

No.43

MODEL ENGINEERS'

WORKSHOP

THE PRACTICAL HOBBY MAGAZINE

SURFACE FINISH

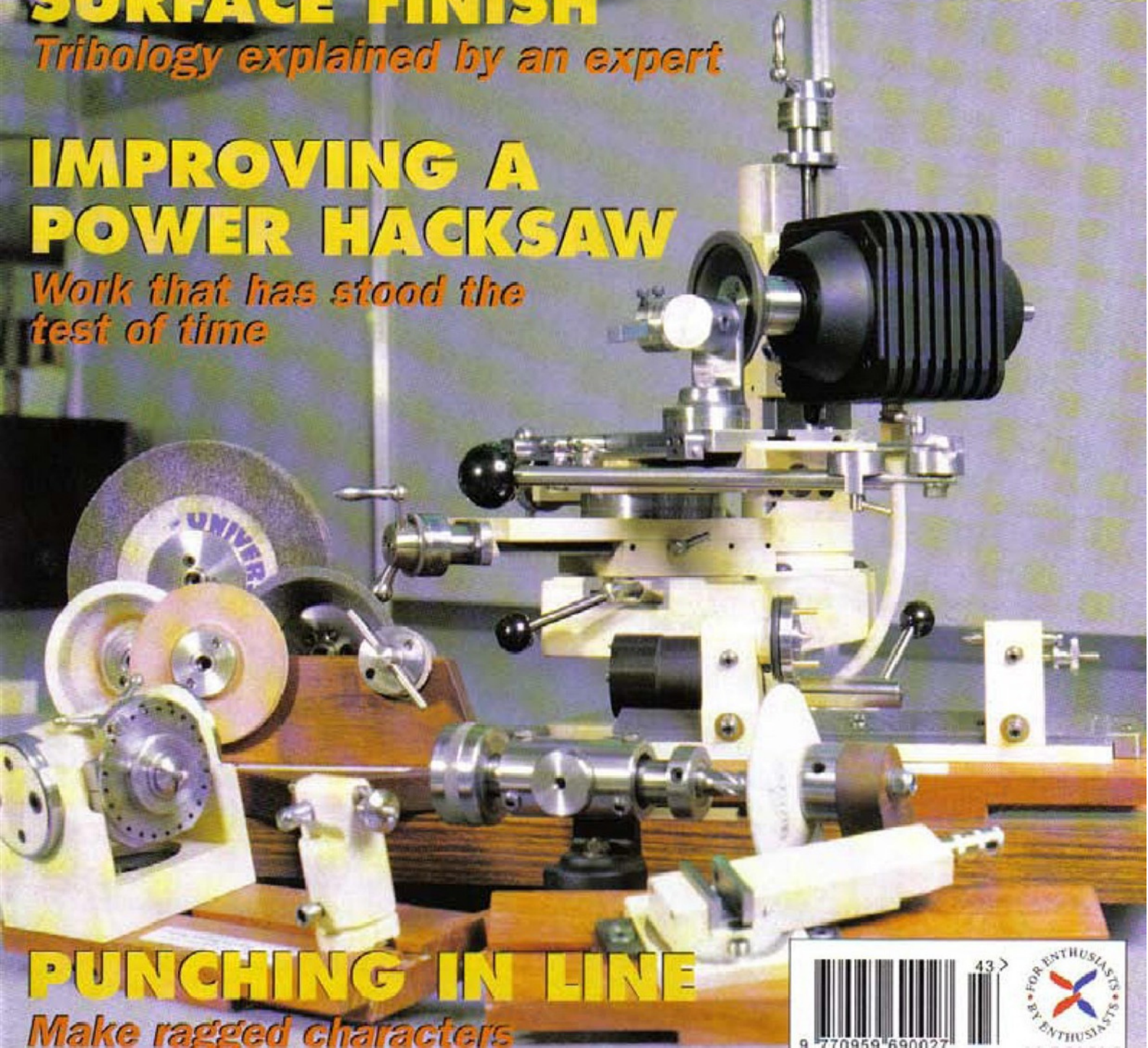
Tribology explained by an expert

IMPROVING A POWER HACKSAW

*Work that has stood the
test of time*

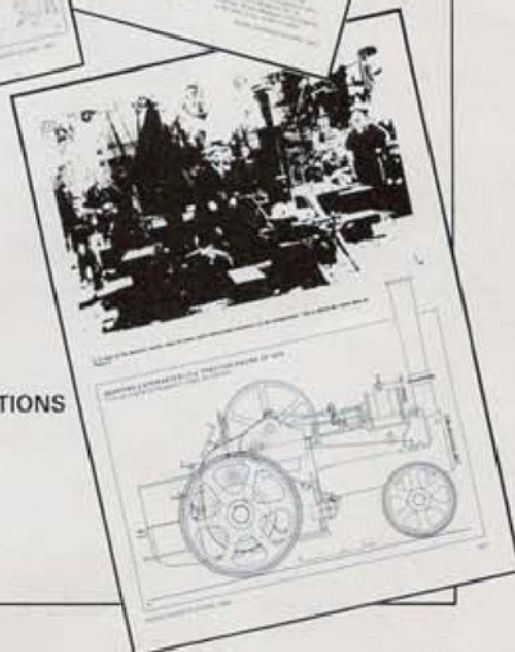
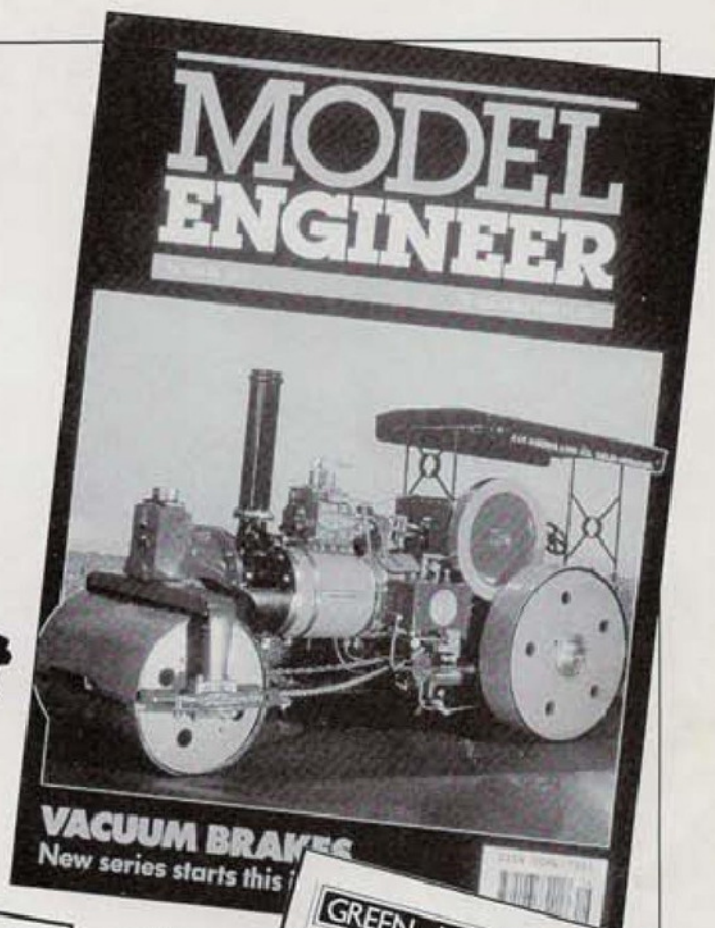
PUNCHING IN LINE

*Make ragged characters
a thing of the past*



JULY/AUGUST 1997 £2.95

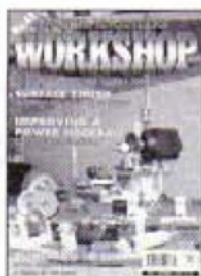
**SOMETHING
TO LOOK
FORWARD
TO...**
...every fortnight



There's something to anticipate twice every month in fascinating Model Engineer magazine! Whether your interests lie in live steam locomotive models, traction engines, internal combustion motors or stationary engines, world famous M.E. will inspire, instruct, advise and encourage. Model Engineer is published on the first and third Fridays each month and costs just £1.40 from all good newsagents; alternatively, you may care to ensure your regular copies through an annual subscription – a mere £33.60 for UK readers (overseas rates and airmail details on request).

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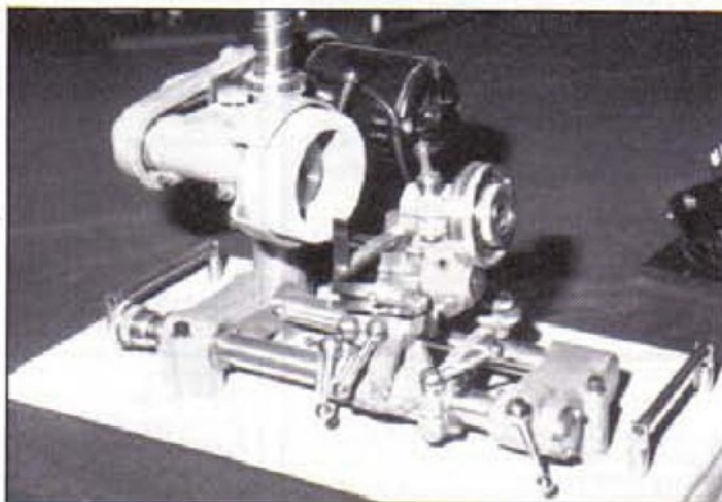
David Machin took a lot of time and trouble to bring his commercially available power hacksaw up to his own exacting standards. In this article he passes on some of the results which have been proven over a long period.

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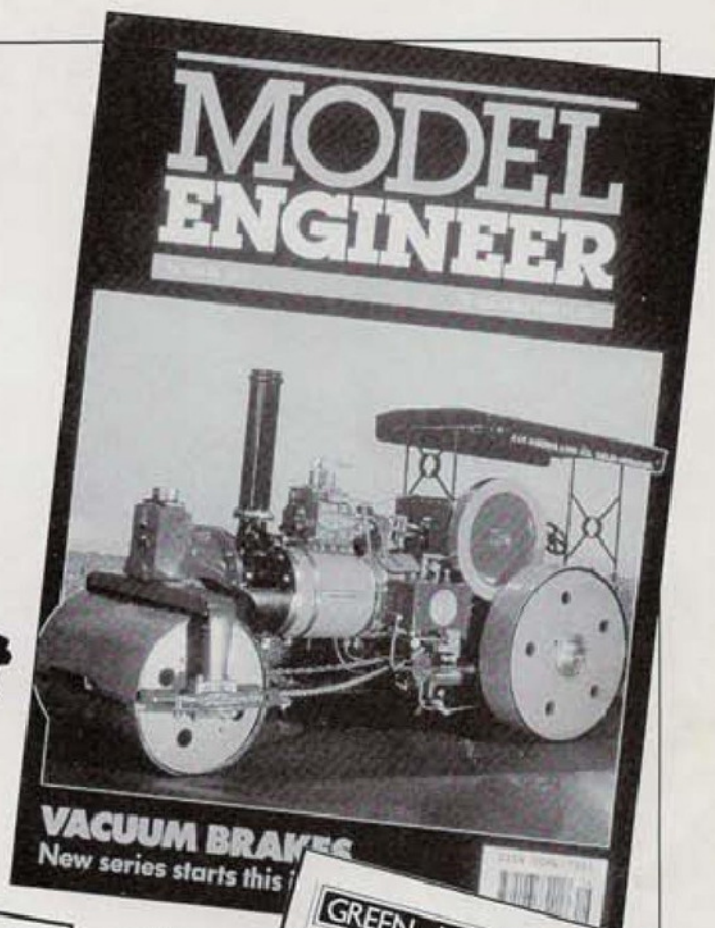
On the cover

With grinding and metal finishing dealt with at some length in this issue it was felt that picture of Derrick Crossland's self designed tool and cutter grinder and a host of accessories would make a fitting subject for our cover this time. Derrick has previously gained an award for this excellent tooling, this year visitors to the M.E. Exhibition had the chance to admire it again when it was entered for the Duke of Edinburgh Challenge Trophy.



Many hundreds of the very versatile Quorn Tool and Cutter grinder have been made since it was introduced to the hobby in the 1970s by the late Prof. Dennis Chaddock. Over the period since its inception, builders have inevitably found more ways to increase versatility of the machine, as well as introduce subtle design changes. One builder's ideas on the subject start on page 34 of this issue.

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ON THE EDITOR'S BENCH

The engineering activities are centred around a workshop established especially for the week, and staffed by the Technical Editor of *Model Engineer*, Mike Chrisp, Roger Nicholls of Peterborough and myself, ably supported by Roger's son, Lee. For many years, I was joined by the founding Editor of *M.E.W.*, Stan Bray, who has now 'hung up his micrometer', but still puts his head around the door from time to time, to make sure that we are keeping up the standards.

Most of the equipment used comes from our own workshops, but this year, we were loaned one of the Russian lathes marketed by Proops Brothers, of Fleckney, Leicester, to whom we are indebted. This arrangement allows visitors to see, in operation, a piece of machinery about which they may have read only in an advert. Last year, Chester U.K. were kind enough to supply one of their combination machines, which also generated much interest. Much of the work undertaken through the week is concerned with repairs to models from the other disciplines, which have perhaps been damaged in competition, or often due to adverse weather conditions on the flying sites. The varied nature of these tasks provides much of the enjoyment for the workshop team because, with limited facilities and materials to hand (it is impossible to transport the entire contents of our workshops) our ingenuity is frequently tested to the limits. Being confronted with the remains of a severely damaged aircraft engine and the plea "Do you think that you could do anything about this?" sometimes makes us think that we have met our match, but I can recall only a few occasions when we have had to admit defeat. Kind words written in our workshop log and a donation to our charity box are a tangible addition to the glow of satisfaction we experience from the rescue of what at first sight appeared to be a basket case.

We usually arrange to have some form of project to occupy us during the quieter spells, and this year these consisted of the assembly of some attractive miniature cannon from part machined components supplied via a friend of Ted Jolliffe, Editor of *Model Engineer*, and the construction of a steam plant to the *Vivian* design, originally produced by the late Andrew Smith. The drawings for this mill engine have been revised by Hugh Mothersole of HRM, and the castings are being produced by A.J. Reeves & Co. of Birmingham, who kindly supplied a set, together with the materials for a small test boiler. The facilities to hand did not allow the machining of all the components, but work will continue to finish the project.

As previously mentioned, a portable track for 3 1/2in. and 5in. gauge locomotives (loaned by the Peterborough Society) is available for the railway enthusiasts, and the private road system within the holiday complex provides an ideal venue for the steam road vehicle owners to operate in relative safety, with a

stiff climb back from the beach causing some healthy exhaust sounds.

Each evening, apart from the model boat sailing programme on the indoor pool, a forum, lecture or video show is organised, each covering a specific aspect of the hobbies. Traditionally, Monday is the engineering teams' evening, and this year, Mike Chrisp presented a slide show illustrating the varied aspects of our hobby. This generated an interesting discussion on the way ahead for model engineering and sowed a few seeds for the future. On Thursday, the Boat Forum evening, Mike and I were invited as guest speakers, to give our thoughts on the care and maintenance of model marine steam plants, again a good example of the sort of cross-fertilisation that this type of gathering allows. Mike's final engagement of the week was to present the prizes at the exhibition of work created by those attending the Craft Club held in the ballroom of the site's hostelry. The work produced by these ladies and gentlemen never ceases to amaze and delight us. Many of the skills exhibited have been gained through the week, thanks to the expertise and patience of a talented team of instructors.

An added attraction this year was a grandstand view of the replica of Captain Cook's ship *Endeavour*. The week coincided with her voyage from Boston in Lincolnshire to the home port of the prototype, Whitby, where great celebrations had been arranged. On her trip North, she rounded Flamborough Head, and turned close inshore, to come within easy viewing and photographing distance. As the Haven holiday site is situated right on the cliff top of Filey Bay, many of the modellers temporarily abandoned their pursuits to enjoy this unique occasion. Waves were exchanged with the crew, then she fired a salute to the town of Filey, before turning out past Filey Brig to continue her journey, looking a fine sight with the sun on her sails.

Once again, Model Week at Primrose Valley had provided much enjoyment and entertainment, and we look forward to next year.

Ken Whiston

It is with regret that I must record the passing of a 'household name' in the hobby engineering world. K.R. Whiston Ltd. of New Mills, Stockport was a veritable Aladdin's Cave of surplus tools, materials and gadgets, from which many a model engineer has stocked his home workshop. The famous slogan "Seen my Cat?" was to be seen in many an advert, and the 'cat' was packed with goodies at amazing prices.

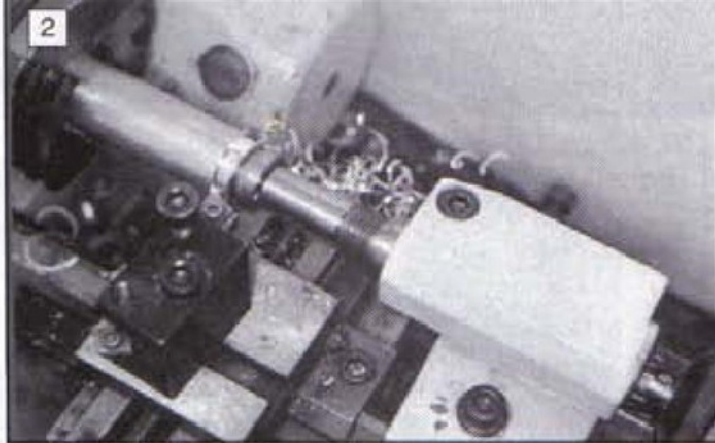
Ken also operated a surprise bonus system, and depending upon the value of the goods ordered, would include a substantial 'extra' in the consignment, though occasionally these were of obscure origin, and would require a vivid imagination to identify a possible use!

I never had the privilege of meeting Ken, but I am told that he was a kindly and generous man, a model engineer who understood and appreciated our requirements, and who went to great lengths to provide a service. Our thoughts are with those he leaves behind.





A set of home-made tipped cutters.



The small double ended tool holder in use.

TUNGSTEN CARBIDE TOOLING DOESN'T HAVE TO BE EXPENSIVE

Although modern tool tips seem to be readily available on the surplus market, suitable toolholders can still be very expensive. Bob Loader set out to make his own in a variety of sizes.

I first saw tungsten carbide tipped tools demonstrated at the British Industries' Fair at Castle Bromwich in, I think, 1947. I was one of a group of apprentices on the first of quite a few outings to various engineering activities. It was impressive, especially as we were more used to high speed tools, often not quite sharp, used on not quite the most efficient machines.

Since then, I have been aware of the material, but not a great user of it until a few years ago, when I dispelled one or two wrong ideas.

I used to think that small lathes lacked the power to use it to its maximum, and I had doubts about the sharpening. That was before I tried the small tips, and found them so good. Now I use tipped tools for most of the plain turning jobs, leaving the high speed steel for special shapes and where there may be a lot of grinding to do to get the shape right. The tips I use are the Stellram ones in the smallest size.

Early misgivings

My first thoughts have been proved wrong on several counts. Tips can be sharpened, as long as it is just a touch up, and a diamond

hone will do everything which an India stone will do for high speed steel, better in fact, because the hones do not clog up as much as a stone.

Another reservation I had was cost, not so much the cost of the tips, because they last a long time. What I did recoil from in horror was the cost of the holders. I was very reluctant to part with about £30 for a holder; regular readers will know my reputation for meanness! My view has always been, why buy when it can be made?

A very useful item

Given that the holders can be made reasonably easily, the tips are very useful indeed. On the Unimat, they will shift metal quickly by taking a lot of small cuts at high speed, rather than a smaller number of heavy cuts at slower speeds, with which a larger, more powerful lathe will accept.

An assortment of holders can be made to cope with all the usual turning jobs. One other thing I like about using tips is that they were originally developed for high speed cutting without coolant, among other things. Since then, improvements in the material and in modern coolants and oils have changed

that. To someone like me though, who works indoors, the ability to work without coolant is greatly appreciated.

Making the holders

There are several variations, and some are easier to make than others. The most awkward bits are making a register to locate the tip and a modified screw to hold it. The holders can be made from material out of the odds and ends box. Although all but one of the holders I've described are for the Unimat, they can be scaled up, and larger tips used for bigger lathes. **Photo 1** shows a selection of home made holders with the tips clamped in position. From top to bottom, a 10mm square, a boring tool, a single ended holder and a double ended one for turning and facing.

Single ended holder

This one (**Fig. 1**) is the easiest one to make. It is just a length of mild steel, 6mm square, with an angled cut-out holding the tip in a position where it can turn and face.

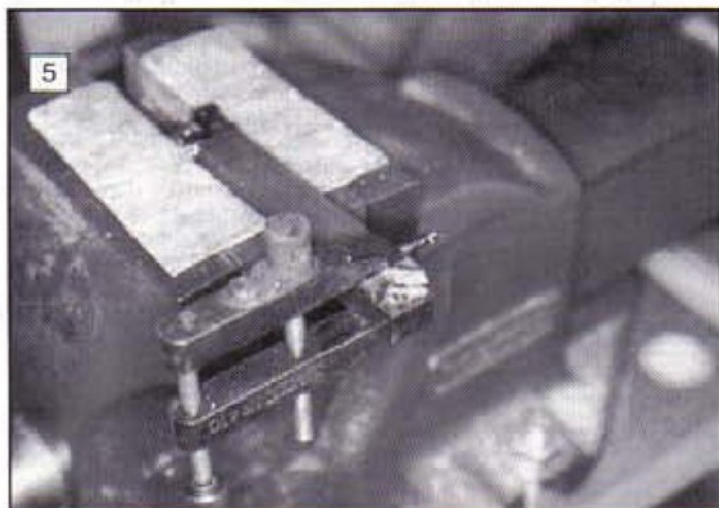
The cut-out must be angled at 10deg. vertically, so that it matches the clearance



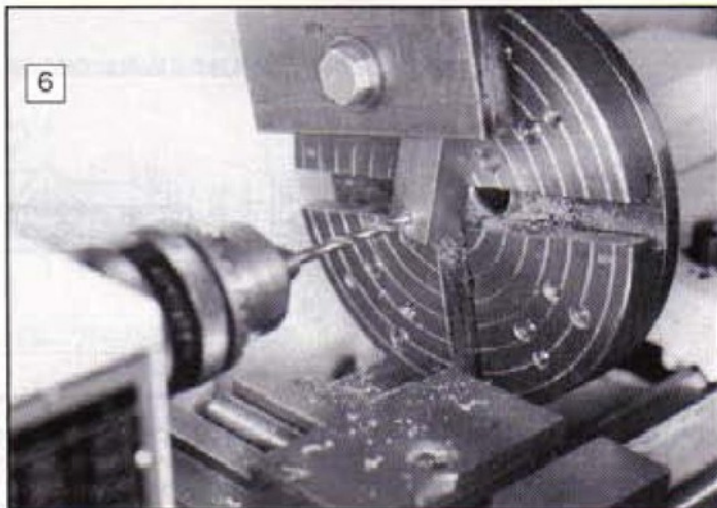
Two inserts filed to fit the tips, ready to separate and finish.



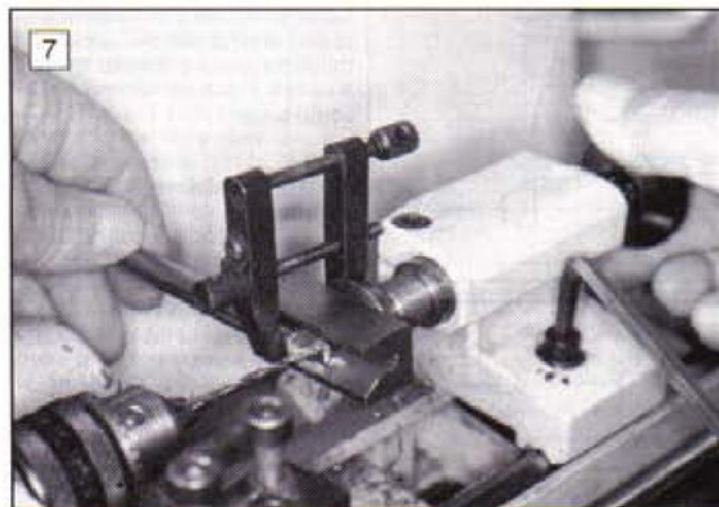
A finished insert being tinned for soldering.



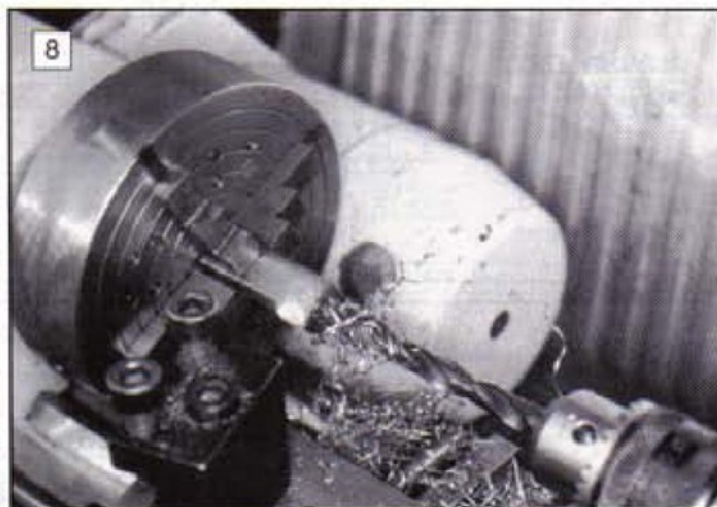
An insert soldered in position on the body of the 10mm square holder.



Drilling the tapping size hole in the end of the 10mm square holder.



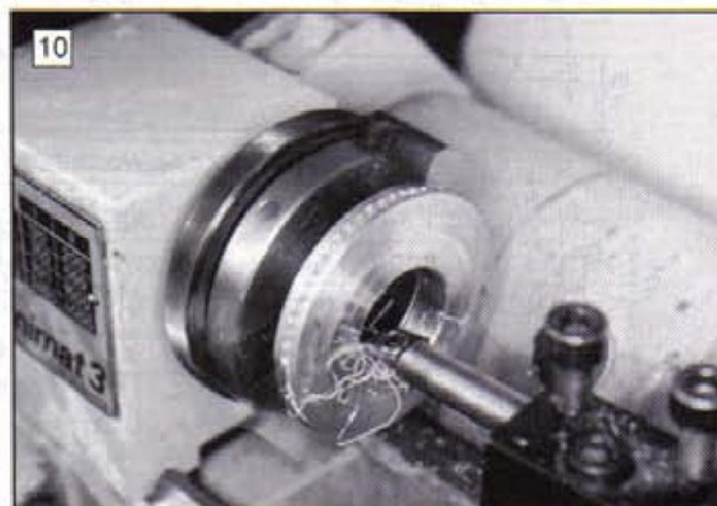
Using a crutch centre for drilling the tapping hole in the boring bar.



Drilling through the jacket for the boring bar.



Splitting the jacket for the boring bar.



The boring bar in action.

angle off the tip and fits snugly. It could be milled, but the setting up would be tiresome and involve a compound angle. I prefer to file such jobs, it is often quicker. Once the tip fits, it can be clamped lightly in position and the hole spotted through for the screw. A 4.2mm drill is the right size, or a scriber can be used to mark the outline and the centre picked up and punched. It may sound strange for the screw size of 3mm to have a clearance hole of 4.2mm

through the tip. Don't worry about it, it fits and does the job.

When the M3 hole has been drilled and tapped, the holder is finished except for the screw to hold the tip. This can be made from a cheese head, turned to a countersunk shape at 60deg. included, or better still, a cap head screw modified as in **Fig. 1**. A cap head will be more durable, because it is made from better steel. Whichever screw is used, it needs to have

more thread than is required, so that it can be held in a chuck or collet for turning the angle. If a cap head is used, turn it with a tipped tool if possible because the forming processes for making the hexagon socket and the straight knurling tends to work-harden the head. If high speed steel has to be used, cut the speed down and use light cuts.

When finished to the dimensions in **Fig. 1**, the holder should sit nicely in a Unimat 3 tool post. It can be adjusted for height while

©

* ITEM 2 - STANDARD
TIP, STELLRAM REF. NOS.
EPMM 53XT,
EPMA GH I,
EPMM GH I (SEE TEXT).

6 MM. SIMPLE TOOL HOLDER - ASSY.

3 MODIFIED
CAP HEAD
SCREW

1 TOOL HOLDER BODY - B.M.S.

FIG. 1.

As with the first holder, the centre height can be adjusted by filing the bottom of the finished holder, so that no packing is needed. The M3 holes are spotted through and drilled and tapped the same as the previous one. **Photo 2** shows it in action, turning some tube.

I made this one so that I could send it to Harold Hall for him to try on his Myford. We had discussed the merits of tungsten carbide, and he kindly sent me a couple of tips of a different design and size than those I use. I shall be making a holder to fit those some time in the future.

Back to the 10mm one shown in **Fig. 2**. It is made with inserts to locate the tips. They are made from 3mm x 12mm steel strip, and can be filed flush with the body when everything is finished. **Photo 3** shows them filed ready for separating and finishing. It is always best to leave the piece as big as possible for as long as possible, to make it easy to hold in the vice.

The tips have to fit snugly, and the 10deg. clearance can be seen on the left hand one in the photograph. The 2mm relief hole in each insert can be filed with a small round file. It is easier than drilling, and will save you saying "My word!, how unfortunate" should you overshoot when sawing or filing the angles.

The 10mm square bar has 3mm steps cut into each end to insert. **Figure 2** is not completely finished, but as long as the 68mm on the right and the inserts fit, there is little latitude about the shape of the vital thing is to avoid too much. Tungsten carbide is quite hard material and the tips need all the strength possible.

The inserts can be riveted using small rivets, or they can be soldered to the body. I chose to solder them. It has to be done with a good heat source; I use my small

©

Technical drawing of a 10mm square tool holder. The drawing includes a front view (top) and a side view (bottom). The front view shows a long rectangular body with a square end on the right. Callouts 1, 2, and 3 point to specific features: 1 points to a small circular feature on the left end, 2 points to the square end, and 3 points to the main body. Dimensions include a width of 10mm and a length of 68mm. The side view shows the profile of the tool holder, with a width of 10mm and a height of 3mm. The text "10MM SQUARE TOOL HOLDER" is written at the bottom.

NOTES :-
1. RIVET OR SOFT
SOLDER ITEMS
LAND 2. TO BODY
ITEM 3.
(SEE TEXT)
2. STELLRAM
TIPS ITEM 4.
AS SPECIFIED
IN FIG. 1
3. ITEM 5. AS IN
FIG. 1

1. TURNING TIP
INSERT - B.M.S.

FIG. 2

it is being made, so that it will be exactly on centre when clamped down. File the bottom of the holder or the bottom of the cut-out. Always check with the clamping bolts firmly tightened because there is often a bit of movement when the final tightening is done.

This one, **Fig. 3**, is made in two parts riveted together, and is my favourite for

general work. The top plate has the shapes for the tips cut out by sawing and filing. I used 3mm x 12mm. mild steel strip, and had to file the width to 10mm. I did this after assembly. All the dimensions are in **Fig. 3**, and the finished holder is the bottom one in **Photo 1**. The cut-out in the one photographed is decoration, and I cannot remember why I did it. Notice the outlines of the rivets and take a lesson from them; if rivets are used, don't countersink too deeply. Someone will have

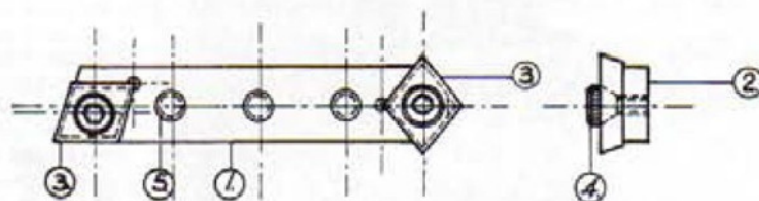
propane torch. The easiest way to do it is to tin the body and the inserts separately, then sweat-solder them together. Start by making sure that everything is thoroughly cleaned. I did the body first. It was easy to tell when it was nearly hot enough because the smear of flux I put on it began to spit and splutter. A dab with the solder, without putting the flame to it and it should have covered the cut-out. It didn't, so I rubbed it with a piece of wire and a bit more flux. That did the trick, the solder spreading nicely, and I wiped it off with a clean rag. The result was a very thin coating which looked like a coat of silver paint. I did the other end the same way.

The two inserts had to be held differently for tinning. Even if they could be held in the vice, the jaws would act as a heat sink, and anyway, the vice is a new one and I didn't want to make a mess of it. The answer was to hold the inserts in a small clamp, as in **Photo 4**. The insert has got its solder coating and just needs wiping. Use an old clamp and hold the torch at about the distance it is in the photograph.

Both inserts were tinned and wiped off. I checked to make sure that they still fitted the steps in the body, and filed off the little bits of excess solder. I also broke the edges where they butted against the steps. When all was well, I fluxed the steps lightly and clamped the inserts in place, one at a time. All that is needed is a gentle warm up and capillary action does the rest. When the solder runs, a little extra can be dabbed on. The result is shown in **Photo 5**, where the facing insert has been fixed. All that remains to do is to clean off any excess (there's bound to be some), and file the inserts flush with the body. You will soon find out where you have used too much solder, and it is a nuisance to clean off the surface of the step where the tip fits. It **must** be done, so that the tip fits flat.

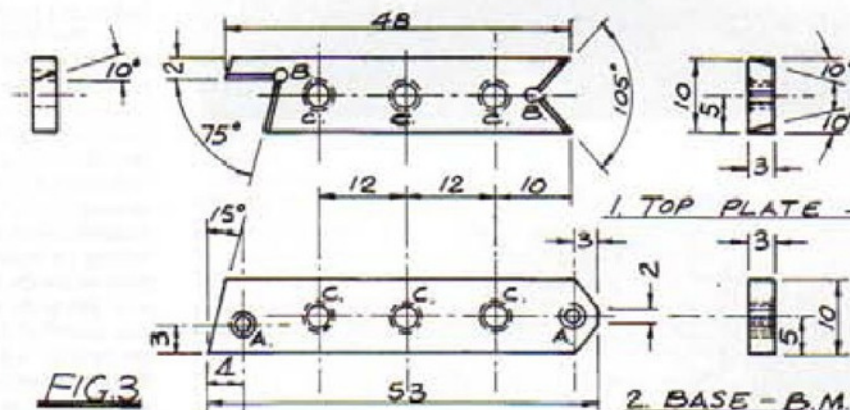
I used ordinary cored solder and Fluxite for the flux. The mess left by the flux can be cleaned off with meths. It is important not to get the work too hot. It shouldn't show the tempering colours. Other fluxes can be used, but avoid the acid based ones like Baker's

DIMENSIONS IN MILLIMETRES.



6MM DOUBLE-ENDED TOOL HOLDER.

3 TIP-SEE FIG.1
4 MODIFIED CAP HEAD-SEE FIG.1
5 3MM STEEL RIVET IN 3 POSITIONS.



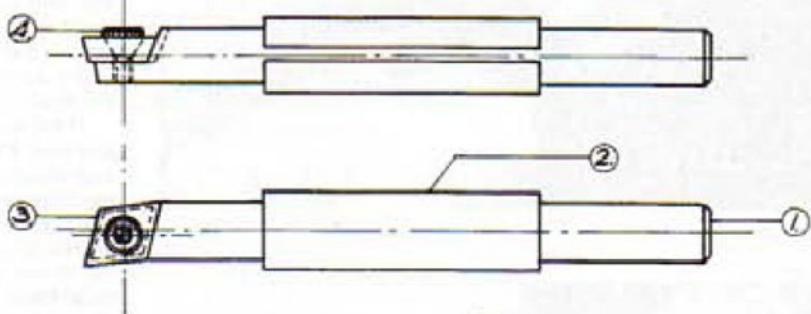
HOLES DATA-
A. TAP M.3
B. DRILL Ø2.5
C. DRILL Ø3
C'SINK TO Ø4.

FIG.3

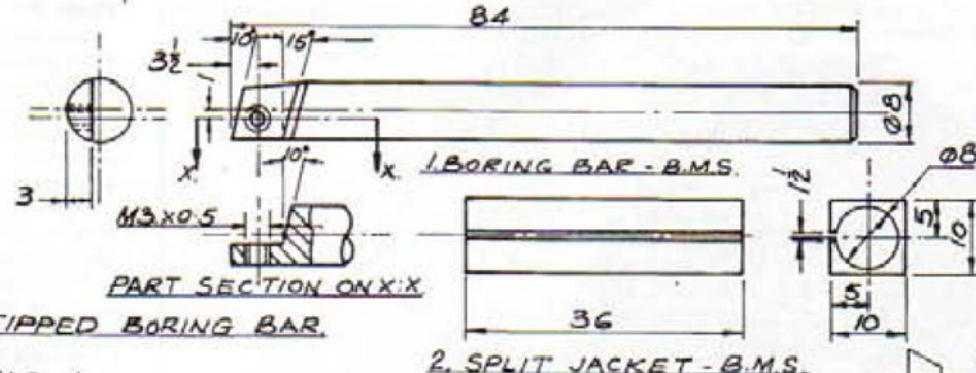
1. TOP PLATE - B.M.S.

2. BASE - B.M.S.

DIMENSIONS IN MILLIMETRES.



ITEMS 3 AND 4 AS DETAILED IN FIGS.1 AND 2.



TIPPED BORING BAR.

FIG.4

2. SPLIT JACKET - B.M.S.

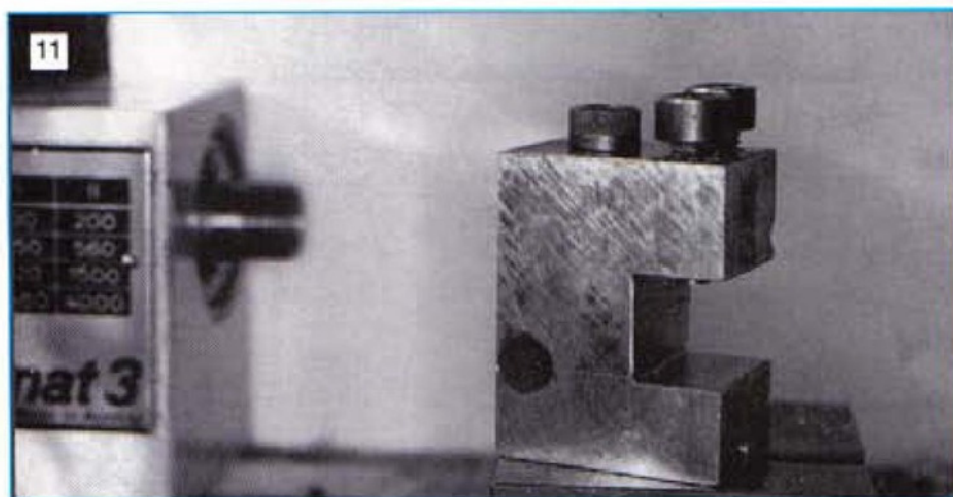
Fluid as they are corrosive and not easy to clean off.

I haven't tried to get the work hot enough with a soldering iron. I don't think it would, even the largest one there is, so if you haven't got the equipment to solder the inserts to the body, rivet them.

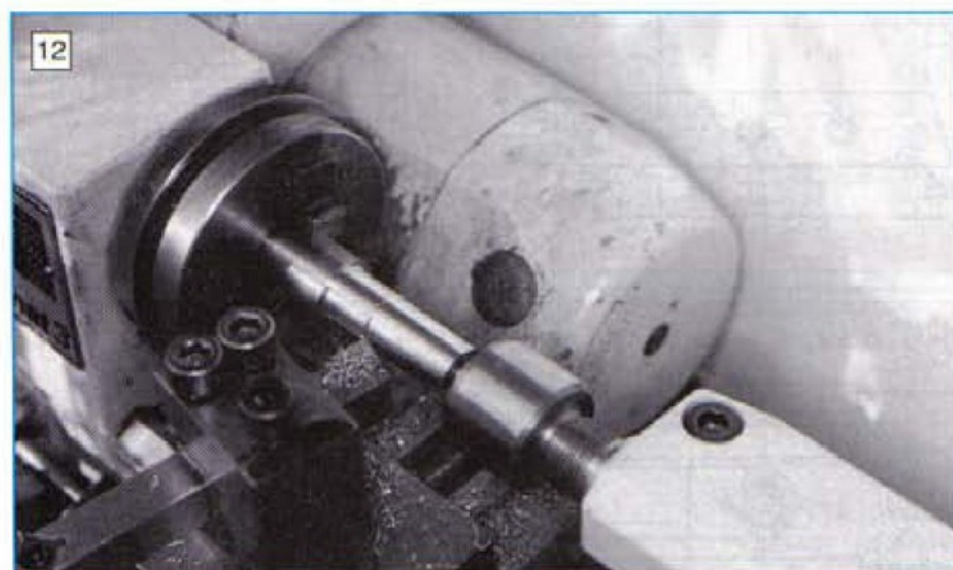
The last job was to clamp the tips in position and spot through for the drilling and tapping of the M3 screws. The drilling could be done before cutting out the step. **Photo 6** shows my way of doing this. I use the

Unimat as a drilling machine, with a face plate for the drilling table, so I have to be a bit careful about the clamping, hence the big burly strap clamp. If a drilling machine is to hand it is much easier.

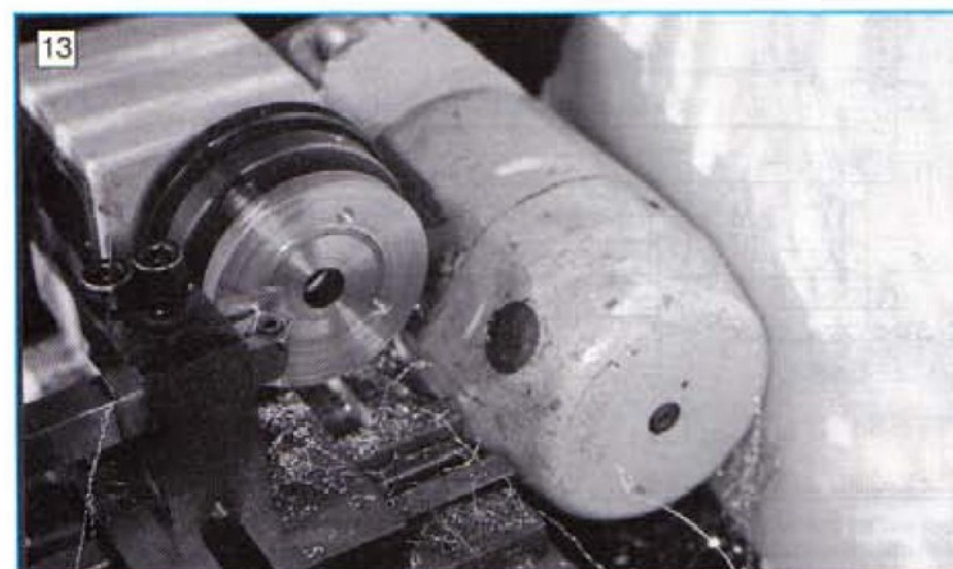
The tips are the same ones as specified in **Fig. 1**. They're common to all the holders, as are the M3 screws. The only difference is that the screws will be of different lengths to suit the holders. For the 10mm square holder they will be between 6mm and 7mm under the head.



The enlarged tool post.



The 10mm square tool holder used for turning.



The 10mm square tool holder used for facing.

Tipped boring bar

A set of tools for the lathe would not be complete without a boring bar. The dimensions are shown in Fig. 4, and it is simple to make from 8mm diameter mild

steel, very similar to the single ended one in Fig. 1, having a similar cut-out to take the tip. I know that these boring tools work well because I used one when I worked part-time for a small company which made cleaning equipment for jet engines. Almost all the

pieces were made from stainless steel, and one of them was a collet which came in roughly drilled. It had to be bored out to fit a tube precisely, and the tubes had slight variations in the diameter. I used a boring bar very similar to the one described here, with the same tip. It must have done hundreds of the collets with hardly any attention.

The only difficult operation, once the cut-out had been done and the centre marked for the tapped hole, was the drilling. I used a crutch centre in the Unimat tailstock (see Photo 7). It had to be clamped. I have done similar jobs before, and if not clamped, it will try to rotate in the vee as the drill takes hold. The crutch centre is home-made.

Another home-made accessory was used to make the split jacket which holds the boring bar. This was the 4 jawed chuck I made some time ago. It is not perfect and the jaws tend to spread a bit, but it does everything I need it to. I used a piece of 10mm square mild steel, and once it was running true and had been faced, it only needed drilling 8mm to take the bar. The drilling, as is normal on the Unimat, was done in stages. Photo 8 shows it well under way. When the hole was through, the jacket was reversed and the other end faced. After de-burring, I split the jacket by hack sawing (Photo 9), de-burring the inside of the slot with a fine three-square file. A split jacket can be done away with and the boring bar can be held on a shallow vee block if it is thought to be too much trouble to make the jacket. As I have made it, it just fits the Unimat tool post, although when the bar is swivelled to bring the cutting edge on centre, the tool has a slight negative rake. As Photo 10 shows, it doesn't seem to make any difference to the finish of the bored bit or the faced section of the disc.

There is a solution to the fit of tools in the tool post. Photo 11 shows mine. Make an over-sized tool post with a larger slot to hold the tools which are a tight squeeze in the standard one. It was made very quickly, from a piece of scrap cast iron. I used it to try out the 10mm square holder and it worked a treat. Photo 12 shows the turning end and Photo 13 the facing end.

Just one small point about the boring bar in the jacket. The place to position the clamping screws is directly over the split because it will only pinch the bar if the clamping force is on the edge. Look at any boring bar of this type in a typical workshop and you will find most of the scars left by the clamping bolts right down the middle. The smallest size the boring bar will cope with is about 12mm.

Except for the 10mm tool holder, the tools I've described are for the Unimat and lathes of similar size. As I mentioned previously, they can be scaled up for larger machines. A selection of tips and holders will make most plain turning jobs easier and quicker, with good finishes. Grinding can be done using a silicon carbide wheel. The one I use is 125mm diameter and 13mm wide, with a centre hole of 12.7mm. The specification is CG 60 KV, and it fits nicely on the grinding attachment which I made for the Unimat. When a tip no longer cuts well it is because a small chip has come off the tip. By careful grinding, it can be turned into a radius tool, and will keep churning on for some time; a radius tool has a longer life than an edged one.

Making the holders reduces the cost of using tips to suit even my shallow pockets.



COMPUTER CONTROL FOR PRACTICAL ENGINEERS

In this, the third article in the series, Richard Bartlett describes how to drive the system from files created in a simple Computer Aided Drawing package

Recap after parts 1&2:

You can now write control files directly in your preferred text editor for jobs which include plain turning, milling and drilling.

You can use the 'LOOP' command to take advantage of the multi-pass facility.

You can run the 'COMPUCUT' program to execute your control file, using the parameters in your own 'PARAM' file.

You can prove the control file by watching the performance of your machine simulator.

This is CNC machining:

YOU PRODUCE A CONTROL FILE OF TWO OR THREE DIMENSIONAL DATA, WHICH IS INPUT TO THE COMPUTER PROGRAM, WHICH TRANSLATES THE DATA INTO LOW LEVEL ELECTRONIC SIGNALS. THESE SIGNALS ARE FED DOWN A CABLE FROM THE COMPUTER TO AN INTERFACE WHICH TRANSLATES THE PROGRAM INSTRUCTIONS INTO SIGNALS REQUIRED TO DRIVE STEPPER MOTORS. THESE SIGNALS ARE THEN AMPLIFIED AND FED TO STEPPER MOTORS WHICH YOU HAVE CONNECTED TO THE AXES OF YOUR MACHINE.

Please **re-read** the above paragraph, which gives an essential over-view of what we are about. From an understanding of this will follow the motivation to tackle the rest of the course which is 'getting all the help we can in translating our ideas into control files'.

Only fairly simple ideas can exist over a period wholly in our minds. The dimensions and structure of a project such as a clock, engine or machine tool are best held in the form of an engineering drawing. If we accept this, then what we need for creative CNC engineering is a process that takes in our ideas in the form of traditional drawings and outputs the co-ordinate data needed for our control file.

This is what Computer Aided Drawing (CAD) can offer us, with the added bonuses that it will provide a neat printout of our input drawing and generate all the co-ordinates with the unfailing accuracy that we have come to trust any electronic calculator to provide.

Matters arising from Part 2:

1) I neglected to mention that, when using a single 5 1/4in. floppy system, you create a 'working' disk by copying onto a formatted disk: LIST.COM, PARAM.nnn, JOBn.CON, COMPUCUT.EXE, and all the support files SCREEN.nnn. COMPUCUT.EXE needs the SCREEN.nnn files and COMPUKEY.EXE needs all the COMPUCUT.nnn files to be present on the disk.

DOS allows the easy copying of related files by using the * character as a 'wildcard'. For example; assuming we are logged to A: with the 5 1/4in. system master disk in the drive, then <COPY SCREEN.* B:> <---> would read SCREEN.001, SCREEN.002..... etc into memory, then prompt you to put your target disk into the drive and press any key. DOS will then write all the SCREEN.nn files to the target.

2) Several errors crept into the control file listing for DEMO1.CON. Do remember that each statement must end in a semi-colon. Just for practice try and identify and predict the outcome of these errors, I counted THREE and each would invoke a program failure.

3) If your word processor does not allow you to save files with a numeric extension, then save them with the .DOC or .TXT extension, then quit the editor and, at the

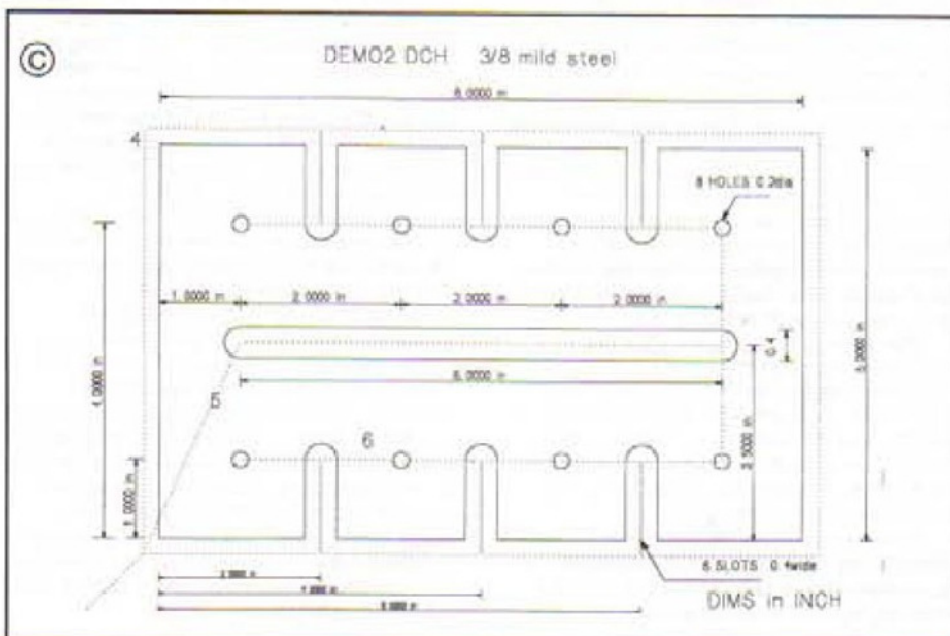
DOS prompt, use the RENAME command to change PARAM.DOC to PARAM.002 for example, by typing <REN PARAM.DOC PARAM.002> <--->

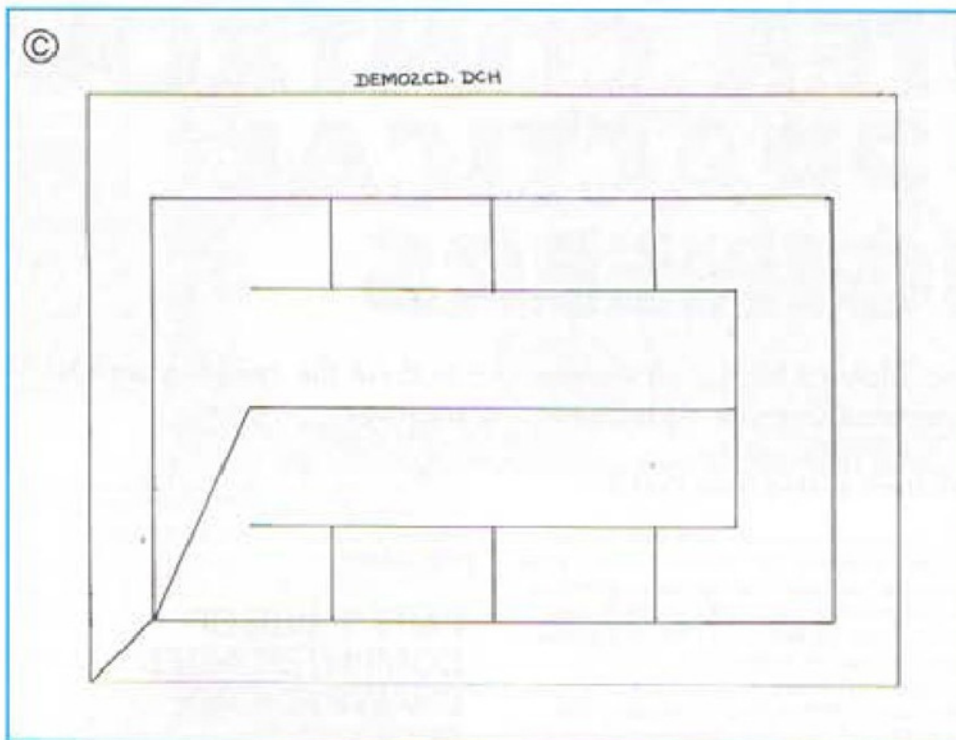
PART 3: USE OF COMPUTER AIDED DRAWING (CAD) PROGRAMS

Your pencils will be forever sharp; you have a selection of lead widths; your tee-square, set-squares and compass all have digital readout and will index in any increments you choose, and your rubber never soils the paper. In fact it will even 'UNrubout'. This is no doubt the scenario seen by the *Sorcerer's Apprentice*, and we all know what happened to him! and YES, something of the sort will happen to you, but fear not, one press of the big red reset button and all will be back to a clean sheet.

CAD like many powerful programs presents us with so much choice that whilst we are learning to use the basic tools we can be tripped over by the others. Do learn on a simple package, I like DraftChoice for DOS which is an entry level program, available as inexpensive 'Shareware'. If you find that it suits your needs you can register quite cheaply. It does not require a maths co-processor.

The normal output devices for CAD packages are plotters, printers and disk files. The disk files can be in either printer or plotter format. The industry standard format for





plotting is the HEWLETT PACKARD GRAPHICAL LANGUAGE (HPGL). Plots are two dimensional, the plotting pen being driven in the X and Y axes by stepper motors, with a small solenoid lifting or lowering the pen to the paper. The difference between the plotter bed and our XY table is one of scale. Our machine tool must be more rigid, have greater thrust available for feeding, and be more accurate than the plotter, but in all essentials the plotter can be seen as a two-dimensional machine. For this reason the HPGL control language is as relevant to our X and Y axis driver as it is to a plotter table. It follows from this that any CAD package which can output control signals to a plotter, can output control signals to the X and Y controller of a lathe or mill. 2-D machining is satisfactory for a small number of applications, but COMPU-CUT's strength is in its facility for multi-pass 3-D machining with a programmable 'pick feed'. For the reasons explained above HPGL files do not contain 3-D data, so Z axis data must be edited in by you in your text editor.

What the CAD program does pass down as the HPGL plot file, is the two-dimensional data plus Pen-UP and Pen-DOWN in the form of an ASCII text file. As an example, look at the print of **DEMO2.DCH**, a job involving milling and drilling in a flame cut blank of 8.1 x 5.1 mild steel. The DCH extension tells us that this file is a DraftChoice drawing file. $\frac{3}{8}$ in. thickness has been chosen to clear the decision to take several cuts in Z, using our small 'own-made' vertical miller. (More about the machine in another article). Please note that practicalities such as clamping the work etc. are ignored for the sake of clarity of explanation.

The drawing has a border 10.000in. x 7.500in.. If drawing for A4 paper, use this size, as it helps the scaling of the drawing. The bottom left hand corner is absolute zero or X0,Y0. Again for clarity, a non-standard 0.4in. cutter is used, to allow all drawing features to fit my preferred drawing grid of 0.1in. pitch with a reasonable viewing size.

The cutter centre paths are shown as the dotted lines. The numbers 4, 5 and 6 adjacent to the cutter paths are simply reminders of the drawing layer on which each group of cuts is

drawn. This would be obvious if viewed on screen, by each layer being in a different colour.

DC (DraftChoice) is initialised as A4 paper, dimensions = inches, grid 0.1,0.1, thin solid lines. The drawing details are then drawn on layer 1, as shown by the solid lines and text on the print.

The next phase is to draw on the cutter paths IN THE ORDER IN WHICH THEY WILL BE CUT. These are displaced by one cutter radius from the plate profile. Each group of cuts has its own layer. For example, the first cut will size the plate and mill in the six slots in the edges. I will call this CUT4 because I have, quite arbitrarily, chosen LAYER 4 on which to draw it. The HPGL file will direct the plotter to draw layer 4 with pen 4. The layer 4 data can be found within the HPGL file listing by looking for the SP4 (select pen 4) statement, the SP5 statement will mark the end of CUT4 data.

The HPGL file will be given the extension .PLT, so the file DEMO2.PLT will be the plotter file for our steel plate milling/drilling job. Listing this file will show a lot of data. You need to consider how much data HPGL needs to draw the letter 'O'. The near-circle is drawn as a polygon, with the number of sides being set by the resolution you have chosen, each side being defined by its end points. You can just see this 'thrupenny bit' effect if you look at any plotted drawing. You can now appreciate that text takes up a lot of room in an HPGL file, and in this example it is just a distraction.

Turn off the drawing layers that hold the text and job profile, and save the layers 4,5 and 6 as DEMO2CD.DCH (cutter data). Now plot these to .PLT disk files as DEMO2.PLT (milling), DEMO2.001 (c'drilling) and DEMO2.002 (drilling). Selecting the HP7475 plotter as the plotting device and selecting LOW resolution. Because our cutter paths are straight lines defined by their end points, we lose nothing by selecting LOW. It is a good to adopt the habit of setting the resolution at the lowest acceptable value when cutting curved paths because it saves file space. COMPU-CUT holds 7000 commands in **any** PC, which is a high capacity for straight line machining, but is soon filled up by curved paths, particularly if the resolution is set unnecessarily high.

THIS COMPLETES THE 2-D DATA GENERATION FOR DEMO2 BY CAD.

The files created are:

DEMO2.DCH The fully annotated drawing.
DEMO2CD.DCH The cutter paths drawing.
DEMO2.PLT The HPGL plot file of cutter paths.

Those actually following this course by 'doing it' will, almost certainly, testify to the fact that it is easier to do the above than to follow the text by reading and re-reading through it. Basically, the above describes drawing the component and plotting it out to a file.

List DEMO2.PLT and you will see the command to select pen 1, to raise the pen, to travel to 0,0. Next is pen down, plot absolute to 10000,0 then plot absolute to 10000,7500. If your plot file does not give these values of 10 x 7.5 then alter the FACTOR parameter in the plot dialogue box until the plot is produced to size. Once true size is achieved, make a note of the scale factor and save the drawing configuration to set this as default for future use.

This CAD output of two drawings and one listing per component can provide the backbone of your project documentation.

DEMO2.PLT

PU;SP0;IN;PU;SP0;SP1;PU;PA0,0;
This initialisation occurs at the beginning of each .PLT file

PD10000,0;PD;PA10000,7500;PD;PA0,7500;
PD;PA0,0;PU;SP0;
Draws the 10 x 7.5 border

SP2;PU;SP0;SP3;PU;SP0;
Moving the plotter pen carousel

SP4;PD;PA800,800;PD;PA800,6200;PD;
PA3000,6200;PD;PA3000,5000;PD;PA3000,6200;
PA5000,6200;PD;PA5000,5000;PD;PA5000,
6200;PD;PA7000,6200;PD;PA7000,5000;PD;
PA7000,6200;PD;PA9200,6200;PD;PA9200,
800;PD;PA7000,800;PD;PA7000,2000;PD;
PA7000,800;PD;PA5000,800;PD;PA5000,
2000;PD;PA5000,800;PD;PA3000,800;PD;
PA3000,2000;PD;
PA3000,800;PD;PA800,800;PU;
SP0;

SP5;PD;PA2000,3500;PD;PA8000,3500;PU;
SP0;

SP6;PU;PA2000,5000;PD4000,5000;PD;
PA6000,5000;PD;PA8000,5000;PD;PA8000,
2000;PD;
PA6000,2000;PD;PA4000,2000;PD;PA2000,
2000;PU;PA0,0;
SP0;

Reminders:

SP4 (select pen 4) indicates layer 4 on the drawing which is the milling of the periphery. SP5 indicates layer 5 which is the milling of the central slot. SP6 indicates layer 6 which is the drilling of 8 holes. The first three lines can be edited out as they are plotter initialisation, drawing the border and driving the carousel. The SP0s at the end of layer 4 and layer 5 must be edited out

You are now ready to write your control file. Open EDIT and give a SCreen command to remind you of the job title etc. Import the file

DEMO2.PLT edit in the REMinders and the Z axis increments within the loops. Note that LOOP06; means seven cuts, as the LOOP parameter is the number of repeats.

You might arrive at something like:

DEMO2.CON

```
SC, This is DEMO2 Drilling and Milling of
8.1 x 5.1 x 3/8 steel;
REM The data is edited from DEMO2.PLT,
an HPGL file produced by CAD;
REM Scales should be set to 1step = 1thou inch;
REM Mount job on 1/4inch packing, set
datum corner X0.8,Y0.8inch;
SC, Chuck a 0.4inch END MILL, and set
0.01 clear of work;
REM SP4 draws line 4 on drawing, the
cutter centre path of profile;
REM Note that PD commands are ignored;
RTRAV;
PD;PA800,800;STRV;
LOOP06;
CD062;PD;PA800,6200;PD;PA3000,6200;PD;
PA3000,5000;PD;
PA3000,6200;PD;PA5000,6200;PD;PA5000,
5000;PD;PA5000,6200;PD;
PA7000,6200;PD;PA7000,5000;PD;PA7000,
6200;PD;PA9200,6200;PD;
PA9200,800;PD;PA7000,800;PD;PA7000,
2000;PD;PA7000,800;PD;
PA5000,800;PD;PA5000,2000;PD;PA5000,
800;PD;PA3000,800;PD;
PA3000,2000;PD;PA3000,800;PD;PA800,800;PU;
LOOP;
CU400;
REM SP0 CAD indicating the end of cut,
external profile complete;
REM SP5 This is the 6inch slot;
PD;RTRAV;PA2000,3500;PD;STRV;
LOOP07;
CD50;PA8000,3500;PU;CD50;PA2000,3500;
LOOP;
CU400;
REM SP0 indicates milling now complete;
SC,Chuck a BS2 centre drill and set 0.01
from work;
RTRAV;PA2000,5000;
STRV;CD150;RTRAV;CU150;PA4000,5000;
STRV;CD150;RTRAV;CU150;PA6000,5000;
STRV;CD150;RTRAV;CU150;PA8000,5000;
STRV;CD150;RTRAV;CU150;PA8000,2000;
STRV;CD150;RTRAV;CU150;PA6000,2000;
STRV;CD150;RTRAV;CU150;PA4000,2000;
STRV;CD150;RTRAV;CU150;PA2000,2000;
STRV;CD150;RTRAV;CU150;PA2000,5000;
SC,Chuck a 0.2 dia drill, and set 0.01 clear of work;
STRV;CD450;RTRAV;CU450;PA4000,5000;
STRV;CD450;RTRAV;CU450;PA6000,5000;
STRV;CD450;RTRAV;CU450;PA8000,5000;
STRV;CD450;RTRAV;CU450;PA8000,2000;
STRV;CD450;RTRAV;CU450;PA6000,2000;
STRV;CD450;RTRAV;CU450;PA4000,2000;
STRV;CD450;RTRAV;CU450;PA2000,2000;
STRV;CD450;RTRAV;CU450;
SP0;
```

That completes the CONTROL FILE, this is saved as DEMO2.CON and this is the file name entered in response to COMPUCUT's prompt for an input file. Note that the PU and PD commands which are left over from the HPGL file do not have to be removed, they are ignored.

Note that the CAD package was initialised for inches, with 1 drawing unit = 1 thousandth of an inch. This is ideal for drawing, but a standard (suggested) 'compucutter' is likely to have 20 TPI screws and 200 steps per rev. motors, (1 step = 1/4 thou.) so set SCALE = 80 (20 x 4) in your PARAM file if your machine follows this example. At run time, COMPUCUT

will expand the loop statements into the linear machining sequence and save this as DEMO2.CUT. The capacity of the .CUT file is 7000 commands for Version 1.

That completes the introductory use of a CAD program as a 'DATA CALCULATOR' and I'm quite sure that some folk will be thinking that CAD seems to be 'much ado about nothing'. Certainly it's been a lot of typing for very little, but remember DEMO2 is a deliberately simple job which you could easily draw and program manually, to enable you to check what the CAD produces both as a data calculator and drawing aid.

DEMO3

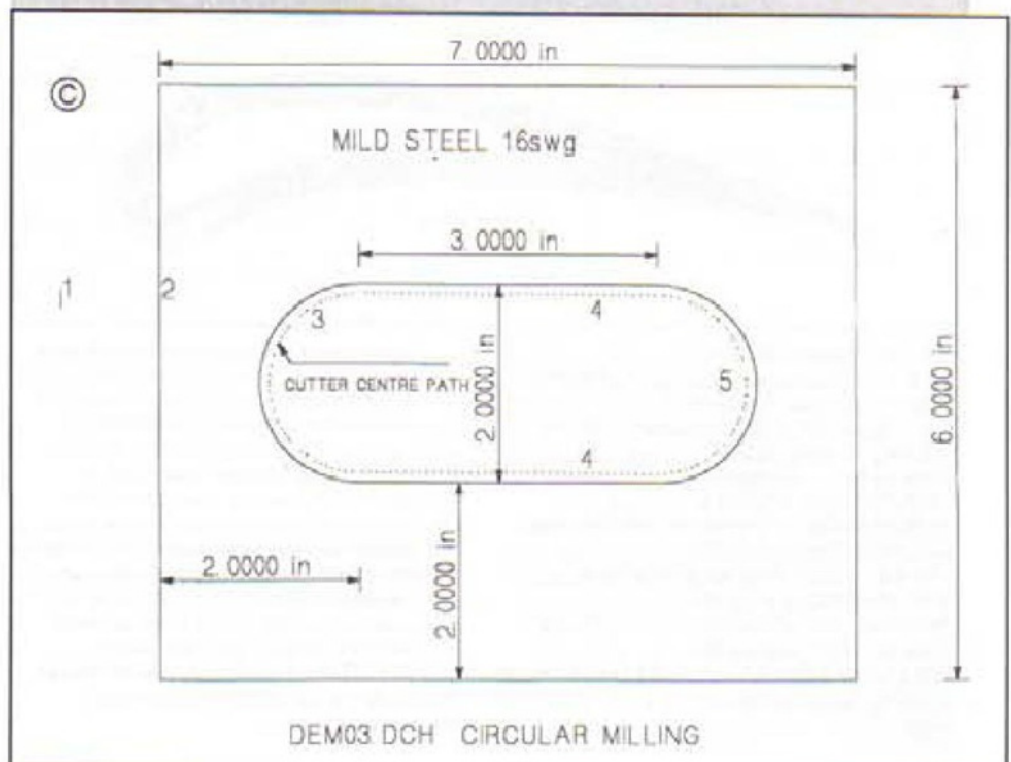
This demonstration gives a clue to the power of CAD for data generation. Look at **Drawing DEMO3.DCH**, which shows a slot with semi-circular ends in a 16 swg sheet. Hopefully you will recognise that the sheet thickness is now simply a setting for the LOOPnn command and represents no complication other than possibly needing the use of a longer cutter.

As previously, the layers on which the cutter paths are drawn have been saved to a jobnCD.dch type file, in this case DEMO3CD.DCH. The CAD program calculates the end points of the short chords which form the polygonal model of the circular forms, and in a few seconds these are safely stored in an HPGL form file called DEMO3.PLT

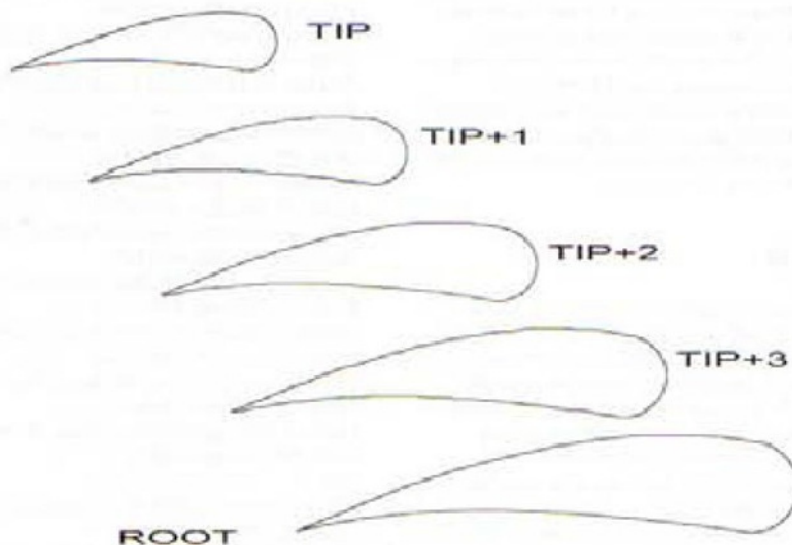
DEMO3.PLT

```
SP3;PU;PA3000,3100;PA2964,3100;PD;
PA2924,3104;PD;PA2888,3108;PD;
PA2848,3112;PD;PA2812,3120;PD;PA2776,
3128;PD;PA2740,3140;PD;
PA2704,3152;PD;PA2668,3164;PD;PA2632,
3176;PD;PA2600,3192;PD;
PA2568,3212;PD;PA2532,3232;PD;PA2500,
3252;PD;PA2472,3272;PD;
PA2440,3296;PD;PA2412,3320;PD;PA2384,
3344;PD;PA2356,3372;PD;
PA2332,3396;PD;PA2308,3428;PD;PA2284,
3456;PD;PA2260,3488;PD;
PA2240,3516;PD;PA2220,3552;PD;PA2204,
```

```
3584;PD;PA2184,3616;PD;
PA2172,3652;PD;PA2156,3688;PD;PA2144,
3720;PD;PA2132,3756;PD;
PA2124,3796;PD;PA2116,3832;PD;PA2108,
3868;PD;PA2104,3904;PD;
PA2100,3944;PD;PA2100,3980;PD;PA2100,
4020;PD;PA2100,4056;PD;
PA2104,4096;PD;PA2108,4132;PD;PA2116,
4168;PD;PA2124,4204;PD;
PA2132,4244;PD;PA2144,4280;PD;PA2156,
4312;PD;PA2172,4348;PD;
PA2184,4384;PD;PA2204,4416;PD;PA2220,
4448;PD;PA2240,4484;PD;
PA2260,4512;PD;PA2284,4544;PD;PA2308,
4572;PD;PA2332,4604;PD;
PA2356,4628;PD;PA2384,4656;PD;PA2412,
4680;PD;PA2440,4704;PD;
PA2472,4728;PD;PA2500,4748;PD;PA2532,
4768;PD;PA2568,4788;PD;
PA2600,4808;PD;PA2632,4824;PD;PA2668,
4836;PD;PA2704,4848;PD;
PA2740,4860;PD;PA2776,4872;PD;PA2812,
4880;PD;PA2848,4888;PD;
PA2888,4892;PD;PA2924,4896;PD;PA2964,
4900;PD;PA3000,4900;PU;
SP0;
SP4;PD;PA6000,4900;PU;PA6000,3100;
PD3000,3100;PU;SP0;
SP5;PU;PA6000,4900;PD6036,4900;PD;
PA6076,4896;PD;PA6112,4892;PD;
PA6152,4888;PD;PA6188,4880;PD;PA6224,
4872;PD;PA6260,4860;PD;
PA6296,4848;PD;PA6332,4836;PD;PA6368,
4824;PD;PA6400,4808;PD;
PA6432,4788;PD;PA6468,4768;PD;PA6500,
4748;PD;PA6528,4728;PD;
PA6560,4704;PD;PA6588,4680;PD;PA6616,
4656;PD;PA6644,4628;PD;
PA6668,4604;PD;PA6692,4572;PD;PA6716,
4544;PD;PA6740,4512;PD;
PA6760,4484;PD;PA6780,4448;PD;PA6796,
4416;PD;PA6816,4384;PD;
PA6828,4348;PD;PA6844,4312;PD;PA6856,
4280;PD;PA6868,4244;PD;
PA6876,4204;PD;PA6884,4168;PD;PA6892,
4132;PD;PA6896,4096;PD;
PA6900,4056;PD;PA6900,4020;PD;PA6900,
3980;PD;PA6900,3944;PD;
PA6896,3904;PD;PA6892,3868;PD;PA6884,
3832;PD;PA6876,3796;PD;
PA6868,3756;PD;PA6856,3720;PD;PA6844,
```



TWEENY3.DCW tweens have 100 points



1:



Use ARC and BEZIER functions to draw
ROOT and TIP to a scale of 2 or more,
expanded by the radius of the cutter.
Define each as a COMPLEX entity.

Use TWEEN function to draw
10 intersections from ROOT to TIP
these will become the CUTTER PATHS.

2:



3688;PD;PA6828,3652;PD;
PA6816,3616;PD;PA6796,3584;PD;PA6780,
3548;PD;PA6760,3516;PD;
PA6740,3488;PD;PA6716,3456;PD;PA6692,
3428;PD;PA6668,3396;PD;
PA6644,3372;PD;PA6616,3344;PD;PA6588,
3320;PD;PA6560,3296;PD;
PA6528,3272;PD;PA6500,3252;PD;PA6468,
3232;PD;PA6432,3212;PD;
PA6400,3192;PD;PA6368,3176;PD;PA6332,
3164;PD;PA6296,3152;PD;
PA6260,3140;PD;PA6224,3128;PD;PA6188,
3120;PD;PA6152,3112;PD;
PA6112,3108;PD;PA6076,3104;PD;PA6036,
3100;PD;PA6000,3100;PU;
SP0;

The two layers of interest here are the semi-circular cuts drawn on layers 3 and 5, as can be seen from the above file the cuts are made in a clockwise direction. This plot file is LOW resolution, which means the semi-polygonal ends have a lesser number of sides. More professional CAD packages will offer higher resolutions than their entry level counter parts, but observe how the sheer quantity of raw data mounts up when circular functions are plotted. The calculation of point-to-point plot lines to model circular or part circular forms is called 'circular interpolation'. Again, remember COMPUCUT Ver. 1 has a 7000 total command limit so do not use higher resolution than necessary.

There are not enough trees left in the world to list all the files for these example programs, but by studying the previous control file structure it will be seen that the above data represents the four elements of the slot as defined by the drawing layer and SP number. Import the plot file into your text editor and add the Compucut commands as necessary.

The conclusion to be reached from this example is that a job which would have to be swung on quite a large faceplate if turned, or indexed on a rotary table if milled (yes it could be bored as it's so thin) is machined without moving it on the table. This advantage would be further amplified if we needed the inside (male) component of the circle or part circle, as for example, in a loco wheel.

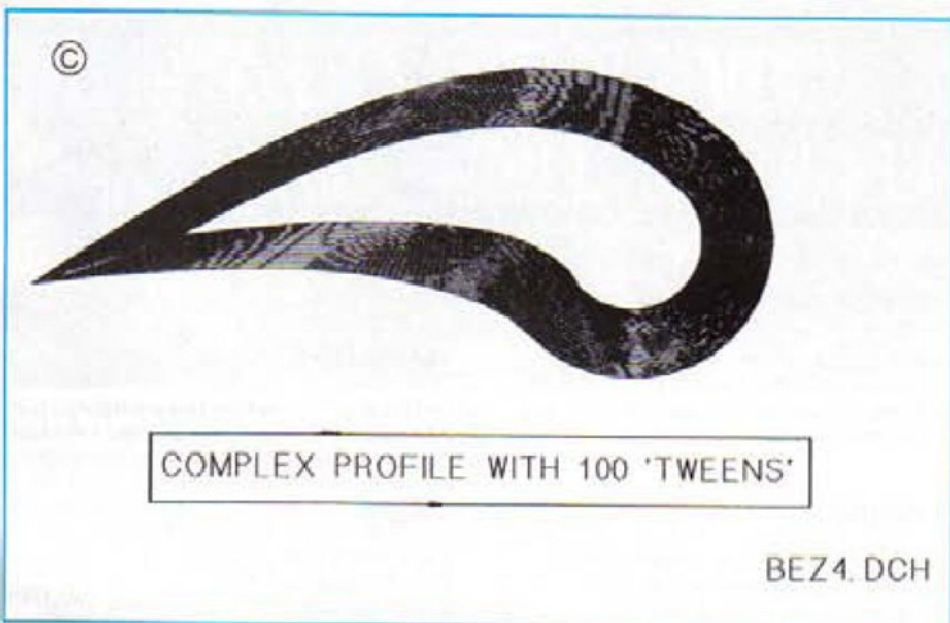
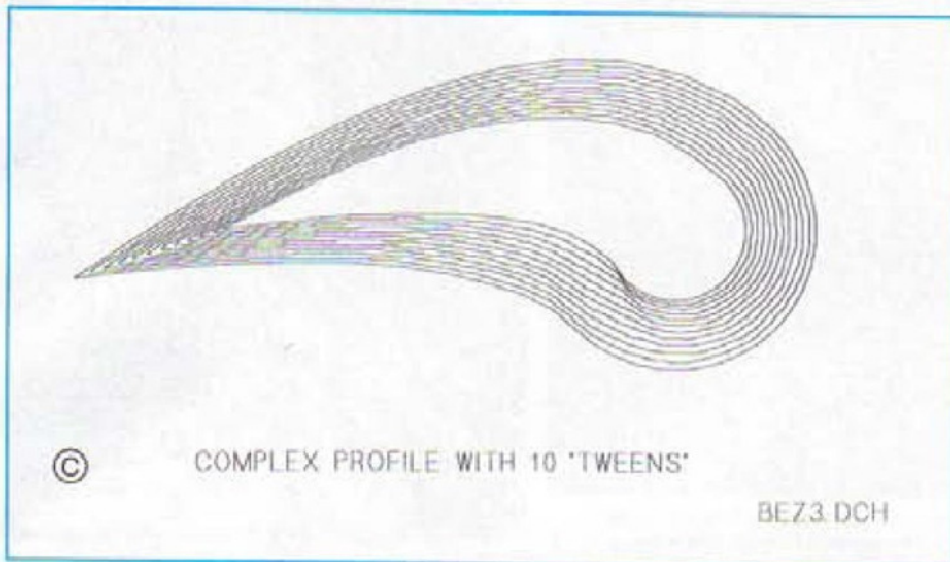
Look through the menu options of your CAD package to see the facilities on offer and experiment with whatever looks as though it might help your project along. The items that might be of immediate interest in DraftChoice are BEZIER curves and TWEENS.

A BEZIER curve is the software equivalent of a complete and comprehensive set of 'french curve' drawing templates. The ends of the line are defined, then the line can be 'pulled', non-symmetrically if need be, to form an aerodynamic or other shape. If one were involved in making aero wing ribs of thin but strong and light material to reinforce foam or to support a thin covering, then a set of ribs can be modelled by the computer as intersections lying between a ROOT profile and a TIP. The root and tip profiles are drawn using one or several bezier curves. The number of equally spaced intersections are specified together with their number of plotting points (similar to resolution) then the TWEENS command is invoked to produce the set of ribs, which progressively change from root to tip. (See Drawing TWEENY). The intersections generated by TWEEN can be utilised by cutting each intersection starting with the tip, then adding a Z move before cutting the next intersection. This would produce a solid but stepped 'wing' or blade, the steps equal to the Z feed, and is pseudo 3-D machining. (see Drawing DEMO4).

Drawing BEZ3.DCH shows the low resolution 'undulations' along the tween intersections. Higher resolutions give smoother results, but they use up a lot of out memory. BEZ4.DCH shows more intersections at higher resolution, but the resulting file would fill this magazine!!

Pie in the sky

This technique could be useful for turbine blading. The sort of job for which the 'COMP-U-CUT' system was designed would be a multi stage axial compressor, the rotor blades machined from discs of dural shrunk onto a rotor shaft which is held in a dividing head and supported by a tailstock. The blade is machined (milled) using X, Y and Z axes. At completion of one blade, the dividing head is indexed by a fourth stepper. At the completion of one blading set, the next blank disc is moved to the cutting station and the cutting sequence repeated with the new profile. The COMPUCUT software can currently drive six steppers to allow such ambitious jobs. The creation of tapering, twisting, multi blades in multi stages has a slight 'down side' and that is, it runs the old PC/XT class machines clean out of memory. Projects such as these which



must be 'state of the art' for home machinists, require a 386 base unit on the machine with plenty of RAM. This allows the 'master' computer (kept indoors!) to generate the data and then down-load this to the 'slave' on the machine, using a serial link such as 'LAP-LINK'. The serial link is convenient because the data files for the projects hinted at here are megabytes in size and would run to many disks if using Backup/Restore.

Meanwhile, back in the shed

With their feet firmly on the ground, are 'compucutters' who are actually doing it! and doing it in a big way. Some lucky folk have come up with serious motors found on the ex-equipment trail, and I would like to remind them that the COMP-U-CUT interface has three modes of operation:

1) Light current

As supplied, fused at 10 amps and typically suitable for size 23 steppers up to 1.5 amps per phase, with 1 amp available from AUX. To be run from 12v battery or battery charger.

2) Heavy current with interface in free air

Should be wired to the 'Heavy current

connection diagram' and externally fused. Ideally, each motor should be fused. Typically for size 34 motors up to 5 amps per phase.

3) Heavy current with forced draught cooling

Should be wired to 'Heavy current connection diagram'. Each motor supply should be protected by magnetic circuit breaker rated to 2.5 times phase current. Forced draught should be adequate to maintain the heat sinks below 70 degrees C. Please give motor details at time of ordering interface for phase currents greater than 5 amps.

See also: Power supply diagrams.

In conclusion

CAD, whilst not essential for plain turning, milling or drilling, is a powerful cutting data calculator for circular functions. It helps us to keep adequate documentation by requiring formal 2-D drawings as input. It would be almost accurate to state that CNC is about generating the cutting data as easily as possible. If you can draw it, CAD can digitise your drawing. If you can define the lines by mathematical equations CAD

can digitise these. These digitised profiles can be translated to HPGL files and we have just seen how to edit these files into pseudo 3-D by effectively adding together the set of 2-D slices through the solid model, each slice being located by a Z feed.

To put the foregoing into perspective, it may be helpful to state the limitations of this system. Compucut is designed and built for amateurs by an amateur. Its amateur status is reflected in the following respects, which are compared with the 'professional' situation shown in *italics*:

1) It uses **OPEN LOOP** control. If the feed motor has insufficient torque to maintain the movement signalled by the computer, then the lost steps will give an error.

Full industrial systems use closed loop control. By using an engraved glass scale or inductive linear transducer the computer can read in the actual position of the bed on the slide. Consequently the lead screws are not used directly in the measurement system.

2) It uses **UNIPOLAR DRIVE**. The torque available from a motor is 70% of that quoted in the manufacturers data. L/4R is recommended (Apply 12v to a nominally 3v motor, use limiting resistors)

Bottom end / small machines use Bi-polar stepper drives which are more powerful (1.4 times), run faster due to current chopping amplifiers, and have higher resolution when used with 'micro-stepping' drivers. Full industrial drive is by servo motors or hydraulics.

3) It relies on a third party data processor (2-D CAD) for all circular functions. Which defines our 3-D format as PAXx,yy;CDnn rather than PAXx,yy,zz.

Data processing is often part of the system software, output is industry standard 'G' codes. 3-D data would be down-loaded from the design office who would use powerful 3rd party software..

4) It uses no GUI (graphical user interface). As we have seen, we need to know or learn the basics of our DOS.

GUI front end inputs serial data, disk file or directly keyed data.

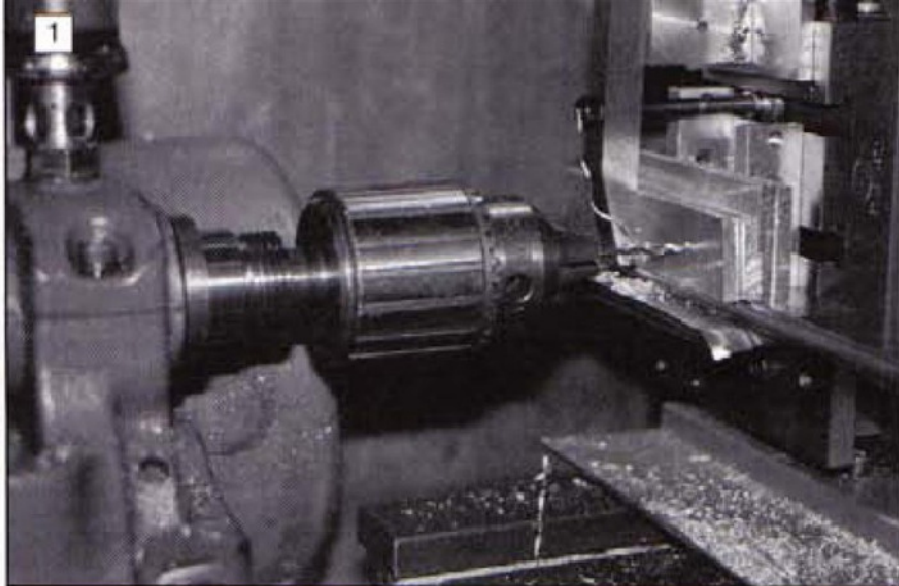
5) It is available, affordable, easily learnt and is probably FIVE+ times more accurate than most dove-tailed slide machines to which it will be fitted. On this basis it can be considered to be the 'APPROPRIATE' technology.

The software starts at £2000

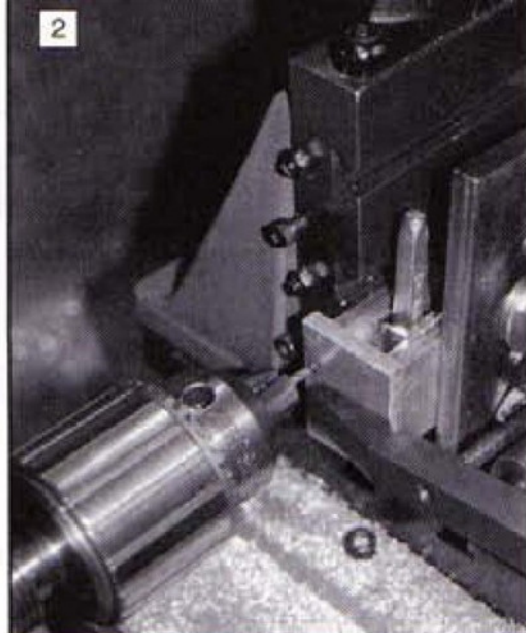
I hope that these articles have provided enough background information and potential hands-on learning to allow the non-computing practical engineers to weigh the pros and cons of DIY CNC and decide whether or not it has a place in their workshop. Future articles (at the Eds. discretion) will deal with applications of CNC and the building of small special purpose CNC machines without casting iron.

Next time we will look at how to digitise a 3-D profile directly, enabling us to copy, and scale if necessary, components that we cannot draw.





Drilling (6BA tapping) holes in side pieces and spacers. The angle plate and spacing bar serve as guides while setting up. Note the 3/4in. spacers behind the work piece to protect the vertical slide when the drill breaks through. (Operation 2.4)



Drilling the first hole in an end piece. (Operation 3.6)

A SIMPLE NUMBER/LETTER PUNCH JIG

Neatly stamped numbers and letters enhance any piece of work. Paul Boothby describes the manufacture of a device which will make the task easy.

Introduction

This little device will guarantee accurate and repetitive stamping by number/letter punches on any flat surface on which it can be clamped. Strings of up to twenty characters can be stamped horizontally. If the shanks of the punches are square, strings can also be stamped vertically. The jig has been designed specifically for use with a Roebuck 1/8in./3mm punch set, but

could be modified for other sizes of punches providing every punch in the set has a shank of consistent size, and is square or rectangular in section.

Principle

The principle of operation is the successive displacement of rollers of constant diameter in a row by the insertion of an object (in this case, a punch) of rectangular or square section. Providing the stamps are all of a consistent size, this size is immaterial, because the spacing between successive characters is determined by the diameter and the number of rollers displaced, as shown in Fig. 1. Roebuck 1/8in./3mm stamps have 1/4in. nominal (see 'performance', below) square shanks, but when using the dimensions given in the design, characters will be stamped every 4mm. By using a second, similar set of rollers some distance above the first set, angular stability is achieved, guaranteeing every punch will be presented perpendicularly to the surface to be stamped (Fig. 2).

Dimensions and units of measure

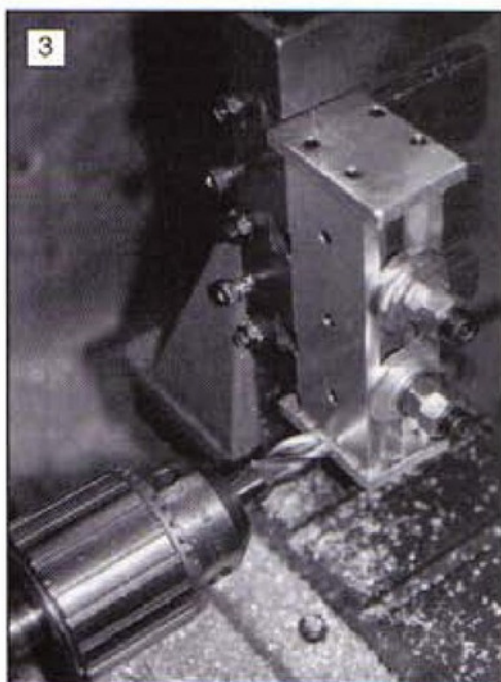
At the present time, those of us using Imperial machine tools are faced with a dilemma: do we use metric or Imperial measurements? The current trend is to phase out Imperial sized stock, and replace it with metric equivalents. The obvious answer is to use metric stock but work to inch dimensions when using older machines.

Tolerances

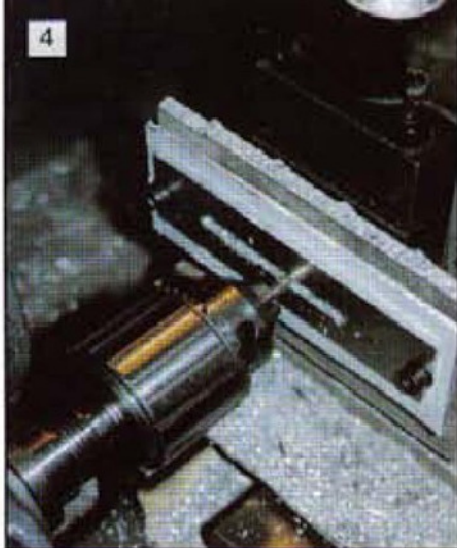
The jig is constructed using an add-on principle; each piece is added on, then machined to suit. Therefore every part will be made an exact fit, and unless particular care is taken, it is unlikely any two parts other than the rollers will be interchangeable. The dimensions given in the drawings are theoretical, and small deviations from those given are unlikely to cause problems. An example of this is in the overall width of the end pieces. In the diagram, the width is shown to be 1.199in.(!) It is not expected anyone would build the jig to this dimension, and this theoretical size is only arrived at from the following:

Thickness of side pieces (2 x 6mm) = 12mm = 0.4724in.
Thickness of spacer pieces (2 x 6mm) = 12mm = 0.4724in.
Thickness of punch = 0.250in.
Shims (operation 3.3) = 0.004in.
Total width = 1.199in.

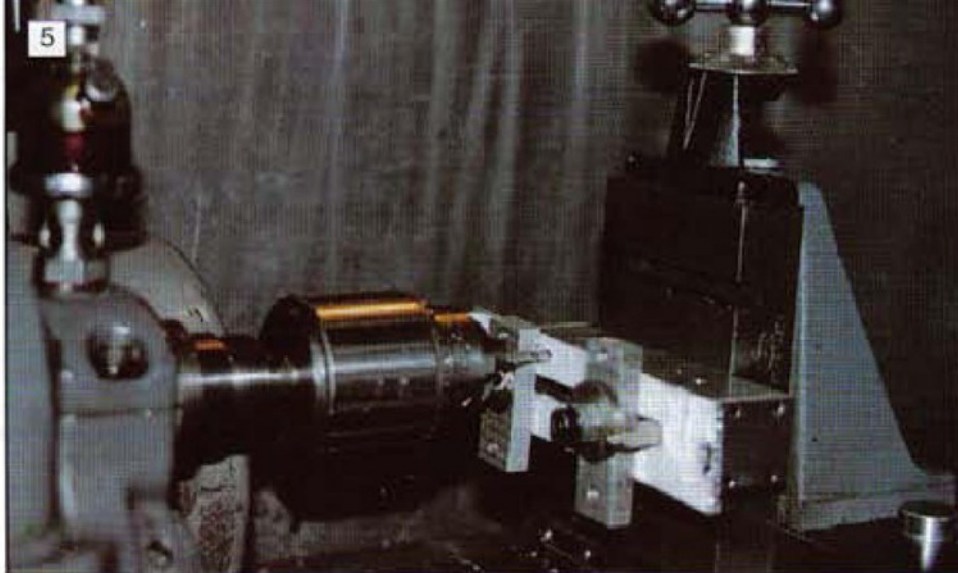
If the jig were made from Imperial stock (1/4in.) then the width of the end piece would be 1.254in.. Hence it is not intended that the dimensions of the individual components are given to be worked to, but only to indicate the approximate size for cutting purposes. In the case of the positions of the screw holes, the important point is that they be located more or less centrally in the edges of the side pieces, and not so close to the edge that the side of the counterbore is lost when the piece in question is machined to its final size.



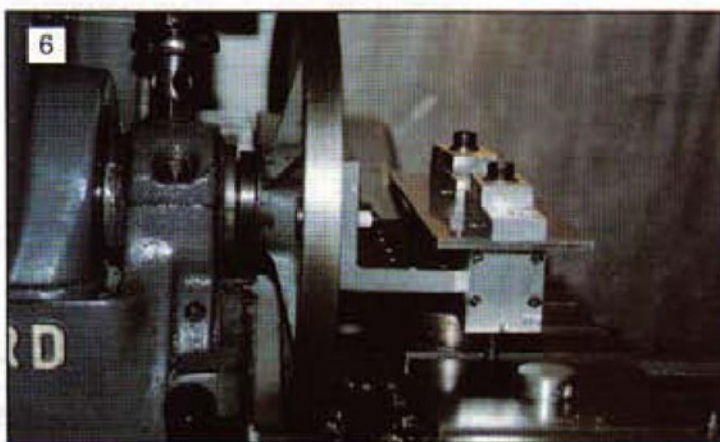
Milling the side edge of an end piece. Note the positions of the end pieces relative to the top tee slot and the bottom of the slide. (Operation 3.14)



Milling the punch slot in the top and bottom plates. (Operation 4.4)



Counterboring one of the ten holes in the top piece. (Operation 4.11)



Setting the work perpendicular to the lathe axis using an angle plate bolted to the face plate. The packing used is the outer shell of a discarded taper roller bearing. (Operation 4.15)



Setting the work parallel to the lathe axis using an accurately centred piece of PGMS bar. (Operation 4.21)

Equipment and materials required:

Because the jig is expected to see only light duty, the metal chosen was aluminium alloy as opposed to steel. The final design was fabricated from 3mm and 6mm sheet, and the rollers from 4mm diameter steel bar. The screws used (38 off) were 6BA x $\frac{5}{16}$ in. blacked steel cheese head.

The jig can be made with hand tools only, but a lathe of around $3\frac{1}{2}$ in. centre height, such as a Myford ML7, will make the job more easily and quickly, using the following accessories:

2 x 2 x $\frac{3}{8}$ in. Angle plate, machined with parallel and square faces and edges
Vertical Slide
12 x $\frac{1}{2}$ -1in. dia. Precision Ground Mild Steel (PGMS) bar, accurately centred at each end.

All holding and clamping bolts, and tee nuts used were 0BA.

Construction

For simplicity, details of manufacture are given in 'Operation Sheet' format, as follows

1. Preliminary work:

1.1 Cut all flat pieces about $\frac{1}{8}$ in. oversize except the top piece. Cut the top piece about 1in. longer than its finished length. This is to allow the accommodation of temporary holding bolts used during milling (operation 4.2).

2. Machining and fitting the sides of the jig:

2.1 Fit the vertical slide as near the front of the boring table as possible, and align it perpendicular to the lathe axis. Fit an angle plate and align its upper surface parallel to the boring table using a dial indicator.

2.2 Mark the positions of the three screw holes in one of the spacing pieces.

2.3 Mount both spacer pieces and side pieces using spacers and shims as shown in **Photo 1**.

2.4 Start each hole with a No.0 centre drill and complete with a 6BA tapping drill ($2.2\text{mm} = \frac{5}{32}$ in.).

2.5 Identify the orientation of each piece to assist in later assembly. Remove the pieces and remount one side piece. Drill through each of the holes with a 6BA clearance drill ($2.8\text{mm} = \frac{3}{16}$ in.), and counterbore sufficiently deep so that the screw heads are just 'submerged' (about 0.010in.) below the surface. Repeat the operation on the second side piece.

2.6 Tap each hole in the spacer pieces and assemble on the side pieces.

2.7 Mount one side assembly on the angle plate on the vertical slide as close to perpendicular to the lathe axis as possible (**Fig. 3**).

2.8 Mill the edge of the side piece sufficient to remove the saw marks.

2.9 Next mill the edge of the spacer so that a shoulder results which is 0.160in. deep. Take care to mill as close as possible to the surface of the side piece without cutting into it.

2.10 Turn the assembly around to mill the other shoulder parallel to the first. To achieve this, lightly clamp the assembly and measure the perpendicular distance from the face of the drill chuck to each end of the milled edge of the side piece using a vernier calliper.

2.11 Clamp tightly and mill the edge of the side piece, taking only light cuts. Check frequently for parallelism, and reset the work if necessary.

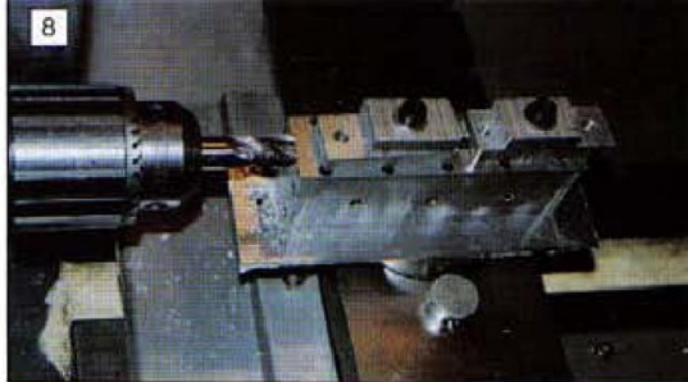
2.12 Repeat operation 2.9.

2.13 Repeat operations 2.7 to 2.12 on the second side assembly, but this time ensure that the widths of the second side/spacer assembly match that of the first.

2.14 Remove the work and the angle plate.

3. Fitting and milling the end pieces:

3.1 Remount the vertical slide parallel to the lathe axis, using the rear slot of the boring table but do not tighten the holding nuts.



Milling the end edge of the top plate (Operation 8.22)

3.2 Fit an accurately centred $\frac{1}{2}$ in. to 1in. diameter PGMS bar between accurate centres and move the cross slide until the vertical slide is flush against the bar, as shown in figure 4. Tighten the holding nuts.

3.3 Using the angle plate as a clamp, position and clamp the two side assemblies (separated by two number/letter stamps and two 0.002in. shims) to the vertical slide. The angle plate will act as an anchor for a second clamp (3.6). Adjust the assembly so that it is parallel to the boring table surface before final tightening. **Photo. 2** shows this set-up after milling and the clamping on of an end piece (operation 3.6).

3.4 Mill one end of each assembly square to its length, and free from saw marks.

3.5 Mark on the milled face the position of one of the fixing screw holes. Fit a No. 0 centre drill and position it over the centre mark.

3.6 Offer an end piece up to the milled end of the assembly and clamp lightly in position (**Photo. 2**). The bolt holding this clamp is supported by the other side of the angle plate (just out of view on the right). If clamped too tightly, it is possible that the set-up of the side pieces may be disturbed.

3.7 Start the hole, then drill $\frac{3}{4}$ in. deep with $\frac{3}{32}$ in. (2.2mm) drill (6BA tapping) through the end piece and into the side piece. By drilling deeper than required avoids the need to use a plug tap.

3.8 Open up the hole to $\frac{1}{64}$ in. (2.8mm, 6BA clearance) but **only** to the depth of the end piece.

3.9 Counterbore the hole as in operation 2.5.

3.10 Tap the hole, fit a cheese head screw and tighten.

3.11 Repeat operations 3.7 to 3.10 for the other three fixing holes. Drill and tap 6BA the two holes for the roller adjustment screws.

3.12 Turn the assembly around and repeat operations 3.3 to 3.11 on the other end.

3.13 Remount the assembly vertically on the vertical slide, as shown in **Photo. 3**.

3.14 Mill the sawn side edge of the lower end piece flush with the surface of the side piece.



Jig bolted to the graduating plate, ready for punching the test line of M's. (Operation 8.3)

3.15 Repeat operation 3.14 on the other three side edges of the end pieces.

3.16 Reset the vertical slide as described in operation 2.1, omitting the angle plate.

3.17 Fit the assembly to the vertical slide as in operation 3.13 and repeat 3.14 and 3.15 on the remaining (top and bottom) edges of the end pieces.

4. Machining and fitting the top and bottom pieces:

4.1 Drill two temporary mounting holes $\frac{1}{4}$ in. dia. in the top and bottom plates at 5in. between centres. On the top piece, lightly scribe a line between the hole centres. (The holes in the bottom plate will remain after completion, and will serve as locating holes for future attachments).

4.2 Drill the holes in the mounting plate as shown in **Fig. 5**, and fit it plate to the vertical slide using hexagon head bolts and tee nuts but do not tighten yet.

4.3 Mark on the top piece the centre line and the extremities of the punch slot.

4.4 Mount the bottom piece with the top piece above on the mounting plate using spacers so as to clear the hexagon head mounting bolts. (**Photo 4**)

4.5 Align the centre line of the slot with the centre height of the lathe and parallel to the boring table, adjusting the hexagon head bolts as needed.

4.6 Start the slot by drilling through both plates with a No. 1 centre drill and $\frac{3}{16}$ in. drill.

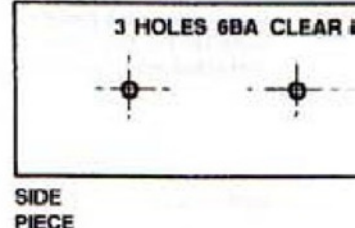
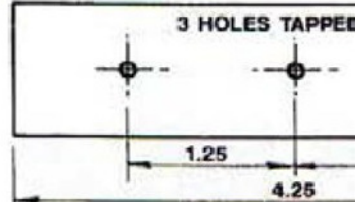
4.7 Mill the full length of the slot using a $\frac{3}{16}$ in. end mill. Do not take cuts deeper than 0.030in. on each pass. Open out the slot to its finished width, symmetrical with the scribed line and taking cuts no deeper than 0.010in. at a time. Check the progress by inserting a punch- see section 9. File the ends of the slots square.

4.8 Mount the body assembly on its side on a suitable parallel packing piece resting on the lathe bed. Insert two punches into the body, near the ends of the cavity and fit the top piece over them. Lightly clamp the assembly to the vertical slide using the slot in the top piece. (**Photo. 5**). Adjust the body assembly in relation to the top so that the slot is symmetrical longitudinally to the body cavity. Fully tighten the clamps. (The two punches ensure alignment laterally).

4.9 Start one of the top plate fixing holes, then drill $\frac{3}{4}$ in. deep with $\frac{3}{32}$ in. (2.2mm) drill (6BA tapping) through the end piece and into the side piece. When drilling the end holes remove the respective screws in the end pieces, as the holes for these screws interpenetrate.

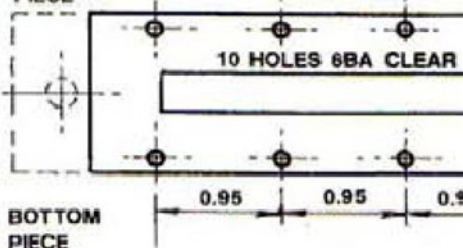
(C)

SPACER PIECE

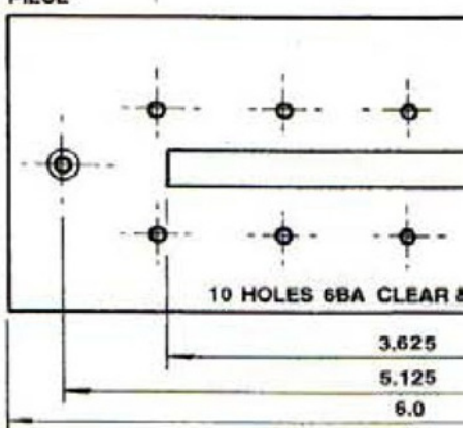


SIDE PIECE

TOP PIECE



BOTTOM PIECE



4.10 Open up the hole to $\frac{7}{64}$ in. (2.8mm, 6BA clearance) but *only* to the depth of the top piece.

4.11 Counterbore the hole as for operation 2.6.

4.12 Tap the hole, fit a cheese head screw and tighten. Where applicable, replace the end piece screw.

4.13 Repeat operations 4.9 to 4.12 for each of the other fixing screws.

4.14 Turn the assembly over, fit the bottom plate in position and repeat operations 4.8 to 4.13. Remove the assembly.

4.15 Rest the assembly on suitable parallel packing on the boring table and clamp it by passing the clamping bolts through the slot. Use an angle plate

bolted to the face plate to ensure the side face is perpendicular to the lathe axis. (Photo 6).

4.16 Mill the side edge of the top plate to *just* flush with the side piece.

4.17 Repeat operations 4.15 and 4.16 on the opposite side edge of the top piece.

4.18 Invert the assembly and set up as described in operation 4.15.

4.19 Mill the side edge of the bottom plate to size.

4.20 Turn the assembly around and repeat operations 4.18 and 4.19 on the opposite side.

4.21 Fit the PGMS bar used in operation 3.2 between centres. Position

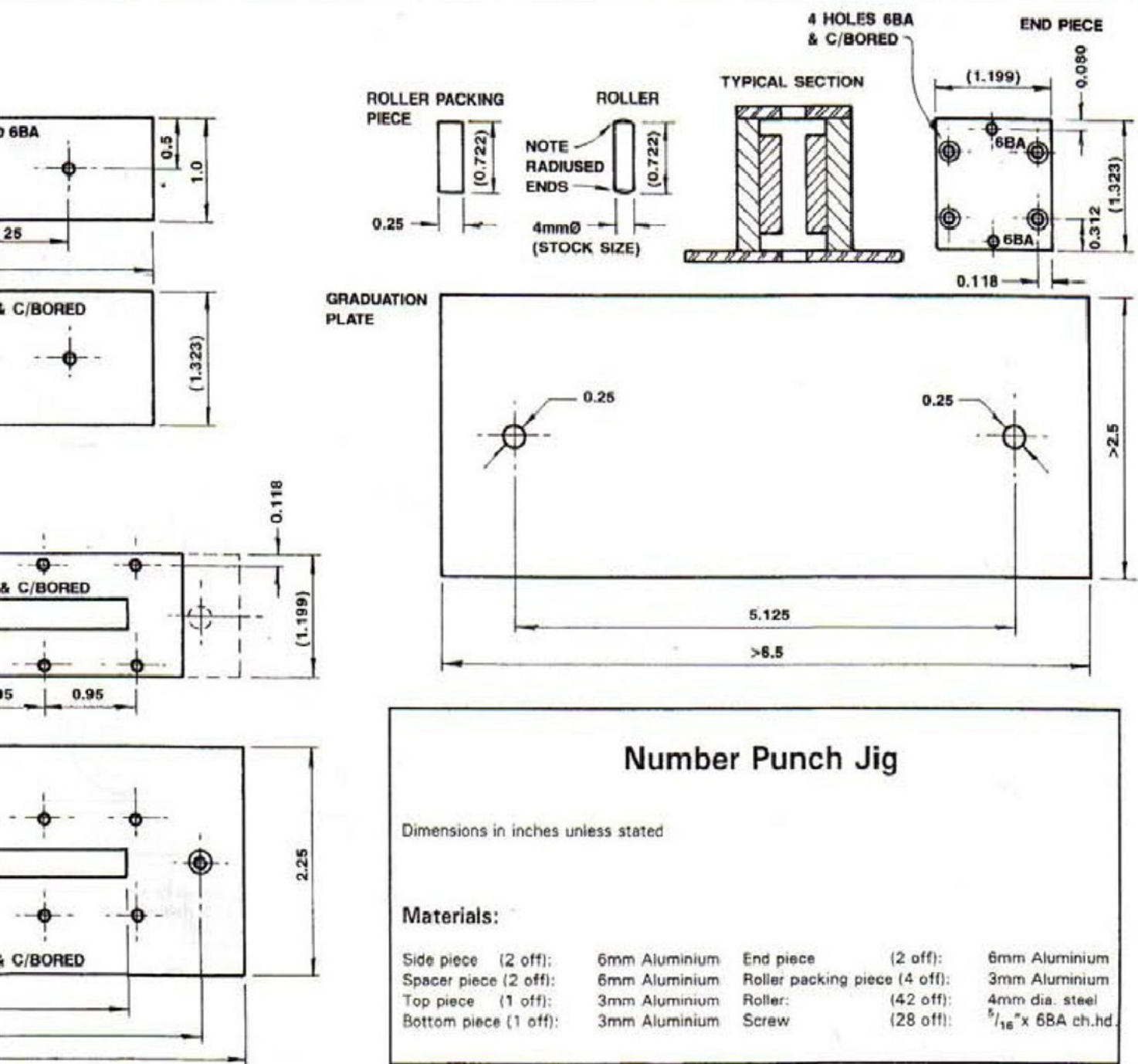
the assembly on suitable parallel packing on the boring table and loosely clamp it by passing the clamping bolts through the slot. Advance the cross slide until the top side edge of the assembly in contact along its whole length with the PGMS bar. Fully tighten the clamp screws and remove the bar. (Photo 7).

4.22 Mill the end edge of the top plate to *just* flush with the side piece. (Photo 8).

4.23 Repeat operations 4.21 and 4.22 on the opposite end edge of the top piece.

4.24 Invert the assembly and set up as described in operation 4.21.

4.25 Mill the end edge of the bottom plate to size.



4.20 Turn the assembly around and repeat operations 4.21 and 4.25 on the opposite side.

5. Rollers and Packing Pieces:

5.1 Rub the stock for the rollers with fine emery cloth so that it is bright. It need not be polished.

5.2 Cut the rollers to length. This length should be about 0.010in. shorter than the distance between the side plates, which is theoretically 0.722 inch. This operation would benefit from some of the mass production methods as described in *The Amateur's Lathe*¹. Be sure to leave both ends of each roller smooth, and convex. (See notes to operations 6.5 and 6.7)

5.3 Take five rollers and heat them to red heat and allow to cool. This will give the rollers a blue/black colour, and these will be used later as marker rollers.

5.4 With the vertical slide mounted parallel to the lathe axis, mount the angle

plate on the slide, parallel to the boring table.

5.5 Clamp a packing piece hard up against the slide, on the angle plate. Mill one edge. Repeat this operation for the other three packing pieces.

5.6 Position the milled edge of the packing piece against the slide and mill one edge. Repeat for the other pieces. (At this stage each piece should have two milled edges perpendicular to each other).

5.7 Take one piece and clamp the shorter side against the slide, and mill to the finished width (0.250in.). Lock the boring table to the lathe bed.

5.8 Without disturbing the clamped packing piece, push up to it, and against the slide, a small piece of shim steel with clean cut, squared off sides. Clamp this shim to the angle plate. This will give an accurate stop for positioning the other packing pieces.

5.9 In turn, clamp the other three packing pieces in the same position as the first, and mill the second long side of each.

5.10 Remove the shim, and mill the remaining edge to give a finished size of the same length as the rollers (operation 5.2). Lock the boring table.

5.11 Repeat operation 5.8 and 5.9 on the remaining edges of the pieces.

6. Assembly:

6.1 Ensure all parts are unambiguously and indelibly identified, regarding their relative orientations.

6.2 Dismantle all parts, clean them, removing all rough edges, burrs and swarf.

6.3 Fit the side spacing pieces to the sides, then fit the end pieces.

6.4 Load the bottom magazine with 21 rollers and a roller packing piece at each end.

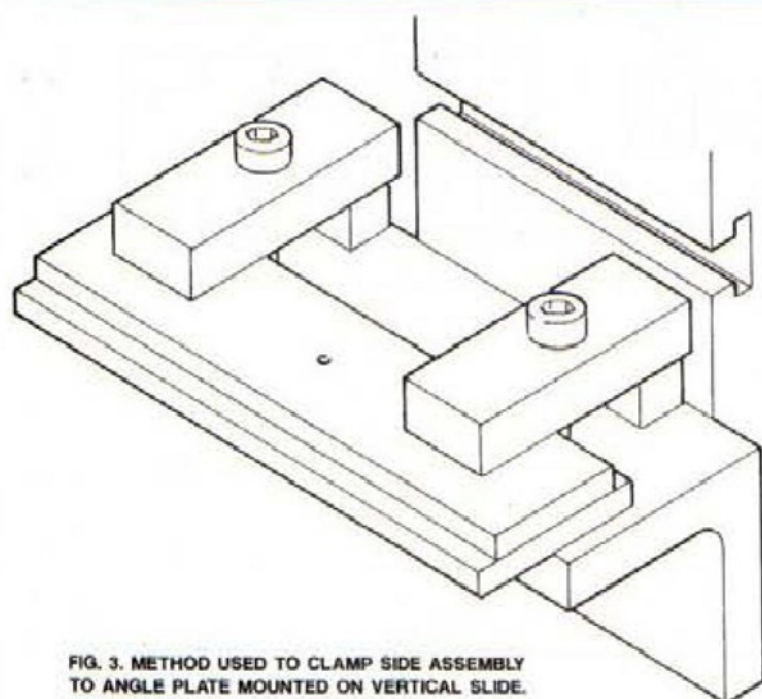


FIG. 3. METHOD USED TO CLAMP SIDE ASSEMBLY TO ANGLE PLATE MOUNTED ON VERTICAL SLIDE. (OPERATION 2.7)

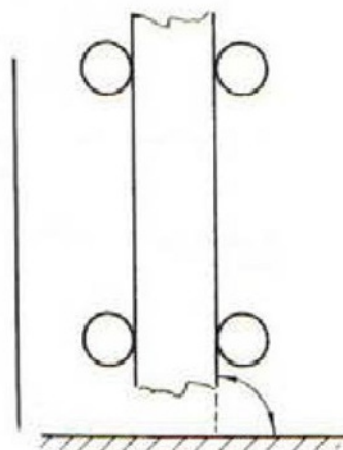


FIG. 2. A SECOND SET OF ROLLERS ENSURES A PUNCH IS HELD PERPENDICULAR TO THE WORK PIECE.



FIG. 1. CHARACTER SPACING ONLY ON ROLLER DIAMETER

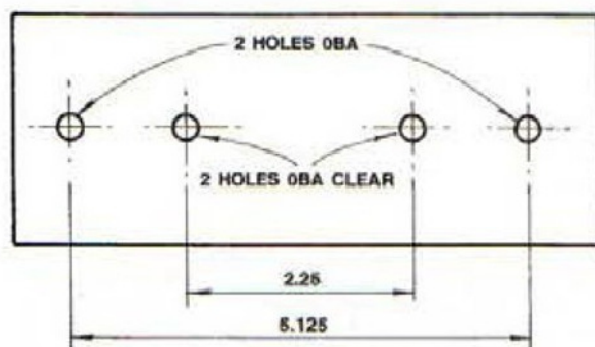


FIG. 5. MOUNTING PLATE.

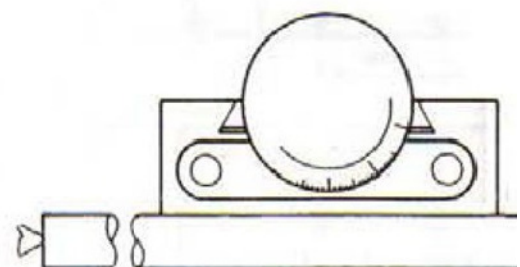


FIG. 4. SETTING UP OF VERTICAL SLIDE PARALLEL TO LATHE AXIS. (OPERATION 3.2)



Transferring the inter-character scribe marks to the upper surface of the bottom plate. (Operation 8.3)

6.5 Ensure *all* rollers run freely without hindrance by gently tilting the assembly.

NOTE: If any roller jams or stops prematurely, it is most likely the cause will be due to an excessive radius on the end of that particular roller.

6.5.1 Ensure that the roller is 0.005in. - 0.010in. shorter than the width of the slot, and that both ends have a significant radius. Correct each roller now if necessary.

6.6 Fit the bottom plate, tightening the screws from the centre outwards (i.e., in a similar sequence to tightening cylinder head bolts).

6.7 Ensure all rollers run freely without hindrance by gently tilting the assembly.
NOTE: If any roller jams, it is most likely the cause will be due to the slot not being deep enough. Remove the bottom plate, and examine the surface. A shallow slot will cause an impression of the offending rollers to appear in the surface of the bottom plate.

6.7.1 Measure the depth of the slot and determine the amount of metal to be removed, to bring the slot to the correct depth.

6.7.2 Mark the edge to be machined. Slacken an end plate, and remove the offending spacer plate.

6.7.3 Mill the offending edge by the required amount, and reassemble.

6.8 Repeat operations 6.4 to 6.7 on the top plate and magazine, placing the blued rollers at positions 3, 7, 11, 15, and 19. The blued rollers assist in counting character positions.

7. Adjustments:

7.1 Check the thicknesses

of the shanks of all punches in the set. It is possible they are not all the same. (See section 9).

7.2 Insert the thickest punch into the jig in any position.

7.3 Tighten the bottom packing piece adjustment screws equally until just causing an interference with the punch, then slacken very slightly.

7.4 Tighten the top packing piece adjustment screws as in 7.3 but also check using a square that the punch is presented perpendicular to the face of the jig.

8. Graduating the base plate:

8.1 Drill two $\frac{1}{4}$ in. holes at 5in. centres in the graduating plate.

8.2 Mill at least one end and one side flat and perpendicular to each other.

8.3 Bolt the jig to the plate and support the assembly on a smooth flat hard surface. (Photo 9).

8.4 Scribe a line on the graduating plate around the base plate.

8.5 Punch a full line of 'M's.

8.6 Separate the jig and graduating plate, and remove the bottom plate from the jig.

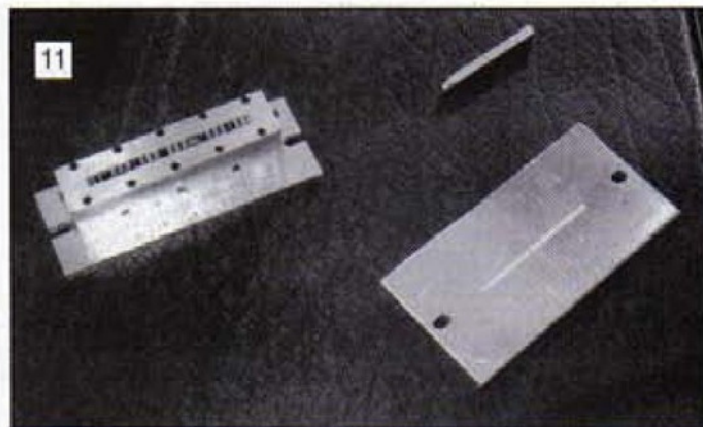
8.7 Using a square and **sharp** scribe, scribe lines between all the 'M's, square across the width of the graduating plate. (Photo 10).

8.8 Likewise scribe lines along the length of the plate, on the top and bottom edges of the M's.

8.9 Bolt the bottom plate to the graduating plate in the same orientation as in operation 8.3. Ensure the base plate accurately aligns with the scribed lines on the graduating plate made in operation 8.4.

8.10 Transfer the scribed lines on the graduating plate to across the full width of the bottom plate.

8.11 Repeat operation 8.10 for the lines marking the tops and bottoms of the M's.



The completed jig and graduating plate. Note the positions of the blued rollers have been marked on the graduations with a centre punch.

8.12 Separate the two plates and centre-punch over each of the scribed lines which mark the positions of the blued rollers in the top magazine.

8.13 Reassemble the jig.

9. Performance and observations:

One concern which appeared while making the jig was the finish and accuracy of the punches themselves. Prior to assembly, it was noticed that not all of the characters had been centrally formed on the shanks of the punches. Some were high, others low and some were left or right of centre. No discernible twist was found. One further observation was that new and unused punches in the same set varied in length from 2.700 - 2.783in.. Shanks were found to fall into two distinct sizes: 0.250 x 0.250in. and 0.246 x 0.246 inch. This latter observation leads to care being required when selecting punches when cutting the punch slots in operation 4.7, and setting the clearances in section 6 (adjustments), to avoid possible jamming in use. At first this deviation of 0.004in. caused some concern regarding the possible twisting of a 0.246in. punch in a gap of 0.254in. wide, which would give a clearance of 0.008 inch. This fear was dispelled when the angle of twist was calculated as being only 1.83 degrees.

Thus relatively large deviations (say, up to 0.01in.; 2.29deg.) in shank size can be accommodated in the jig without noticeable detriment to the angular alignment of the stamps.

One final concern was that of the inconsistency of shank width. Although all the shanks were parallel for most of their length, at the hardened end, many of the stamps had burrs and swollen shanks attributable to forging during their manufacture. These flaws prevented them from either entering, or exiting the slots. Thus, in order for them to fit easily into the jig, many had to be rubbed down on a sharpening stone to give a good enough finish (i.e., parallel sides and free from burrs) to allow them to be used in the jig.

Footnote

¹Available from Nexus Books, £8.75 plus £1 p&p. Nexus Books, Nexus House, Boundary Way, Hemel Hempstead, HP2 7ST.



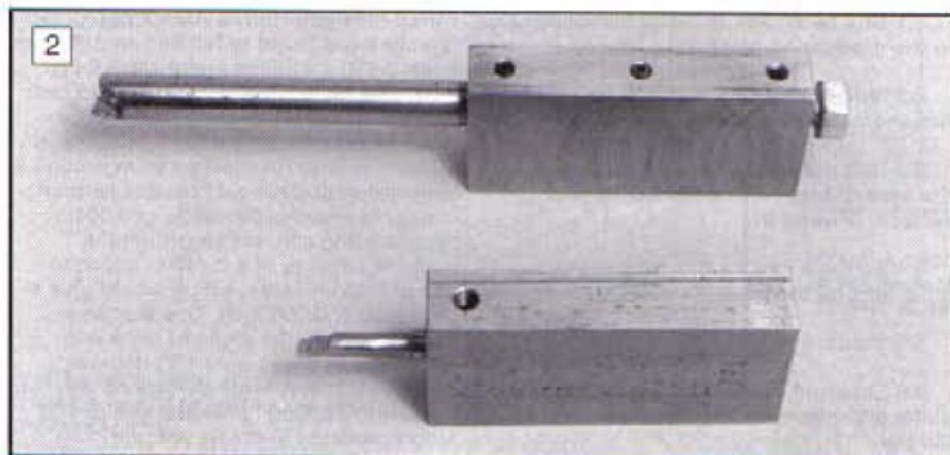
PARALLEL

A BEGINNERS GUIDE TO THE

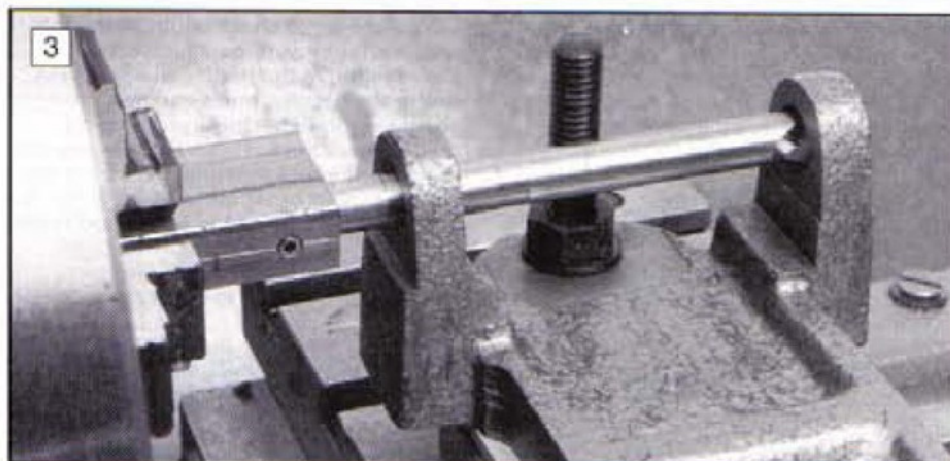
Part 8 LATHE



1
A range of centre drills, but two should be sufficient for the average workshop user



2
Two boring tools for use on the top slide



3
The larger boring tool in Photo 2 mounted in a four jaw chuck and boring a hole in a casting. Size of hole is arrived at by adjusting the chuck jaws

DRILLING, REAMING AND BORING

Harold Hall now addresses one of the most common machining operations, and explains the techniques which can be employed on the lathe

Drilling: the methods

There are several methods of drilling using the lathe, some powered by the lathe's own motor, others from a separate motor, such as an add on mill/drill head. With the latter, the cross slide becomes an X/Y table, but otherwise are much like the use of a normal drilling machine. This article only discusses those methods where the lathe provides the power, either with the workpiece rotating, or the drill rotating.

WORKPIECE ROTATING

This is the most common method and the simplest of all tasks performed on the lathe, but rules must still be observed. Positioning a drill when using a drilling machine, or a pistol drill, is frequently by a centre punch mark, but this is not possible on the lathe, due to difficulty in making the mark exactly on centre. However, if one attempts to use a normal length drill without guidance, it would probably start off centre, maybe even break. To overcome this, the position is first established using a centre drill which, being short, rigid and securely held, starts accurately on centre unaided.

Centre drills, seen in **Photo. 1**, are available in many sizes, six from 4mm to 12.5mm diameter, plus smaller and larger sizes, but two should be sufficient to start with, say 5mm and 8mm diameter (Imperial BS2, and BS4). Do use the largest that the task will accept, as smaller sizes are prone to break. With the end centred, drilling can commence; straightforward, but not without its pitfalls. Typically, if the drill is not sharpened correctly, it will drill oversize. Even new drills are supplied to a tolerance, $-0 +0.15\text{mm}$ for a 6mm drill. If hole size is important, check by drilling a piece of scrap first. Sharpening a drill by hand is a task only mastered by a few, and most home workshop owners, not having to sharpen drills that often, will have little chance of mastering the art. It is a good idea to

purchase a reputable drill sharpening attachment for the offhand grinder.

Deep holes

A common situation on the lathe, less so elsewhere, is the drilling of deep holes. These can, even if the drill is cutting true to size, wander as they pass through the part, making the hole off centre at the parted-off end. The reasons are many and complex, but the following are a few pointers:-

a) A drill with unequal cutting edges will cut oversize but can also wander.

b) A long drill will flex and be more likely to wander, so do use the shortest available, even if it is changed to a longer one to achieve the required depth.

c) A high feed rate, a damaged drill or a misaligned tailstock are other possible causes.

d) A drill which is clogged with chips or swarf will tend to wander and cut well oversize—withdraw often to clear chips etc. from the flutes.

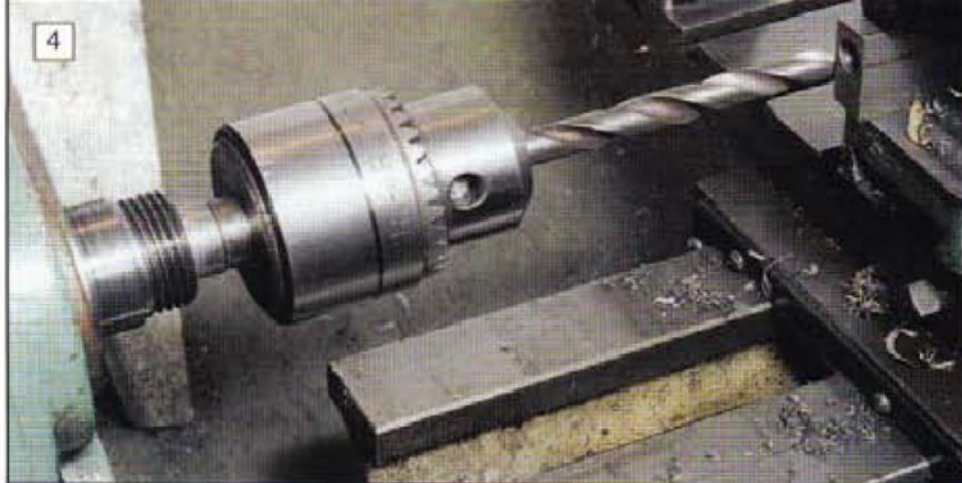
One method that may reduce the effect, is to drill a slightly smaller hole, in depth about three times its diameter, then, using a boring tool, to open this up to the diameter required. With the hole started true, there is a better chance that it will continue in this way. Of course, if the hole is large enough to finish bore the complete depth, this is without doubt the best way to proceed.

Another means of achieving a true hole, if the geometry of the part will allow, is to start with a workpiece outer diameter larger than required. Then, after drilling, reduce the outer diameter to size with the part mounted at the headstock on a taper stub mandrel, turned in situ, whilst the other end is supported by the tailstock centre.

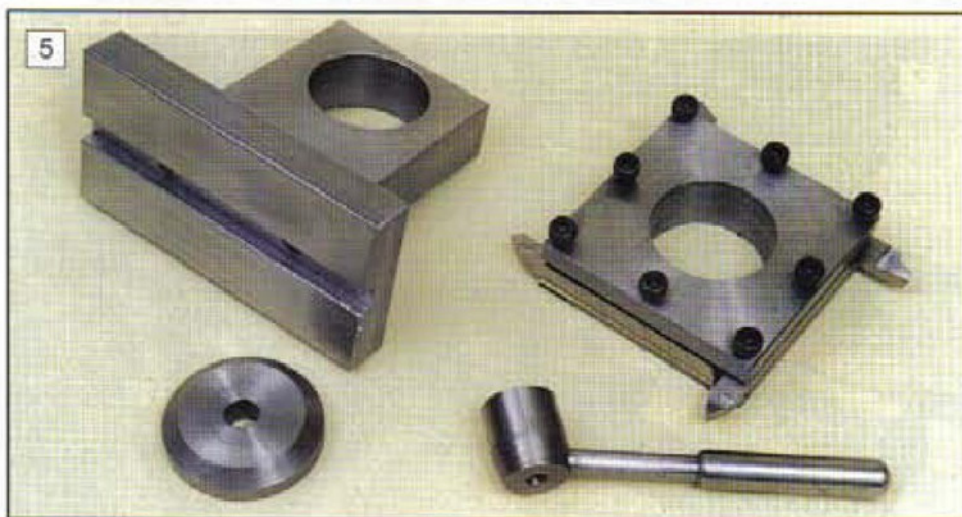
Accurate hole size

The method chosen for achieving an accurate hole size will depend on the size of hole, the accuracy required, and the equipment available. If a drill of the required size is available, but does not drill accurately, first drill with one of a smaller size, followed by the required diameter drill. This reduces errors due to a poorly sharpened drill, and a reasonably accurate hole will result. As a rough rule, the smaller drill should be 1mm smaller at 5mm, up to 2mm smaller at 12mm diameter. A word of warning, if tried with a pistol drill it could be very dangerous, due to the drill attempting to pull itself through when holes are enlarged by a small amount. It is almost as dangerous if attempted on a pillar drill, particularly if the workpiece is not firmly held. On the lathe, the tailstock feed is much more controlled, and there should be no problem, except maybe if the tailstock taper is a bad fit, when the chuck may be drawn from the socket. Some materials, such as brass and bronzes, are more of a problem in this respect.

Another problem with drills that cut over size, and one that can easily cause confusion, is that a through hole will reduce to size where it breaks through. This only happens if drilling a hole in one go, or from a very small pilot. If you turn a part to fit the hole, a taper mandrel maybe, a problem will arise if you use the smaller end as a gauge. The smaller diameter is only at the very end, and can be removed using a taper reamer, or a round file.



Drilling a part mounted on the top slide



A small drilling table for mounting on the top slide

Reamers

If greater accuracy is required, use a reamer, D bit, or bore to size. For high precision and a good finish, a reamer will take some beating. They are expensive and may be beyond the available budget, certainly for the larger sizes. Reamers are not made in the range of sizes that drills are, but only in 1mm steps over most of the range likely to be found in the home workshop.

A typical reamer has a tolerance of ± 0.006 to ± 0.015 mm, much closer than a drill. Note that the hole is larger than nominal, at least for a new reamer. Achieving this accuracy in practice depends on the reaming being done correctly. Misalignment between the drilled hole and a reamer fitted into the tailstock chuck will cause the reamer to enter at a slight angle. Because it can cut on its side, this produces an oversize hole. To avoid this, it would be better to hand hold and rotate the reamer, making it more likely that it will line up with the drilled hole. **Do not under any circumstances do this with the lathe running!** A floating reamer chuck¹ that permits axial movement, avoids the problem.

The size of the pre-drilled hole is important but not crucial. Remember that the difference is small, and if the drill is drilling oversize, the drilled hole could be larger than the required reamed hole. As a guide, for mild steel, the hole should be about 0.2mm smaller at 3mm, rising to 0.5mm at 25mm. Do not make the difference any less, as a reamer does like at least this amount to remove. For soft materials, say aluminium, increase by around 50%.

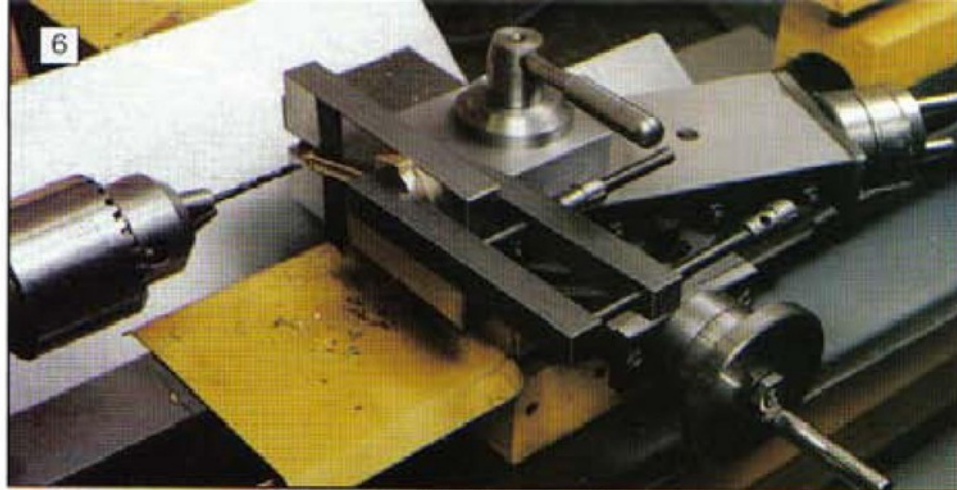
D bits

A D bit can be produced much more cheaply than a reamer, and yet produce a hole, the accuracy of which will be similar. Finish may not be as good, but with care will not be far behind. D bits are listed in a few catalogues, but mostly get made in the workshop. Drawing **Sk. 1** shows the general principle. They are made from silver steel and hardened and tempered. If made in the workshop, it can be of any size, so if the required size does not conform to a standard reamer the D bit can provide the solution.

To use a D bit, first drill a hole, 0.5mm to 1mm smaller in diameter than the eventual hole, and as deep as the hole has to be made. Now, using a boring tool, open up the hole to very slightly less than the D bit diameter and to a depth equal to its diameter, using this to start the D bit accurately. Run the lathe at about half the speed used for a comparable size drill, using plenty of lubrication and withdrawing the bit frequently to remove swarf.

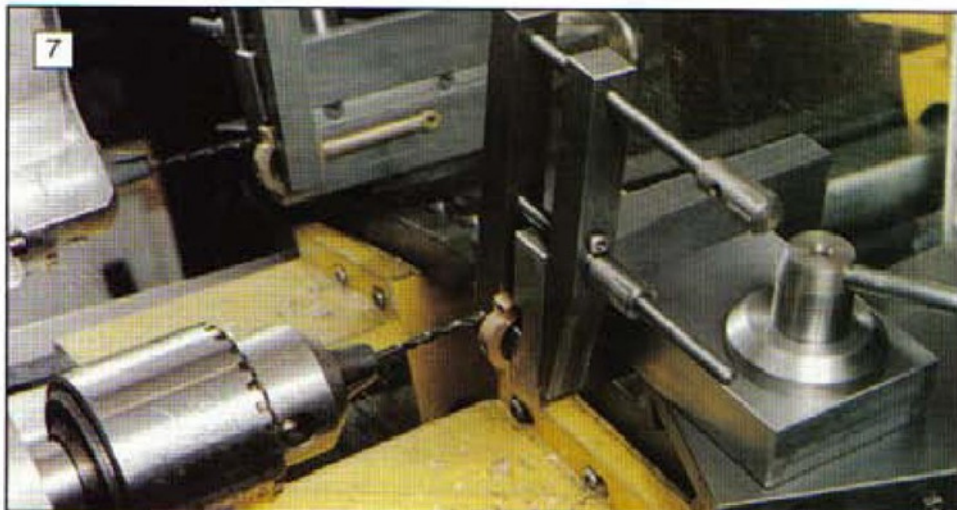
Another use for the D bit, is as a drill. The hole requires starting by drilling a short hole and opening this up to size with a boring tool, a D bit will then adequately drill a hole. I have not had a need to do this in anger, but have tested the process, just to prove it is viable. A major advantage is that very deep holes can be drilled and, providing the bit is started true, there is little tendency for the hole to wander. Remember that home made D bits are by and large made from high carbon steel, the main enemy of this otherwise excellent cutting material is heat. Do not allow the work or bit to overheat as this will spoil the D bit, and incidentally the

6



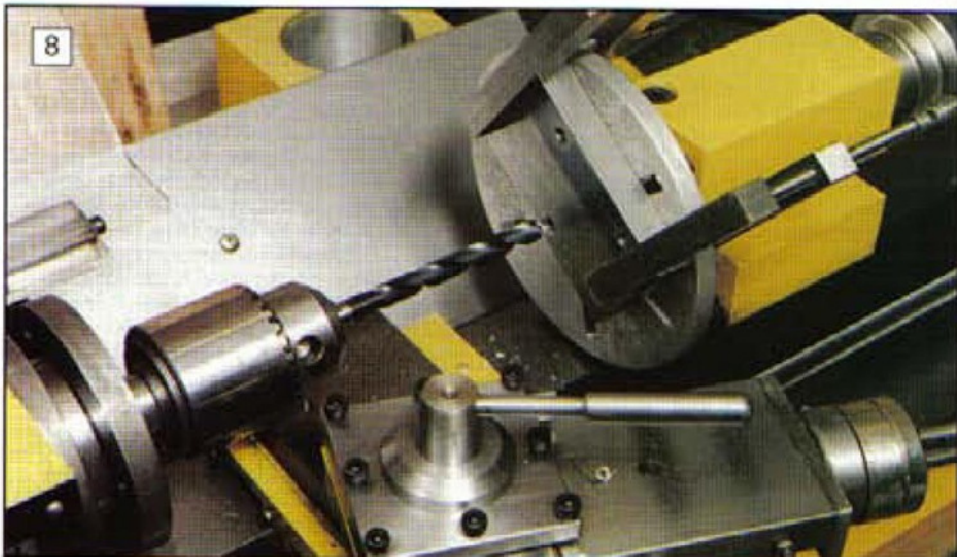
The drilling table in Photo 5 being used to drill a small steam engine part. The top slide is set at an angle to miss the tailstock and the feed applied by the saddle leadscrew

7



The table in Photo 6 has been moved through 90DEG. for drilling another hole in the part. A mirror has been placed at the rear to show the operation more effectively

8



Using a faceplate mounted on the tailstock as a drilling table

hole in the part being machined. Plenty of lubricant, and frequent withdrawal to clear chips are essential, as is lowering the mandrel speed.

Boring holes

Producing holes to size using a boring tool will depend on the relative diameters and depth. For smaller diameters the reamer or D bit will be more convenient

when the hole is of appreciable depth.

Photo. 2 shows two boring tools, the smaller works down to 4.5mm diameter and to a depth of 20mm, the larger down to 9mm diameter and to a depth of 60mm. Boring can produce holes with an accuracy and finish almost matching that achieved by a reamer, though much more care will be required. When it comes to larger holes, say 12mm plus, the costs of drills and reamers can be prohibitive, and boring is the only way forward.

Large hole, small lathe

With a smaller lathe it will sometimes be required to drill a hole that needs more power than the lathe's motor can deliver. In this case it will be necessary to produce the hole in stages, progressively enlarging it until the required size is reached.

Lever feed tailstock

A major disadvantage when drilling from the tailstock, especially with smaller drills, is that the screw feed isolates the user from the pressure placed on the drill (i.e. there is lack of 'feel'), leading to drills being broken. If many small holes, say 3mm and below, are drilled, the acquisition of a lever fed tailstock will be worth considering, as it will provide the same feel as a sensitive drilling machine. Only one lathe maker appears to list a lever feed as an extra, but making ones' own is possible ^{2,3}.

DRILL ROTATING

Considering now the situation where the drilling device rotates and the workpiece is held stationary. Even boring holes in this way is possible, either with a boring head, or a boring tool in the four jaw chuck (**Photo. 3**). Here the boring bar (**Photo. 2**) is mounted in the four jaw chuck and the hole diameter varied by adjusting the chuck jaws.

Little needs to be said about drilling in this manner as it would only be repeating earlier comments, but why do we use it? The reason is to make holes in shapes that cannot easily be held in either the three or four jaw chucks, or on the faceplate.

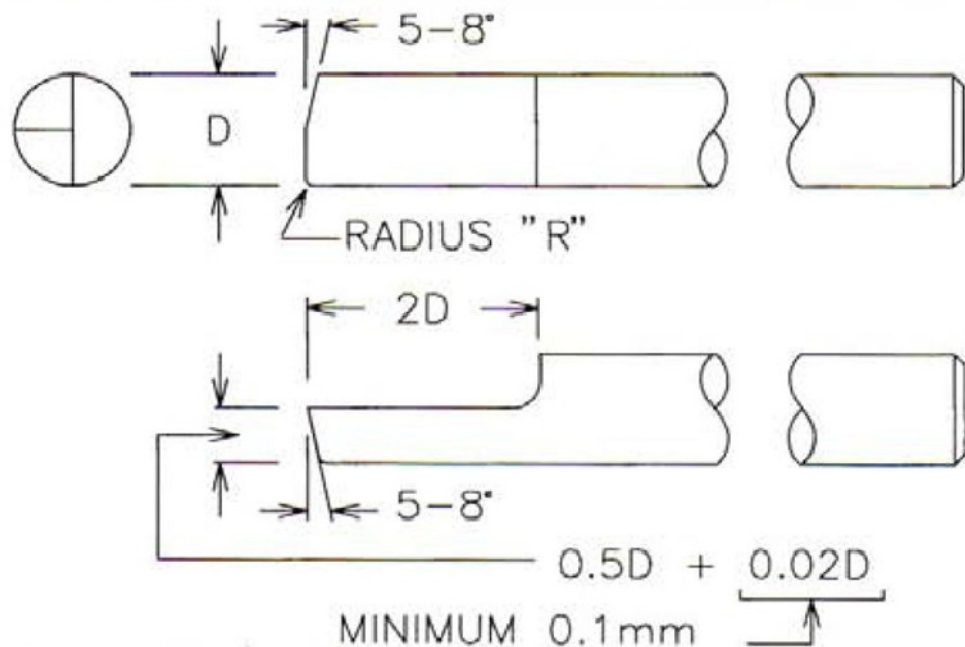
If a drilling machine is available then the need to use the lathe in this way will be a rare and specialised occurrence, such as if accurate hole centres are required, when using the calibrations on the cross slide will be a help. However, as is evident from articles in the magazine, some do not have a drilling machine, and the lathe is used for most drilling.

With the drill in a headstock mounted chuck, the workpiece has to be held and fed. This can be done using the top slide, saddle or tailstock, and is akin to a horizontal drilling machine. As when upright drilling, it is essential, except for light tasks, that the workpiece be clamped in position. A centre punch mark will be necessary, or the hole will need to be started using a centre drill.

Using the top slide

Drilling with the part held on the top slide is certainly the easiest method, though it has limited use. **Photo. 4** shows the body of the boring bar, already seen, being drilled in this manner. Ultimately being used on the top slide, it needed the hole to be at centre height. In other cases, packing would be required. To determine the amount of packing it will be necessary to know the height of the lathe's centre above the top slide. To measure this, turn a short length of material to a diameter, such that the top slide can just pass under it and check the gap with a feeler gauge. This thickness, with half the diameter of the turned part, will be the height required. Do keep a note book to

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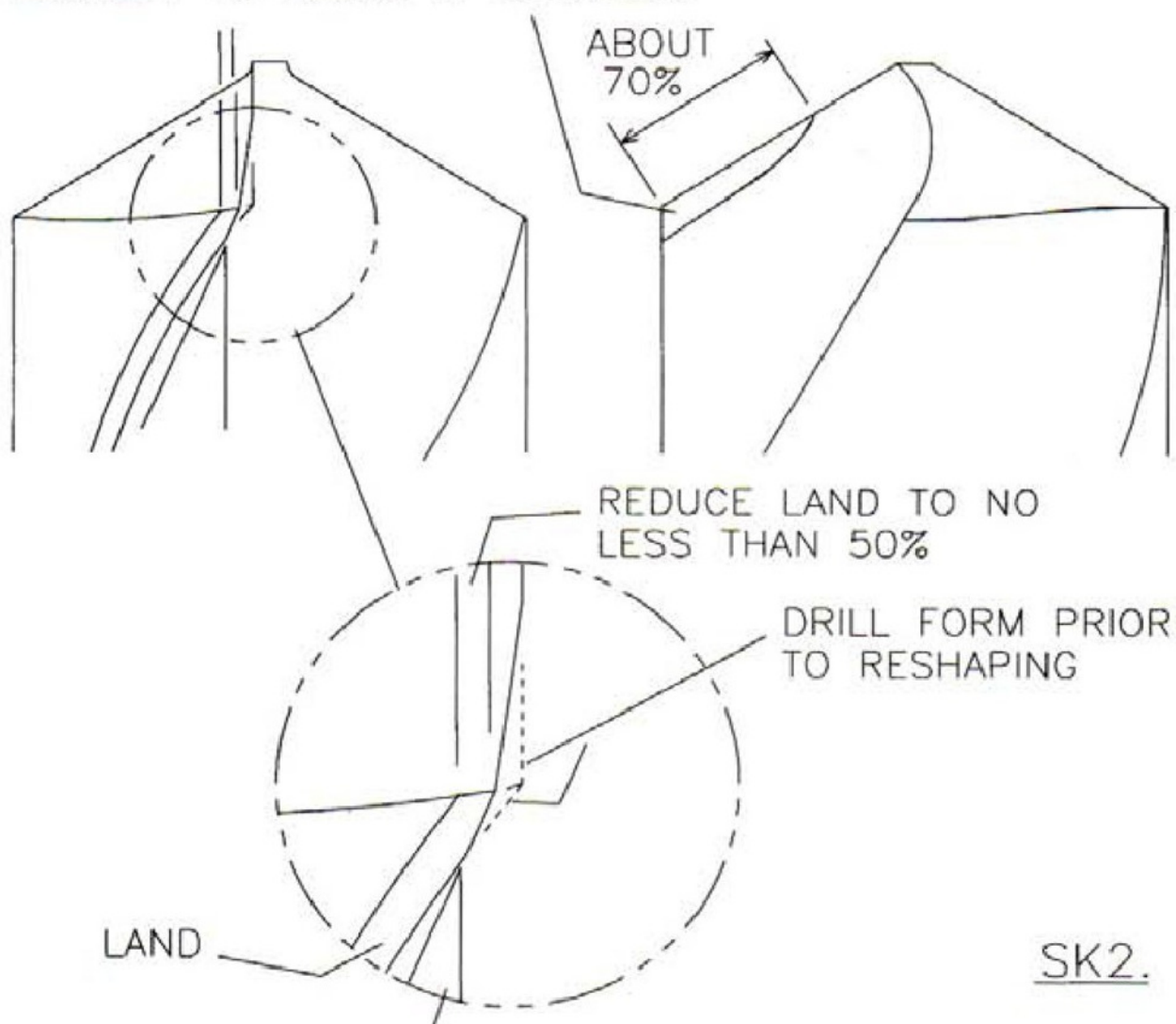


R ABOUT 0.02D, MINIMUM 0.1mm

D BIT PROPORTIONS.

SK1.

MAKE SMALL FLAT TO REDUCE HELIX ANGLE
LOCALLY TO ABOUT 5 DEGREES.



SK2.

record this and similar data; you will then only have to make the test once.

A piece of 'T' iron could be made into a drilling table for the top slide. **Photos. 5, 6 and 7** show the idea, but in this case it made from two pieces. Having written and read the article, I feel I have underestimated the usefulness of this approach and have returned to this section as I believe the method has distinct advantages and is worthy of greater comment.

Its main advantages are the speed at which it can be set up and its adaptability. Remove the tool holder (in this case a four way post) and, using the same fixings, the drilling table can be fitted in a matter of a few seconds. Also, it can be positioned conventionally at right angles to the drill as in **Photo. 6** or parallel to the drill as in **Photo. 7**, or at any angle in between.

Readers may be confused by the fact that the top slide in the photos is set at an angle. The reason for this is that in the case of the lathe being used, the Hobbymat MD65, the topslide is long, in most cases very beneficial. The tailstock also cannot be removed as it can on many lathes. The combined result is that there is insufficient room for the drill chuck and longer length drills. This is overcome by setting round the top slide, thus preventing it from fouling the tailstock, and by using the saddle leadscrew for feeding the workpiece.

The slot in the face of the table prevents it from being damaged by the drill as it breaks through the workpiece, but, if made exactly at centre height, can also locate the work for cross drilling. After use, the toolholder can rapidly be refitted to the topslide. This adaptability makes the device a very worthwhile addition to any workshop not equipped with a drilling machine.

Using the cross slide

This is able to cope with larger items, and if an angle plate is used, there will be more scope for clamping the part securely. The centre height above the cross slide will be worth measuring. Do this as above and make a permanent note of the value. If holes in a straight row are required, the cross slide leadscrew will provide a method of accurately setting them out. If a vertical slide is available, drilling in two axis is possible.

Using the tailstock

Drilling with the part supported and fed by the tailstock is possible, and several manufacturers list drill pads for the purpose. They are usually small and give little scope for securing the part being drilled. A better method is to use the faceplate on the tailstock. A few lathes have the same fitting on their tailstock as on the headstock, whilst others list adapters. If not available, making an adaptor is not difficult⁴. **Photo. 8** shows a tailstock mounted faceplate being used for drilling. On a larger lathe with more power for drilling larger holes, the action of the tailstock is much better for the purpose than the leadscrew, not least because the feed is directly in line with the drill itself.

Sometimes, a combination of cross slide and tailstock is used when drilling a large hole in an item mounted on the cross slide. In this case, the required pressure on the drill may be more than should be applied using the leadscrew or the rack and pinion. To avoid this, the workpiece can be mounted onto the cross slide, but the feed applied by the tailstock, but this is only possible on a lathe with half nuts on the leadscrew. To do this the barrel of the tailstock is placed at the rear

of the workpiece or mounting device and, being in line with the drill, is perfectly placed for providing the drilling pressure.

Drill types

Browsing through a list of drills available from a manufacturer will, for most home workshop owners, be a surprise because of the large number of types listed. Thirty nine, plus variations such as finish, in one catalogue. These include, lengths, helix angles, sharpening geometry and thicker webs for demanding materials. The supplier to the home workshop is likely to have available only a limited number, probably Jobber, Stub and Long series, only the Jobber in many catalogues.

The Jobber is, for the home workshop, a drill that will be accepted for most applications, even if not ideal. Some industrial users take the standard Jobber and modify the cutting edges to suit the task in hand, but this is rarely absolutely necessary in the home workshop. These variations will be for materials, such as brass, stainless steel, and plastics, and are beyond the scope of this article, except maybe drills for brass, which is a common requirement.

Special drills for brass are made with a much slower spiral than the standard Jobber. The benefit of this form is almost equally well achieved by reducing the helix angle at the cutting edge only, as shown in **Sk. 2**. There will be a temptation to drill brass using an unmodified Jobber and this is understandable. In the lathe with the controlled feed of the tailstock this may be acceptable for the occasional hole.

Long series drills are what you would expect from the name and are used for deep holes. Stub drills are the opposite, being about half the length of the Jobber. Their use is limited, but sometimes, can be used without a centre drill and are preferable for drilling tough materials; if nothing else they are less likely to break. They may find use on the smaller lathe, where the limited distance between headstock and tailstock, further reduced by headstock and tailstock chucks, may make the use of a standard length drill impossible with a longer workpiece. Some writers recommend the use of stub drills when drilling tapping holes, as the reduced tendency to wander can give a more accurate hole size, and thus greater control over the depth of thread.

Speeds/feeds

We now come to the question of speeds and feeds and again, we have to understand that there is a wide range of speeds that will give acceptable results. The main problem with drilling speed will be whether the speed is high enough for the smaller drills. It is obvious that a small drill, say 1mm, is very easily broken, and the greater the feed rate (feed per rev) the greater this possibility. We are almost invariably involved in hand fed drilling, and the feed rate for this is very indeterminate. If the speed is set very low, then it would become almost impossible to hand feed at a low enough rate to ensure that the drill does not break. Running the machine too fast is much less of a problem. Provided that the machine is not objecting and the swarf being produced is not just fine dust, indicating rubbing rather than cutting, all should be well.

Because lathes normally have only a limited number of speeds, there is no benefit in attempting to quote a speed for each drill size. If

this were done then only a few sizes would require speeds that line up with those available, surely indicating how flexible the use of machine speeds really are. Even in industry, until the arrival of electronically controlled drive motors, machines had only a few speeds available.

Hopefully these notes and the following speeds will relieve the beginner of the worry of choosing drilling speeds.

Drill size	RPM
1.5mm	4000
3mm	2000
6mm	1000
12mm	500

These speeds are for mild steel and copper and can be increased by 50% for brass and by 100% for aluminium. For tougher materials, silver, stainless and high tensile steels, reduce by about 30%. Under ideal conditions, such as a robust machine with pumped coolant, these speeds could be increased by 50%. However, most home workshop machines will not have speeds high enough and, even if available, may not have the power required.

It is interesting to consider the comments of a very reputable U.K. drill manufacturer regarding drilling problems, such as oversize holes, holes not straight and poor hole finish. In these comments, the only problem caused by too high a drill speed was rapid wear of the cutting edge. Also of interest, that the speeds given, around twice those above, were based on only one half hour actual drilling times between re-sharpening.

As feeding a drill is almost invariably a manual operation, quoting a feed rate is not relevant. Providing swarf is not like fine dust, indicating too slow a feed, all should be well. The effects of too high a feed rate are likely to be very apparent. These will be too high a generated temperature and the machine, in particular the drive system, objecting.

Lubrication

Applying a lubricant to a drill being used in the lathe is a hit and miss affair. Rotation of the workpiece, helix of the drill, emerging swarf and the horizontal mode, all make it difficult for the lubricant to get to the cutting edge. However, relieving the drill of the swarf is not automatic, and it will be necessary to withdraw the drill to clear it.

If a substantial flow of coolant is applied, it will, on removal of the drill, wash away the swarf as well as cool and lubricate the drill. More likely, as suds pumps are not often found in the home workshop, the swarf will require brushing away. After brushing clear, the brush can be charged with a lubricant and applied to the drill. If the result is excessive fumes, the drill is getting too hot and the speed and/or rate of feed, if heavy, should be reduced.

The subject of cutting coolants and lubricants will be covered in detail in a future article in the series.

References

1. Floating reamer chuck. M.E.W. Issue 24 page 35.
2. Compact 5 conversions. M.E.W. Issue 10 page 26.
3. ML7 tailstock lever feed. M.E.W. Issue 16 page 30.
4. Modified MD65 Faceplate M.E.W. Issue 35 page 23.

FIRESIDE READING

THE CLOCK REPAIRER'S MANUAL



~ Mick Watters ~

The Clock Repairer's Manual

This is a book suitable for the newcomer to clock repair and renovations. Although the preface states that there is likely to be material which will benefit the professional repairer as well, I suspect that there will not be a great deal that is new, and that the style in which the book is written may draw criticism of repetition from the experienced worker.

For the beginner, however, the information is presented in a clear and straightforward manner, with simple line drawings and explanatory photographs backing up the text. The method used is to describe a number of tasks in 'operation sheet' format, with step-by-step instructions on the dismantling, refurbishment and re-assembly of a simple timepiece, a striking

clock and a chiming version. The vehicles used to illustrate the various operations are clocks which are frequently encountered on the secondhand market, often being found at car boot sales, and which can usually be acquired for a few pounds. For instance, the first process describes simply the stripping and cleaning of a Smiths eight-day timepiece.

During each successive set of instructions, all the individual operations are defined, thus leading inevitably to a measure of repetition. It does have the advantage, however, that the raw beginner could set about the task with the book propped open, and not have to keep referring back to an earlier chapter.

Interspersed between these practical activities are chapters explaining the operation of such elements of the subject as the pendulum, escapements, chiming and striking mechanisms and the fusee. The repair of worn holes and pivots and the replacement of jewels receive detailed coverage, and tasks such as the re-waxing and re-silvering of dials are also explained.

One chapter is devoted to the use of the watchmaker's lathe, and the book closes with a fifteen page section on gear cutting and repair.

The author of the book, Mick Watters, is a Fellow of the British Horological Institute, and works as an Instructional Officer for Horological training. His words on the re-working of the products of the American Ansonia Clock Company have almost persuaded me to delve into the 'innards' of the example which ticks comfortably alongside me as I write. It would be nice to hear it strike again.

The Clock Repairer's Manual by Mick Watters is published by The Crowood Press Ltd., Ramsbury, Marlborough, Wiltshire SN8 2HR at £17.99. ISBN 1 85223 960 3

THE BACKYARD FOUNDRY

B. Terry Aspin



WORKSHOP PRACTICE SERIES 25

The Backyard Foundry

This book has its origins in *Foundrywork for the Amateur*, published way back in 1954, and which was so popular that it progressed through a number of editions and many impressions. The author, B. Terry Aspin will be no stranger to the readers of *Model Engineer*, being a close confidant of Chuck, the original Muddle Engineer, whose exploits he chronicled in strip cartoon form. For me, the high point of these was when Chuck set about machining the boiler for a miniature locomotive from a solid block of copper!

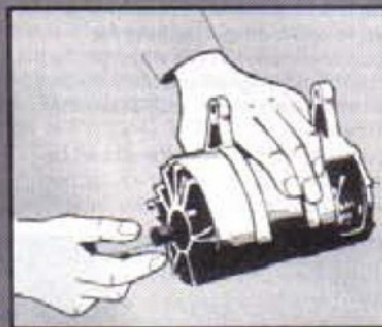
The Backyard Foundry, No. 25 in the Nexus Workshop Practice Series is packed full of practical tips on all aspects of producing metal castings (aluminium, bronze and iron) in an amateur environment. After an overview of the process, it goes into detail on such subjects as pattern and core making and the construction of suitable furnaces, as well as the practicalities of the casting procedure. Examples of numerous products are shown, and chapters are devoted to the casting of locomotive cylinders and wheels. Another of the projects illustrated is the production of castings for a *Quorn* tool and cutter grinder to Professor D. H. Chaddock's design.

This little book will give much help to anyone setting out to produce his own castings, or to someone wishing to make patterns to take to a local foundryman.

The Backyard Foundry by B. Terry Aspin is No. 25 in the Nexus Workshop Practice Series, and is published by Nexus Special Interests at £6.25 plus £1 p&p. ISBN 1 85486 146 8*

ELECTRIC MOTORS IN THE HOME WORKSHOP

V J Cox



WORKSHOP PRACTICE SERIES 24

Electric Motors in the Home Workshop

Almost inevitably, when one of the contributors to *M.E.W.* is dealing with a subject which concerns electric motors, he quotes as a reference Jim Cox's book on the subject, No. 16 in the Nexus Workshop Practice Series. This has now been joined by another book from the same author, entitled *Electric Motors in the Home Workshop*.

As stated in the introduction to the new volume, correspondence arising from the original work showed great interest in two of the subjects covered, namely the use of motors from discarded equipment and

simple methods of operating industrial three phase motors from domestic single phase supplies.

This new work, therefore, concentrates on these aspects, informing readers as to how to identify motors from various sources and commenting on their operating characteristics and the adaptations required in order to be able to use them in the home workshop environment. Single phase induction motors, three phase induction motors and commutator motors are the subject of detailed review, with circuits necessary for successful starting and running being illustrated.

The chapter on speed control reviews methods involving supply voltage variation, pole changing and electronic frequency control, plus the use of the power MOSFET for the control of DC supplies.

Mobile Power examines the use of motors and control systems in battery driven vehicles (e.g. miniature passenger hauling electric locomotives), while further coverage is given to the subject of battery power supplies and the attendant charging systems.

This book is about the safe practical application of electric motors from a number of sources, and is an essential companion to Jim Cox's earlier work.

Electric Motors in the Home Workshop by Jim Cox is No. 24 in the Nexus Workshop Practice Series and is published at £6.75 plus £1 p&p. ISBN 1 85486 133 6*

*In the unlikely event that your bookseller or trade supplier cannot supply a copy, these books may be ordered by post, or credit card phone order to Bailey Distribution Ltd, Units 1a/1b Learoyd Road, Mountfield Road Industrial Estate, New Romney, Kent, TN28 8XU. Tel. 01797 369966. Fax. 01797 366638.

DRIVING & GUARDING THE QUORN

Professor Dennis Chaddock's classic design, the Quorn tool and cutter grinder has been built by many of our readers. Philip Amos describes a number of modifications which he has made in order to increase the versatility of his example



Motor top cover, belt guard & original wheel guard.

The kit of castings available in Australia in the mid 1980s was for the Mark I form, and so did not include castings for the belt guard or the wheel guard. The motor available from the kit supplier was a 1/6 HP 240 volt 50Hz split phase unit, foot mounted. The belt available was a synthetic rubber ring of circular cross section.

These availability's allowed a Quorn grinder to be built and used, but also led to some restrictions and the need for some modifications. It may be of interest to other Quorn builders, or potential builders, to read how these problems were addressed.

Motor

The split phase motor does not require a capacitor in the starting circuit for normal

use (but see later). It was wired up as shown in **Drawing 1**. The starting winding can be readily identified, as it is the one connected in series with the centrifugal switch in the 'as bought' condition. When at a later time the motor was fitted with a larger pulley to drive small internal grinding wheels and points, it seemed to be labouring during starting. References 2 & 3 indicated that performance could be improved by converting it to a capacitor start motor; and this was done by inserting a 50 microfarad 250 volt AC capacitor in series with the starting circuit, as shown on **Drawing 1**. This could be conveniently mounted beside the switches on the back of the motor mounting plate, using a single screw fastened stirrup (**Photo. 2**).

Measurement of starting current showed a 2 1/2 times reduction in the case of the 2 5/8 in. dia. pulley driving the spindle, and a 3

times reduction in the case of the 7 1/4 in. dia. pulley drive. It is therefore recommended that such a capacitor be fitted at the outset, as it will benefit the operation of the machine.

Motor Mounting

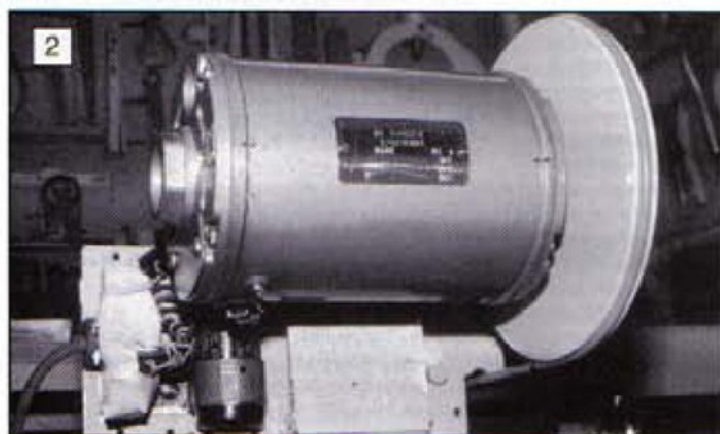
As the available belt was a synthetic rubber ring, it was of a fixed length, and so some means to adjust the distance between motor and spindle pulleys was required to allow its use. Two pairs of angle brackets were used, with one pair having slotted holes. These were attached to the motor and motor mounting plate with 1/4 in. BSW hex. head screws, 20mm long, nuts and lock washers. The arrangement is shown on **Drawing 2**.

For the configuration needed to use the larger pulley, an intermediate plate of mild steel 185 x 76 x 3mm was used with four studs 1/4 in. BSW, 15mm long brazed in (see **Drawing 3**).

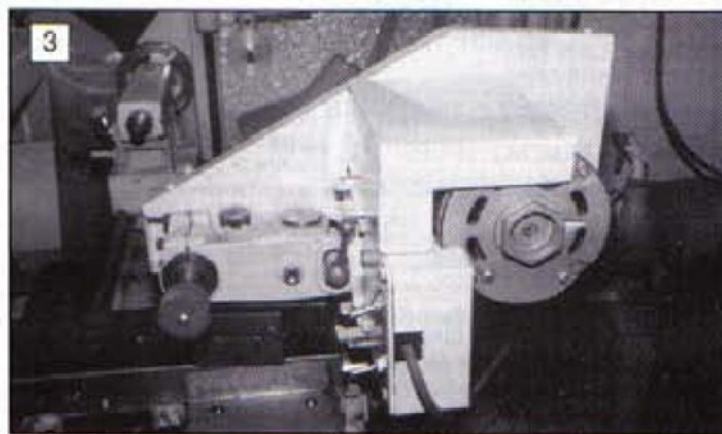
Motor Covers

As the available motor is an open ventilated type, there must be some concern about deposition of grinding dust into its insides. To reduce this, a top cover as shown in **Drawing 4** was fabricated from 24 BG (0.63mm) galvanised steel, folded, pop riveted and soft soldered. This cover is arranged to allow ample air flow for ventilation of the motor. It is attached to the top of the motor mounting plate with two brass knurled head 3/16 in. BSW screws, 10mm long.

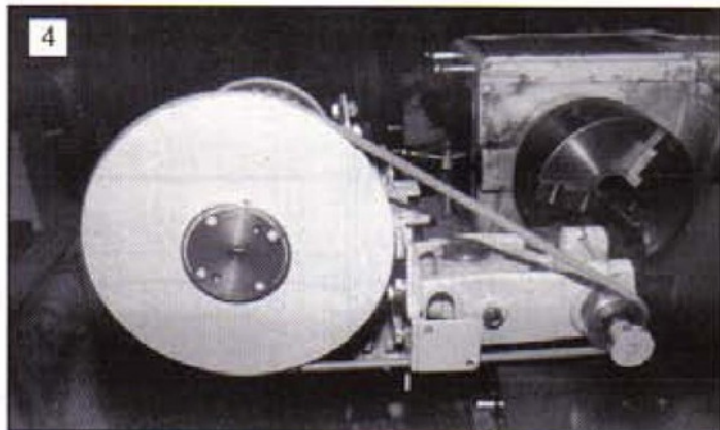
Because the Quorn wheelhead can be mounted either way up, duplicate tapped holes were provided in the motor mounting



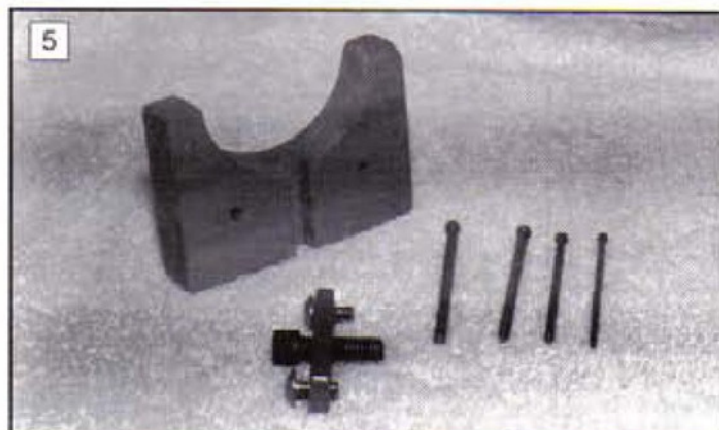
Capacitor fixed to rear of motor mounting plate.



Motor top cover, switch cover, & belt guard for large pulley.



Large pulley & polyurethane belt.



Pulley boss support block, removal jack & drifts.



Belt joining jig, end cutting jig, thermocouple & butane torch.



Large pulley belt guard.

plate, so that the cover can be attached to whichever side is uppermost. This top cover could not be used in the configuration required for the larger motor pulley, and so a second cover was made for this purpose. The differences are noted as 'B' on **Drawing 4**.

Another metal cover, lined with insulating sheet material, encloses the rear of the control switches and wiring behind the motor mounting plate, and is attached with two No. 8 x 10 mm pan head self tapping screws - see **Drawing 5**. The opposite end of this space is closed off with a piece of perforated sheet aluminium, again attached by two $\frac{3}{16}$ in. BSW mushroom head screws, 5mm long (see **Drawing 6**). These covers can be seen in **Photos. 1 & 3**.

Pulleys

The normal pulleys are made to the designs in Reference 1. Professor Chaddock also devotes a couple of pages therein to the use of the Quorn with small dia. grinding wheels and/or grinding points. Attention is drawn to the need for higher spindle speeds than those used with the normal (100mm dia.) grinding wheels, and refers to a $7\frac{1}{4}$ in. dia. motor pulley for this purpose.

In my case, with the standard pulleys, the no load spindle speed, measured with a stroboscope is 4800 rpm, inferring a motor speed of 2972 rpm. Nameplate load speed is 2850 rpm. For a $7\frac{1}{4}$ in. dia. pulley, the spindle speed would be 13260 rpm - well within the spindle bearings rating of 15000 rpm.

Professor Chaddock describes the manufacture of his pulley by the pattern making method of overlapping radial laminations of wood. His photograph shows a metal boss and flange bolted to this. I adopted a similar shape, but made the pulley from $\frac{3}{4}$ in. thick solid timber - it was in fact a piece of a chimney mantelpiece I had removed from a previous house and was at least 80 years old, so it was adequately seasoned. The pulley can be seen in **Photo. 4**.

It was first sawn out to an octagon, 8in. across the flats, and screwed to a wooden false faceplate, which in turn was bolted to the normal faceplate. The four screws, No. 12 x $1\frac{1}{4}$ in. long, were placed in positions outside the ultimate $7\frac{1}{4}$ in. diameter. The piece was then faced down to 12.7mm thick and bored 25mm diameter. A mild steel boss was turned to conform to **Drawing 7**, with its nominal 25mm dia. being gradually reduced until it could just be pushed into the wooden piece with hand pressure. The boss was then drilled and reamed 0.375in. for the motor shaft.

Four holes were drilled No. 4 (tapping size for $\frac{1}{4}$ in. BSW) through the steel boss and the wooden piece. These were opened out to $\frac{1}{4}$ in. and countersunk in the wooden piece, then tapped $\frac{1}{4}$ in. BSW in the steel piece. Four steel screws, $\frac{3}{4}$ in. BSW 20mm long countersunk head were then used to attach the wooden piece to the boss, which was gripped in the 3 jaw chuck, and the assembly supported by a tailstock running centre in the shaft hole. The OD was then machined to size and the pulley groove cut as shown in **Drawing 7**.

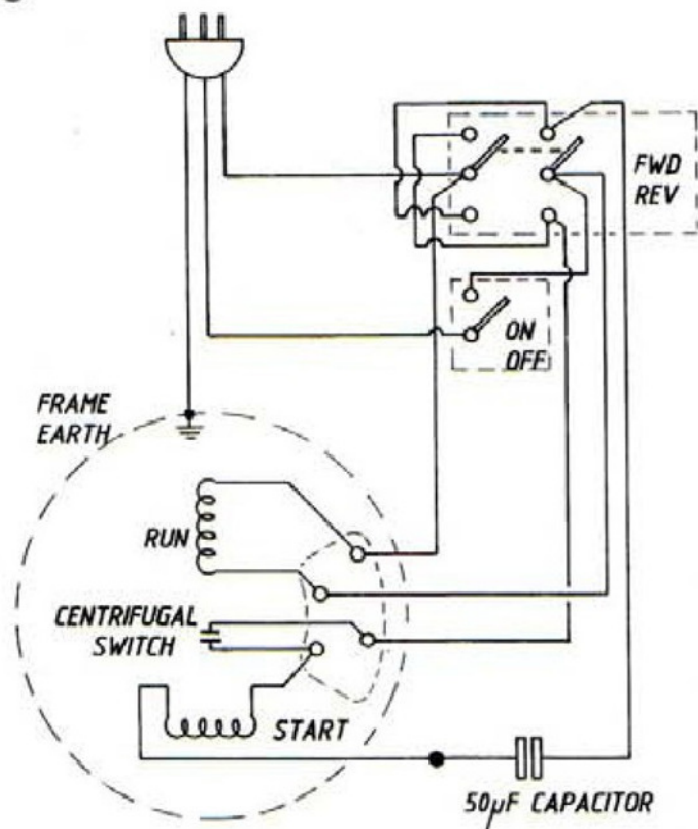
A hole is tapped 2 BA for 1in. depth and counterbored $\frac{3}{16}$ in. dia. x $\frac{1}{2}$ in. deep, to

allow a normal length tap of this size to be used to obtain a full thread to the shaft hole for the use of a socket head grub screw.

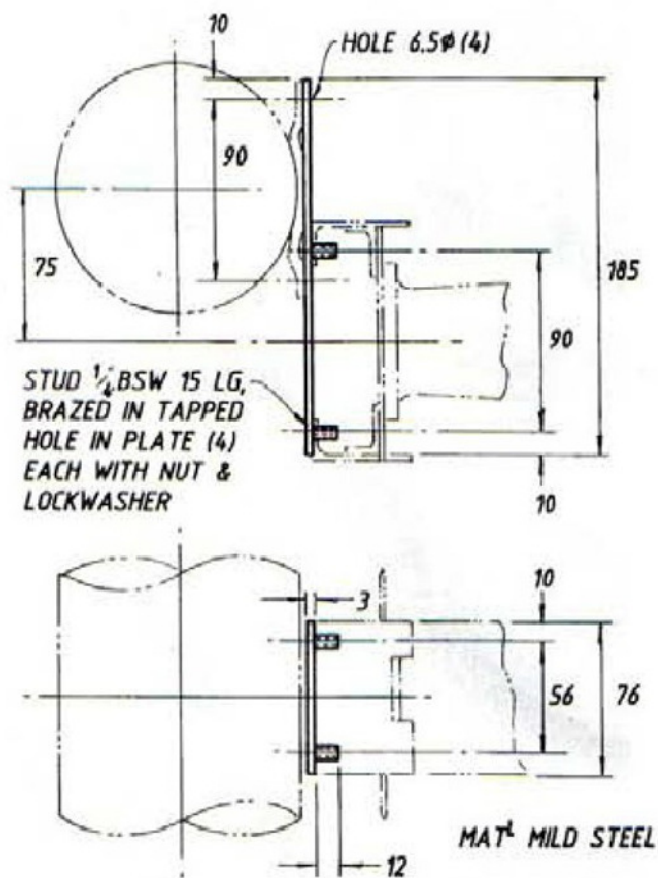
This pulley was then finished in paint - primer plus two coats of gloss. It was tried without a belt on the motor, and it was found that its inertia caused the grub screw end to be dragged sideways through the steel shaft. This became worse after each start. Hence it was decided that more positive fixing was required, and after unsuccessful trials with a $\frac{1}{8}$ in. taper pin, the means was finally resolved as a 4mm nominal dia. spring roll pin driven into a 4mm drilled hole. This can be knocked out with a suitable dia. parallel punch (3.7mm) provided the pulley is appropriately supported to avoid strain on the motor shaft and bearings. This protection is given by a hardwood block machined to the boss flange dia., and having a groove in its face to allow the emission of the roll pin and punch (See **Drawing 8**).

The pulley is withdrawn from the shaft with a simple jack comprising a $\frac{5}{16}$ in. BSW socket head cap screw working through a short bar attached to the boss with two $\frac{3}{16}$ in. BSW mushroom head screws $\frac{1}{2}$ in. long (see **Drawing 9 & Photo. 5**).

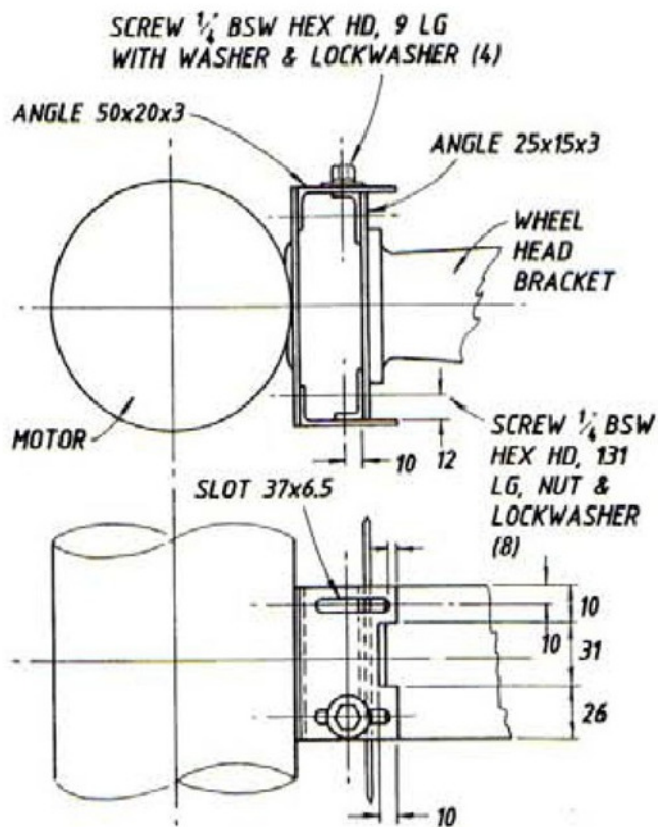
Replacement of the pulley on the shaft is by tapping with a soft hammer, with the pulley oriented as nearly correctly as possible, and then using a series of 30deg. pointed drifts of increasing dia. (made from nails) to align the holes in the boss and the shaft. The grub screw is tightened to hold the items in correct relationship and the roll pin is tapped in using parallel punches, with the pulley again supported on its block. The aim is to have the roll pin extending out



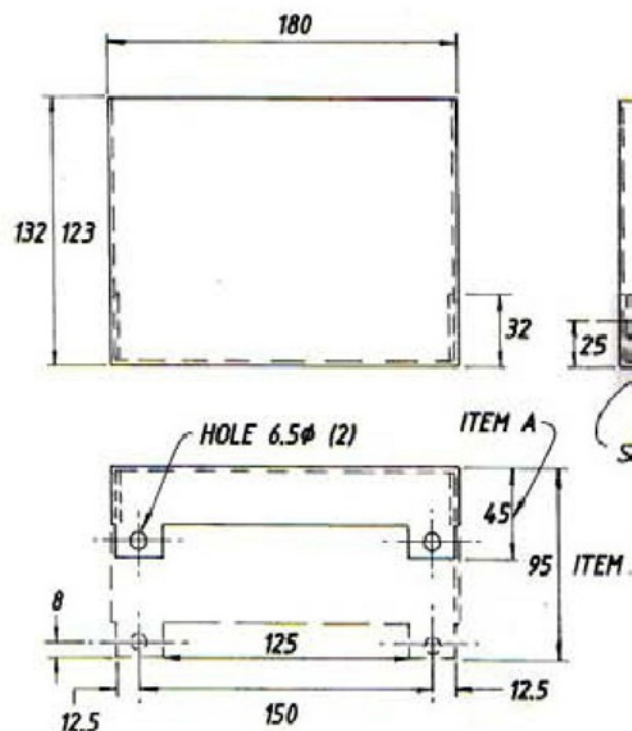
DWG. 1. MOTOR WIRING DIAGRAM



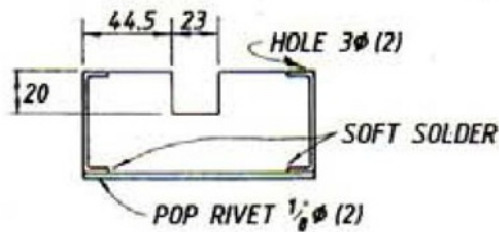
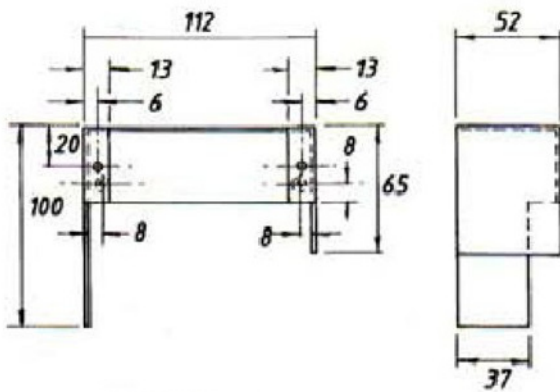
DWG. 3. INTERMEDIATE PLATE



DWG. 2. MOTOR MOUNTING



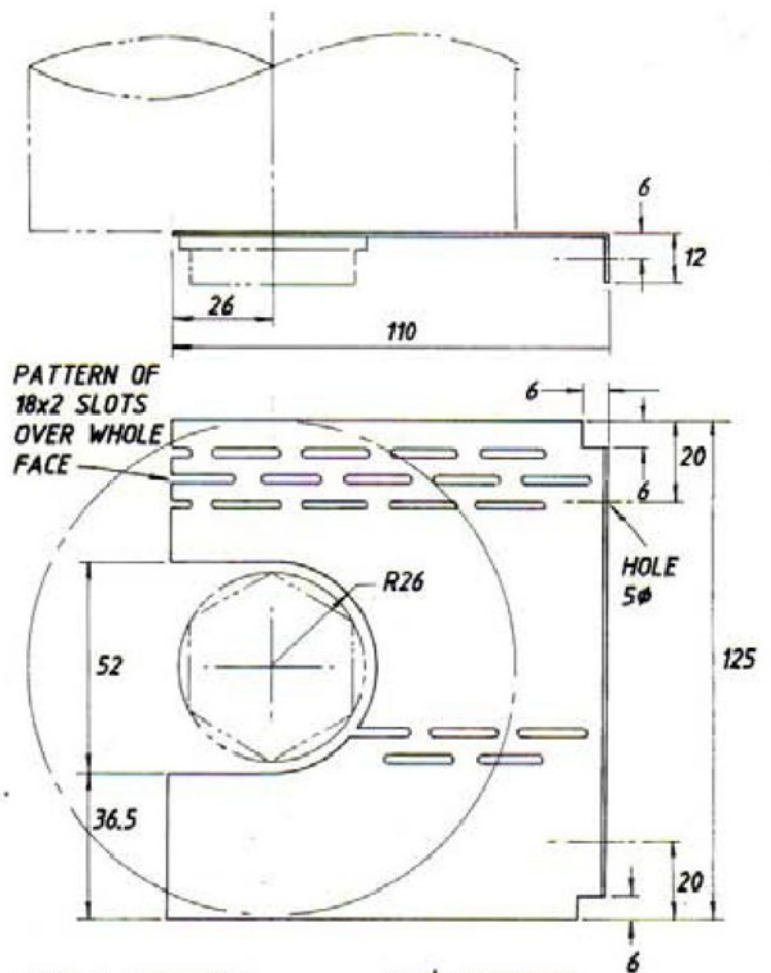
DWG. 4. MOTOR COVERS



DWG. 5.
SWITCH COVER

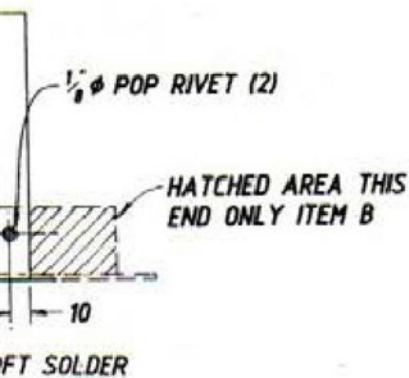
LINED WITH SHEET
INSULATION 11h

MAT^L 24BG
GALVANISED STEEL

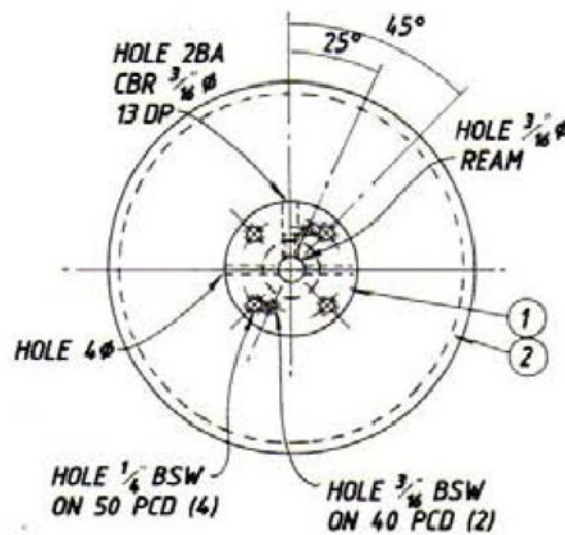


DWG. 6. END COVER

MAT^L ALUMINIUM

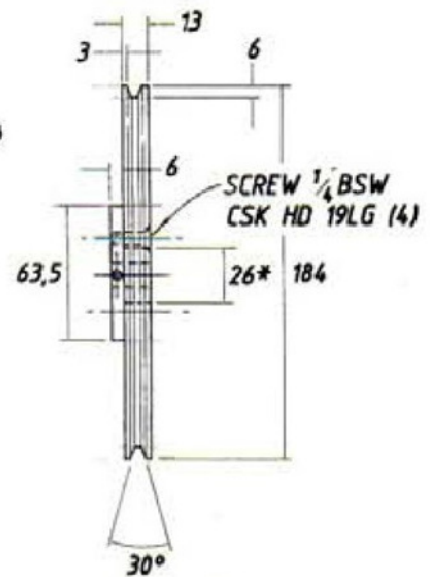


MAT^L 24BG
GALVANISED STEEL

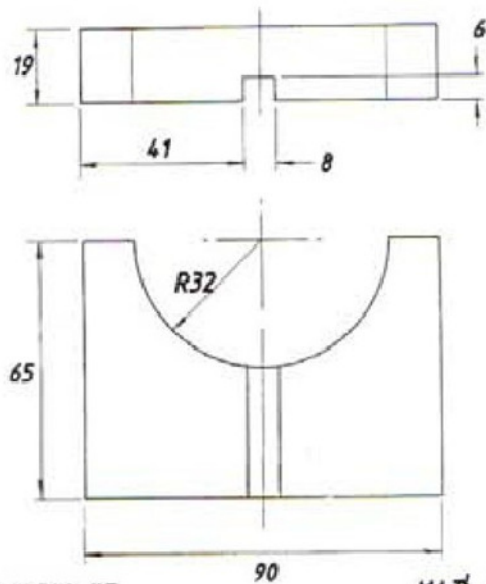


DWG. 7.
LARGE PULLEY

MAT^L: ITEM 1 MILD STEEL
ITEM 2 WOOD

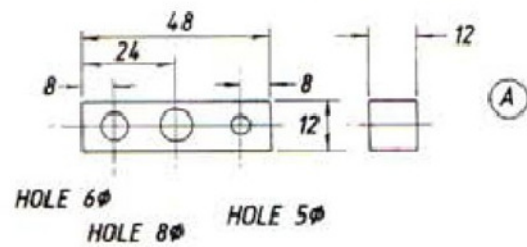


* SEE TEXT



DWG. 8. ROLLPIN JIG

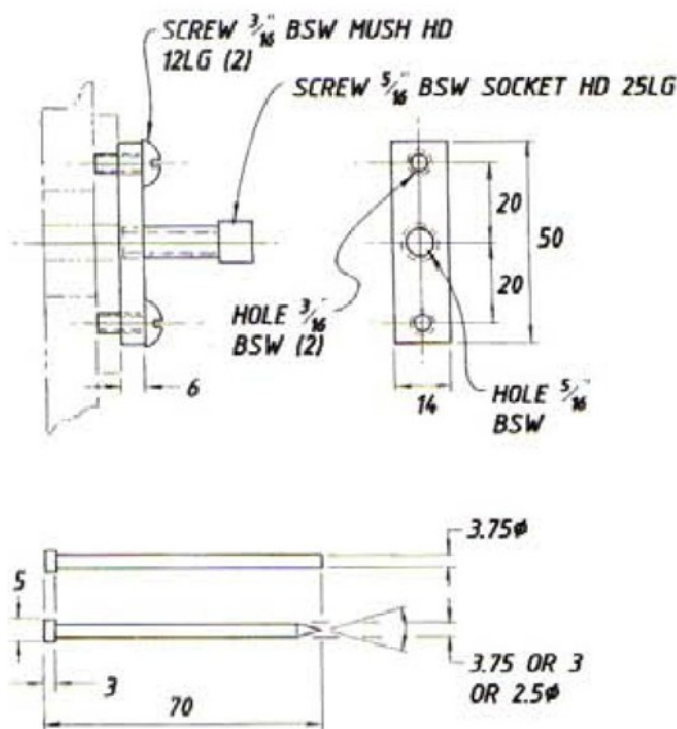
MAT^L H/WOOD



DWG. 11.

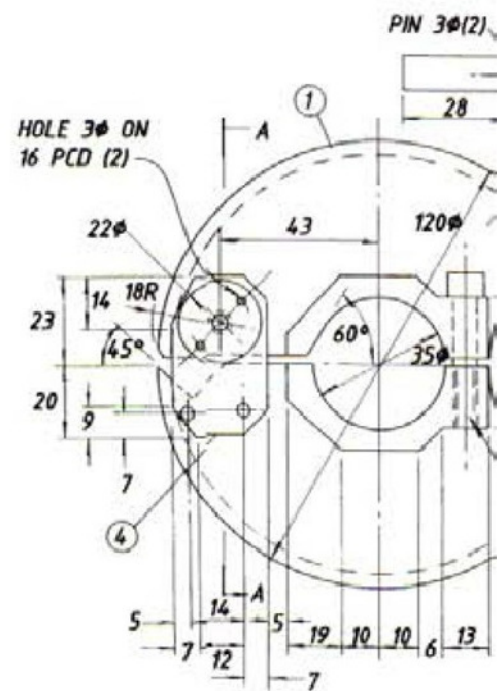
A. CUT OFF JIG
B. JOINING JIG

MAT^L: MILD STEEL
MILD STEEL & WOOD



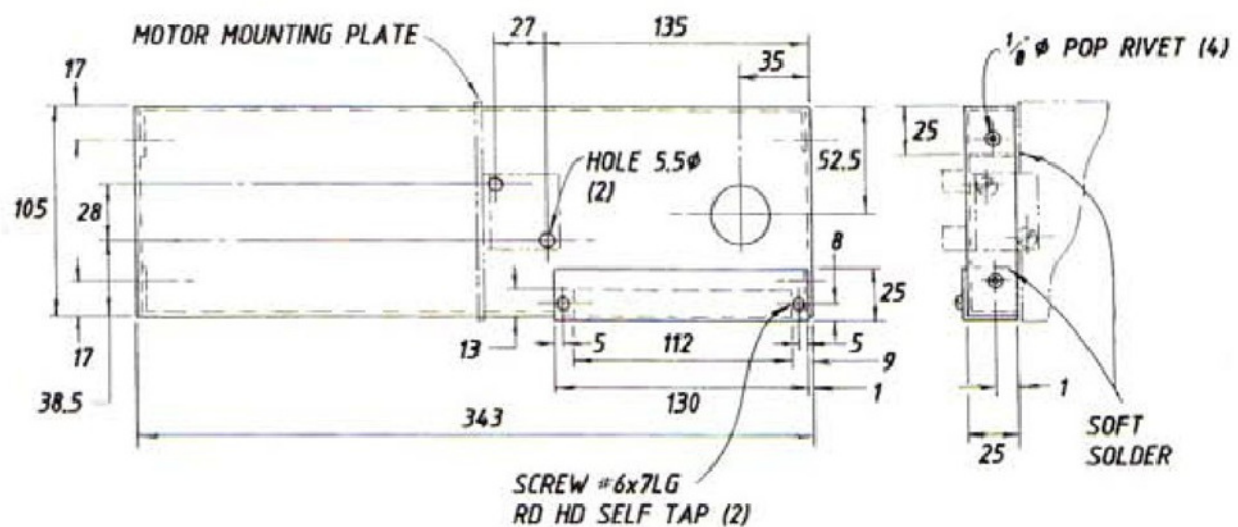
DWG. 9. PULLEY JACK & DRIFTS

MAT^L MILD STEEL



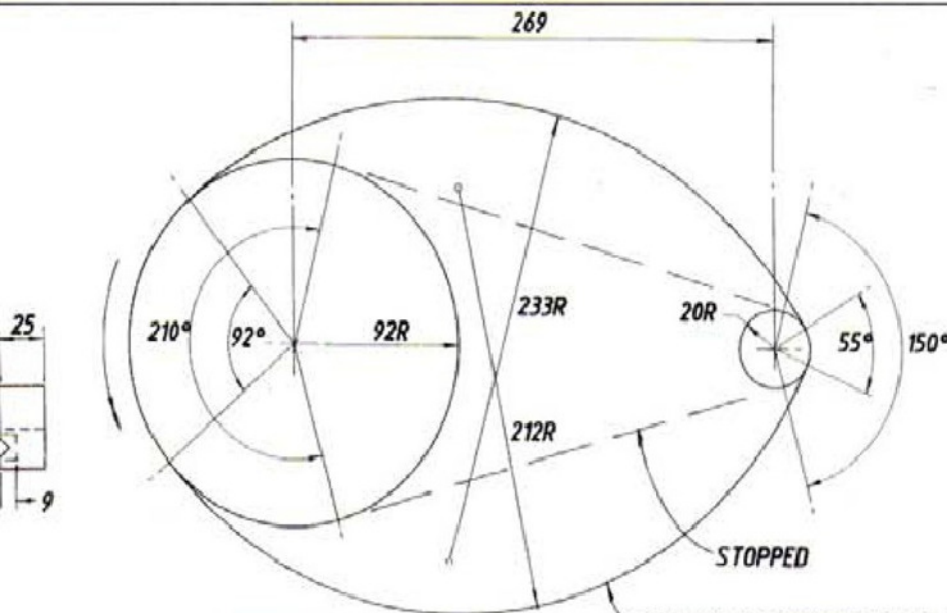
DWG. 14. REVISED WHEELGUARD

MAT^L

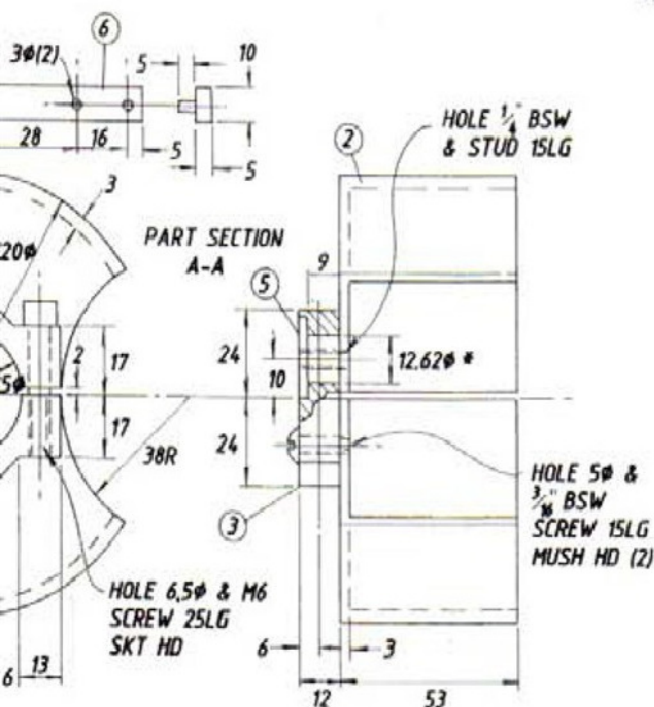


DWG. 12. BELT GUARD

MAT^L 24BG
GALVANISED STEEL

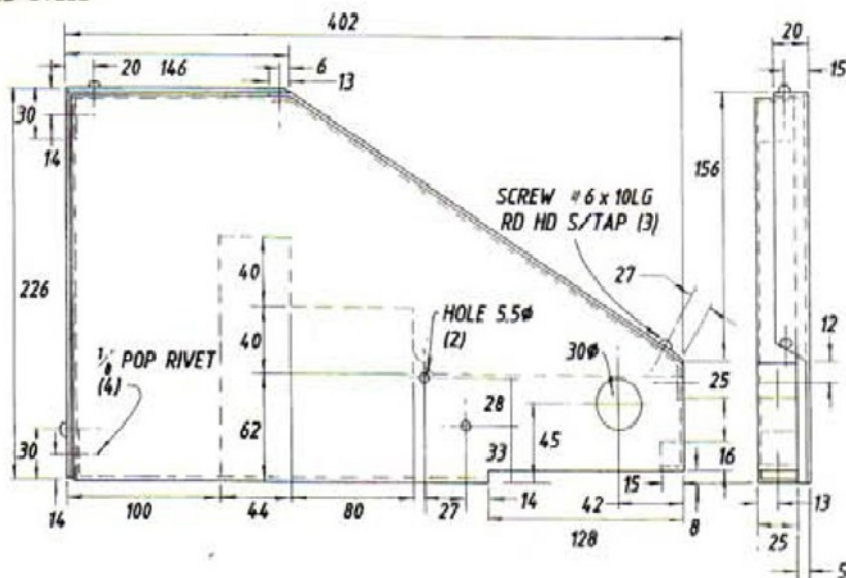


DWG. 10. RUBBER BELT



* SEE TEXT

MAT¹ MILD STEEL



DWG. 13. BELT GUARD

ALL TURNED OVER FLAPS
SOFT SOLDERED

MAT¹ 24BG
GALVANISED STEEL

equally from both sides of the shaft into the boss. The pin is 25mm long; a longer pin was not selected, as this adds greatly to the force required to drive it in and out.

Belt

After careful measurement of the available synthetic rubber belt, it was confirmed that it is in fact a BS O-ring 443 (7 1/2in. ID 1/4in. dia. cross section). It proved satisfactory for use with the normal size motor pulley. By analogy, a larger BS O-ring 451 (11in. ID 1/4in. dia. cross section) was obtained for use with the larger pulley for internal grinding. This was found in practice to be quite unsuitable, as in operation it belled out as shown in **Drawing 10**.

This happens because, when rotated at high speed, the belt tries to form a circle due to centrifugal force. This is opposed by tension in the belt, but if the belt is 'stretchy' this opposing force is insufficient to keep the belt in close contact with the pulleys. As will be seen from the drawing, this provides inadequate arc of contact on the pulleys to give sufficient driving torque. Thus a decision was taken to use 6mm polyurethane extruded round section belting for both length belts. The length required in each case was determined by wrapping the belting around both pulleys and marking where its end came. The data sheet suggests 10% stretch be adopted, but I used 5%, which seems adequate and puts less transverse load on motor and spindle bearings. A simple jig comprising a piece of steel with drilled holes for the various sizes of belting allowed the belt ends to be cut exactly at right angles to the length, using a razor blade (see **Drawing 11**).

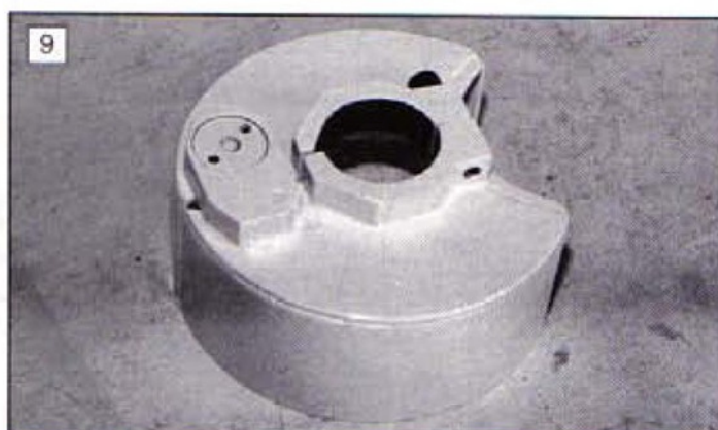
The recommended technique for joining the ends together is to hold both ends against a heated blade, slide them sideways off the blade, and push them together, holding them in place for minute. This is easy to write but harder to do if one has only two hands. Hence a jig was made to facilitate this operation. As shown in **Drawing 11 B** & **Photo. 6**, this comprises a piece of steel strip pushed into a sawcut in a block of wood, which has a V-groove cut in it and a wider gap at the middle of the groove to accommodate the bulge of the belt material which occurs as the ends are pushed together. This block can be held in a bench vice as shown in the photo. The data sheet suggests heating to 140deg. C, but how this can be judged is not indicated, so I attached a thermocouple to the top of the strip, which was heated by a small butane torch. I found 140deg. C to be less than adequate, and used 200deg. C for my belts. After joining, excess material is shaved off the bulge with a razor blade. Even using this jig, I found it difficult to get the ends exactly in line, but the resulting belts seem to operate well in service.

Belt guard

The belt guard was fabricated from 24 BG galvanised steel to form a simple rectangular box by folding, pop riveting and soft soldering as shown on **Drawing 12** & **Photo. 1**. The hole for the head of the spindle draw bar was made larger than the head, so that the guard could be removed, leaving the draw bar in place and vice versa.



Original wheel guard.



Revised design wheel guard.

The guard was supported on a small angle bracket attached to the motor mounting plate with 2 x $\frac{3}{16}$ in. BSW round head steel screws 7mm long, and the guard was then attached to this bracket with two brass knurled head $\frac{3}{16}$ in. BSW screws 10mm long.

At a later stage, when the Quorn was used on the lathe for cylindrical grinding, it was found that the underside of this belt guard fouled the topslide, so a piece was cut out of the guard to provide clearance, and a loose piece made to fill the gap in normal service. This piece is attached to the guard with two No. 6 x 7mm long pan head self tapping screws.

Obviously, for the larger pulley, another belt guard is required. This was again fabricated in 24 BG galvanised steel, and is shown on **Drawing 13 & Photos. 3 & 7**. In order to adequately guard the belt in this configuration, the cover must be two sided. The outside is attached, as before, to the motor mounting plate, and the inside is then attached to the outside with 3 x No. 6 x 10mm long pan head self tapping screws.

When operating with the larger motor pulley there is considerable noise and vibration, and belt guard drumming accounts for much of this. It has been found necessary to fit lock washers under the knurled head screws holding the belt guard and motor top shield in place, as these tend to vibrate out.

Wheel guard

As there was no casting for this item provided, a fabricated item was produced (**Photo. 8**) by scaling the drawing of it shown in Fig. 55 on page 64 of reference ¹, as that drawing was incompletely dimensioned.

The resulting part was virtually a fabricated equivalent of the cast one, and was used satisfactorily for some years, but it had two deficiencies. Firstly, its axial length did not extend sufficiently to shroud the cup wheels used on the machine (as obtained from Model Engineering Services), and secondly, it is often necessary to remove the guard to be able to set the machine for various jobs, and to achieve this, the grinding wheel had to be removed first to allow removal of the guard, which proved tiresome.

To overcome these problems, a revised design was made, which hinged open to allow its easy application and removal, and which had increased axial length

(see **Drawing. 14 & Photo 9**). It is entirely made of mild steel, with the components brazed together.

Construction was as follows:

1. The outside profile of the backplate (item 1) was bandsawn from 3mm plate, and a 1in. hole drilled in its centre. A $\frac{1}{4}$ in. BSW hole was also drilled and tapped as shown.

2. The shroud (item 2) was rolled from 50 x 3mm black strip on hand rolls - a Taiwanese triple machine; 30in. rolls / guillotine / press brake - this operation required multiple passes as the machine was just about at its limit of capacity.

3. The boss (item 3) was made from a piece of 50 x 12mm bright strip and drilled 1in. dia., then drilled No. 4 and tapped M6. It was then bandsawn to its outside profile.

4. Items 1 and 3 were brazed together, and the main hole bored out to 35.05mm, which was an easy fit over the wheel head spindle.

5. An 18mm length of $\frac{1}{4}$ in. BSW studding was brazed into item 1, so that 12mm projected on the boss side. The other side was filed off flush.

6. The hinge (item 4) was drilled, reamed and counterbored and the chamfers bandsawn and dressed with a file.

7. The hinge nut (item 5) was machined $\frac{1}{4}$ in. BSW internal and 12.62 mm external, to be an easy running fit in item 4. The shoulder dia. allows clearance to the counterbore. The two holes in the face of the nut are for a pin spanner—item 6—and were drilled through the spanner holes to ensure line up. The pins are Loctited (680) into the spanner body.

8. The hinge and nut were assembled on to item 1, and tapping holes No. 24 were drilled through hinge and backplate. These were opened out to $\frac{3}{16}$ in. BSW in the backplate and to $\frac{3}{16}$ in. dia. in the hinge. The hinge could then be held in place with two $\frac{3}{16}$ in. BSW mushroom head screws 20mm long when later required.

9. The shroud (item 2) was then brazed to the backplate (item 1).

10. The assembly was set up in the milling vice on the drill/mill, with its front to

rear axis horizontal, and split with a $\frac{1}{16}$ in. wide slitting saw. After filing both edges smooth, a small clearance V was cut with hacksaw and file, and the rear edges chamfered to allow the top to pivot on the hinge pin through 35deg., which yielded an opening in the front of about 120mm, to easily clear the 104mm dia. of the grinding wheels. A chamfer was also filed on the rear upper section of the boss bore, to ensure no interference between the boss and the wheel head spindle. The M6 tapping hole was completed through the lower half of the boss, and was opened out to 6.5mm in the upper half.

11. The hinge was now attached to the lower half with its screws, and brazed in place. The screws were then removed and discarded.

12. The whole contraption was assembled and fitted to the wheel head, being secured in place with a cap screw M6 x 25mm long.

13. The wheel guard was given a coat of red iron oxide primer and two coats of grey enamel. The hinge nut was locked in place with Loctite 241 Nutlock.

Conclusion

This article relates some problems encountered with particular aspects of manufacture and use of the Quorn, and how these were addressed, and amplifies some of Professor Chaddock's information. This may be of interest to those contemplating building one of these very useful machines.



References

1. *The Quorn Universal Tool and Cutter Grinder* - Professor D.H. Chaddock. TEE Publishing, The Fosse, Fosse Way, Radford Semele, Leamington Spa, Warwickshire, CV31 1XN. £10.95 plus £1.40 p&p.
2. *Electric Motors* - Jim Cox Workshop Practice Series No. 16 Nexus Books, £6.95 plus £1 p&p.
3. *Electric Motors in the Home Workshop* - Jim Cox Workshop Practice Series No. 24, Nexus Books, £6.50 plus £1 p&p. Nexus Books, Nexus House, Boundary Way, Hemel Hempstead, HP2 7ST. Tel. 01 442 66551. Fax. 01442 66998.

MYFORD TAPER TURNING ATTACHMENT IMPROVEMENTS

Solving a handling problem led David Dew to develop a simple setting up device

A weighty problem

The Myford taper turning attachment is a heavy cast iron angle bracket which attaches to the back of the bed with three $\frac{1}{4}$ in. BSW screws into any of six tapped holes, allowing it to be positioned where needed along the bed. On top of this bracket is a centrally pivoted Vee slide, with a sliding member which has an adjustable gib strip. All this is surmounted by the arm which links it to the cross-slide. In action, one must release the feed screw in order that the cross-slide may follow the taper set by swivelling the vee-slide.

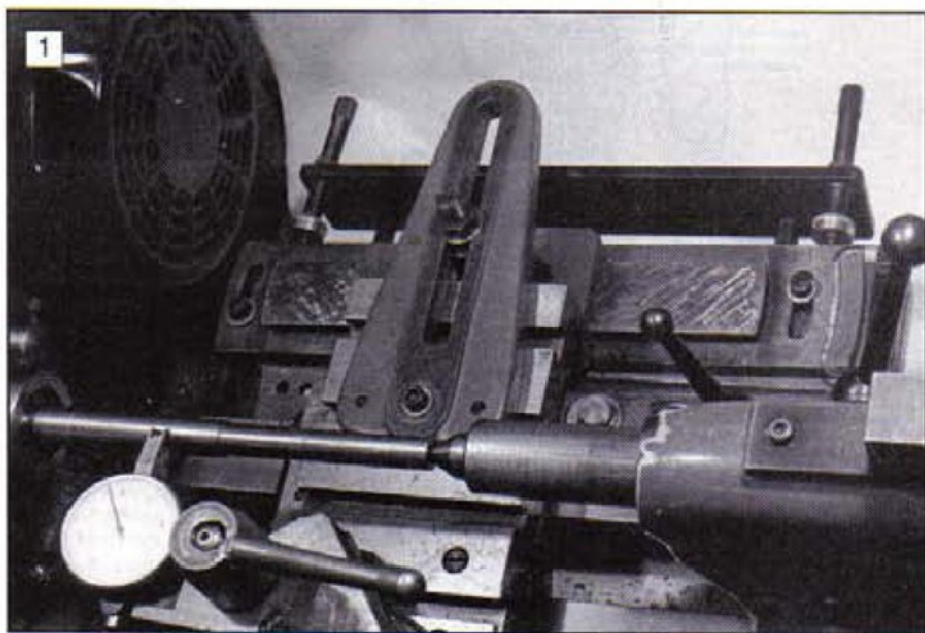
Attaching it to or removing it from the bed is difficult. There you are, leaning right over the bed, supporting this heavy casting in one hand, whilst feeling around with a screw in the other for a hole which you cannot see! I have resorted to using a mirror. I abhor the operation, and try to leave the attachment where it was last used as long as possible. George Thomas reckoned he never took it off at all, and club-mate George said his last came off some eight years ago, and the next taper he needed was going to be cut "at the wrong end" to avoid shifting it.

My problem seems to be further compounded. I believe I have an earlier attachment designed for the short cross-slide on the ML7. The long cross-slide fouls the upper works of this Taper Turning Attachment, so I have left the main bracket in place, but it was necessary to remove the plastic fiducial mark, the slide and the pivoting member.

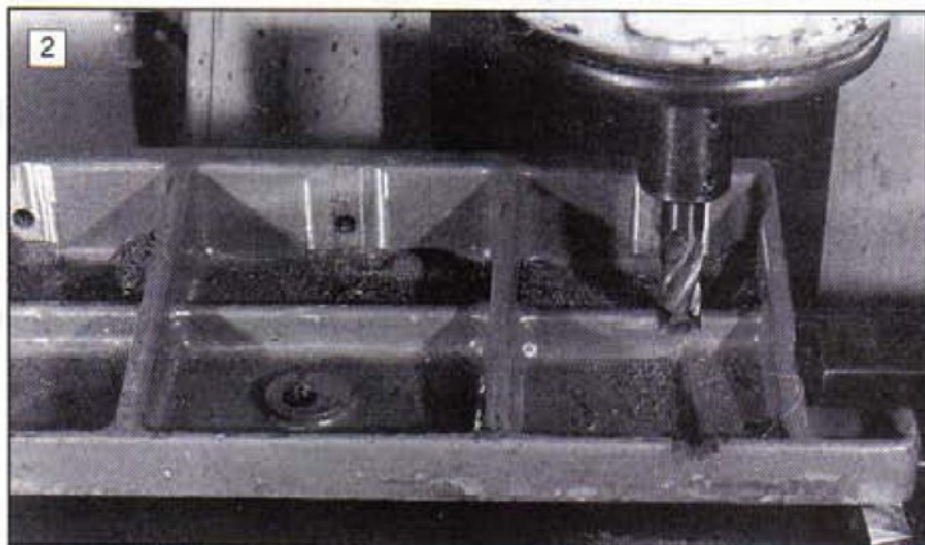
Recently the thing just had to come off completely. While I was doing it, I thought how much easier it would be if it had legs down to the tray, to support it level, and studs already in the bed, so that it could be slid into place. A bit more thought suggested that it probably only needed the studs, as it could be offered onto them, and should hang there while the nuts were done up. If the 'nuts' were long enough to protrude beyond the rear of the casting, then they would be easier to handle and tighten. These extension nuts lead to another development, which will be described below.

The studs work a treat! If you do nothing else, do fit these. I bought a three foot length of $\frac{1}{4}$ in. BSW studding from a local nut & bolt stockist. This is getting rarer, and the first place I went to had none—so don't give up. You might say I could have screwcut these and saved money and petrol. The studding cost just 50p. (Be warned—the Taiwanese copy lathe is tapped $\frac{1}{4}$ in. BSF).

Run a tap into the lathe holes to clean them out and check the length. Mine were all about 13 turns deep. I say all because I have both a Super 7 and an



The modified taper turning attachment.



Milling flats for extension nuts.

ML7. (The Super 7B was acquired while secondhand prices were low recently, and I hadn't the heart to part with my 1953, two owner ML7. I have since found how useful it is to have two up and running in the 'shop).

Cut six studs (per lathe!) to length required. Clean up the ends and, using a couple of nuts, wind them hard into the bed. Now offer up the taper turning attachment and just see what a difference there is already. The extension nuts are best made from $\frac{1}{4}$ in. BSF hexagon, and should be tapped the same both ends. You might decide that is enough gadgetry, but the next bit will really make a difference when you come to use it.

Setting the angle

Most work done with a taper turning device needs to be accurate to super-accurate. Morse tapers, for example, need to be no more than about a thou. out over 2 inches. Milling machine tapers, too, have to be good. If stretching a screw pitch when cutting worms, then again you need to set the attachment to exactly the same angle as the tail-stock set-over angle, or else the thread will vary in depth. Making tapers for beam engine columns or for con-rods is not demanding, but if you are solely a model maker, then a quick positive means of setting is still useful.

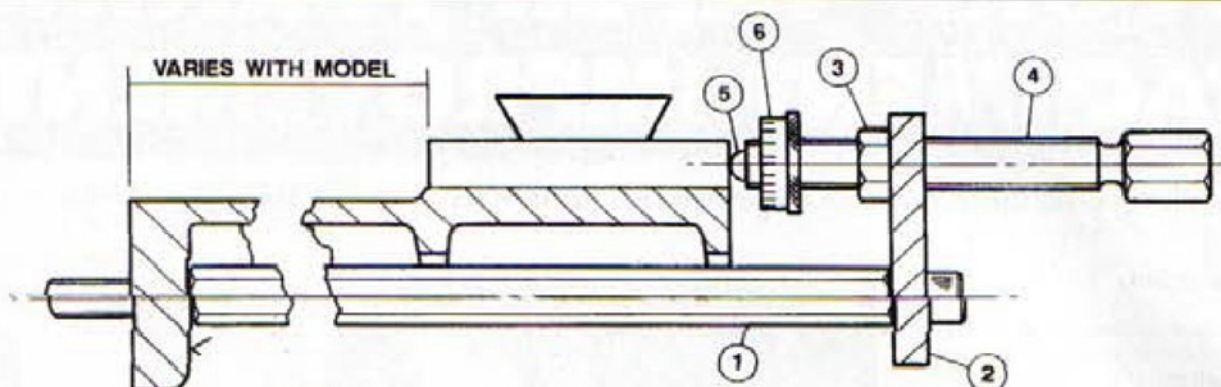
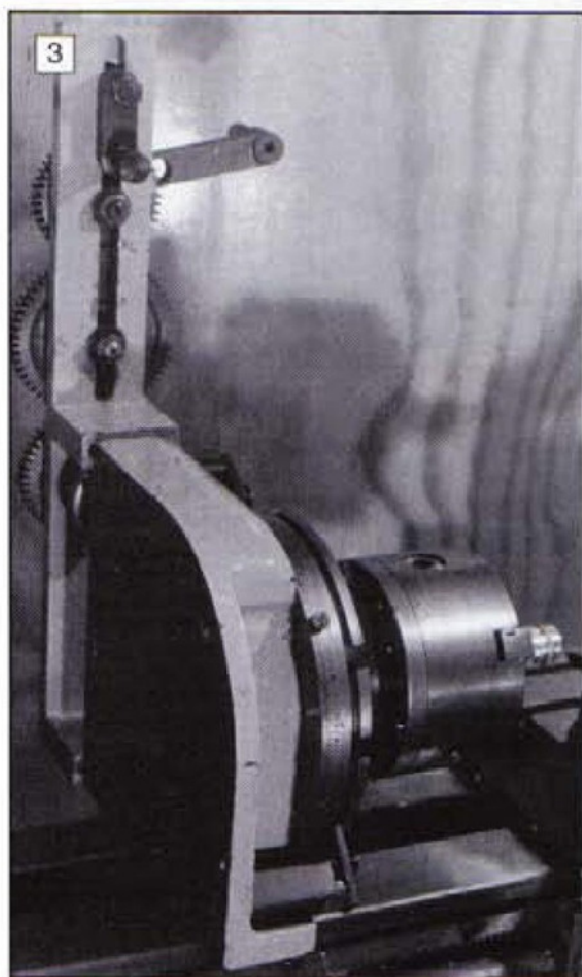


FIG. 1.
MODIFICATION TO MYFORD
TAPER TURNING ATTACHMENT



Change gears on a dividing head, for quick indexing.

The problem with the Myford attachment as supplied is that there is no way of making precise very small adjustments. It is case of slackening off the two end clamping screws, then hitting one end or the other. The DTI is not much use, as the deflection is according to the pivot point, not the job. Even if you become skilled enough to tap a few tenths at a time, normally everything shifts when the clamp screws are pulled down.

The late George Thomas wrote of the problem in a throwaway line which I had not noticed previously. He suggested the use of pushing screws at each end, onto and from behind the pivot slide. I had previously tried pushing screws from the

front, but found that there is insufficient space, especially with the very narrow unit I have. Mr Thomas appears to have thought that idea not worth pursuing relative to his superbly engineered solution published in *M.E.* and in his book *'The Model Engineers' Workshop Manual'*. He cut a segment of a gear on one end of the pivoting member, and engaged this with a special worm with micrometer drum, and could set it angularly to 0.0001 radians. (or about $\frac{1}{63000}$ part of a circle!).

It must have been a delight to the Master. A complex gearing and mathematical juggle to get a meaningful calibration. A difficult leadscrew gear ratio to cut the correct worm pitch. The worm to cut and develop, then cut again. A hob to make, with a modified pitch, as it is not helical; gashed, hardened and sharpened. The utmost care and accuracy required to get it near the theoretical limits of accuracy. I know I would slip up somewhere, even if I found the time to try it!

A simpler solution

This new design (Photo 1) has screw adjusters at 10in. centres on the far side of the pivot. There is some calibration, but it is likely to be somewhat approximate. It is able to set the angle roughly, then to make fine adjustments

measuring on the job. With a calculator in the workshop, it does not matter any more whether we use sines (as in sine-bar) or tangents. This uses:

'screw setting = 5in. $\times$ tan(required angle)'
So the setting for 6deg.(half angle) is tan. 6deg. $\times$ 5 = 0.526in.

The screw needs $1\frac{3}{4}$ in. of working travel for 10deg. (Up to $2\frac{5}{8}$ in. on versions which go to 15deg.) You may well have insufficient space for two 4in. long 'micrometer' heads. Anyway, too many other errors will come in to justify making anything super-accurate. The centres will alter slightly with the angle, and the final accuracy depends on the initial parallelism. However, it makes life easier if the screws

are a 'nice' pitch, such as 40TPI. This can be divided into 25 to give one thou. per division. The position for the graduated dial is not ideal, and a zero mark was omitted altogether for want of a sensible place to put it; one can judge the dial reading at 12 o'clock.

Manufacture

Because of the different size castings I have found, to put dimensions on the drawing would be misleading. (see Fig. 1)

Make the double-ended extension nuts (Item 1) first. I have only made two long ones, as the unit seems secure with that, but you could make a shorter third centre one.

It is necessary to 'adjust' the casting. On mine, the two webs foul the new nuts, and the abutment face is on casting draft. I first chiselled clearance in the webs, which is quick and doesn't need a machine set-up. Then I found that the draft does matter of course. A spot facing tool is the obvious, but I hadn't one. In my case, the whole thing went under the mill, the draft taken off locally, and the clearance in the webs done properly (see Photo 2). I suppose I could have used the cold chisel on the draft too. The amount removed can hardly affect such a robust casting.

The plate (Item 2) can come from the Short End Store, (often known as the scrap-box). Mine came dead to length, - $10\frac{25}{32}$ in., complete with two random lightening holes. It needs to be at least $1\frac{3}{4}$ in. wide. By fixing nuts (Item 3) in it, rather than tapping it, it can be of almost any thickness. The screws (Item 4) should be chosen to suit taps and dies you have. I suggest at least $\frac{5}{16}$ in. and as fine as possible. $\frac{3}{8}$ in. $\times$ 40TPI works well.

If tapping the nuts, make these before the screws. The bar certainly doesn't have to be hex, as they are Loctited in place. For the screws, 0.437in. or 10mm hex is ideal for $\frac{3}{8}$ in. dia. Cut off the bar for two plus parting. Find two steel balls (Item 5), about $\frac{1}{4}$ in diameter. Centre both bar ends, so that the ball can go in to half diameter. (Knurl the middle if round.). Turn and screwcut each end between centres, protecting the made thread from the carrier with some rolled shim. 0.0160in. is the depth for proper form of 40TPI BSW. If you grind the tool to a sharp point,

then the depth becomes 0.0200in. (and 0.0225in. down the flank). My die cut a bit slack (even opened up), so the screws were cut to a free fit. (They need to be easy for all those turns with the fingers). I should have put an undercut in mine, and then the screw cutting could have been at about 200 rpm, so that each pass would take about 35 seconds. Part off and face.

Take the two screws and make a small fine saw cut part way down each centre, to let out excess flux, steam and solder. Support them upright, fill the centres with flux and then soft solder. Lay the ball on the solder I used a small propane torch. I got solder down the first thread or two, and was very pleased I had the die!

The little graduated dials (Item 6) are 'friction-gripped' onto the screws. I used a 'Teflon' hydraulic pipe sealant, which doesn't seem to set. Turn them both on the same bar, leaving a 'space' and without parting-off, then transfer the chuck if necessary to the dividing device. I cannot tell you how to divide them as everyone has different gear! (The lathe mandrel end is 25T). I assure you I did not make the fancy set up in **Photo 3** just for this job! It has a sprung detent on the input handle. It was geared to 100 input turns per revolution, so four clicks per mark was used for this 25 mark dial. (It didn't seem worthwhile mounting a compound train to get one click for one mark).

Everything then went into the Koldblak for instant finishing. That way I hide a lot of blemishes; it gets some rust protection. You might recognise it as a part that you shouldn't throw out, and it matches Myford's Parkerised finish (**Photo 4**). I've bought yet another 'Drill Box' from the DIY

store for £3.50 to put it all in, so that it can live in a stack of these boxes with the dividing head, and the SPAM tool-post drill, which also have many bits.

Test results

Using a centred No. 2 Morse male with a parallel tail, which I use for SPAM mandrels, I first set the taper turning attachment parallel, using a $\frac{1}{10000}$ in. clock. Both screws were wound in as tight as I could with fingers, then turned the '0's to twelve-o'clock. Now $2 \text{ MT} = 0.04995\text{in./in.}$ inclusive. The attachment base is 5in., so $5 \times 0.024975 = 0.124875$ or 0.125, or five turns nearly exactly. It was very close. Just two more 'tweaks' and it was as close as the clock could read on a non-precision taper. Much, much quicker than before, and far more positive.

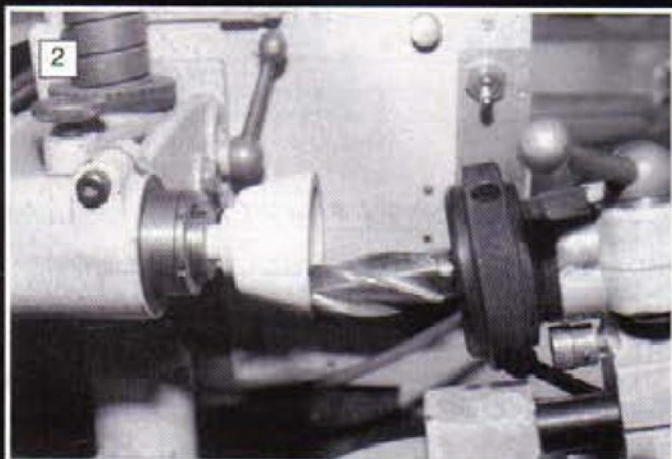
In conclusion, an expensive accessory like this will greatly benefit from the small amount of time these modifications will take.



3/8in. x 40TPI screws, with one thou. dials.

IN OUR NEXT ISSUE

COMING UP IN ISSUE, NO. 44, WILL BE

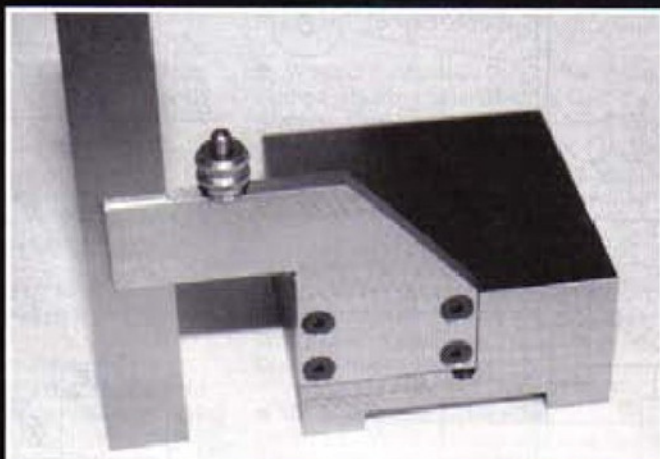


A FAR REACH VICE SQUARE

A useful aid to setting-up is described by Peter Rawlinson.

SHARPENING END MILLS ON THE QUORN

Philip Amos shows us how to get the best out of the machine.



DIMENSIONAL MEASUREMENT FOR MODEL ENGINEERS

David Boote explores the needs of the model engineer against scientific and industrial practice.

Issue on sale 2 August 1997

(Contents may be changed)

PRECISION BENDING BARS

Len Walker describes some very simple tooling which continues to give him job satisfaction out of proportion to the effort involved in the manufacture

These were designed to cater for reasonably small sheet metal parts, which require accurate 90deg. bends, such as brackets and clips. Instead of the usual barney, with odd bits of BMS being juggled into position in the vice to act as bending bars (even those bolted at each end) it often seems to need three hands to line up everything, with the final result being rather uncertain.

This set-up allows you to concentrate 100% on the accurate **setting** of the work. The bars, resting on the vice, look after themselves (i.e. you are in charge, instead of running behind!).

To set the work at the required height above the bars, simply add the

dimension to the bend, plus the selected bend bar radius, either 0.050 or 0.100in.) Scribe a line on the work at this total dimension, lightly nip the work between the bars in the vice, and set the scribed line level with the top face of the bending bars. Check that the work is at 90deg. using a small square resting on the top face. When satisfied, tighten the vice and gently tap the job over in say, three even stages, keeping the work 'level' at each stage.

Use a piece of hardwood (on end grain), as a forming punch, in order to prevent marking the work.

This will produce work, free from twist, i. e. which will lie 'flat' when stood on edge on a surface plate.

Construction

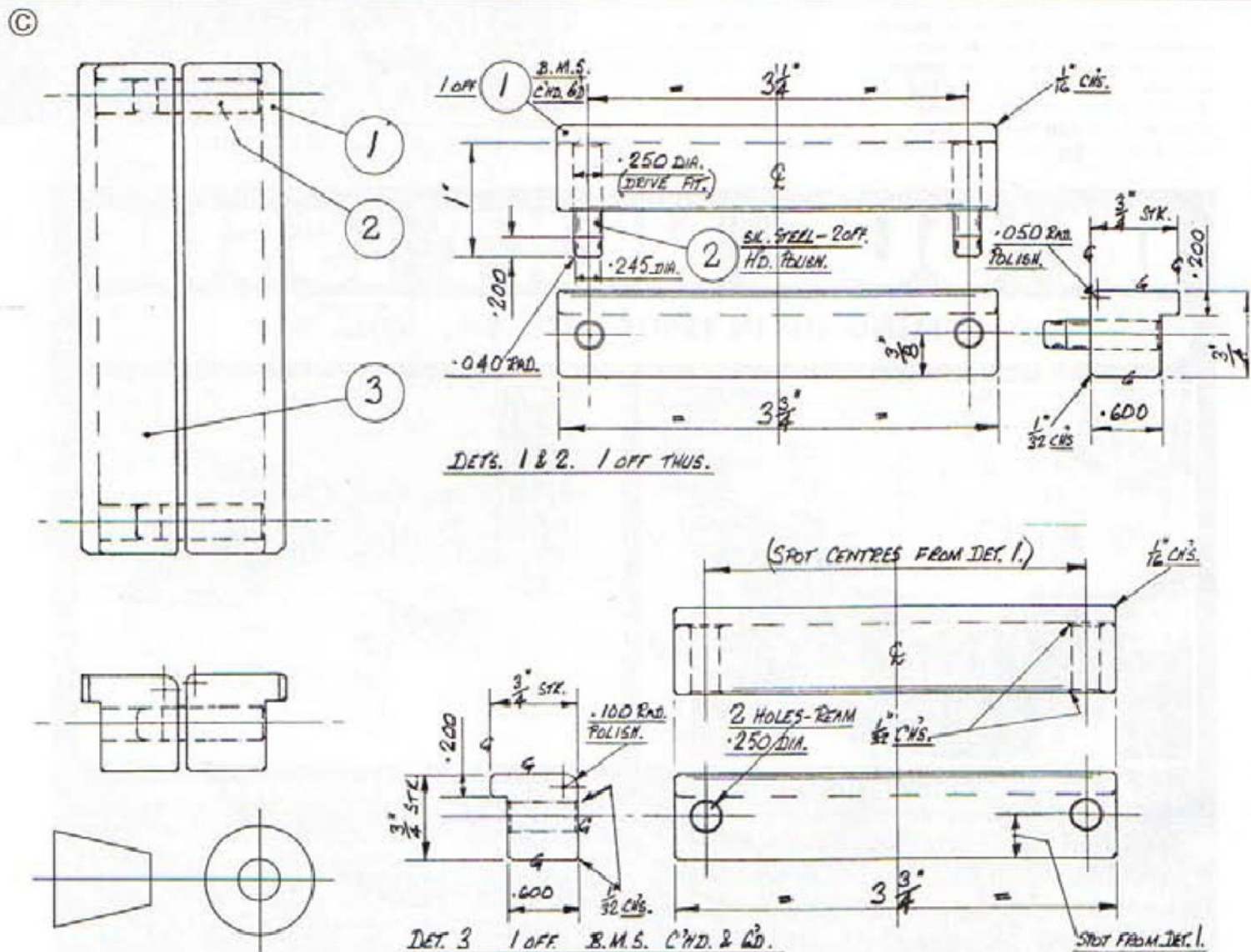
A few notes may help matters.

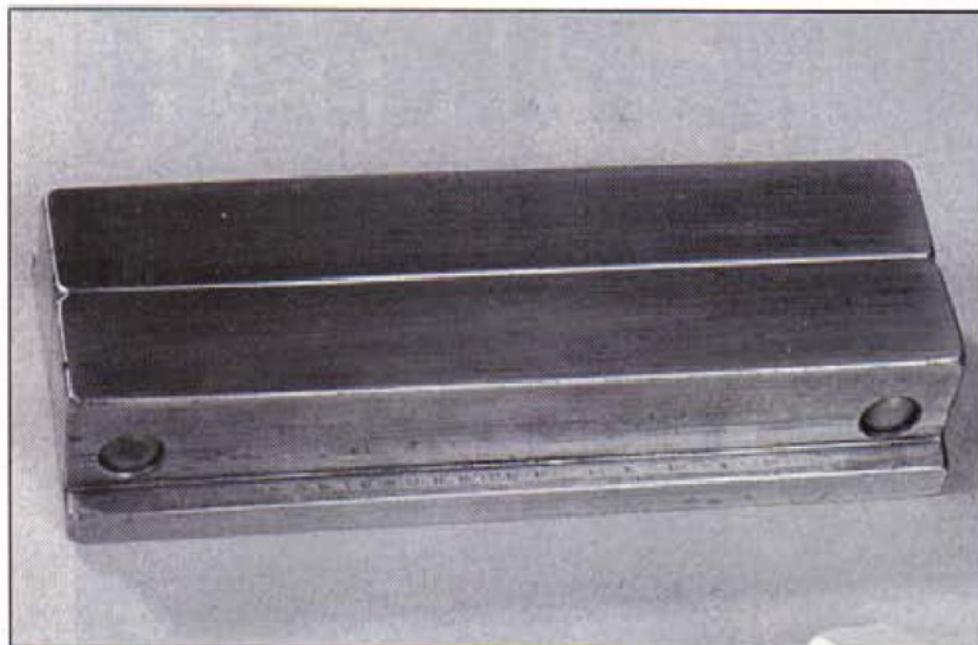
If black bar is available, use it. It avoids most of the distortion caused by the release of the skin stress of bright steel during machining.

If bright steel is used (the material most of us have to work with), stress relieve the bars beforehand, to minimise movement during machining and case hardening, otherwise you may find that you are grinding off some of the hard case.

For anyone who might benefit, the sequence of operations is as follows:

7. If bright material is used, stress relieve. Heat thoroughly to red heat and allow to cool slowly.





The finished bars, as seen at a recent M.E. Exhibition, when Len was good enough to exhibit many of his devices in the Loan Section.

2. Surface grind both blanks parallel and square.

3. File ends square. Mark off and drill (on one bar only) two holes $\frac{1}{32}$ in. dia. (at this stage).

4. Using this bar as a jig, line up with the other bar, using a toolmaker's clamp at each end. Clamp the pair to the drilling machine table and drill and ream the two $\frac{1}{4}$ in. dia. holes through both bars.

Separate the pair and lightly chamfer the holes.

5. Mill the blanks to size, matching the 0.200in. dimension on both bars.

6. Carefully file to form the 0.050in. and 0.100in. bend radii, then polish.

7. Case harden (a 0.015in. to 0.025in. case will do). Your local Technical College evening class might help here.

8. Grind top and bottom faces flat and parallel.

9. Grind 0.200in. wide faces, with bars resting on 'inside' faces.

10. Grind inside faces, with bars set level (one at a time), in a grinding vice—and resting on the 0.200in. wide faces.

11. Repolish bend radii.

12. Make and fit two hardened and polished silver steel dowels. (Note tapered lead-in).

Why does it always seem to take longer to write down how to do the job than to do the job itself? Anyway, hopefully, these notes may guide some aspiring (or should it be perspiring?) brother further along the track.

I found that the satisfaction gained from using this simple device well repaid the modest effort required to make it. The much more civilised attitude to setting up the work certainly paid dividends. After all, it is the capacity to take pains over each detail that eventually produces first class work. When I gaze in wonder at Cherry Hill's masterpieces, I realise that I will always be a 'butcher' (no offence meant) - but at least I can try.

Good luck, and work safely.



LINKUP

- Reader to reader service
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FOR SALE

• Metal Turning BGSC lathe. Treadle and power operated. 6in. centre height. 56in. between centres £50.
C. Turpin, Tel: 01705 462082 for details (Portsmouth).

• Three Schaublin (Swiss) double ended taper collets. Suitable for use in the collet attachment of the Emco Unimat lathes. Sizes $\frac{1}{16}$, $\frac{1}{8}$ and $\frac{1}{4}$ in. £15.
G.W. Reeve, Tel: 01476 561204 (Lincolnshire).

• Adjustable angle plate, unused, size 7 x 4in. To fit small milling machine. £40 plus postage. Rotating centre, also new. No. 2 Morse taper £15 plus postage. Both for £50 plus postage.
Tel: 01274 678455 (Bradford).

WANTED

• Issues 1 to 28 Model Engineers' Workshop.
N. Sharp, Tel: 0117 9670826 (Bristol).

• For Aciera F3 Mill, swivel table, parts for power feed, any accessories. Also ABB ACS inverter. Mike McGuigan,
Tel: 01273 559940 (Brighton).

• Hand operated shaper or planer. Any condition.
Tel: 01246 434454 (Chesterfield).

• For E.W. Lathe, the chuck and headstock casting.
L. Ferris, Tel: 01446 781523 (South Glamorgan).

• Mill/Drill wanted by retired engineer just starting model making. Am able to collect.
Tel: 01322 220082 (Kent).

• Small lathe wanted for Vintage Motorcyclist's workshop, to manufacture small fixings, spacers etc., to assist with rebuilds. Very basic model would be ideal (to match my engineering skills!).
Mike McGarry, Tel: 0161 748 5270 (Fax: 0161 747 3901) (Manchester).

• Advice/information. I have a Raglan $5\frac{1}{2}$ in. centre lathe and would like to know if anyone can help to set up a traverse for the cross slide. What screw cutting gears would be needed?
J. Bennett, 67 Pelsall Road, Brownhills, West Midlands, WS8 7DL.
Tel: 01543 360230.

• Instruction manual or photocopy and any tooling for a Smart and Brown Model A lathe. Gerry Garland, Kilcahill, Clare Galway, Co. Galway, Eire.

• Model Engineers' Workshop, Issue 2, Autumn 1990, in good condition to complete the series for South African hobbyist. Details and price to W.R. Willis.
Tel: 01761 410714 (Midsomer Norton).

• Sinclair C5 motor, brand new, ideal for battery powered car or loco. £40
Fletcher Tel 01723 362537 (Scarborough).

• Wanted desperately for Boxford lathe - change wheels, powered cross-feed, gearbox. Complete lathe considered. Cash or exchange for magnetic chuck, 7 in. four jaw chuck or surface table. Would also like milling machine. Low war pension dictates purchase.
Tel: 01246 865503 (Derbyshire).

• Model Engineers' Workshop Nos. 1 to 6, 8 and 10 to 16. Cost + P & P to Ken Whitbread, 5 West View Cres., Nambour, Queensland 4560, Australia.

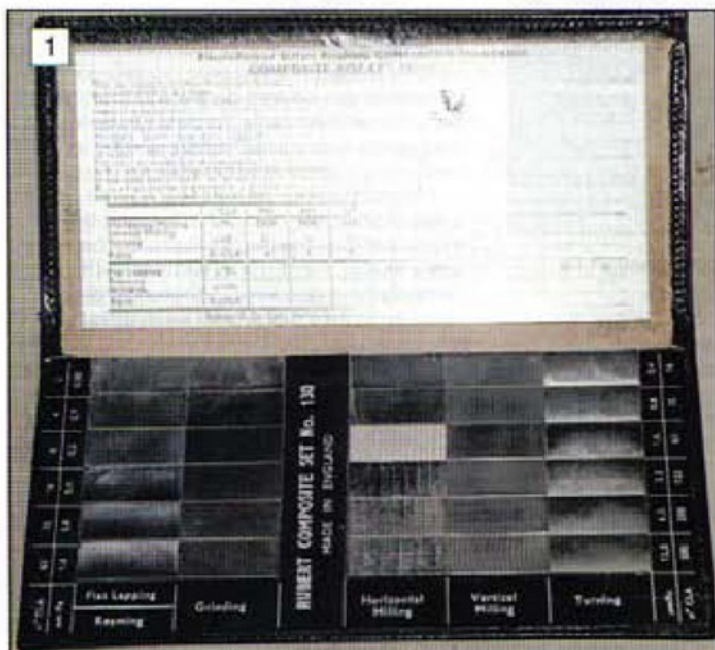
• Operators manual for EmcoStar Universal Woodworking Machine (basic power unit plus planer/thicknesser module, diecast worktable model).

Also, can anyone provide further information on the Hayes-Aspin rotary valve engine featured in M C I Hunter's book 'Rotary Valve Engines'? Would like to know if this was commercially mass produced and where they were used.

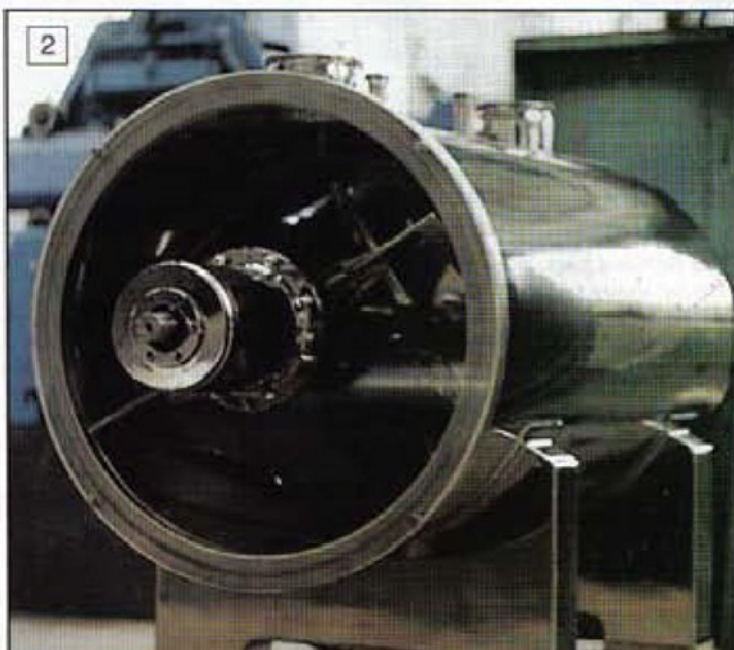
Andre P. Rousseau, PO Box 425, Papakura, Auckland South, New Zealand.

SURFACE FINISH ON METALS

Alan Jeeves presents an over-view of the subject of surface finish and makes some suggestions as to how to obtain desired finish in the home workshop environment



A set of comparison gauges.



High quality surface finish on this pharmaceutical mixer.

There are perhaps two reasons for bringing about a particular standard of finish upon the surface of metal objects. The first reason is to reduce (or increase) the amount of friction which occurs between two surfaces, and the second reason is simply for the sake of appearance. It follows, therefore, that many different surface finishes can be sought, and achieved by the use of miscellaneous methods. Stock materials too come with varying degrees of surface finish, from rough castings to ground bar or polished sheet.

Techniques of originating the required finish vary tremendously, utilising every means available, ranging from machined surfaces to hand worked surfaces, such as filing, scraping, or polishing with abrasives. It will become clear then that surface finishing can be a much more complex subject belying first impressions and perhaps misconceptions held by the newcomer to our hobby. Indeed the study of surface finish is a science.

Tribology

By describing what amounts to the roughness or smoothness of a surface as a science is not a casual cliché but a fact. The study of friction (a direct result of surface finish) is called Tribology and one who works in this particular field is called a Tribologist. The word tribology is a combining form,

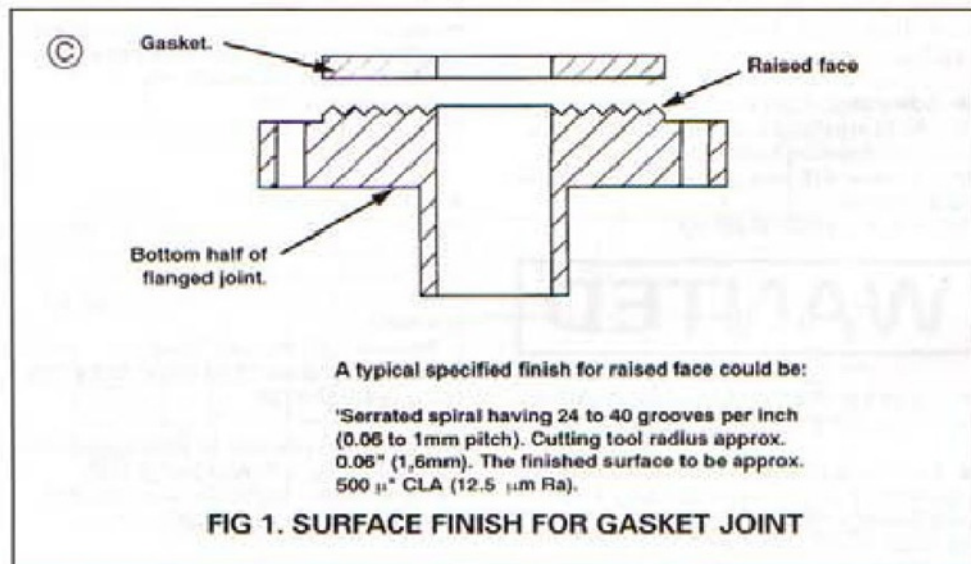
tribo- (ology), and is taken from the Greek 'tribein' meaning to rub. In this context (tribological) reference to surface finish is generally regarded as a 'specified' finish, with a view to providing a particular mechanical advantage, such as reducing wear or aiding lubrication, or it could even refer to quite rough surface finish for the purpose of increasing the surface contact area for a gasket fit (Fig. 1).

It appears then that tribology is mainly confined to industrial use, where not only

the attainment of superior surface finishes are of great concern, but also the speed at which they can be generated is (economically) important.

Cosmetic Finishes

Perhaps of more practical significance to the model engineer is the finishing of metal surfaces in order to enhance the appearance of the project, and I guess, for





Scraping. Note blued area.



The headstock of this c.1820 lathe by James Fox of Derby is not very sturdy



The chuck is counter-balanced to compensate for a top-heavy job, to achieve a better finish.

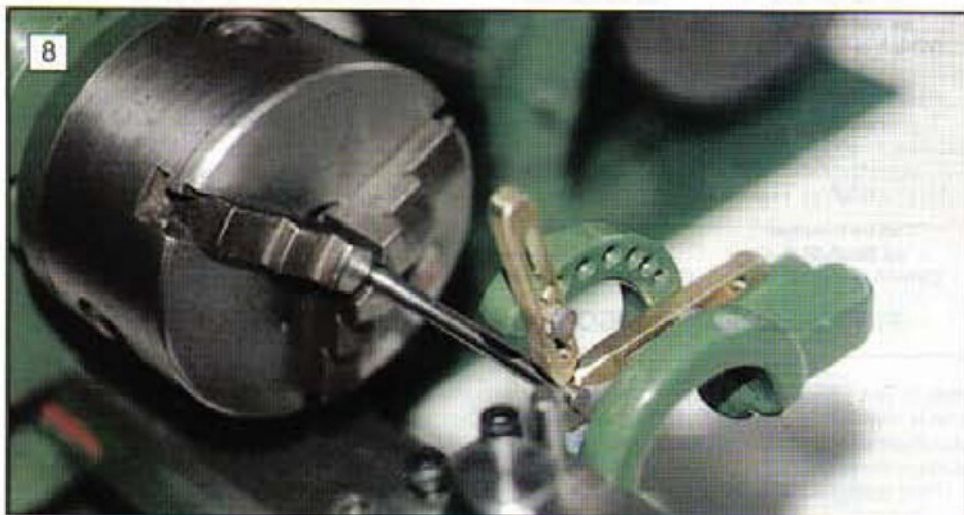


A diamond lap for fine finishing tool sharpening.

the most part, hand finishing methods are the order of the day. Traditionally, the man who polished metal for his livelihood (especially tin plate or galvanised iron) was not called a tribologist but a 'White Smith'



Carbide tipped tools and inserts.



A travelling steady can improve finish on the lathe.

and his only concern was not with friction, but in making the metal look nice. Hand scraping, on the other hand, was primarily undertaken by the fitter, to achieve excellent flatness, although cosmetic finishes were often applied to scraped surfaces also. One particular process, of producing a symmetrical pattern on metal, which has stood the test of time, especially with horologists, is engine turning and visitors to the National Science Museum in South Kensington may see magnified examples of this attractive finish on the surface of the stainless steel tables in the cafeteria.

Specified Surfaces

Whether a surface is rough or smooth is relative. A piece of fine emery cloth may be considered smooth, but if the same texture were applied to a sliding surface, it would be considered rough. So what is rough and what is smooth? Clearly a system is required to describe different finishes, and the most convenient method is by comparison. Extremely accurate measuring of surfaces can be carried out using modern electronic instruments, but for most applications, comparing a finish with a sample of a known

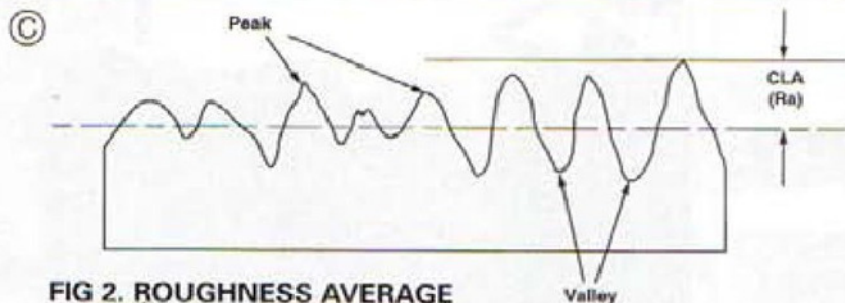


FIG 2. ROUGHNESS AVERAGE

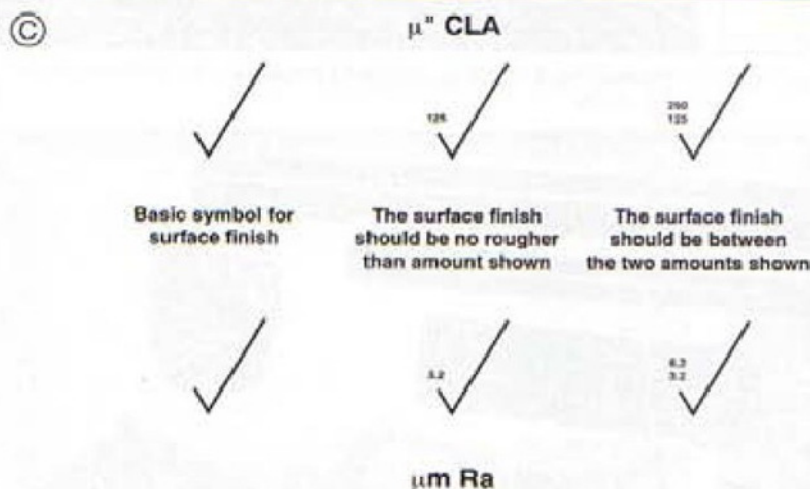


FIG 3. SURFACE FINISH SYMBOLS

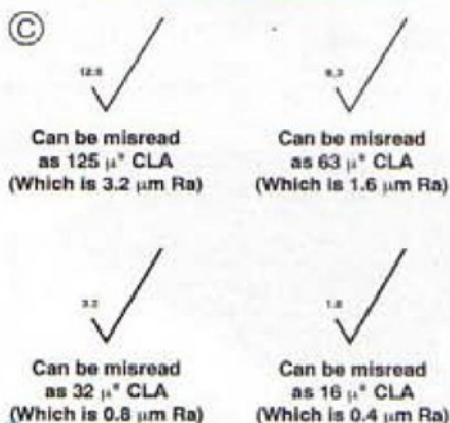


FIG 4. READING SYMBOLS

parts of an inch or millionth parts of a metre - and is defined as the 'Centre Line Average' (CLA) or the 'Roughness Average' (Ra). Sometimes (rarely) it is called the 'Arithmetic Average', as this value is defined numerically. Specifying surface roughness in two different units (millionths of an inch and millionths of a metre) can be somewhat confusing, and so it is usual to define millionths of an inch (Imperial units) as CLA, and millionths of a metre (metric units) as Ra. One millionth of an inch (0.000001in.) is called a micro-inch and is written 1μ in. One millionth of a metre (0.000001m) is called a micrometer, and is written 1μ m. Some of the older textbooks may refer to a unit called a 'micron' which has exactly the same value as a micrometer but the micron is now an obsolete term, having been replaced by the S.I. unit. One millionth may also be written 10^{-6} and a micrometer may also be described as one thousandth of a millimetre (0.001mm or 10^{-3} mm), but surface finish will always be specified as μ in. or μ m.

Clearly 1μ in. is a much smaller unit of length than 1μ m, and the Imperial may be converted to the metric, or vice-versa, by using the following factors:-

$$\begin{aligned} 1\mu\text{m} &= 39.3700787 \mu\text{in.} \\ 1\mu\text{in.} &= 0.0254 \mu\text{m} \end{aligned}$$

Symbols

It is all very well having a method of determining a surface finish, but you need to be able to communicate what you mean to other engineers, and everyone must understand what everyone else is talking about. The recognised symbol for specifying a particular finish is a 'tick', incorporating a numerical value which represents the average depth of the valleys and peaks - the CLA or Ra. Figure 3 shows a selection of these symbols

which are typical of those found on engineering drawings. The upper symbols are expressed in μ in., whilst the lower ones are expressed in μ m. This can be quite confusing at first glance, but on most modern drawings and sketches, the metric units are used. Care must be taken to determine which units are being used, as many Imperial values are similar to metric values, being distinguished only by a tiny decimal point, which may not be immediately apparent on small or dirty drawings. Figure 4 shows a few examples.

Gauging the finish

When a surface has been machined, it can be compared with a set of gauges which have already been machined to accurately represent certain surface finishes, and the way to do this is visually and by touch. It would not be practical to produce a comparison gauge for every one millionth of an inch of difference, and so gauges have evolved which represent typical finishes which may be expected for different operations (e.g. turning, milling, grinding). This greatly reduces the number of gauges required per set. Additionally, the gauges are categorised into different operation. Thus if lathe work is being undertaken, reference need only be made to the comparison gauges for turning. As a consequence, the coarsest comparison gauge in the turning category will usually be 1000 CLA (25 Ra), and the finest will be 8 CLA (0.2 Ra), encompassing just eight different gauges. After a little practice and some experience has been gained, a certain surface finish can be compared with the set of gauges and numerically identified as being of a certain texture or somewhere between two textures.

Other finishes

By the use of comparison gauges, the surface finish can be controlled and kept between specific limits of texture, but many craftsmen work to the rule of eye. They can tell by instinct if the finish is up to the standard they require or not. If not, they will have to adopt techniques for improving the finish. The connecting rod on a model traction engine has absolutely no need to be polished free of tool marks. It will work just as well whatever the surface finish, but most builders will insist on this and other visible parts being brought to a high standard of finish. Why should this be? It is only making for more work. The answer is probably the same as the reason why we don't all paint models the same colour - personal satisfaction. Whenever a model is on show at an exhibition or rally, you don't see spectators measuring all the parts with a micrometer or calliper. They inspect with their eyes.

Lathework

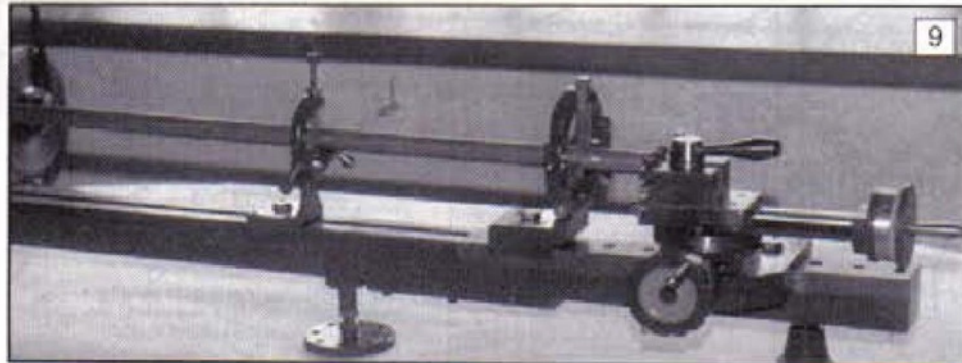
Most of the mechanical models produced at home will doubtless be made up of many turned components. The lathe is unrivalled as the main workshop machine tool. The majority of these lathes will be small machines - some extremely small - and a good many have suffered much wear in a former life. This adds up to a less than perfect surface finish on any work which is produced on them. The

texture is a very reliable way of working. All that is required is a way of identifying and communicating to the engineer, the required surface finish.

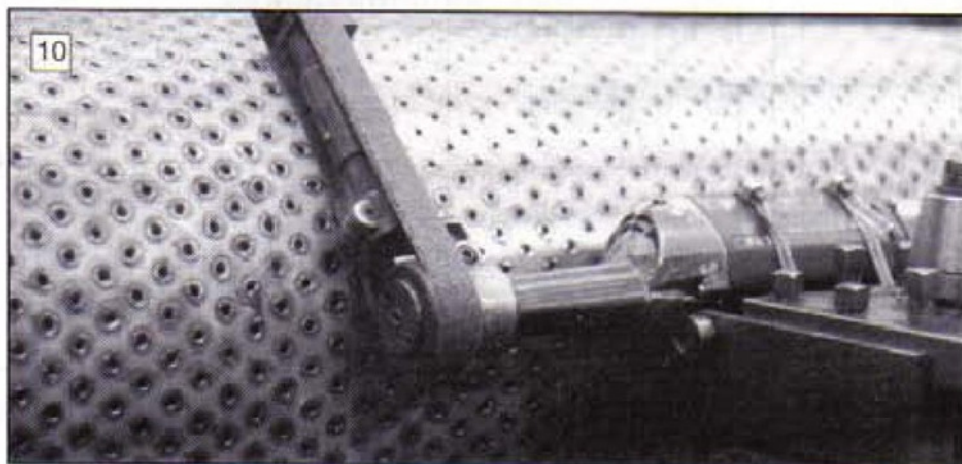
Past designers would specify finishes in broad terms, such as 'rough machine', 'smooth machine', 'polish' or 'grind'. However, we now see a surface finish in a different light.

Valleys and peaks

Figure 2 represents the magnified surface of a workpiece. It will be seen that there are high spots and low spots all over it. The low spots are termed 'valleys' and the high spots are known as 'peaks'. If the mean difference between the valleys and the peaks is taken, an imaginary centre line can be drawn, this line representing the average depth of the surface irregularities. This average can now be measured in very fine units - either millionth



Two steadies are also useful for some jobs.



An emery belt mounted in the lathe toolpost.

lathe must be firmly positioned in the workshop, and free from rock. The more vibration that is absorbed by the cabinet or bench on which it stands the better. Cabinets can be filled with accessories, the weight of which then add to the rigidity of the support.

Any wear should be examined with a view to countering it. The most likely areas of concern are the headstock bearings, slideways, and tailstock quill. Sometimes, slight adjustment to the slideway gib strip will achieve dramatic results, and some headstock bearings are adjustable and so can be 'taken up'. Regular oiling, too will assist in keeping the lathe working at its best.

Lathe Tools

A surface roughness of $0.4 \mu\text{m Ra}$ ($16 \mu\text{in. CLA}$) is normally taken to be the finest finish for general turning work, but this can be improved upon whenever the situation calls for it. Turning tools must be the correct ones for the job and be kept sharp. I guess most of the small lathe owners will use high speed steel tools, but I do know one or two who go for the carbide 'throw away' tipped tools because the question of re-grinding is conveniently avoided with these types. Carbide tools are really for the rapid removal of stock and also for dealing with the more difficult materials. They should, for a good surface finish, be run at high speeds, with a large depth of cut, a situation which is not always possible in the small workshop. There are specialist tips available which will generate an improved finish with a light (say 0.25mm) cut, and some will remove hardened material, but generally speaking, carbide tipped tools have not, up to now produced the best results in the home workshop situation. However, much research and development is taking place in this area, and it will be interesting to see how some of the new products perform on our type of work.

High Speed Steel, on the other hand, can be relied upon to produce excellent results when used in the home workshop environment. As its name suggests, it can be run at quite high cutting speeds, although not as high as is possible with carbide tools. As the lathe spindle is slowed down (compared to industrial use) and light finishing cuts are taken, high speed steel can give good results. A quite modest speed and fine feed with a good sharp tool may be all that is required. The tool should be carefully ground, and a small radius should be ground or stoned on the cutting edge (Fig. 5c). Stoning is preferable for finishing the cutting edge as, like the workpiece, the tool

too will benefit from a good surface finish to reduce friction. Coolant or even oil will assist in creating a good finish, even though HSS tools will cut for prolonged periods without being cooled. If chatter occurs, the radius may be too great, and re-grinding may improve matters. Increasing the rate of feed can also reduce chattering, but will inevitably generate a rougher surface.

Carbon steel tools

Before the widespread use of HSS, machine cutting tools were forged from a high carbon (around 1%) steel, and heat treated to the required hardness. Such high cutting speeds as are possible with HSS were not feasible using carbon steel, as once heat started to build up, the temper of the tool was 'drawn', and the cutting edge was softened. Higher production rates being the primary reason for adopting HSS, carbon steel was all but forgotten as a means of making metal cutting tools. This does not mean that carbon steel tools are of no use. Sometimes, a far superior finish can be attained with a light cut using one of these tools than can be had with a high speed tool. This can be especially so with brass. One great advantage of using carbon steel and making your own cutting tools is that the hardness of the cutting edge can be controlled. Once the steel has been hardened it is 'glass hard' and needs to be softened by tempering. The tool can, therefore, be kept that bit harder than HSS, and careful use can produce splendid results. Some brasses really come up well when cut with a carbon steel tool which is left very hard, and for small work, tempering may not even be necessary. These tools are likely to shatter, though, if extreme care is not taken, and safety glasses are an absolute must (they should be anyway).

Carbon steel which is suitable for making cutting tools is generally available, and the most popular way of obtaining it must be in the form of silver steel. It can be machined or filed to shape before heat treatment, and is very easy to harden and

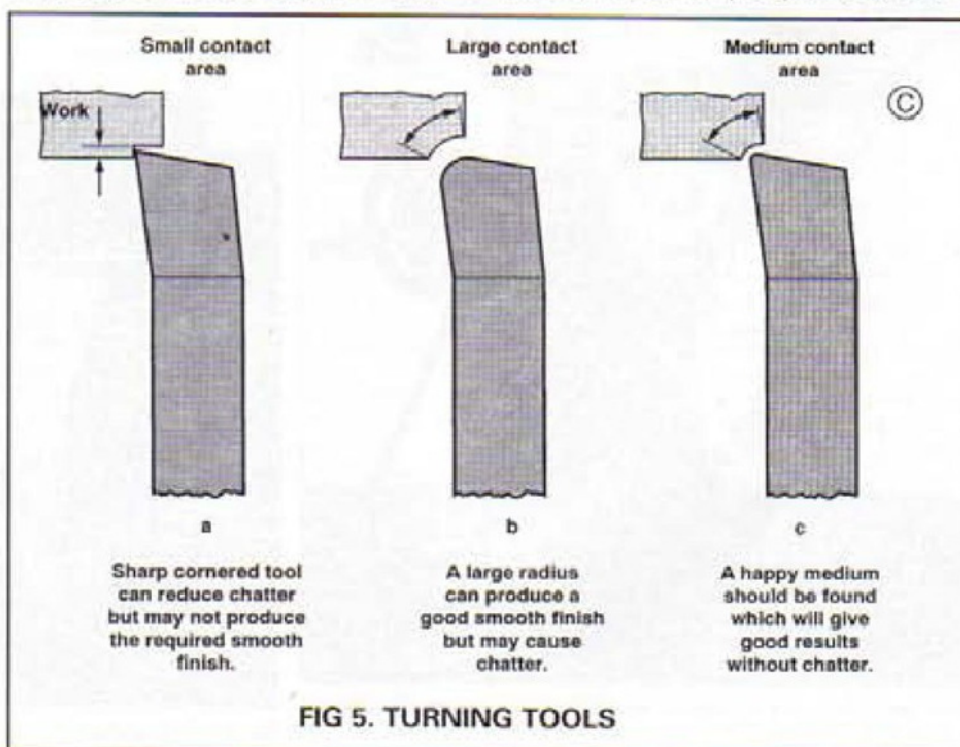


FIG 5. TURNING TOOLS

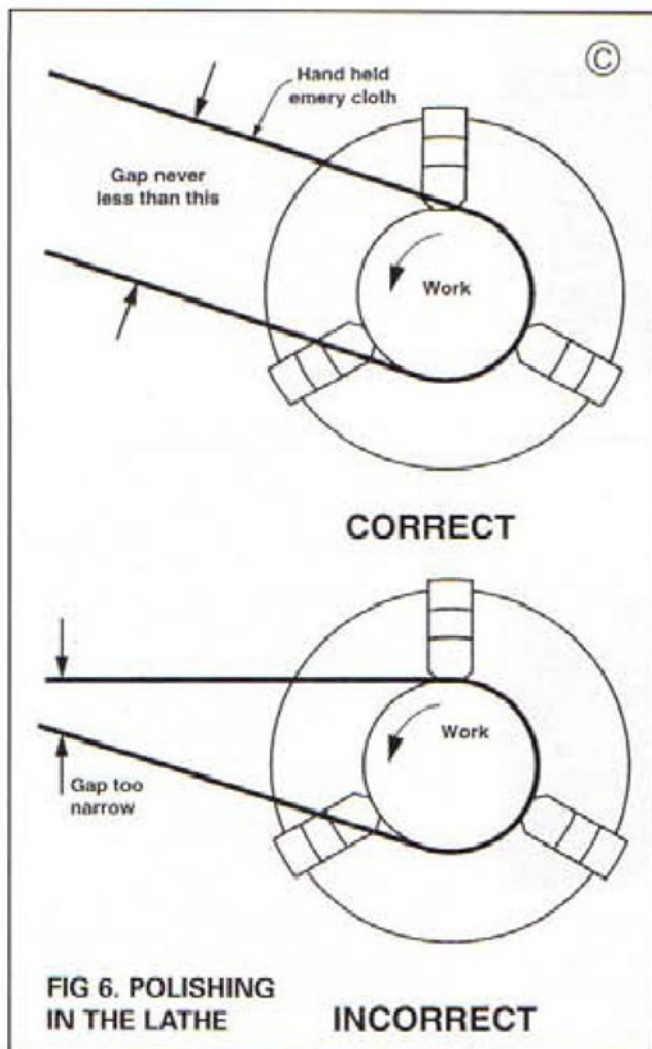


FIG 6. POLISHING IN THE LATHE

Symbol	Example	Meaning of symbol
=		Lay roughly parallel to the leader line which represents the surface to which the symbol applies.
⊥		Lay roughly perpendicular to the leader line which represents the surface to which the symbol applies.
X		Lay roughly diagonal in both directions to the leader line which represents the surface to which the symbol applies.
M		Lay is multidirectional.
P		Lay is particulate, non-directional, or protruberant.
C		Lay is roughly circular in relation to the centre of the surface to which the symbol applies.
R		Lay is roughly radial in relation to the centre of the surface to which the symbol applies.

FIG 7. LAY SYMBOLS EXPLAINED

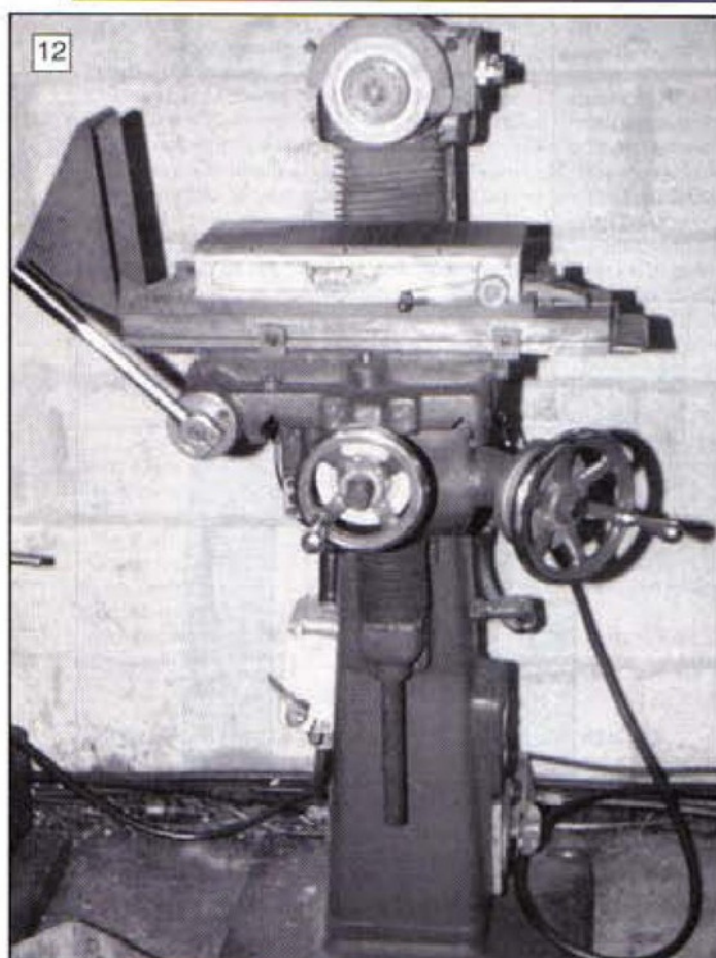
temper, being successfully quenchable in water as well as oil. Some carbon steels must be quenched in oil to avoid cracking or distortion, so this makes silver steel a particularly attractive option.

Improved lathework finishes

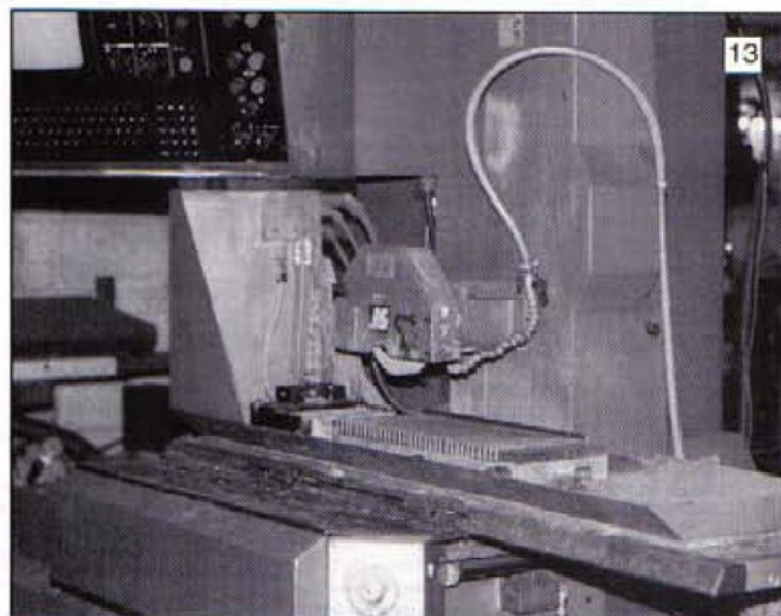
The quality of finish of lathe work can be improved upon greatly by polishing. This is not strictly turning, but is carried out whilst the work is still in the lathe, the workpiece



Worlds Apart - This ancient hand grinder would not produce a good finish, 63 μ in. CLA (1.6 mm Ra) or worse



This hand operated surface grinder would give reasonable results, 32 μ in. CLA (0.8 mm Ra).



But this CNC surface grinder will produce a superb finish, 2 μ in. CLA (0.05 μ m Ra).

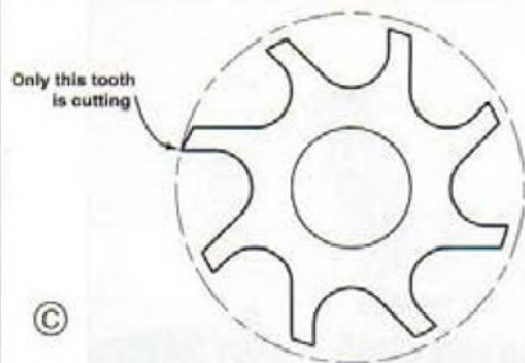


FIG 9. CUTTER INCORRECTLY GROUND

being in rotation and the polishing medium stationary (as opposed to conventional polishing). Certain dangers become apparent when polishing by this method, especially when trying to finish bores, so a few precautions must be observed. No work should be undertaken without safety glasses and a mask to prevent the inhalation of dust and abrasive.

The simplest method of polishing in the lathe is by using emery cloth of the correct grade for the finish required. This process is potentially a source of great danger, as it is possible for the cloth to wrap itself around the revolving workpiece, causing the fingers to be drawn towards the job and become trapped. At least, this can result in friction burns and cuts, but more likely, broken fingers (or worse!). The cloth should be held lightly enough to be easily taken out of the hand if it grabs. Grabbing is likely if the emery cloth is pulled too closely around the job (Fig. 6). Loose clothing should also be secured where there is the slightest danger of it getting caught up in the works.

Improvement to finish occurs quite rapidly, and a small amount of oil deposited onto the surface gives good results. Polishing with emery is a recognised method of removing machine marks, and emery is available in 'utility rolls' which are supplied especially for this purpose.

One other precaution to be taken before using any abrasive material on the lathe (or any other machine tool, for that matter) is to protect the vulnerable working surfaces of the machine. There is little point in trying to eliminate the effects of wear in the search for a better finish, then introducing a potential source of increased wear when doing the job!

Milling Cutters

Small milling machines are quite capable of producing very good surface finishes, even with light finishing cuts. In order to do so, however, the cutting edges of the tool must be perfectly sharp. I say cutting edges because the majority of milling cutters have at least two cutting edges, as opposed to one (single point) edge of the lathe tool. Most fly-cutters and boring head tools are single point cutting tools, though.

When milling, the same range of degrees of roughness can be expected as with turning, except that the 'lay' of the texture is different. When turning diameters in the lathe, the pattern of the finish is always like a fine screw thread, to a greater or lesser degree, running around the circumference. Milling however, produces a distinctly different pattern on

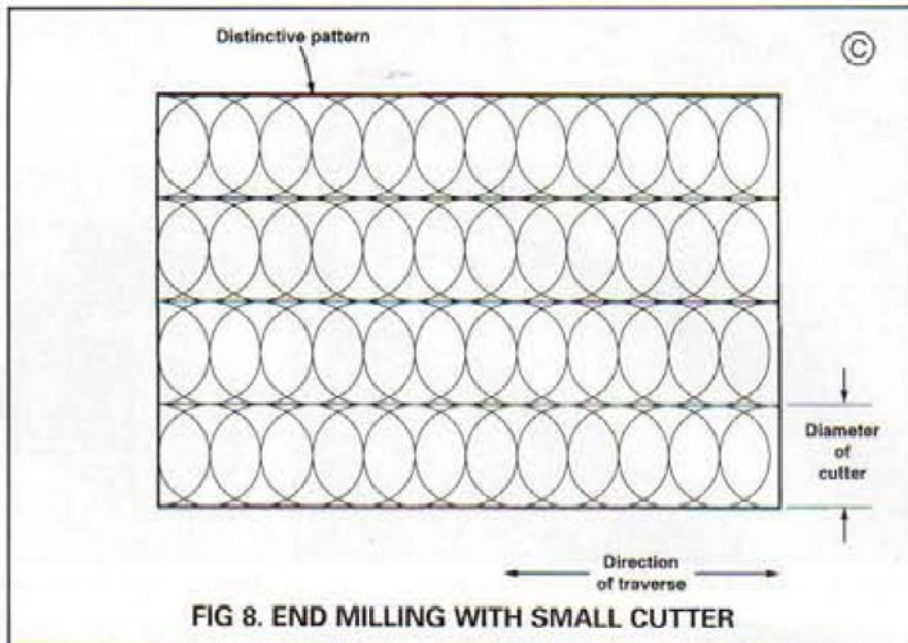


FIG 8. END MILLING WITH SMALL CUTTER

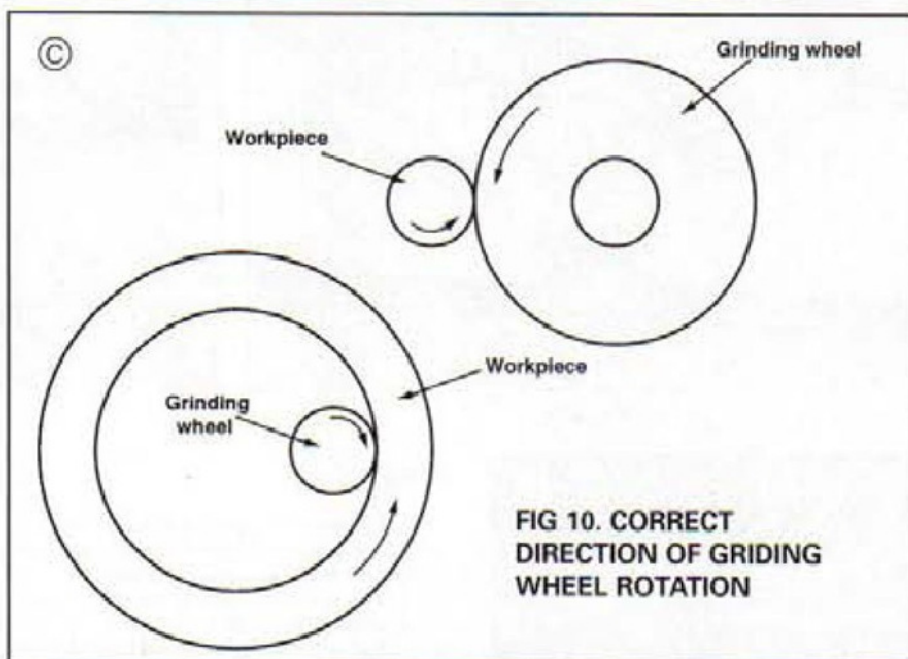


FIG 10. CORRECT DIRECTION OF GRINDING WHEEL ROTATION

the surface of the metal. If the cutter is not of a large enough diameter or width to encompass the work area in one pass, the surface of the workpiece begins to take on a 'striped' appearance. To improve upon the milled finish, the work will have to be removed from the machine and ground, filed, scraped or polished as a separate operation, unlike turning which can be enhanced with emery cloth under power, and whilst still in the chuck.

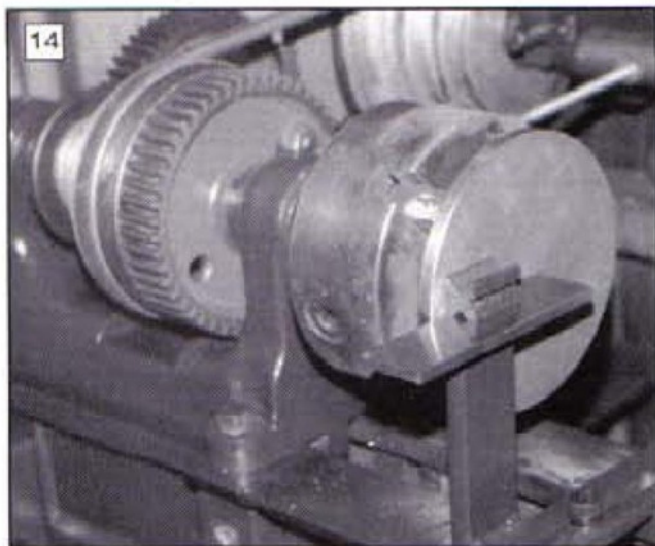
Generally speaking, the more cutting edges (teeth) a milling cutter has, the smoother the finish. If a single point fly cutter is used, a fine feed will have to be engaged for reasonable results. Sometimes, it is an advantage to make two passes of the cutter at the same setting for a good finish. On the cheaper milling machines, without the benefit of power traverse, getting an acceptable finish with a single point cutter can be quite frustrating.

With multi-point milling cutters, correct re-sharpening is imperative. This can only be successfully carried out on a tool and cutter grinder, to ensure that all the teeth are in the same plane. If there is any error here, the cutter becomes a single point device (or however many teeth are, by chance, in the same plane). (Fig. 9)

Grinding

Fine surface finishes, between $1.6 \mu\text{m}$ Ra ($63 \mu\text{in. CLA}$) and $0.05 \mu\text{m}$ Ra ($2 \mu\text{in. CLA}$) can be obtained by both surface and cylindrical grinding. Many craftsmen grind their work (when facilities are available) for appearance only. A very professional finish is possible in exchange for small outlay of time by cosmetic grinding, especially on milled parts, where surface grinding removes (perhaps) irregular milling marks. Grinders are not the type of machine seen frequently in home workshops, but quite a lot now have small outlay of time by cosmetic grinding, especially on milled parts, where surface grinding removes (perhaps) irregular milling marks. Grinders are not the type of machine seen frequently in home workshops, but quite a lot now have small outlay of time by cosmetic grinding, especially on milled parts, where surface grinding removes (perhaps) irregular milling marks.

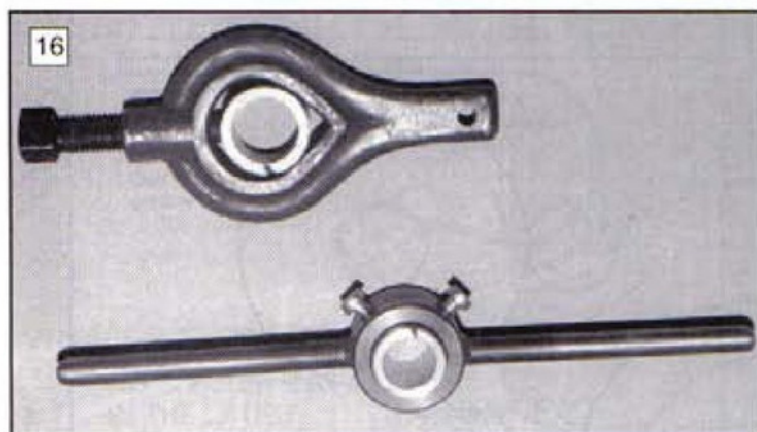
One of the most important considerations when grinding is to keep the wheel 'sharp' by regular dressing. The wheel should, of course, be of the correct grade for the work, be securely mounted and running in the correct direction (Fig. 10). A small pneumatic die grinder, suitably held in the lathe tool post can be very effective on bore grinding work.



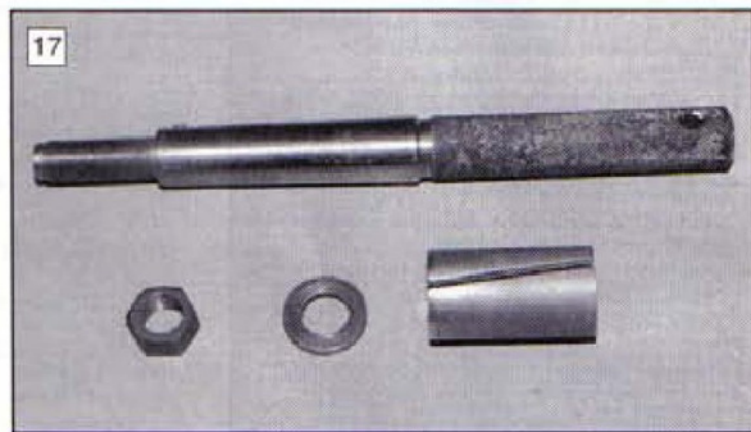
A face lap mounted in the lathe. (with work rest)



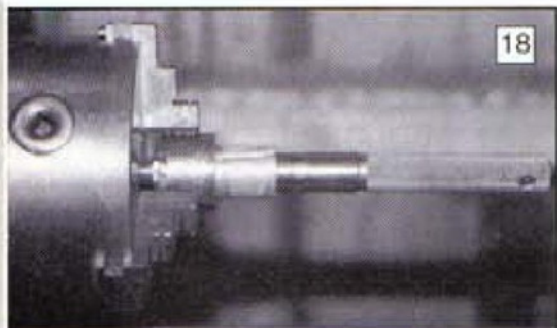
Small flat laps with lapping compound.



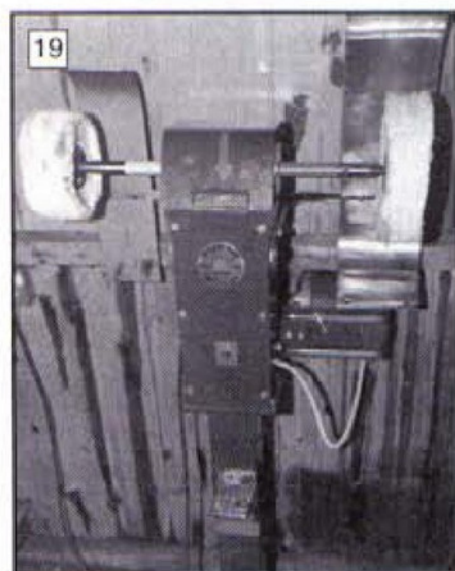
External laps.



Internal lap.



Internal lap in use in the lathe



A polishing machine for fine finishing.

Filing

Up to now, all the methods discussed have been different types of machining. The quality of the finish has been dependant upon several factors, such as the condition of the machine, the condition of the cutting tool, and the speed at which the metal is removed. It is now worth considering some of the methods which can be adopted which do not involve the use of machinery, or to be more accurate, the use of cutting tools under power. Polishing using a fabric mop mounted in a pistol drill chuck can hardly be described as machinery, although a machine is in use.

One of the easiest methods of improving a metal surface, whether it be a rough casting, a milled face, or, whatever is by the use of a file. The range of files which is available is surprisingly large, and by the use of the correct file and method of use, good smooth surface finishes can be achieved. Filing should be carried out carefully and deliberately, and good results will be enjoyed by the use of 'draw' filing. Files should be kept clean for the best results, so regular brushing with a file card is helpful. Any particles of metal retained in the file teeth are likely to scratch the surface of the work, so the file card will remove such particles before any damage can be done. A good idea is to coat the cutting face of the file with ordinary chalk when finishing work, as this helps to prevent clogging.

Scraping

Whenever a really flat surface is required, usually on cast iron, scraping is often the

selected method. The workpiece is rubbed on a surface which is known to be flat, and which has been coated with engineers' blue marking paste, thus leaving blue areas on high areas of the work. These are then scraped away, then the process repeated until the desired result has been attained. The flatness of the surface is described in 'spots per inch', the more blue markings per square inch of surface, the flatter the work.

Scraping can also produce a very decorative finish on metal surfaces, known as 'frosting' or 'feathering'. Quite a lot of practice is required to produce a good scraped surface, but the result can be very pleasing. The main requirement for successful scraping is in the sharpness of the very hard scraper which is used, and regular stoning is recommended, in order to maintain a keen edge.

Lapping

For finishes of extreme fineness, metal objects can be lapped. This process is best carried out on hardened material, but reasonable results can also be obtained on some softer materials. The main object of lapping surfaces is to obtain a very accurately dimensioned component, combined with a superior smooth finish, and slip gauges are a good example of lapped components.

Being accurately dimensioned, their finish is such that they can be 'wrung' together, and adhesion of the two (or more) is possible entirely due to the fine quality of the surface finish (0.025 μm Ra, which equates to

1µ in. CLA). Lapping is not just restricted to flat work, but cylindrical and bore work are also possible. Laps are made out of a soft material, and charged with abrasive, whereupon they are abraded against the component, until the surface is as required. This is a very slow process, and the surface finish must be quite good before lapping begins. Plenty of lubrication is needed, and laps may have to be especially made for each job. It is not usually advantageous to lap work unless an accurate dimension is being sought.

Polishing

Very high quality surface finishes are obtained by polishing metal (0.012 µm Ra / 0.5 µ in. CLA), but dimensional accuracy cannot be maintained. Polishing can be carried out in the lathe and also by hand, but a small polishing machine consisting of a fast revolving spindle ending in a cone shaped threaded portion, onto which is attached a polishing mop is normally used. The mop is charged with abrasive, and the work is offered to it for polishing. Surprisingly, the mop requires regular cleaning with a wire brush to remove any particles of metal which have become lodged in it, as, just like with the file, these particles can scratch the surface of the work. Differing grades of polishing compounds are available, and it is better to have several mops, each charged with a different grade of abrasive.

Polishing lends itself to such applications as a model traction engine flywheel rim. In reality the cast iron (usually crowned) rim of the flywheel would have become smoothly polished because of the frequent slipping of the leather belt which was used to drive all the implements. It would, therefore, be reasonable to reproduce this polished finish on a model, the flywheel being a focal point of the machine.

Maintenance of polished surfaces

Having decided upon a desired finish for a project, it is as well to try to stick to the plan. It may be that parts are to be smooth filed, draw filed, cleaned up with emery cloth, or highly polished to an almost mirror finish. Castings on original full sized locomotives were rarely brought to smooth finish before painting, but may only have had seams and very rough areas levelled at the 'fettling' stage. Likewise, connecting rods and crankshafts which were milled would not have the machining marks removed before fitting, although the machining would be of good quality. Piston rods, on the other hand, would be very smooth, as they reciprocated within a steam tight gland.

A great disadvantage of machine marks on a model is that they are out of scale, and they are probably better removed. Bright steel against a well painted background always looks good. However, the finer the finish the worse it will look if it is allowed to deteriorate. Working steam models will be exposed to moisture in the form of condensing steam, and perhaps to the weather.



A honing machine for accuracy & finish on bores.

Storage through the winter months can also take its toll on the polished metalwork. It will, then be very difficult to maintain a working model in absolutely mint condition, but with tell-tale signs of use, such as a few pit marks here and there. Superficial rust must be removed before any real damage has been done. Plenty of oil smeared on metal surfaces prevents most deterioration. On non-working models, metal parts can be oiled or lacquered.

Some steel parts can be protected by heat treatment or by chemically colouring them, firearm parts in particular being finished using these methods. Browns and blues are great favourites of the gunsmith, and barrels especially can be chemically treated with or without heating (depending upon the chemical), and solutions are available which are ready to use. Barrel finishes are often overlooked by modellers, but are extremely useful products to have to hand.



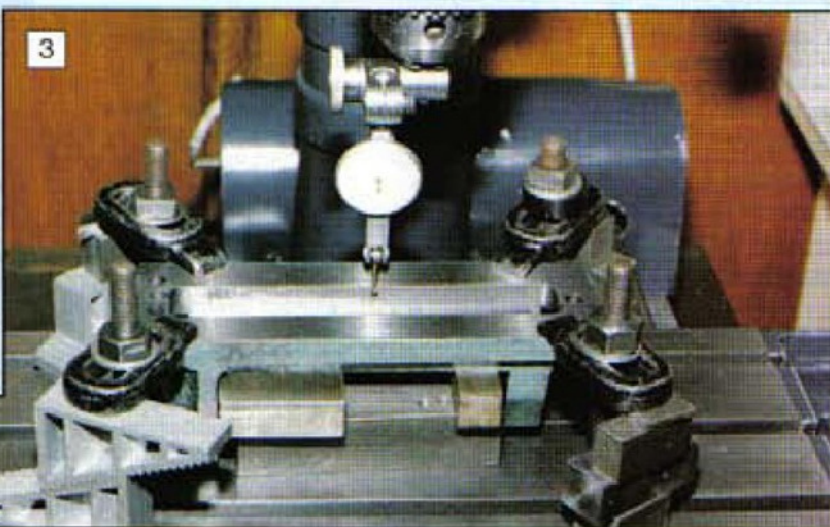
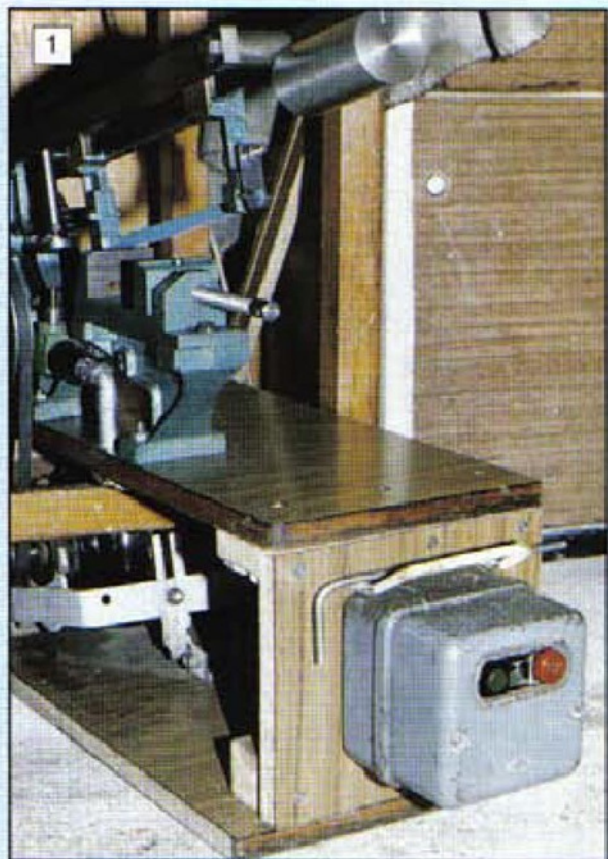
Cutting compound can enhance finish, especially when screw threading



A model cannon barrel, with brown barrel finish.

IMPROVEMENTS TO A SMALL POWER HACKSAW

The improvements David Machin made to his Blackgates power hacksaw will have a much wider application, in particular those he made to the machine vice. The majority of the electrical modifications could also be considered for many motor switching systems.



This article has been written in response to a request. In a previous article on workshop layouts, a photo of at least one layout included a Blackgates power hacksaw. A sharp eyed reader noticed that I had done some modifications to the saw, and asked for more details. I hope that the resultant article will be helpful to more than one reader!

Before going any further, I should say that, as sold, the saw is good value for money and, once motorised, will work well and save you time by doing the rather tedious work to enable you to get on with the more interesting aspects of our hobby. One reason why the saw appealed to me in particular was its compactness. In a small workshop, this is important.

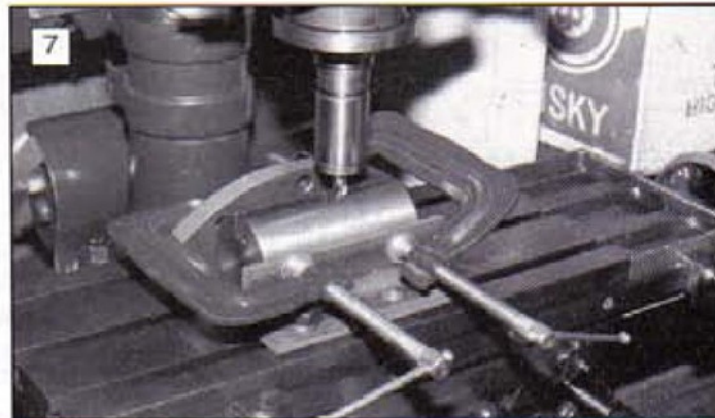
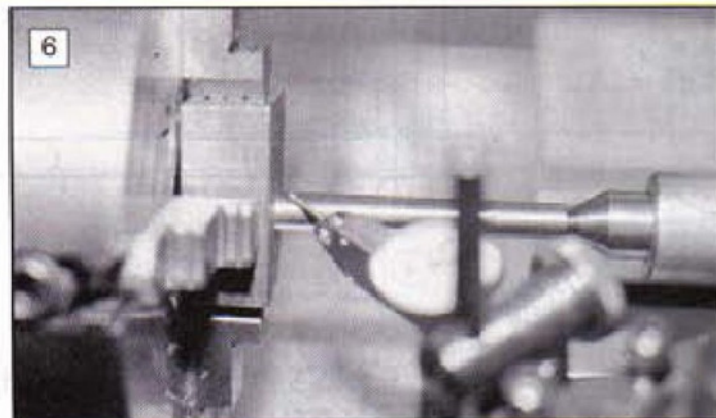
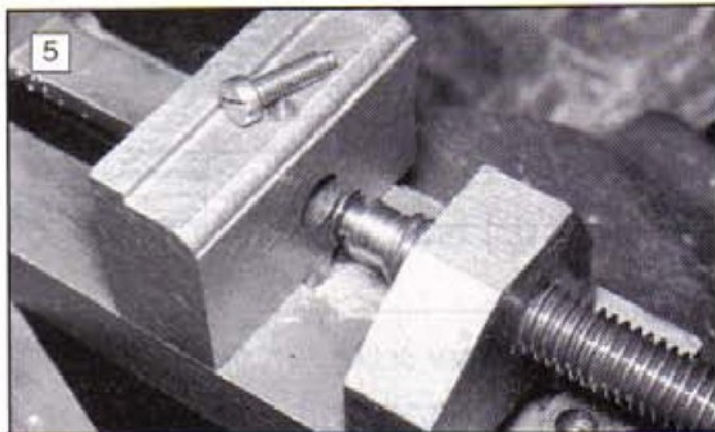
Photo. 1 shows the complete saw and the method of mounting and driving it. I used plastic faced chip board for the 'cabinet', obtained from a skip! This was screwed together using pine wood corner blocks. It is located under a table which supports a milling machine. The rear of the

cabinet has two small wheels fitted, so that the saw can easily be lifted by the front handle and pulled out for use, and just as easily put back out of the way when not required. The position of the saw on top of the cabinet is arranged such that the fixed face of the vice of the saw is just in front of the table leg when the saw is pulled out for use, so that bar up to about 4 ft. long can be accommodated. The saw is bolted to the top of the cabinet with $\frac{5}{16}$ in. dia. bolts and nuts. In **Photo. 1** a little of the motor mounting details can be seen, complete with the method of adjusting and locking the tension of the belt.

A few words on motorising the saw may help. I used a $\frac{1}{4}$ hp. induction motor, running at 1425 rpm on 240 volts. This was

an ex-washing machine motor. It must have been old, because modern washing machines use commutator motors, which need electronic control. In any case, I would suggest you have a look at Jim Cox's books on electric motors. They are Nos. 16 and 24 in the Nexus Workshop Series, and are written for model engineers by a model engineer. The theoretical side of a very complex subject is cut to a minimum, and the text is easy to understand. Mr Cox gives advice as to where to look for and how to select scrap motors.

The saw's pulley and sprocket reduction system is designed for the 1425 rpm speed of an induction motor to give the correct surface speed of the saw blade, so it is worth seeking this type of motor. They



power all sorts of machines other than washers, so there should be plenty about. They seem to go on for ever, and are very reliable. Scrap merchants are a good source.

I have used an N.V.R. (No Volt Release) starter. This is not absolutely necessary unless you fit an auto stop switch. More on this later. A simple toggle or rocker switch of about 3 amps rating will be quite satisfactory.

To take the drive from motor to saw will need a belt of 'M' section ($\frac{3}{8}$ in. at the widest point) to fit the pulleys supplied. To find the belt length required, I have been unable to find a mathematical formula for V belts. No doubt there is one somewhere. My formula, which I admit is only approximate: $L = 2J + (r\pi) + (R\pi)$ where L is the length of belt required, J is the distance between the pulley centres, r is the radius of the smaller pulley and R is the radius of the larger pulley. The distance between pulley centres for J is taken at the mean of the tension adjustment. To give an example: On my machine, the pulleys are $\frac{8}{16}$ in. apart, and the pulleys are 2in. and 24in. dia. So $L = 16.25 + 3.14 + 7.85 = 27.24$ in. Since belts are now sold in metric lengths, the belt fitted is 700 mm. (I said it was only approximate). I find that good quality and value of supply of belts is at a car accessory and spares shop. The shop I use has its belts stocked by size as well as car type, so it's an easy matter to obtain one of the size required.

Back to the modifications. One problem is that I am working from (fallible) memory. Another is that I did not at the time take photographs of any of the methods of carrying out the work. However, I have mocked up some of the methods and set-ups, and photographed these in the hope that they will explain when words won't.

The reasons for carrying out the modifications are as follows: to improve its accuracy; to increase its longevity; and to make it more convenient to use.

Improvements to the vice

I shall describe the modifications in the order I did them, as far as I can remember. The first was to the vice. As supplied it had a circular keep plate, which was rather small to be effective in holding the movable jaw square to the fixed one (and without jaw lift). What is needed is a larger and rectangular keep plate, to increase the area of support. **Figure 1** shows the assembly of the vice with a larger keep plate. **Photo. 2** shows the underside of the vice with the modification completed. The first job is to mill a little more metal from each end of the main vice casting, to make room for the increase in size of the keep plate. The areas for removal are shown as shaded portions on **Fig. 1**. This needs careful setting up. **Photo. 3** shows the set-up on a milling machine. (I doubt whether this can be carried out on a vertical slide on a lathe). Note the use of parallels underneath the vice. Initial setting should be to ruler measurements, then use the DTI to check the parallelism of the originally machined surface to the table ways. When all is correct, milling can be completed in stages, taking care to machine to the original dimensions. If this proves difficult, no harm will result if a light skim is needed. I am fairly sure that I did just that because $\frac{27}{32}$ in. is an odd measurement for the width of the groove. However, if any metal is removed from the horizontal face, then a similar amount will need to be taken from the bottom of the moving jaw. This will be dealt with later. The vice jaw keep plate is next. From **Photo. 2** it appears that on my keep plate, it was milled all over from a larger piece, to make sure that it did not protrude above the surrounding surface. The keep plate is quite straightforward to make, but care is needed when marking out for the holes. Originally, only one

screw was used for securing the keep plate. Providing two holes, in addition to the (now) unused one leaves little room for error. It is a good plan to drill tapping size holes in the keep plate first, and then to transfer the exact position of these to the jaw, by assembling the parts and clamping keep plate and jaw together with toolmakers clamps. **Photo. 4** shows the method. Finally, if you are using Allen screws, (recommended due to their strength and superior tightening properties), the holes in the keep plate will need counterboring.

On reassembly, make sure that the movable jaw can, in fact move under firm hand pressure. If not (particularly if you took a skim from the horizontal surface and the bottom of the jaw) carefully examine the assembled parts. Is there a gap between the bottom of the jaw and the keep plate? If so, measure this with a feeler gauge. If the gap is so small that your thinnest feeler gauge won't enter, then an even scrape on the underside of the shoulders should do the trick. A gap larger than say, 0.002in. will need to be shimmed. Shimstock is available from our usual suppliers, in various thicknesses, but tin cans also provide quite good shim material. The chief difficulty with thin material is to drill clean holes in it without burr. In our case, if the piece of shim is sandwiched between keep plate and a piece of (expendable) strip mild steel and then clamped, drilling through the 'sandwich' should produce a clean pair of holes.

If, on the other hand, the jaw is too loose, then a little metal should be removed from the bottom face of the jaw, either in the lathe or miller. This time, you will need to use the feeler gauge on the gap between shoulders and horizontal (top) face of the main vice casting. This will give the amount to be removed, but allow, say, 0.0015in. extra for clearance.

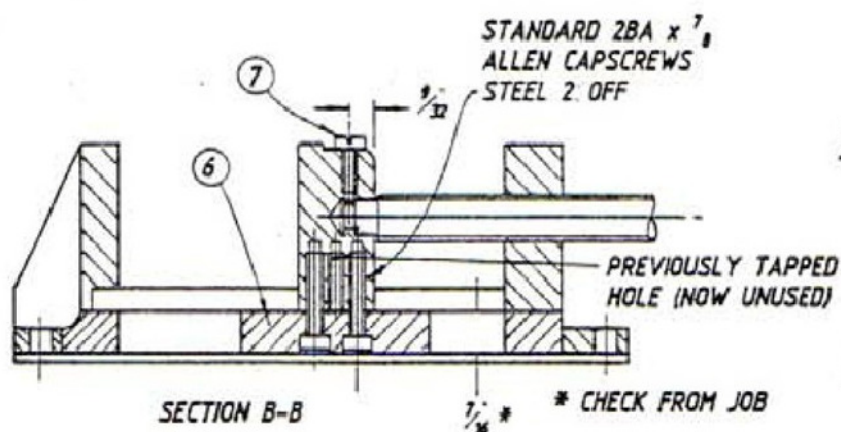
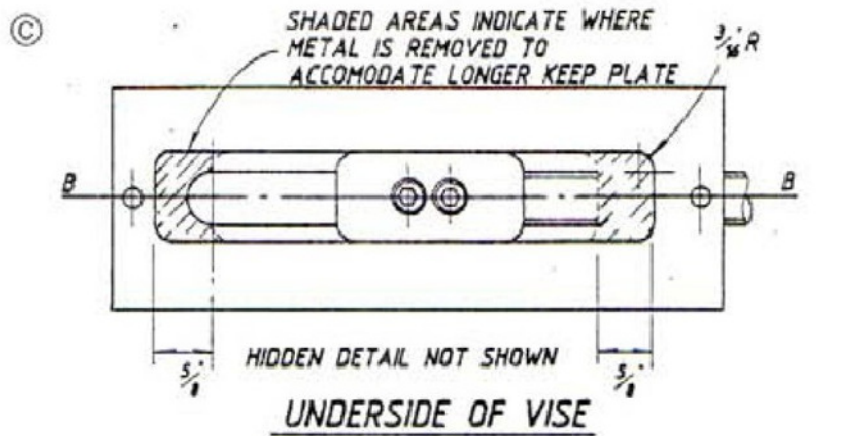


FIG. 1. ASSY OF VISE SHOWING MODIFICATIONS

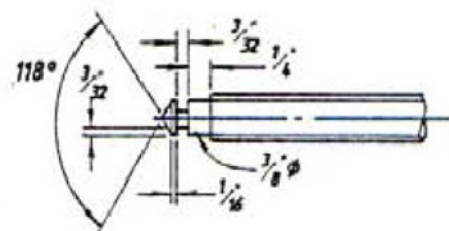


FIG. 2. MODS TO EXISTING MAINSCREW

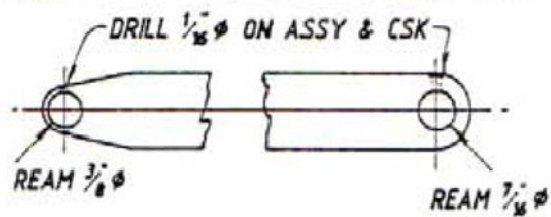


FIG. 4. MODIFIED CON ROD

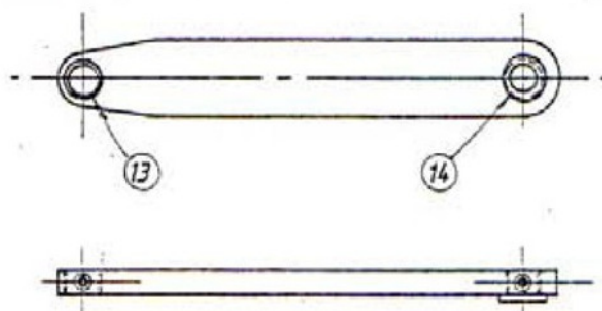


FIG. 3. ASSY OF CON ROD TO SHOW MODS

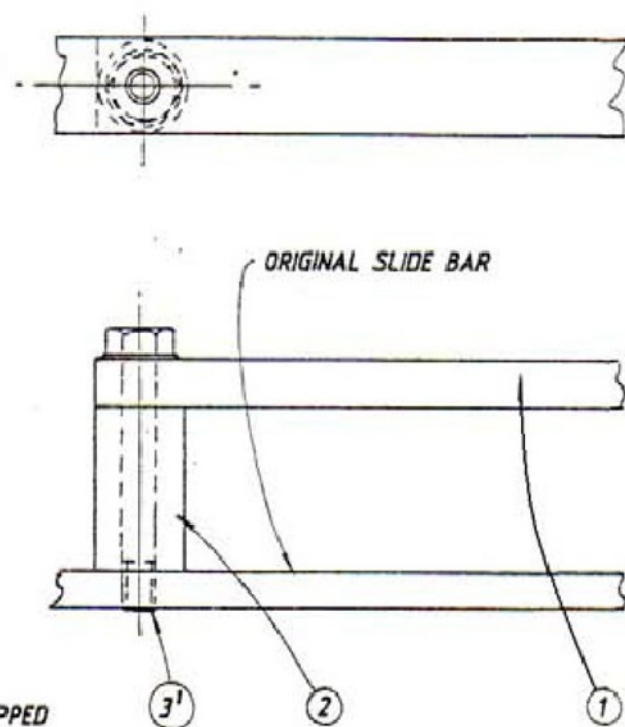


FIG. 5. ASSY OF STEADY BAR WITH SLIDE BAR

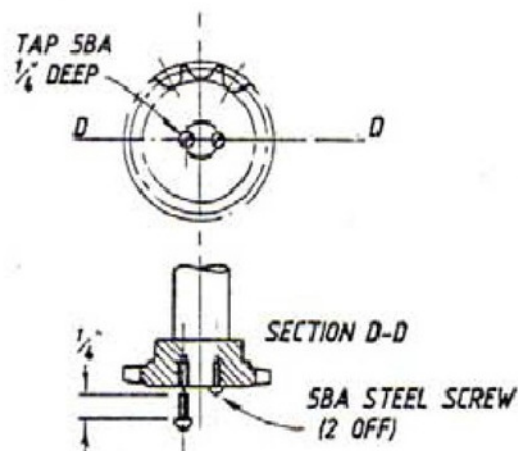


FIG. 8. SMALL SPROCKET MODS

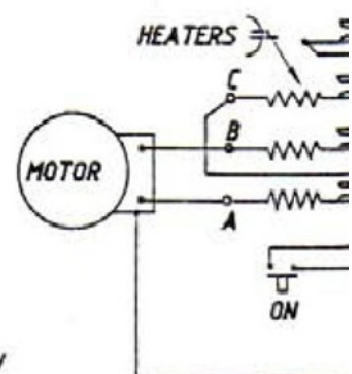


FIG. 7. STARTER WIRING

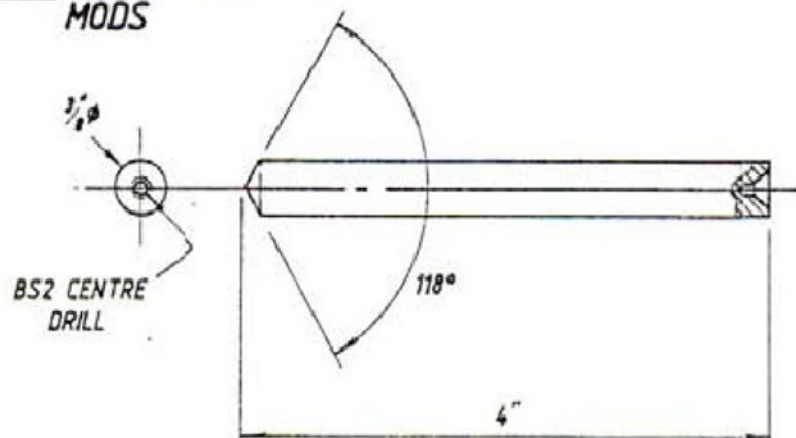


FIG. 9. WOBBLER OR CENTRE FINDER, B.D.M.S. EN1A

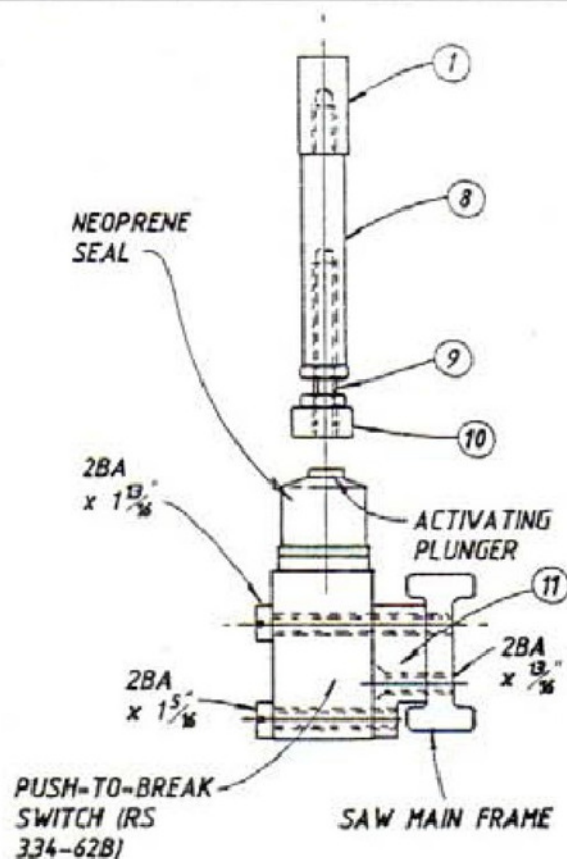
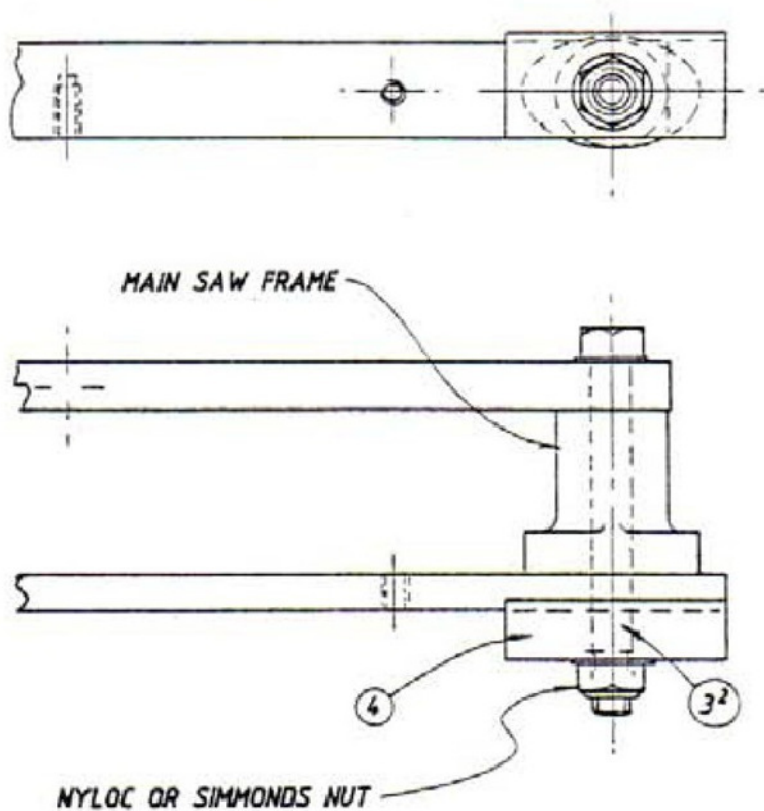
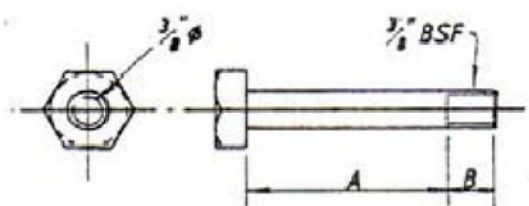
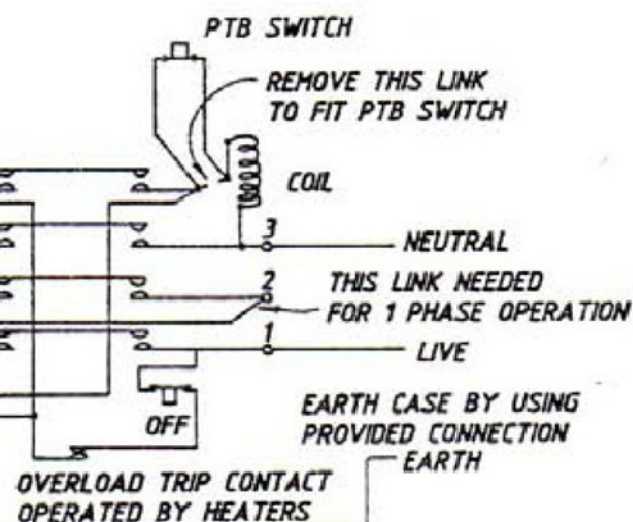


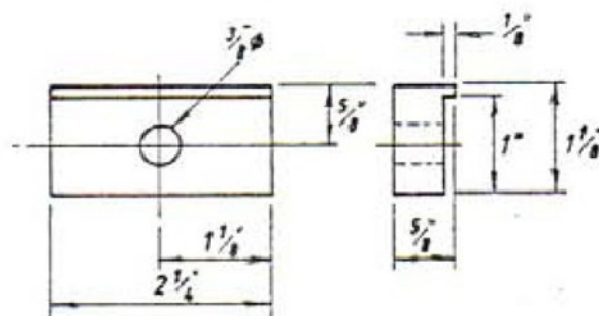
FIG. 6. GENERAL ARRANGEMENT AUTO STOP ASSY



DIMENSION	A	B
BOLT 1	2	9/16"
BOLT 2	3	5/8"

NUT FOR BOLT 2 NYLOC OR SIMMOND TYPE REQUIRED

③ BOLTS, B.D.M.S. EN1A 1 OFF EACH

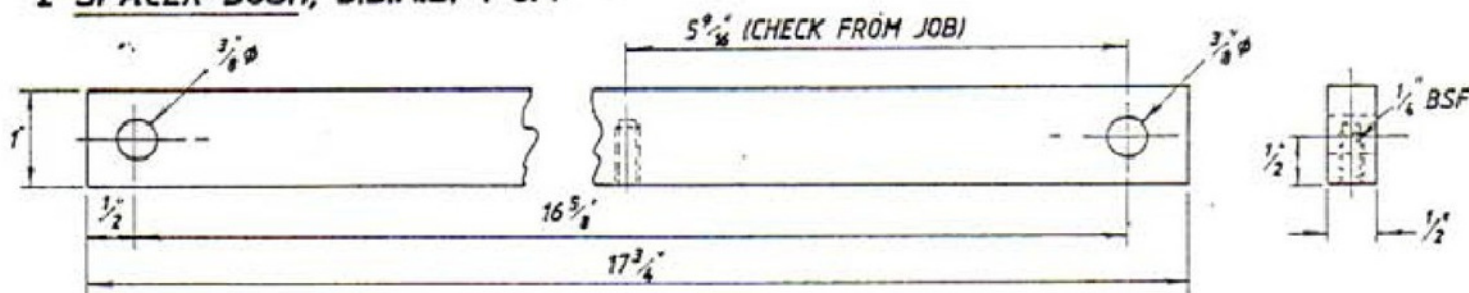


④ THRUST PLATE, B.D.M.S. EN3B 1 OFF

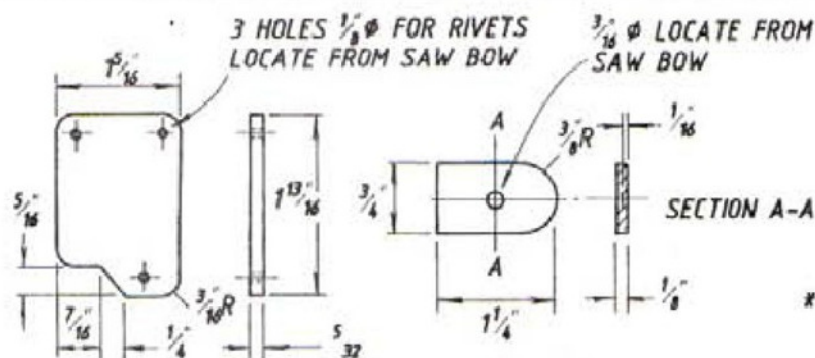
5 DIAG FOR M.E.M. MODEL N° 42ADS



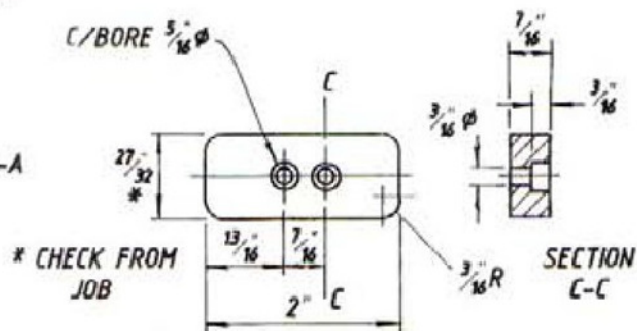
2 SPACER BUSH, B.D.M.S. 1 OFF



① STEADY BAR, B.D.M.S. EN3B 1 OFF

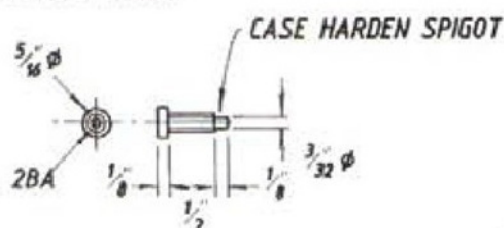


(5b) GIB

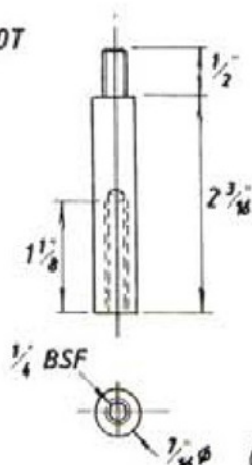


(5a) SLIDE PAD
MAT^L BRASS OR
CAST IRON 2 OFF EACH

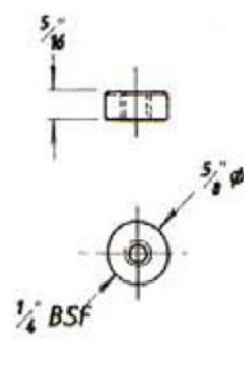
(6) VISE JAW KEEP PLATE
MAT^L B.D.M.S. EN3B 1 OFF



(7) SCREW, MAT^L
B.D.M.S. EN1A 1 OFF

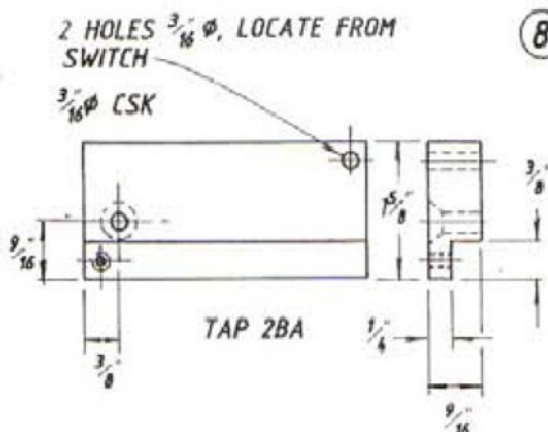


(9) ADJUSTMENT
SCREW, MAT^L
B.D.M.S. EN1A 1 OFF

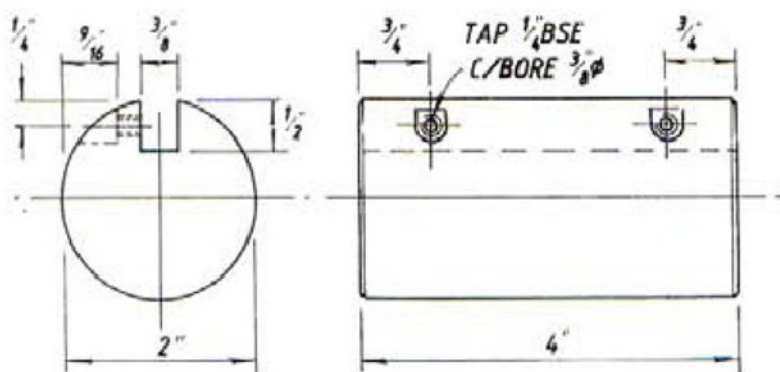


(10) FOOT, MAT^L
B.D.M.S. EN1A 1 OFF

(8) PUSHROD, MAT^L
B.D.M.S. EN1A 1 OFF



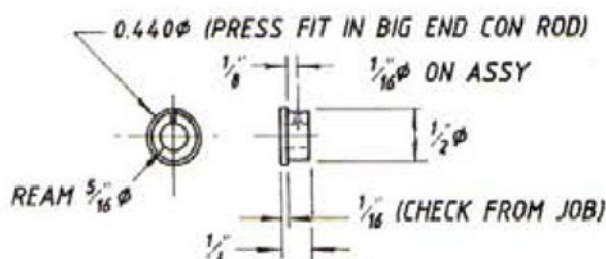
(11) SPACER, MAT^L B.D.M.S. EN3B
1 OFF



(12) WEIGHT, MAT^L B.D.M.S. EN1A
1 OFF



(13) BUSH, MAT^L PHOS.
BRONZE, G.M. OR
BRASS 1 OFF



(14) BUSH, MAT^L PHOS. BRONZE, G.M. OR BRASS 1 OFF



For those who would prefer not to do such a drastic modification, an alternative is recommended. Don't do any milling to the main casting of the vice, but make as large an area of keep plate as possible. (Even a rectangular keep plate would be an improvement). I have tried, without success, to remember the 'as supplied' shape machined at each end of the casting of the keep plate groove. My guess is that it is semicircular at each end, and passes under the fixed jaw at that end, but probably doesn't pass under the 'nut' at the other. In any event, the keep plate could be made to fit. The shape would then be the rectangle previously mentioned, extended by a semi-circular section at each end, so that when the moving jaw is at its extreme position at either end, the keep plate will just fit and not interfere with the working of the vice in its degree of opening and closing. With the use of two screws for fixing, this would greatly improve the performance of the vice.

The next modification to the vice comes under the heading of convenience. As supplied, the movable jaw closes and tightens the workpiece under pressure from the screw. When the screw is reversed, the movable jaw stays where it is. The modification to be described retracts the movable jaw when the screw is reversed. (See **Fig. 1**, and **Photo. 5** for details).

The first part to be tackled is the movable jaw, which is set-up in the four jaw chuck, so that the shallow hole, drilled in it as supplied, is outermost. This hole needs to be deepened, but it is important that it remains on the same axis as the original one, because the main screw may bind and be difficult to turn if not. The hole should be set to run as truly as possible by eye, then centralised using a 'wobbler' (**Fig. 9**). It is important to make sure that the rear face of the jaw is hard up to the front faces of the chuck jaws, so that the hole soon to be drilled will be square to the front face. **Photo. 6** shows a mock up of the described procedure. (Those readers who have made and used wobblers before may want to point out that my wobbler has no 'error amplification' system. However, such devices add complexity, and are, I believe, not really required in this instance). Even though a shallow hole exists, it is essential to centre drill and pilot the hole in the usual way. Care should be taken with the depth of drilling, too, when the final diameter is reached.

Next, the main screw needs to be spigotted as shown on the drawing in **Fig. 2**. It is necessary to protect the threads on the screw, so wrap one thickness of a piece of aluminium sheet around it. A piece of about 20 swg (about 1mm) thick will be

satisfactory. If the three jaw chuck will grip the piece truly, then machining can be completed. If not, use the four jaw to set the screw to run truly. It is important to machine the spigot to the correct length such that, on assembly, the movable jaw will have a small clearance between the end of the screw thread and its face. **Fig. 1** should make this clear. This will ensure that when the vice is tightened, all the thrust is taken on the end of the screw and not on the thread. More than normal clearance on the diameter should be allowed for, too. I would suggest machining to, say, 0.370in. dia. This allows for any misalignment and promotes easy movement. It is necessary to machine the $\frac{3}{32}$ in. wide groove at this stage. The groove could be made a little wider than nominal in case of a misalignment error when later fitting Item 7. Again, an additional 0.005in. will be satisfactory.

Item 7 is next. The case hardening should be left until after the screw has been tested in the jaw. Very careful marking out is needed to locate the tapped hole for the newly completed screw. If the position of the groove in the main screw is carefully measured, the centre measurement can be transferred to the jaw. After drilling and tapping, the parts can now be reassembled for a trial fit. Remember that we are aiming at the tightening thrust being taken on the end of the main screw, not Item 7. Looking down the tapped hole in the jaw, to see the position of the groove, is a useful check. When all is well, the small spigot on Item 7 may be case hardened.

Speeding the cut

With the saw in use, I found that the machine took a long time to saw through a piece of bar. I tried putting gentle pressure on the saw bow, at what I have called the slide bar (this is the piece of $1 \times \frac{3}{8}$ in. steel bar, along which the saw bow moves backwards and forwards). This increased the rate of sawing, and did not seem to put any discernible stress on the saw or the motor. I hung various weights on that part of the slide bar that is used as a handle, to experiment on the effect of more or less weight on the time taken to saw through a standard test piece. The results I have long forgotten, but this led to the making and fitting of Item 12, so presumably this was the optimum. A piece of 2in. dia. bar was (slowly) sawn off, and faced to length. A groove was milled down the whole length, so that it could be fitted to the slide bar handle. If you have a milling machine and a machine vice big enough, then the procedure is simple. If you have a $\frac{3}{8}$ in.



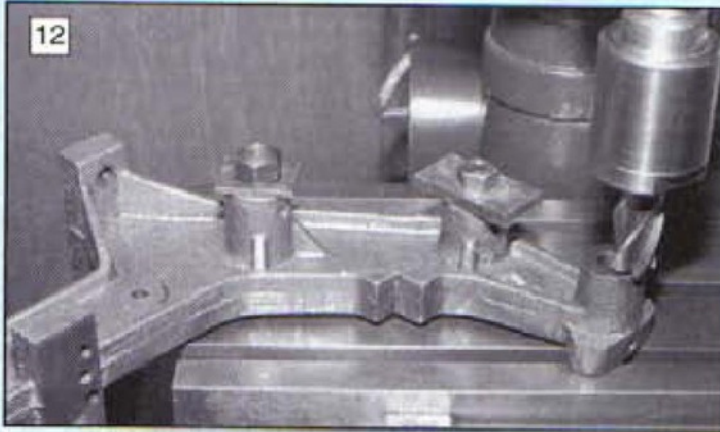
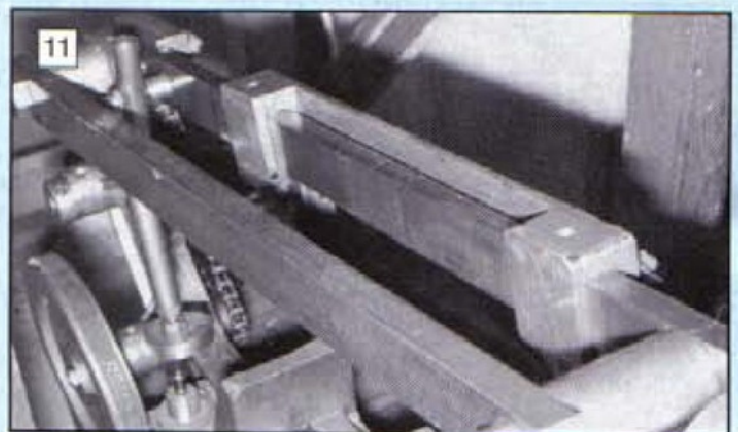
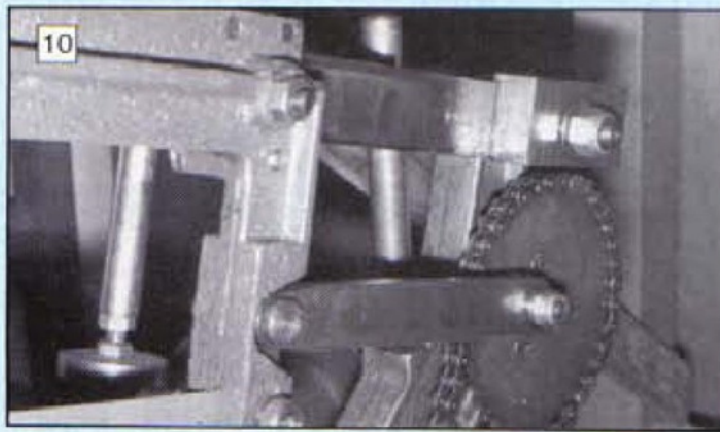
dia. slot drill, then the groove can be milled in stages until the correct depth is reached. Slot drills normally produce a groove equal to their nominal size, so test with the slide bar to make sure it fits. It is so much easier to take another shaving whilst the workpiece is set-up! If you have only end mills, then it is better to use a slightly smaller size, say $\frac{5}{16}$ in. dia., because an end mill tends to cut a wider groove than its nominal size. In this case, set-up as before and mill to depth in stages. Unlock the table cross slide and move the slide $\frac{1}{32}$ inch. Re-lock and mill more metal from the side of the groove, arranging the feed so that the work moves against the direction of rotation of the cutter. To complete the process, repeat for the other side, to bring the groove to the correct width, testing that the slide bar fits.

I have offered an alternative for gripping the workpiece, in case your vice isn't big enough. This is shown in **Photo. 7** and uses an angle plate and a piece of hefty angle, both bolted down with the workpiece is placed between the two faces. G cramps are used to grip the workpiece, before the angle iron bolts are tightened. If you haven't an angle plate, then another piece of angle will serve just as well.

If you don't have a miller, then I have shown a suitable set-up for the lathe in **Photo. 8**. Note that the same bolts are used to clamp the angle plate as are used to clamp the 'fingers'. The workpiece also needs packing up, so that the axis of the bar is on the centre line of the lathe. Since it is difficult to adjust the height, I would suggest the use of a $\frac{3}{8}$ in. cutter for finishing to width, whatever its type. In view of the difficulty in 'taking a shaving', I would suggest that you have a new $\frac{3}{8}$ in. dia. end mill to hand, in case there is difficulty in getting the slide bar to fit. A new cutter will be ground to the full $\frac{3}{8}$ in., whereas a sharpened one is likely to be less.

Before the holes can be tapped for the fixing screws, it will be necessary to mill flat surfaces to enable the drill to enter squarely, rather than at an angle. If it is thought that this is not necessary, then we need to consider what happens if drilling is attempted. As the drill is brought down to the sloping surface, it will tend to follow the line of least resistance. Since we have hard metal on one side and fresh air on the other, the drill will bend. If you keep the pressure on, the drill will break. Whilst set up, centre drilling and drilling to tapping size can be completed.

If using the lathe for milling, it may not be possible to achieve movement in the vertical plane because of the difficulty in clamping the workpiece to a vertical slide. The set-up can be as previously described,



except that the groove will be set vertical, of course, and packing used to bring the work piece to the correct position. Next using a slot drill, take a plunge cut, i.e., as if drilling. The cut will need to be carried out in stages to clear cuttings from the cavity. This will create a counterbored hole with a flat bottom to allow centre drilling and drilling to tapping size.

Finally, the slide bar should be placed in its slot and the tapping size drill used to spot through on to the slide bar. This should be carried out before the set-up is dismantled, if possible. Burrs on the inside of the groove will need to be removed so that the bar can be fitted. Tapping the holes in Item 12 can then be started, so that the tap will be in line with the previously drilled hole. The workpiece can then be removed and the tapping completed. The slide bar should have the spotted holes deepened with a $\frac{1}{4}$ in. dia. drill (clearance for $\frac{1}{4}$ in. BSF) so that on assembly the Allen grub screws will still hold the weight in position even if they slacken. This is a safety measure, of course, but I have to say that in 8 years the screws have not loosened, and if they did, any looseness would be felt because every time you use the saw you have to lift the saw bow by the weight.

Better connecting rod bearings

The next modification comes under the heading of longevity and refers to the connecting rod which takes the drive from the crankpin on the large sprocket to the gudgeon pin on the saw bow. As supplied, the bearing surfaces are, I believe, mild steel. This is not good practice, and rapid wear usually takes place because, with the exception of cast iron, two similar metals should not be run together. To improve this, I simply made the holes in the connecting rod larger and fitted bronze

bushes. The finished rod is shown in **Photo. 9** and **Fig. 3**. (The shoulder on the big end bush is to reduce end float on the crank pin).

Now to the procedure. First, set-up for drilling and reaming the holes in the connecting rod. It is essential that the holes are square to the surface, so careful checks should be made on this. Reaming will need to be carried out at a low speed (say about 200 rpm), so if your drilling machine—like mine—hasn't this low speed, then it may be better to do this work on the vertical miller or on the lathe. If you are using a hand reamer, make sure that when setting up, you leave sufficient clearance under the workpiece to allow the reamer to bring the hole to correct size. The reason for this is that a hand reamer's cutting edges are tapered for the first third of its length. Machine reamers are parallel.

The hole at the crank pin end should be drilled to a diameter of $\frac{23}{64}$ in. and the other end to $\frac{27}{64}$ in. If you have it, a drill closer in size to the reamed one is much better, but should leave a minimum of 0.004in. for the reamer to remove. Aim for a good finish by using a lower speed than normal and plenty of soluble oil. A well finished drilled hole will ultimately lead to an accurately reamed one. On the big end of the connecting rod, a small countersink should be made on the $\frac{7}{16}$ in. dia. hole, on the side that will abut against the shoulder of the bush soon to be made. The reason for this will be explained presently.

The bearing bushes can now be made. As already stated, I used bronze, but gunmetal or brass may also be used, as they are all classed as medium to low speed bearing materials. For the little end bush, rod of a size larger than the nominal $\frac{3}{8}$ in. dia. will be needed. This is because the size of a reamed hole is larger than nominal, to allow clearance for a running fit for a shaft of exactly the size stated on the reamer.

Making the bushes is quite straightforward, but a few words may help, particularly to save expensive material.

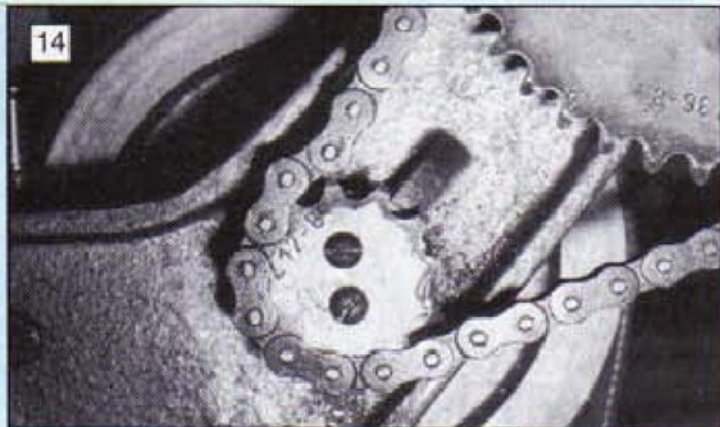
First, if using a machine reamer, a reaming size hole needn't be drilled much deeper than the finished width of the bush. If using a hand reamer, then a hole would have to be deeper, because of the taper on the reamer, as explained earlier. In the latter case, leave the reaming until later, and in the meantime, drill no deeper than would be needed for machine reaming.

Machining the outside diameters needs care to give the necessary press fit. The dimensions for this are shown on the drawings of Items 13 and 14. It is very helpful to machine the outer ends of the spigot to the nominal diameter for a short distance, say $\frac{1}{16}$ inch. This will allow the bush to be started easily and squarely in the holes in the connecting rod. As stated on the drawing for Item 14, the shoulder width should be checked from the job, so that only a little end float clearance is made. 0.003in. would be ideal. Part off a little longer than required, to allow facing to the correct length. The bushes can now be pressed in, using the bench vice.

Suitable protection for the workpiece, such as vice clamps, will be necessary if your vice jaws are serrated. Use of the turned down portion of the bushes will be found very helpful when starting to press the bushes in. Regarding the need for countersinking on the big end: if you have machined Item 14 with a lathe tool that has a small radius, it will leave a similar radius on an internal corner. If a countersink is not made in the mating part, then it will be impossible to bring the face of the shoulder flush with the surrounding surface.

Regarding these press fits: if you find that in spite of your best efforts, the bushes are a push fit, then they may be fitted using Loctite high strength retainer.

Where only a hand reamer is available, reaming the bushes may be completed



now. The set-up can be the same as the one already used to ream the holes in the steel part of the connecting rod. You may find that further reaming is necessary, even where a machine reamer was used, since pressing in a bush can often make the bore smaller. Finally, drill $\frac{1}{16}$ in. dia. and countersink for oil holes, as shown on the drawing. Deburr the bores by putting the reamer through once again. The completed and reassembled connecting rod can be seen in **Photo. 10**.

Steadying the bow

The next modification was for accuracy. As supplied, the sliding bar is unsupported and tends to flex a little. I added what I call a steady bar, to increase rigidity. This can be seen in **Photo. 11** and the general arrangement drawing in **Fig. 5**. To do this modification, the saw frame will need to be stripped of all components.

The steady bar, Item 1, is shown as $\frac{1}{2}$ in. thick, but $\frac{3}{8}$ in. would probably do equally well. To improve the appearance, the ends could have a radius profile, if you wish. However, the sharp corners should all be chamfered as a safety precaution. The holes should be drilled tapping size at the handle end and clearance size at the other. The steady bar can then be clamped to the slide bar with toolmakers clamps at the handle end, and by a $\frac{3}{8}$ in. bolt and nut at the other. Ensure alignment before drilling through the handle end with a tapping size drill. Dismantle the parts and, in the steady bar, open up the hole at the handle end to $\frac{3}{8}$ in. dia. Leave the hole shown as $\frac{1}{4}$ in. BSF until later.

Now we need to turn our attention to the saw frame. The tapped hole by which the slide bar was fixed to the frame needs to be drilled all the way through at a diameter of $\frac{3}{8}$ in. To set up for this, it is necessary to ensure that the drilled hole is square to the elliptical face. Use can be made of one of the $\frac{5}{8}$ in. dia. holes in which the sprocket shafts run, and the larger sprocket shaft, complete with its sprocket. First ensure that the countersunk screws securing the sprocket are flush or slightly lower than the surrounding face. I found it necessary to remove them, and to countersink a little deeper. The sprocket and its shaft are then clamped to the table of the milling or drilling machine (ideally the former) with its spindle vertical, using Myford face plate clamps or similar. Taking the frame, the $\frac{5}{8}$ in. dia. hole nearest to the tapped hole can be slid onto the upturned shaft to locate the frame correctly. However, this is a tenuous hold, and further clamping will be needed. First,

carefully pack up under the casting, so that there is no distortion when the clamping is carried out. It is particularly important to:

- a) make provision for drill thrust and
- b) to make sure that you won't drill a hole in the drill or mill table!

When all is checked, the hole may be drilled (in stages) to $\frac{3}{8}$ in. diameter. Location of the original hole's axis can be found by using a tapping size drill gripped in the drill chuck, the miller table being moved until the drill will just enter. If using the drilling machine, a second pair of hands would be useful, since the whole assembly will have to be positioned and finally bolted down once the position is located.

Once the hole has been drilled, the face through which the drill broke will be found to be unmachined. While this is not essential, (because the steady bar will act as a strut) it can readily be milled flat, and this time we have two faces to utilise for bolting down to the table. **Photo. 12** shows the set-up. A word of warning: take very great care that the casting is well supported when bolting down, or you could easily break the brittle cast iron. Try to support in the way shown, if possible. If you don't have a miller, then the humble file can be used to make the surface reasonable, if absolutely necessary. A $\frac{3}{8}$ in. dia. bolt and washer can be used as a guide to flatness here. When completed, carefully measure the distance between the faces to find the length of Item 2, the spacer bush.

The bolts, Item 3 can either be bought or made as you prefer. A self locking nut is specified so that, once tightened, it will hold its position. An alternative would be to use locknuts.

The last item to complete this group is the thrust plate. Its function is to provide additional rigidity to the slide bar, by pressing firmly the steady bar against the elliptical face. If you wanted an easier option to the steady bar, this could be usefully be added as a 'stand alone' modification.

The details are shown in the drawing as Item 4. I must admit that at $\frac{5}{8}$ in. thick it is probably a bit too hefty. A piece $\frac{1}{2}$ in. thick would be equally effective. The milled step is made simply to make sure that the plate stays in the same relative position to the slide bar. The suggested depth is shown as $\frac{1}{8}$ in., but this is not, of course, critical. The only point to mention is to make sure that the $\frac{3}{8}$ in. dia. hole is drilled with the plate and the slide bar clamped together, using the hole in the slide bar as a jig to guide the drill. This is rather a large hole to drill without a pilot hole, so having 'spotted through' with the $\frac{3}{8}$ in. drill, change to a



smaller one, say $\frac{3}{16}$ in. dia., to pilot drill, then open up in stages until the final size is reached. It is essential to keep the parts clamped together, particularly for the final drilling.

The parts can now be reassembled. Aim to tighten the Nyloc or Simmonds nut such that the slide bar and bow assembly will fall easily under its own weight, without lateral shake. **Photo. 15** shows the thrust plate assembled with the Nyloc nut.

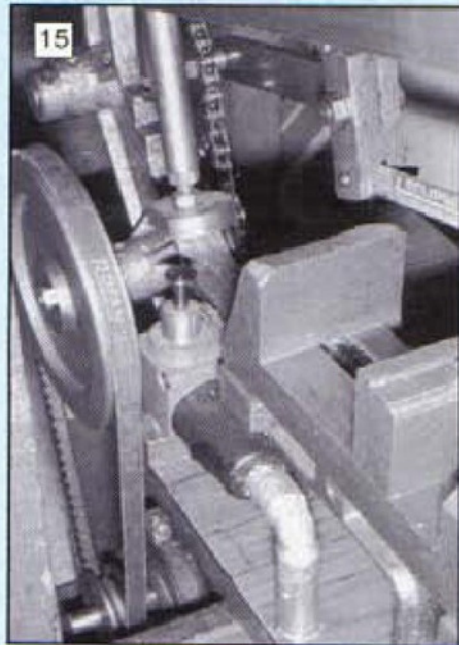
Securing the drive sprocket

The next modification came about through necessity. One day the saw was busily getting on with its work, when the small sprocket came off its shaft. To make sure this didn't happen again, the following procedure was carried out: the sprocket shaft's length was first reduced slightly by facing so that it was flush with the surface of the sprocket. Then with the parts reassembled, two holes were drilled on the joint line between sprocket and shaft, using a tapping size drill. The holes were tapped and two screws were fitted. **Figure 8** gives the details. I used 5BA screws, but a near size, such as M3 or 6BA would be just as effective. Roundhead, cheese head or Allen cap are all equally effective screw types. **Photo. 14** shows the completed modification. No further trouble has been experienced. For many readers, this modification will not be necessary, since I understand that a modification has now been made by the manufacturers, to avoid this problem.

An Auto-stop

Now to the Auto-stop device. It is really an addition rather than a modification. First, a word about the saw's own auto-stop. This is an ingenious and simple mechanical system. It comprises a strut which is pivoted on the slide bar, and two steps on the main frame, on which the strut can be placed to support the saw bow. When the saw bow is lifted, the strut will support the bow on the upper step, and at the end of a cut, the strut will rest on the lower step, thus the saw blade is prevented from cutting deeper. This latter feature is not always reliable and in any case, it doesn't stop the motor.

At the time I was setting up the saw, K. R. Whiston's catalogue came through the letter box. It contained details of an inexpensive surplus industrial change-over switch, operated by a hefty plunger, and this seemed ideal for auto-stopping of the saw. So it later proved. The switch can be



seen in **Photo. 15**. It's really a hefty micro switch, and according to how it's connected, can either connect (make) or disconnect (break) a circuit when the plunger is pushed. The ability to switch off at the end of a cut is all that is required, so only the P.T.B. (Push To Break) connections are needed (the common and break). If these are wired with the toggle or rocker switch previously mentioned, the machine will certainly switch off at the end of a cut. The snag is that, unless you remember to switch off at the toggle switch, it will start again as soon as the saw bow is lifted! This is clearly unsafe. What is needed is relay which will automatically switch off the power if the P.T.B. is operated. An N.V.R. starter does just that. I mentioned this earlier. This can be seen in **Photo. 1** as the grey box with the red and green buttons at the front of the 'cabinet'.

I managed to get this one secondhand. A few general words on these starters may be useful. Many N.V.R. starters are made to operate 3 phase motors. They can, however, easily be made to work on single phase to run single phase motors. The component which determines single or three phase working is the relay coil. This can be either 415 volts or 240 volts, the latter for single phase working. The 240 volt coil used with my saw's starter is shown in **Photo. 16**. Its location inside the starter can be seen in **Photo. 17**. The different voltages of coil are interchangeable, but only on a particular make and model of starter. If you should see a similar starter offered cheaply, check carefully: it could be fitted with either coil voltage and if its like the one I used, it's doubtful if a 240 volt coil could be obtained as a replacement because of its age. If the vendor will wait, it's worth finding out. If buying new, only a low power one is required, because a $\frac{1}{4}$ hp motor only draws about 190 watts. The dealer will advise on this. Two more features come with these starters. One is that if power to the starter is interrupted, such as switching off at the 13 amp plug, and then switching on again at the plug, the motor(s) being controlled by the starter will remain off until the green start button is pressed again. This is the meaning of No Volt Release. Another feature is that if the motor becomes overloaded, the current rises and the starter will automatically



switch off the power to the motor. This is called the overload trip. It operates by part of the starter circuit being wired with heater coils. If the current rises, these coils get hot and expand, thus tripping a specially designed switch. When the coils (and motor) cool, the red (reset) stop button is pressed and the motor can be restarted - always assuming that the cause of the overload has been found and rectified. The overload trip is adjustable within the designed limits of the starter. The adjustment can be seen in **Photo. 17** - a green knob operating a pointer along a scale marked in amps. This should be set to the full load current of the motor. For a $\frac{1}{4}$ hp motor this is about 1 amp. For single phase working all three heaters are utilised by wiring in a link. This can be seen in **Fig. 7**, together with the other details of wiring for single phase.

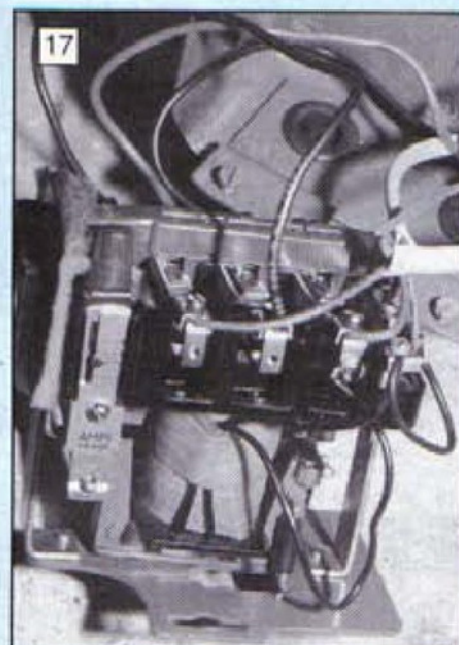
Back to the P.T.B. switch. It is doubtful if a switch is still available similar to the one I fitted, since K.R. Whiston retired some years ago, and the business was closed soon after that. (Ken Whiston died recently, after a full and active life). I believe that some of the stock went to Proops, but I would think that all switches have been sold by now. I did consider recommending the inexpensive microswitch, but rejected this idea because such a switch, being made of plastic, is insufficiently robust, has external connections and is not sealed against the ingress of the fine swarf.

A suitable switch

However, I have found a switch which passes all the tests on suitability. It is available from Electromail—the retail side of Radio Spares, and is available under Part No. RS 334-628. Their address is PO Box 33, Corby, Northants, NN17 9EL. Tel. 01536 204 555. Many shops selling electronic parts may also be able to get the switch for you from R.S. I have drawn a General Arrangement to show the switch, together with the other parts, in **Fig. 6**.

Mounting the switch

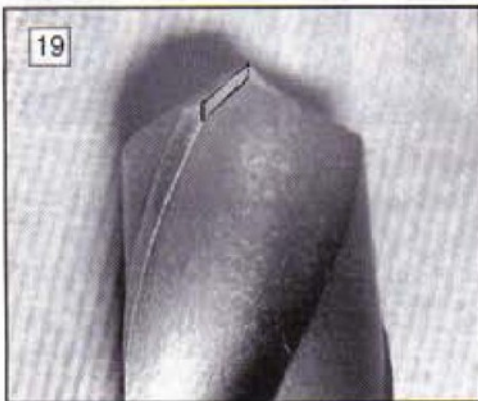
To mount the switch, a spacer will be needed. This is drawn as Item 11. The



material specified is mild steel, but any material you have to hand will do. As shown, a groove will need to be milled to fit the frame. However, two suitable pieces could be riveted together as an easier option. One hole is countersunk to accommodate a countersunk screw, so that the spacer can be fitted to the frame and allow the switch to lie flush with the surface. One long screw fixes both spacer and switch to the frame and the remaining screw fixes switch to spacer. The fixing holes in the switch are actually 5mm dia., so this size of screw could be used if you prefer. You will also need 5mm taps, of course. There is little room to fit the switch, so take care with the placement. As far as wiring up is concerned, cable entry is through an M20 ξ 1.5 pitch hole at the small face at the rear of the case. It is essential that once the connections have been made, this is sealed to prevent entry of swarf. Electricians conduit could be used here, together with an elbow, but a method similar to the one I used may be useful. Referring to **Photo. 15**, it will be seen that my conduit was 15mm water pipe and an elbow. The neoprene seal was cut to fit over the pipe and, where the pipe passed through the plastic faced chip board, Araldite was used to fix it. Since the pipe is a good conductor, and wires were to pass through it, I soldered an earth wire to the pipe.

The other parts, Items 8, 9 and 10 can now be made. Item 9 could be made from a length of studding. Note that Item 10 is locked with a nut to Item 9. The nut could be dispensed with if you soft soldered or used Loctite to fix the foot to the screw. Another alternative would be to machine foot and screw from a solid piece of $\frac{5}{8}$ in. dia. bar. The location of the push rod in the steady bar can now be established, such that the foot is central over the activating plunger when all other adjustments have been made. With the steady bar drilled and tapped, the parts can all be assembled. The foot should be adjusted so that the P.T.B. switch breaks just as the bar is sawn through.

The N.V.R. starter can now be fitted. Fixing holes are provided to fasten the starter box to the cabinet. Also, partly cut



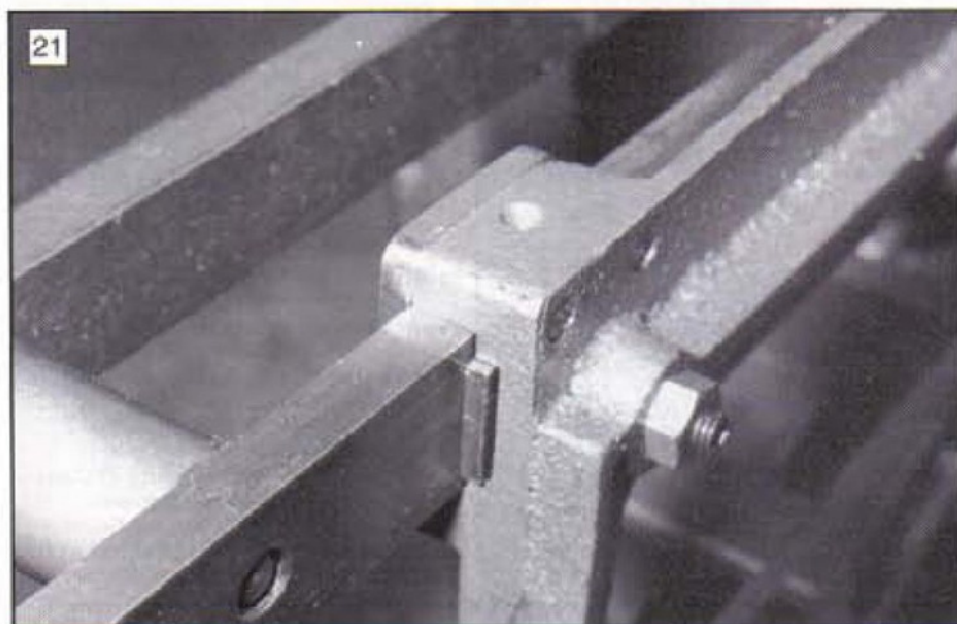
3/4in. dia. hole are provided. An appropriately positioned one can be knocked out. On my version, the wires are passed through the rear of the starter, through the cabinet front, and are clipped to the top surface of the bottom board. This arrangement makes the use of conduit unnecessary, since no wires are in a vulnerable position. Where wires pass through a hole in metal sheet, such as the back of the starter box, a rubber grommet should be fitted.

Circuitry

Having explained the practicalities of wiring, we now need to look at the necessary circuits so we know where the wires are to go. All starters are supplied with a wiring diagram, often inside the starter box (Photo. 18). I have drawn the wiring diagram and the P.T.B. switch as it applies to the MEM starter, Model No. 42 ADS, in Fig. 7.

A different make and model of starter will have a different diagram, of course, but the principles are the same. Please note that on the diagram, where wires pass over each other no electrical connection is intended unless a small spot at the intersection indicates this. If you are not too happy about doing the wiring, then it is probably best left to an electrician. However, if the wiring is done on a logical basis and one wire at a time, it isn't really difficult. Make sure that the starter box, motor, P.T.B. switch, conduit and saw frame are all earthed. Starters have an earth point mounted on the inside of the box. This can be used to connect the incoming green and yellow earth wire of the supply cable from the 13 amp. plug. The same connection can also be used for the cable going to the motor and to the P.T.B. switch. The motor will have an earthing point on the metal frame, usually on or near the removable cover for the main connections. The P.T.B. switch has an earthing point inside the case. The latter is metal and should earth the saw too, because it has been screwed to the saw frame. It may be necessary to earth the copper conduit in the way already described. A check can be made for earth continuity with a multimeter set to measure ohms or with a battery and bulb, with the plug removed from the socket, of course.

Before leaving the electrics section, may I respectfully give a word of warning, particularly to beginners. **240 volts is lethal** and when checking and/or adjusting any wiring, please **always remove the plug from its socket**. In that way you will be safe.



Improved gib strips

Now to the last modification. It concerns the slide bar bearing surfaces. First the gib strips. As supplied these are made from aluminium strip. This material at least passes the different-metal-on-bearing test as previously discussed for the connecting rod bearings, but is not as good as one of the copper alloys or cast iron, since the latter have lower friction properties. The drawing shows the details of the gib, Item 5b. I used 1/8 x 3/4in. brass strip. Again, this is quite a simple modification, easily completed. The gib needs to be prevented from floating out when in use, so the gib screws serve the dual purpose of preventing float and adjusting the clearance of the saw bow on the slide bar, by means of a shallow hole positioned where each screw the gib against the slide bar. The position of the hole can be marked by fitting the completed gib into the saw bow, fitting and tightening the screw. This will nip the gib hard against slide bar and mark the required position. The size of the hole should be clearance for the screw. A word of warning here. If a twist drill (particularly a new or freshly ground one) is used on brass, you may find that it will snatch and/or cause the workpiece to rise up the drill, in spite of it being gripped in a clamped down vice. To prevent this, a small flat is ground on the lips of the drill as shown in Photo. 19. It perhaps should be said that drills for brass should have straight flutes (no helix), and these are probably still available - at a price.

Non-ferrous slide pads

What I have called the slide pads, item 5a, were fitted fairly recently, and the

modification came about through some hard use. During a long sawing session, the saw was heard to be slowing down and it almost stopped. Close examination revealed some 'scuffing' (metal sliding parts tearing bits out of each other). This can be seen in Photo. 20 as a deep scratch. I discovered that the slide pads were (what I believe to be) mild steel. The slide pads were painted over and I had no reason to suspect a problem. I thought the slide pads would be made from cast iron, so steel ones were a surprise. The old slide pads were removed by drilling out the rivets, and new ones made from brass. Since I hadn't a wide enough piece of strip, suitable lengths of 1/4 x 3/16in. strip were silver soldered long edge to long edge and machined flat on both sides in the four jaw chuck. The pieces were then cut and filed to the profile of the original pads. The holes for riveting were located by clamping the new pads to the saw bow and drilling through the original holes. Getting rivets of the required length may be difficult, so 1/8in. dia. annealed mild steel rod may be used, the heads being formed into prepared countersinks. If plain rod is used, it is essential that hammering is done from each side alternately, as the riveting progresses. The completed modification is shown in Photo. 21.

A final word on lubrication of the slide bar may be helpful. Because I have had to dismantle my saw for photographs, I happened to find, with the connecting rod removed, and the gibs correctly adjusted, that the saw bow was quite stiff to move by hand, up and down the slide bar. I had been using motor oil of 20/50 grade. Using thinner oil of about 10W grade has much improved the freedom of movement, so I commend it to you.

SCRIBE A LINE



A Taylor and Fenn Vertical Milling Machine

From Ray Teicher, Moe, Victoria, Australia

From 'Down Under', Hello my English friends. I spent nearly a year in your lovely country between the Scottish border, Hardwick aerodrome and the Sudan, flying agricultural aeroplanes and eventually helicopters. Trouble is, I kept hitting the ground, and am now retired at the ripe old age of 55. I have filled the last year, fanatically interested in machinery workshop, and have always been a woodworker.

Now to cut a long story short, I recently purchased a 'Taylor & Fenn M-50 A' Vertical Milling machine. It is a monster, and was built in Hartford, Connecticut, U.S.A., and the date in the power department (and it is nearly as involved as a mini power station) is 1939. The serial number is 542.

I thought I had a beauty when I first laid eyes on it, but when I got it home I found there was no rust, no damage to any of the nuts and bolts, nothing broken, the gears, spur, bevel, worm and rack show no wear. All the ways are in excellent condition, the whole beast was just covered in grease and gunge, and underneath I am finding a real Cinderella. So far, the only major replacement is going to be the two duplex bearings in the quill sleeve, and that is mainly through dirt ingress. I suspect a swallows nest fell into it.

I am writing a manual for it as I dismantle it completely for refurbish to new, painted hammertone sea green to show off the polished handles, levers and graduated dials, etc. Sounds yuck,

but is beautiful to behold. But I have no handbook, and I would dearly love to have either an original maintenance manual, or a good photocopy. I have never seen one before, and have never heard of the company, I don't know if it even still exists. I would appreciate if anyone can give me any history or information as to its existence. I am willing to pay full costs of the above and look forward to hearing from some kind person out there in 'swarfland'.

Please reply to Ray Teicher, 2/B Evelyn St., Moe, Victoria, Australia.

Is anything new?

From Marcos Diniz, Lisbon, Portugal

I have a couple of treasures I'd like to share with you technology buffs. I hope you'll find them as thought provoking as I did.

Item 1 - If you visit the ruins of Ostia (the harbour used by the ancient Romans), you'll find a bronze faucet, some 6in. or 7in. diameter, dated from the 4th to the 6th century A.D., that was used to turn off the water supply for the entire city, and it looks as if it was turned in a lathe.

Item 2 - In the Xi'an Archaeological Museum, China, you can see a bronze sword, dated from about 200 BC., that is described as chrome plated! They say it will still slice through 19 sheets of paper.

Alas, in neither case was I able to take a photo, or even get very close to them. But, there they are! and I would greatly appreciate some feedback on this.

Disposal of chemical waste

From Dr. R. Stephen, Hambleton, Rutland

In your Editorial in M.E.W. 42, you mention the problem of the disposal of waste sulphuric acid. This can easily be disposed of at home if the acid is mixed with a substance to neutralise it. There are lots of readily available substances that can be used, e.g. garden lime (calcium oxide), calcium carbonate (marble chippings) or washing soda (sodium carbonate).

All these substances will react with the acid to form a totally harmless product. In the case of the calcium compounds, the acid forms calcium sulphate, and with the sodium carbonate it forms sodium sulphate. Both these substances can be disposed of in the dustbin without any problem to anyone. The acid is simply added to the marble chips etc. contained in a plastic bucket big enough to contain everything. Initially the mixture will fizz like mad, giving off carbon dioxide. The acid will be completely neutralised when all fizzing stops. What is now left is a quite harmless mixture of water, calcium carbonate and calcium sulphate.

It would be perfectly safe to throw it away in the garden.

Changewheel information

From A Hennessy, Dublin, Eire

I note your request for data on change wheels for various lathes. My lathe, bought for £40 about 35 years ago, is fairly unusual, though I occasionally see one offered in the secondhand lists.

It was manufactured by the Logan Engineering Co. of Chicago, Illinois, and is somewhat similar to a South Bend, with raised vee ways. Its main vital statistics are as follows:

Between centres:	24in.
Swing over bed (no gap)	10 1/2in. diameter.
Headstock spindle:	Ball bearings 3/4in. bore clear. No. 3 M.T.
Spindle nose:	1 1/2in. dia. x 8 TPI.
South bend attachments for 9in. or light 10 lathes will fit.	
Tailstock spindle:	No. 2 M.T.
Drive is by a three-step flat pulley. Together with backgear and a two-step motor pulley this gives a range of 12 speeds from 25 to 1200 r.p.m.	
Power cross-feed is available	
Leadscrew:	8 TPI.

The change wheels are as follows:

D.P.:	16
Pressure angle:	14 1/2 deg.
Width:	7/16in.
Bore:	5/8 in.
Keyway:	1/8in. wide

The standard set was as follows:

16, 18, 2 x 24, 2 x 32, 36, 40, 44, 46, 48, 52, 54, 56, 2 x 60, 64, 72.

With these all standard American and British threads can be cut, and fine feeds can be set up.

Some wheels were missing when I bought the lathe and others were damaged. I succeeded in casting three new teeth into the 72T wheel many years ago, using the sound teeth. The fix is working perfectly still. However, by diligently scouring scrap yards with a sample gear in my pocket I have amassed an extensive collection of gears and have had considerable fun converting them to serve in my change wheel collection. Hardened gears have to be softened and usually they have to be bushed and bored to 5/8in. I have found that this can be done with sufficient accuracy by simply holding the gear in a good 3-jaw chuck (about 98% of the time!)

I have also found that for change wheel (or dividing) duty, where the loading is light, 20deg. and 14 1/2deg. pressure angle gears can be run together successfully.

Among my extra wheels are ones of 21, 27, 42 and 50 teeth. These enable me to cut metric threads using the ratio 200:63 which equals 3.174603.

1/8in. = 3.175mm so the above ratio matches this with an error of only 1 part in 8000. As this is only 0.01mm in 80mm, I think it is as accurate as is needed for any purpose unless you are making precision leadscrews.

I give below a table of change wheels to cut some metric threads. The first and third in each line are drivers; the second and fourth are driven. Idlers to be interposed as required:

Pitch mm	Driver	Driven	Driver	Driven
0.5	21	50	24	64
0.75	21	50	36	64
1.00	21	50	24	32
or	21	50	48	64
1.25	21	50	60	64
1.50	21	40	36	40
1.75	21	40	42	40
2.00	42	40	24	40
2.25	42	40	27	40
2.50	42	40	30	40
or	21	40	60	40
2.75	42	40	36	48
			44	40
3.00	42	40	36	32

2.75mm pitch has three pairs of drivers and driven

Other metric pitches can also be derived. Note that the 21 and 42 tooth gears are the key gears enabling the ratio of 200:63 to be set up with only two steps for most metric threads.

(The above letter is typical of a number received in response to the suggestion that we should gather data on the specification of lathe changewheels. Thanks to all who have replied. Please keep the information coming - the more the better.

Readers owning Logan Lathes may be interested to learn that spares and repair parts are still available from Logan Actuator Co, 4956 N. Elston Ave, Chicago, IL 60630. Tel. 312-736-7500. Fax 312-736-6854. Address enquiries to George or Scott Logan. Especially listed are Gears, levers, crossfeed screws and nuts, but many other parts and accessories are available, both for lathes and shapers—Ed.).

A larger lathe—information sought

From Anthony Walton, Tulsa Hill, London

I would be grateful if any of your readers could tell me the make and model of the smallest lathe with a **FOUR** Morse Taper spindle, whether in current or only former production.

Preferably such a lathe should have:
a) a **FOUR** Morse Taper tailstock, and
b) a flat (not vee) bed, even if the flat bed is split down the middle, and
c) the modern geared head for screw cutting.

But the main requirement is a 4 MT spindle.

South Bend lathes

From B.T. Kyle, N.S.W. Australia

I am writing to you in request for information on South Bend lathes. I have been a subscriber to your magazine for

twelve months now and I have seen articles that contained photographs of these lathes, with which I gather that their owners are very happy. The reason for this request is to become familiar with the different models that were made and exported to this country, as there are sometimes secondhand machines for sale in the local paper, which I gather would be older models. I have a lathe at the moment which is Chinese; it is my first lathe and although it is quite simple in design and accurate in its machining, the quality is just not there. If you could help with this request or advise me of someone who may be able to help with information about

these lathes, it would be very much appreciated.

Request for a cutting speed spreadsheet

From Mike Atkinson, Nr Callington, Cornwall

I find a lot of the information in your Data Book invaluable, particularly the thread details and am sure much of the other information will be of use to me once I have moved on from the beginner stage.

I seem to remember reading somewhere your request for other details that might be of use. I am therefore wondering if you might supply a set of cutting speed tables for use on the lathe and milling machine.

I have a list I did find for milling which improved the finish I have been getting as I was running a too slow a speed but what really brought the matter to light, was when I bought one of the Arrand 16mm index tipped mills and found that it should run at 2900 rpm.

I telephoned Arrand to check that my maths was correct and their technical department assured me they had been run at 4000 rpm in aluminium.

Some form of table giving rpm based on diameters of various materials for HSS & index tips would be very useful. I personally rely on index tips as they give a superb finish, last well and do not need any expertise or special machinery to re-sharpen them.

I have been trying to get a spreadsheet to list the materials and sample cutting speeds with a view to getting the calculations done by spreadsheet, but so far no success. I seem to be struggling here as well.

I hope the suggestion is of use to you, meanwhile I will have to get my pocket calculator out and estimate the rpm

based on the little information I have. (Has any reader constructed such a spreadsheet which he would be willing to make available to others?—Ed.).

Back numbers of M.E.W. and a search for a DC speed controller

From A. J. Frost, South Wigston, Leicestershire

I have been a regular subscriber to Model Engineers' Workshop from issue No. 18 and, wishing to obtain a full collection, have managed to purchase many back issues, but it is frustrating to find that most of the earlier issues are now not available. I cannot obtain issues No. 2, 4, 9, 11 & 14, and I am informed that there is no intention of reprinting any of these. I feel that there are many individuals like myself, who would appreciate the opportunity to obtain a full set. Surely, it must be to your financial benefit if all back issues were available, even as photocopies.

I have been attempting unsuccessfully to build a 110V DC Speed Controller for a shunt wound motor (Table Traverse for a Bridgeport Series 1 Universal Milling Machine) and although I have made many successful electronic projects, from computers to other diverse circuits, I have also had failures, and the DC Controller featured in Issue 3 (Winter '90/91, page 60, ref. E Hadden Deering) constructed for the above motor, was one of them. In Issue 5, Scribe a Line, G. Bartlett (page 59) makes a passing comment to the H-D circuit that this be avoided "mistakes and all". I suspect that some correction was made in Issue 4, but since no back issue is available, the project has been put in the drawer gathering dust.

I have also purchased the two Nexus Workshop Practice Books on Electric Motors by Jim Cox, finding them both to be extremely informative, but again an attempt to adapt the circuits within for 1/2hp DC has not proved successful. If any reader has successfully built a speed controller that will operate with the 370 watt shunt motor described, and which is suitable to operate a milling machine table with the varying feed rates required for machining, then I would be obliged for any details, or of any successful adaptation of the other circuits mentioned.

Still room for the vertical slide

From Richard Atkins, Wanganui, New Zealand

The Editor's Bench for Mar/Apr '97 quotes a visitor from Australasia as saying "Why not buy an Asian Milling Machine...", suggesting that vertical slides are old hat.

Many years ago I bought one and disposed of my vertical slides. Five years ago I moved into a retirement village, entailing a severe reduction in available space. Result, a vertical slide ordered from Warco, and the mill and other gear disposed of.

We have to adjust to circumstances.

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