

No. 109

OCTOBER 2005

MODEL ENGINEERS' WORKSHOP

THE PRACTICAL HOBBY MAGAZINE

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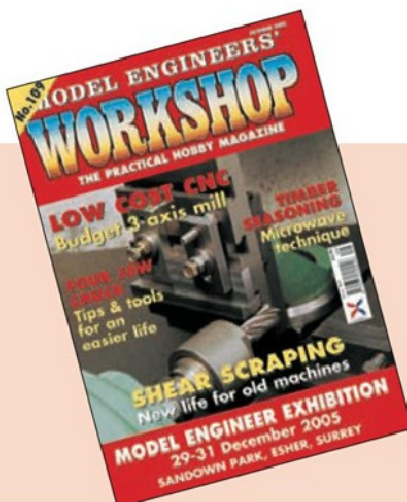
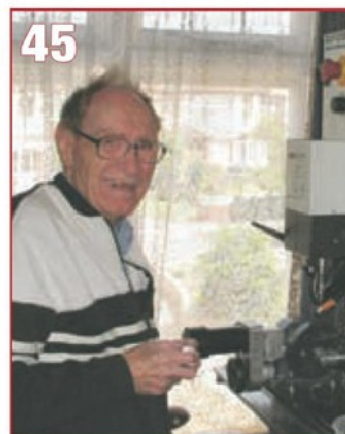
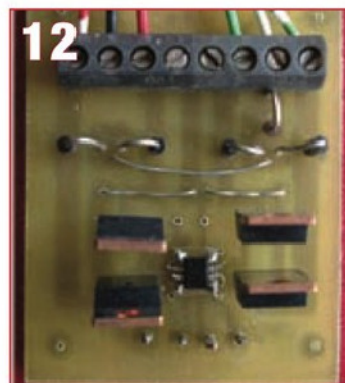
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On the Cover

Milling in the lathe requires sharp cutters. On page 17, Harold Hall describes a grinding rest, ideal for milling cutters and other tools.

See page 56 for our special subscription offer!

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18. SLOT DRILL SET (THREADED SHANK) [1/16, 1/8, 1/4, 3/8, 1/2, 5/8, 3/4] or (m/m) 3, 4, 5, 6, 7, 8, 10, 12 m/m]
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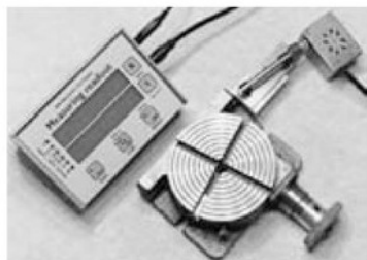
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These films are good instructional aids - not only do you have your tutor there, on your TV, you can interrupt, go back over points and generally take the whole thing in at your speed, as and when you like. Rudy was American, and so are the techniques shown, but in the few instances where practice differs, it is covered in the tape. Rudy was no professional "on screen" performer, just an ordinary model engineer, but his presentation is all the more acceptable for that. These films really were shot in Rudy's workshop, which produced some problems, and a few "warts" are visible, despite attempts to eradicate them. Don't buy these tapes if you are experienced and know all about the operations involved - the *Fundamentals* lathe tape in particular is aimed at the raw beginner. And please don't expect them to turn you into an expert in a couple of hours, but they will give you a solid understanding of the operations involved.

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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

SILVER STEEL 1 X 13" OF EACH

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
R2	3/8 x 1/2 - 3/8 x 1 - 3/8 x 1.1/2	11.87
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R4	1/2 x 2.1/2 - 1/2 x 3	21.15

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5"NG	Dholpur	2-8-4	3.1/2"G	Cant. Lamb	0-4-0
5"G	Butch	0-6-0	3.1/2"G	Petrolea	2-4-0
5"G	Chub	0-4-0	3.1/2"G	Iris	0-6-0
5"G	Simplex	0-6-0	3.1/2"G	Doris	4-6-0
5"G	Springbok	4-6-0	3.1/2"G	Rainhill	0-2-2
5"G	King John	4-6-0	3.1/2"G	Heilan Lass.	4-6-2
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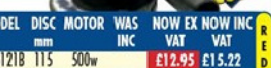


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Spindle Taper
Diameter of Spindle
Diameter of Column
Throat

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455mm
145mm
90mm
3MT
63.5mm
66.65mm
165mm

Max distance
spindle to table

320mm

Height with head at top
of column
Width
Depth
Spindle speeds
Motor
Weight
Head tilting

1067mm
775mm
559mm
400-1640
1 phase 1/2hp with F/R switch
295lb
90-90 worm gear tilt mechanism

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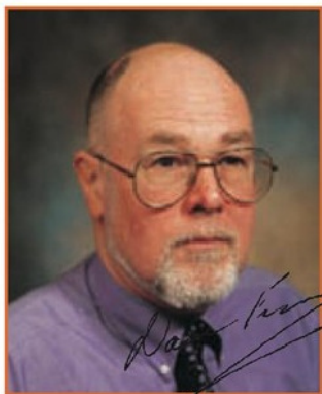


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Northern Showroom

It is always gratifying when, after making an introduction, the two parties progress to a constructive relationship. A couple of years ago at the Donington Exhibition, I was able to arrange a meeting between George Newton, of Newton Tesla, and Roger Warren, of Warco. This lead very quickly to an arrangement, by which Newton Tesla would supply inverter drives tailored for a number of Warco machines.

One of the difficulties for prospective Warco customers in the north, who want to see and touch before buying, has been the long distance to the showroom at Chiddingfold, in Surrey. To address this, Warco has teamed up with Newton Tesla, to open a new showroom, stocked with almost all of the machine range, in Warrington, immediately adjacent to the Newton Tesla complex, just five minutes from the M62. On arrival, customers should go to the main reception, from where George Newton or one of his colleagues will take them to the new showroom.

Orders will be despatched from the main works, which will also continue to handle telephone sales, spares, and despatch enquiries.

More Data from Colin Usher

In his article elsewhere in this issue, Chris. Fouweather pays tribute to the utilities software developed by Alan J. Munday. Colin Usher has been in touch to advise that Alan has been busy again and has produced a package for easy access to thread data. It's available on Colin's website. Apologies to Colin, but I can never remember the correct website address, however, using Google and searching UK pages for Colin Usher always gets there very quickly.

From Paper Engines to Paper Cars

During and after the 39-45 war, the Merlin engine was affectionately known within Rolls-Royce as the "Paper Engine" since the weight of paperwork massively outweighed the engine. Are we heading for a similar situation concerning motor vehicles? Not long ago, a motor enthusiast

ON THE EDITOR'S BENCH

friend phoned me, concerned by a rumour that there was a July 1st deadline for changing to new format registration documents, with the threat of an £80 penalty for non compliance. It seems that he was right regarding the deadline, (after which the existing V5 has no validity) but no information has come to light about a penalty (yet), although the possession tax still looms. Not so many years ago, one log book was issued for a vehicle, and that single document stayed with the vehicle throughout its life, via the various owners, providing a useful potted history. We then moved to the one page V5, (replaced for each change of owner or address or specification) which is now replaced by the two page V5C. In addition, further unnecessary paperwork and postage costs (not to mention penalties) are generated by the SORN system. No doubt this is all worthwhile job creation.

It is interesting that the rumour of an unannounced penalty charge did not surprise any of the people contacted. Motor/motorcycle/motorsport enthusiasts are all too often an easy and compliant target for yet more stealth taxes. If French farmers were the prey, DVLA would be rapidly submerged under a vast pile of steaming dung.

And then the Workshop Police?

I am told that some bright spark in Whitehall has come up with the idea that workshop machinery should be registered in much the same way as cars. Apparently this has been set off by worries that decommissioned or replica firearms could be turned into active weapons. (Presumably by an army of disaffected octogenarians) If so, then this would have serious implications for all model engineers. All such schemes cost massive amounts of money to set up and administer, so who pays, and how much? What machines should be covered? To be properly effective, it would have to cover every Black and Decker drill, since with attachments and ingenuity, even these can be converted to operate as precision lathes. An email query on this to a government contact is at the time of writing still, after several weeks, unanswered.

This looks like yet another hair brained idea spawned by a civil service bureaucrat, probably holding an Oxbridge "first" (history, arts, or political science?) but with zero qualifications as regards practical life experience; clearly not enough to do and too much time to think (but without the attention span to properly think through). For my money, because of

the growing numbers of metal detectors, the future threat in unauthorised firearms will come, not from reactivated replicas, but from new high tech designs using ceramics, carbon fibre and advanced plastics. Thinking laterally in terms of weapons of modest destruction, just consider the possibilities open to any anti-social teenager with radio controlled plane and a box of fireworks.

Midlands Model Engineering Exhibition

Now in its 28th year, this highly respected show moves from the previous site at Donington to the Warwickshire Exhibition Centre at Leamington Spa. One exhibit, which will be of particular interest to MEW readers, is the "The George Thomas Tribute". Through the efforts of Bob Studer, Bill Bennett, and Neil Hemingway, a complete collection of the GHT creations will be assembled, mainly showing the builder's own prototype examples. In addition, his own Myford lathe complete with attachments, and his Union tool and cutter grinder will be shown.

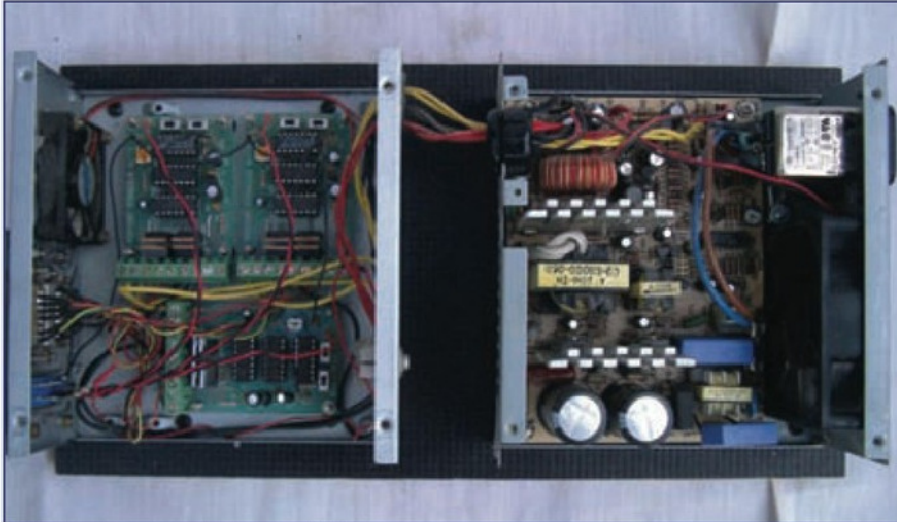
Other displays, which will appeal to those, whose interests are less oriented towards steam power include clocks, a section devoted to i.c. engines, and another to gas turbines. It is understood that this may be the last opportunity to see the Gerald Smith collection of i.c. engines as a complete entity, as it is likely to be offered for auction later in the year. More information will be found in the pull out supplement in the centre of this issue.

75th Model Engineer Exhibition

Later in this issue, you will find the entry form for the exhibition. Established in 1907, this will be the 75th in the series, and will again take place at Sandown Park.

While support for the show in terms of quantity and quality of models grows consistently year on year, the number of items appearing in the Workshop Equipment classes forms a relatively small proportion. As before, I would emphasise that such devices are welcome even (or perhaps particularly) when they are clearly produced with function in mind, rather than to "exhibition finish". Again, for those unwilling to step into the competition arena, entries in the Loan category are equally very welcome. Novel ideas or their unusual execution, on show at exhibitions, are just the catalysts to spur others on to further endeavours.

CNC FOR FREE (well almost)



1. Power supply and stepper drivers.

Background

Many model engineers will have considered CNC but are put off either by the cost, the complexity, the learning curve or a combination of all three. I was one of them but about a year ago, Dave, a friend of mine, persuaded me that we ought to have a go. At the time I did not expect to have any personal requirements for such a facility, as most of the things I make are one off's. I then began to think I had missed the point, as whilst the industrial requirement is for the rapid production of many of the same item, a CNC machine will allow the amateur to make things which he cannot do easily by manual methods e.g. 3D machining.

One thing I must stress is I have no professional experience in this field but I hope to record our trials and tribulations. The result is a small machine capable of milling a 6x6x2in. cube. The whole thing was built from the scrap box with the exception of a few sintered bushes and some of the electronics. It is not state of the art, fast or big but it does allow one to draw a part in a drawing package and machine the result. It is eminently scaleable to suit your requirements and the principles could be applied to a lathe or spark erosion tool. The total investment in the project was less than £50 (this is not a mistake).

The complete CNC package

The basic principles have been set out on a few occasions in MEW but I will briefly touch on the important elements. Many

high end systems use closed loop control employing servo motors with encoders for speed and accuracy but they are outside the scope of this article, which will concentrate on stepper motors. In order to make a complete CNC system you need the following elements

1. A drawing package (CAD), unless you propose to write code instructions manually. (This is quite feasible but can be time consuming for more complex parts)
2. Some means of converting the drawing to a language that the CNC machine understands. This is normally a DXF to G code converter but there are many other variations, e.g. HPGL, on which CompuCut, is based.
3. Ideally, a means of simulating your tool paths without cutting any metal. Without this, you would first have to do a dummy run, either cutting air or perhaps a piece of MDF or plastic.
4. A program to drive the stepper motors from the G code.
5. The electronics to drive the stepper motors. Some of the commercial packages combine functions 2,3 and 4
6. A power supply to drive the motors and electronics.
7. A computer with a parallel port.

1. CAD

This is just the drawing package element, which could be either 2D or 3D. The good news is that there is a number of free 2D

Chris Fouweather describes his low budget approach to multi axis CNC machining

drawing packages available for download on the internet. Some of these are detailed in reference 1. Having drawn your part you normally save the result as a DXF file, which appears to be the most popular file format for the next step. Possibly one of the easiest packages to learn is Autoshetch, which is sometimes given away free with computer magazines. Learning a CAD package can be time consuming but it is essential to make any progress. If you already have a drawing package, which can output DXF files you are in business.

2. DXF to G code converter

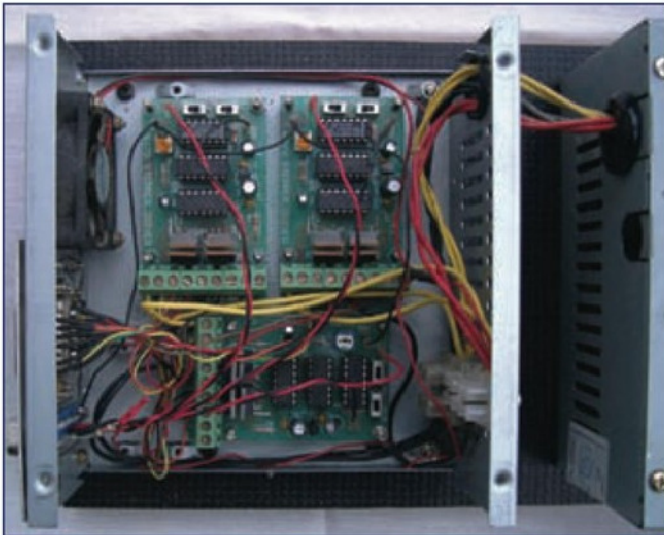
As with all programs for CNC these packages can be anything from free to thousands of pounds. One very simple free Windows program is Ace Converter (reference 2) which whilst only suitable for 2D work is perfectly adequate for our purposes. A description of the various standard G codes is included in an article on CNC by Peter Rawlinson in MEW 69. It should also be pointed out that it is not too difficult to write G code instructions in Windows Notepad. Dick Stephens has described the Desk CNC and Deskam software in various articles in MEW.

3. Simulation

It is fair to say that most of the expensive packages will have some form of simulation facility built in but there is a free download. (reference 3)

4. Software drivers

There is a big issue over whether these drivers should run in Windows or DOS. This is not the place to start a war. If you intend to run your program on an older cheap lap top or office cast off, in keeping with the overall cost of this project, then DOS is probably a pre-requisite. If however you purchase some Windows software then the chances are you will be purchasing a computer (preferably a laptop for the convenience) with a processor speed of over 1Ghz. For the present I have used the free downloadable version of TURBOCNC (reference 4) which, so far as I can see, does everything that a model engineer could ask, on more axes than his brain could handle and with enough speed to satisfy the most demanding. Its only disadvantage is that it runs in DOS.



2. Detail of enclosure with three drivers.



3. Connector sockets on driver box.

5. Electronics to drive the Stepper motors

Stepper Motors can be either bipolar, unipolar or hybrid and this has a bearing on your electronics. Generally bipolar motors are more powerful than unipolar ones for the same size and the hybrid motors can be run in either configuration. As surplus motors are cheaper than new it may be necessary to work with what you have.

In simplistic terms the electronic circuitry to drive unipolar motors is much easier than that for bipolar motors especially when combined with a cheap microprocessor. One further complication is stepper motors are generally not run at their marked voltage and current ratings. Their speed and torque characteristics are improved by running them at elevated voltages considerably higher than the rated figure. In consequence you either have to add dropper resistors or use pulse width modulation (PWM). Dropper resistors generate heat, wasting energy but PWM costs more. A simple controller using dropper resistors, which should be adequate for many purposes, may be obtained from reference 5, below. One further enhancement is micro-stepping which allows a 200 step motor to work with up to 1600 steps or in some cases even higher. It will complicate this article too much to go into micro-stepping but suffice to say it does have advantages but with a financial cost. I do include references to home made micro-stepper systems (reference 6) but I have no experience of their use. Other alternatives are available, such as the commercial ready made or kit (reference 5) and a complete DIY project (reference 7). In reality there is not much difference in price between any of them unless you happen to have a big electronic scrap box. The commercial version comes out at about £11 in kit form with the advantage of an onboard pulse generator, which allows you to test the steppers and the mechanical aspects without using the computer. **Photo 1** shows the completed commercial stepper motor drives with a computer power supply and a closer view of the driver

electronics is given in

Photo 2. The connections to the computer and stepper motors can be seen in **Photo 3.** A single DIY stepper motor driver is shown in **Photo 4.** There is not much to it just 4 mosfets, 5 diodes and a microprocessor. It is a good idea to have separate leads to each motor to avoid any cross talk between each lead.

6. Power supplies

Most amateurs seem to use computer supplies for a 12v and 5v supply. We paid a visit to the local computer shop and came away with 9 for absolutely nothing. Only four worked but by stripping out the electronics from the duds you have a perfect box for the electronics, which matches the power supply and contains a fan to cool the control mosfets. We also used one working power supply for the dc spindle motor drive. The completed electronics and power supply can be seen in **Photo 1.** There can be a problem with them however in that some do not put out the full 12v unless the 5v supply is loaded with a resistor. Full details on conversion can be found here (reference 8). Even if you have to purchase a computer power supply they are inexpensive from CPC (reference 9) or a computer fair. Conventional transformer power supplies at the currents we are considering can be expensive.

I would add that unless you are confident of your soldering capabilities you should not venture inside the box as they are switched mode supplies with the full mains voltage on the board. One further issue is that because they are switched mode supplies you have to start the milling spindle motor from zero current otherwise the supply trips out. You cannot just switch on the motor to full power. No problems have been experienced with the stepper motors. One further source of a cheap power supply is a large current battery charger but because they contain a conventional transformer, they are considerably larger, and will need a big smoothing capacitor of something like 5000uf. The 5v supply for the electronics can also be produced by using a 5v regulator such as a 7805 or a dc/dc converter.

Other software

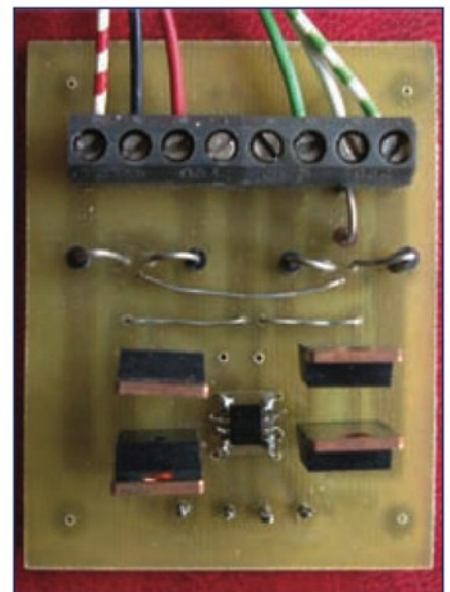
It is truly amazing the amount of free software available for legitimate downloading including AutoEditNC which is a Windows program to assist in the creation and testing of Numerical Control programs in the G and M code format (M code covers items such as end of program, pause, etc. It is a specialised text editor with NC code creation tools. It will simulate the movement of the machine tool so that you can test your program. Download from

www.betatechnical.com/autonc.htm

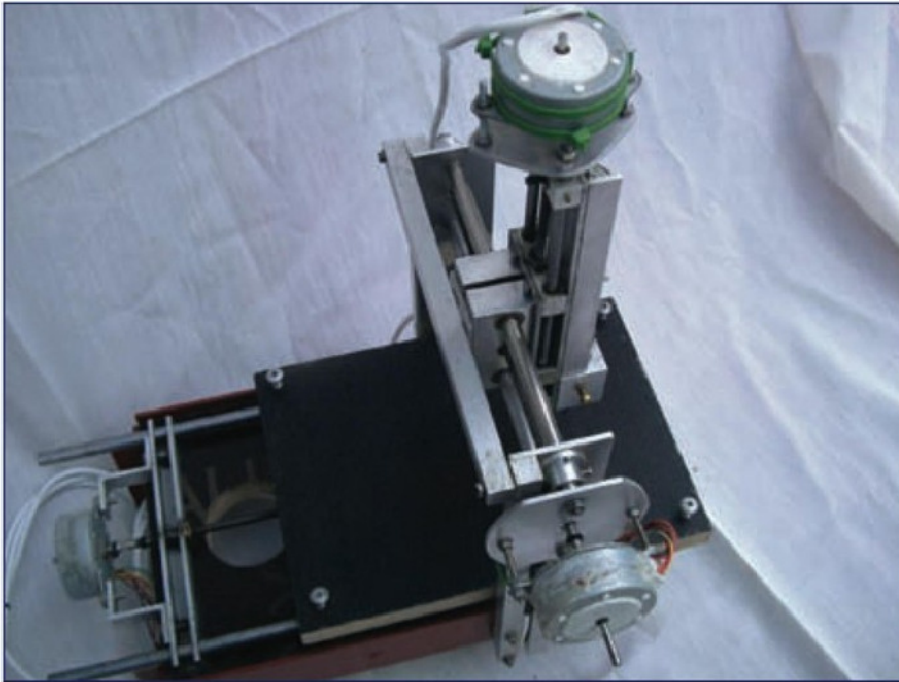
Another potentially useful program allows the conversion of drawings to vectors and hence enable you to convert your drawings into a form with which the CNC machine can operate. See Reference 10. Software to convert grey scale bit maps to G code allows you to engrave photographic images. See Reference 11

The milling machine

At the start of this project we had no real idea whether any of this would work but in any event my friend only wanted a small machine for engraving and milling aluminium. Most home grown machines



4. A single DIY stepper driver.



5. Completed machine, viewed from above.

of this size tend to use commercially available rotary tools such as a Dremel or its cheaper clones. This did not seem a good idea, as the bearings in many of them are not designed for side loads. They are also large which significantly increases the overall height. To that end I built a small ball raced spindle driven by a toothed belt and machined the nose to take collets from a rotary tool. The motor used was a 150 watt DC model motor (speed 600) which is available from most model shops.

I was pleasantly surprised at the run out on a 3mm tool but I suspect that that is just luck. A better solution would be to machine the nose for ER16 collets which are starting to drop in price. Also as my friend is as frugal as I am, he salvaged several scrap printers containing 48 step unipolar motors. At a first inspection they did not look too impressive but on connecting them up to the driver they looked viable. In conjunction with a 1mm pitch lead screw the minimum movement on the table is about 0.0008in. per step, which seemed more than adequate for a first try. Despite their humble nature these motors have remained in place for a year before the acquisition of something more suitable via EBAY. However I cannot really recommend their use.

Construction

Initially I found a commercial product based on flat mild steel sections and attempted to copy it, but it was not long before I discovered the dreaded stick slip and the idea was abandoned. The resultant machine is based on sliding circular slides with bronze bushes. It is not ideal but it does enable you to make it fairly accurately by boring all the duplicate parts in a conventional milling machine using stops at each end. I do not propose to give a blow by blow account as its construction is self evident from **Photos 5-6**. All of the motion screws are 6mm x1mm pitch in bronze nuts which should have had backlash compensation

but the desire to see it work overtook us, and I am only now in the process of making the anti-backlash nuts. A selection of jobs for illustrative purposes is shown in **Photo 7** – a 3D male mould for a propeller, a knob, **Photo 8** which Dave insisted on making on the miller rather than get me to make a form tool, a stencil, **Photo 9**. The stencil is supposed to generate the outline of a dove but some detail was lost because the cutter used was too large.

The commercial stepper drivers referred to above are rated at 6amp. but I would be fairly certain that with this



6. Front view of machine, clearly showing gantry arrangement.

current draw they would require heat sinks on the mosfets. I have driven them at 2.5amp. without any sign of heating. You should check carefully if you are running at higher currents. Remember with unipolar stepper motors it is each phase which draws the motor current and at rest a 1amp motor would draw 2amp as two phases are energised. One thing I did not realise is that all stepper motors generate a considerable amount



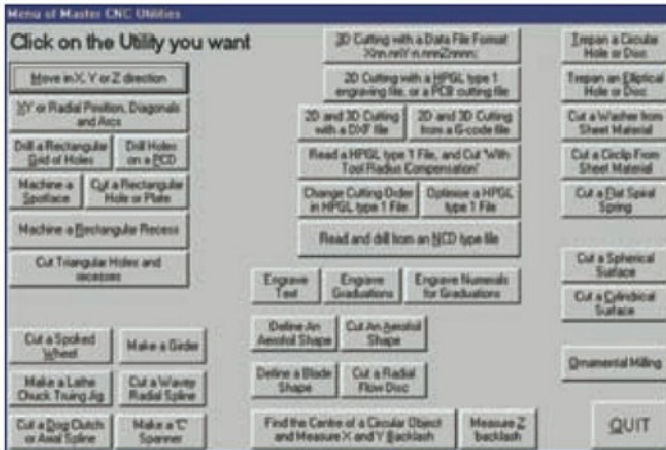
7. A mould for a propeller.



8. A small knob, (to prove we could, but which might have been more quickly made on the lathe).



9. Stencil milled from sheet.



10. Menu screenshot from Master Utilities

of heat. The conventional wisdom is that if you can hold one without discomfort they are ok.

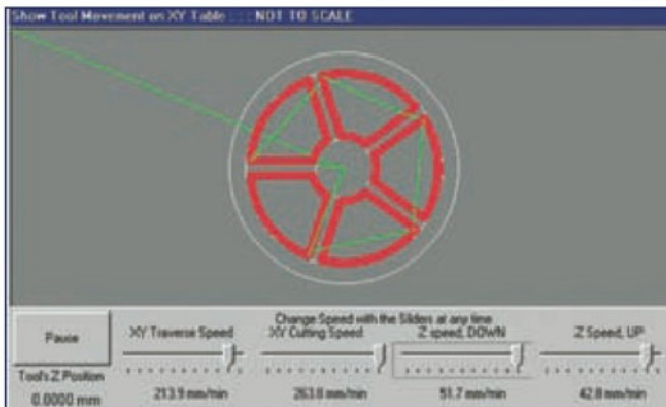
One thing I would strongly recommend is to make the gantry arrangement adjustable so that the final step would be to place a box angle plate on the table and clock all three axes. I seem to recall that the late George Thomas had a box angle plate, which he had purchased and did not find it useful. For setting up three axis milling machines it is close to perfect. Once alignment had been obtained a few dowel pins stopped everything moving.

One further item I found useful was a structural adhesive. Most of the gantry is constructed from aluminium. In itself it was probably not strong enough or did not have enough mass to damp vibrations. I therefore made extensive use of Loctite 330 multibond structural adhesive to add further aluminium sections, which were drilled through and bolted when dry. It was a good use for a whole load of surplus aluminium bar I had in the scrap box.

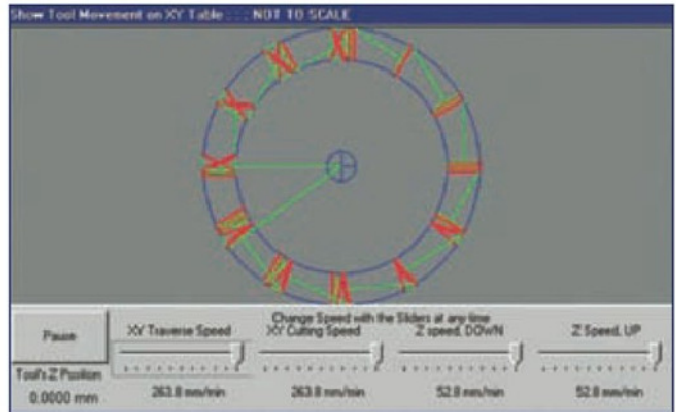
I am so impressed with Dave's machine I am in the process of making one for myself. In the light of experience, I will use linear bearings but other than that, the overall design will remain the same.

Master Utilities Program - Reference 14

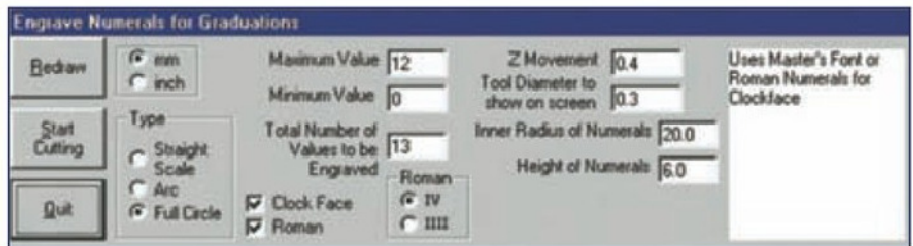
Just as I start to finish this article I have come across the software utilities (Master) of Alan Munday. In the first form I saw it (version 9) it was remarkable but



13. Toolpath for crossing out wheel.



11. Toolpath for clock numerals.



12. Menu for clock face numerals.

in the latest version it is exceptional. This is how software should be. It runs in Windows and has an opening menu with a whole load of canned cycles which demonstrates that he put a great deal of thought and time into the project. Where else would you find the parameters for milling a clock face with a few mouse clicks? It even allows you to see the simulation on screen. In its latest version it even imports DXF and G code files directly. At present it does not have offsets for the tool but that can be taken care of in the drawing. A fine piece of work. I think on my Mk 2 milling machine I will set up the stepper interface such that it is ready for the Master program. TURBOCNC can be configured in software such that it will work with almost any of the output connections to the parallel port. Thus I can use the same interface for any program. The entry menu of the program is shown in Photo 10. To demonstrate its versatility I have reproduced screen shots of a few of the canned cycles including engraving a clock face Photo 11, with its menu Photo 12, a crossed out clock? wheel Photo 13 and a "C" spanner Photo 14.

Connections for master program

Printer Port pin usage is:-

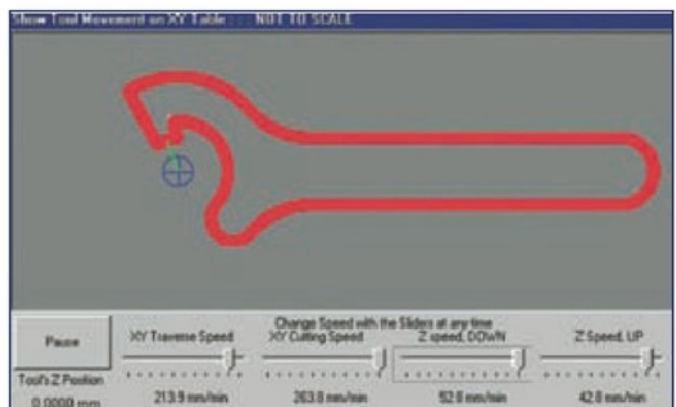
OUTPUTS: pin 4= X direction, pin 5= X clock, pin 6= Y direction, pin 7= Y clock, pin 8= Z direction, pin 9= Z clock.

INPUTS: The program responds to the total change in input, not to pins individually, so any of the input pins 10, 11, 12, 13 can be used for X, Y, Z end-stops and an Emergency Stop Switch.

Consequently, DO NOT HAVE ANY STOP SWITCHES ENGAGED WHEN YOU START THE PROGRAM.

All of the connections refer to a standard parallel port connected to the stepper interface via a 25 pin to 36pin printer cable. At the printer connection end (i.e. the 36 pin) pins 33,14-30 are connected to each other and the 0v ground of the stepper motor electronics and also the power supply ground.

It should also be pointed out that computer parallel ports are somewhat delicate in electrical terms and not designed to drive large currents. Before connecting up double check all wiring. It is not that difficult as there are only two



14. Toolpath for "C" spanner.

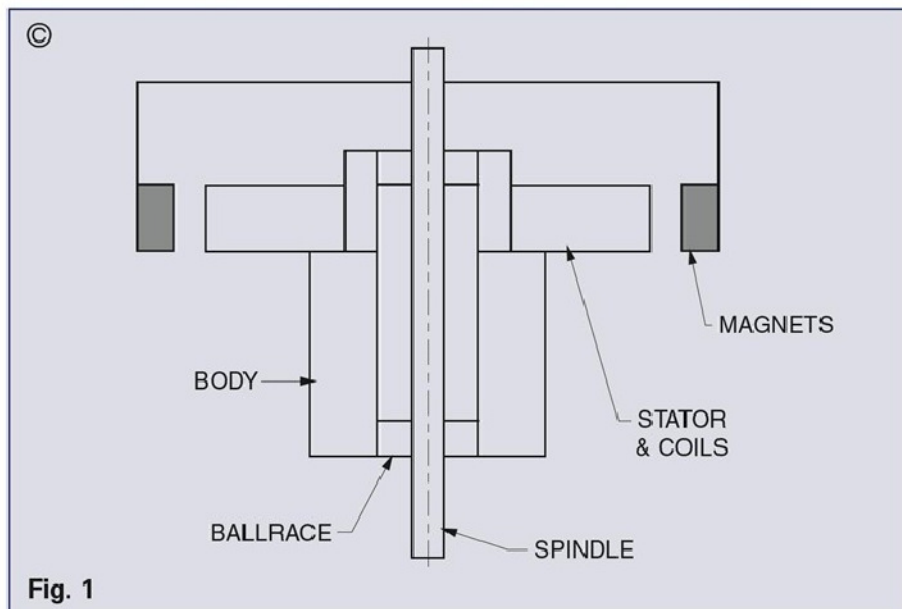


Fig. 1

wires for each axis together with the ground connection. One tip is that both the 25 and 36 connectors normally have the pins marked in the moulding. You might need a glass to see them, as they are frequently very small.

The next machine

We have been more than impressed with our first efforts so the 48step scrap yard motors are being replaced by some new NEMA 23 motors acquired on Ebay at a knock down price and I am in the process of building a slightly bigger machine for my own use. As the principles are proved it will have round linear bearings but will retain the gantry arrangement, as it is easy to make a rigid machine.

One of the reasons I have made reference to more than one program source is I find that I click with some packages but struggle on others. With a range of shareware you have a reasonable chance of alighting on something you can comprehend. One thing I am proposing is to drive the new machine spindle from a brushless motor. In recent years aeromodellers have been flying their planes using motors made from discarded computer CDROM drives. They are 3 phase brushless motors, which can be rewound to give more power when combined with Neodymium boron magnets. A single CDROM is only good for about 50 watts but if you stack the stators together you can utilise more power. However for our application the best source of suitable stators will be old angle grinders or similar brushed ac universal motors. The intention is to mount the stators on the top of the milling spindle with the magnets rotating and attached to the spindle itself. Do not dismiss this as a model toy as modellers have produced motors well over 1000 watts. You can purchase brushless controllers for 20v and 100+ amps. There is a tutorial for winding - reference 12 and winding schemes for various numbers of stators - reference 13. A diagram to illustrate my idea is reproduced in Figure 1. If you do not want the hassle of rewinding and machining you can purchase brushless motors via normal

model outlets and drive the spindle via a toothed belt or pulley. One of the advantages of winding your own brushless motor is that you can tune it for speed or torque depending upon your requirements.

It is self evident that all of the ideas outlined here can be used for say a wheel cutting engine, rotary table or spark erosion. Turbo CNC has the ability to run 8 stepper motor drives so bring on the Octapod.

CNC is here to stay and we need to learn with something that is cheap to build. The principles outlined will work with almost any machine. As time progresses and you outgrow its limitations you can update individual bits. Very few of us need speed so you can stay with steppers. If you need greater accuracy and repeatability upgrade to ball screws but be prepared for a shock. Linear bearings are nice but take a chair if you are going to get a quote from the bearing shop. The individual bearings are expensive whilst complete assemblies are unbelievable. You could buy a complete X3 milling machine for less than the cost of the linear slides. One piece of advice given on an American site is to finish the machine completely before you fire it up from the computer. It is so mesmerising to see all three axes running under computer control that I can see his point.

Conclusion

The result is not fast, particularly accurate or pretty but the principles can be applied to any machine tool you may choose to convert. It did not seem wise to try to make something much larger without first having convinced ourselves of the viability of CNC in the home workshop. £50 is a lot less than the cheapest CNC machine at say £2000 and we have learned a great deal. Once the basics have been mastered we can move on to something bigger, smaller, more sophisticated? I do feel somewhat embarrassed writing this article having seen some of the superb machines described in MEW but until we came down to make one you do not realise where to start. Hopefully others may make speedier progress.

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<http://www.cadadvance.com/65form.htm>
http://www.givempower.de/FelixCADIt_promo.html
<http://users.pandora.be/desi-iii/>

REFERENCE 2

Ace Converter
www.yeagerautomation.com/ace.htm

REFERENCE 3

<http://www.cncsimulator.com>

REFERENCE 4

TURBOCNC
www.dakeng.com/turbo.html

REFERENCE 5

Stepper motor drivers (kits and ready made)
www.quasarelectronics.com

Kits £8.47 each 1-4 £7.20 each 5+
 Ready made £14.43 each 1-4 £12.26 each 5+, a clear case for a joint project with a friend.

REFERENCE 6

<http://pminmo.com>

REFERENCE 7

DIY stepper driver
<http://aeropic.free.fr/indexenglish.htm>
 Look under CNC cutting, then IF stepping

REFERENCE 8

MODIFYING A COMPUTER POWER SUPPLY
<http://home.cogeco.ca/~rpaisley4/ATpsu.html>
<http://www.bavaria-direct.co.za/models/gadgets/psu.htm>

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CPC Faraday House, Fulwood Preston, Lancs, PR2 9PP Tel 08701 214377
www.cpc.co.uk

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THE LATHE ONLY WORKSHOP 2

In this, the second of the series, Harold Hall describes a Simple Grinding Rest

In the introduction to this series in the last issue I stressed that attempting to carry out milling on the lathe with blunt cutters was not to be recommended, due to the additional load this places on the relatively light weight machinery. Because of this, it seems sensible to start the constructional items with a device for sharpening, end mills.

Fully sharpening an end mill though, demands quite complex equipment and most workshops get by, using much simpler methods, or alternatively have their cutters sharpened professionally. The basic rest described in this article will though give good results when sharpening the end teeth and having done this, the user will find an appreciable improvement in the cutter's performance, particularly when surfacing. Sharpening the sides is really a task for a fully fledged cutter grinder, but some simpler methods do achieve acceptable results. You could consider adding to the rest the accessory (Ref.1) I developed for a much more involved rest.

Having emphasised the application to end mills, I should add that the rest would be of considerable help in sharpening many items of workshop equipment from screwdrivers to the more complex items such as lathe tools.

Common design feature

A common feature on many grinding rests, both commercial and those for construction in the home workshop, is the



1. Three typical grinding rests, two commercial, one made in the workshop.

method of adjusting the angle and distance to the wheel. This invariably consists of a link, or links, pivoted at both the base and the rest's table. **Photo 1** shows two commercial rests, together with the Hart design that was available for many years for home workshop construction. All exhibit this design approach.

Whilst this concept is very versatile, in use it is more demanding to set up than would first appear to be the case. Primarily, the lower pivot adjusts the distance to the wheel and the upper pivot the angle to the wheel. However, it will be obvious that each will have an effect on the setting of the other. Initial set up is therefore a case of trial and error, a case of set distance, set the angle, reset distance, reset the angle, and repeat until the desired result is obtained.

Problem overcome

The method of overcoming this situation adopted in this article is to make the

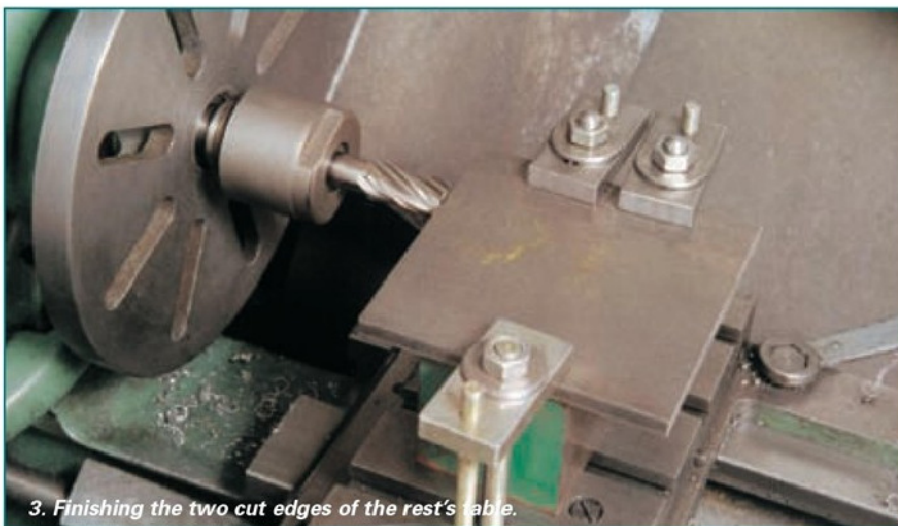
method of setting the distance to the wheel a linear one rather than angular. This should be obvious from the drawings and **Photo 2**. All these rests, attempt to overcome many of the disadvantages of totally free hand sharpening without the complexity and cost of a tool and cutter grinder. A few examples of how this is achieved are given at the end of the article

Manufacture

This item is ideally suited to being made using a lathe and vertical slide and is a good starter item to gain experience in working methods. Much of the work is very similar so it will be worthwhile working on many of the items in parallel rather than one at a time. It will though be necessary before you commence work on the item to decide whether the height of the rest as drawn will suit the grinder with which it is to be used. In my case it is being used with a 150 mm grinder having



2. The completed rest.



3. Finishing the two cut edges of the rest's table.

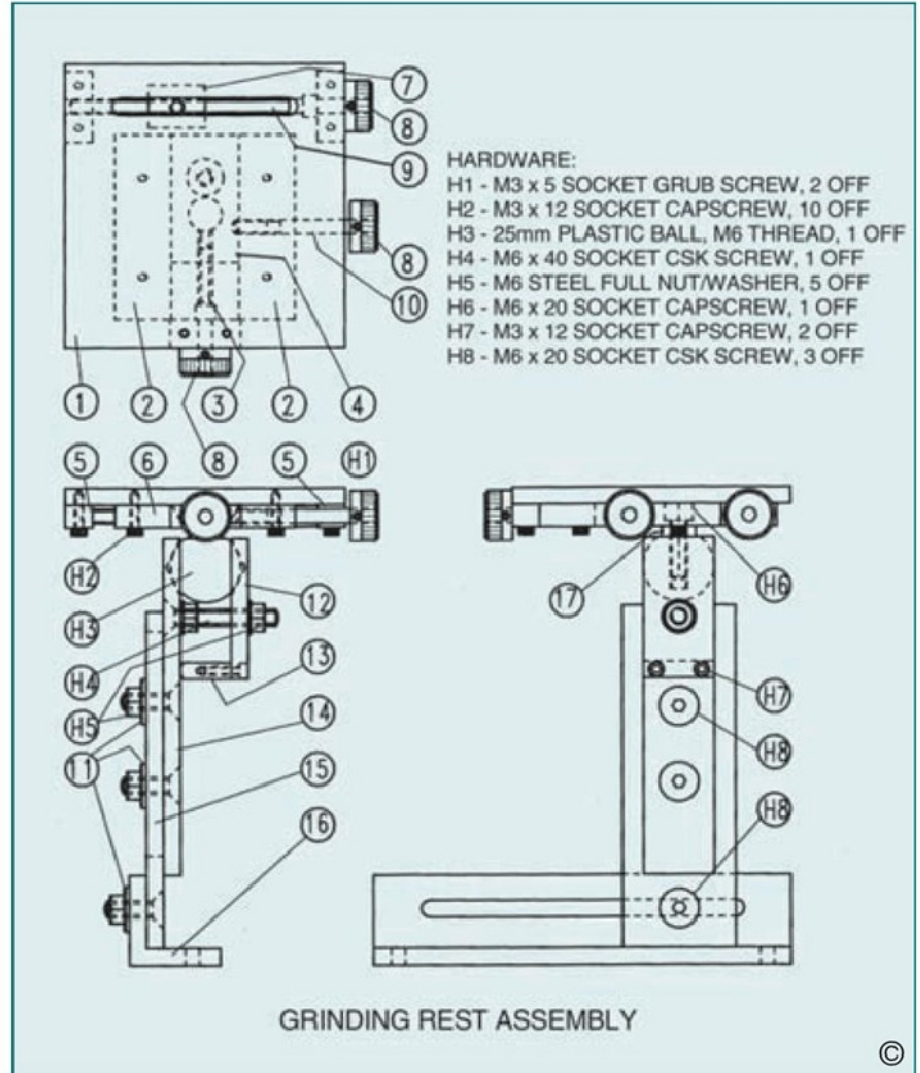


4. The method of finishing the ends of the various rectangular bars required.

its spindle 170 mm above the mounting surface. If being used at an appreciably different height, items 14 and 15 may need their lengths changing. As our editor commented recently, double ended grinders are nowadays available from numerous sources at very low prices.

Rectangular bar parts

With the exception of the feed screw bearings, cut the rectangular bar items to length plus a little for machining. The cut edges of the table will be too long to machine using the method proposed below, so prior to assembling the vertical slide, machine this using the technique seen in **Photo 3**. The photo shows that the faceplate is fitted to the lathe, it is though not left over from a previous operation but is there for a purpose. An engineers square off the faceplate was used to position the edge of the table not being machined ensuring the machined edge will be square to it. The height of the packing is not crucial providing the workpiece is within the diameter of the cutter. Do

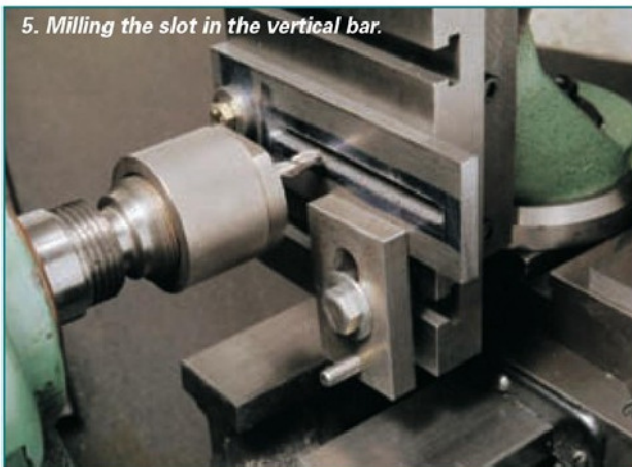


though remember that if the table is at the lower half of the cutter, feed will be from the rear forward, and if the upper half, then from the front towards the rear, thereby ensuring that the feed opposes the cutter's rotation.

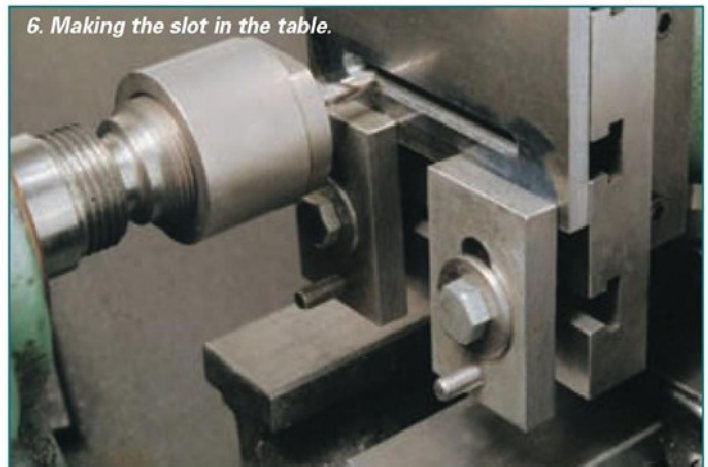
Now machine ends of the remaining items to length, generally as shown in **Photo 4**. Note the use of the support bar fitted in the lower tee slot, a simple but frequently used device. However, the feed screw bearings (5) are too small for this set up and ideally require a vice for the purpose. At this stage, I am assuming that you do not have a vice for your vertical slide, (two will be featured later in the series) and propose the following. Take a

piece of bar, say 70 mm long, and machine one end as above. Remove and cut off a length of 11 mm and return to the vertical slide and machine the end once more, repeat until you have the three pieces required. Leave the machining of the second side till later.

Drill and countersink the hole in the vertical bar (15) and using this, plus an additional clamp, machine the slot, **Photo 5**, similarly the slot in the table, **Photo 6**. Do use a 6 mm slot drill for the task, as end mills are not suitable for making closed slots. Having made that point I should add that the small cutters known as "throw away end mills" have three cutting edges and are suitable as end mills and



5. Milling the slot in the vertical bar.



6. Making the slot in the table.



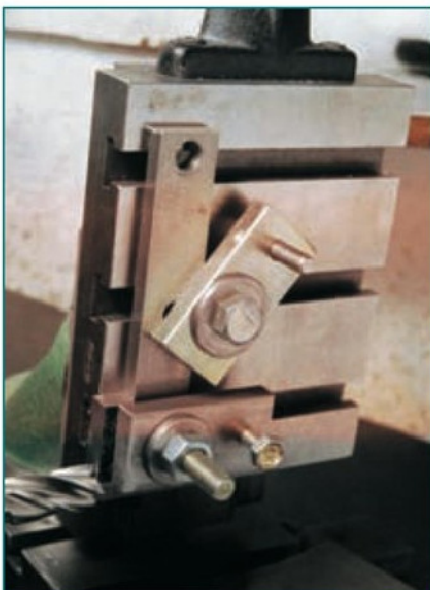
7. Making the slot in the base angle.

slot drills. These tasks are instances where front and rear cross feed stops would be a decided advantage. If milling on the lathe is to become a major operation then providing some should be given serious consideration.

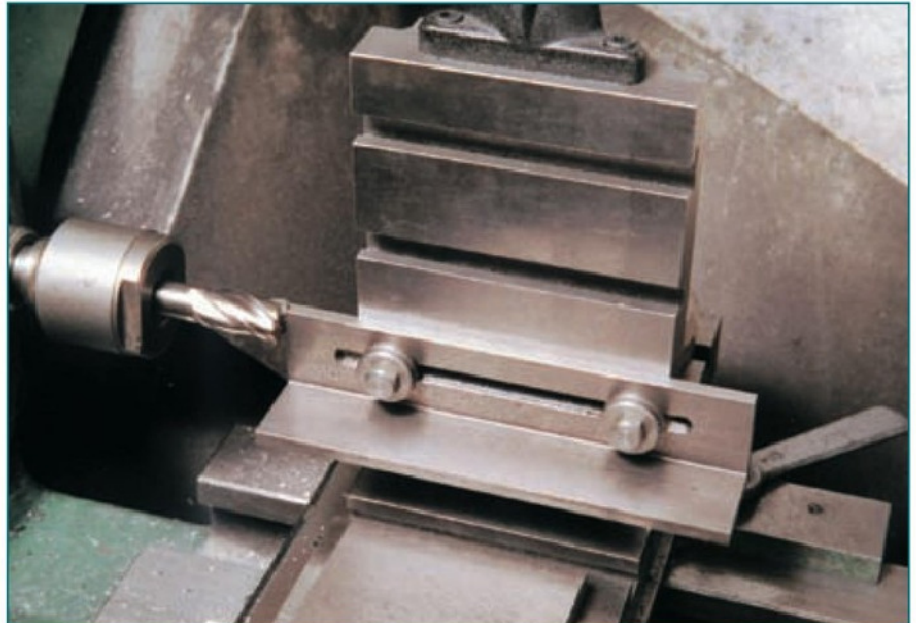
Base angle (16)

Cut a length of bright angle to 150 mm, plus and with slot drill still in the machine mill the 110 mm long slot, **Photo 7**. Use two parallels to space the angle off the slide and a third to keep the parallels apart, a sort of H formation on its side. This should enable the cutter to break through without damaging your parallels.

Turn the vertical slide so its face is parallel to the axis of the lathe and fit the base angle using screws through slot just made and machine ends, **Photo 8**. If your



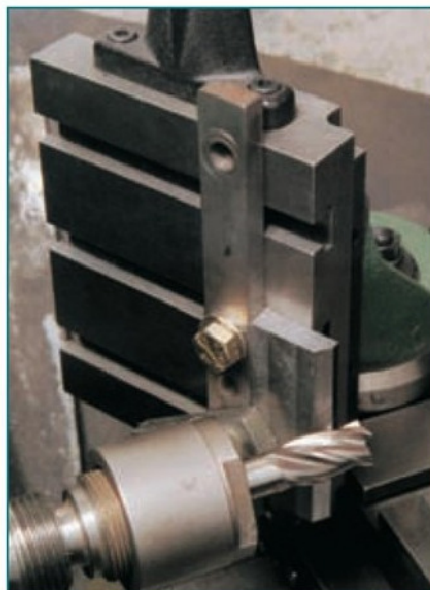
9. The feed screw bearings were too small to have their ends finished by the method in photograph 4.



8. The vertical slide has been turned to line up with the lathe's axis for finishing the ends of the base angle.

tee nuts take larger screws you will need to make two suitable for M6 screws. As these will be found useful elsewhere I would suggest making more, say six. I had intended to machine the ends prior to making the slot but found it impossible to mount the angle securely in a position where this could be accomplished. This was largely due to the fact that with the slide in this position its available traverse is much restricted and it was impossible to clamp the item in a position that would work within that limited range. The set up does though highlight a feature that is often useful, especially when using a vertical slide with its limited size. That is, using the components own holes to take clamping screws, see also photograph 5.

With the slide still in this position the second side of the bearings can be machined as shown in **Photo 9**. Note the vertical fence used to position each part accurately. This was set up using a square off the cross slide face.



10. Making one of the dovetails. The angle is not crucial as all the dovetails are machined at this setting.

The dovetails

Set the slide round to an angle of about 30 degrees and machine the dovetails as illustrated in **Photo 10**. Do take note of the dimensions, the inner dovetail has been reduced from 25 mm to 24 mm and working to the 20 mm dimension reduces the width of the outer dovetail slightly. Again note that a fence has been set up to position the three parts involved, the clamp holding the part is just visible behind the chuck. Position the fence using a square off the lathe's bed.

Next mark out remaining hole positions and drill, tap and countersink as per the drawings. Note that metric countersunk screws have an internal angle of 90 degrees. You may choose, as I did, to use the dovetails and bearings as jigs for positioning the holes on the underside of the table. The M3 blind holes in the table being only 4.5 mm deep will probably have to be tapped using only a plug tap. Whilst this is not impossible it may be a problem as starting with a plug tap is not easy. As a result, if the first few threads are sub standard there will not be much depth of good thread. You could make my tapping stand (ref. 2) that has controlled feed that would overcome the problem. It would also be a good project for the lathe only workshop.

As an alternative, take a length of steel, say 25 x 10 and around 100 mm long, and tap an M3 through hole in the centre. With the tap in the hole and just projecting from the other side, locate this in a hole to be tapped and clamp the bar at both ends onto the table. This will then feed the tap into the hole being tapped and should give adequate results. To produce this very shallow thread you will need to drill the tapping hole as deep as can be without actually breaking through and will need to set the drilling machine down feed stop to do this reliably. First, test your setting by making trial holes in a scrap piece of steel the same thickness as the table. If your tap also has a pointed end you may need to grind away a little of this.

Finally, with the vertical slide still on the lathe, make the central web on the fence

11. In the absence of a suitable vice the fence carrier can be machined as shown.



carrier (9), making the width of the web a close sliding fit in the slot on the table. Take note that although you used a 6 mm slot drill the slot may be appreciably larger. This is another instance where using a vice would be easier. However, on the basis that a vice is not yet available the method shown in **Photo 11** will produce the required result. In this the fence carrier is positioned snugly between two supports and held in place with a single clamp. It will be necessary to machine one side then turn round and machine the other. Drill and tap as per drawing.

Turning operations

Next stage requires some turning, but with a difference. For this you will need a lathe that will swing 115 mm, either over the bed, or in the gap if the lathe has one. The task is to turn the ball seating in the height adjuster (14) and head clamp (12), **Photo**

12 shows the method using a small boring tool. The height adjuster is held to the faceplate using a screw though one of its countersunk holes and additionally supported by two support pieces, one on either side. The shorter head clamp will require a small clamp on the end or alternatively it could be made longer initially with a suitable fixing hole and then reduced to length after turning.

If your lathe cannot accommodate this you could use a large countersink or drill a large hole, say 12 mm diameter and very generously remove its sharp edges. Both of these ideas will affect the spacing of items 12 and 14 and will require the length of the clamp spacer (13) to be changed to suit.

I have suggested that the feed screws should be made from two parts that are pinned together as illustrated on the drawings. This will avoid turning long slender diameters needing the use of a travelling steady. However, should you

12. Boring a ball seating.



consider this preferable then make them completely from 8 mm diameter.

The knobs are straight forward as drawn but you may wish to calibrate the two used with the feed screws. M5 has a pitch of 0.8 mm so 40 divisions would give 0.02 mm per division, a common value on metric equipment.

Assembly

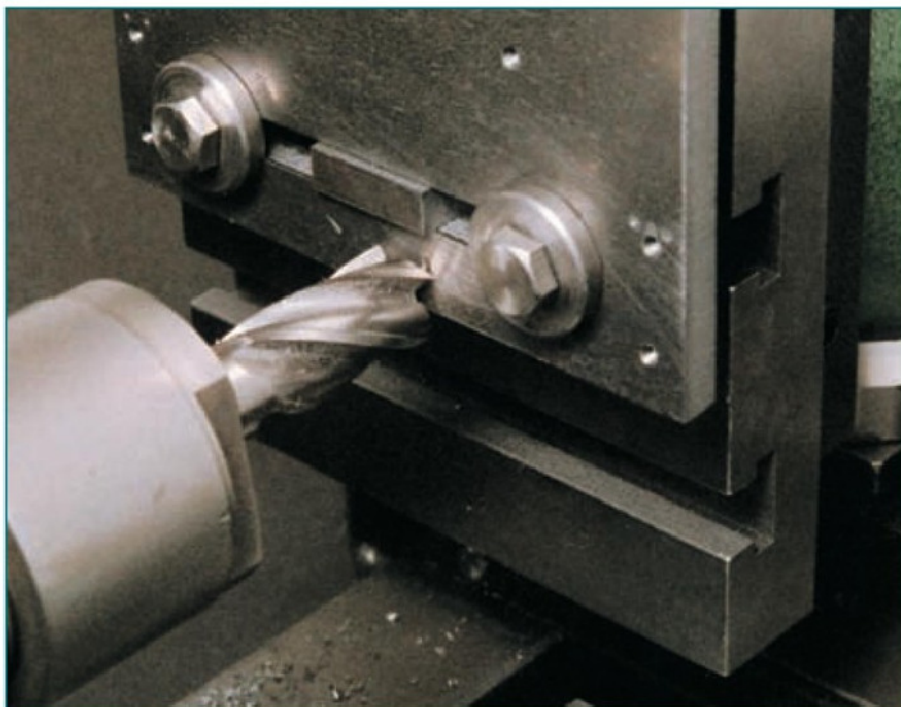
First, assemble the ball between items 12 and 14, measure the spacing and machine the clamp spacer to suit. Also place the fence carrier in the slot in the table and mount on the vertical slide as shown in **Photo 13**, again you will need some M6 tee nuts for this arrangement. The table will be holding the carrier against the slide but do take care how you tighten the screws so as to prevent the table tilting.

Whilst stationary, bring the end mill up to the table's face and provisionally set the saddle stop at this position. Next make a very small adjustment to the saddle stop so as to just prevent the rotating cutter contacting the table. With that done, reduce the central web of the carrier so that it is only just thicker than the table.

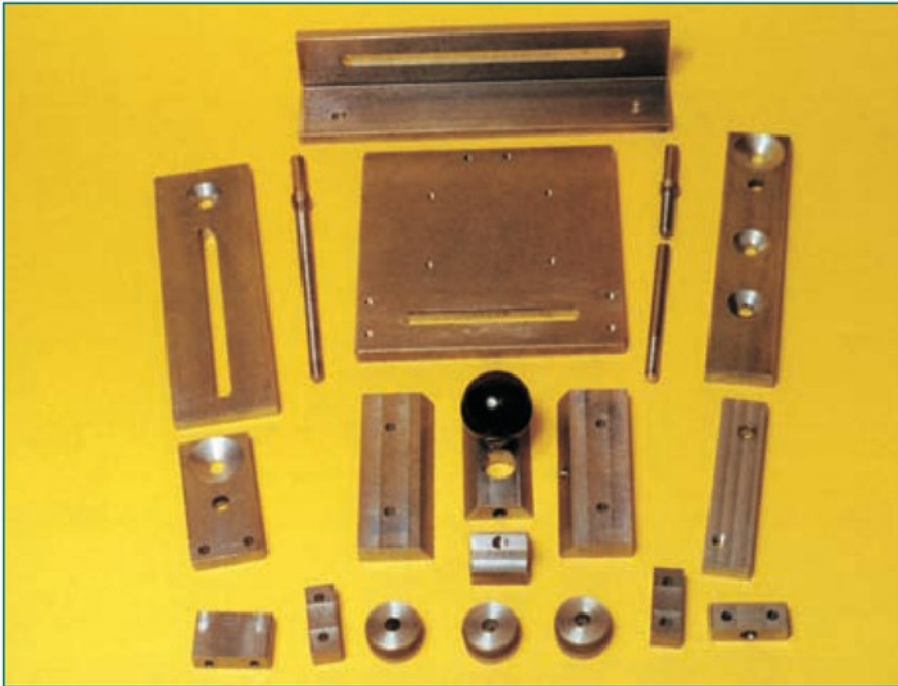
Debur and chamfer all parts as considered preferable and the parts are ready for assembly, **Photo 14**. Do not add any lubrication to the feedscrews or dovetails as this will only make it difficult eventually to clean any grinding dust from them. **Photo 15** shows the major items in the assembled rest. Do note the nut used to lock the countersunk screw (H14) into height adjuster. The reason for this is that the head of the screw is covered at some heights by the vertical bar. I do though find that when using countersunk screws the head grips the countersink sufficiently for the nuts on the other side to be tightened without the need to restrain the head, the additional nut may therefore be unnecessary.

Using the rest

First and foremost I must stress that only the fine feeds should be adjusted whilst the grinder is running, coarse adjustments only being carried out with the machine STOPPED! Therefore, initially the coarse



13. Reducing the central web of the fence carrier to the thickness of the table.



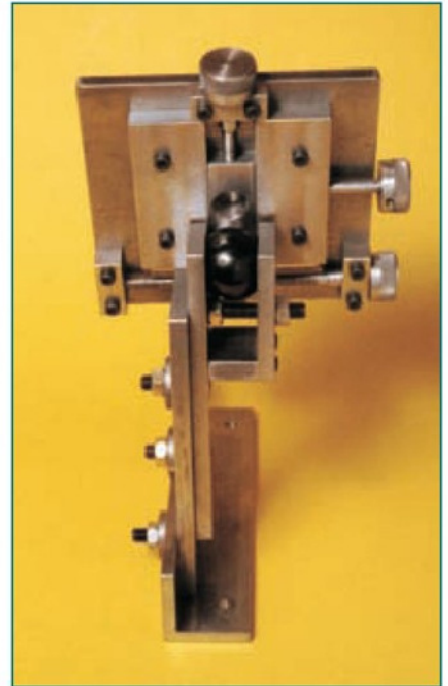
14. This photograph of the finished parts shows that they are all easily made on a lathe with vertical slide.

feeds should be used to set the angle and locate the rest in close proximity to the wheel. The fine feeds can then be used to set the amount to be ground away and to limit the movement in the other direction to avoid the wheel touching parts which should not be ground at this stage, the other cutting edges of an end mill typically. Having discussed in depth the subject of using a grinding rest in previous issues (Ref. 3) I cannot justify going into great detail for other than the sharpening of end mills. If you do not have access to the issues in question then this was also covered in Number 35 of the workshop practice series. "Milling a complete course"

A few comments are though necessary before going into detail regarding sharpening end mills that for simplicity uses an unorthodox approach. First, and probably a surprise to the newcomer, is the fact that normally sharpening only takes place at the corner of the wheel as

illustrated by Sk. 1. To ensure this is the case the surface being ground has to approach at a small angle, sufficient to ensure the item being ground does not rub along the wheel's side. An angle of 1 degree would be more than enough and is the angle that is set by the fence (18). However, the item being ground, at its most simple, a screwdriver, or more complex a lathe tool, will have its requirement in terms of the finished angle. This angle is achieved by setting the tool in its holder at the required angle to the fence and is achieved by placing the holder at an angle on a base as can be seen in Photo 16.

With the lathe tool in the photograph having been set up in this way, grinding takes place by traversing the tool down the side of the wheel guided by the fence with depth of cut controlled by the cross feed screw. Traverse is limited by the stop screw in the fence and the actual position initially established by the infeed screw.

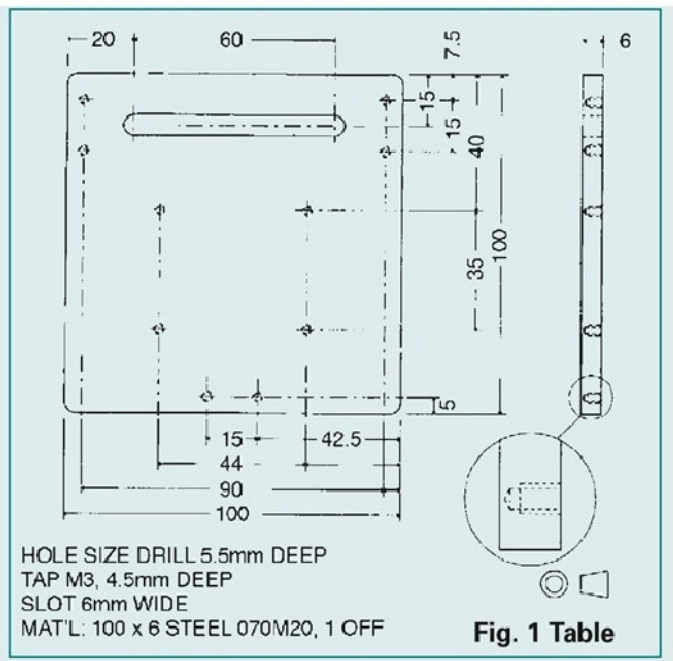
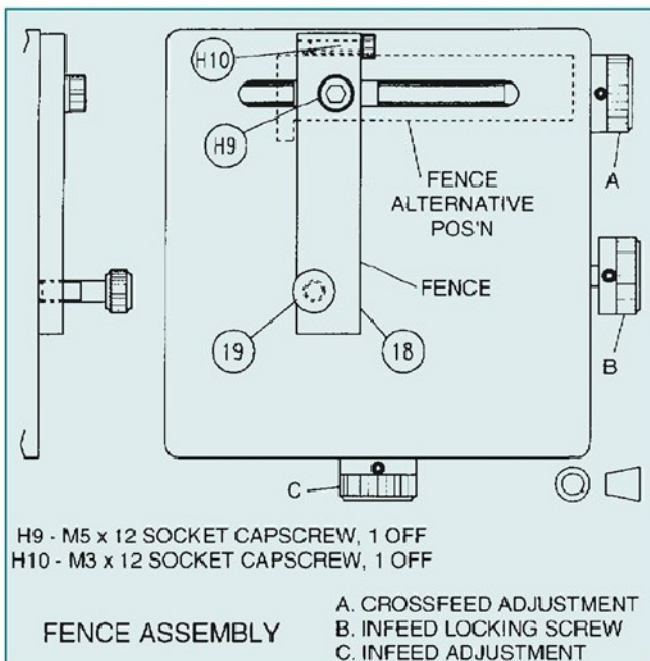


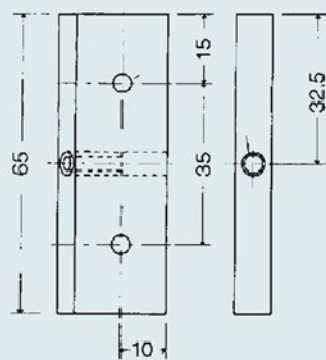
15. A view of the underside showing the working parts.

Depth of cut should be very small, say 0.01 mm (0.0005in.), this being judged by the amount of sparks generated, and perhaps any audible slowing of the wheel. Additional depth will then be placed on after the cutter has traversed the side of the wheel say around five times.

End mills

The end teeth of end mills are though sharpened quite differently, that is, they are just plunged into the outer diameter of the wheel with no wiping action. Of course a wiping action would be used if they were being sharpened on a tool and cutter grinder. Ideally the outer diameter of the wheel will have been freshly dressed so that it is reasonably cylindrical. In this case it is essential that the fence is set at an angle so that it results in the end teeth being very slightly concave. The end mill is held in a simple square holder and this is

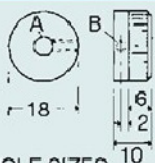




HOLE SIZES
A 3.5mm, 2 OFF
B M5, C/B 5.5, 10mm DEEP
HOLE B IN ONE PART ONLY

MAT'L
25 x 8 STEEL 070M20
2 OFF

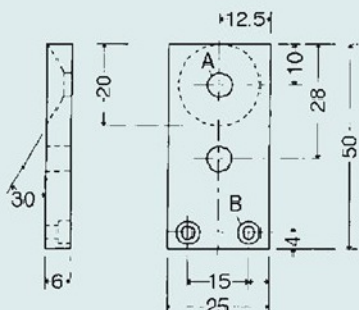
Fig. 2 Outer dovetails



HOLE SIZES
A 5mm
B M3

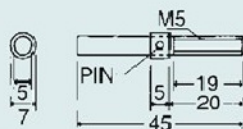
MAT'L
20mm DIA STEEL
230M07
3 OFF

Fig. 8 Knob



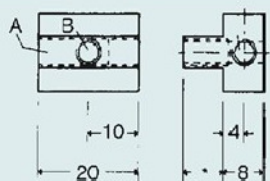
HOLE SIZES
A 6mm, 2 OFF
B 3.6mm, C/B 5.6mm, 3.5mm DEEP, 2 OFF
MAT'L
25 x 6 STEEL 070M20
1 OFF

Fig. 12 Head clamp



MAT'L
5mm DIA STEEL 230M07
8mm DIA STEEL 230M07
MAKE FROM TWO PARTS
PIN TOGETHER OR
MACHINE AS ONE
FROM 8mm DIA
1 OFF

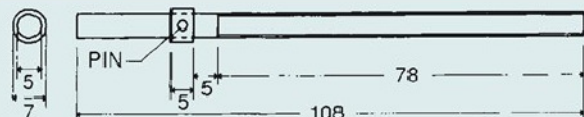
Fig. 3 Infeed screw



NOTE * INITIALLY 8mm FINISH
TO 6mm ON ASSY

HOLES
A 5.5mm, 14 DEEP
B M5, 9mm DEEP
C M5
MAT'L
16mm SQ. STEEL 070M20
1 OFF

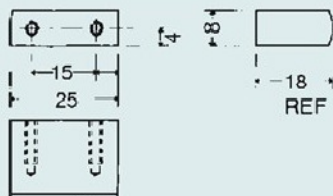
Fig. 7 Fence carrier



MAT'L
5mm DIA STEEL 230M07
8mm DIA STEEL 230M07
1 OFF

MAKE FROM 2 PARTS
PIN TOGETHER OR MACHINE
AS ONE FROM 8mm DIA

Fig. 9 Crossfeed screw

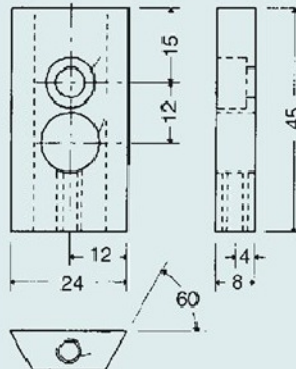


HOLES M3 x 10 DEEP, 2 OFF
MAT'L 25 x 8 STEEL 070M20

NOTE
18mm DIM. IS A REF. VALUE, CHECK
SPACING OF ITEMS 12 & 14 AFTER
MAKING BALL SEATINGS & MAKE
TO SUIT

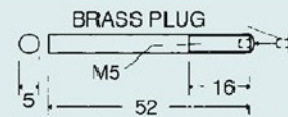
1 OFF

Fig. 13 Clamp spacer



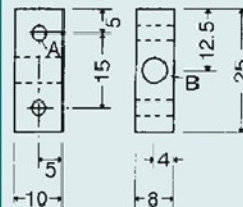
HOLE SIZES
A 6mm, C/B 10mm, 6.5 DEEP
B 12mm
C M5
MAT'L
25 x 8 STEEL 070M20
1 OFF

Fig. 4 Inner dovetail



MAT'L
5mm DIA. STEEL 230M07
5mm BRASS
1 OFF

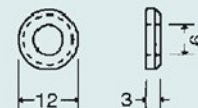
Fig. 10 Traverse locking screw



HOLE SIZES
A 3.5mm, 2 OFF
B 5.5mm

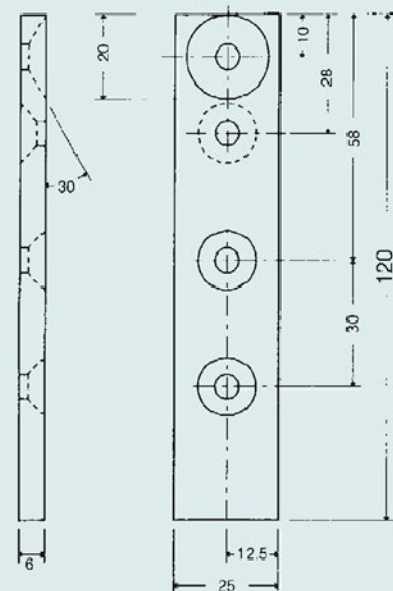
MAT'L
25 x 8 STEEL 070M20
3 OFF

Fig. 5 Feed screw bearings



MAT'L
12mm DIA
STEEL 230M07
3 OFF

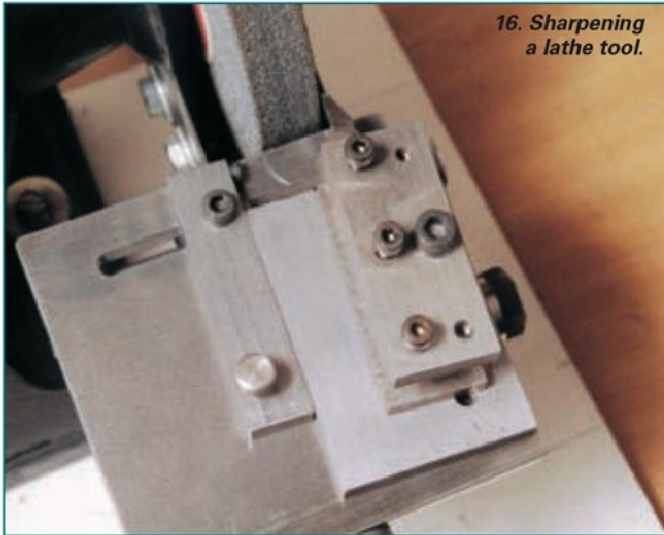
Fig. 11 Washer



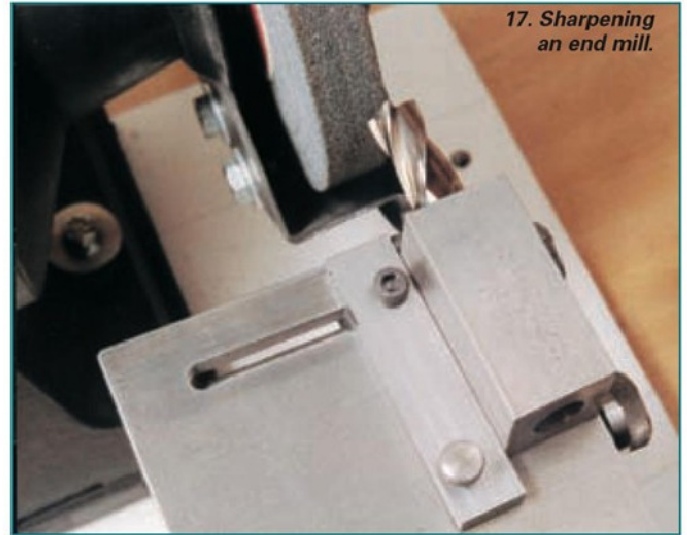
HOLE SIZES
A 6mm
B 6mm, CSK 14mm DIA., 90°, 3 OFF

MAT'L
25 x 6 STEEL 070M20
1 OFF

Fig. 14 Height adjuster



16. Sharpening a lathe tool.



17. Sharpening an end mill.

traversed down the side of the fence until it contacts the stop screw. The infeed is set such that at this position the end mill just contacts the wheel with a very small number of sparks generated. The cross feed screw is used to position the fence such that the edge being sharpened is ground to the centre but more importantly that the wheel does not contact the other cutting edges. The holder is then rotated 90 degrees and the second edge plunged at this setting, followed by the third and fourth, **Photo 17**. The cutter can then be inspected and if considered necessary a little extra depth of cut placed on, the process then being repeated.

After having been sharpened a number of times the width of the face will become over wide. In this case the secondary angle should be ground first to reduce the width using the same process but at an increased angle. Then the cutting edges can be

sharpened. As a guide, a primary angle of about 5 degrees and a secondary angle of 10 to 15 degrees would be about right in the absence of more precise requirements.

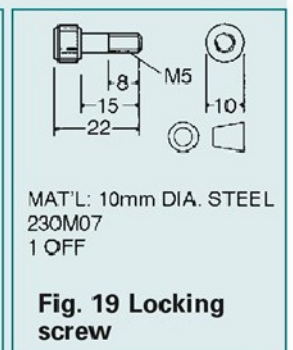
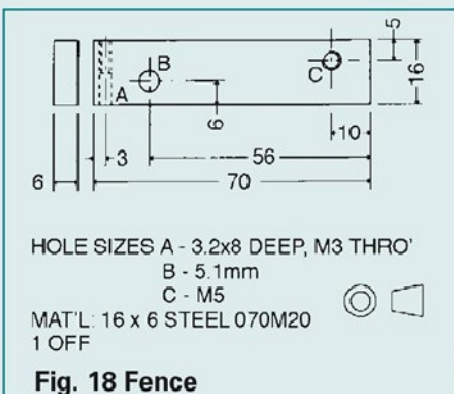
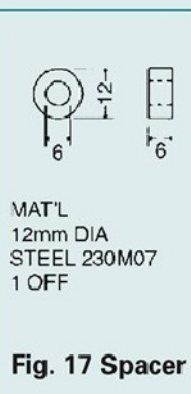
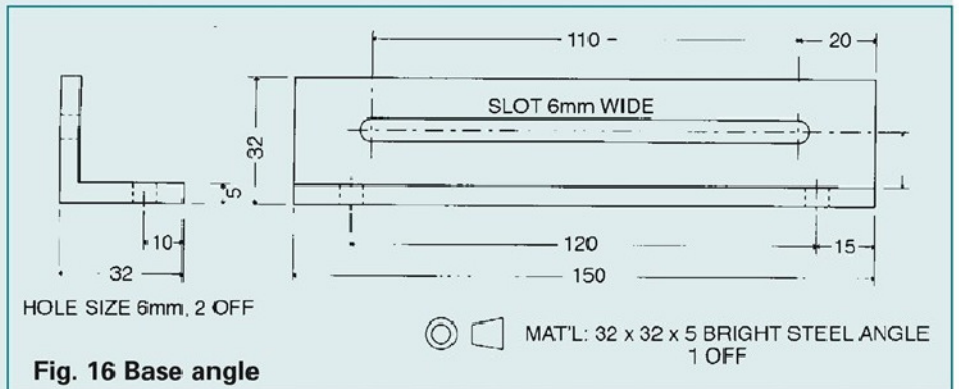
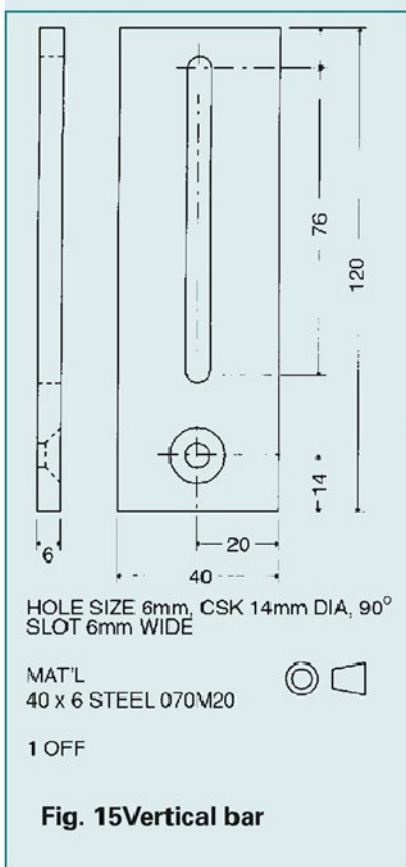
The rest's table should be set such that the angle at the height at which grinding will take place conforms to the required angle. This is easily done as illustrated by **Sk. 2**. The holders required for the end mills consist of a piece of 25 mm square steel around 50 mm long. This should be bored a close fit for the cutter shank and concentric with the sides. A single grub screw is included to securely fasten the cutter in the holder. **Photo 18** shows three holders, one with end mill fitted, note that the cutting edges are arranged to be parallel with the holder's sides. Cutters having three or six cutting edges, typically dovetail cutters, small end mills, etc., can be held in a hexagonal holder, but for this a much thicker fence would be required. Dovetail cutters do

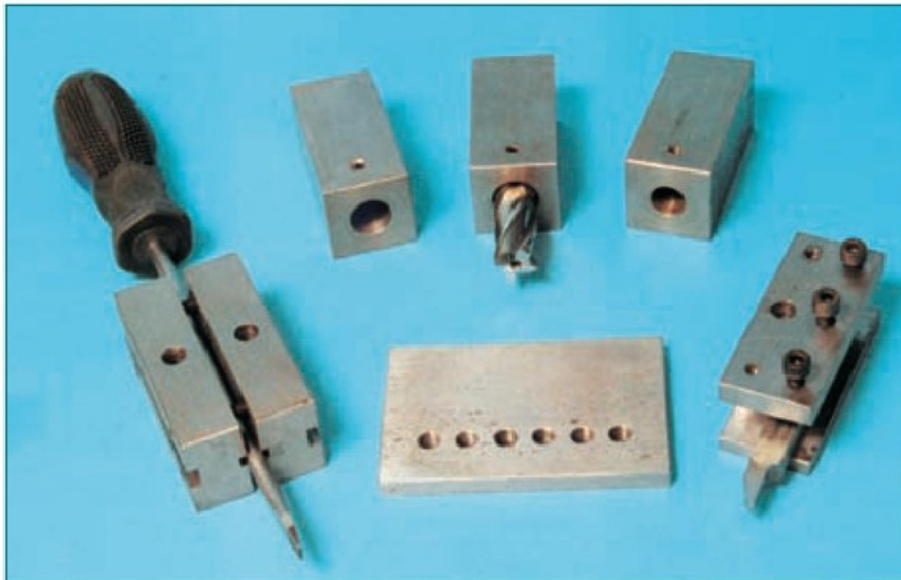
not have a helix, so the sides can also be sharpened, as can also tee slot cutters.

The photograph also shows a holder for square items, typically a lathe tool as shown, and another for round items holding a screwdriver. These are fitted at the required angle onto the base that is shown in the centre of the photograph.

Both the grinder and the rest need to be mounted on a robust base so as to avoid movement due to the forces necessary to hold the cutter in place. However, do not be too firm with your positioning of the item being sharpened, as this will cause the rest to flex a little, causing errors from tooth to tooth.

Having made the rest you will certainly find it helpful in maintaining your cutters in good condition for the remaining projects in the series, an economy toolmakers vice being the subject in the next issue.





18. Some typical accessories for use with the grinding rest.

An important lesson

Whilst not directly relevant to this article it is worth commenting on a condition that can cause extreme problems if it is not taken account of. Readers may have noticed that in photograph 14 there is evidence of some parts being machined on their main faces even though they are called to use bar material of the required size.

Having made many items from stock materials in the past I have almost always

purchased the correct sizes for the job in hand. This has resulted in me acquiring a large amount of steel in many different sizes. Wishing to see the stockpile reduce I have decided to use what materials I have, even where this necessitates bar being machined down to the required size. For the dovetails typically, I used 10mm material that needed reducing to 8mm. Being aware of the problem I first reduced the material to around 8.5mm and as a

Tee slotted cross slides

In the last issue, I commented on the desirability of a tee slotted cross slide particularly for workholding when milling in the lathe. Earlier, issue 105, (*Scribe a Line*) contained a letter from me appealing for information on current suppliers of these items. If your lathe is not fitted with a T slotted cross slide then the first place to approach is obviously the supplier, or manufacturer, of the lathe to which you wish to fit one. If not available from this source then the following may be able to help.

Slides from the following firms may cover present day machines, obsolete machines, including smaller size industrial machines, Harrison, South Bend, Atlas, etc., some also supply other spares, leadscrews, leadscrew nuts, change gears, etc. Mostly made to order, slides can be supplied for any lathe providing the dimensions are available, these can be taken from the existing non slotted slide.

"Lathe Parts" 26 Kensington Street, Keighley, West Yorkshire. BD21 1DP
Tel. 07720 870891 (Between 1800hrs and 2000hrs weekdays) E-mail
sales@latheparts.co.uk Web site www.latheparts.co.uk

RDG Tools, 35 West End, Hebden Bridge, West Yorkshire. HX78UQ
Tel. 01422 845222, Fax. 01422 845999, E-mail rdgtools@aol.com, Website
www.rdgtools.co.uk

J Ward, 27 Trent Row, Foulridge, Colne, Lancs, BB8 7QF, Tel 01282 869262

G and M Tools, The Mill, Mill Lane, Ashington, West Sussex, RH20 3BX E-mail
sales@gandmtools.co.uk Web site www.gandmtools.co.uk Tel 01903 892510 Fax 01903
892221

Metal Lathe Accessories, P.O. Box 88, Pine Grove Mills, Pennsylvania 16868, U.S.A. Tel
(814) 234 3543. E-mail mlatoolbox@aol.com Web site sc-c.com/metallathe. Readers
should note that there is presently no UK source for parts from this supplier.

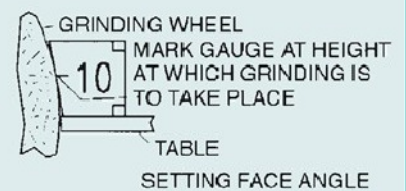
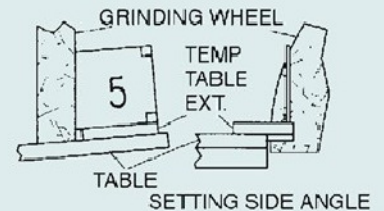
I would like to thank all those readers who have, in reply to my letter in issue 105, helped me to compile the above list. Readers may also like to consider Derek Cooke's alternative to a tee slotted cross slide published in MEW issue 101 page 38.

More information and parts

An extensive source of information for small machine tools (over 330 makes), including very early machines to the present day (and remanufactured parts for some), is available from **Tony Griffiths**, Wardlow, Tideswell, Buxton, Derbyshire, SK17 8RP Tel. 01298-871633. Fax. 01298 872874. 7 days 08:00 to 23:00 GMT. E-mail tony@lathes.co.uk. Web site www.lathes.co.uk.



SK1



SK2 Table to wheel angle

result of this, on inspection, found that the reverse side was decidedly concave along its length. This is due to the released stresses that the machining causes. I did not measure the amount but it would have been in the order 0.2 mm in the centre.

The second side was therefore lightly machined, sufficient to flatten the surface. The first side was then machined a second time to bring the thickness to size. You may ask why not bring it to size when machining the second side. As machining of the first side was accomplished gradually across its width the resulting distortion would also have happened gradually. The first pass finally being bowed as on the reverse side but the final pass being almost flat, as no further movement would take place. The side had, as a result, a very complex shape. Having a milling machine I did of course do this preparatory work on that but essentially all the work was carried out on the lathe for this and the other items in the series.

In making the very last item in the series, a retracting tool holder, this problem surfaces with a vengeance in one of the parts. Even though it is small, some complex machining is necessary that results in distortion occurring.



References

1. Milling Projects for Beginners (9) (End Mill Sharpening accessory) MEW issue 92 Page 12
2. Tapping stand. MEW issue 105 page 12
3. Milling Projects for Beginners (7a) (grinding rest accessories and their method of use. MEW issue 90 page 12, and later issues.

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.

TasDevil Laser Line Scanner

For anyone using a CNC machine, a method of digitising models is a big plus in terms of time saved in program preparation. Most Laser Line Scanners cost thousands of pounds and are outside the budget of most hobby enthusiasts. By assembling a machine from readily available mass market, consumer products and providing the necessary software to convert the generated point cloud data directly to G Code or HPGL(CON) files, it has been possible to produce the TasDevil for a more affordable figure.

It can be used with any CNC machine and can digitise statues or base relief models so that they can be reproduced with a CNC machine. Simple objects like violin backs or Windsor Chair seats can be scanned by moving the lasers and camera with the X axis and keeping the model stationary. A 3D object that has been cast can be scanned by placing the mould separation line parallel to the X axis. Other 3D models, e.g. a bust of Beethoven, can be placed on the rotary table and the XYZ coordinates extracted and converted to a G Code or HPGL(CON) file for milling.

The TasDevil is available in two parts. The hardware and the software. The hardware assembled costs £299 and the software including detailed instructions so that you can buy your own components (and save about £100) costs £499. Assembly from components is simply by mounting them on a track and can be completed in less than an hour. Details available by e-mail from allan@tasdevil.co.uk

Arc Euro Trade

Ketan Swali has been touch to advise that by the time this issue is published, he should have organised stocks of gear hobs. It is probable that both high speed steel and solid carbide will be available at prices substantially lower than typical industrial levels. These will no doubt be of interest to enthusiasts of gear hobbing, whether by traditional change wheel techniques, or by the system described by Brian Thompson in MEW Issue 108. One point that is not always appreciated is that, for any particular tooth size, to cut a wide range of gear teeth numbers using involute cutters requires the full range of (usually eight) cutters. Conversely when using the hobbing process, just a single hob is needed.

Fireside reading

I have recently been passed copies of two books, each in its own way a "Classic" for model and amateur engineers. Each has been around for some time, but the contents are as valid today as when originally published. Both have recently been reprinted by Special Interest Model Books, and each is a welcome addition to the editorial library.

The Amateur's Lathe by L H Sparey

For some time I have enjoyed access to an earlier 1974 copy of this work, which was I believe, first published in 1948. As a result, you will not find mention of more modern accessories such as digital calipers or read outs. A photograph is given at the start of the book, which shows the authors workshop. From it and the accompanying caption it is evident that in keeping with the norm of the post war era, no separate milling machine is installed, such work being done mainly on the lathe. Thus, readers with a particular interest in Harold Hall's new series will also find much here to their liking.

Seventeen chapters entitled - The Lathe,- Choosing a Lathe,- Installing the Lathe,- Lathe Accessories,- Measuring Equipment,- Lathe Tools,- Drills and Reamers,- Holding Work in the Lathe,- Marking Out,- Plain Turning and Boring,- Taper Turning, Crankshaft Turning, Disc and Ball Turning,- Screwcutting,- Milling, Shaping, and Grinding in the Lathe,- Lapping,- Metal Spinning, Spring Winding, Turning rubber etc,- Production Methods in Small Lathes, Care of the Lathe and Its Accessories,- guide the reader through just about any operation that can be dreamed up for a small machine, and are followed by an appendix which gives much useful tabulated information.

The book is copiously illustrated with both photos and line drawings, the latter including dimensioned details for a number of accessories including tailstock die holder, tailstock turret tool holder, and dividing head. Priced at just £8-95, this book will be of particular interest to novices, but also to experienced machinists, as a number of the techniques described may not be encountered in mainstream industrial training.

Model Engineer's Handbook by Tubal Cain

This book is not a "how to", but a compilation of useful facts, figures and tables that will save miles of legwork and hours of hunting in other reference books. It was first published in 1981 when calculators were in relative infancy, but this third edition, first published in 1996 does continue to include a few pages of logarithms and instructions for using a slide rule, apparently in response to reader demand. Beyond this, the information amassed is generally of a timeless nature. Thirteen sections are entitled: S I Units and Metrication,- Workshop Calculations,- Standard Tapers and Collets,- Screw Threads,- Workshop Practice,- Metal Joining,- Properties of Materials,- Steam and the Steam Engine,- Air and Gases,- Boiler Work,- Piston and Gland Seals,- Electrical Memoranda,- General. Extending to 240 pages, this veritable mine of reference data is priced at £9.95.

Historically, the first book I have tended to reach for, to answer workshop questions has been my old (1940) copy of Machinery's Handbook, however for the future I think that much information will be found more rapidly (and in a more up to date form) in *Model Engineer's Handbook*.

www.lathes.co.uk

In the last issue, Harold Hall mentioned Tony Griffiths as a source of information on machine tools. Historically Tony has been involved in buying and selling small machine tools for over thirty years. The web site was introduced originally as a sort of public access database to augment the trading activities, however like Topsy it grew, and is now probably the most respected (and visited) site of its type worldwide, offering information on around 330 machine types.

Tony's business has moved away from dealing in machines to supplying information, spare parts etc. Information comes in the form of manuals, parts lists, and books (e.g. Workshop Practice series) of interest to the amateur engineer. Spare parts are stocked for Southbend and Boxford lathes, with items such as feedscrews, steadies and threading indicators being recently added to the range. Facilities are available to produce castings, and even to create an unavailable spare part from scratch.

The regular stock also includes a range of drive belts, round, flat, and vee. The web site is well worth a visit, as not only does it give a mine of reference information, but also carries a list of sales and wants, so you may either find a bargain or be able to dispose of unwanted items.

MICROWAVE TIMBER SEASONING

Jack Cox introduces a novel approach to moisture content control.

Like Harold Hall before me, I feel a little embarrassed about writing an article on wood in what is essentially a metalworking publication but, in some cases, it may be helpful to have at least an understanding of the way wood can behave. Metal is a nice stable material to work with, in the sense that parts made to fit today, will in almost all cases, still fit next week or next year. Wood is basically a little less well behaved, in that it is quite likely to change its dimensions over time.

The main problem with wood, as distinct from metal (or even most plastics) arises from the fact that it can gain or lose moisture from its surroundings, and will 'move' (i.e. undergo dimensional changes) as a result. If moisture is lost, the wood will shrink; if moisture is gained, it will swell. In the following, only the problem of shrinkage is discussed, as this is the more likely event. So why does it matter? Indeed, it may not be important or even noticeable in some cases but, where wood and metal are combined in a model or other artefact, or where two or more pieces of wood are glued together (and particularly where the assembly comprises different species of wood), it is possible to end up in a little trouble. As a simple rule of thumb, it is possible to assume that wood (of any species) will move significantly in both 'cross-grain' directions, but to a negligible degree along the grain (**Fig 1a**). Differential movement of this nature can bring particular problems with it. Consider a plain mitred joint as in **Fig 2a**. If this joint is part of a frame construction, where the free ends of the two mating members are constrained, then the cross-grain shrinkage, combined with the relative lack of long-grain shrinkage will produce the effect shown, essentially that of an incorrect mitre angle. In **Fig 2b**, which may be a wood nameplate glued to a metal model, the glue may well hold the timber dimensionally stable at the actual joint line - but this won't stop the wood moving elsewhere, as the drawing illustrates.

Moisture content

The amount of moisture contained in a given sample of timber is normally expressed as a percentage of its 'bone-dry' weight, and is referred to as 'moisture content'. In the UK, a moisture content of around 12% is normally aimed at; in the USA it is nearer 8%. It is a mistake to assume that any timber brought into a 'home environment' as furniture or decoration is required to be bone-dry. It

would be equally mistaken to assume that timber which has been 'seasoned', or 'air dried' or 'kiln dried' is immediately suitable for conversion into a model or a piece of furniture or whatever. The objective for any timber used in this way must be to make sure that the wood is in equilibrium with its environment, in that its moisture content must match that of its surroundings fairly closely at the time of introduction, or it must be allowed a period of stabilisation in its intended environment before being worked. The formula for calculation of moisture content (shown in **Fig 1b**) is very simple indeed, however, making the necessary measurements can be rather less so. Moisture meters of various types are available on the market, but the better types are fairly expensive, that shown in **Photo 1** being a good example of the 'non-invasive' type, in that it does not require probes to be stuck into the wood, but is merely laid upon a flat surface. In the absence of equipment of this type (but given a reasonably accurate weighing device for small items), it is a fairly simple matter to take a small sample of the timber being used, weigh it, and then dry it in a domestic oven (not a microwave type) until its weight remains constant, at which point, the formula of **Fig 1b** may be applied. In view of the fact that one is



1. Typical moisture meter

merely trying to remove water, it is not necessary to exceed 100degC by very much. It may well be that the sample will split and distort during the process (holly being particularly prone), but this does not matter.

The microwave alternative

It may well be that 'acquired' timber, particularly that recently felled, is somewhat unknown in terms of moisture content, the simple way of finding out being as described above. If the passage of time is of minor importance, air-drying is difficult to beat. If accelerated drying is necessary, this is not best carried out in a normal 'radiated heat' oven, however, as the process requires bringing the entire oven to a moderate temperature for lengthy periods, and is not particularly convenient or economic. A microwave oven, on the other hand, operates by excitation of water molecules within the substance being heated and is 'on' only for quite short periods, whatever the process.



2. Wood stacked in microwave oven.

CAUTIONARY NOTE

Perhaps however, a word of warning here might be appropriate: one must be very careful about oven-drying many of the 'exotic' timbers, often described as 'rosewood' (of which there are hundreds of types, the name often being applied to woods which have a distinctive pleasant smell when worked, but strictly to the genus 'Dalbergia'). The problem here is that the smell, which is acceptable during normal operations, becomes quite overpowering and positively unpleasant, as the wood tends to exude a viscous substance under high-temperature conditions. It is possible to make a domestic oven of any type unusable for a long time as a result. It is better in such cases to use a hot plate outside. For the microwave drying to be described later, such woods should be placed in a disposable 'oven bag', as used for roasting food, during the process, but in any case, it is quite difficult to season 'exotics' rapidly by any method, and the process should be avoided for these timbers if possible.

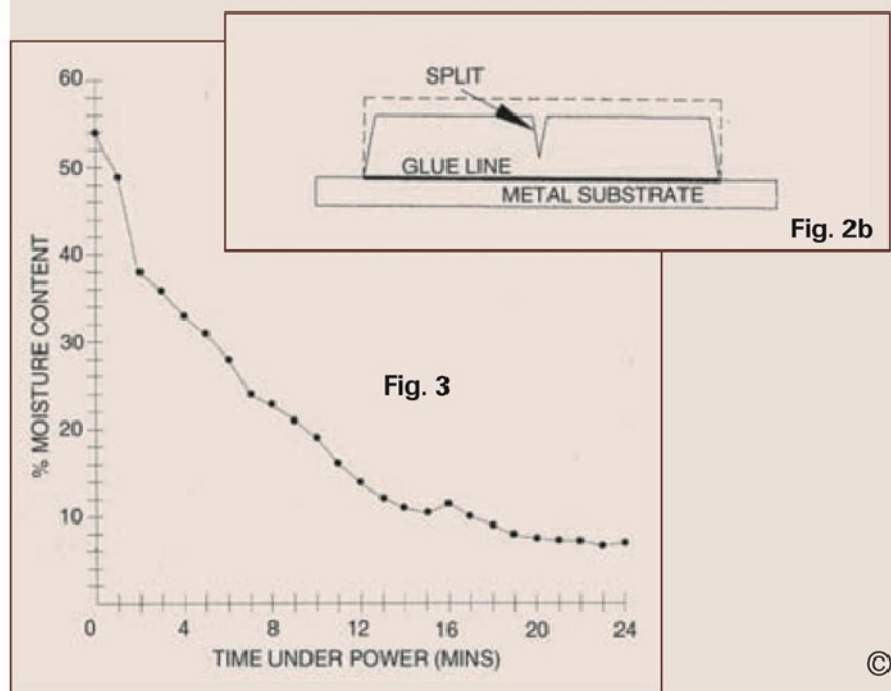
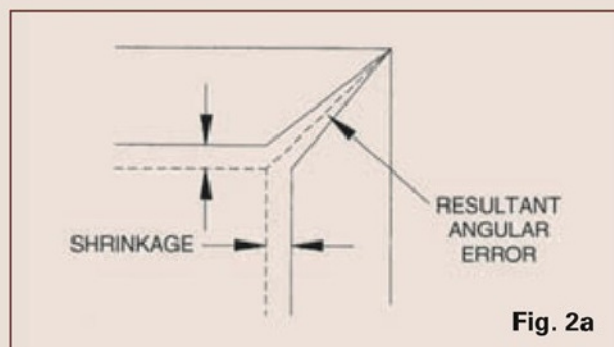
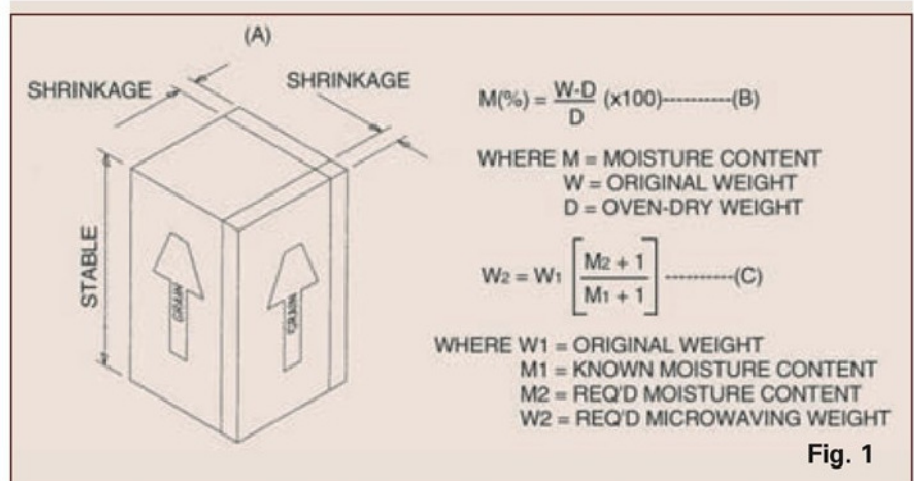
It is therefore quite possible to make a piece of wood unbearably hot inside and at the same time very easily handled externally. This can lead to the somewhat erroneous supposition that the microwaves work from the inside out in some magical way. The fact is that normal radiated direct 'heat' has to penetrate from the outside and will then do so by conduction at a rate determined by the thermal resistance of the material being heated (metal being low and wood fairly high). Microwaves also have to penetrate but, with wood, they are rather good at it, and once inside, generate the heat 'on-the-spot'. The big problem is that the heat, once generated, has to find its way to the outside by conduction, which can be a fairly slow process. This can lead to timber, which appears quite normal on the outside, being found to be discoloured and even charred on the inside. The foregoing is a very simple explanation of the 'goings-on', but they are more complicated than this, in ways, which neither I, nor any of my associates, fully understand. However, it is possible to formulate a very simple procedure for microwave seasoning. To begin with, a small sample of the bulk timber is weighed, fully dried in a 'radiated-heat' oven, and re-weighed, to determine initial moisture content by means of the formula of Fig 1b. Each piece of the bulk quantity is first weighed, the weight (W1 in Fig 1c) being conveniently recorded on the wood itself, then stacked in the oven with its companions (see Photo 2), micro waved at full power for one minute (and positively no longer!!), followed by a one-hour rest period, this process being repeated as often as necessary to bring the wood to the required weight (W2 as calculated from Fig 1c) and therefore moisture content. The foregoing is based upon an 800 Watt appliance, but I suspect that a couple of hundred Watts up or down will not make a material difference, but perhaps a little experimentation is desirable in such cases. The appliance used was also capable of rotating the contents about one rev. per second, a desirable feature to ensure even heating. (One must also make the assumption that all the wood being dealt with is of the same original density (or 'wet-weight') as the small sample dealt with earlier, and is therefore at the same original moisture content, otherwise calculations will be meaningless. It follows that even microwave seasoning is not necessarily an 'instant' process, but can take days (but this is far better than months of air-drying).

Results

Fig 3 shows a result averaged from a number of samples seasoned during an experimental session a couple of years ago (and published in sister magazine 'The Woodturner'). The curve is highly typical, the bumps probably being due to the fact that, although the actual microwaving time was only 24 minutes, the session actually took the better part of three days, and bedtime beckoned on a couple of occasions, giving rise to two extended rest periods for the wood. The important point to note is that the curve is tending to flatten out long before zero moisture content is reached, and is in

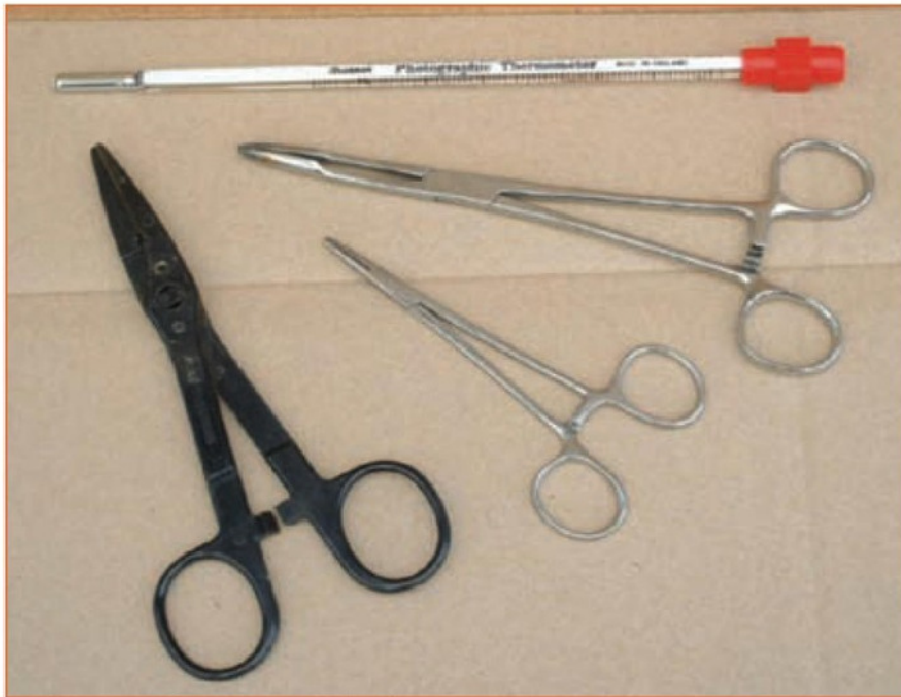
fact asymptotic to a value of about 8%. I have no explanation whatever for this effect, and to the best of my knowledge neither has anybody else. In fact another well-known contributor to 'The Woodturner', working along much the same lines, obtained a very similar result, and tended (unfairly, I suspect) to blame a fixed error in his moisture meter. In the absence of further knowledge therefore, it would appear necessary to simply accept the phenomenon, since it is highly unlikely that a figure of below 8% is desirable. It does however demonstrate the need for a conventional oven to produce a sample at 'oven-dry' weight.

The foregoing notes are intended only for the seasoning of fairly small quantities of timber, such as can be contained (and rotated) in a domestic microwave oven. Provided that the oven is automatic in the sense that power and time can be relied upon, so that the wood has no chance to 'cook', the process is viable and can save a good deal of seasoning time, and more importantly perhaps, spare the grief of having wood 'move' after completion of a project. Having suffered this problem quite a lot in my early woodworking days, I can assure readers that it is very much to be avoided.



SHEET METAL ETCHING 2

John Purvis concludes his description of this “no force” process, ideal for small, delicate parts.



18. Selection of forceps shown with photographic thermometer

Exposure

You are now ready to transfer the images to the metal. As supplied the coated metal sheet consists of five layers. There is a green layer of photosensitive film on each side of the metal, with a very thin transparent film over each of these. They are there to protect the photosensitive layers from mechanical damage, but they also make the coated sheet easier to handle since, without them, the coatings would be slightly tacky and prone to pick up dirt and dust. These protective films will be removed after exposure and before development. It is quite safe to handle the coated sheet in subdued light provided that the exposure time is kept as short as possible. The piece of coated metal sheet should be cut to about 10mm. larger than the area of the images, on each side. The material can be cut in the usual ways by guillotine or hand shears but it must remain perfectly flat. If hand shears are used, leave about a millimetre to allow a second cut to remove any distortion. The alternative method of cutting thin sheet by scoring and breaking is impracticable as it will damage the photoresist, but it can be cut easily with a fine bandsaw. If you lay it on a piece of hardboard and cut both at the same time, then burring will be reduced. The small remaining burr can be removed with a fine file. The cut sheet is

placed between the transparent masks and fixed to the lower (i.e. the larger) one with three small pieces of PVC tape. Do not overlap the edge of the metal with the tape any more than necessary as, if the tape is too close to the image, it will keep the mask away from the metal and affect the exposure. For this reason it is helpful to use cheap, low quality tape since this is usually thinner. The upper transparency is then fixed in the same way (shown in **Drawing 2** previous article). The “sandwich” is then placed in the light box and each side is exposed for a suitable time in turn. I suggest using a timer with an audible signal as it's very easy to forget that the box is running and ruin the work. The exposure time for your particular box will need to have been established using test exposures, and this will be described in the section dealing with light box construction. My own box needs four minutes and most boxes are likely to be of this order. Calibration is a chore but it needs to be done only once, though you should recalibrate if you change the coated sheet supplier.

Developing

The next stage will be to develop the exposed sheet. The developer can be bought ready made but it is much cheaper to make up your own. Put about half a litre

of water in a one litre plastic lemonade bottle and add 12.5 grammes of caustic soda (sodium hydroxide), shake until the material has dissolved and then top it up to a litre. *If weights are a problem then reasonably new coins can be used. A 20p coin plus a 2p coin will be less than half a gramme light, and a £1 coin plus a 5p coin less than half a gramme heavy, close enough for the purpose.*

Please note that caustic soda is corrosive and must be handled with care. If you happen to have distilled water readily available from a dehumidifier or a condensing tumble dryer then this can be used, but tap water is quite suitable. The Caustic Soda is readily available from the big DIY suppliers much more cheaply than when sold as PCB developer. It is in the form of small pellets and is sold mainly for cleaning drains. The developer solution is not particularly strong but any spillage on hands or working surfaces should be washed off promptly and this applies particularly to the pellets of the material. Use plastic or glass containers and keep it away from aluminium alloys, which it will attack, and your eyes. Apart from these commonsense precautions the developer is not difficult to handle. This is the recommended developer for sprayed coatings but it is equally suitable for precoated sheet, though the manufacturer's recommended developer for film coated material is sodium carbonate (washing soda). This is as readily available as caustic soda but it is much more “user friendly”, needing no special precautions at all. The solution strength is 8.5 grammes in a litre of water. *A 20p coin plus a 1p coin will be close enough.* However, I have found it difficult to get good results with this developer and cannot recommend it; as a result, I always use caustic soda. Furthermore, if you do decide to try sodium carbonate you will still need a caustic soda solution to strip the resist after etching, which will be described later.

For sprayed coating the developing time is quite short, about 15 seconds but film coatings are less critical, usually requiring between 15 and 45 seconds. This varies considerably with temperature so the developer should be at, say, 25 degrees Centigrade, though it doesn't really matter which temperature you choose as long as you standardise on it. Warming is fairly easily achieved by leaving the bottle in the airing cupboard overnight, or by standing it in a bowl of hot water for a time. If some of the solution is warmed in this way and some left cold then the two can be mixed to adjust the temperature. This might seem tedious but it is essential to be able

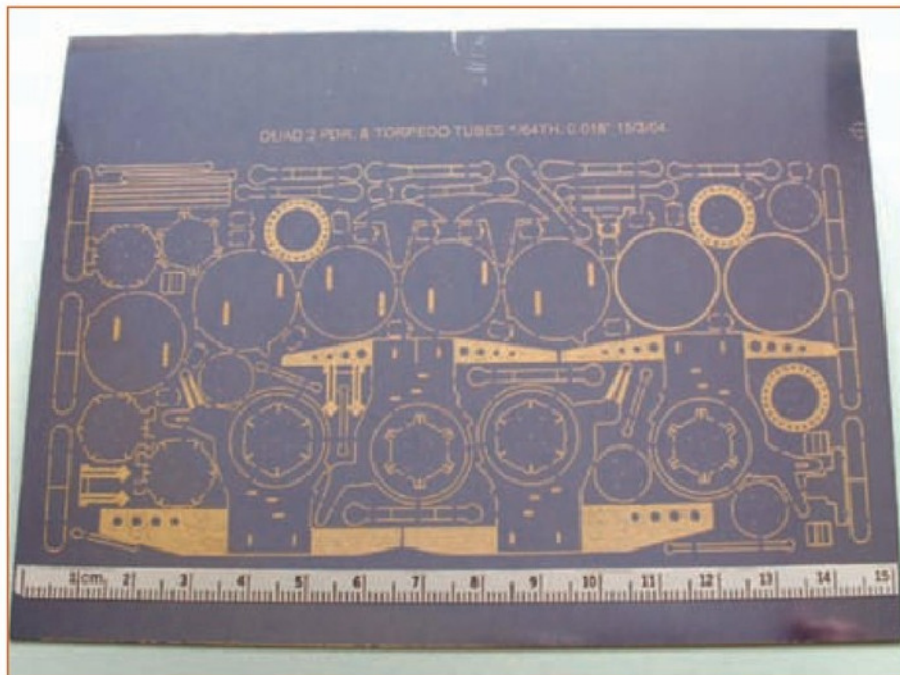
to control and reproduce the development process accurately. With experience the developing time can be varied to suit differences in temperature but it will still be useful to know what the temperature is.

The sheet must be held vertically in order to allow the developer equal access to both sides. The best method is to hold the top edge in locking forceps, of plastic or stainless steel. Various patterns of suitable stainless steel forceps are widely available from model suppliers. They are "surplus" surgical equipment but ideal for our purpose. Similar plastic forceps are also available, though much less readily, and these will be useful during the etching process where stainless steel is unsuitable. The plastic forceps are usually disposable items included in dressings packs, so it might help if you happen to know a nurse. Some plastic forceps do not lock, but can be made to grip by wrapping a rubber band around the handles. Both types of forceps are shown in **Photo 18**, together with a photographic thermometer.

After exposure the coating which was protected from the light will still look much the same but the unprotected coating will have become a lighter green or, possibly, blue (depending on the coating material) so the image will be visible. The transparent protective film must now be removed. It can be picked up if you rub your fingers across the edge of the sheet and it will then peel off very easily. It's a little more difficult to put it down though, as it carries a static charge. Put the sheet into the developer quickly and agitate it a little, then remove it just as quickly after about 20 seconds (for caustic soda) and plunge it immediately into a bowl or bucket of water to stop development. The unwanted film is not dissolved by the developer but lifts and peels off and, in the wash water. This can be helped by gently brushing the surface with a soft brush. If bright metal is visible along the etch lines then development is complete. If not, the sheet can be returned to the developer for another 5 to 10 seconds and the process repeated until the appearance is right (**Photo 19**).

It can sometimes happen that, while mainly satisfactory, one small part of the image is insufficiently developed. This can result from the transparency having been held a little away from the photosensitive layer, perhaps by a piece of PVC tape placed too close. In this case it would not be practicable to develop the entire sheet more but it can be carefully dried off and the affected area gently swabbed with a cotton bud dipped in developer, but take care not to overdo this. If you are really unsure whether the sheet has been developed enough for etching a quick check is to immerse it in etchant for a minute or so when the lines should become visibly dulled. Lines remaining bright will have been inadequately developed and can be treated again. However, the etchant is acidic and the developer alkaline so material transferred from one to the other must be thoroughly washed in between.

A relatively rare problem, mainly confined to older material, is to find that one side develops faster than the other. The "fix" for this is fairly obvious, but it works. When the faster side is satisfactory rinse and dry the sheet and cover this side with "low



19. The appearance is right when bright metal is visible along the etch lines.

tack" plastic tape or film, then continue to develop the other side. If you can't find suitable film, try an arts supply shop.

Do not discard the used developer as it will be needed again after the sheet has been etched. Only one stage now remains before etching, but it is important. Dry the sheet thoroughly and inspect it for faults. There is likely to be some damage to the photoresist film where it was gripped by the clamps and some at the edges of the sheet, caused in cutting. You might also find small scratches or, rarely but possibly, pinholes. There might even be lines in the wrong place, or a cut line that should have been a fold line. All of these can easily be retouched and repaired with the photoresist pen or with cellulose dope on a small brush, provided that you have remembered to look for them before etching. Generally, I prefer to use dope. It is a little more trouble but is a complete resist, which not all resist pens are. There will also be patches of bare metal where the sheet was masked by the PVC tape, and these can be covered with the dope, or with the same pieces of tape that caused them (I hope that you didn't throw them away). With care, it is also possible to put in a line that was missed by scribing it carefully with a small cutting knife. This is preferable to a scribe point as the resist is slightly brittle and can flake at the edges of the line.

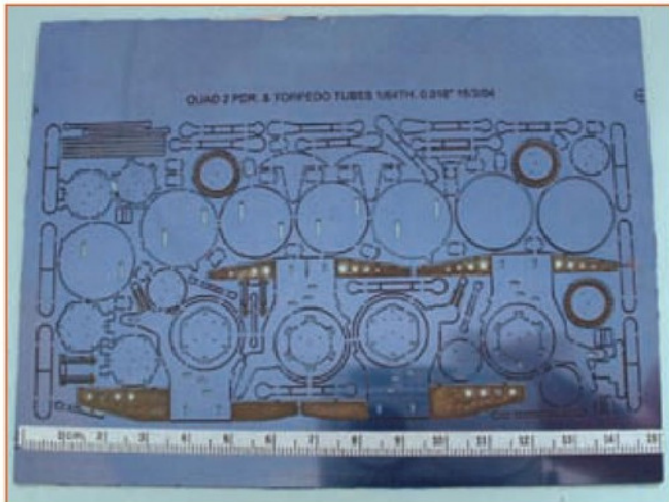
Etching

The etchant is a strong solution of ferric chloride, which can be bought from electronic component suppliers in the form of pellets to be dissolved in water. The pellets are usually in 250 gramme prepacks and no weighing is needed but you will need the one litre bottle again to measure the water. 500 grammes are dissolved in about 0.75 litres of water, which is then topped up to 1 litre. Full instructions will be included in the pack and, as with the developer, distilled water is not necessary unless you want to use it. Once made up it can be used repeatedly and should be

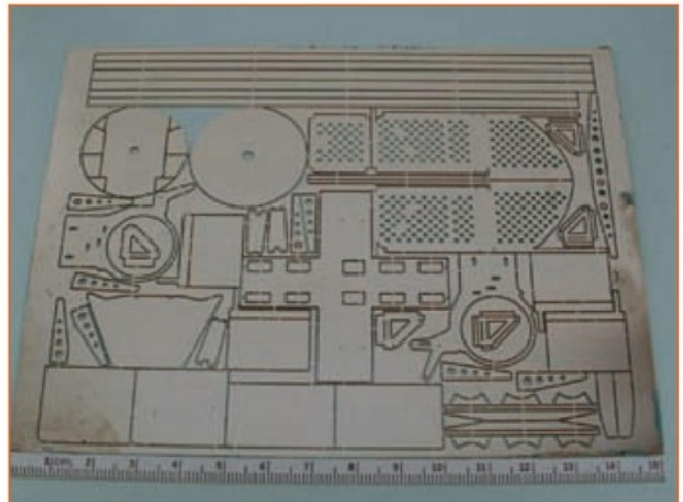
stored in glass or, preferably, plastic containers. It is corrosive, but not highly corrosive, and the recommendations made above for handling the developer also apply to the etchant. Apart from being corrosive it also stains if not promptly rinsed off and I have more than one yellow polka dot shirt to prove it. Any tools or equipment used with ferric chloride are best kept for this purpose and if you intend to do the developing and etching on the draining board, which is conveniently close to rinse water, thorough cleanups might avoid management disapproval (been there, done that, got the T shirt – a spotty T shirt).

Unlike industrial practice, the etching time is not calculated but is based entirely on visually checking progress at intervals (i.e. have a look at it from time to time). The actual time will, of course, depend on the metal thickness but also on the temperature of the etchant and how much it has been used. As the etching time is much longer than the developing time precise temperature control is not needed but it is helpful to use the etchant warm (overnight in the airing cupboard again). As a rough guide a 0.25mm. brass sheet will take about 75 minutes to etch in new solution at 25 degrees Centigrade.

The sheets should be suspended vertically in the etchant, in the same way as when developing. In this case it is not only to allow the etchant free and equal access to both sides but also to help clearance of the etching by-products. Industrial etching provides for this more effectively by spraying the etchant, which is not really practicable at home. I have tried bubbling air up through the etch tank using a fish tank air pump, which does help the etching process but generates a fine mist of corrosive etchant over the top of the tank. This, in turn, can cause rusting of nearby equipment. Since it is difficult to cover the tank effectively without interfering with access to it I have abandoned this approach. Agitating the sheet by hand requires constant attendance so this is not really practicable either, though some sort of



20. Before removal of resist.



21. After removal of resist

mechanical device might help. Peter Rawlinson mentioned a rocking table system in the May/June 2004 issue of MEW, and Chris Fouweather described a method of air agitation in the August/September issue. Both also suggest a higher etch temperature. However, while a higher temperature will give a faster etch, you will need to take more care in deciding the end point to avoid the risk of over etching. This is much more critical than when etching PCBs as the etch is from both sides and if the etching is allowed to continue after the line is cleared the edges of the masking will be undercut and the line widened. Similarly, holes will become larger than the designed size. On balance, for etching metal it's probably better to take a little longer and be a little safer.

Either of the suggested methods of agitation should improve the uniformity of the etch. Without agitation some variability of the etching across the sheet is inevitable, particularly on large sheets. In addition, horizontal lines will tend to etch more quickly than verticals, though these effects can be minimised by rotating the sheet 90 degrees at about twenty minute intervals. When examining the sheet to decide when the etching is complete you might find an area in which the lines are not completely cleared when the rest of the sheet is etched, in which case it is much better to settle for this. The residual metal in the incompletely etched lines will be extremely thin and easily removed but leaving the sheet in longer will almost certainly result in some of it becoming over etched and, perhaps, unusable. Overall, however, this is not a serious problem but more a factor to allow for.

If a construction line is required on the surface, perhaps to help in assembling etched components, it can be included in the design at a line width of about 0.125mm. Then, after the sheet has been etched for about five minutes, it should be rinsed and dried and the construction line blanked with the photoresist pen before continuing with the etching. Don't be tempted to rinse and dry the partly etched sheet and put it aside to complete the etching later. If this is done then small areas of resist, for example lettering, can dry out and separate from the metal.

Removing the resist

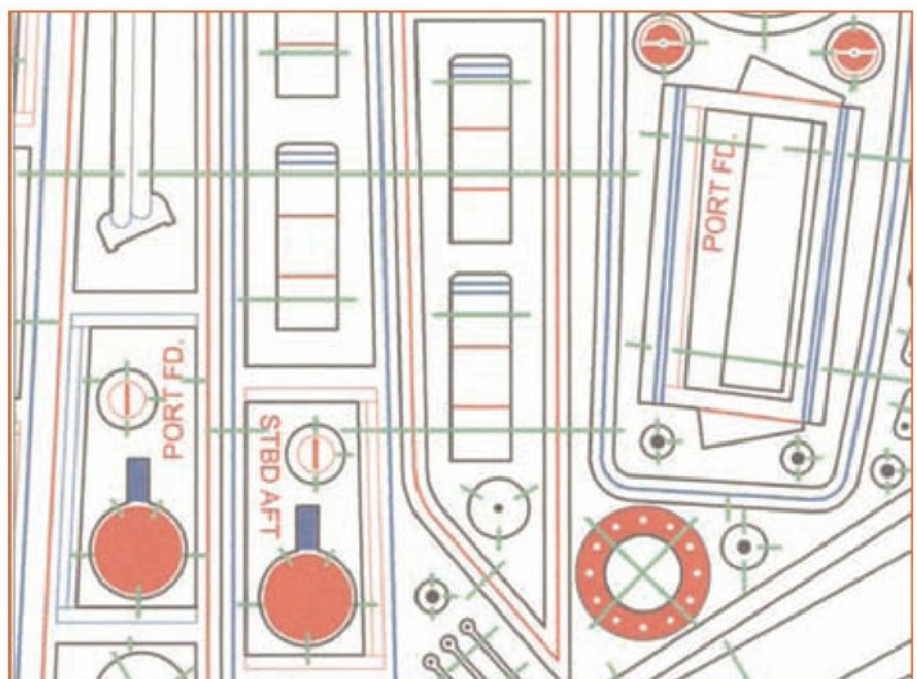
After rinsing the sheet thoroughly it can be put back in the developer to remove the resist film. In a few minutes the film will lift from the metal. Depending on the coating material, it might also become paler and difficult to see until the sheet is lifted out of the developer but the use of the soft brush again will help to remove it. Temperature and time are not critical but the metal shouldn't be left in the developer any longer than necessary or the surface can become discoloured, though it can easily be cleaned with a glass fibre pen or some fine "wet and dry" paper. Alternatively, try Cillit Bang which really does clean up brass as well as the TV advert shows.

If you have used sodium carbonate developer you will need to make up a Caustic Soda solution for stripping. The manufacturer's recommendation for this is a 1.5% to 3% solution. A £1 coin, plus 2p and 1p coins are almost equal to 20 grammes which, made up to a litre, will give a 2% solution.

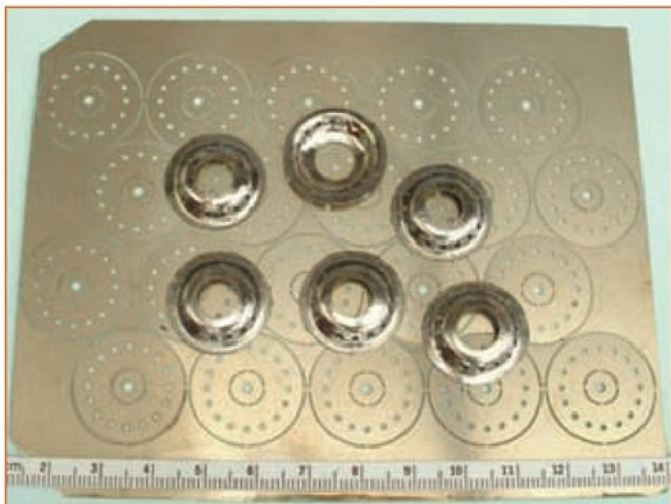
The used caustic soda developer can now be discarded but the film should first

be removed from it, which is easily done by pouring it through a nylon mesh kitchen strainer. As the film is rinsed in the strainer it will return to its original colour and can then be thrown away. Disposal of the used developer is no problem either, as caustic soda is used in much stronger solutions for cleaning drains and it can simply be washed down the sink though, if the caustic soda solution is to be used only for stripping, it may be kept for reuse. Acetone will remove etch resist pen marking. It will also lift the resist film, though much less easily than the developer, and it is an additional expense and could present a disposal problem. Typical etched sheets, before and after removal of the resist, are shown in **Photos 20 and 21**.

The Swordsman requirement included a number of ventilators, which were to be pressed to shape and needed to be thinner than the main sheet of etchings, which was 0.5mm thick. The blanks were made from 0.25mm. brass, then annealed, pressed and nickel plated, though the use of a suitable nickel silver alloy might have avoided plating. These represent another



Drawing 3.



22. Finished ventilators with a sheet of etchings.



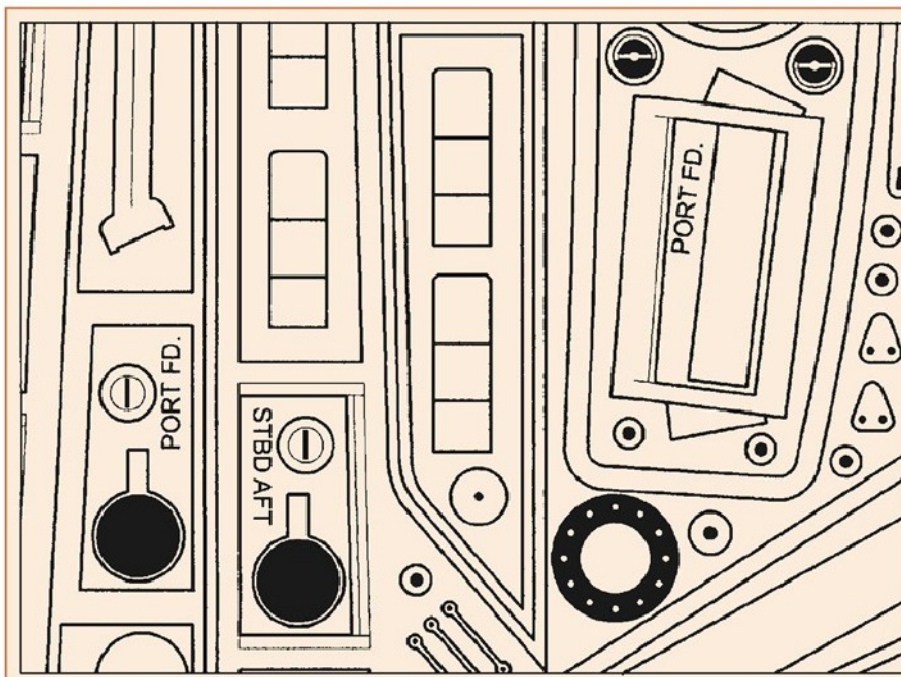
23. Full size item for comparison.

application for etched components and some finished items are shown in **Photo 22**, together with a sheet of etchings. The holes become elongated in the pressing operation so an attempt was made to compensate for this by designing them as ellipses rather than as round holes. For comparison, one of the full size fittings is shown in **Photo 23**.

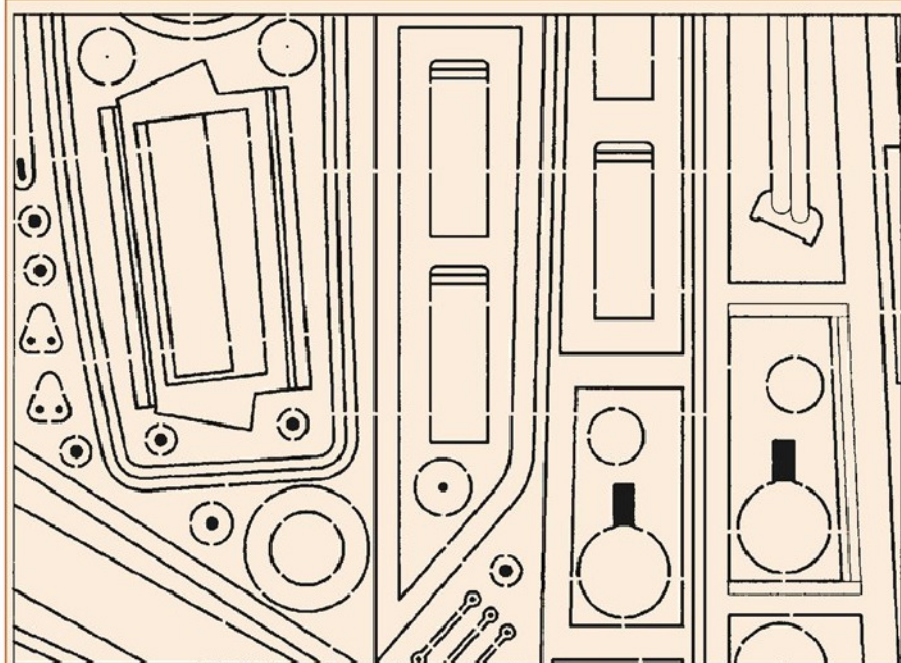
Metal thickness & quality

The choice of thickness is largely governed by the scale of the model and/or the particular component being made. For modelmakers one of the advantages of etched metal is the opportunity to make components in scale, or near scale, thickness and this would be wasted by using material that is too thick. However, there are some practical considerations. I have used 0.2, 0.25, 0.3 and 0.5 mm. (8, 10, 12 and 20 thou.) material depending on the application, and thicker or thinner sheet is completely practical. If no surface detail is to be added then any thickness can be used, but if half etching of large areas is part of the design then the final thickness becomes a factor. I half etched some gunshields from 0.25mm. brass to show raised detail and consequently they ended up mainly 0.125mm. thick. This made assembly more difficult, which might have been avoided if I had started with 0.3mm. sheet. The difference in final thickness of the etched areas would have been only 0.025mm. (1 thou.), but it is surprising how much this can affect the handling. A further factor is the prominence of the surface detail, which becomes progressively greater with increasing sheet thickness. This can be either an advantage or a disadvantage, depending on the component that you are making, but should be taken into consideration. The badges and nameplates shown in **Photo 6** of part 1 of this article, were made from 0.5mm. material, giving a minimum thickness of 0.25mm. and prominent raised detail. These will eventually be painted to leave the plating showing only on the raised detail.

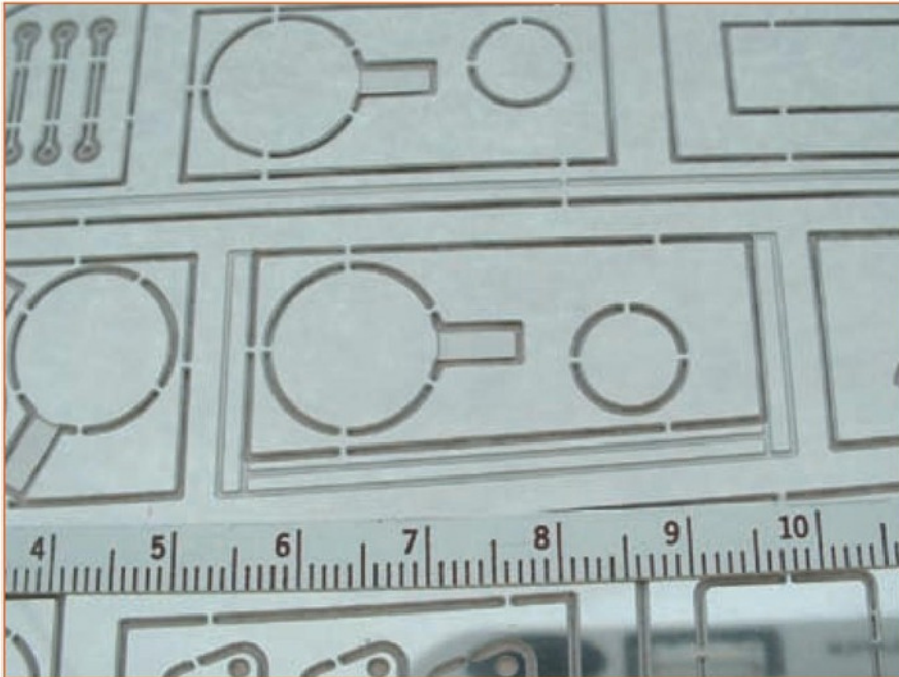
The metal will, of course, be the standard product which the supplier uses himself, and which he would have used if he had done the etching for you. Brass and



Above: Drawing 4



Below: Drawing 5



24. The "frying pan" shapes are exhaust pipe cover flaps.

nickel silver will normally be "half-hard", which is ideal for most work. It is stiff enough to stay flat in normal handling and will allow bridging tabs to be cut with a craft knife tip without distorting or buckling, but material etched down to half thickness is softer than the full thickness sheet, which contributed to my problems with the gunshields. Where the thin section is surrounded by full thickness material (as in the "Swordsman" nameplate shown previously) this usually causes no problem, though a nameplate etched from sheet thinner than about 0.5mm. can become bowed. The supplier attributes this to the loss of the surface stresses in the side that has been etched away. However, if the thinned section has tabs (there are some examples in **Photo 20**) then it is likely to buckle when the tabs are cut. Not a major problem, but something to be aware of. If you have a particular requirement, for a highly polished surface or for a springy phosphor bronze, for example, the supplier will usually be able to help.

Storage

Ferric chloride solution can be kept in plastic or glass containers for long periods and there are no special storage conditions apart from the usual commonsense precautions of clearly labelling it (including the warning "Corrosive") and keeping it well away from children. Used caustic soda developer should not be kept for reuse but, fortunately, it is not expensive to make up as required. However, if it is a solution used only for stripping it may be stored and reused, with the same storage precautions as for ferric chloride. Coated metal must be kept in the dark and protected from extreme temperatures, particularly heat. I keep it wrapped in black paper, in a biscuit tin. Don't rely on plastic binbags alone, they're not opaque enough. Properly stored it has a nominal shelf life of a few weeks but I have used material that was over a year old without problems apart from the developing time being

slightly extended, sometimes a little more for one side than for the other. If requested, the supplier will usually cut the standard 12in. x 18in. sheet into two or four parts, which makes packing, subsequent cutting and storage all much easier.

Computer design

As noted earlier, producing the artwork and transparencies on a computer is quicker, easier and more accurate but it is also cheaper since the cost of materials is much lower than the copying work which it replaces. Using new techniques is always frustrating in the early stages when you could be making better progress with the old methods but there are great advantages in computer designing. If you are an old hand at Computer Aided Design then you won't need any advice from me, but, if it is new to you, I hope that you can be persuaded to give it a try. The following general notes assume that you are familiar with the computer, but not with CAD.

Drawing can be done in many programs, and some are specifically designed for it. However, graphics and photo editing programs work in bitmap, which builds images up from small units, or pixels, and if a drawn line is enlarged enough it will be seen to consist of a series of small squares. This system is too coarse for engineering drawing and CAD programs produce vector drawings, in which a line will remain a true line however much it is enlarged. Vector drawings are not confined to the squared grid format imposed by pixels and are completely scaleable. On the monitor screen a curved or diagonal line in vector might look as if it is stepped but it will print as a true line. That is a bit simplified but the underlying point is that you will need a vector based drawing program, preferably a CAD program which will also have a range of drawing aids and shortcuts. There are several of these, the industrial standard (and probably the best) being AutoCAD. Unfortunately, AutoCAD is very expensive and is never available as a magazine



25. Full size exhaust cover flap.

"freebie". I believe that TurboCAD is probably the best of the others and a free copy of version 7.1 of this was given away with "PC Format", September 2003 issue, and "PC Answers", October 2003 issue. If you don't already have a CAD program of some sort then there might be some back numbers still available. Alternatively, you might find other CAD programs being given away or sold off cheaply as newer versions are produced. (See also *Chris. Fouweather's comments this issue pp12 - 15- Ed.*) However, if you have difficulty in obtaining any of these TurboCAD has now reached version 10.5 Pro (costing, at the time of writing, about £200) but earlier versions are being sold at reduced prices.

Version 8 is the oldest and cheapest I have found currently available and it can be bought for about £15 as an upgrade for current TurboCAD users. The "stand alone" version for new users is about £25 but the UK distributors have kindly agreed to make it available at the "upgrade" price of £15. You shouldn't have any problem in buying at this price but, if you do, mention having seen this article in "MEW". Though more expensive than buying a back number it will get you a later version and, more usefully, a manual which tells you which buttons to push.

These notes on CAD artwork preparation will cover only the stages of the work since the different programs vary in the ways in which they do things. However, these should be covered in the program manuals or the help files, together with the basic drawing techniques. You will need to decide at the start whether to work in the model scale or in the measurements of the prototype. The first, in which all drawing dimensions will be those of the model, is probably easier unless you are working from a dimensioned drawing of the full size subject. In this case, setting the scale ratio in the program will enable you to take sizes straight from the drawing dimensions. You can then work to these dimensions on the screen but the program will convert them to model size when printed. Similarly, it is possible to work from a drawing in one scale and produce the finished designs in another. Line width can easily be set, but must be taken into consideration when drawing. As in drawing manually, if a rectangle is required then the line width must be added to each dimension so that the



26. Tank made from 2mm polystyrene sheet shown with chemical packs.



27. Home made light box.

enclosed rectangle will be the correct size. The line width of the finished drawing can easily be changed but, if it is, the rectangle will need to be redrawn to new dimensions to allow for this. Producing repeat drawings of components is simply a matter of instructing the program to do it, and separate component drawings can be made and then brought together in a composite design. The design for the 18in. x 12in. sheet for the Swordsman was done in this way. When they are brought together (by "copy & paste") it is a simple matter to rearrange and nest them to make the best use of space.

Use of layers

When the basic drawing is complete, including all cut and fold lines for both sides, it can be separated into layers. Layer 1 might consist of all of the cut lines, common to both sides, layer 2 might be the fold lines and detailing on one side and layer 3 the fold lines and detailing on the other. The bridging tabs could then be added to layer 1 and subsequently separated as layer 4. In order to differentiate between the layers when they are all viewed together it is common to make each layer a different colour. If this has been done then layers 1 and 2 together would be converted to black to print the first transparency. Layers 1 and 3 together converted to black, plus layer 4 converted to white, would be used for the second transparency. One of the two will need to be reversed to a mirror image before being printed, which is simply a matter of instructing the program to do it. However, if text forms part of the design it will not reverse with the rest of the image unless it has first been converted to flexible format. Again, this is just a matter of giving the program the right instruction.

Drawings 3, 4 and 5 provide an example of a layered design and in these you will see that adjacent components share common cut lines. In **Drawing 3** the lines common to both sides, i.e. the cut lines, are in black, the lines and areas to be etched only on the front of the metal are in red and those on the back of the metal in blue. The bridges, or tabs, which will be on

the back, but in a different colour, are green. In **Drawing 4** the blue and green lines are removed and the red have been changed to black. In **Drawing 5** the red lines have been removed, the blue changed to black, the green changed to white and the drawing reversed.

The transparent masks can now be printed from **Drawings 4 and 5**. These drawings are actually taken from the Swordsman design and contain examples of single sided etching to produce surface detail. In the upper right corner there are two lifting handles and, lower down, an exhaust pipe flange with raised bolt heads. The "frying pan" shapes are exhaust pipe cover flaps. These are reduced to 0.25mm. thick with a 0.5mm. rim. The opposite side of each of them has the "handle" reduced to 0.25mm. to allow it to be rolled to form part of the hinge. These flaps can be seen in the detail from the etched sheet in **Photo 24** and, full size, in **Photo 25**.

Transparencies can be laser printed, but inkjet printers are more common and are equally suitable provided that they are set to give an adequately dense black. The standard "plain paper" or "transparency" settings are unlikely to be dense enough but a little trial and error printing of black panels on an overhead projector transparency should quickly enable you to find a suitable setting for your printer. As a guide my HP880c is satisfactory on "other transparency film" provided that it is also set to "best" and is using HP ink. My Epson 980 gives good results when told that it is printing on "premium glossy photo paper" or is set to "photo quality inkjet paper", "black and white" and "best". If a transparency for positive photoresist is needed the program can invert the black on white to white on black before printing.

If the design is to be etched professionally a layered drawing is usually acceptable and the company concerned will advise on the preferred colours. However the file format will also need to be one which the company can handle. Acceptable formats are likely to include Encapsulated PostScript (eps), Windows meta file (wmf), Drawing Exchange format (dxf) and AutoCAD drawing file (dwg).

TurboCAD can convert into all of these, though you might have some difficulty with dwg since there are different versions of this corresponding to the version of AutoCAD used.

Equipment

While some of these items of equipment, and all of the materials must be bought, most of the things needed can be made, "found" or borrowed from the kitchen (provided that they're not for use with ferric chloride). Sources of supply and costs will be given at the end of this article.

The main items required are: -

- Drawing pens.
- An etch resist pen.
- A white correction fluid pen.
- A photographer's thermometer.
- An ultraviolet light box.
- Developing and etching tanks
- A plastic bowl or bucket.
- A 1 litre measure (a plastic lemonade bottle will do).
- Plastic forceps or tongs.
- A kitchen timer (or similar).
- Small scales, to weigh up to about 42 grammes (these are not readily available but small balances made for weighing letters sometimes turn up at boot sales).
- Developer.
- Etchant.
- PVC insulating tape.
- Thin double sided tape.

The items which are less readily available are the larger sizes of developing and etching tank and the light box. I keep a plastic "Ovaltine" container full of etchant since this has a plastic screw top and the mouth is wide enough (65mm.) to take very small work. Larger tanks should be generally rectangular to keep the volume down and a cut down "Sunny D" bottle will accept pieces up to 110mm. square. The largest sheets which I have etched are 6in. x 9in. which is a quarter of a standard sheet, and for these I have made up tanks (250mm x 275mm x 45mm) from 2mm polystyrene (**Photo 26**). The flange around the top is for stiffening and the pouring lip is well worth fitting as these tanks hold almost 3 litres

and are not easily emptied without spillage. Alternative tanks might include the "Tupperware" type containers for breakfast cereals, which are available in two sizes.

My home made light box (**Photo 27**) is very similar to the box described by Peter Rawlinson in the May/ June 2004 issue. It is a plywood box 220mm x 410 mm x 80mm with a 165mm x 270mm panel of 4mm glass set into the top. There are four 8 watt fluorescent tubes under the glass and 50mm from it. The inner two are UV tubes, 70mm. apart and the outer two are standard light tubes, 120mm. apart. A 25mm thick pad of polyurethane foam is fitted in the lid to press on the glass when the lid is clipped shut. The box has an electronic timer that switches the tubes off and sounds an alarm when the set time period has elapsed. The tube inverters can be switched to drive either the UV or the light tubes but the UV tubes are subject also to a microswitch and will not come on until the lid closes. A second switch is fitted to start the timer when the lid is closed. The timer and alarm are not essential as a kitchen timer would be equally effective, but do fit the lid switch to prevent the UV tubes being visible when they are on. The fluorescent light tubes and the inverters which supply them can be obtained fairly cheaply by taking them from a fluorescent lead lamp or camping light, and the UV tubes can be bought from an electronic component supplier.

Construction of the light box can be greatly simplified by adopting the idea of one of my fellow club members who is equipping himself for metal etching and is basing his light box on an old scanner. This is an excellent idea as it provides the box, the glass screen, the lid and pressure pad and the mains connection lead and clamp. It reduces the work required to installing the tubes, drivers and switches and fitting a suitable clip to the lid. One of the older, deeper scanners would be preferable to a "slimline" version since it will enable the tubes to be set far enough from the glass to obtain a good spread of light and avoid large variations in light density across the screen. This has not been a problem with my box so the spacing given above should be satisfactory. However, at first I was concerned that it might cause difficulty and made both opal and clear diffusers, to fit under the glass, from old fluorescent light fittings. They were not needed but should provide a solution if you encounter this problem. The inside of the box should be white or lined with aluminium foil, or the reflective material that is sold for backing radiators.

Whether you make or buy a light box you will need to establish exposure times for each type of coating that you use. Spray coatings will differ from film coatings, precoated PCBs will be different from precoated metal, and both can differ between suppliers. Calibration is tedious but not difficult. Print a small test transparency and expose small pieces of sheet for varying periods, in the same position on the glass each time, and then develop them under standard conditions. Exposure times and developing times are interactive but exposure time is longer and easier to adjust. I suggest that you expose the first sample (one side only, with the film in place) for four minutes. Remove the film and develop it for a fixed time at 25°C.

Suppliers

The following list is not exclusive and there are other suppliers. The examples given are mainly sources that I have used, though I have included some alternatives. I have, of course, no connection with any of them, except as a customer. The guide prices given include VAT and were correct at the time of writing.

TurboCAD v7.1	PC Format Magazine	0870 444 8470
TurboCAD v8	PC Answers Magazine	01225 442244
	Avanquest, The Software Centre, East Way, Lee Mill Industrial Estate, Ivybridge, PL21 9GE. Telephone: 01752 895100. E- Mail: sales@guildsoft.co.uk	
Thermometer.	Jessops	£8.50
Twin tube fluorescent lamp (12V)	Argos	£15.00
Twin tube fluorescent lamp (Rechargeable).	Argos	£15.00
Replacement 8 Watt tubes	Homebase	£3.00
Sodium hydroxide (Caustic Soda) 500gms.	B & Q	£2.78
	Homebase	£2.49
Cereal containers	Sainsbury etc.	£3.00

The following items are available from

Rapid Electronics Ltd., 01206 751166
Severalls Lane, Colchester,
Essex, CO4 5JS.

They are also available from several other sources but usually at higher prices.

UV exposure box with timer.	£124.00
Two 8 Watt UV tubes with starters.	£14.50
Ferric chloride for 1 litre of etchant.	£4.50
Ferric chloride for 5 litres of etchant.	£14.00
Etch resist pen.	£0.90
Glass fibre pen	£4.70
LCD timer with alarm (85-1465)	£10.00

Precoated 18" x 12" metal sheet can be obtained in various materials from:

Photo Etch Consultants Ltd., 01543 371133
Unit 19, Maybrook Road,
Brownhills, Walsall, WS8 7DG.

Approximate prices for brass sheet are:

Up to 0.25mm.	£11.60
0.3mm.	£11.90
0.4mm.	£13.90
0.45/0.5mm.	£15.25
0.55mm.	£16.35
0.7mm.	£17.30
0.9mm.	£27.45

There is no minimum order.

Packing & delivery extra.

Alternatively:

Photofabrication (Services) Ltd., 01480 475831
14, Cromwell Road,
St. Neots, Huntingdon, Cambs. PE19 2HP.

Approximate prices for brass sheet are:

Up to 0.3mm.	£8.23
0.4mm.to 0.5mm.	£13.16

Other thicknesses are also available.

Minimum order value £35.25. Packing & delivery extra.

The handling and processing described above will be suitable for photoresist film coated sheet from either of these suppliers.

Subsequent exposures, if required, can be adjusted up or down until you are satisfied and I would suggest initial steps of 30 seconds. Finally, expose a strip laid across the full width of the glass to check that the spread of light is sufficiently even.

The final stages

The etched sheet needs very little further treatment before the parts are used. If the sheet is placed on a flat wooden surface, with the bridging tabs uppermost, they can easily be cut with the tip of a craft knife, as

noted above. The stubs of the tabs can be cleaned off with a small, fine file, or a piece of "wet and dry" wrapped around a piece of wood. The cut edges are not square, but are actually as shown in **Drawing 1**. In practice, the effect is very slight but the edges can easily be dressed, if required, when removing the tab stubs. However, use a light touch as it is easily overdone. Half etched areas might have a dull and discoloured finish, but this is readily removed with the glass fibre pen, or the Cillit Bang suggested for stripper discolouration.



DRILL GRINDER 2

Mr J. Winkel of Sassenheim, Holland continues with an overview of, and constructional notes for, his drill, tool and cutter grinding machine.

An overview of the grinder

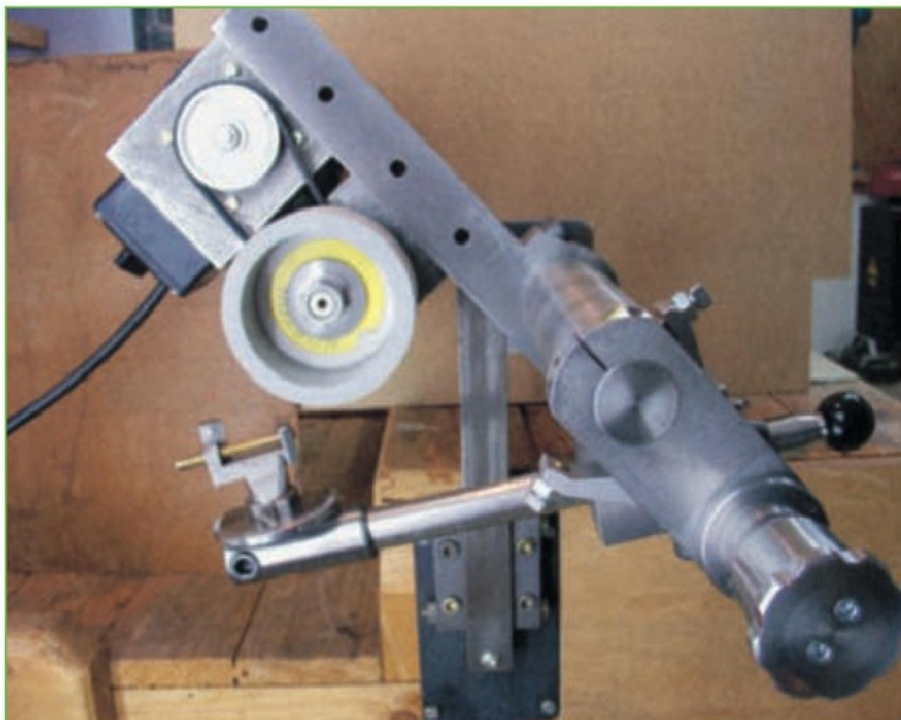
The main part is a frame bar 50mm dia. – 300mm long, with a connection part (4) mounted to or on the workbench. To this bar are connected grinding wheel assy, which can be clamped in a convenient position, and a second guiding shaft, which can rotate around its axis and be moved axially (stroke ~ 10 mm). On this guiding shaft is mounted an axially movable and rotateable connection part (6). In this part a swing arm 5 is clamped, also axially movable and able to rotate in a desired position by using the degree scale and indicator on the reverse side.

In a bored location hole at the other end of the swing arm (5) different toolholders can be clamped, to set in any desired position, if need be, using a degree scale and indicator. For grinding drills, the pivot pin 43 has a preset ring for a desired drill tip angle but can also be used with the scale for other angles. There are two adjustable stops on guiding shaft 22 (to limitate the rotation in two directions).

The electric motor rotates clockwise (looking on the shaft). The lower section of grindingwheel is used for grinding tools so that tool motion is against wheel rotation.

Grinding tools is done by using toolholders (Drg 40) which shows various accessories.

- Drill holder 41,42 and 43.
- Lathe tool and dresser holder 57.
- Part 61, toolholder for cutters. discs are to set on the rear of the shank for 2,3 and 4 position., all my cutters have only four shank diameters, namely 6,10,12 and 16mm.



1. Grinder fitted to bench showing later fixing.

For grinding a single point lathe tool for internal thread and to get an accurate angle, part 59 is clamped in swing arm 5 (photos 5 and 14). The lathe tool mounted in part 57 in turn located in part 58, has its point on the centre line projected from part 59. Parts 55 and 56 may be used to set the correct angle.

Photos 4 and 5 show a later addition to improve setting edges at 180degrees.

Notes on building methods

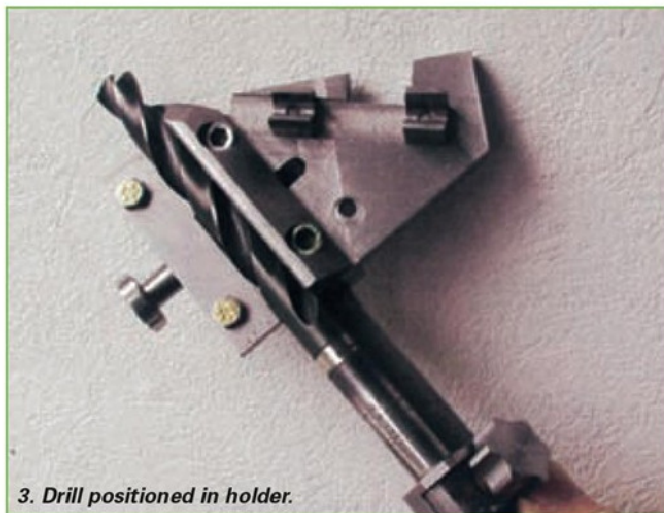
The manufacturing methods used by others will depend very much on the equipment available, but I will offer a few comments on my own methods. I never used a scriber to mark out lines. I position the workpiece on the milling machine table

as accurately as possible, setting it square and parallel to determine the x,y and z-datum locations and use the slide micrometer dials to locate the exact locations. I start by centre drilling all the possible features at one setting and then proceed with drilling, tapping, boring etc as necessary.

This is all easy to do quite precisely with the Myford VM-B milling machine I have. For extended head movements, I use an adapted electric pistol drill to rotate the hand wheel. After changing tools, resetting in Z-direction is easy to do with a digital scale. A 55mm outside diameter drill chuck with a 20mm shank can be placed in the collet chuck for drilling and tapping threads; during tapping the shank is only guided in the collet chuck (the collet chuck is loosened a little, so the drill chuck can be easily rotated manually in the collet and



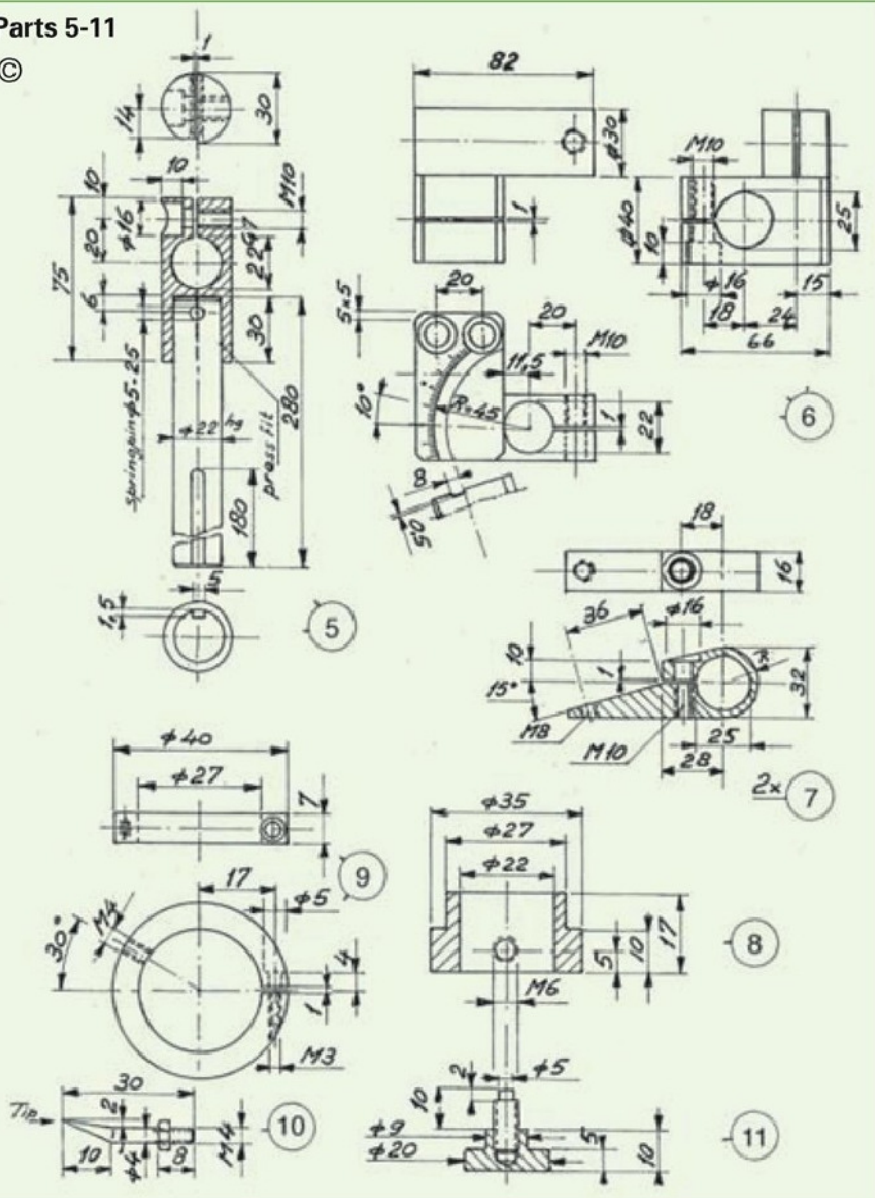
2. A selection of attachments.



3. Drill positioned in holder.

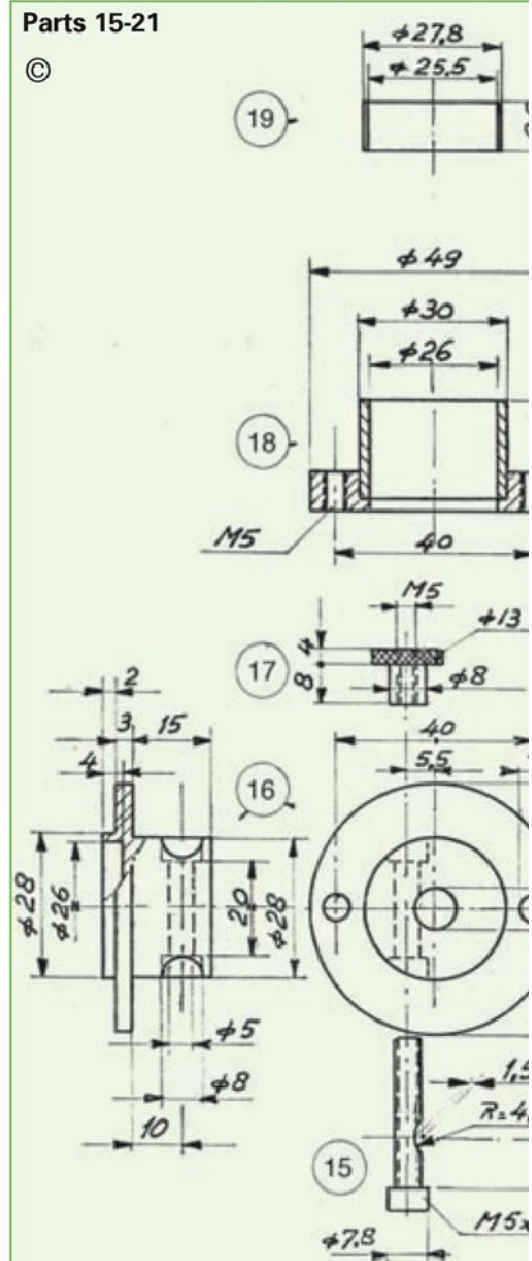
Parts 5-11

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Parts 15-21

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carbide tipped tool allows an optimal speed / diameter relationship. My personal tip for achieving an excellent finish is to machine holes from **BOTTOM TO TOP**. Thus you are pulling the boring tool upwards. That's the reason why all the components featuring large bores are designed with through holes.

The main advantages are:

- Chips are falling down through the whole diameter.
- Feed is more constant with "pulling the string", (the feed is contra gravitation force.)
- No stick-slip effect.
- There is no chatter, so there is a very good surface finish.

This means also that I could use (contrary to the theory) a bigger diameter boring tool 18mm x 90 mm long, at the end holding an adjustable 6mm tool bit to make bores from 22mm dia. upwards. Here the tip of the boring bit is sticking out just 2 mm (following a 21mm drill).

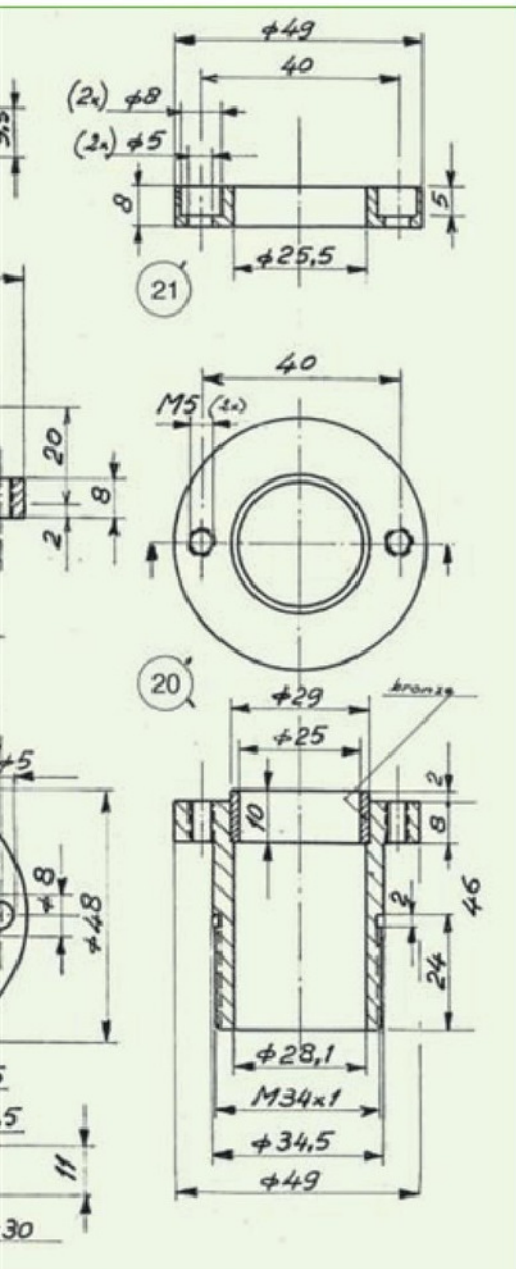
The 62 mm bearing location hole was also done in this way.

Parts 12-14

using the drill quill to lower and raise the collet chuck.)

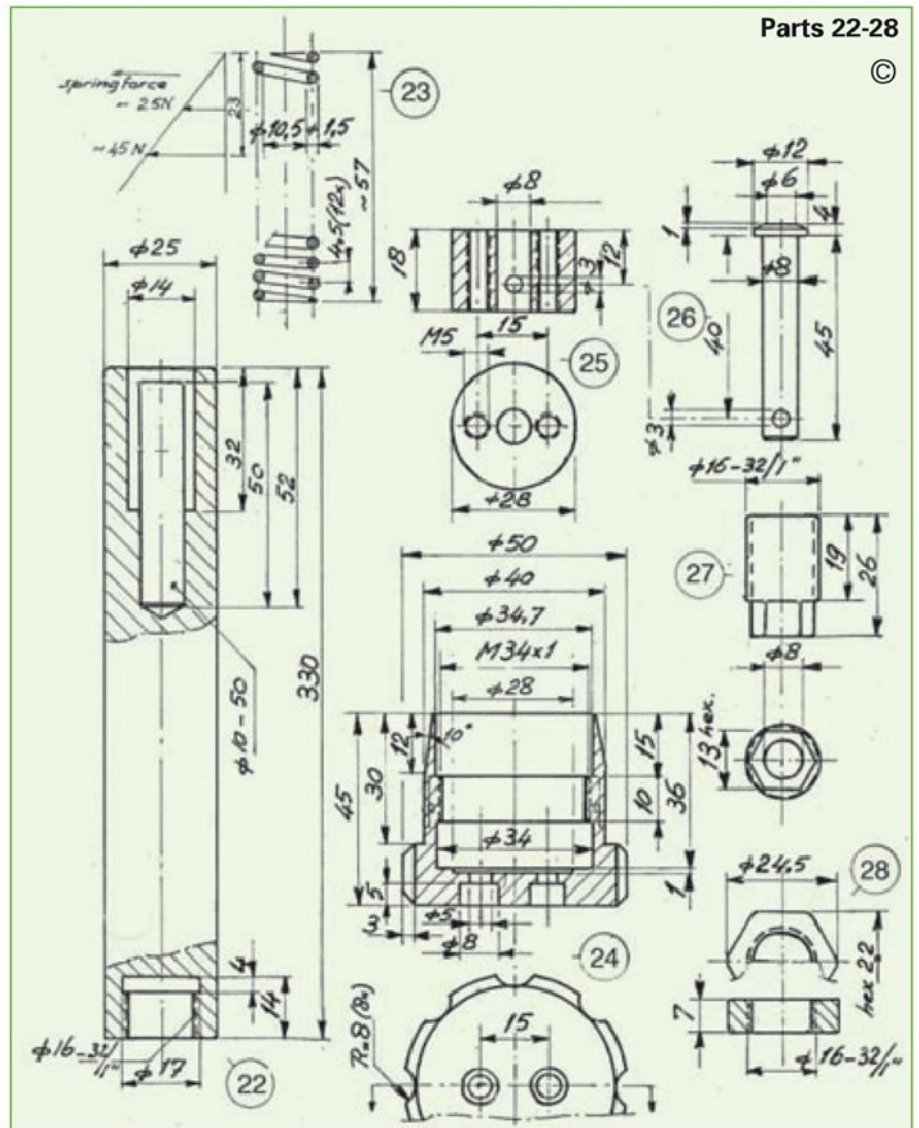
This job required a considerable

number of faced surfaces, and for these I employed a boring head (its inertia gave a good flywheel effect.) Using a tungsten



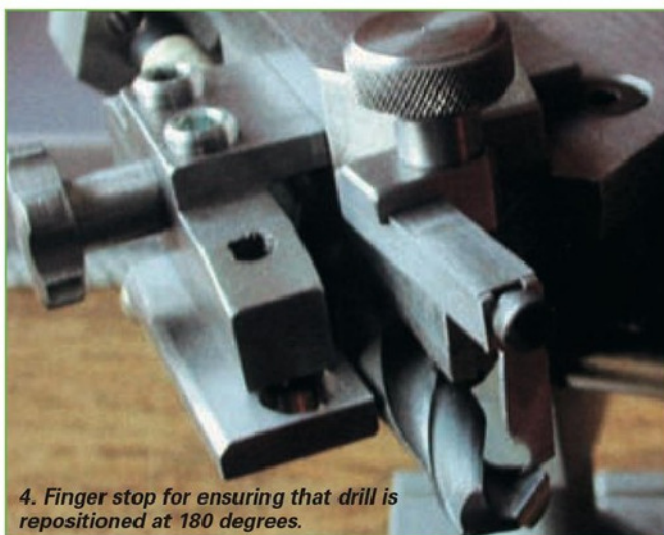
For the most mill and drill operations, the work is located in a milling vice.

In its original form, this milling vice was located in the middle slot on the mill table. In this position, the rear of the vice could foul the vertical column.



Modification to the vice consisted of cutting two extra slots. This allowed the use of four bolts, and also a rapid set up arrangement using close fitting eccentric pins, which adjust squareness. These fit closely the Tee slots and those in the vice base, and allow fine adjustment by having the two diameters arranged with about 5 thou eccentricity. Rotating one or both pins then moves that bolt position a small amount prior to nipping

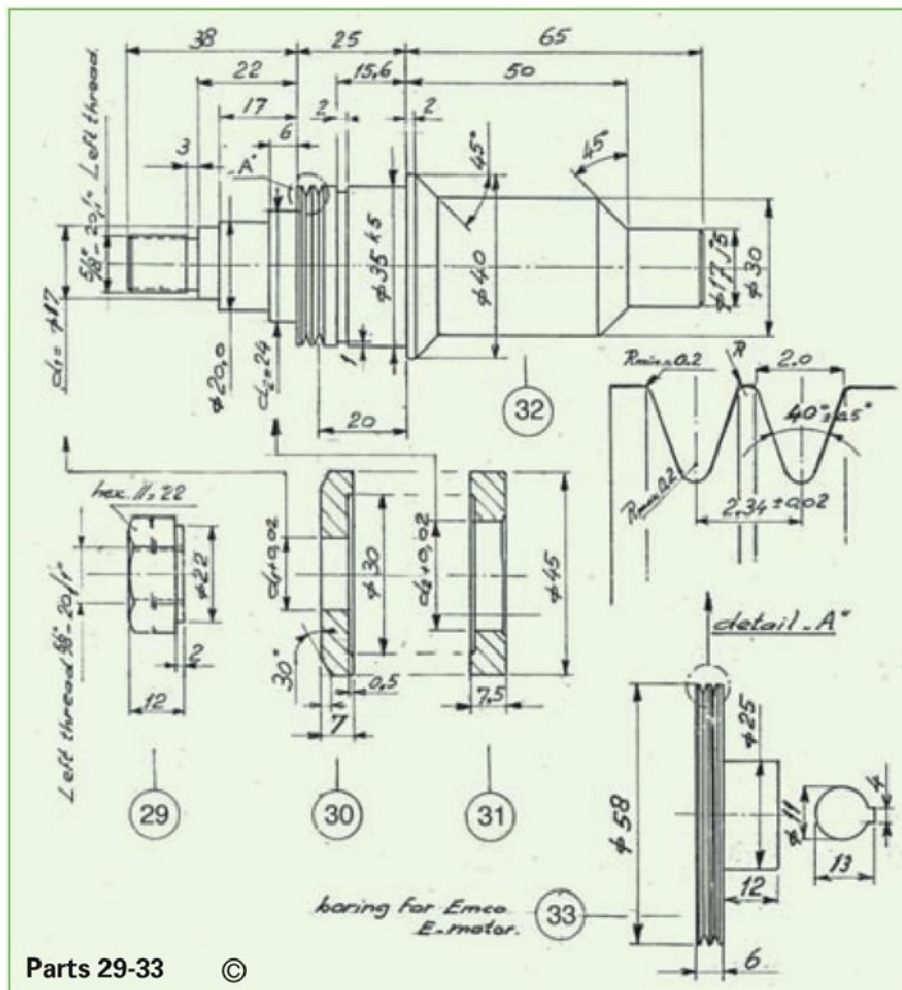
up. The pins are then removed and replaced by bolts. For levelling, I use either parallels or a very sensitive spirit level (one line = 0.04mm/m). Angular positioning is achieved by using a combination of four jaw chuck and rotary table. Setting the workpiece in the chuck is mostly done in the lathe, accurate changeover to rotary table being achieved by a close fitting location spigot.



4. Finger stop for ensuring that drill is repositioned at 180 degrees.



5. Grinding with finger stop in position.



Parts 29-33



Notes on drawings

Let me begin by saying that apart from a few exceptions, I did not put tolerances on the drawings. (I do not undertake series production or spare-parts). All the parts are made from normal bright mild steel material (except some bronze bushes). The bolts chosen have been reworked in the lathe to reduce the head diameter to just less than the selected end mill size. As my Myford lathe has an 8 tpi leadscrew, most of the threads are Imperial.

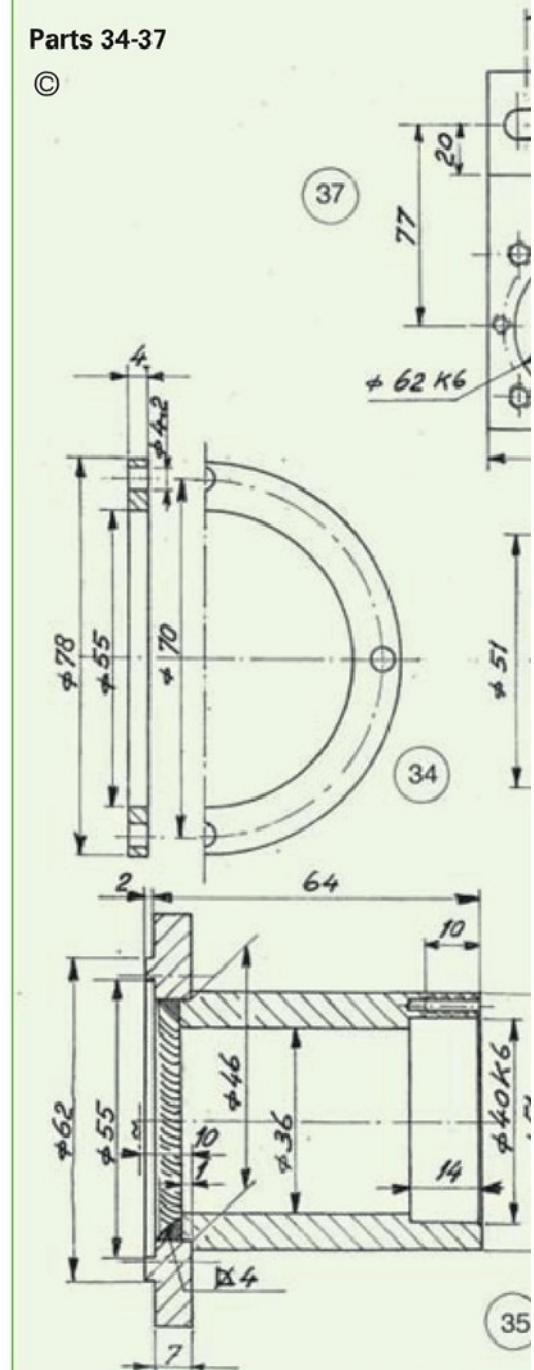
Drng 4 Grinder attachment to workbench Attachment of the 50mm dia mainframe bar to the workbench is by a 30mm square bar. Three methods are offered. I made method B (photo 2). The mark one version (see photos 9 and 11) is not recommended. The bore dia 50mm +0,01/ +0,05 clearance,

is made after clamping together with the bolts. Create a slot on one side only! The other bolt is always tightened.

Drng 5 First : shrink fit the 22mm dia connection (interference 0.01-0.015) (warm the 30mm dia part in oil 170° C) Later a safety pin can be made. All the machining is done in the milling vice. A tolerance is quoted for the 22mm bore (G7) because there are different parts to clamp in this bore (most 22h9).

Drng 6 Both parts are from square 30mm and 40mm steel and are silver soldered together. If in doubt, use an extra security bolt M10 (as I did). The suggested bore to shaft clearance here is 0,02-0,04mm. The two degree graduations are made with a 0.3mm slitting saw with a longer saw cut every 10 degrees. At the middle of the

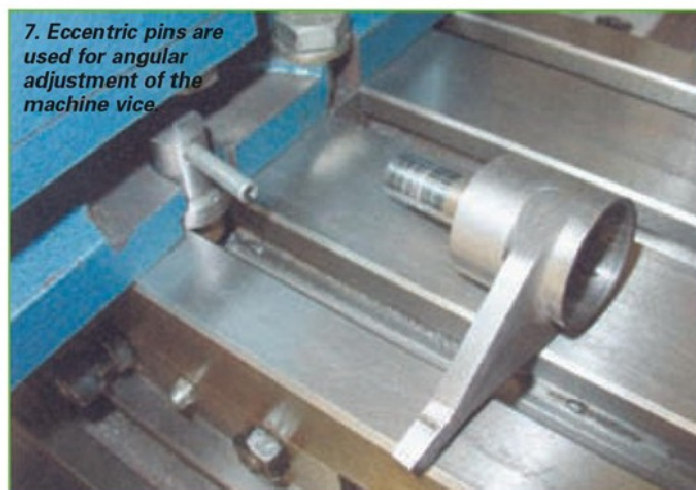
Parts 34-37



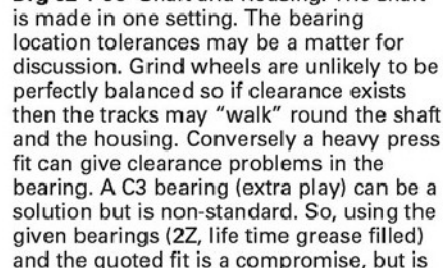
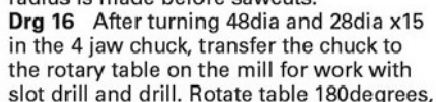
scale I drilled a dimple, which is used as zero point. All the different clamps are made with socket head cap screws, but to clamp part 5 (22 mm dia.) it is better to use

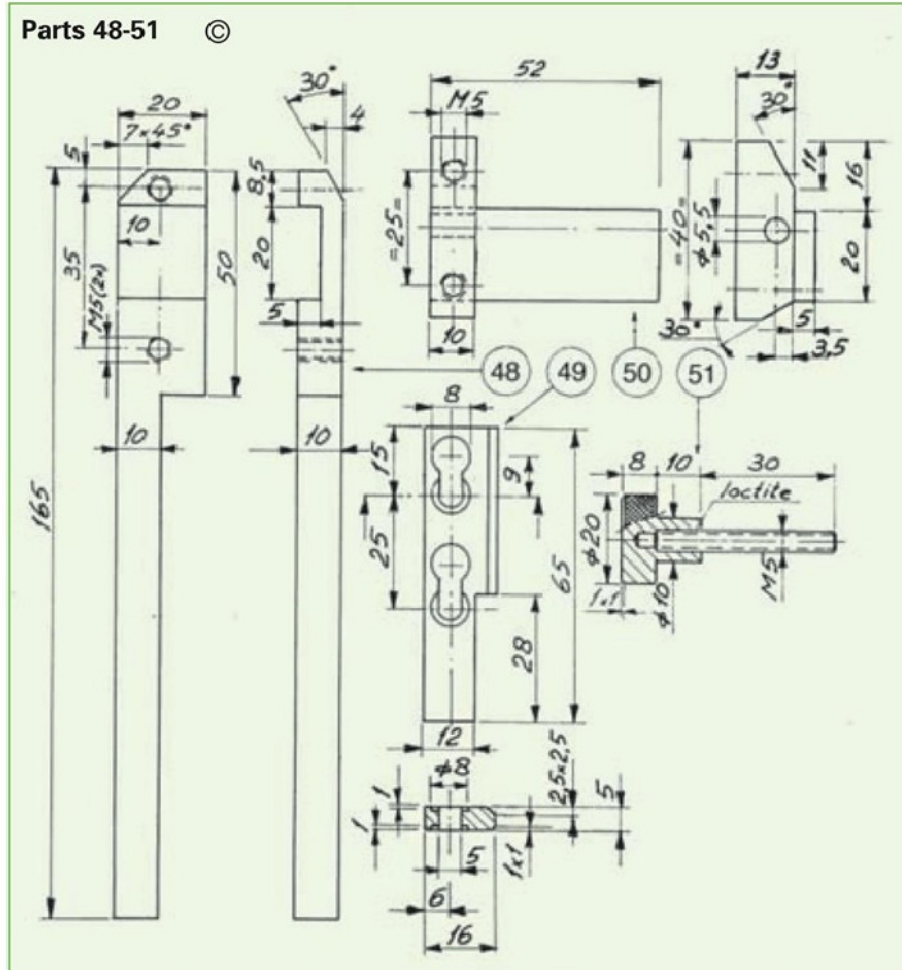
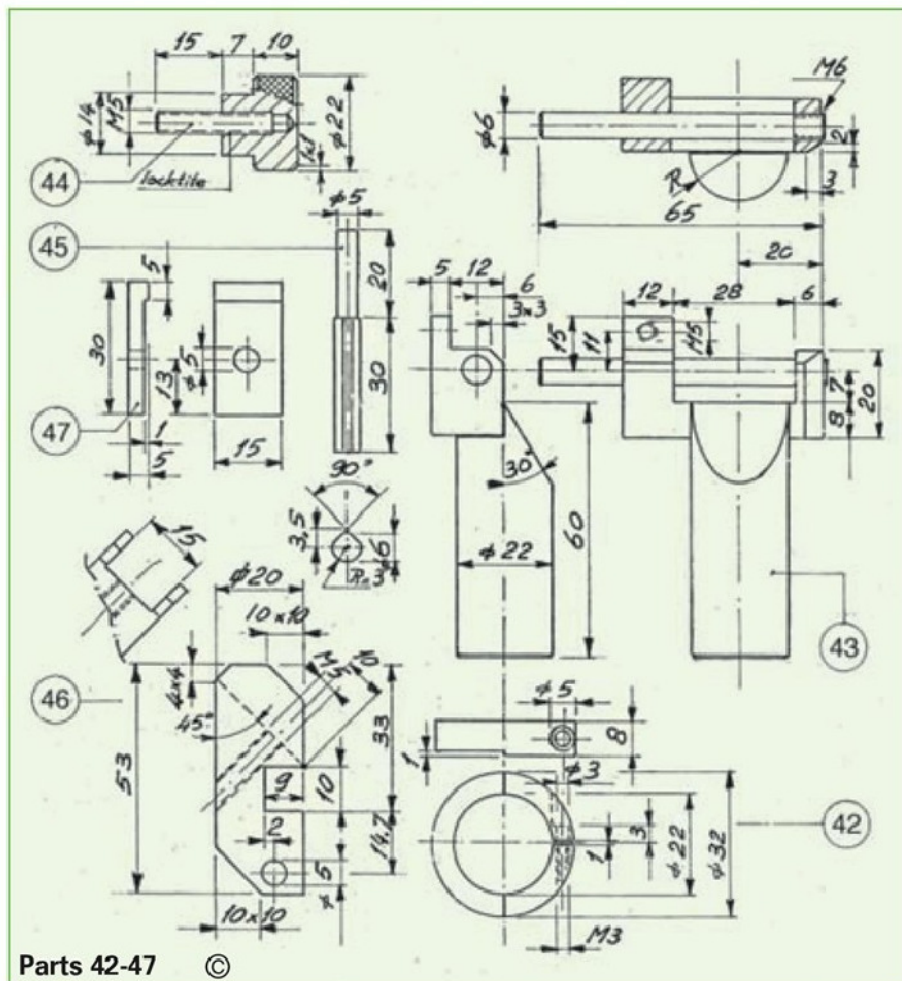


6. An adapted pistol drill is used for extended head movements.



7. Eccentric pins are used for angular adjustment of the machine vice.





smooth running. A good surface finish is important to prevent fretting problems leading to play in later life.

Drq 35. Fabricated item, finish machined after welding to ensure bearing alignment.

Drq 37. made on milling machine (single set up).

Assembling the grinder housing

Drq 3

1. Fit main bearing on shaft and lock with circlip A35 x 1.5 (installation load applied to inner race)
2. Fit rear bearing in housing. (force applied to outer race)
3. Fit rear bearing (with housing) to shaft (pushing on inner ring) until housing flange ring 62mm dia. is touching and in line with outer bearing ring.
4. Push connecting plate 37 over outer ring, remembering that this is backed up by the housing flange ring.
5. Assemble remaining parts.
6. Check by hand for smooth rotation of the shaft. Also note that the shaft is held axially by only the main bearing.

Drq 38 diametral features were turned on the lathe, prior to transfer to the mill.

Drq 39 first make the two clamping plates 30x20x78 and bolt these to the 40mm square shaft. Using the mill, face one side (see drawing), bore the 50mm dia and tap holes in one setting. Finally dismantle and mill away one mm from one end of each clamping plate.

Drqs 43 & 50 made from two parts silver soldered together.

Drq 52 This was made from a 130mm length of 20mm dia. bar, which was first set in the lathe with about 100mm out of the chuck, centred and faced. It was then transferred to the rotary table and the bar supported by using the milling vice and parallels. Clamp the bar in the vice, then clamp vice on the table, making sure you loosen all the clamps before rotating.

Drq 53 Set milling vice in line on the table. Machine rectangle 70mm x 80mm x 8mm thick and keep in rectangular form until the final profiling is done. Clamp plate with the 70 mm against the jaws, horizontal, using parallels, determine zero point, make the 16mm wide cutaway and the holes. Rotate the vice through 45° and determine zero point again. (For this, I use a ground pin 10mm dia.

Drq 56 The protractor disc is marked in two degree intervals over a range of 200 degrees. The divisions were cut with a 0.3m thick slitting saw, and each 30 degree line has a secondary dimple (centre drilled). The zero line is identified by two dimples (see Drq), and the underside is partially relieved one mm for location.

Drq 57 The item is fabricated by silver soldering together 2 parts: 20mm x 30mm x 50mm long, and an 80mm length of 25mm dia. bar.

Drq 62-66 show the adaptor for holding end mills, incorporating a division feature for two, three, or four flutes.

The third and final part of this description will appear in the next issue and will provide the remaining drawings for parts 52-70. These will include the finger stop arrangement added later.



General view of new workshop,
part of a large garage.

Bill Morris gives hints and
tips on changing location.

MOVING WORKSHOPS

This article is not about workshops that reduce one to tears by their sublimity, but contains hints about moving your workshop from one place to another. In an aside in an e-mail to David Fenner, our Editor, I mentioned that I was moving my workshop and he suggested a few words on the subject "would not go amiss." My last move was over a distance of about 700 km and plainly not a do-it-yourself matter, but unless you want to be reduced to tears for another reason, a certain amount of self-packing is needed. My current move is to a home where I plan to spend my retirement and is being carried out over several weekends. However, each trip involves crossing a harbour by vehicle ferry, followed by half an hour on bumpy and pot-holed roads before winding my way through a gorge and then climbing from sea level to over 300 metres to the top of a mountain pass, before a long and tortuous descent to a plain in the far north of New Zealand. Needless to say, there will be hints about securing loads on trailers!

Planning

Plan ahead if you can, so that you have some idea of what will go where. You may not have a lot of choice if pushed for space, but bear in mind that you have to be able to operate your beloved machine tools and it helps if you can get at a vice without banging your elbows on something else. As well as what might be called the standing footprint of your machine tool, you also have to take into account the walking footprint, the space you need around it to operate it comfortably. I once got as far as bolting down and grouting a shaping machine,

before I realised I would have to remove part of a window frame to allow the ram to operate over its full range.

Help the professionals

If you are letting the professionals do the job, you can help them a lot and improve your own peace of mind by attaching your precious machine tools to pallets, which can often be had for the price of firewood. The pallets make it much easier to lift heavy loads on and off removal trucks. Use at least one coach bolt at each end of the tool and ensure that they pass through the bearers of the pallets at each end, even if it means that the tool sits on the pallet diagonally. If you simply attach the tool to the planks, you may well find that they part company with the rest of the pallet at the first bend in the road. The rounded ends of the coach bolts will be in contact with the ground and are much more "draggable" than ordinary hex-head bolts. If you use rollers to make life easier, the head will also pass easily over the rollers.

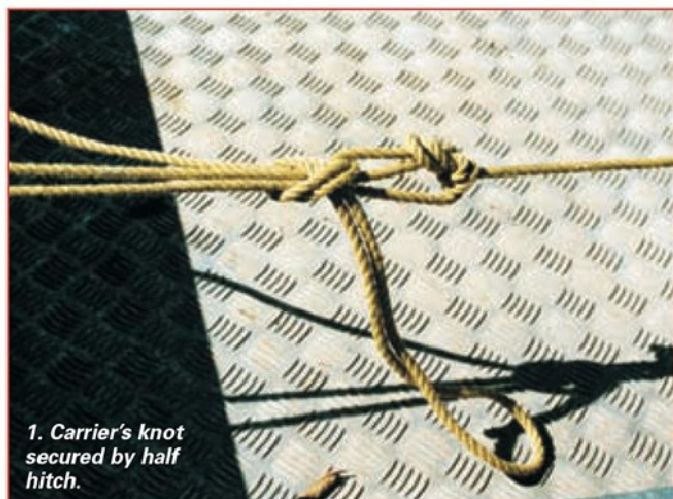
It helps removers too if you palletise boxes of tools and materials. In this case, bolting down is not quite so important, but you will need some very sailor-like lashings to make sure that everything stays on. Try to imagine that your pallet is on a small vessel during a gale that lasts several hours. In the days before container ships, cargo was secured from movement using dunnage, scraps of stout timber nailed, wedged and chained into place. You too can use dunnage. Chains would be going too far, but a few pieces of "two by four" framing timber nailed on to the seat of the pallet, might well stop your precious box of

measuring instruments being crushed by a sliding box of steel off-cuts.

Boxes and packing

The lighter, less delicate items can go in cardboard cartons, using old newspaper as packing in time honoured fashion, though if items are prone to rust and there is going to be a delay before unwrapping, a smear of rust preventative is wise. White soft paraffin (Vaseline) mixed fifty percent with gasoline (petrol) is cheap, effective and won't acid etch your favourite set of slip gauges. For more delicate items it is worth procuring or making stout wooden boxes. These do not have to be made from gauged (planed) or treated timber and can be nailed together, using a commercially made one as a pattern, since you do not want to lift a box and find that its floor and contents get left behind. Lifting handles can be made simply and cheaply by sacrificing a little of your garden hose, threading cheap polypropylene rope through hand-sized lengths, passing it through two holes in the side of the box and knotting it on the inside of the box. Bear in mind, though, that poorly tied knots will work undone, especially when tied in ropes that are made of slippery artificial fibre, so make sure that your reef knots are correctly formed and tie off each end with an overhand knot or tape them. Long, slender boxes can be converted into shelving after arrival at the other end.

Obvious as it sounds, there is little point in having lifting handles if the box cannot be lifted by a normal human being. I am a seventy-five kilogram man in his late fifties of average fitness. I can lift a twenty kilogram suitcase and carry it down steps (and up again at the other end) in the



1. Carrier's knot secured by half hitch.



2. Mill-drill on trailer, about to be dismantled.

London Underground though why there are not lifts provided is beyond me. I cannot do it for long. I can stagger with a load of thirty kg clutched, more or less precariously according to its size and shape, for a few paces. If two people are going to carry a box, then it can weigh forty kg gross, but if you are going to be on your own to do all the lifting, then keep the weight down to under twenty kilos unless you want to join the ranks of the ruptured on a surgical waiting list. Tempting as it is to pile the boxes high, emulating professional removers who do not have to pay the insurance premiums and excesses,

there is a limit to what a cardboard carton will carry on top of it without being crushed, so use a little common sense. The resistance to crushing can be increased by securing the top (and bottom too) with proper, broad, parcel tape going the full length of the flaps, rather than using bits of string that double as lifting handles. Dragging heavy boxes along a floor is made much easier if you lay down a stout sheet of plastic on the floor.

Label the boxes so you know what is in them. At the other end, the temptation is just to open everything and stack them "somewhere for now." This too often

becomes a permanently inconvenient place, so try to plan ahead.

Moving the immovable

So there you are, one or two pallets of tools and materials and one or two pallets of heavy machine tools. How on earth do you get the latter off their stands and on to the pallets in the first place, or into your hired van or in my case, on to the tray of the trailer? If you can, get help, lots of it. Two average men can manage a Myford ML7 in reasonable comfort, but if you are a lucky owner of something bigger, on a purpose-built stand, more people will be needed. However, with science and cunning, a seventy five kilogram man in his late fifties etc., etc., can, single handed, get a 350 kilogram lathe off its stand weighing in at about 80 kg on to a light trailer and back on again at the other end of the trip. The same goes for a 600 kg surface grinder (that's over half a tonne) and a 135 kg mill-drill. The Alba A1 shaping machine may yet defeat me, for reasons that will become clear. I cannot of course cover all eventualities, but can give some general hints.

The first principle, call it Morris's first principle if you like, is to take the thing apart if you can. Of course, if you have ignored well-written articles in MEW on lathe alignment and the like, your machine tool may never be the same again when its parts are re-united, but perhaps the Editor has plans to reprint a few of my earlier articles... If you cannot take it apart,

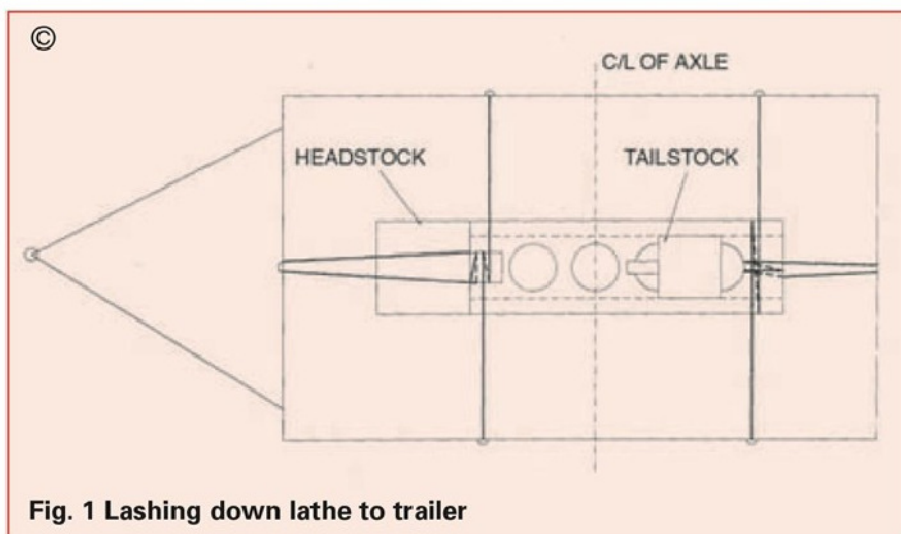
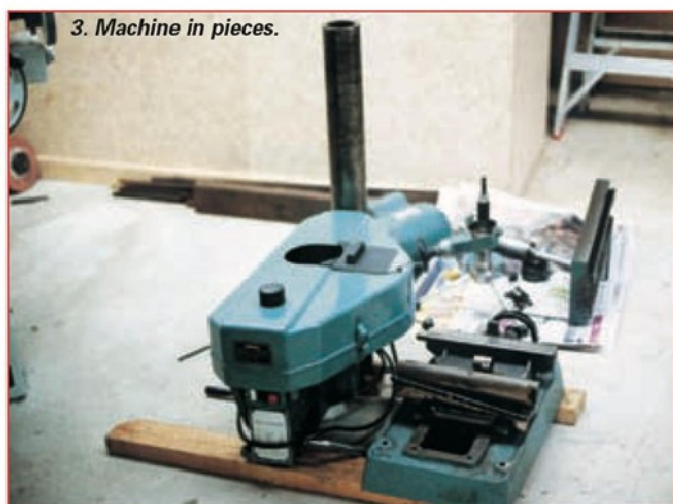


Fig. 1 Lashing down lathe to trailer



3. Machine in pieces.



4. Column threaded through body. Note safety rope.

5. Column upright and bolted to base.



6. Assembled and repainted.



redistribute the weight so that it is more evenly spread. Even if you cannot bear to part the lathe's headstock from its bed, you can at least remove the tailstock, top slide, cross slide, motor, gears and gear sectors, with a reasonable chance of reuniting them. My lathe's headstock, stripped of everything easily strippable, including tumbler reverse cluster and covers, fell into the category of only-just-carryable for a short distance, so it was worth removing even quite small bits weighing perhaps only a few hundred grams each. To get the bed to a manageable state, I removed everything removable including gearbox, lead screw, feed shaft and carriage. There was no question of my being able to lift the whole bed single handed so I had to get help from somewhere.

If you have an object weighing forty kg and lift one end a few cm of the ground, effectively the ground is lifting twenty kilos and you are lifting the other twenty. As the angle from the ground increases, your share gets less and the ground's share gets more, providing the end of the object does not slip along the ground and a shattering disaster ensue. I could just lift one end of the lathe bed single handed, so the ground had to lift the other end. My second principle is to avoid unnecessary work. This can be re-stated as "Avoid lifting through unnecessary height". If you have to lift something heavy twice, don't put it down to the ground between lifts, but rest it on some support at about waist height.

Since I wanted the bed on the trailer and could not get trailer to lathe, I had to move the lathe to the threshold of the old corrugated iron garage that serves (or served) as a workshop. This can be done remarkably easily using rollers, nothing fancy, just lengths of 25 mm steel water pipe, collected and kept against the day when I might have to move. The material is, after all, not much good for anything else in the amateur's workshop. But first you have to get the machine on to the rollers. A crow bar is as good as anything else, no doubt, but I don't own one. However, I have a 1500 mm length of stout 25 mm square tubing with a tab of 8 mm plate, 30 x 60mm welded on one end to form a very long-stemmed "T" which I use for lifting and prying heavy weights. Introducing it under one foot of the lathe stand and levering away from the lathe, lifts it enough for a piece of pipe to be rolled under. With four pieces judiciously

distributed and two more ready to receive the rolling load, half-tonne weights can be moved with less effort than it takes to buy a ticket for the London Underground.

So, one end of lathe is close to the tray of the trailer. Remove some of the rollers, so that the lathe won't move, unbolt the headstock and stagger with it to some stout support placed nearby for the purpose, like an upended wooden box, a "Workmate" or something similar. The naked lathe bed can then be slid on to the trailer and walked, lifting only one end at a time into position. The other parts can be put on to the tray of the trailer, but my third principle might be "Don't let things roll about," and on the whole, re-uniting the major bits, if only roughly, makes them less liable to damage as well as providing convenient points for lashing down. The headstock and bed fall into the latter category, but the carriage and tailstock do not. You may think that the tailstock when locked to the bed will form an ideal lashing point, but just imagine again that gale lasting several hours. If you still can't think that the tailstock might slip, just take my word for it, it can and will. If you are relying on professionals and think that they might use something like a leadscrew or feed shaft as a lashing point, you had better be there when they put your machine into their truck.

Placement

Once you have your machine on the trailer, think carefully about where it is going to

be on the tray. Too far forward and there will be too much downward load on the tow bar, and vice versa. As a rule of thumb, if you cannot comfortably lift the trailer from the tow ball, you probably have too much weight forward, but be careful when you carry out this test, with wheels chocked of course, lest you have too much weight aft and get launched into orbit or to the local accident and emergency department. Where you put it will depend on what else is going on the trailer of course, and my preference is to have the major load just ahead of the axle and distribute other loads fore and aft, using stout wooden boxes and their contents as dunnage, together with bits of two by four timber. Assuming that everything is guarded against sliding, they then have to be guarded against bouncing and rocking by lashings.

Lashings

Lashings have to be of adequate strength to do their job and 10 mm diameter rope of some synthetic material will serve most amateur purposes, bearing in mind that knots made in most synthetic materials have a distressing tendency to slip, something that I was always conscious of in the rock climbing days of my youth. So, follow your round turn and two half hitches, well snugged down, with an overhand knot. If you're going to be high fallutin' and use a bowline for some purpose, secure the loose end with an overhand knot. Sheet bends are insecure

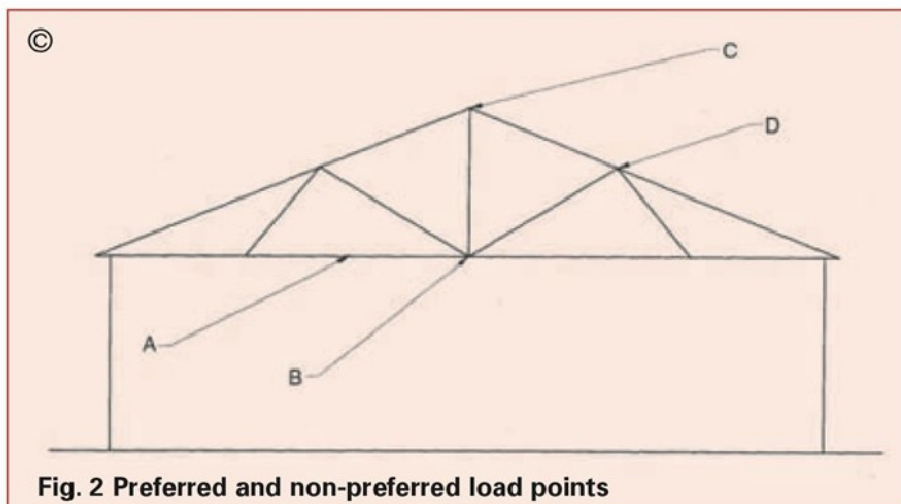


Fig. 2 Preferred and non-preferred load points

7. Hauling shaper up plank and into trailer.



in most artificial ropes. Knots are not necessarily more secure for being big, so a few knots well chosen, tied and placed are better than a thing the size of two fists. "Keep it simple, stupid." You won't stop something as heavy as a lathe from rocking and even falling over on to its back simply by tying it with some downward pressure. You need to take at least one turn of the rope around, say, the spindle, as shown in **figure 1**, with a further lashing with pulls at right angles to the first. A similar lashing at the tail end of the bed leaves the machine with only one degree of freedom, upwards. Short of bolting it to the trailer, you will have to rely mainly on gravity for that, though your tight lashings may have some downward component of pull. If your trailer is fitted with a winch, then this can make life considerably easier first in pulling the machine on to the trailer bed, and secondly in applying a forward tie.

Many of us will own only one or two lengths of rope and the temptation is to take the lashings from one tie-down point to the next until you run out of rope. The problem with that is that if the lashings work loose or give way at one point, every point follows suit. Think of rope as a tool to be used for your own purposes and be prepared to cut it, so that one important lashing can be independent of another. Thus the arrangement in **figure 1** can be improved if four separate ties are taken from the lathe to each side of the trailer. This would then obviate the possibility of the lathe moving gradually sideways, the movement being accommodated by the loops in the ropes. The cost of a bit of rope is small compared to the cost of a new machine tool. You will of course be workman like and secure the cut ends against fraying. If you do not, it may lead to frayed nerves. You don't have to be obsessive and do a back splice or sail-makers whipping. Insulating tape lasts remarkably well. For modern man made fibres apply heat to the cut end. One easy way is to light it with a match, allow to burn for a few seconds, then extinguish by shaping/squeezing with wet fingers. One piece of information not often discussed concerns the reduction caused to the strength of a rope by knots. A simple bowline with overhand knot will reduce rope strength to about 60 percent, while a carrier's knot secured by a half hitch as in **photo 1** may reduce strength to less than 40 per cent.

The modern ratchet straps used by hauliers are available in a variety of sizes, although some are rather long for our

purposes. They do though allow you to really tighten things down. Both with rope lashings and ratchet straps, it pays to stop after the first two or three miles and inspect for security/tightness. If it can work slack, it will, and it will show up quite quickly.

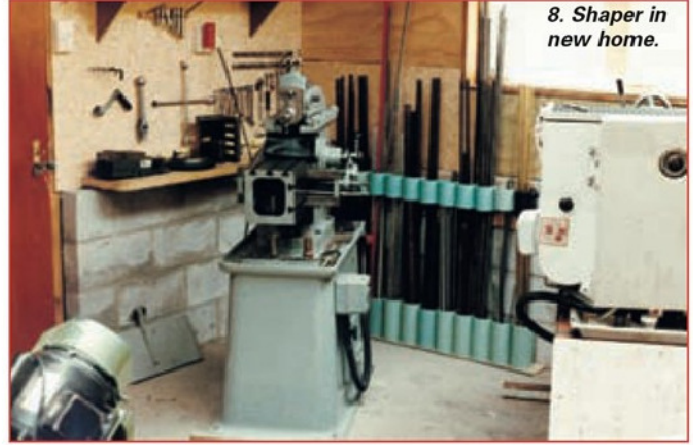
Hand tools first

Let us now assume that you have reached the new workshop of your dreams. Among the first things you should unpack are your hand tools and the racks upon which you store them so carefully and systematically. Fix the racks in place and as you unload the tools, put them into their assigned places. The alternative, from which I am suffering to some extent myself at the moment, is a bench littered with homeless tools, some of which you need now, to fix the new door lock, but cannot find, since you do not usually associate wood chisels with hacksaws. "Why does he not follow his own advice?" you may say. Well, experience is what teaches you to recognise when you have made the same mistake again.

Pulling down the roof

Getting the machine tools back on to stands and moved to their new places is a reverse of getting them off, though you may have the opportunity to use a little more science if you have a block and tackle such as a handy winch, allowing a four fold gain in lifting power over your unaided efforts. Such tackles, however, need to be hung from something and my fourth principle is that strong bits of rafters are never above heavy weights to be lifted. To this might be added that there is never anyone to hold the rope when you want to manoeuvre something into place. Bear in mind when you attach your tackle to the rafters of your new workshop, that the rafters are intended to carry the load of the roof, a downward, compressive force. Your tackle will be applying a downward force too, but not necessarily to a point designed to take it. A load applied at point A in **figure 2** tends to bend the horizontal member, which may only be of "two by four", and applies tension to the joints of the two diagonals, which normally know only compressive forces and may be secured by only a couple of nails. The position may be a little better at point B, but will be much

8. Shaper in new home.



better if you can get a sling for your tackle over point C or D.

Even if you don't use a tackle because of the weight of the object, it can help to make the job more convenient, and sometimes just a loose lashing can make an awkward load a bit safer while you take short cuts.

Photos 2 to 6 illustrate the removal of a mill-drill single-handed. I took the opportunity to repaint it as I did so. **Photo 2** shows the machine about to be removed in pieces from the trailer. The home made steel stand could be walked into place. **Photo 3** shows the dismantled machine on the floor. The base with cross slide was in the just liftable category and was secured in place atop the stand. The stripped down body with motor and delicate parts removed was a fairly easy lift on to a piece of board atop the replaced longitudinal slide and a piece of stout rope secured to a strong point of the rafters was an insurance against disaster as I manoeuvred the column into the body (**photo 4**). Some lifting and wiggling then got the column back into place on the base without too much trouble (**photo 5**), and the motor, quill, capstan wheel and so forth could then be reassembled as shown in **photo 6**.

Readers may feel that I have an embarrassment of space. It is true that I have added the luxury of a dark room, but I still have to move the shaping machine to its new home in the corner behind the lathe. The machine weighs 367 kg, half of which is the base, which I cannot take apart. I suspect I will need to add an inclined plane to rollers and handy winch or, worse still, have to pay someone to move it for me!

Post Script

Since preparing this article, some further time has elapsed, with further thought and activity devoted to moving the shaper. Following a partial strip down it did indeed prove possible, with the aid of a hand winch, to persuade it to climb up a greasy plank and into the trailer. The operation is shown under way in **photo 7**, and the machine in its new surroundings in **photo 8**, which also shows one solution I have found useful for bar storage, using scrap drain pipe found at the local dump. The bottom pieces are long enough to support shorter lengths without losing them completely, and are glued with building adhesive to a plank. The upper pieces are screwed to another plank, which is then screwed to the supporting wall.



Gordon Cornell with his Wabeco CNC mill



ICE PROGRAM REVIEW

Malcolm Stride examines an unusual development tool for two stroke engine enthusiasts.

Background

Gordon Cornell (photo 1) has spent many years working with two stroke engines both in a professional and hobby capacity. He worked at ED and Frog in the 1950's (many readers will remember their ranges of engines from that time) and after a period in the motor industry in Coventry is now producing in very limited numbers, a range of high performance engines (photo 2) under the "Dynamic" label. For those interested, the performance of these engines is pretty spectacular, the 92 series Dynamic 061D 1cc. diesel produces some 0.3 BHP (300bhp per litre), turning a Cox 6x3in propeller at around 23,000 rpm.



An example of the Dynamic engine range

Model engineers have an ever increasing variety of tools to assist them in their endeavours these days and one of the growing areas is that of computer programs designed to perform various tasks which in earlier days may have been carried out using long winded manual calculations or that before the advent of computers would have been impossible.

The tool that is the subject of this article, is a program for analysing the anticipated performance of two stroke internal combustion engines and is a useful device for those engaged in studying such engines, building engines or even running them in situations where performance is important. The program was written by Gordon Cornell and Bob Collet who have a wealth of experience in the design and building of two stroke engines.

The program is written in Visual Basic and will run on computers running Microsoft Windows versions up to and including Windows XP. One refreshing thing about the program is that the installed version only takes up around 50Mb of hard disc space and is not resource hungry. This means that it can be loaded and will run happily on quite a basic computer configuration.

Design manual and ICE Program

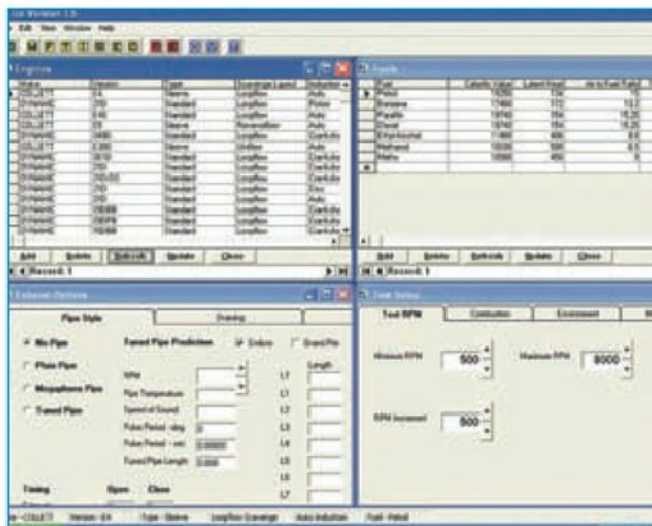
Although this feature is primarily about the ICE program, the complete package available from Gordon includes a two stroke engine construction and design manual "Model Engine Mechanics" (described briefly in Fireside Reading MEW Issue 108). This is a tome of some 150 pages which will provide those interested with a vast amount of information on the subject and I think must be a work of major importance in the field. Both this and the ICE program manual have been produced as good quality comb bound A4 size books with colour photographs and diagrams. However neither has been professionally edited so readers will need to approach them with that in mind. In fact Gordon is keen to hear from anyone who is prepared to assist with editing the books in order that they may both be improved.

Having said that although the layout and style sometimes makes the books slightly hard work to read, the amount of information included and the high level of detail makes persevering well worth while.

Program purpose

The ICE (Internal Combustion Engine) program was originally produced to "provide a tool to assist in the development of the internal combustion engine". Gordon is keen to stress that the program is a comparison tool to enable the evaluation of potential changes to the design of engines and I think the performance of his own engines demonstrates the benefits of such an approach.

For those who do not build engines but are interested in gaining extra performance using tuned pipes or other means, then the program will enable comparisons of the different options to be



The opening screen display from ICE

made. This is dependant on the user being able to provide the full dimensions of the engine required by the program.

Program basics and principles

The program is based upon equations and formulae generated from first principles, rather than using those derived from empirical (observed) data. The view taken is that the empirical approach can be misleading and may lead to mathematical errors. An example of this approach is that the timing diagrams are calculated from the actual dimensions of the engines ensuring that it is accurate.

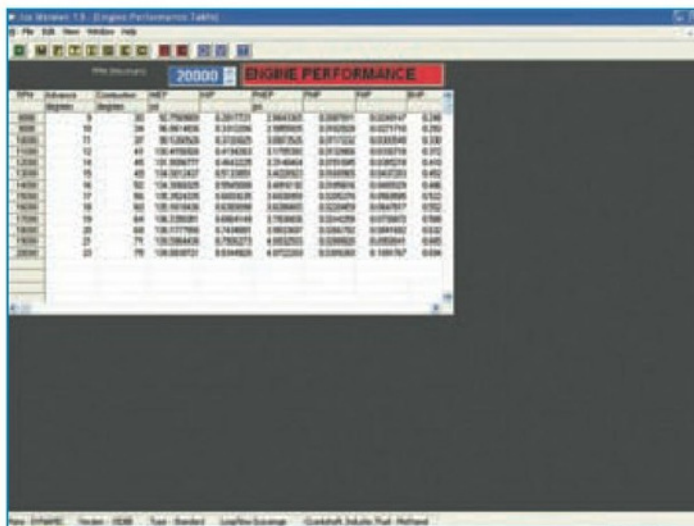
The calculations used in the program cover both the volumetric and mechanical aspects of the engine and as an indication of the level of detail involved the mechanical calculations take into account the coefficients of friction of the different types of bearings used. Readers will be pleased to know that this data is already supplied as part of the database. For those with experience of such things, all the program data is held in a Microsoft Access database which can be accessed outside the ICE program if required. If enough people use the program, then it would seem useful to exchange such data to build up a comprehensive engine database.

Program overview

The program is supplied on a CD-Rom disc and is manually installed using the Windows Add/Remove programs function. The program installed on my computer with no problems and once installed, clicking on the ICE desk top icon launched the program within a few seconds.

"Help" files are supplied, which are accessed from the main screen windows. Unlike most professional programs however there is only a small index built in. Once into the help, users have to scroll through the screens to find the entry required. This can be eased to some extent because the user can add "book marks" at points in the help for ease of access later. I would recommend that users do this right from the start because you will need to refer to the help a lot during the early learning stages.

The program is supplied with a database of engine information covering the Cornell Dynamic designs and also some of the Bob Collett sleeve valve engine designs. This does enable users to experiment right from the start and the original database can be reinstated from the CD-Rom should the experimentation get out of hand! Before starting I would suggest that intending users read the manual. This is a complex program and because of its nature is not very forgiving

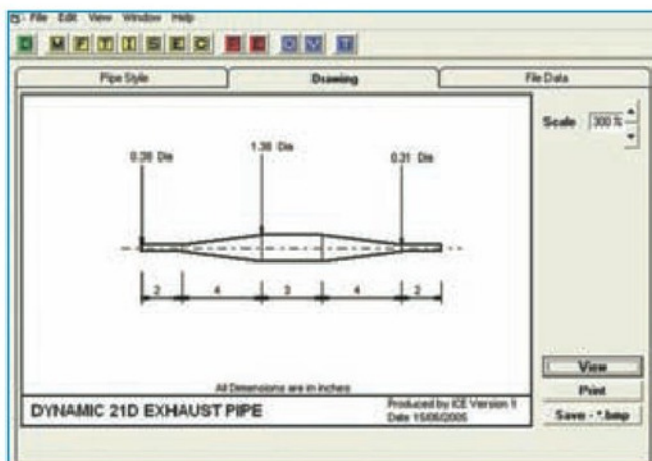


The performance table display for a Dynamic 21D after calculation

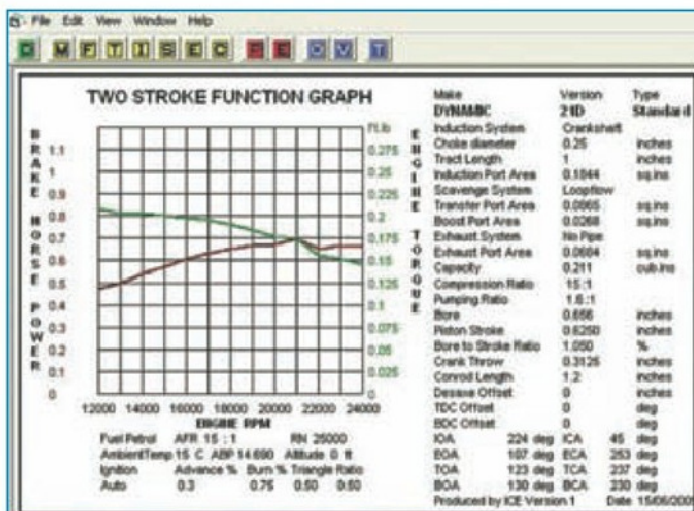
of errors in data or use. Gordon makes a comment in the manual that "users are advised to refer to the appropriate sections in the manual during the learning process". In other words, read the instructions first this time!

For example, the program relies on the user knowing the approximate operating rev. range of an engine and then setting this at the appropriate point. If this is not done, then the results can be confusing. This is one aspect of the program that Gordon is keen to improve so if there are any computer whiz kids out there who would like to help I suggest they get in touch with Gordon. Having said all that, I found that once I had got used to the way the program works (after 6 to 8 hours) I could experiment and get results out quite happily.

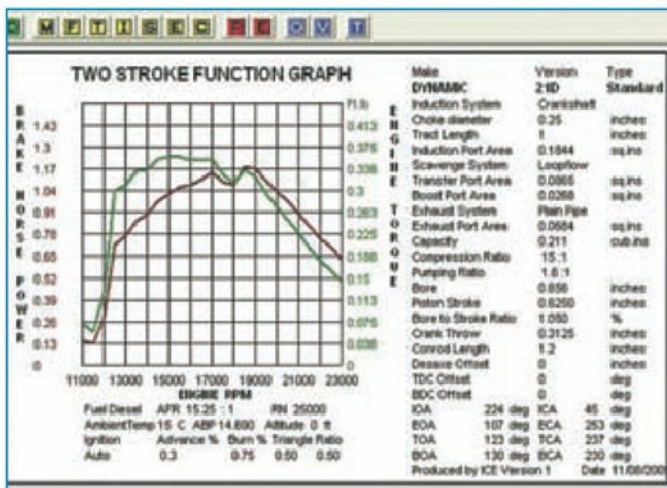
Once the program has been launched, the user is presented with a screen showing four windows (screen 1). These are the engine database window, the exhaust options window, the fuel type window and the test set-up window. The windows can be enlarged to fill the screen when each is in use and there is a facility to restore the default set of data windows. In use, the data for an engine is input (use the manual to ensure correct data) and after selecting the relevant engine record the calculation process is run by clicking on the correct (P) button on the tool bar. After the calculations have been carried out (which



The Dynamic 21D tuned pipe screen drawing produced by ICE



The BHP/Torque graph for a Dynamic 21D with no exhaust pipe



The BHP/Torque graph for a Dynamic 21D with a plain exhaust pipe

only takes a few seconds) the screen changes to display the performance table window (screen 2) showing a vast range of information for the engine being evaluated.

This is where the information in the manual is essential in order that all the information can be understood. Readers should be under no illusions that this is serious technical information and most of us will need some considerable help in interpreting it. The output data can also be produced in graphical form; the most familiar example to many readers will be the classic BHP/Torque curves.

Data details

The input data needed for the engine to be evaluated is very comprehensive and includes a very detailed set of dimensions for each engine. This is specified in the manual as dependant on the engine type selected. The program will cope with various engine types including sleeve valve and standard porting, different scavange layouts including uniflow, loop flow and reverse flow and different induction types including automatic (reed valve), crankshaft controlled and piston controlled.

All these are well defined in the design manual and in all there are about 90 different pieces of information that need to be supplied, some of which are simply entered as zero values where they are not applicable to the engine in question. Some form of data entry function would be useful here so that once an engine type, scavange layout and induction type are selected then non applicable data items can have suitable values set automatically by the program. Those with experience of using Access databases could no doubt provide this as a separate function based on the information in the manual.

In addition to the basic engine information the user can also specify the fuel to be used, the type of exhaust system and the test environmental conditions including temperature and altitude.

The features that can be evaluated by the program cover the following areas; basic mechanical features, gas flow through the engine, thermodynamics (cylinder temperature and pressure etc), crankshaft mechanics (inertia, balance etc), sleeve mechanics (sleeve drive loads etc), exhaust system (gas flows, pressures),

induction system (gas flows, velocities), performance (BHP, torque, mechanical efficiency) and exhaust performance (temperature, tuned length etc).

Outputs: tables, graphs

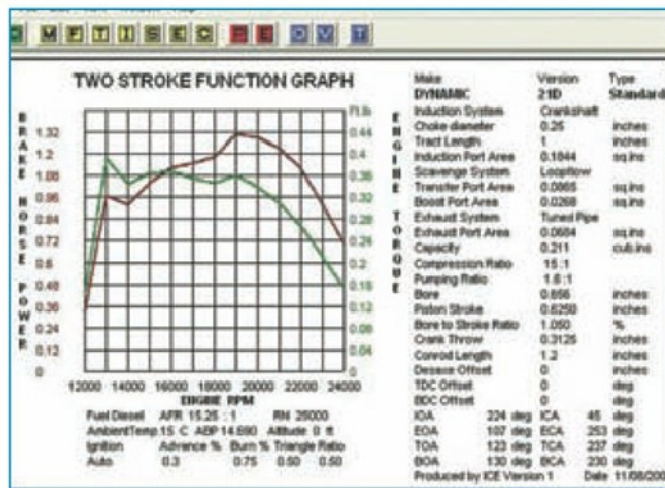
In addition to the performance table shown by default once the calculations are complete, a range of other data is available grouped under the headings listed above. The different tables are selected from the tool bar and provide a very extensive picture of the engine operating characteristics. They can be viewed on the screen or printed out to aid comparison of results.

The information can also be output in the form of graphs, the data for which are selected by the user and the graph can also be viewed on the screen or printed. To produce a graph, the user selects the relevant table to use followed by the 'X' axis data which can be angle, piston stroke or cylinder volume. Two functions can then be selected for the left and right 'Y' axis and the graph produced. The classic example of this is the aforementioned BHP/Torque curve plotted against RPM. The program does not recalculate the results at this stage.

In addition to the performance graphs there is one facility which I found very impressive. The user can specify the type of exhaust pipe to be used and then run the calculation. Once this has been done a dimensioned drawing of the pipe in question can be printed (screen 3). This sounds like a very useful function for establishing a sensible tuned pipe design before cutting metal. It could also be used to establish the best commercial tuned pipe to be used for a particular engine.

Examples, tuned pipe effect

As some examples of the output graphs produced by the program I have evaluated the effect of three different exhaust systems on the Dynamic 21D. The results are shown in screens 3, 4 and 5 and the whole took under five minutes to produce. I don't believe that such calculations would be practical if performed manually.



The BHP/Torque graph for a Dynamic 21D with a tuned exhaust pipe

Conclusions

Having used the program for a few weeks now, I am very impressed with the functionality it contains. It is not a program that one just loads and uses. Users will need to spend time with the manual and unless you are an expert in two stroke engine design I would suggest the Model Engine Mechanics book as well. Having done that and got used to the program it works very well and produces a set of results in less than five seconds. In fact I have just timed that on my computer whilst writing this review. It also launches in about the same time, which in comparison with most commercial programs is impressive.

Because ICE is not a professionally produced program, there are some things which could be tidied up but that does not detract in any way from it being a very impressive tool. I suspect that it may also be unique in its field. It is still under development with improvements and additional functions being added on a regular basis.

For those engaged in two stroke engine design it is a must have if only for the fact that it may question some perceived design wisdoms. Even those who just have an interest in engine design will find this a fascinating program to use and will gain a lot of knowledge from that use.

The ICE program CD (which includes the manual) and the book Model Engine Mechanics are available at special price of £45.00 for both (plus £2.00 postage) at the time of writing.

Gordon Cornell can be contacted at 19 The Earls Croft, Cheylesmore, Coventry, CV3 5ES or by e-mail at gcornell@tiscali.co.uk

Company open sessions

Several of our suppliers have adopted the policy of having open sessions in house where prospective customers can examine equipment at first hand. Following successful events at Chester and Warco, Myford will have their annual open house 26th to 29th October.

MYFORD SEVEN, C AND SHEAR

1. Cross slide lock fitted to lathe

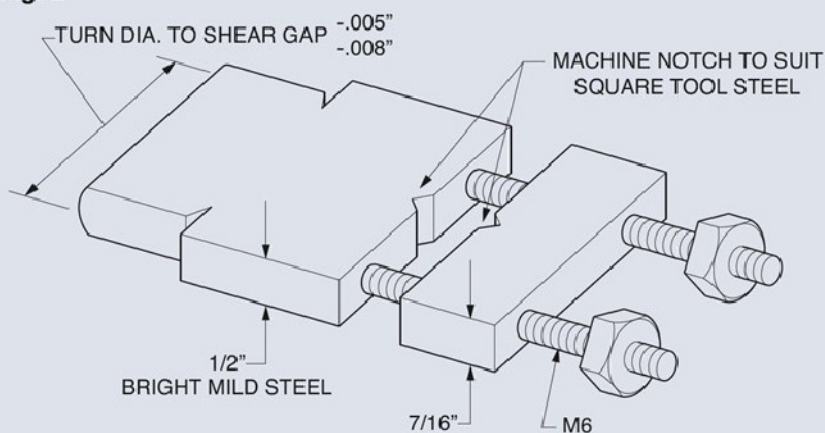


John McIntosh first describes a simple accessory, then outlines a technique for rejuvenating an ageing bed.



2. Component parts of cross slide lock.

Fig. 2



Cross slide lock

I am aware that some owners of ML7 lathes will simply tighten one or two of the screws acting on the gib strip to effect a slide lock, however once correctly adjusted, I prefer to leave mine well alone. The Super Seven features a more rigid (normally) fixed position gib, which does not lend itself to ad hoc locking. Hence I offer this easily made gadget, which can be fitted to both ML7 and Super 7 variants. The concept is extremely simple, so no dimensioned drawings are given. **Photo 1** shows the cross slide lock fitted, bolted in place using the $\frac{1}{16}$ in. BSF tapped holes in the saddle. The tapped holes are used for the travelling steady. **Photo 2** shows the component parts: - the mild steel drilled, tapped and notched plate, the brass pad, the fixing screws with screwdriver slots

and the clamping screw. When the lock is not fitted the tapped holes in the saddle are plugged with $\frac{1}{16}$ in. BSF grub screws to keep the threads free of swarf.

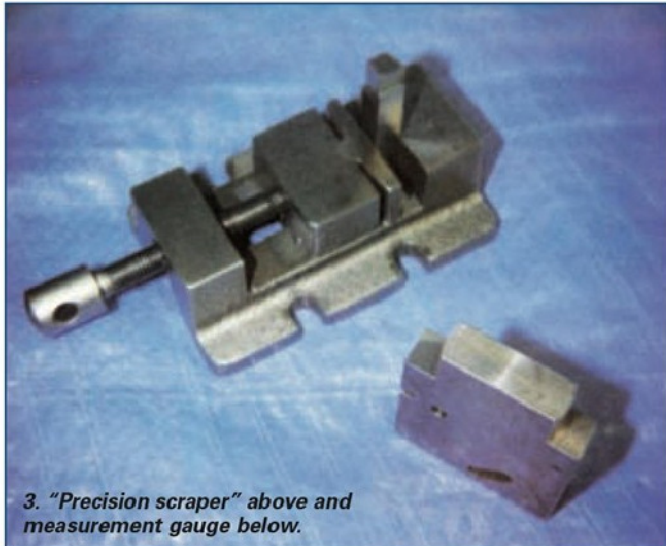
Shear scraping

Most lathes do most of their work close to the chuck, and thus wear to the bed tends to occur preferentially in this area. My ML7 long bed lathe, purchased second hand at auction in 1980, clearly no longer in its first flush of youth, was no exception, and was now becoming difficult to adjust for saddle to shear clearance. Correct adjustment near the tail stock end gave unacceptable clearance at the head end. **Photo 3** shows a gauge, right hand bottom, turned from scrap $\frac{1}{2}$ inch thick bright flat bar. The gauge had undercut shoulders to facilitate measurement of the shear gap in

conjunction with feeler gauges. The shoulders kept the gauge square to the shear gap. **Fig 1** shows the results of a dimensional survey. It was assumed that the shear gap could be taken as a datum in terms of straightness as well as dimension. It was judged that the variation in front and back shear thickness (measured vertically) was acceptable. The width of the shears required adjusting and it was decided to use a piece of square tool steel held in the Myford machine vice as a precision scraper. This was selected because the machined top of the vice could slide on the shears while holding the tool steel cutting edge square and this is shown in **Photo 4**. **Fig 2** shows an

Item and ref size	POSITION FROM HEAD				
	1	5	9	13	17
DIFFERENCE FR					
Back Shear TK. .500	-.001	-.0015	-.0013	-.0007	-.00
Back Shear width 1.375	zero	zero	zero	-.0008	zer
Shear Gap 1.385	zero	zero	zero	zero	zer
Front Shear width 1.725	+.0183	+.015	+.0155	+.0175	+.0
Front Shear TK. .500	-.0015	-.0025	-.0015	-.0013	-.00

CROSS SLIDE LOCK R SCRAPING



3. "Precision scraper" above and measurement gauge below.



4. Illustrating how the scraper is used.

alternative design from 1/2 inch thick bright mild steel bar.

Using the precision scraper the back shear +0.001 inch at the 37 inch station was taken down to zero. The front shears were scraped down to +0.0155 inch. This operation was carried out without removing the saddle. After the shears had been scraped, the saddle was adjusted and could move freely over the complete length with no excess clearance. The individual shear widths plus gap were confirmed using a 4-5 inch micrometer. The dimensional survey showed that no restoration was required on the shear top and bottom surfaces. Had this been necessary then the top surface would require testing for straightness and flatness. It may be possible to borrow a

precision straight edge and small surface plate. Failing that, these items can be made using the three-piece method where items A and B are blued and scraped to each other. This is followed by blueing and scraping A and C together, then B and C and so on until all edges or surfaces have identical bedding. The precision straight edge and small surface plate can then be used to test the shear top surface. If

adjustment is required then the saddle should be removed so that shear top surface and the matching saddle surface can be scraped. When this is complete the shear front and back thickness can be surveyed. The underside of the shear can be scraped to size using the precision scraper already described but using an alternative blade configuration made from the appropriate size of square tool steel.



END ALONG LATHE SHEARS (inches)					
	21	25	29	33	37
OM REFERENCE SIZE (inches)					
08	-0.0008	-0.0008	-0.001	-0.001	-0.0015
0	zero	zero	zero	zero	+0.001
0	zero	zero	zero	zero	zero
172	+0.0172	+0.0173	+0.0175	+0.018	+0.018
1	-0.001	-0.001	-0.001	-0.001	-0.0008

A Note on Beam Deflection

A precision straight should not deflect excessively under its own weight and the following formula will enable appropriate limits to be determined. The following example calculation considers a straight beam made from a steel flat bar half an inch wide by two inches deep by one metre in length.

The standard formula gives centre deflection of beam supported at ends as:

$$\text{Deflection} = \frac{(5WL^3)}{384EI}$$

Where W = beam mass x g = beam volume x density x g = (LBD) x density x g

Density = 7860 Kg/m³ for mild steel

g = gravitational constant = 9.816 m/s²

L = beam length = 1 metre

E = Young's Modulus = 210x10⁹ N/m² for mild steel

I = section moment of inertia = $\frac{(BD^3)}{12}$ for a rectangular section

B = beam width = 12.7 mm

D = beam depth = 50.8 mm

$$\text{Beam mass} = \frac{(1 \times 12.7 \times 50.8 \times 7860)}{1000^2} = 5.07096 \text{ Kg}$$

$$W = 5.07096 \times 9.816 = 49.777 \text{ N (that is force in Newtons)}$$

$$I = \frac{(12.7 \times 50.8^3)}{(12 \times 1000^4)} = 138.744 \times 10^{-9} \text{ m}^4$$

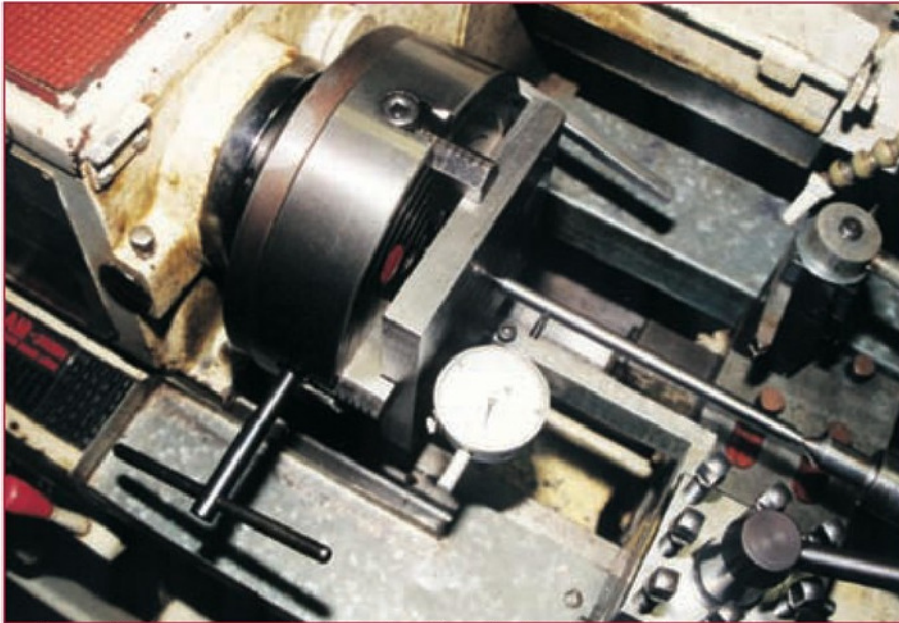
$$\text{Central deflection} = \frac{(5 \times 49.777 \times 1^3)}{(384 \times 210 \times 10^9 \times 138.744 \times 10^{-9})} = 22.245 \times 10^{-6} \text{ m}$$

$$= 0.022245 \text{ mm}$$

$$= 0.0009 \text{ inch}$$

The beam width B has no effect on the deflection as it cancels out in the equation.

FACILITATING THE USE OF THE FOUR JAW CHUCK



1. Piece of bar set eccentrically in the four jaw chuck using wobbler, dial indicator gauge, T handled key (front) and bent bar key (rear).

The chuck with four independent jaws is generally reckoned to be superior to the self centring three jaw chuck in two respects:

1. It is possible to achieve improved centring accuracy.
2. It can provide a firmer grip on all shaped workpieces. It is, however, less convenient to set up, and more time consuming. This article addresses these latter concerns.

Setting up

(a) Circular cross section workpieces

With a dial indicator gauge at lathe axis



horizontal centre height bearing on the workpiece periphery to provide measurement, the chuck jaws are operated in horizontal pairs until the gauge deflection by the workpiece adjacent to (say) jaw 1 is the same as that adjacent to jaw 3. This is repeated for jaws 2 and 4, following, which it is to be expected that the deflections adjacent to all four jaws will be the same.

(b) Centre punch mark on workpiece

In this case a "Wobbler" is used between the centre punch mark and the tailstock centre; and the same procedure is used as in (a) above but with the dial indicator gauge bearing on the "Wobbler" body towards its workpiece end. See reference 1 and photo 1.

Jaw Operation

Four jaw chucks are provided with a T handled operating key, which is quite effective in moving the jaws as required. The jaws are reversible to allow greater flexibility in the shapes and sizes of workpiece, which can be accommodated. However the time taken to manipulate four jaws in sequence, especially if they are to be removed and reversed using the T handled key is considerable. This tends to be a deterrent to the use of the four jaw chuck.

Advice for tyros from the late Philip Amos

Brace type key

There is not much work involved in making up a key similar to a carpenter's drill brace. I noticed this concept in reference 2. My design is generally similar and is shown in drawing 1. The Bradley design is joined together mechanically; mine has some joints brazed to improve stiffness.

Some people have commented adversely on the brace concept, regarding it as a method of applying added (excessive?) torque on the chuck jaw operating sockets. But if its use is merely to speed movement of the jaws this criticism is invalid. Thus the chuck brace can be used to rapidly get the jaws to near their final position, and the T handled key used to finally position them.

Concept

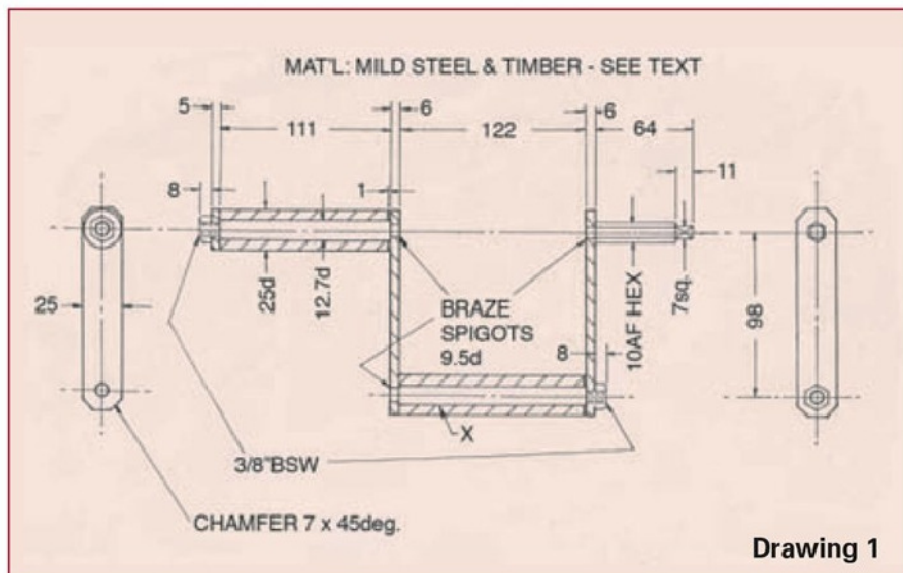
As shown in drawing 1, the actual "key" on the brace is a piece of 10mm AF hex steel with a 7mm square filed on one end, and a short length reduced to 9.5mm diameter at the other. This is a survivor from an earlier attempt to use a socket spanner brace, which turned out to be not very convenient. A piece of 12.7mm diameter steel could easily be used instead.

The main handles of the brace are of 25mm diameter timber, drilled 13mm diameter axially to allow free turning on the 12.7mm, diameter steel "axles". These latter are turned down to 9.5mm diameter at one end and threaded $\frac{1}{4}$ inch BSW at the other, so that they and the key can be brazed into 9.5mm diameter holes in the brace "arms". The other ends screw into $\frac{1}{4}$ inch BSW holes in the arms and are locked with nuts.

The length of the wooden handles was chosen to suit my hand size. Those with larger hands may require additional length for comfort. To ensure correct assembly the axle 'X' should be tightened in position at its threaded end; the assembly rested on a horizontal surface and its other end brazed in place. This ensures that the arms are set parallel.

Bent bar key

In setting a workpiece on centre, it is necessary to slacken one jaw to allow its opposite number to be tightened. Usually, this is done by moving the jaws by half the difference between dial indicator gauge readings. However, with only one key this slacken/tighten routine cannot happen simultaneously and each seems to affect



the other slightly, so that there is a lot of repetition. A second key would allow both jaws to be moved at once; in this case the final setting can often be achieved first time.

On my lathe there really isn't room behind the chuck to fit a second T handled key, so a Bent Bar type has been made which fills the bill successfully. **Photo 1** shows a piece of bar being set in my four jaw chuck using a wobbler and dial indicator gauge, and involving both the T handled key and the bent bar key. **Drawing 2** depicts the Bent Bar key with the T Handled key to the same scale for reference.

Manufacture

The jaw driving screw sockets on my chuck are 7mm square - as measured with drill shanks. Thus square steel bar of this size would be the easiest to use; but alas my smallest stock was 10mm square so I had to use that. Using a length of about 160mm, the long end was placed in the bench vice; the section to be bent was heated red, and then bent at right angles using a large "King Dick" adjustable wrench (originally from my grandfather's tool kit). After cooling, the long and short ends were hacksawn to length and the short end filed to 7mm square. The corners were rounded until the key would just fit neatly into the sockets. Finally the key was blackened with a proprietary chemical treatment.

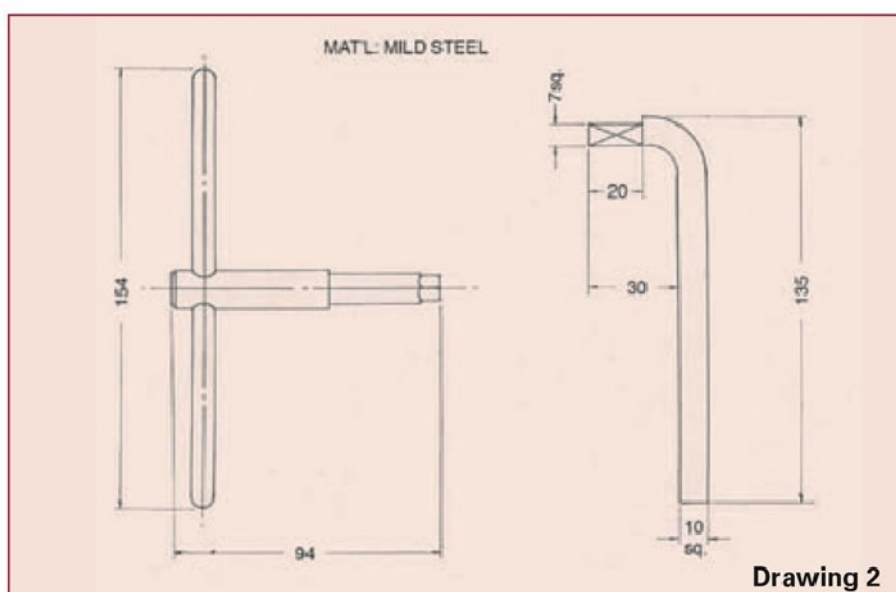
Conclusion

The two chuck keys described in this article speed the use and adjustment of the four jaw chuck, and make it a much more attractive option than previously.



References

1. **Creating Holes** - Philip Amos -MEW 67 Aug/Sep 2000
2. **The Amateur's Workshop** - I. Bradley - 1950



IN OUR NEXT ISSUE

Coming up in Issue No. 110 will be



Tailstock Power System

Peter Rawlinson cuts down on manual effort.

Modified Vice

Budget precision from Harold Hall



A Gear Cutting Attachment for the lathe

Dyson Watkins describes his solution.

Modifications to the X3 Milling Machine

Dick Stephen takes a further step in search of perfection.



Issue on sale 21st October 2005

(Contents may be subject to change)

Scribe a Line

Mr Bert Coyle of Victoria, Australia, writes:

I would like to request assistance via Scribe a Line. In the winter issue 1990/91, Mr Alan Buttolph described the building of a gearbox for the ML7 lathe. I have a lathe 6½in. centre height by 36in. between centres which I would like to build a gearbox for. In the Buttolph article, the author mentioned a gearbox designed by Mr L. H. Sparey. Can anyone supply information concerning where the plans can be obtained, or has anyone got plans they would sell. I have the *Model Engineer Plans Handbook Part 2*, but the plans are not listed. I would appreciate any help from other readers.

Mr Tom Bartlett, of Swanley writes:

Readers may be interested in something of the history of the Crossness Pumping Station.

When the Members of Parliament moved back into the newly rebuilt Houses of Parliament in the 1840's they soon discovered that there was one considerable drawback to being next to the River Thames, the smell. The river had always served the purpose of being the city's only means of getting rid of it's sewage, and in continuing to do so, it became necessary for the Honourable Members to adopt the use of nosegays of strong smelling flowers to overcome the smell of the sewage as it was washed back and forth by the tides during the hot days of an English summer.

A decision was taken to deal with the problem and this was to result in the building of a very large sewage works at Crossness near Erith in Kent to form part of a scheme to drastically improve the way sewage was dealt with in London, then a city which had a rapidly increasing population. Crossness was to include a very large pumping station driven by the four of the largest rotative steam powered beam engines in the world and would remain in use for many years. The solids in the sewage were separated from the water which was returned through a large brick lined tunnel to a point at the mouth of the River Thames and still does; with increasing amounts of sewage to deal now it looks as if it will have to be duplicated in the foreseeable future.

When the more convenient electric power became available to drive the pumps the beam engines were allowed to fall into disrepair. Vandals broke into the works and stole the valuable bronze parts from the engines to sell as scrap,

Mr. Chris. Moore (Managing Director, Myford Ltd.) writes:

Re: Bullwheel/backgear on Super 7 Plus and Super 7 Plus Sigma Lathes

I would like to add to the information given on page 11 of *MEW* Issue 108. In redesigning the Super 7 headstock so that it could accept a spindle bored 26mm, my father somehow managed to completely overlook the fact that users of original small bore lathes had grown accustomed to having a 60 tooth bullwheel/backgear which readily lent itself to dividing on the spindle. Over the years a number of dividing attachments had been conceived to suit, most notably Radford's design which was later much improved by G.H. Thomas. Therefore the new Super 7 Plus and Super 7 Plus Sigma models arrived on the market with a 67T bullwheel/backgear.

By the time a customer drew our attention to this redesign work, work to introduce the Connoisseur was well underway. There and then, father decided to do the corrective work, have a 60 tooth backgear and fit some simple indexing to the machine. Therefore all Connoisseurs have the 60 tooth bullwheel, and finally the other two machines were upgraded earlier this year from machine serial no. SK 171371.

For those customers who have the earlier machines, it is possible to update the machine. The parts required are:-

1	15393 60T backgear	£70.03
1	15396 Sleeve gear	£30.93
1	15398 53/16T backgear cluster	£37.49
	Post and packing	£ 6.20
		<u>£138.45</u>
	V.A.T. @ 17½%	<u>£ 24.23</u>
		<u>£162.68</u>

Whilst the bits are reasonably straightforward to fit, the customer will have to make some tooling to extract the sleeve gear from the vee cone pulley. Also, when the new sleeve gear is pressed into place the bore is quite likely to close down fractionally. At the factory, to create the correct fit, we put the assembly on a hone, whereas in a home workshop situation, the customer may have to resort to using a half round scraper.

this badly delayed the work some years later of some enthusiasts to recondition the engines and bring them back to their as new state which existed in 1865 when they first worked. This task was to take many years of work and would ultimately become part of the Museum

complex to which the public are admitted by appointment which can be made by ringing 0208 3113711. Visits start at 1.45pm and the nearest railway station is Abbey Wood. Restoration is not complete, but visitors are welcome. Phone to enquire about admission.

Tom Smith of Stockport writes:

Other readers may be interested in a couple of additions to my Myford ML7. As an alternative to Peter Rawlinson's ingenious arrangement (*MEW* Issue 105) for powering the topslide, I offer a mechanical set up based



System driven from a pulley attached to the handwheel.

on a flexible tool drive. As can be seen from the photo, drive is taken from a pulley fitted to the leadscrew handwheel, to a second pulley, which drives the shaft. The chuck end of the shaft may then be connected to convey power to either the cross slide or the top slide.

In addition, I would like to mention my clasp nut release for the ML7 which I rate one of the best accessories ever to be added to the ML series lathes, and which I strongly feel never had the publicity, which it richly deserved. Basically it does "exactly as it says on the tin".

It will:

1. Run a cut at any speed up to a pre-set point, which can even be set with a micrometer head. Try as I may, I cannot envisage a more accurate method of stopping the cut. It is even self-adjusting for wear!
2. Given the correct shaped tool it can be used to cut on the return stroke

Laurie Dryburgh of Coventry writes:

I was fascinated by the Dick Stephen article on the centring microscope in the May issue. Just reading prior to reading it I had been measuring up a standard brass 22mm Tee fitting, left over from some plumbing and consigned to the scrap bin. The dimensional accuracy was excellent and it occurred to me that it could be used as a main body casting with very little modification.

Also in the scrap box was a No. 2 Morse taper arbor, which I had acquired at Donington "in case it came in handy." This was machined down in two steps to fit two thirds of the way through the fitting, and the smaller diameter portion was sawn off at 45degrees. A small piece of a broken OHP mirror (silvered on the working surface) was fixed using double-sided adhesive tape to the angled surface, and trimmed to fit the bore using a diamond wheel in a mini drill - a somewhat laborious process. As I only intended to use the microscope for lining up centre punch marks, I fitted cross hairs of fine wire through four small holes in the copper pipe side arm at the focal point of the eyepiece lens (another scrap box item).

The whole thing is assembled with Loctite and adjusted on assembly by twisting the mirror arbor. Surprisingly, it set up spot on and the whole thing took only an afternoon. The accompanying photos show the device in use and in component form. It may not be pretty but it works, and should save a lot of time which, wife permitting, might be used for proper modelling.

Whilst searching through the scrap box for items for the microscope, I came upon a little gadget, made some time ago, which may be of interest to some readers.

Having earlier finished a Vulcan beam engine, I thought it looked a bit bare under the base plate with just the boiler pump, so I thought I would make a feed water tank out of some tin plate and simulate rows of rivets at the joints. Making a dome punch and aligning it with a matching recess to punch out rows of rivet heads seemed a lot of work so this is what I came up with.

The device is made from a piece of suitable flat bar. The first hole through the jig is the diameter of the rivet heads and spaced from the edge just less than the rivet centres. A saw cut goes across the hole at right angles and far enough past to space the rivets from the edge of the plate to be punched. Finally, the hole is drilled out as far as the saw cut to the diameter of a ball bearing selected to be about 20% larger than the intended rivet head.

In use, the block is held in the vice, the plate is pushed into the saw cut, and the ball bearing is dropped down the hole and punched with a short length of rod and a light hammer. Sliding the plate sideways until the new rivet head appears and repeating the procedure gives a neat row of simulated rivet heads in less time than it takes to describe.



Centring microscope completed



Component parts of microscope



The device in use.



Miniature punch for simulating rivets.

- (controlled by hand) thus saving a fine finishing cut.
3. I regularly use it for 'blind' boring, as it is just as accurate to set inside or outside.
4. The tool is permanently fitted and ready for use, and the previous lever functions are unchanged. I'm



Flexible drive taken to cross slide.



Drive taken to top slide

sorry I do not have the name of the designer of this little wonder, which bears some similarity designs shown in recent issues of this magazine, but he should be aware that, when MEW Gold Medals are awarded, I will be the old bloke cheering loudest.

LINK UP

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

To advertise goods of a greater value, please contact our Classified

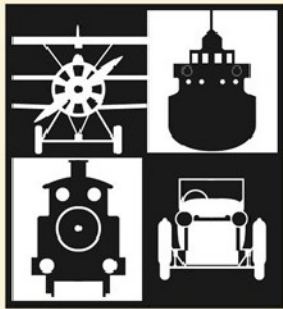
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WANTED

- Wanted: Copy of MEW Issue No. 58. Please phone Neil on 01235 817 963 (Oxon).
- Wanted: Student requires back copies of magazines e.g. Live steam, Australian Model Engineer, Home Shop machinist. Also books on locomotive building, steam engines, model engineer, metals, before 1960's only. Any condition tatty /torn. Must be cheap or free. Phone Steve 01642 505 847 Cleveland.
- Help Wanted
"Precise" gauge blocks. I have a set of these gauge blocks with the trade name "Precise" or "Precision" which are similar in purpose to slip gauges except that they are approx. 3/4in. square section instead of the usual slip shape. The individual blocks are identified by a code letter/ number rather than having the size engraved on them. However, the sizes (as checked with a comparator and a set of slips) seem not to follow any expected theme. When they were new - many years ago - the lid of the box contained a chart giving the sizes. Does anyone else have a set and, do they have the chart? A copy would obviously be of great assistance.

I have a second request for information concerning a Moore and Wright 2000 Micrometer -this is the sliding digital instrument. It works well but there is a small (!) accuracy problem. At 0.030 in. the error is 1 or 2 tenths which progressively increases so that at 1.000 in. the error is 0.030 in. and the max reading (when open to 1 in. +) is 0.97 or so. The device zeroes without problem. The machine appears to work by reading a glass scale with some signal processing. The circuitry includes three subminiature preset pots of unknown effect. Before I dive in, screwdriver in hand, has anyone any experience or advice about the instrument please? Do I attack the electronics or the mechanical arrangement?

Please contact M. Leafe with solutions to my problems at Tel: 01924-460864 or email malcolm.leafe@btopenworld.com



THE MODEL ENGINEER EXHIBITION

Please return completed form to:
Model Engineer Competition, The Leys,
Church St., Twyford, Bucks. MK18 4EU

ENTRY FORM - COMPETITION & LOAN MODELS

ENTRY NO.

OFFICE USE ONLY

CLASS	ENTRY NO.

PERSONAL DETAILS (Please print)

Surname Forename(s) Age

Address
.....
.....

Post Code Home Tel: Daytime Tel:

Model Club or Association

Have you entered before? (Y/N)

Do you purchase or subscribe to a Highbury House Communications plc magazine? (Y/N)

How many years have you been a modeller?

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

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

Entry Class (competition entries only)

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

Model Description
.....
.....

Model Scale Length Width Height Weight

Type of construction
.....

Parts not made by you and commercial items
.....

Have you supplied a photograph? (Y/N)

Are you supplying Judges Notes? (Y/N)

Value of model (Highbury House Communications plc will not insure the model unless a value is entered) £

Name and address of local newspaper
.....

TO HELP YOU GET THE BEST FROM THE MODEL ENGINEER EXHIBITION

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

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

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

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

Club exhibits

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

Additional forms

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

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

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

COMPETITION CLASSES

Engineering Section

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

Railway Section

- B1 Working steam locomotives 1in scale and over.
- B2 Working steam locomotives under 1in scale.
- B3 Locomotives of any scale, experimental, freelance or based on any published design and not necessarily replicas of full size prototypes, intended for track duties.
- B4 Scratchbuilt model locomotives of any scale, not covered by classes B1, B2, B3, including working models of non-steam, electrically or clockwork powered

steam prototypes.

- B5 Scratchbuilt model locomotives gauge 1 (10mm scale) and under.
- B6 Kitbuilt model locomotives gauge 1 (10mm scale) and under.
- B7 Scratchbuilt rolling stock, gauge 1 (10mm scale) and under.
- B8 Kitbuilt rolling stock, gauge 1 (10mm scale) and under.
- B9 Passenger or goods rolling stock, above 1in scale.
- B10 Passenger or goods rolling stock, under 1in scale.
- B11 Railway buildings and lineside accessories to any recognised model railway scale.
- B12 Tramway vehicles.

Marine Models

- C1 Working scale models of powered vessels (from any period). Scale 1:1 to 1:48
- C2 Working scale models of powered vessels (from any period). Scale 1:49 to 1:384
- C3 Non-working scale models (from any period). Scale 1:1 to 1:48
- C4 Non-working scale models (from any period). Scale 1:49 to 1:384
- C5 Sailing ships and oared vessels of any period - working.
- C6 Sailing ships and oared vessels of any period - non-working.
- C7 Non-scale powered functional models including hydroplanes.
- C8 Miniatures. Length of hull not to exceed 15in for 1:32 scale; 12in for 1:25 scale; 10in for 1:16 scale; 9in for 1:8 scale. No limit for smaller scales.
- C9 For any model boat built from a commercial kit. Before acceptance in this class the kit must have been readily available for at least 3 months prior to the opening date of the exhibition and at least 20 kits must have been sold either by mail order or through the retail trade.

Scale Aircraft Section

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

Model Horse Drawn Vehicle Section

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

Junior Section

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

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

Model Vehicle Section

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

DUKE OF EDINBURGH CHALLENGE TROPHY

Rules and Particulars

1. The Duke of Edinburgh Challenge Trophy is awarded to the winner of the Championship Award at the Model Engineer Exhibition.
2. The trophy remains at all times the property of Highbury House Communications PLC.
3. The name of the winner and the date of the year in which the award is made will be engraved on the trophy, which may remain, at the discretion of Highbury House Communications PLC in his/her possession until required for renovation and display at the following Model Engineer Exhibition.
4. Any piece of model engineering work will be eligible for this Championship Award after it has been awarded, at The Model Engineer Exhibition, a Gold or Silver medal by Highbury House Communications PLC.
5. No model may be entered more than once.
6. Entry shall be free. Competitors must state on the entry form:
 - (a) That exhibits are their own bona-fide work.
 - (b) Any parts or kits that were purchased or were not the outcome of their own work.
 - (c) That the model has not been structurally altered since winning the qualifying award.
7. Highbury House Communications PLC may at their sole discretion vary the conditions of entry without notice.

COMPETITION RULES

1. Each entry shall be made separately on the official form and every question must be answered.

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

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

4. Models will be insured for the period during which they are in the custody of Highbury House Communications PLC
5. A junior shall mean a person under 18 years of age on December 31st in the year of entry.
6. Past Gold and Silver medal award winners at any of the exhibitions promoted by Highbury House Communications PLC are eligible to re-enter their model for the 'Duke of Edinburgh Challenge Trophy.'

Past winners at any of the exhibitions

promoted by Highbury House Communications PLC will not be eligible for re-entry into the competition unless it has been substantially altered in any way.

7. Highbury House Communications PLC reserve the right to:
 - (a) Transfer an entry to a more appropriate class.
 - (b) Describe and photograph any models entered for competition or display and to make use of any such photographs or descriptions in any way they may think fit.
 - (c) Refuse any entry or model on arrival at the exhibition and shall not be required to furnish a reason for doing so.
8. Entry into the competition sections is not permitted by:
 - (a) Professional model makers.
 - (b) Anyone who has a financial interest in the direct supply of materials and designs to the public.

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

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

IMPORTANT NOTE PLEASE MAKE COPIES, INCLUDING PHOTOGRAPHS, OF ALL INFORMATION RELATING TO YOUR MODEL, AS Highbury House Communications PLC WILL NOT ACCEPT LIABILITY FOR ANY LOSS.

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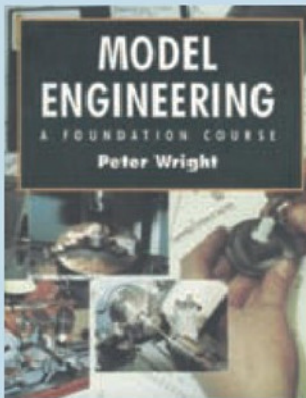
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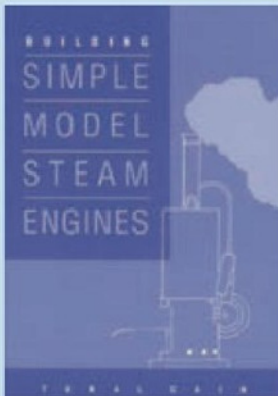
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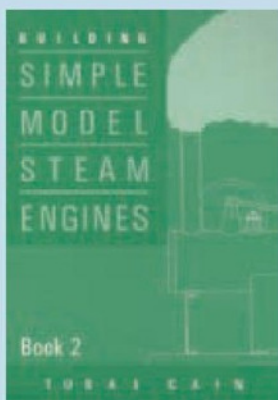
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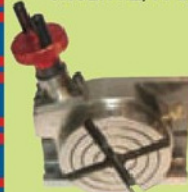
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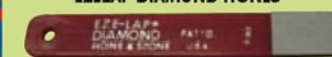
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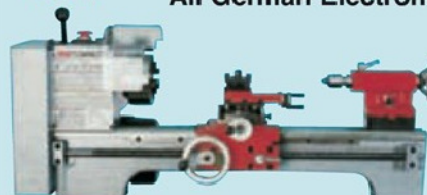
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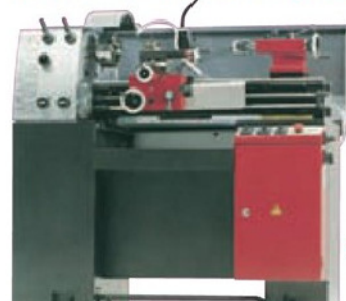
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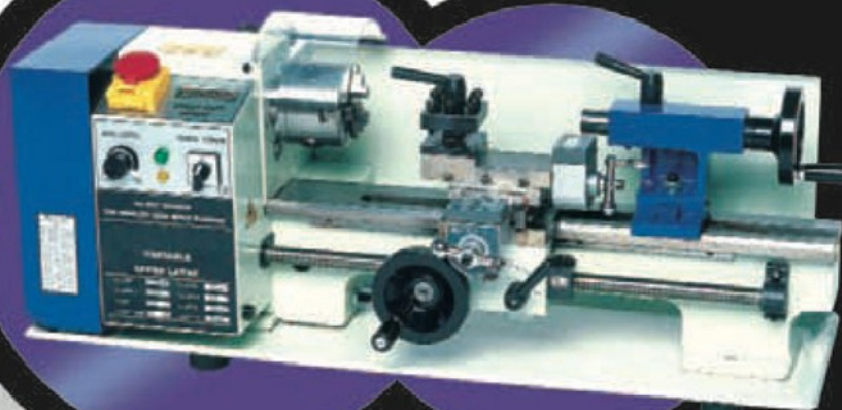


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