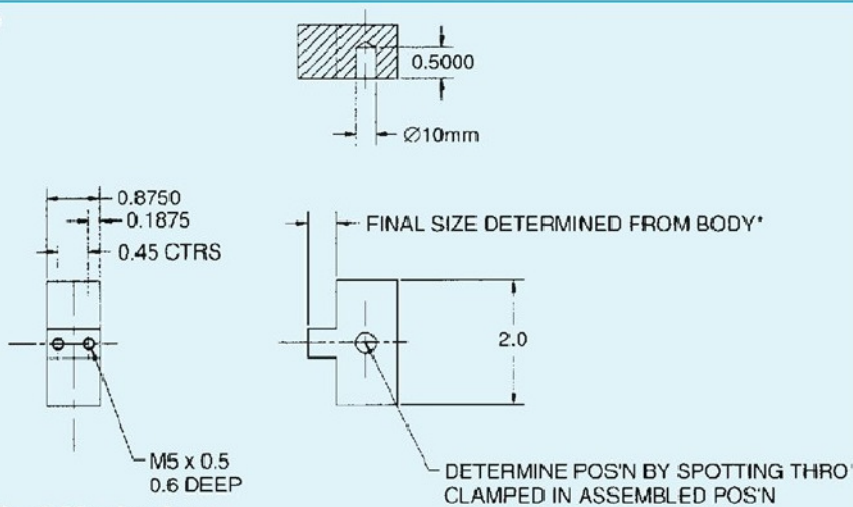


Fig. 2 Moving jaw

Long slot

If the long slot should be tackled next then it will avoid the need to re-set the slide later. This time mount the block (**photo 2**) using studs passed through from the bottom into 'T' nuts or strips for added strength. Clock up true and set the cutter on centre. I tend to use a wobbler for this job, but a centring needle or a sticky pin will be accurate enough. I used a 12mm end mill for this task, taking light cuts to avoid excessive cutter deflection. When the slot has been completed, follow this up by milling the tracks for the moving jaw bottom plate.

The outer ends can be squared up next. Use parallels under the body to avoid possible damage to the slide surface. If preferred, the slide can be swung through 90 degrees and the end to be trimmed allowed to project a little beyond the edge of the slide. It is worth getting the ends square, in the event that the vice might need to be used on end at some point in time.



4. Screw retaining plate with moving jaw and shouldered plug.



5. The complete set of parts for the vice.



6. Underside view with jaw bottom plate clearly visible.

Fig. 3 Screw retaining plate

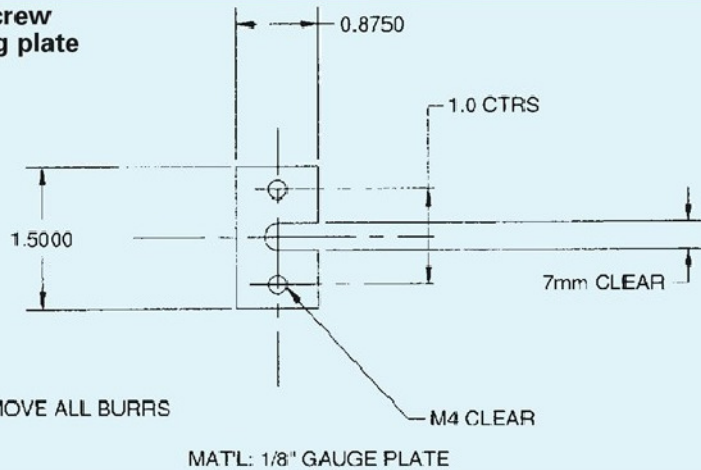


Fig. 4 Jaw bottom plate

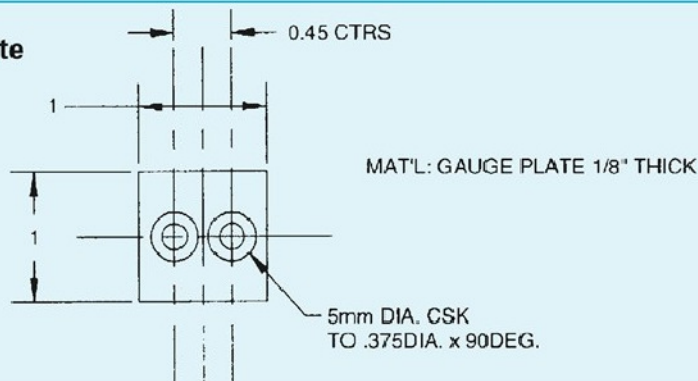
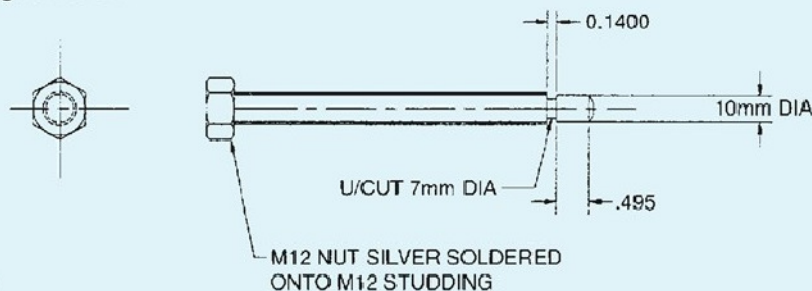


Fig. 5 Screw



While set up in this fashion, it is worth drilling and tapping the M12 hole. This thread does need to be axially true in order to avoid alignment problems later that could cause binding of the screw nose with the walls of the hole in the moving jaw.

Sliding jaw

This part is detailed in **Fig 2**. To commence the machining process, it was squared up in the four-jaw chuck, and most of the waste material that would have needed to be removed by milling was roughed out at this stage. In the absence of a milling vice, I used the one of the jaws of the newly completed vice body as a small angle plate for mounting the sliding jaw during the next stage of milling. I used a couple of toolmaker's clamps to secure the part in place (**Photo 3**) and set up carefully with a dial indicator. Slip gauges were used to determine the slot width, the slip stack being measured with a micrometer in order to arrive at the finished width. Thus the dimension aimed for would be the same, avoiding any errors creeping in

from the use of several measuring instruments e.g. a micrometer and a vernier caliper. The length of the tenon was then trimmed back to match the depth of the mating slot in the body. Carefully remove any burrs.

The next stage is to drill the hole in the back of the sliding jaw into which the nose of the tightening screw will engage. The method I used which is by no means the only way to do this stage, is to clamp the jaw into the slot up against the M12 hole. I used a toolmaker's clamp for this, then spotted through with a 10.2mm drill. Swap the drill for a 10mm size and take it down to depth.

Screw retaining plate

A small piece of $\frac{1}{8}$ in. gauge plate was used to make this (**Fig 3**). Cut out the part and file to size. Mark out and drill the three holes. Do not cut the slot into the centre hole just yet. Make a shouldered plug with one end to fit the 10mm hole and the other end to fit the centre hole. This can be

turned from any convenient piece of scrap metal, and discarded after use. Push the larger end into the hole in the jaw, and then slide on the retaining plate. The plug will hold the plate so that both holes are concentric. Clamp squarely in position without covering either of the fixing holes, and spot through to transfer the hole positions onto the jaw. The plate can be removed now, and the tapping holes drilled to depth. Tap the two holes. The slot can now be cut in the plate and cleaned up to just fit over the undercut in the nose of the thread. The plate, with moving jaw and shouldered plug are shown in **photo 4**.

Jaw bottom plate

This can also be made of $\frac{1}{8}$ in. thick gauge plate, (**Fig 4**) as there is just enough thickness to accommodate the countersinking for the screw heads. I made the plate to 1in. square. This allows some material to project on either side of the jaw tenon. I decided not to remove the surplus material as it provides a little more margin around the edges of the countersinks. Assemble the jaw into the body, and clamp against the fixed jaw. Using the plate as a template, spot and then drill the first tapping sized hole. Tap to depth, next insert the first screw which will prevent movement while spotting and drilling the second hole. Attach the bottom plate. Clean thoroughly and reassemble. Check the working clearance which needs to be the minimum needed to allow for easy sliding. Adjustment can be made to the working clearance, either by the use of shim, if too tight, or by removing the required amount by skimming in the lathe.

Screw

Purists may accuse me of cheating here but I used a length of studding for this part (**Fig 5**) and silver soldered a matching nut on the end. The end was then skimmed over in the three-jaw chuck. A tommy bar hole was drilled through the nut with a 5.5mm drill. The nose of the screw was then turned to provide a loose fit in the mating hole in the jaw. The extreme end is turned to an angle matching that of the 10mm drill point. The tip is faced off flat for a small diameter equating to the drill's chisel edge length. Check fit in the hole to establish the position for machining the undercut. Should the clearance be excessive, there will be more backlash when winding the jaw back. I have allowed the end of the spindle to transfer the thrust directly to the jaw and added a dab of grease on final assembly. The nose end can be seen in **photo 5** together with details of the other parts.

Comments

The body has been left square all over with the view that it could be useful at a later time for setting up, where the vice could be used on end, or perhaps on its side. The jaws have been left 'soft'. If at a later time they show signs of deterioration, then I will face them with harder gauge plate jaws. Apart from these considerations, the vice is very satisfactory, and a useful piece of tooling. Enjoy.



TRADE COUNTER

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

The Harrogate show provided an excellent opportunity to chat to a number of suppliers and catch up with recent developments.

Myford



Sensitive drilling attachment from Myford

Several new accessories were on show. The sensitive tailstock drilling attachment had earlier been seen very briefly at the Sandown Park exhibition. I say very briefly because this device is so obviously desirable that the display prototype "walked" within two hours of the show opening. Thus the unit on display at Harrogate was modified for more permanent attachment to the machine. The chuck capacity is given as 0 to 4mm, and the jaws do indeed have sharp gripping edges to cater for very small drills. As can be seen from the **photo 1**, where a number 60 drill has been used on a brass component, the lever arm is light in weight and makes it very easy to apply delicate finger pressure for fiddly jobs.

The large faceplate option is not new, but now, to match it, a suitably sized "Keats" type angle plate has been introduced. Both are shown in **photo 2** beside the smaller standard faceplate for comparison, the offset position giving an impression of the eccentricity which might be set. The quality of the angle plate lives up to what we have come to expect of Myford. Any turning work naturally requires various cutting tools, and the new set of twelve turning tools incorporate the Myford "Boat" system which allows fine adjustment of the tool height without the expense of adjustable tool holders. Included in the set are those for left and right turning, internal and external threading, parting, and boring. **Contact Myford on 0115 925 4222**



Small and large faceplates shown with Keats type angle plate.

Warco

Two new machines were on display, both hand operated. First is the "Croppit" bench shear (**photo 3**) easily capable of cutting 3mm material. Extra cutting force is generated by the reduction gear arrangement which moves the blade. In addition the profile of the blade supports makes it easy to do long straight line cuts. Smaller parts may be successfully nibbled close to required profile for final finishing by finisher or file.

The second is the "Magnum" bender (**photo 4**) which has a very small footprint, but again capable of handling 3mm material by about 150mm across. The device is the brainchild of Paul Prince who has evolved it to deal with precision forming of components for light aircraft. Notable features are the interchangeable rear bedplate (the standard has slots for backstops), two position bending bar giving alternative bend radii, and rare earth magnets set into the base to retain steel components during set up.

For more details on these contact Warco at 01428 682 929 or visit www.warco.co.uk



"Croppit" demonstrated by Roger Warren



Magnum bender also from Warco

Arc Euro Trade

The display of tooling and machines included the recently announced combination guillotine/bender (**photo 5**) and also the range of stepper motors and drivers. One of the new large motors was shown under power fitted with an aluminium disc of about one inch thickness and three inches diameter. Trying (unsuccessfully) to stall the motor by hand gave some impression of the torque being produced and confirmed my view that these will offer a low cost route to retro-fitting CNC to professional size equipment.

Since the show I have learned that as a result of many customers asking them for information on how to fit taper roller bearings to their mini-lathes, there is now an area on their website titled "Projects & Articles". By clicking on this title, you can see articles on: C3 Mini Lathe headstock bearing change, Myford ML7 cross slide leadscrew thrust bearing modification, and power supply for the larger stepper motor. **More information is available from Arc Euro Trade on 0116 269 5693 or at www.arceurotrade.co.uk**

Mini Shear Brake from Arc Euro Trade



D M Machining Services

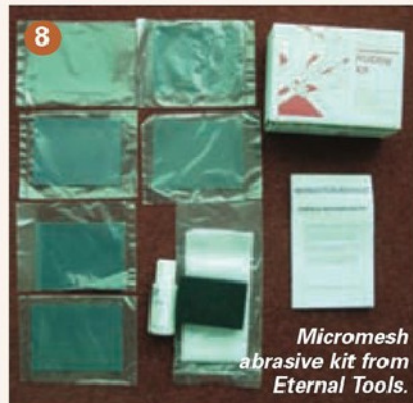
On a rather different tack, I made contact recently with Mike Parsons, who runs D M Machining Services, and who has been offering a bespoke service to the motorcycle fraternity, producing copies of obsolete parts, and redesigned items such as stainless wheel spacers, float bowl drain screws, and remote carb balance kits. This facility to handle prototypes may also be of interest to model engineers whose projects outgrow their workshop capacity. **Mike can be contacted on 01384 836 461 or at 65 Lyde Green, Halesowen, B63 2PQ**

New Polishing Kit from Eternal Tools

I was interested to have a look at this kit, as some time ago, I had attempted to make a 45 degree prism in Perspex. Machining the shape was not a problem, but polishing to optical clarity proved to be another matter. The kit contains Micro-Mesh sheets in grades 2400, 3200, 3600, 4000, 6000, and 8000, a container of Micro-Gloss liquid, a polishing flannel, and a semi-rigid foam block. The makers claim that the cushioned structure of Micro-Mesh makes for more even cutting and a longer abrasive life (up to six times longer) than conventional sheets. It can be used either wet or dry on metals, plastics and wood, and as one of the applications quoted is restoring the optical clarity of aircraft windows, I felt that revisiting the prism might be instructive.

The now somewhat battle scarred lump of Perspex was unearthed from the scrap box and treated quickly by rubbing against each sheet while laid on the foam block. After the 8000, it was probably about as good as before. Applying the liquid polish however did give an order of clarity not previously achieved. This was a quick trial conducted against the clock, but nevertheless produced a good result. Given more time and care, it should be possible to rival commercially polished items. Should I at some time wish to pursue the prism project, then the method is now available. As noted above it should also be emphasised that while I chose a quick test on plastic, the kit is also suitable for wood and metal.

The complete kit can be obtained from Eternal Tools priced at £19.95 plus £2.50 post and packing, but free delivery if purchased on line. **They can be contacted at 159 High Street, Pershore, Worcs. WR10 1EQ, by phone 0114 268 5472 or website info@eternaltools.com**



**Micromesh
abrasive kit from
Eternal Tools.**

Engineer's Tool Room

In addition to the conventional machines and tooling, Reg. Pugh is in the process of adding CNC conversion hardware (photo 6) to his range. At present the items available include size 23 and 34 stepper motors, 16mm dia. x 2mm pitch ballscrews and nuts (available to length up to 2100mm), cast aluminium direct drive and reduction drive adaptors for size 23 or 34 motors (either as cast or machined), zero backlash drive couplings, and micro switches (limit switches). **More details can be found on the website www.engineerstoolroom.co.uk or by phoning 01443 442 651.**



**Selection of CNC related items
available from Engineer's Toolroom.**

Reeves 2000 Press release

"Reeves 2000 are pleased to announce that over 8000 products are available to purchase on-line. Customers are requested to go to our main site at www.AJReeves.com and then to the shop. This site is fully secure for web orders. Despatch is normally same or next day from over 100 tonnes of stock.

There is an extensive range of new products not in the printed catalogue that can be ordered on line, or purchased in our shop. The printed catalogue will continue to be available and updated from time to time. This can be ordered by telephone, in writing, or on line.

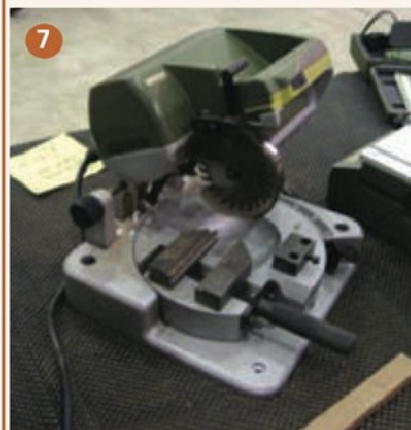
New products include books such as the magnificent "Doble Steam Car", drawings and castings for steamboat engines, our range of steam fittings and drawings related to road going vehicles." **Reeves 2000 can also be contacted by phone on 01827 830 894.**

Chester (UK)

With the growth in the popularity of large scale model making has come a matching rise in the ownership of larger machine tools. Whilst many of us may aspire to full size toolroom equipment, few of us can accommodate a full size Bridgeport or similar. The new 836 Turret Mill aims to solve this dilemma by having a footprint comparable to a smaller machine, but with an R8 Spindle and table size of 910mm by 200mm offers near Bridgeport capacity. Table travel is 600mm by 240mm which of course may be augmented by head rotation and overarm travel. The drive motor is 1.5HP, and standard accessories include coolant, X axis power feed, one shot lubrication, and a 1/8" threaded drawbar. Price has been set at £2995.00, extremely competitive against a real Bridgeport. **Chester are on 01244 531 631, and will be pleased to give more information.**

Jean Burhouse

Exhibited on the stand was the full range of Proxxon machinery which included both the thicknesser announced last year, and the just introduced miniature chop saw (photo 7). As with all Proxxon equipment, this is aimed at the smaller scale enthusiast, and efficiently cuts sections of wood or light alloy either square on, or at an angle. An interesting feature is the vice, which has two moving jaws, ensuring that the material stays in position on centreline.



**New Proxxon Chop Saw from Jean
Burhouse.**

Fireside reading

Hand Scraping

The full title reads *"Learning the Lost Art of Hand Scraping from Eight Classic Machine Shop Textbooks"*. As the unabbreviated form indicates, this book collates relevant chapters from eight respected engineering reference books dating from 1880 to 1917. The numerous sources spread over almost forty years ensure that differing emphases are included. As many of the original sources predate the widespread use of photographic material, the illustrations are by way of good old fashioned engravings and drawings which are printed with good quality showing fine detail. If you want to learn how to make a scraper and then use it, this little 48 page book will let you into the secret. **Reprinted by Lindsay Publications, it can be obtained from Camden Miniature Steam Services, price £3.95 plus £1.00 for UK post and packing.**



Machine Shop Essentials, Questions and Answers

by Frank Marlow

In almost all respects, this volume is a complete contrast, being 500 plus pages of bang up to-date material. As the introduction comments, the book covers manually controlled machines as might be used by model makers, instrument makers, car and motorcycle enthusiasts and gunsmiths.

While it does not set out to cover CNC machinery, it does include digital measuring equipment, DRO's and the Sherline electronic rotary table controller (similar to "DivisionMaster") along with other items of modern tooling. As the title indicates, the presentation is in Q and A form, typified by the opening question "What are the essential measuring and marking out tools, and how are they used?" Twelve chapters are headed: Measurement Tools, Layout and Job Planning; Basic Hand Tools; Filing and Sawing; Grinding, Reaming, Broaching and Lapping; Drills and Drilling Operations; Threads and Threading; Turning Operations; Milling Operations; Fastening Methods; Machine Shop Metallurgy; Safety and Good Shop Practices; Other Shop Know How. Appendix one covers sharpening steel lathe tools, while two deals with (American) sources of supply.

What you will not find in this book is page upon page of reference data, as you might find in "Machinery's Handbook". Thus in the section on taps, few tapping drill sizes are given, but the concept of "Percentage engagement" is clearly explained and it is noted that tap loading can be reduced by up to 65% by changing from 80% engagement to 60% which is adequate for most situations. This is also a book almost totally devoid of photographs. It does however boast over five hundred line drawings, which illustrate topics with excellent clarity of detail. In many instances, a section view shows what the camera cannot.

In summary, it may be thought that the use of the word "Essentials" in the title is to understate the scope of the book. It provides rather more than just the bare essentials for most of what one is likely to encounter in amateur or low production machining work. **The ISBN is 0-9759963-0-4 and it can be obtained from Camden Miniature Steam Services price £28.25 plus £4.60 UK post and packing. Camden can be contacted by phone on 01373 830151 or by post to FREEPOST (BA1502), Rode, Frome, Somerset, BA11 6UB.**



Model Engine Mechanics by Gordon Cornell

This book is unusual in that, as it is aimed at a niche market, (constructors of model two stroke engines) the author, Gordon Cornell has decided to print and publish off his own bat. The author has been closely involved with small size engines since working for E.D. and Frog in the 1950's. Since then, after working in the motor industry in the midlands, he has manufactured small batches of his own state of the art, "Dynamic" model aero engines. Visitors to Donington exhibitions in recent years may have seen him surrounded by fascinated spectators, producing typical components on a Wabeco mill at the Pro Machine Tools stand, and long term MEW readers may recall his articles on equipment related to engine making. The book runs to 156 colour printed A4 pages, and is comb bound with thick covers to open flat as befits what is essentially a reference manual.

Sections of the book give detailed information on not only design aspects, but also practical manufacturing advice, with clear illustrations of many of the jigs and fixtures used. Topics such as cylinder, piston, crankshaft and con rod manufacture, were found to be particularly interesting as was a description of the author's internal combustion engine workshop. Processes such as grinding, honing and lapping are discussed along with work undertaken using his more recently acquired Wabeco CNC mill.

Along with the book is offered an engine analysis program on CD - "ICE" which is complementary to the book. The introductory price for the book is £20.00 plus £2.00 UK post and packing, and for the analysis program £50.00. However, if purchased with the book then the CD is just £25.00. For enthusiasts of model two stroke engines, the book may be the nearest thing to a bible. For those interested in working up their own designs, as a development tool, the analysis programme could offer a short cut route to evaluating alternatives. It is hoped to feature an in depth review of the "ICE" software in a future issue of MEW.

Gordon Cornell may be contacted by post to 19 The Earls Croft, Cheylesmore, Coventry, CV3 5ES or by email to GCorneil@tiscali.co.uk



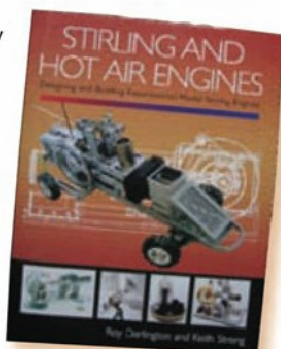
Stirling and Hot Air Engines

by Roy Darlington and Keith Strong

Anyone who has attended a Model Engineering exhibition cannot have missed the Stirling Engine Society stand, and the affable, irrepressible co-author, Roy Darlington demonstrating and explaining the intricacies of the engines. Within the book, after a brief historical review, chapter 2 deals with principles and performance enhancing techniques. Later chapters deal with design variations (beta, gamma, alpha/rider etc), low temperature differential, martini, and marble engines. Descriptions are given of several of Roy's own designs including detailed plans for the beta engine used to power one of his boats. An efficient Stirling engine will usually have some components which demand a higher order of precision than many other sectors of model engineering. Hence a significant part of the book is devoted to workshop practice and techniques, going into particular detail not only on such subjects as piston and cylinder assemblies, but also meths and butane burners. Having spent much time in industry optimising factory layouts, Roy's comments on workshop equipment and planning are especially well founded.

In the first instance this work offers much to the Stirling engine enthusiast (both beginners and experienced) but also imparts much, by way of techniques, which may be taken to other branches of the amateur engineering hobby.

Published by Crowood Press and priced at £29.95, the book is in hardback 7½in by 10in format which allows drawings to be reproduced with excellent clarity, and extends to 240 pages. The ISBN No. is 1 86126 688 X and it will be available through good booksellers.



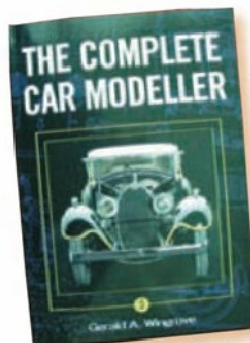
The Complete Car Modeller (2)

by Gerald Wingrove

Gerald Wingrove will be known to many readers as a master craftsman in his chosen sphere of automotive modelling, so that it comes as no surprise that he has been commissioned on numerous occasions by no less than Lord Montagu of Beaulieu to furnish exquisite replicas.

As with volume 1, (see MEW issue 96 page 29), this is a revised edition now published by Crowood Press, is softbound and extends to 134 pages. In contrast to volume 1, this book focuses on the techniques used in the production of a single model, the Weinberger Bugatti Royale. The five chapters guide the reader through: Tools and Materials; The Chassis; The Engine; Bodywork; and The Finishing. Within the first of these, some of the ideas for a space saving and ergonomic workshop are particularly ingenious, as are the purpose made tools. Discussion of the chassis includes making the wheels, and

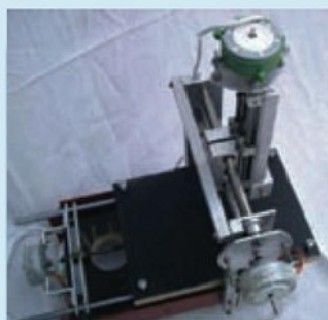
touches on metal etching, used here for the battery box. The engine section covers first the analysis of the shapes and the splits for fabrication, followed by detailed advice on how to work with and assemble these small components. "Bodywork" offers not only a masterclass in diminutive panel beating but also a valuable insight into door catch and hinge making, and also soldering techniques. "Finishing" examines chrome plating, brass blacking, painting, and fabric fitting and comments on the availability of fine leather.



For those whose workshop expertise may be concentrated on machining activities, this is a work, which will shed light on many alternative techniques, and guide the aspiring car modeller to greater achievements. Priced at £14.99, the book should be available from good booksellers (ISBN 1 86126 750-9).

IN OUR NEXT ISSUE

Coming up in Issue No. 109 will be



CNC for Free

Chris Fouweather describes a capable system built at low cost.

Facilitating the Use of the Four Jaw Chuck

Philip Amos discusses techniques and introduces some time saving gadgets



Simple Grinding Rest

Correctly ground tools made easy with this device from Harold Hall



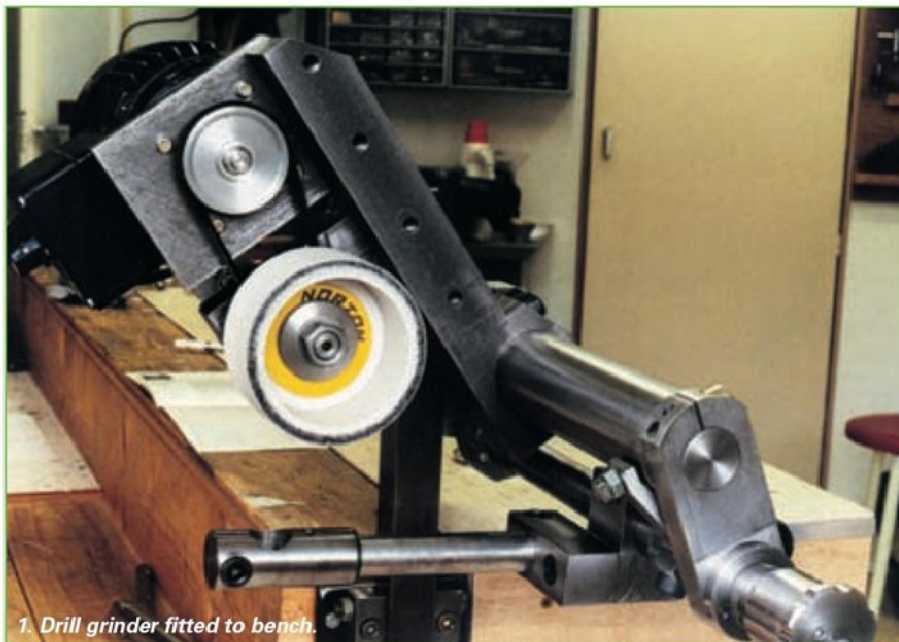
Microwave Timber Seasoning

Jack Cox adopts a novel approach to moisture content control

Issue on sale 9th September 2005

(Contents may be subject to change)

DRILL GRINDER 1



1. Drill grinder fitted to bench.

This article will look at drill point theory, then proceed to describe the device designed initially to create effective drill points, but which also exhibits the versatility to sharpen other tooling. This first section includes various assembly/sub assembly drawings, while the detailed component drawings will be given in **part 2**, which will appear in the next issue of *MEW*.

Philosophy and theory

In spite of the best attentions of apprentice instructors over many years, not everybody can grind a drill by hand as it should be done. The problem is generally, that mysterious swing which you have to give to the drill when grinding. So the philosophy behind making this device was: take the drill, make a controlled swing move, after having "constrained" it with a piece of tooling to follow the path suggested by the theory. The drill should then be correctly

ground. This philosophy was simple, to turn it into reality took two years.

In addition to the "swing" the cutting edges have to be equal, the point angle has to be correct and the whole symmetrical. What I learned many years ago and forgot was the theory, found back in my historical documentation and shown in **Fig 1A**. The ground drill surfaces are formed by parts of two conical surfaces. I have drawn one of them, positioned as drawn in **Fig 1A**. An extra piece of data is given in **Fig 1B** that angle $\varnothing = 55\text{deg}$. It should be 55deg but clearly there is a discrepancy between **Figs 1A** and **1B**. So is there something wrong with the theory? But more about this later.

During the drilling, every point on each cutting edge, describes a circle around the drill axis, and there has to be a clearance on the ground surface behind the edge. In addition, an extra clearance has to be there because there is an axial feed. This feed is

Jan Winkel of Sassenheim, Holland examines the theory of drill point geometry, and describes his drill, tool and cutter grinding device.

constant for any radius, which means that the clearance angle must increase towards the centre. This may be compared to the angle of a propeller blade, which varies with radius. Years ago, our factory toolmaker showed me how to see if there is sufficient clearance, by putting a washer between his fingertip and the drillpoint (see **Fig 2**). He did it with different diameter washers. These washers had to rock on both cutting edges.

Let us have a look at the drill point. The cutting edge lies a distance "a" in front of the drill centre line. This fact gives rise to a clearance angle. It is a point for discussion point whether this "a" effect is enough. The clearance angle effect is more pronounced in the centre, and on the circumference less, (just what is needed).

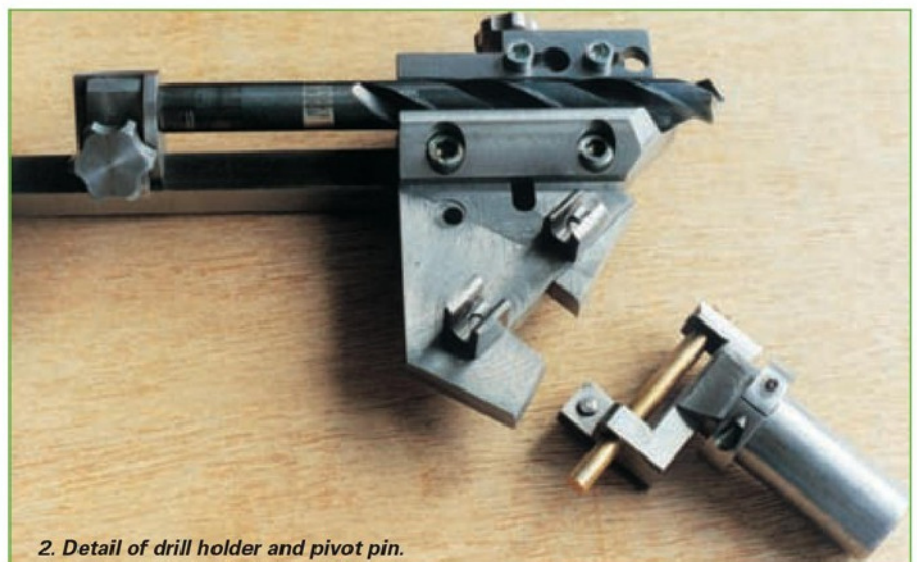
If (see top view **Fig 1A**) the drill is turned a little bit too far to the right this has consequences for the clearance behind the cutting edge. While the results may look good, the drill operation becomes less effective. Close to the centre of the drill it is not so easy to see if there is enough clearance. The washer test is not so useful. (Too small). So here is another "helpful" pointer. The chisel angle has to be 55deg to get sufficient clearance in the centre, but for the time being, it is just one more parameter to aim for.

Grinder layout

In **Fig 3** you see the general layout of the drill grinder equipped with the drill holder. In this layout you can find all the data as given in **Fig 1A**. The mysterious swinging axis is the cone centreline, the "pivot" axis A-A (**Fig 3**) making an angle of 14deg with grind wheel surface. The drill cutting edge

SAFETY NOTE

Before considering the practical layout of the drill grinder which is designed to apply the existing theory, a few words on safety will not go amiss. It should be stated at the outset that for the purpose of clarity, the photographs accompanying this article show all guarding removed. It goes without saying that with the exception of small "Mounted points", grind wheels should always be effectively guarded. The size and shape of guard will be determined in part by the wheel(s) employed and the detail is therefore left to the prospective builder.



2. Detail of drill holder and pivot pin.

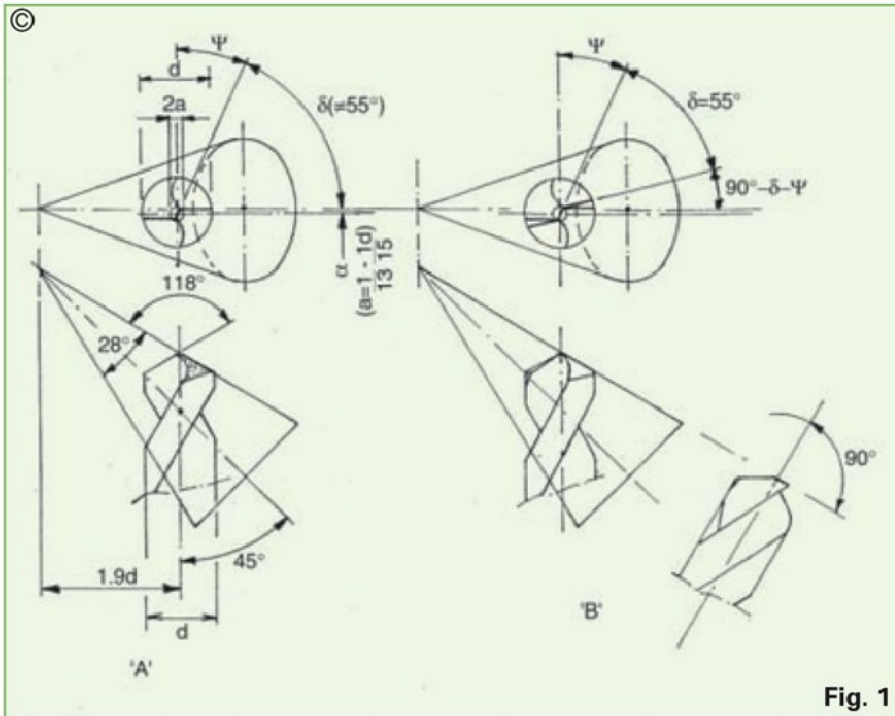


Fig. 1

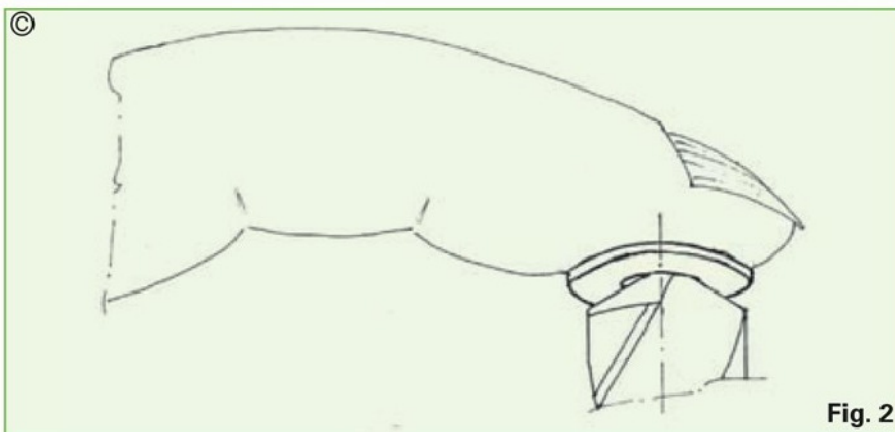


Fig. 2

has, during grinding, to rotate around the pivot pin. (centreline A-A)

The drill is clamped in a V-block. The tip of this V lies in the plane of the centreline A-A. To automatically compensate the distance "a" given in Fig 1A this 90deg V-block is rotated 6deg. With this 6deg rotation, the cutting edge with different drill diameters, will stay (nearly) at the same relative position.

To achieve the 1.9d. dimension, the drill has to move a certain distance in or out of the toolholder. A sighting point is given by

"Z" in Fig. 3. If point Z lies on the centre line A-A than the distance from cone point to drill centreline is not 1.9d but 2.0368d, say approx 2d (my colleague's CAD computer has computed it exactly). The drill holder consists of two parts and is shown in Photo 2. One part, the pivot pin has a short vertical shaft clamped in a swing arm. (5) (The numbers relate to the drawing part numbers.) The pin from this part is set at 14deg with the swing arm (5) so as to ensure a corresponding angle with the grinding wheel face. The second

part is the drill holder 41. Only during grinding are these pressed on the pivot pin 43 with the left hand fingers under part 43 and the thumb on plate 41. This action is shown in Photo 3.

Setting

There are two methods to set the 14deg angle.

- Using a degree scale with indicator which can be used to achieve any required setting. (Drg 55 and 56). (Normally used for lathe tool and cutter grinding).
- The setting ring (42) used to set the desired angle, say 14deg. One side of the top plate is then parallel to the grinding wheel surface. If the cutting edge is touching the grinding surface the top plate makes 90deg with this grinding surface. By turning the swing arm (5) around this axis, the clearance angle from cutting edge will be changed (grinding surface is then not following the theory Fig 1A). For measuring this angle, there is on the reverse side a degree scale, while on the swing arm there is an (adjustable) indicator.

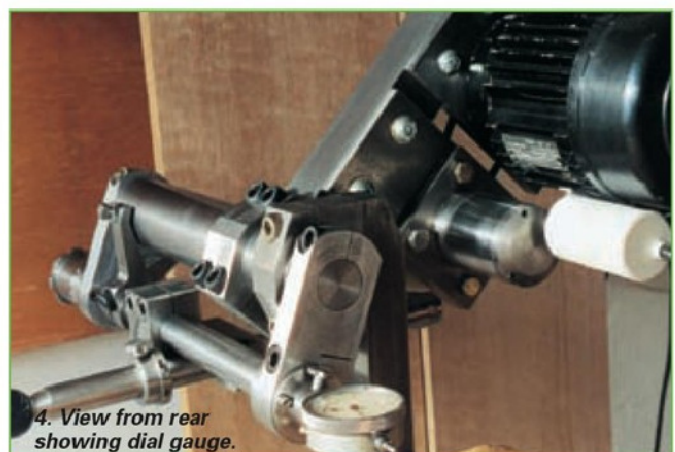
The swing arm holder (6) is clamped on to a guiding shaft 2-22, and these can be moved axially. The guiding shaft can rotate and be axially moved around 10 mm with a fine feed. (actual displacement may be read on a dial gauge).

Grinding the drill

After having clamped the drill in the drillholder a stop is placed against the back of the drill. If necessary, the drill clamp can now be loosened a little bit to turn the drill to the correct position "by eye" holding point "Z" in line with centre line A-A. Then, as said before, clamp with the left hand the toolholder on the pivot pin and move these along the pivot pin as far as possible in the direction of the grinding wheel (against the stop). If you want to see the grinding results during grinding, move the holder back along this pivot pin. (pin remains at 14deg with grinding surface, as said before.) Bring the drill to the grinding wheel with the fine feed knob. As soon as the drill is touching the wheel, the whole can be moved down (swing arm makes a left turn) so that the drill is out of contact with the wheel. In this position a feed is given, say 0,02-0,05 mm (on the dial gauge) then an upwards movement and a pivoting movement around the pin. The whole is a natural



3. Action to grind a drill point.



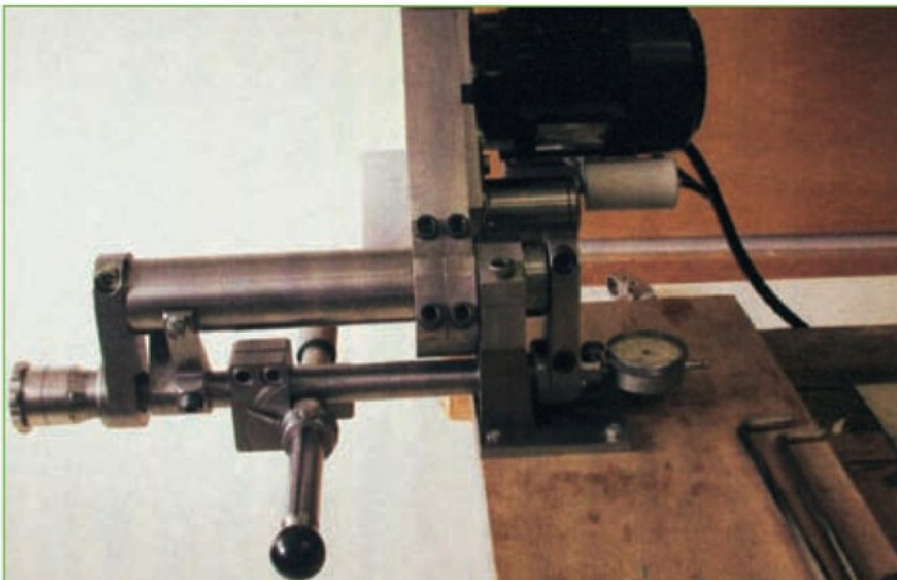
4. View from rear showing dial gauge.



5. Set up for sharpening a lathe tool.



6a. Set up for sharpening an end mill.



7. Mark 1 Bench attachment (not recommended).

movement as if doing it by hand, only now it is guided (see the initial philosophy) and by this mechanical guidance, you do it as it has to be done! It is very important, this vertical movement, because the whole grinding surface is used (the surface will not be grooved) and the drill is holding contact with the wheel for only a very short moment. With this interval you are cooling the drill. After a series of infeeds the first surface is ready. From this moment on, the feed knob should not be turned. Move back along the 14deg pin and take the drill holder off. Rotate the drill 180deg in the V-block (against the stop!) and with care move axially along the 14deg pin to the grinding surface and repeat the movement (not using the feedknob) just progressing along the pivot pin until the axial stop is reached.

(For short drills, the press plate 49, the stop 46 and the extension pin 45 may be employed.)

The critical situation with the clearance angle

Even knowing now how to grind a drill following the existing theory, there is still the critical situation with the clearance angle especially near the centre. The normal situation is that the (centre) chisel can only scrape with a negative cutting edge. If 'a' is increasing, the chisel length will be shorter and the cutting line longer. At the other extreme, the trailing side of the chisel will touch the material and the chisel will no longer be able to scrape. There are now two possibilities:

- Grind the trailing side away (as drillmakers sometimes do). If it is done

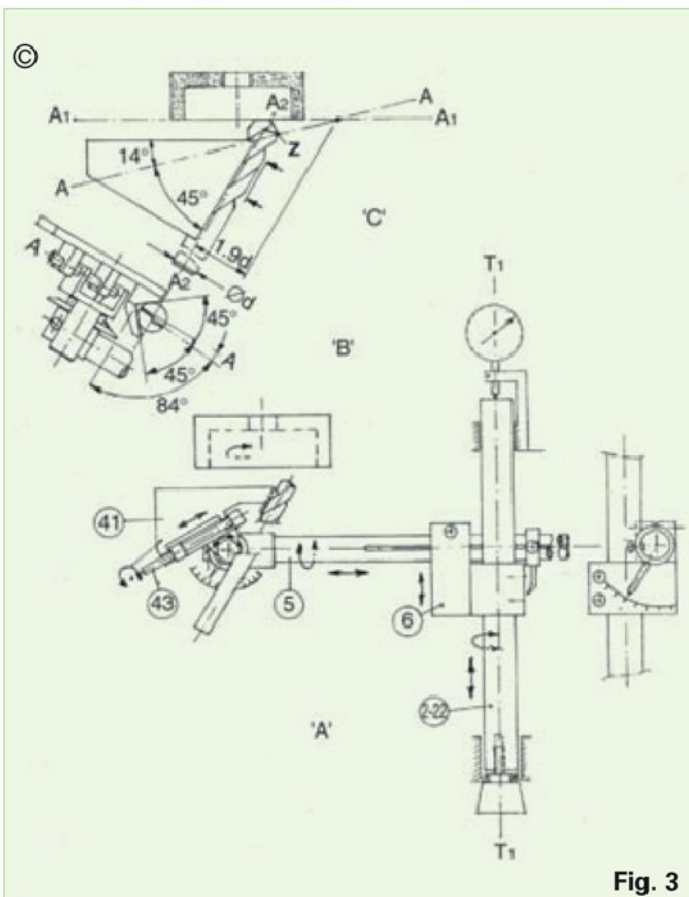
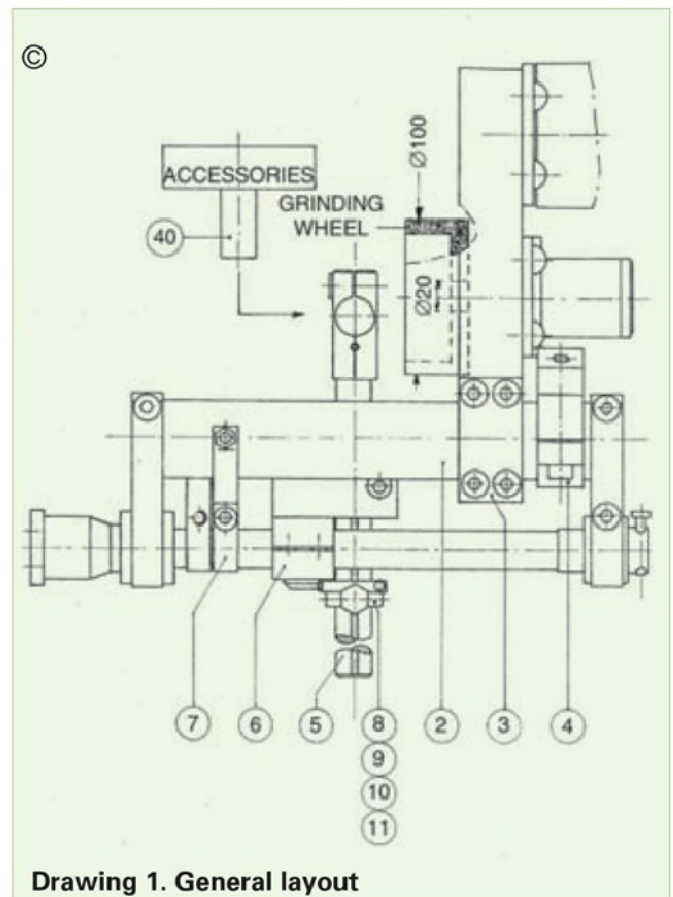
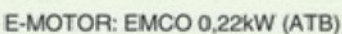
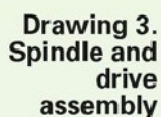
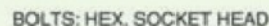


Fig. 3



Drawing 1. General layout

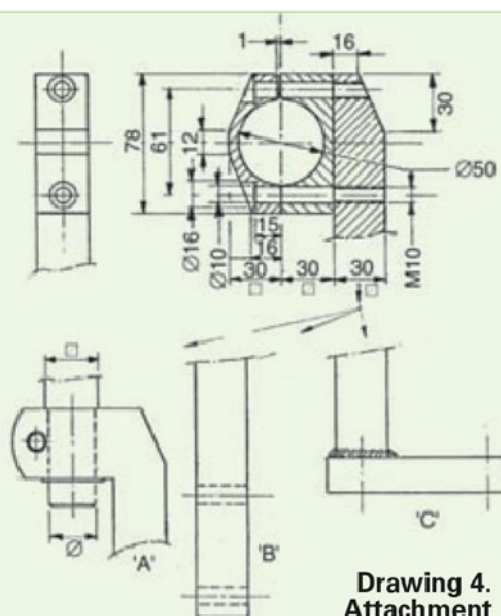


b. Make the chisel longer, angle θ smaller. If too small, the chisel will do more rubbing.

So angle ϑ is a compromise, may be $\vartheta = 55^\circ$ at this stage does not look wrong.

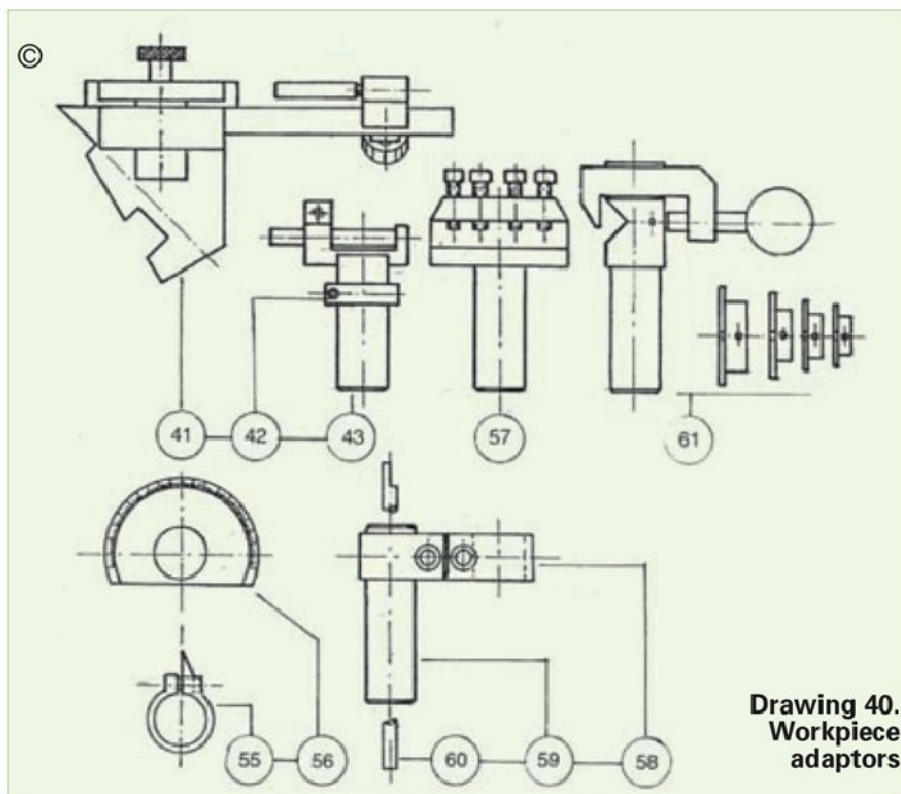
Results of grinding experiments

The first results from a ground drill (diameter 10 mm) looked very good but drilling efficiency was inferior to new "Dormer drills" (they have the chisel



Drawing 4.
Attachment
to bench

CONNECTING ASSY DRG. 2 TO WORKBENCH
'A', 'B' & 'C' ARE SUGGESTIONS



Drawing 40.
Workpiece
adaptors

relieved). It was easy to see : Drills ground according to the theory have an angle $\phi \sim 70\text{deg}$ and that is too much. What I saw in practice was that commercial grinders

give more cutting edge clearance. With this grinder it is easy to do by rotating swing arm 5 (Fig. 3) a certain angle around its own axis. So at this point, the theory appears far

from perfect. The results are better but the angle ' ϕ ' is still far from 55deg . Nearly the same effect can be achieved by:

- shorter distance cone top to axis drill.
- increasing cone top angle, especially for some materials.

Many tests have to be done to give exact information as : - axial load, - life time, all with different diameters. But angle ϕ is still far from perfect.

There is another solution to get $\phi = 55\text{deg}$. Rotate the drill around its own axis a certain angle to the left. (see Fig 1B) Here it is easy to understand that chisel angle ψ is determined by the position of the two cones and not by the position of the cutting line. If the drill has $\phi = 70\text{deg}$ in the normal grinding position and $\phi = 55\text{deg}$ is what you want, then the drill has to rotate 15deg . The ground surface is made in one swing but consists of two surfaces. The first surface from cutting edge to the tangent line of the cone is a flat one, the second ground surface is following the cone contour. The advantage of this flat part is that the clearance angle along the whole cutting line is better. The drill tip angle will increase a little bit but can be easily corrected by slightly reducing the pivot pin angle.

Test summary

There are many settings possible to achieve a reground drill which will perform well, the major proviso being that there is sufficient clearance behind the cutting line at all radii. A few initial observations were: Setting up as in Fig 1A results in inadequate clearance. Rotating the swing arm to give a "pre-clearance" gave a better result but did not reduce angle ϕ significantly. Varying the top cone angle made little difference. Increasing the 1.9d offset appears to give a good ground surface, but gives angle ϕ in excess of 70deg leading to a problem near the chisel edge.

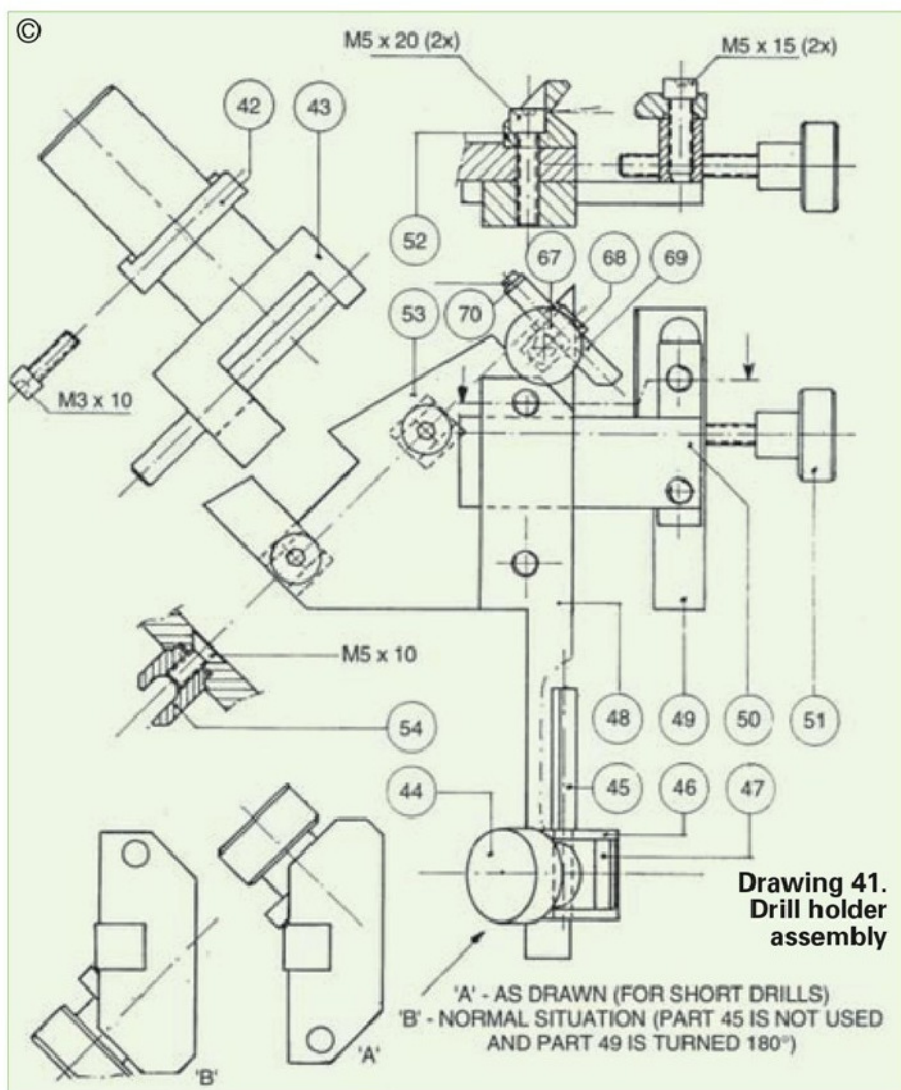
Of all the factors coming into play, the one which really changed matters was rotating the drill around its own centre line. After experimenting with this, best results were obtained by a combination of factors, in line with the later observations which follow. Drill testing was undertaken using a hand drill as it was then possible to gauge the results by "feel".

- Setting a pre-clearance angle by rotating swing arm 5 (see Fig. 93) at 7deg .
- Increasing distance from cone tip to drill centre line to roughly $3d$, this means moving the drill axially $0.38d$ (say $0.4d$) in the V-block, displacing point z by $0.4d$ in the direction of the grinding wheel.
- Rotate drill 15deg around its own centreline.

The chisel angle ϕ is a bit more than 55deg .

It is possible that a slightly better result can be achieved with different settings of the various parameters.

The next part of the article will present the detailed component drawings and deal with the construction of the device, giving brief comment on some of manufacturing methods used.



Drawing 41.
Drill holder
assembly

'A' - AS DRAWN (FOR SHORT DRILLS)
'B' - NORMAL SITUATION (PART 45 IS NOT USED
AND PART 49 IS TURNED 180°)

ROUND WITH DOVETAIL ADVANTAGES

John Crammond offers his solution to vertical alignment.

Background

Round columns on milling machines can be both a blessing and a curse; among their advantages is the ability to swing the head from side to side thereby greatly increasing the amount of table surface that can be covered. Another is that, with the head out of the way, work can be set up far more easily, and the machine can be cleaned down without the risk of cutting the backs of ones hands on sharp tool edges etc.

The main disadvantage is of course the perennial problem of losing accurate location when raising or lowering the head. These days most mills have quill travel, but rarely is it sufficient to allow the exchange of cutters and provide a reserve of feed for the job in hand. Some of you may recall an article in *MEW* Issue 61 where I relayed my experiences over a number of years with a Chester Champion. In it were brief mentions of improvements I had made, and I thought that my uncomplicated way of overcoming vertical alignment problems might interest you.

Simple addition

As can be seen in **photo 2**, My addition consists of only three simple machined parts, and a length of bar, faced to length. Once fitted, it does not in any way restrict or compromise the swing or tilt of the head. Whilst this addition was made specifically for the Chester Champion the principle is applicable to any round column milling machine. The dimensions will obviously change but the end result should be just as effective.

As you can see from the photos and drawings, the lower split column bracket is firmly attached to the mill column rather like an engine connecting rod to a crankshaft journal, however with the machined gap between bracket and cap which is dealt with later, when bolted together, clamps to the column in an unmoveable grip. When in place on the mill, the assembly will control any radial movement of the head, when altering its vertical position, while the head can still be moved left or right by simply slackening very slightly one of the two lower bracket cap head screws.

Lower bracket

I decided to use one inch thick mild steel plate for the lower bracket simply because I had a large piece to hand, though cast iron or aluminium alloy would do just as well. The one inch thickness provides good support to the alignment pillar which you can shrink, press or Loctite into the bracket. At this stage it may be wise to decide upon the material to be used for the alignment pillar, as we need to bore the small hole in the bracket to suit. I selected a nice straight 15in. length of bright EN8, which actually measured out at 0.997in. diameter. The column diameter of a Chester Champion is 70 mm or 2.756in. but check to be safe. The success of the modification depends heavily

on the precise parallelism of both large and small bores, and I considered the various ways that I could accomplish this. I did think of boring both holes on the milling machine, but 70mm is a large hole and will produce a bucket full of swarf. In the end I decided that using the lathe would be easier, more rigid and quicker, so I mounted the embryo plate in the 4 jaw of my Colchester Master 2500 bored the large hole and faced one side of the plate at the same setting. The 4 jaw was then replaced with a faceplate, bedding the freshly machined surface carefully against the faceplate to ensure parallelism and the centre of the small hole was located using a wiggler. As I intended to Loctite pillar to bracket the hole was bored 0.999in. as this adhesive substance requires a small clearance to work its magic to best advantage. It also has a most useful self centering quality, however it pays not to rely entirely on this and the end of the alignment pillar that we are using should be faced slightly concave, and the bracket placed with its machined face on a flat plate levelled as accurately as possible while the Loctite sets. Before permanently attaching pillar to bracket, the bracket needs to be drilled and tapped to accommodate the two fixing screws. Unless you can obtain 1/4in. BSF socket head cap screws 2 1/2in. long you will need to counterbore their holes to allow the screw heads to recede into the bracket. I ended up using 1 1/2in. long ones necessitating counterbores 3/4in. deep. Once done we can split the bracket in two across the diameter of the large hole and face back both sawn surfaces say 10 to 15 thou to provide a gap of around 0.060in. when attached to the column. The bracket will now bolt up firmly, the 45degree chamfer at the bottom of the large bore accommodating the small radius left at the base of the mill column.

I did at one stage consider shrinking the pillar into its hole in the bracket, however I



1. View of finished assembly fitted to mill.

have had one or two utter disasters attempting similar operations. It is almost unbelievable how quickly metal, which has been in the deep freeze for a day will expand and grip a heated part while it is still only half in and not properly lined up. We've probably all done it, and are left with the problem of separating the two parts without damage, and having a second go with our confidence distinctly bruised.



2. Component parts of the assembly.



3. Prepared surface on head for top bracket.

Bracket assembly

With pillar and bracket now permanently united the assembly can be bolted to the column and tested for accuracy. Side to side discrepancies can easily be ascertained by measuring the distance between pillar and column at various places. Fore and aft testing is more involved, and I bolted a highly accurate 9in. box cube to the mill table and carried out a similar procedure. Aim for zero discrepancy in either plane. Let's be clear, if the two holes are perfectly parallel there is no reason why you should not achieve this state, however various factors such as lack of straightness of the alignment pillar, or even a tiny speck of dirt between bracket and column will cause small variations. As with all work it pays to get it right first time, so be extra careful with your machining set-ups where cleanliness is just as important as it is with assembly. Remember that accumulated errors very seldom work in your favour.

Head rework

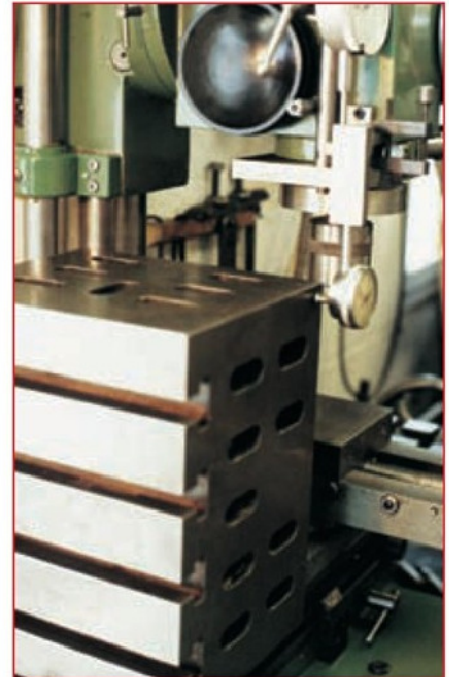
When the alignment pillar and bracket are fitted to the column to our satisfaction we can turn our attention to the large head casting which slides up and down the column, officially termed in Chester's manual 'the main spindle box base'. The top bracket will eventually bolt to this, so we need a flat perpendicular area on the casting's left side, looking from the front. Ideally we would remove the casting to machine this surface, but this would involve dismantling which I did not want to do. Consequently I removed paint and filler from a 1.25in. high strip, over the width of the casting, as shown in **photo 3**. Careful preparation of this surface will be necessary if the alignment pillar is to slide unhindered through the top bracket, and we can use the fitted pillar to check our progress. Cast iron is relatively easy to work with a new file, and I was surprised how quickly I achieved a satisfactory area. To test its parallelism to the column I selected a 12mm thick piece of surface ground mild steel 4in. wide and 9.5in. long. This was clamped to the newly prepared surface, and its distance from the mill column measured at several places. From these measurements it will be obvious where further filing on the head casting is needed, and several attempts later I had a situation where the discrepancy was little more than a thou, at which point I decided not to push my luck further.

This of course was very much the traditional approach to achieving a flat, perpendicular mounting surface, and was undertaken well before the publication of the article in MEW issue 98, by John Feeney, which discussed the use of epoxy resins. It is very likely that an equally effective result could be obtained faster using the methods he described, which in turn would have implications for the manner in which the top bracket size should be determined.

Top bracket and bush

The final part to be made is the top bracket which bolts to the newly prepared surface. Because no two head castings will be precisely the same and the amount of metal we need to remove to arrive at a flat and perpendicular area is indeterminate, the distance from the bolting face to the centre of the bore for the pillar cannot be specified in advance, and will have to be individually measured when the head casting has been prepared and the pillar is in place. I made the top bracket out of 30mm thick continuously cast iron plate purchased from our old friends College Engineering. This was a remnant left over from a previous project and was 4in. wide. Cast iron is, as we know, a good bearing material, and I could have simply machined a bore to suit the alignment pillar; but wherever I can, I prefer to fit a bush, as this can so easily be replaced should the need arise in the future. Consequently I bored a 1.187in. dia. hole and fitted a cast iron bush with a lapped internal bore of 0.9975in. to match the pillar. Lapping produces a far superior wearing surface, and is a process that has been described many times, including an excellent article in vol. 23 of MEW by Mr. Alan Jeeves.

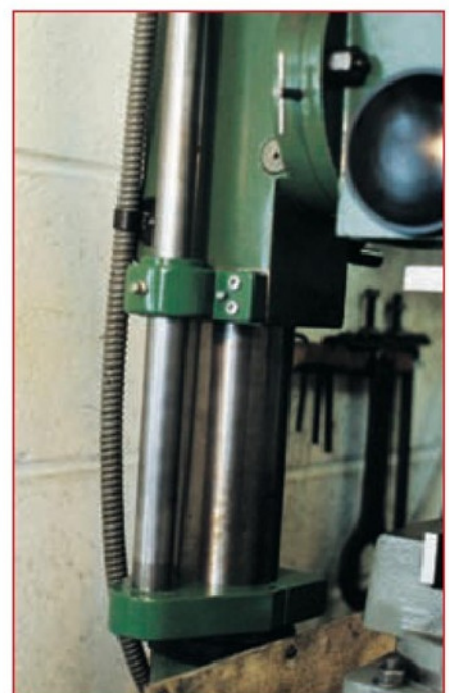
The bush itself needs no detailed comment, though the order in which we machine the important areas of the top bracket warrants some consideration. Some may prefer to machine the bolting face first and the bore second, perhaps placing the newly machined face on an angle plate attached to the lathe face plate. This requires careful measurement of the distance "B" on the drawing, taken from the bolting face of the head casting to the centre of the pillar. Precise marking out on the unfinished bracket and equally precise machine set up is essential. An easier and more certain procedure is to again take the calculated distance "B" and add to this 0.040in. and machine the bore 1.187in. with its centre "B" + 0.040in. from the proposed bolting face, using the 4 jaw chuck. At the same setting face the top surface of the bracket to provide an accurate mounting area for the second operation of machining the bolting face. Once again substitute the 4 jaw chuck with the face plate with an accurate angle plate attached. With the machined top surface of the bracket bedded against the angle plate, and fastened through the bore with a bridging piece and bolt, adjust the bolting face to face the lathe tailstock. No accurate positioning is required other than ensuring that the face to be machined is at right angles to



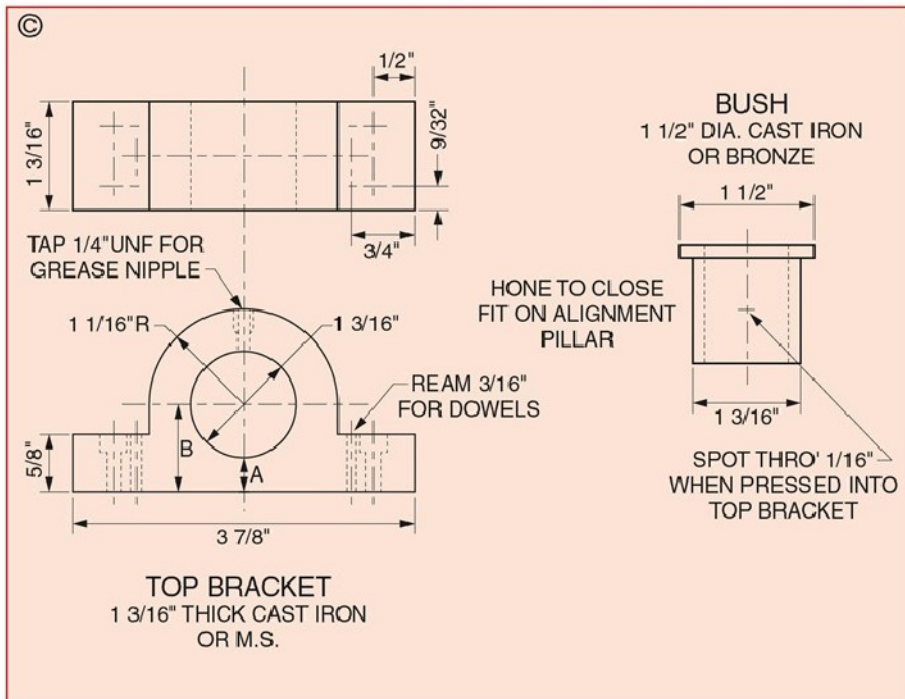
4. Testing with the box cube.

the lathe centre line. With around 0.040in. to be removed we can proceed with confidence as the set up is firm and the distance is easily calculated and readily accessible for measuring. If by some mischance, the bracket is machined too short, then recovery might be by way of introducing shims.

It only remains to drill the four M5 tapping size holes in the bracket and two further holes for dowel pins. The top bracket is now placed on the alignment pillar when it should fit snugly against the head casting. Clamp the bracket to the head possibly using a large "G" clamp, and using the tapping size holes in the bracket to guide a hand drill proceed to drill the four holes in the head say 1/8in. deep; once again the cast iron is easy to work. Tap all four holes in the head M5, and open out the tapping size holes in the



5. Close up of assembly



bracket to clearance ones. Removing any burrs, bolt the bracket to the head and test for free movement of the pillar through the bracket which should of course have had the lapped bush pressed in. When satisfactory, similarly drill and ream the two holes for dowel pins. I used short lengths of silver steel, which fitted stiffly in both head and bracket. For obvious reasons I fitted a grease nipple, whilst the last job can be to provide a generous rounding to all edges and corners,

otherwise as sure as eggs are eggs, you'll cut yourself at some point in the future. Complete the job by either painting or fine finishing the various external surfaces, and stand back to consider your handiwork.

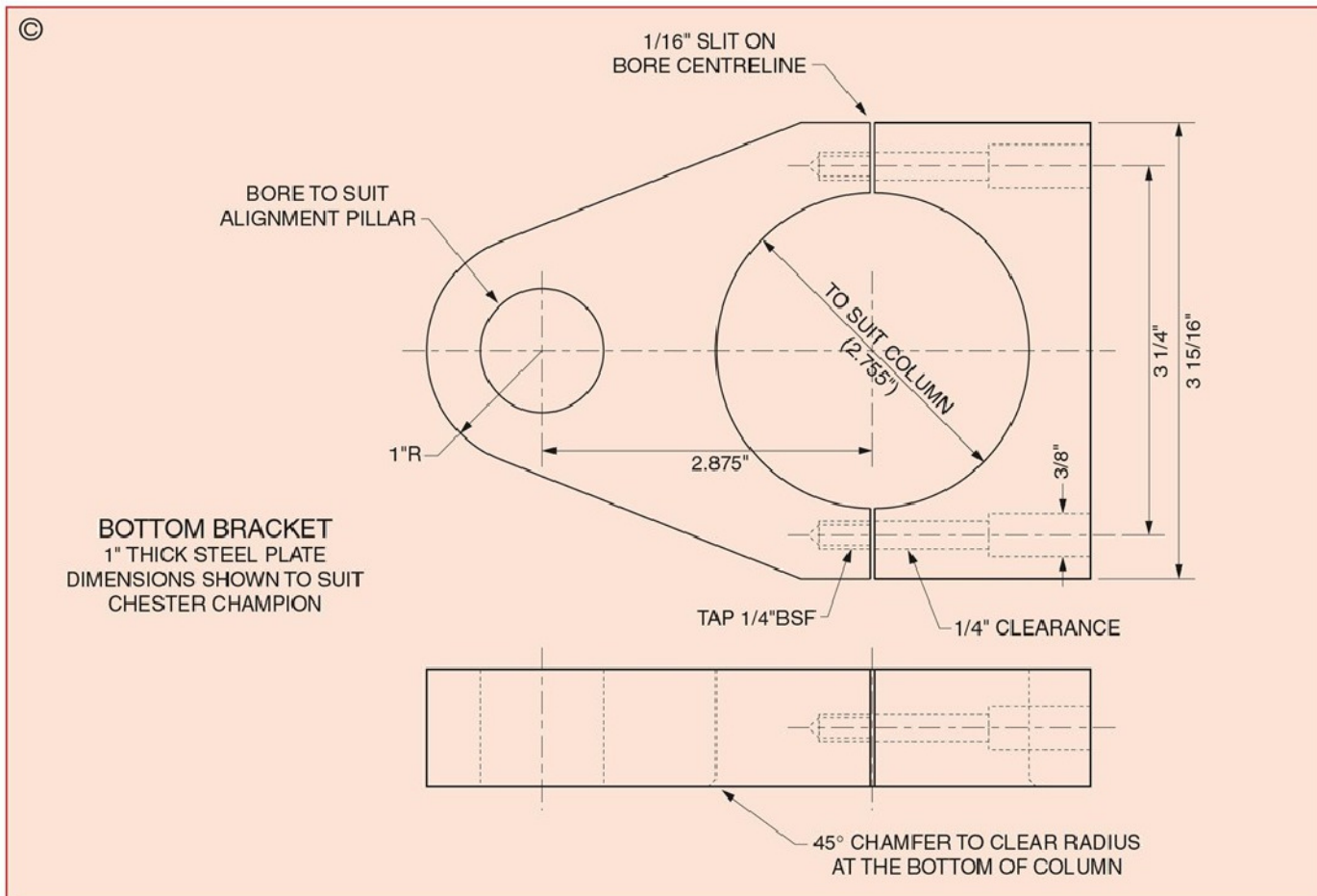
Operation and evaluation

While the mill head is now held firmly even when the column clamp is free, I

never use the machine in this condition and always lock the head to column after changing heights. Like many of my generation my preference for the imperial system of measurements and materials will be apparent, and you may find the use of metric inconsistent. However it is becoming increasingly difficult to find many imperial items these days, and it is even harder to justify paying the higher prices for items measured in inches simply to stick to ones principles. Consequently, like it or not, I'm reluctantly having to compromise: nothing ever stays the same forever does it.

To evaluate the results of my labours I again placed the box cube on the mill table. This cube had originally been a piece of Ordnance test equipment, and still had its test certificate inside. A dial indicator was attached to the head and made to contact a vertical surface of the cube. Over the available 9in. of travel against the cube the indicator registered a difference of less than 0.001in. which I feel must compare well against a similar procedure with a dovetail columned mill.

The end result was more than satisfactory. The care taken to ensure that both holes in the bottom bracket were parallel, and the patience taken to prepare the bolting surface on the head casting have paid dividends. The whole exercise occupied a leisurely weekend and had it not been successful, nothing would have been lost apart from my time. No part of the mill was damaged or altered apart from six small holes in the head, so have a go and enjoy the best features of both dovetailed and round columns.



TOOLROOM TIPS (2)

Blind Pugh discusses oil blacking and other finishes



1. A free cutting mild steel thumb screw. This was oil blacked and has been in use on my door for about 10 years, the recess in the head is purely cosmetic; it makes the head look lighter, without actually reducing the strength of it.

The industrial approach

The machine shop in which we worked was constructed on the same principle as the factory to which it was attached. It had a 24ft high roof and no ceilings; all the services and electricity dropped from that roof, down to the machines and to the benches. The offices and the rooms round the edges also had no ceilings and were just partitioned steel walls and the place where we used to do our oil blacking, was a small room about 6ft square containing a big gas air burner and a tank of whale oil. This tank was never emptied but was topped up when it got too low. It smelt so bad that we thought the whale was still in there. Now one of us had finished the parts for his machine and instead of oil blacking the parts as he went along, he decided he would finish the whole lot after he had completed the machine and strip it back down again and finish everything off. So he went over with practically a handcart of steel parts to oil black. He put them all on the hearth and put the biggest flame he could get and he blew it all over the steel parts until they came up to the appropriate dull red and dumped them all into the whale oil. The upshot was a column of smoke, like something out of Mount Versuvius on a good day. It went up to the roof, and then spread out sideways like the Bikini Atoll cloud. Unfortunately this cloud enveloped a smoke detector and as we were a factory with stored gases including oxygen, we were classified as a high risk fire hazard and every fire appliance from all the neighbouring counties turned up. By this time, of course, Jim had sneaked all his parts out of the tank and was back underneath his machine, assembling it and keeping a very low profile. There was no flame just this solid heavy smoke. It's very rare that it would catch fire and if it did, it was just the smoke and the fumes coming off. Popping

the lid on the tank stopped it straight away. "You were silly there mate," said Jolly Jack. That was one more of his sayings that kept cropping up.

The DIY alternative

Now first of all it has to be steel, you can't oil black brass or aluminium. Brass is blacked chemically and I believe you can get the chemical kits from an advertiser in this magazine. Aluminium is blacked by anodising, which is dipping it into a bath of electrolyte, passing a current through it, then dipping in dye. Dick Stephen described this in his article in Issue 106. Neither of these processes have I ever used, as we used to send it all out to be done. You start by machining to a fine finish as usual and don't bother de-greasing because you are going to get oily anyway.

At this point I am going to disagree with some authorities who reckon you should play safe and use the right oil for the job (heat treatment oil). It is claimed that old engine oil can contain quantities of dissolved petrol and thus be a fire risk. I have not found this to be a problem, but do advocate keeping a metal lid conveniently to hand to snuff any hint of flames. I am a great believer in recycling and happily use old car engine oil, (not the latest synthetic stuff). Use the cheapest engine oil you can get. The old 20/50 or 10/40 or whatever it is, after it's done 10,000 miles in your car it's ideal. It contains a certain amount of acid and a lot of carbon and it's really filthy and that's what you want, the dirtier the oil the better the black, but a clean oil which would get dirtier as it gets on, won't be too bad and you won't really notice the difference.

Heat to the stage at which the work is dull red all over. If it has a hole in it, pick it up with a piece of stainless wire, if not, with a pair of tongs and drop it into your tank of oil. A useful tank is a large coffee tin you can get at the supermarkets. Convince your partner that this is the cheapest way to buy your coffee and snatch a tin as soon as you can get your hands on one. Fill it about three quarters full with this cheap dirty oil and as I say, throw the hot metal in, pull it out and you should have a very nice black. If you haven't and it's grey, you didn't heat it hot enough. Do it again, don't bother cleaning it, just heat it up; the oil will burn off, bring it up to the dull red heat, throw it in again and you will get a better black and if you don't, keep doing it until you get it right. If you overheat it, you go above a dull red then it will scale, the black will come off in patches and I'm afraid you will have to refinish it then, and then try again. One of the toolmakers tried to produce a better

black with this method and he used to oil black it once as before, and then he would bring the oil that was sticking to it up to bubbling point and throw it back in the tank, he used to do that about 10 times and he used to get a black that was a deep rich black, but he said it only works with a coal gas air torch and of course you can't get coal gas any more, it's all methane. It might be worth trying it with your propane burner, but I think it will probably do just as well to follow the normal method. Try not to forget to have finished all the machining before you oil black the work, unless you want a bright finish in the middle of your black, so de-burr all the holes and have it all ready finished. Don't try to oil black stock bar even if it is only part of the job, machine every face because you can see that stock finish underneath the black no matter what. Incidentally, the snail trail left by an end mill isn't really a good enough finish for oil blacking or for anything else. The circular grooves you get, can be really quite deep and if you can, you should try and polish them out. When I say polish, I don't mean bring to a fine shine but the usual draw file finish is what you require.

Going back over what I have said, I tend to say "throw" into the tank of oil, when I really mean "drop" or put into the tank of oil. Throwing hot metal into tanks of oil is not a recommended practice.

Blueing

Highly polished parts are usually blued; this is most usual on screws. Polish the head of the screw to a real mirror shine and then de-grease it. Drill a hole in a piece of eighth thick brass sheet, a free rattling fit on the screw and drop the screw in so that the head is visible to you, making sure that you do not touch it with your fingers. Hold it over a flame and you will see the colour change as the temperature rises. The oxide colour goes yellow, brown, purple and blue, at which time you tip it out into oil or water and then oil depending on how big it is. If it is really big then it needs to be cooled quickly and it is best to go into water. Take it out of the water, dry it properly and then into the oil. The purpose of the brass plate of course, is just to spread the heat and get a more even head colour over the screw.

Larger items, such as, clock screws or clock hands need a different system to get the even colouring, and for this you need something called "blueing salt" which is available from suppliers. Get a small loaf tin, made of steel, not aluminium, which should be big enough for the clock hand you are going to do and pour in the crystals of blueing salt to a decent depth. Obviously when it melts it will go down lower so half full is probably about right.



2. One of a set of 4 brass screwdrivers used for tightening and unscrewing blued screws. A steel screwdriver does tend to scratch the bluing.

Heating from underneath, melt the crystals. Continue melting until you only have a thin line of crystals around the edge of the tin. Now de-grease very carefully the item you want to blue. Again, don't touch it as your fingers are oily/sweaty, and if you do inadvertently touch the work, you will be treated to a blue screw head with a white fingerprint on it. Drop the clock hand or screw into the molten salts and you will see it turn to a beautiful deep blue, remove it from the salts, drop it into water, dry it properly and drop it into oil and that's it.

It's important that you don't put your tongs, wet with either water or oil, back into the molten salts, as the oil or water boils off very ferociously and you can get burn spots on the back of your hands, so dry the tongs or whatever you are using before you go back to the salts again. I have seen it written that the colour doesn't appear until you remove the item from the salts and it gets to the air. I haven't found that to be true, the salts I use always seem to turn the work blue underneath the salt surface and I just do as I said above, pull it out and quench it in water and oil. If you heat the tin too much, the few crystals around the outside of the tank disappear and the temperature of the salts is now unknown. While there are still a few crystals present, you know you are holding it at the right temperature which is I believe about 700 degrees centigrade. The first time I used this system I was preparing some one inch head diameter screws for a regulator and I thought I

would be able to heat this up on my little camping gas burner, suitable for boiling kettles. So I put the loaf tin on top, stood on a stool in my workshop, lit it up, melted the salts, and threw in the first of the screws. I pulled it out after it had gone blue and dropped it, not into the water but on to the floor. I grabbed it with the tongs and hit against the stool and knocked over the whole system. The tank of salts fell across my left hand and then across the wooden workshop floor, which it set on fire. I picked up a bucket of water and threw half its contents on to the flames and stuck my hand into the other half. Then I spent a long time in the A & E at the local hospital and had to go back everyday to have the hand re-dressed for a week, as it went septic. Now "I was silly there mate", so don't do it. I now use a much more stable system. When I last did it, I erected two fire bricks on a proper fire brick hearth with the loaf tin on top, supported and retained by more fire bricks and heated it up underneath with a proper torch. I had a bucket for the water, and my coffee tin full of oil and I have never had another accident since, but just one is too many. 700 degrees centigrade is not to be trifled with.

Tooling

Once you have spent time achieving the lustrous appearance, it's a pity if the effect is marred when you wish to dismantle.

Photo 2 shows a brass screwdriver intended to avoid damaging carefully prepared screw heads.

A "silly" tailpiece

Let me finish with a more amusing "you were silly there, mate" story. We acquired in the workshop a hydraulic lift truck. The first time we came to use it, Jim had on his bench a completed machine, which was about two feet square and quite heavy. The idea was to bring the truck over, jack the table up to bench height, slide the machine across on to it, then lower it down to the ground and wheel it across back to the factory where it was to be set up. Now, because the lift truck was new, it attracted attention. Jolly Jack got involved as well as Jim. They discovered how to jack it up by pumping the handle of the trolley up and down, got it to bench height, slipped the machine across and pulled the truck away from the bench. Now they had to lower it down to the floor and they could not find how to do that. They trotted round and round looking for this switch and attracting a certain amount of attention from everyone, who stopped their machines, watching, and suddenly Jolly Jack found the lever and pulled it. The table with the machine on it descended rapidly to the floor, while at the same time the handle of the machine swept even more rapidly upwards. Unfortunately Jim had a foot on either side of it. They were both silly there, mates.

PS Someone has just told me that you can't oil black free cutting mild steel, unfortunately I didn't know this and I have been doing it for the last 40 years!

TWO CAPSTAN HANDLES

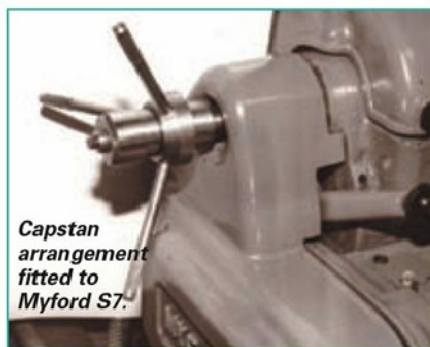
Theo. Gooden of Durban offers a pair of neat adaptations

Background

The value of a facility for slowly rotating the lathe mandrel has frequently been stated in model engineering magazines. Its advantages in certain machining and threading operations as in clock making are manifold. An improvement on the conventional handle is to fit a capstan comprising of three handles. These offer greater control particularly when machining or threading up to a shoulder. Such an adaption is very easily arranged by incorporating a conical boss housing three handles on the usual type of expanding device used to accommodate change wheels on the lathe mandrel for dividing purposes. All the materials could well be available from those off-cuts, which most modellers are reluctant to consider to be scrap metal.

Lathe Application

The photo depicts such a capstan which was designed for the Myford Super 7 and comprises a boss, just under 2in. diameter by $\frac{3}{4}$ in. long with 3off $\frac{3}{16}$ in. B.S.F. tapped holes offset by 30deg. on a spacing of 120deg. Fitted into these holes are three M.S. handles 4in. long x $\frac{3}{16}$ in. dia. knurled



Capstan arrangement fitted to Myford S7.

for about 1 $\frac{1}{2}$ in. $\frac{3}{16}$ in. in from the rounded ends. The other ends are threaded $\frac{3}{16}$ in. B.S.F. for about $\frac{3}{16}$ in. The bore of the conical boss is the same as the Myford change wheels i.e. $\frac{3}{16}$ in.

Care is necessary, as in the case of many lathe operations, notably keeping the hands clear of the path of the handles should the lathe be inadvertently switched on when the capstan is attached. In fact my lathe, which has the usual on/off reversing switch also has an isolating switch, and this is switched off when the device is fitted. However should one err and switch on, there is the cheerful thought that with three handles the spindle will not be unduly out of balance and violent vibrations avoided.

Drill Application

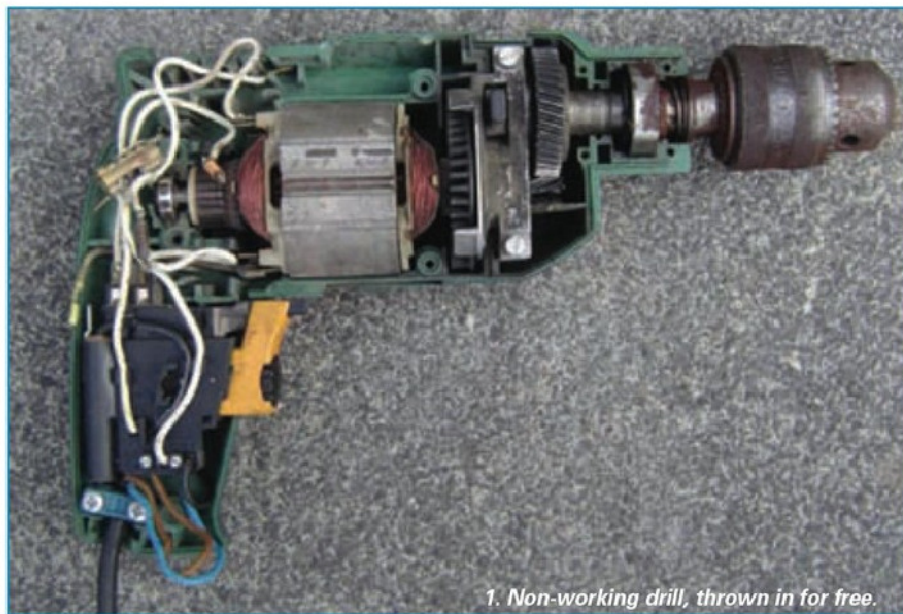
The usefulness of the capstan for hand

rotation was taken a stage further when the box of offcuts produced a M.S. ring 1 $\frac{1}{2}$ in. I.D. and 2 $\frac{1}{2}$ in. O.D. x $\frac{3}{16}$ in. long and the bore, by dint of a watchful angel, was the exact O.D. of the parallel section of the Jacobs type chuck on my Fobco bench drill. Three more M.S. handles 4 $\frac{1}{2}$ in. long x $\frac{3}{16}$ in. dia. were knurled $\frac{3}{16}$ in. in from one end for about 1 $\frac{1}{2}$ in. and the ends radiused. The other ends were threaded $\frac{3}{16}$ in. B.S.F. for $\frac{3}{16}$ in. and the end turned down to $\frac{3}{16}$ in. for $\frac{1}{4}$ in. and beveled, to enable these to pick up the three chuck key holes in the chuck. The ring was likewise drilled and tapped $\frac{3}{16}$ in. B.S.F. on 120deg. spacing round the circumference. When using the drilling machine for tapping holes it is advisable to bolt the item receiving attention to the drill table and to ensure there is clearance for the tap should it penetrate the hole. (Other than a blind hole of course). Again it is advisable to isolate the power source when in use thereby avoiding unnecessary switch-on.

Though somewhat tedious, the drilling machine capstan can also be used for rotating those hole-saws where the lowest drilling machine speed is in excess of the recommended operating speed. Not perhaps a frequent requirement but very helpful when needs must. This attachment, which must be fitted after the tap has been tightened in the chuck, does do away with the juggle of rotating the tap with the chuck key and it does prove very useful where a number of holes in excess of about 6mm. or $\frac{1}{4}$ in. Whit. and above, require threading.



A CHEAP, QUALITY, UNIVERSAL MOTOR SPEED CONTROLLER



1. Non-working drill, thrown in for free.

Background and bargain hunting

Whilst visiting a "Flea Market" I came across an old electric drill. It obviously was not in working order. The wiring had been disconnected, there were no brushes and there was no casing on one side (Photo 1). However the thing that attracted me was the fact that it had an electronic speed control which was operated by the trigger mechanism. It is possible to recognise the fact that a drill has a speed control because it will have a small black wheel set into the trigger switch.

I have an old Unimat SL Lathe which would benefit by having a speed control, and have intended making such a device for a long time but never got round to it. Now here is an item, assuming it is serviceable, that is likely to be cheap, will be well designed, will probably do the job and will save me the effort of designing and building one myself. Since I had bought another item from the stall holder, he agreed to throw the drill in free.

Checking and testing

When I got home I removed the speed controller from the drill, cleaned it up a bit and lashed up a live test. It is fairly easy to see which connections to use. The mains are connected as for the drill and there are only 2 other connections from the unit, both white. The neutral output is connected to a terminal adjacent to the mains neutral connector (straight through connection), the other output is the, controlled, live connection. The test showed that the unit worked perfectly. In use, the speed of the motor is proportional to the distance the trigger is pulled. The maximum distance from off to full on is about 10mm. The mechanism for holding the speed setting on is by means of the little knob set into the trigger and a button at the side which holds the trigger in the ON position. The little knob on the trigger has 8 click (speed)

settings plus the final click which is full speed as if the unit was by-passed. After setting the appropriate click setting the trigger is pulled in and the button on the side of the unit is depressed to hold the switch at the predetermined setting.



2. Modification to backing box

Peter Leggett's money saver.

Mounting and using

I decided to mount the speed controller into a plastic backing box of a 13 Amp mains socket. Obviously a standard sized backing box would be too small but it is possible to buy deeper boxes than the standard type. After careful measurement the backing box was modified by cutting as shown in Photo 2. The sharp bits at the top of the trigger mechanism were also cut and filed smooth. A little bit of trial and error, cutting and filing was required on the inside of the box to make the unit fit. After fitting, a piece of plastic was cut to fit across the inside of the box. This holds the unit tightly to the side and it was then secured in position by silicon mastic. The final product is shown at Photo 3.

The drill that I used was a Bosch with a 450 Watt motor but I should think that any drill having a speed control circuit and adequate power rating will serve the purpose. It is important to remember that the original use was as an integral part of a mains operated electric drill which was double insulated. That means that there was no earth connection. When used with a non double insulated item as I am proposing, it is important to connect a mains lead with an earth connection which must be connected to the earth connection on the plug at one end and the socket at the other, or the motor if it is to be connected direct. The plug should be fitted with a suitable fuse for the power rating. In this case a 3 Amp fuse should be used. The controller can be used with any 230 volt universal motor (motor with brushes) or any direct current load, for example lights or heating, up to 480 watts. It works very well with my Unimat.



3. Completed controller fitted with plug and lead.

Scribe A Line

Ken Thornton writes:

I have recently taken delivery of a set of TIN coated Dormer drills, being 1mm to 6mm in 0.1mm steps, from Greenwood Tools. This new set replaces a previous set of Dormer drills, which are now 20 years old and feeling their age. I am delighted with this new set. I regularly do coordinate drilling on my milling machine and I have always found it very time consuming to change from a centre drill to the final drill for each hole. These new drills do exactly as advertised and drill a true hole without the intervention of a centre drill. I have also used the (Greenwood) Kit-Q-Cut parting tool for some years. I part steel at 630rpm without any of the usual problems of jamming, chattering or digging in. I have no connection with Greenwood Tools other than being a very satisfied customer.

Tom Bartlett writes:

Many screw on chucks suffer from two defects. First the lack of a proper means of removal, (apart from abusing the chuck key or the jaws) and second after prolonged use, changing from three jaw to four jaw and vice versa, the threads become worn losing rigidity. Both of these problems can be addressed by replacing the backplate with one having a larger boss to accommodate two added features.

Brian Wood writes:

Albert Hawkridge asked in Scribe A line (MEW 106) how his late father used a motor stator for use as a demagnetising device. The answer is that the motor housing will have an alternating magnetic field in the rotor space, and by simply drawing the object out of the mouth of the motor housing approximately along the centre line of the unit to about 2 or 3 feet away should be enough to do the business. This makes use of the inverse square law affecting field strength with distance, in that each doubling of distance reduces field strength by a factor of 4. In strongly magnetised objects the effect can be improved by turning it end over end during the withdrawal. One treatment should be enough.

I would recommend that the main field windings are connected to avoid risks of overheating; watches and sensitive things like audio tape should be kept well clear for obvious reasons.

The best way to get such new backplates is to make a pattern, get castings, and machine to suit your lathe. The addition of tommy bar holes will assist with removal, and the question of thread wear can be overcome by incorporating a split tapered threaded bush, adjustable by separate ring nut, and locked by a tapered set screw. This could then be adjusted to give a close fit on the lathe mandrel, assuring continued concentricity over long life.

Mr G. K. Bartlett writes:

While it is perhaps not in our remit to discuss political matters it was good to read your comments on our hyper regulated Society (issue 105) and also comments from other readers. The more people who express views, the better in my opinion, as we are being regulated out of existence. The way things are, I think the general public have been brainwashed to accept anything the power freaks dream up no matter how ill conceived. Re. the electrical regulations and the threats contained therein I think that a lot of practical, people myself, included do their own electrical wiring, not so much to save money but more to minimise disruption. Electrical wiring replacement or modification can be very disruptive and usually needs a lot of remedial redecorating afterwards. I am not

a qualified electrician but most of my working life has been in scientific instrumentation, electronic and mechanical, industrial, hospitals and many years in university depts. This counts for nothing these days and I know the same applies to many people. To be considered a qualified electrician and or gas fitter come plumber requires special vocational courses and one of the main requirements is to know the regulations off by heart, (rather than to understand the underlying theory).

As most of our ilk are somewhat long in the tooth, long since retired and busy in our hobby, who is prepared to spend the time and money to get registered as "acceptable" to took after our own property. I hate electrical wiring; it is damned hard work and I have no desire to do it for anyone else at my age. Last year, however, a very good friend who has done a lot for me since my wife died, had her house rewired by an "approved contractor". Unfortunately almost straight away the circuit breaker on the downstairs ring started intermittently tripping. The contractor was fetched back several times and failed to find the fault. Having many other worries, the lady was really at the end of her tether and I said I would spend a day there and try to sort it. As it happened her son who is an engineering officer on submarines was on leave and as we talked the same language, it was a great help. Although a real strapping chap, he was much more agile than me and able to get in to very awkward places. Fortunately the leakage was measurable on the 2000 Meg ohm range of a digital meter. Having eliminated all appliances, opened up all the sockets and found nothing wrong it was obviously a wiring fault so the options were either open up the ring to eliminate each cable in turn, or try a trick, which consisted of leaving the meter connected and one of us reach under the floor and waggle the cables we could reach while the other watched the meter.

Fortunately the trick worked and we found that a section of the new cable passing through a wall in a hole of more than adequate size was a molten mass and although hidden was easily replaced. I do not blame the contractor and cannot believe the cable was itself faulty nor snagged when fitted but much more likely to have been caught with a blowlamp. As some plumbing was very close I still feel this to be the most likely explanation even though the plumbing work was supposed to have been completed prior to the rewiring.

We have all these regulations forced on us and equipment we buy has to have a CE mark which means little in my opinion but does anyone stop to think about the amount of electrical equipment like TVs and set top boxes which have either external power supplies or transformers which can be left on permanently although the equipment is "switched off". Transformers and switch mode power supplies are very efficient but not 100% so the losses are dissipated as heat.

How much do the losses add up to throughout the country? To avoid this, the choice is add extra switched sockets or a plethora of extension leads. I would never in my working life have considered making equipment, which didn't have a mains side proper on off switch. These days it is almost rare to find this and a lot



Joseph W Jager of Sunderland writes: Re NETTO (Normally Expensive Tools To Order)

Seeing a digital vernier for £9.99 on sale at NETTO prompted an appraisal for a tailstock and carriage DRO for a Boxford AUD. The photos show how a crude but effective use was made of the cheap verniers. Cutting off the hardened jaw was easy using a Dremel type drill and the cutting discs supplied in a Black and Decker accessories set. A micrometer stop was used to fix the head and a simple clamp to the carriage for the bar. Accurate tailstock drilling is now a doddle, all for a total outlay of £19.99.



Cut down caliper used as saddle DRO.



Similar treatment for tailstock readout.

of equipment like radio/cd players have the switch after the power supply so an awful lot of transformers are potentially connected to the grid doing nothing.

Les Pitt writes:

Having just received the April 2005 issue of *Model Engineers' Workshop*. I would like to comment on two of the letters in Scribe a Line. The "tip" suggested by Gert Ravnholt has a built in flaw, namely, if a good, sharp adjustable reamer is used there is the distinct possibility of either leaving ridges on the internal bore or, if the reamer is not tightened enough, slip will result in material being reamed from the bore as turning proceeds. I have actually tried this and I ended with a bore that was oversize and a scrap reamer. I ended up making a simple arbor. It was quicker in the end. The other comment relates to Norman Atkinson's comments on Lignum Vitae. If you find a local bowling club, the crown green type not the ten-pin type, ask if there are any old bowls balls about. The bowls balls are Lignum Vitae and if you are lucky and get a really old one you may find that the white insert is genuine ivory, but don't let the wildlife police know about it or you might end up in court.

Eric Woodley of Stockton-on-Tees writes:

I write in response to Dennis Monk's letter on the subject of 'Screw Threads' *MEW* Issue No. 106. To date I haven't found a more informative publication on this subject than the 'Guide To World Screw Threads' by P.A. Sidders published by Messrs. Industrial Press Inc. ISBN 0-89381-1092-9. Available from U.K. bookshops, usual disclaimer.

If he chooses to purchase this I am sure that he will find much, if not all, of the information that he requires.

Dave Grainger of Melbourne, Australia, writes

Re Care of Ni- Cad cells

During my sojourn with the R.A.F. at Woomera ('62 - '64), I had the responsibility of maintaining the telemetry packs for Bloodhound missiles, and I would like to add a few morsels to the article by Ted Fletcher "Zapping Ni -Cads" (*MEW* issue 106).

They consisted of individual cells linked by plated copper connectors, were packed tightly in containers and were difficult to remove if any had to be replaced. This was because the cells tend to swell a little when fully charged, and thus had to be charged in the pack.

The electrolyte in the nickel-cadmium cell is potassium hydroxide which is highly corrosive and thus the cells have to be sealed. To prevent gassing and possible explosion, the cells must be charged with a constant voltage of 1.46volts per cell. The battery can receive as much current as you can deliver, without damage to the cells, provided the constant voltage is not exceeded.

Unlike lead-acid cells, ni-cads should for the short term, be stored discharged and when wanted for use, should be given 3-4 charge/discharge cycles to bring up to full capacity. This is one of the reasons that the alkaline battery is not used in cars: it is no good as a "float" battery, it needs to be exercised to give its full capacity.

At Woomera, the discharge cycle procedure was to remove all the connectors from the cells and attach a 10 ohm 2 watt resistor across each individual cell. This removes any possibility of reversing the cell's polarity which is mostly caused by storing in a charged state and/or trying to put too much load on the battery, long after the device has given you the message "Hey I'm not well!"

Maybe one of our contributors could come up with a design for a constant

voltage charger that allows one to set the "off load" output volts, and limit the short circuit current commensurate with the capacity of the charger. This might be a boon to radio control fans

Peter Banton of Burton on Trent writes:

I write with reference to the article "Two Heads Better than One?" in Issue 106. Mr. Bells asks for suggestions to make the numbers and divisions easier to read after marking and stamping. The answer is to use engravers wax. This is a hard wax which, I believe comes in several colours although I have only ever used black.

There are two methods by which to use the wax:

- Heat the wax until it is very soft and pliable and then rub into the indentations.
- Heat the metal object until it is hot enough to melt the wax as you rub it on. This method is to be preferred.

In both instances, after applying the wax, leave to cool and then buff and polish the metal. A professional finish is obtained. Note the object to be marked must be scrupulously clean before applying the wax to ensure adhesion.

Mr Ian Dawson of St Leonards on Sea writes:

Re Harold Hall's request in Issue 105 for information about a company that advertised replacement cross slides etc. by chance, when looking for something else, I found the following in *ME* for 7/4/89

"British made vertical slides and boring tables to fit most lathes, vices, rotary tables etc. Prices from £30.00! Phone Ward Engineering 0282 869 262". I have no idea whether the company still exists.

If as I suspect, Mr Hall is contemplating making improvements to the smaller Chinese lathes that are available, can I commend to him the late great Martin Cleaves' articles on fabricating a long tee slotted cross slide and top slide for the EW 2 1/2 inch lathe. Tee slot cross slide: *ME* 8/5/58 & 22/5/58, long top slide to match: *ME* 19/2, 16/4 and 21/5.82. (Edgar Westbury disapproved of the design, so would not publish with the first articles.

As an owner, I can confirm these items are well worth making.

Mr R G Munden of Gloucester writes:

With reference to Mr Norman Atkinson's letter, *MEW* issue 105 on the subject of lignum vitae, he also mentioned Northumbrian pipes. I would be most obliged if he or any other reader could provide me with any details of drawings/plans from British sources for the construction of these bagpipes.

My search has lead me on to the internet, but most sites lead to unfinished works.

Mr John Chambers of Walsall writes:

In a recent issue, you kindly inserted a request on my behalf for any help regarding information on a Viceroy 5in. lathe for an Operators and Workshop manual.

The outcome has been very successful in as much that many readers came to my assistance in various ways, each supplying me with their information or photocopies of the manuals, and so I have now gathered the information required. A number who replied provided useful information, which I am now perusing regarding spare parts or the manufacture of them.

I would like to thank all those who took the time and trouble to help me, including of course the MEW staff.

David Rowland of Crawley writes:

Now come on chaps, there is no substitute for fear. I am referring to Scribe a Line MEW 105 on the subject of leaving chuck keys in the chuck.

When I was beginning my training as a toolmaker, I was assigned to a big, burly, bald turner built like the proverbial brick etc. In his first instruction I was told in no uncertain terms that leaving the key in the chuck was a No! No! In serious engineering, it was just not done. In his deep gruff voice, interjected with expletives, that if I did, the foreman would then be involved, also I would never live it down in the company and finally my mum would be informed.

Now this was all fearsome stuff to a fifteen year old who just a few weeks before had been one of the top dogs in the playground. All this was not very good for the digestive system. Of course it was good psychology because a big industrial lathe can be a dangerous machine, it doesn't jam up like a Mini lathe, it just keeps going.

As a result and after seeing it happen a few times, I cannot physically turn away from a lathe without the chuck key in my left hand, even after 49 years in the trade. May I suggest that if you, heaven forbid, offend, or find yourself weakening, give our editor a phone call. He might be prevailed upon to administer a few growls interjected with threats and a few home truths, which should effect a cure.

Mr C Jamieson of Dundee writes:

It was after reading the articles by Dick Stephen on CNC conversion that a few thoughts came to mind. The final article, which appeared in MEW Issue 104 described a manual control unit which functioned very much as do the electronic handwheels now fitted to industrial CNC machinery. Turning the knob by a specific amount, results in a precisely matching movement of the selected axis.

For many years, model engineers have religiously wound the handles on their milling machines, unless they have either invested in a power traverse system, or built their own such as that described by Mr Douglas Reid in MEW Issue 96. Such systems have tended to require a d.c. motor

with a suitable reduction gear, and a speed control unit, and a suitable power supply.

What now comes to mind is that, with the availability of stepper motors and drivers, and competitive prices, it might now be possible to fit these motors to one or more axes of a manual mill for use as a simple power traverse. Should the user, at some later stage, develop an interest in CNC, then it would be a relatively easy progression, given that part of the mechanical conversion would have already been completed.

What is now needed, for those of us whose knowledge of electronics is rather limited, is guidance on the construction of a power supply, and on the construction of a little black box, which would send suitable signals to a stepper driver, allowing the selection of direction and speed. I am told that this should be relatively easy using a "555" timer circuit.

Perhaps one of our regular contributors

might be prevailed upon to give some thought to these questions and perhaps prepare an article on the topics.

Dave Fenner comments:

On power supplies, I understand that following the successful introduction of stepper motors and drivers to their range, they will be posting circuit information on their website: www.arceurotrade.co.uk.

As regards a little black box, to give stepper signals at variable frequency, this is coincidentally, a subject that was touched upon during a recent telephone conversation with Peter Rawlinson. I believe Peter is now giving this some thought, and I hope to be able to feature the results in a future issue of MEW in the not too distant future.

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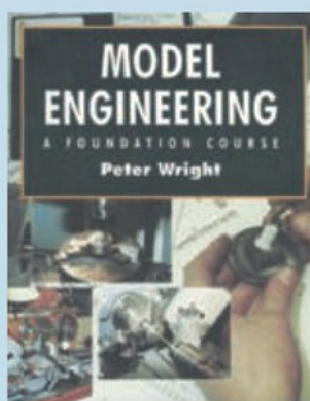
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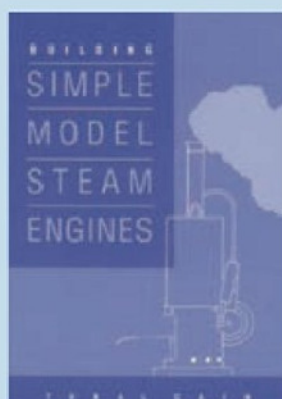
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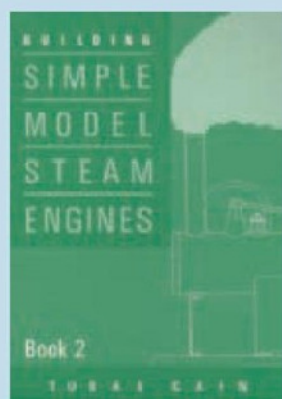
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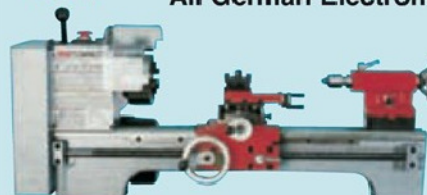
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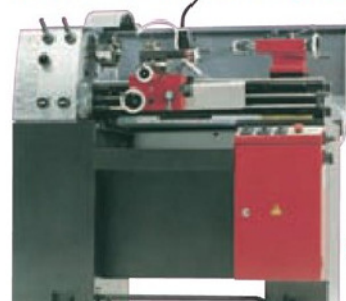
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N5	1/4 x 3/8 - 1/2 - 3/4 - 1	24.65

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P1	3/16 - 1/4 - 5/16 - 3/8 - 7/16 - 1/2	10.25
P2	5/8 - 3/4 - 1	17.70

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Q1	1/8 - 5/32 - 3/16 - 1/4	09.45
Q2	5/16 - 3/8 - 7/16	24.00

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S1	3/32 - 1/8 - 5/32 - 3/16 - 7/32 - 1/4 - 9/32 - 5/16 - 3/8 - 7/16 - 1/2	20.40
S2	3mm - 4mm - 5mm - 6mm - 7mm - 8mm - 9mm - 10mm - 12mm	18.00

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R1	1/8 x 1/2 - 1/8 x 1 - 1/4 x 1/2 - 1/4 x 1 - 1/4 x 1.1/2 - 1/4 x 2	14.28
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5"G	Butch	0-6-0	3.1/2"G	Petrolea	2-4-0
5"G	Chub	0-4-0	3.1/2"G	Iris	0-6-0
5"G	Simplex	0-6-0	3.1/2"G	Doris	4-6-0
5"G	Springbok	4-6-0	3.1/2"G	Rainhill	0-2-2
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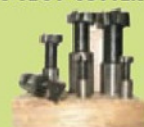
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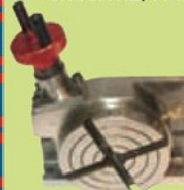
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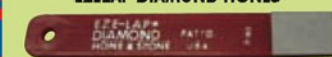
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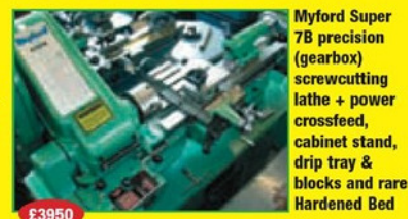
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DRILLING CAPACITY	25MM
END MILLING CAPACITY	25MM
FACE MILLING CAPACITY	65MM
TABLE WORKING SURFACE	190X585MM
MOTOR	1HP
SUPPLY	240VOLT
NET WEIGHT	200KGS

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NVR SWITCH GEAR
INTERLOCKED CHUCK GUARD
MANUAL & PARTS LIST

SPECIFICATIONS

DRILLING CAPACITY	32MM
END MILLING CAPACITY	20MM
FACE MILLING CAPACITY	76MM
TABLE WORKING SURFACE	730X210MM
MOTOR	1.1KW 1.5HP
SUPPLY	240VOLT
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DRAWBAR (M12 THREAD)
NVR SWITCH
INTERLOCKED CHUCK GUARD
MANUAL & PARTS LIST

SPECIFICATIONS

DRILLING CAPACITY	32MM
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MOTOR	1HP
SUPPLY	240V
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