No.56

MODEL ENGINEERS' WORKSHOP

THE PRACTICAL HOBBY MAGAZINE

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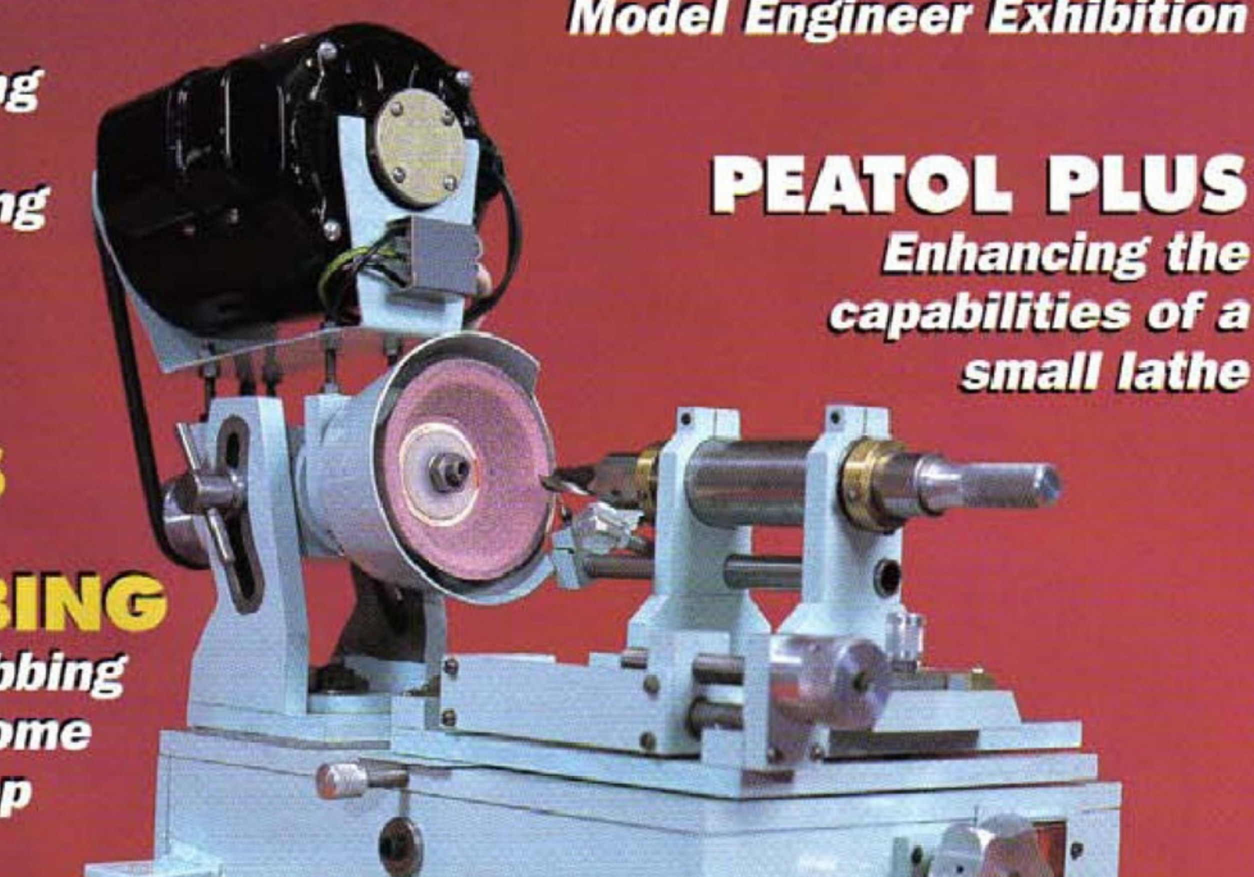

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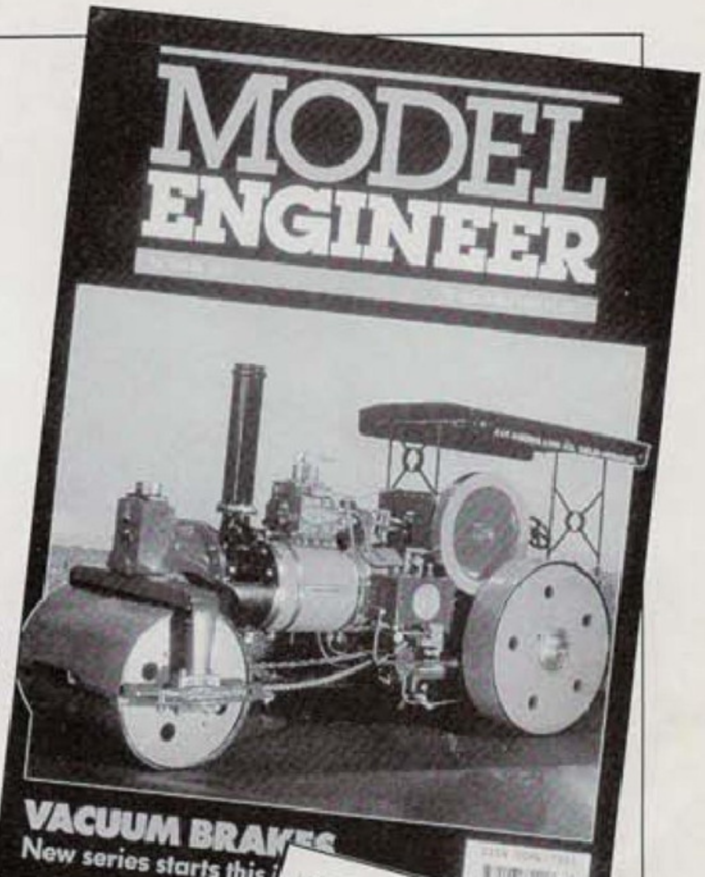
...every fortnight



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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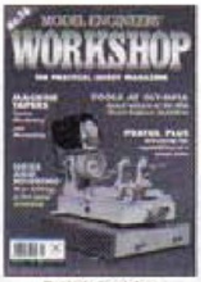

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On the cover

Paul Bowler's workmanlike tool and cutter grinder was awarded a Highly Commended Certificate at the recent Model Engineer Exhibition, held in conjunction with the International model Show at Olympia, London.
(Photo. Jon Jolliffe)

More well constructed tooling at Olympia. These items were displayed on the stand of the St. Albans and District Model Engineering Society.

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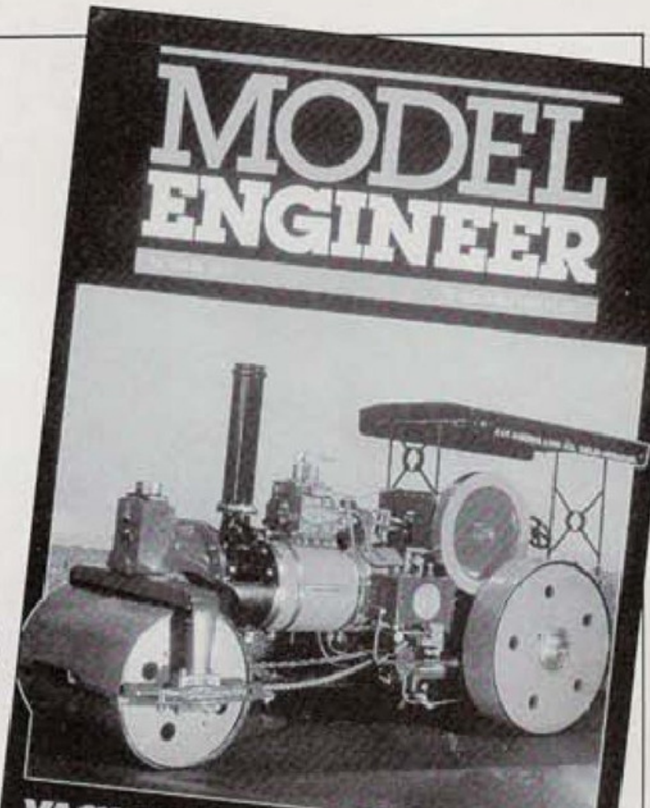

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ON THE EDITOR'S BENCH

May I first thank all those readers and contributors who sent greetings at Christmas and New Year? It is always a pleasure to hear from you and to receive the kind words you send regarding your enjoyment of the magazine. Even better is the opportunity provided by the Olympia Exhibition to meet many of you in person and to be able to exchange views first hand. Your constructive comments provide a fresh impetus when it is time to get back in the office and grapple with the computer.

Looking back at Olympia, I felt that this year the Model Engineer Exhibition had a better sense of identity within the wider International Model Show than we had seen for some years. The central 'village' which last year had been the focus for the celebration of the centenary of Model Engineer magazine was retained, but this time was used to show how the clubs and societies contribute to our hobby. Last year was obviously a time for looking back, so this time a number of us were of the opinion that we should be looking forward, to show how the newer technologies and methods are becoming an integral part of model engineering.

There was no better illustration of this than that provided by the Gas Turbine Builders Association, on whose stand were notable examples of components made using techniques that would have been thought out of place in the home workshop just a few years back. Once again, the crowds round their stand demonstrated the interest which has developed in the subject, and as soon as there was a hint that one of the engines was about to be fired up in the i. c. engine area, then the spectators came running - literally! Other clubs were putting on demonstrations of such subjects as computer aided design as it can be applied to model engineering and the computer analysis of steam engine valve gear.

The usual demonstrations of machining techniques attracted the spectators as always, most of whom had some question or other for those manning the machine tools, so that, as is often the case, there was more talking than metal cutting- but that is the real reason for this activity. To balance the new technologies, The Society of Ornamental Turners were showing that the longer established arts are also growing in popularity.

The Competition and Loan displays were less well supported this year than for some time, but it is accepted that the number of exhibits tends to be cyclical, as many projects take more than a year to complete. It has been thought for some while that the location of the exhibition has not been ideal, access to Olympia to deliver models having become progressively more difficult as the surrounding car parks have been built on. This has been one of the reasons for the decision to seek another venue, the next exhibition being at Alexandra Palace in North London during the second week in December.

Despite numbers being slightly down, the quality of entries in the Tools and Workshop Appliances section was as high as ever, and it gave me great pleasure to see that Peter Rawlinson's CNC Milling Machine was awarded a Gold Medal and also the Bowyer-Lowe Trophy. Reaction to the constructional articles we have been publishing in these pages had already indicated that there was likely to be great interest in this project, and so it proved, with many visitors studying the machine for considerable periods, then seeking out a steward for more information. Sales of the back numbers containing the earlier instalments were brisk. Congratulations must go to Peter for developing a very practical machine tool which was displayed complete with the eight lobed i. c. engine camshaft which was machined with the aid of the CNC dividing head described in this issue. Equally, I feel that congratulations are also due to Richard Bartlett who developed the interface which is interposed between the computer and the stepper motors, because without this the task would have been much more difficult.

Two Silver Medals were awarded this time, one to Geoff Allen who was the previous recipient of the Bowyer-Lowe Trophy for his compound tilting table. Geoff had taken notice of the comments of the judges over his choice of material, and this time produced a new version in cast iron, complete with impressive patterns. Dr. Peter Clark exhibited more of his high-quality tooling, this time a versatile pantograph attachment. As I have mentioned before, it is always a delight to examine one of Peter's projects as the presentation is always impeccable, with a full description of the device and its operation. He has promised to tell readers how he achieves such a marvellous finish without the use of a surface grinder.

The one Bronze Medal went to Maurice Turnbull, another of our contributors, for his toolpost milling attachment, a device with which he was able to machine the long slender leadscrew which was shown as part of the exhibit. An article on this attachment is in preparation.

Two Highly Commended Certificates went to Thomas Husband and to Paul Bowler, the first for a group of attachments including a rotary table, a dividing head and tailstock and a hobbing attachment, while the second was for the tool and cutter grinder shown on the cover.

Our friend Barry Jordan brought more of his miniature machine tools, which the judges decided were better classified as working models in the General Engineering section, as they were likely to be at a disadvantage if judged as practical machine tools. Barry was rewarded with a Gold Medal for his Archdale Radial Arm Drill, while the Clarkson Tool and Cutter Grinder gained a Silver. Another interesting model in the same section was the Scrap Cutting Guillotine which brought a Very Highly Commended Certificate for John Walton.

One of the pleasures of the exhibition was to see the number of young people present, many taking part in the activities which had been arranged especially for them. It was interesting to see that, although the materials have changed, constructional sets seem to be as popular as ever and, in these more enlightened times, with the girls as well as the boys. Both sexes were also represented in a well supported Junior competition section with, among others, the pupils of Truro School bringing a crop of small steam plants and going away with a fair return in medals and certificates. Their efforts were further rewarded when the judges decided that the Students Cup should be added to the collection. We detected the influence of a dedicated and inspirational craft teacher. More power to his elbow!

From much further north came another Gold Medal winner who, as a school project had designed and made a neat 4in. rotary table, based on an existing worm and wheel. Accompanying the final article was the pattern for the base, which showed evidence of modification after a false start which resulted in one scrap casting. As is usually the case, 15 year old Edward Proffitt probably learned more from the failure than he would if he had succeeded at the first attempt. We await his next project with interest.

Although not strictly within the ambit of this magazine, we cannot resist commenting on the work of a lady entrant in the Scenic Diorama, Architectural and Representational Models section. Mrs May King's view of 'The Model Engineer's Workshop 1998' was just perfect. A miniature garden shed was well equipped with working lighting and machine tools which could be set in motion by a set of switches concealed in the base. A full complement of hand tools was in evidence, as was the latest project, a copper locomotive boiler nearing completion. Mrs King should feel well rewarded, not only by the Highly Commended Certificate, but by the pleasure that was given to the many model engineers who inhabit such lairs.

A FIXED STEADY WITH BUSHES

George Swallow of Dorking, Surrey revives an old idea which ensures rigidity when turning longer workpieces and which facilitates setting-up

Having recently upgraded my lathe from a Portass to a Myford , I am having to re-make all the useful add-ons that have served me well for years, but which do not fit the Myford centre-height.

The most indispensable of these accessories, which I have never seen described in MEW, is a fixed steady with exchangeable bushes instead of the usual movable fingers. As the Portass had only 3/8in. through the headstock, this steady has been in regular use for quickly facing and centring the ends of bars prior to turning between centres. I do not claim that it supplants the ordinary form of steady, but it is certainly a great deal quicker to use, and almost every one of my jobs has started with it in place.

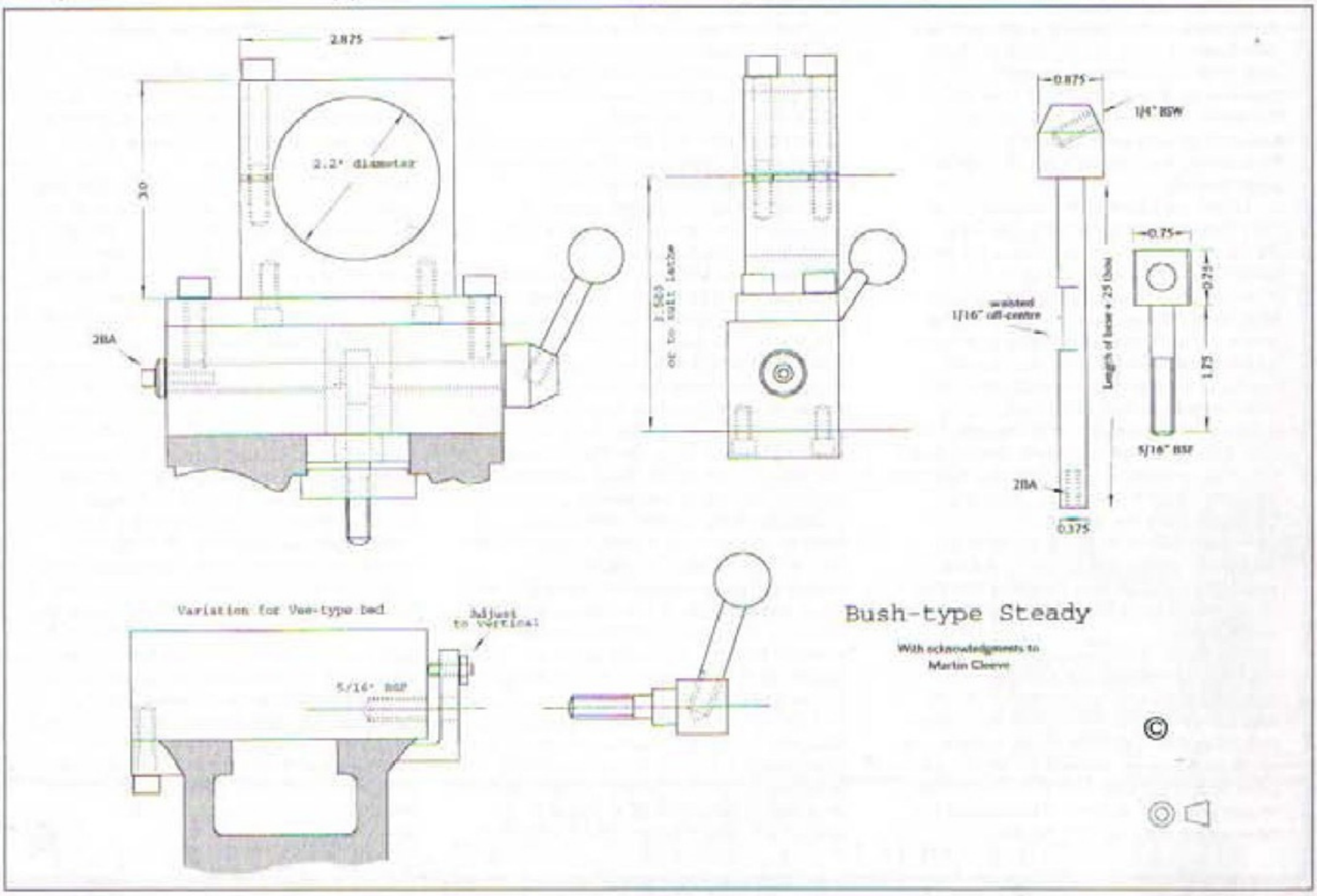
The idea for this steady, and the first version of it, came from the instructions accompanying the Dore-Westbury miller kit, but I found later that the same idea had been published in ME about twenty years earlier by Martin Cleeve, and it is his version from 1957 which I have made this time and which is described here, with the drawings more or less as he presented them. Besides its use as a steady, it can be used as an outrigger bearing for a mandrel carrying a slitting saw or a milling cutter. Martin Cleeve's original version was designed to facilitate parting off 15ft bars into shorter lengths, and he said he had a bushed hole in the shed wall as well!

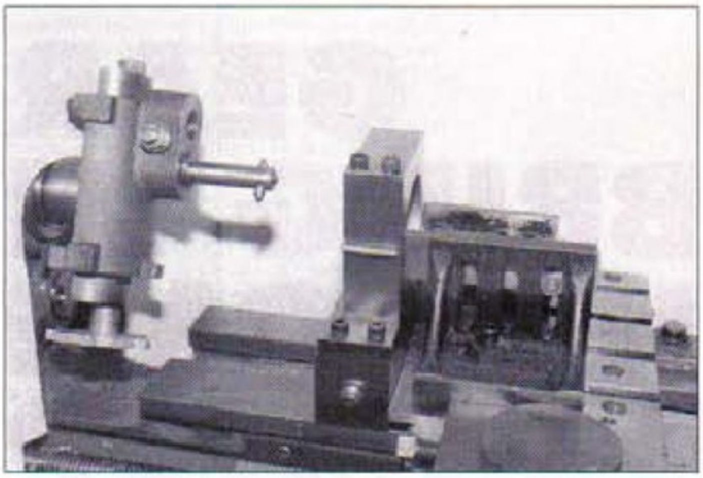
I have given very few dimensions because they are mainly not critical. The fundamental requirements are that the hole in the steady lines up truly square with the axis of the headstock and that the locking arrangements on the bed make sure that this alignment is repeatable. The guide that fits between the shears of the bed must therefore be a very close fit. The various parts are held together with socket head screws, all 1/4in. BSF except for the four 2BA ones holding on the guide for the bed. Only the larger bushes are made wholly of bearing metal; the smaller ones fit into what Martin Cleeve called an 'economiser' of mild steel.

I should perhaps confess that some of the heavy boring and drilling was done at evening classes on a much larger lathe than mine, and I apologise if some gruelling operations seem to be described too casually or passed over. The 7/8in. hole in the base, for instance, took about ten minutes, including the setting up, with a 7/8in. drill in the tailstock. If evening classes are available in your area, they are worth going to, even if you have your own workshop.

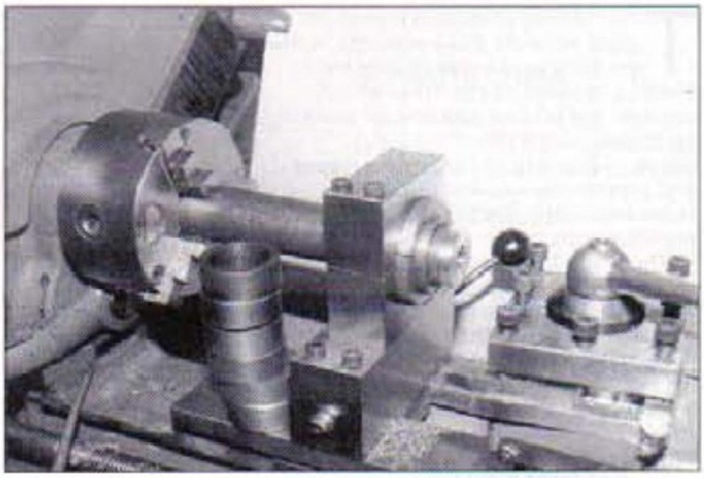
Construction

The construction should be started with the base and the locking device which, on my new version, uses the same cam





1. Finally skimming the bore to size



3. The steady in use

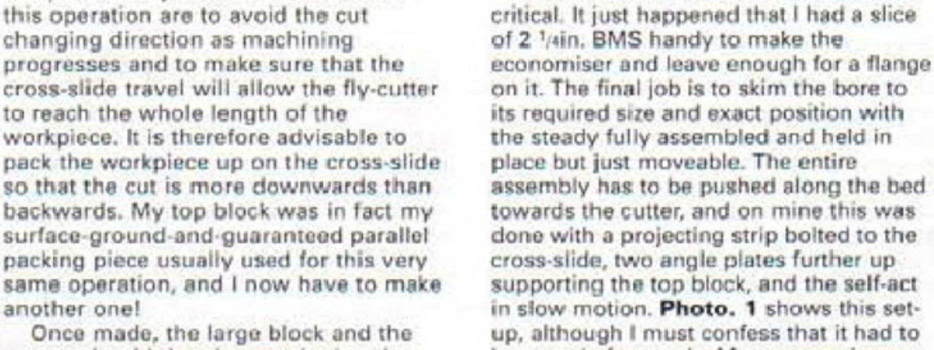
arrangement as on the Myford tailstock. The locking lever runs in a 3/8in. hole all the way through, which passes though 7/8in. transverse hole housing the cam and the drawbar.

I was fortunate to have already a finished piece of BMS the right size for the top block, cannibalised from another redundant Portass accessory. This, in its earlier guise, had been too big for the chuck and had been finished by sweep-facing, clamping the block against an angle-plate on the cross slide and facing each edge in turn with a fly-cutter on the faceplate. The particular hazards with this operation are to avoid the cut changing direction as machining progresses and to make sure that the cross-slide travel will allow the fly-cutter to reach the whole length of the workpiece. It is therefore advisable to pack the workpiece up on the cross-slide so that the cut is more downwards than backwards. My top block was in fact my surface-ground-and-guaranteed parallel packing piece usually used for this very same operation, and I now have to make another one!

Once made, the large block and the spacer should then be attached to the base and the centre of the large hole marked with a centre-drill held in the 3-jaw chuck. A circle can then be scribed from this mark, about 1/8in. undersize, for the large hole to be bored. Having done this marking out, the block can be taken off and the bulk of the waste removed, either by boring in the chuck (if it is big enough), or chain drilling and sawing. It can also be screwed to the faceplate with spacers and the screw holes plugged afterwards. Obviously, the centre of the hole disappears during this operation but the reassembly and final boring in situ will cure this. It occurred to me whilst the boring tool was rattling round my chain-drilled holes that aluminium would have been a better choice than steel for this block.

The 2.2in. dimension of the hole is not critical. It just happened that I had a slice of 2 1/4in. BMS handy to make the economiser and leave enough for a flange on it. The final job is to skim the bore to its required size and exact position with the steady fully assembled and held in place but just moveable. The entire assembly has to be pushed along the bed towards the cutter, and on mine this was done with a projecting strip bolted to the cross-slide, two angle plates further up supporting the top block, and the self-act in slow motion. **Photo. 1** shows this set-up, although I must confess that it had to be posed afterwards. My camera chose the original occasion to breathe its last and produce a blank film.

If no graduated boring bar is available, it is better to make the hole approximately the right size and then make the economiser and bushes **(Photo. 2)** to fit whatever size it turns out to be.



2. The 'economiser' and some of the bushes

After this boring is complete, it should not be taken to pieces again, so the slit at the front and fitting the clamping screws should have been done before the final skimming. A thin piece of metal can be inserted in the slit so that the clamping screws can be tightened up.

Contrary to expectations, a vast number of bushes is not needed. Going from 1/2in. to 1 1/4in. by eighths and from there to 2in. by quarters is quite sufficient and accounts for only ten, although metric sizes may now have to be accommodated as well. Most of my bushes have been made from slices cut from cast iron sash window weights, but for the larger sizes, I have found non-domestic gunmetal plumbing fittings to be a good source. DIY shops rarely stock these, so you may need to browse round a wholesaler's warehouse. For a special size or a one-off occasion, even BMS can be pressed into use, and I have done this occasionally (with the bush held on with a grub-screw) to enclose square and hexagon bar, which would be a trifle noisy with the fingered form of steady!

Standard round bar is usually a thou or two undersize, and the bushes can be made to fit. The classic way of getting concentricity is to turn both the outside diameter and bore the hole at the same setting, but this means a chucking piece to cut off and some waste on each bush as well. For the sizes up to 1 1/4in. I did all the bores first and then turned the outsides on the same nutted spigot, reducing it successively for the next smaller size.

Using the steady

In use, the stock to be turned should be wiped clean with a paraffin rag and then oiled at the point where it is in the bush. For facing and centring of stock bars, it will be sufficient to use the 3-jaw chuck in the ordinary way, but to hold a mandrel and a milling cutter, the 4-jaw and clock-dial may be needed to ensure true alignment of both ends.

This steady has for many years provided me with a halfway house between evening classes and home, and **Photo. 3** shows it in use. Once you have one, you will wonder how you ever managed without it.

GEAR HOBBING IN THE HOME WORKSHOP

Part 1 - HOBS & HOBBING

The production of gears by the hobbing process can be achieved in the home workshop with the aid of a number of home-built items of tooling and equipment. This article is the first of a short series in which the process will be explained and suitable equipment will be described. Here, Ivan Law, an acknowleged authority on the subject and author of the Workshop Practice Series book 'Gears and Gearcutting' explains the fundamentals.

The hobbing process is one of the most accurate ways available in the production of involute gear teeth. Model engineers, in the main, do not consider the process suitable, or even applicable, to the home workshop believing that it is an industrial process and outside the scope of our - in comparison to industry - sparse and primitive workshops.

There are, I believe, a number of reasons for this attitude; one is the lack of understanding of the fundamental principle governing the functioning of both hobs and the hobbing process. Another is the high cost of suitable commercial hobs. It is true they are expensive, but surprisingly the cost of a hob for any given DP and pressure angle is usually less than a standard set of eight form cutters. A third reason is the belief that suitable hobs cannot be produced with the equipment we have at our disposal; and, finally, if we do have a suitable hob we do not have a machine on which it can be used.

I understand it is the editor's intention to deal with these problems in future articles in M.E.W., and I have 'volunteered' to introduce the series by discussing in simple language what a hob is and how it functions.

Understanding the requirement

I have said many times, in connection with a variety of subjects, but it is worth repeating because of its relevance, that when faced with a problem it is necessary to first of all understand what the problem is. Once that is fully understood then a great step forward has been made towards finding a solution. We will therefore begin by looking at the shape of a gear tooth and why that shape is needed.

Gear tooth profile

A gear is far more than a disc with slots in its periphery. Gears with incorrectly formed teeth may, for a while, transmit motion and therefore power, but to keep on working effectively and efficiently the teeth must have a definite and specific profile. There are a number of profiles that can be used, however, these articles will only consider teeth based on the involute curve. The reason for this is that the majority of gears produced to-day are based on the involute curve, as this shape is ideally suited to the generating methods used in modern production engineering.

Although model engineers, in the main, cut their gears one tooth at a time using a suitable form cutter, as opposed to a generating process, the involute profile is almost always used.

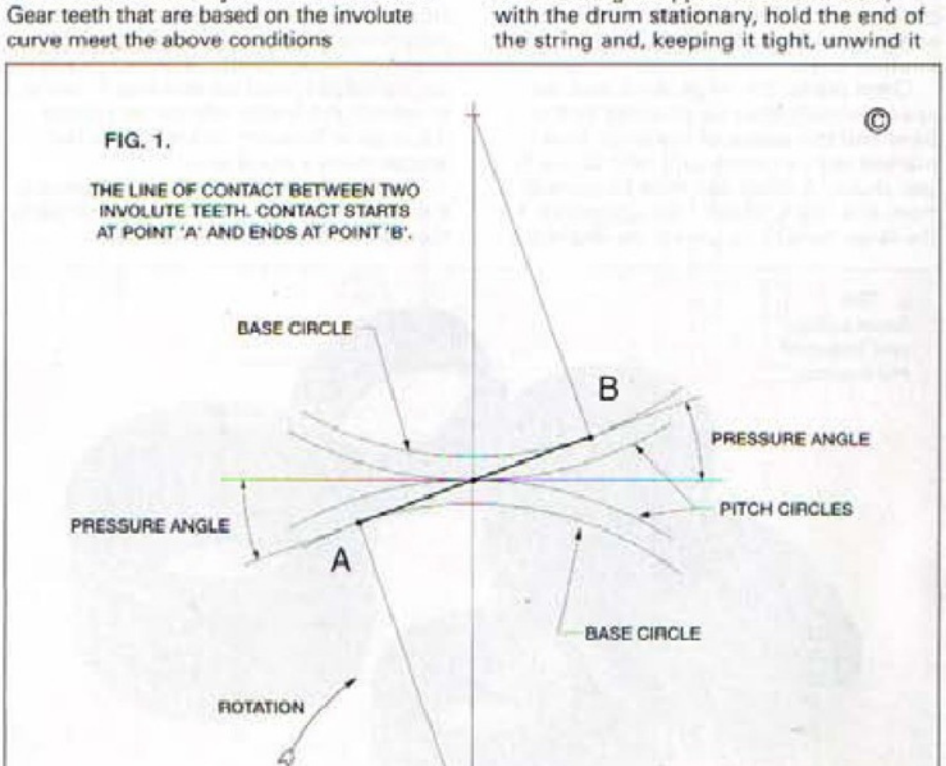
Just what performance are we trying to obtain from a gear tooth? First of all, the gear teeth must not rub on each other, as this causes friction, heat and rapid wear. In order to reduce friction to a minimum, this phenomenon being the enemy of engineers, the gear teeth must push on each other but not slide. They should roll on each other along the line of contact until the point of disengagement is reached. As a matter of interest, the line of contact between two involute gears is a straight line along the pressure angle, as shown in **Figure 1**. (Much more about this pressure angle later). Secondly, and often not realised, there must be constant relative velocity between two mating gears. If the drive shaft incorporating the driving gear moves at a constant velocity then it is important that the driven shaft also moves at a constant velocity - though not necessarily at the same velocity, and not in a series of jerks and hesitations. Gear teeth that are based on the involute curve meet the above conditions

The involute curve

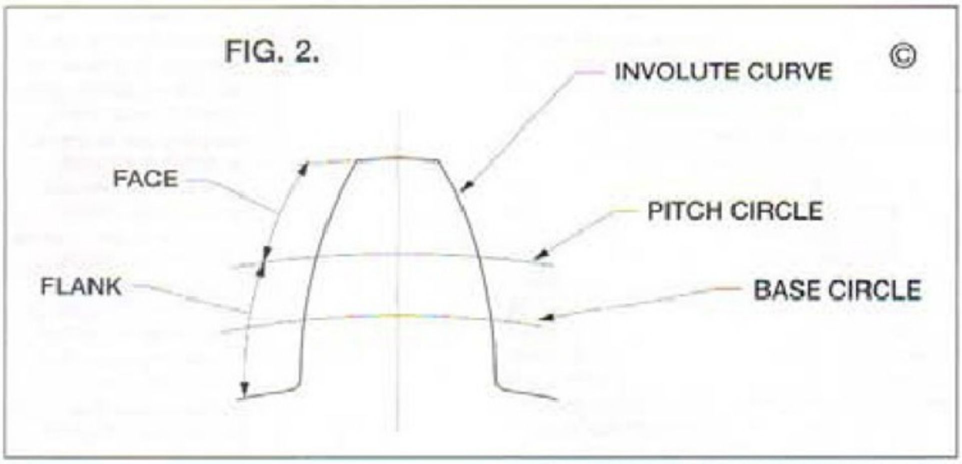
What is an involute curve? ... and how is it applied to a gear tooth profile? I will not quote the technical definition of an involute curve as it may not help! From our point of view, think of a disc or drum with a string wrapped around it. Now, with the drum stationary, hold the end of the string and, keeping it tight, unwind it

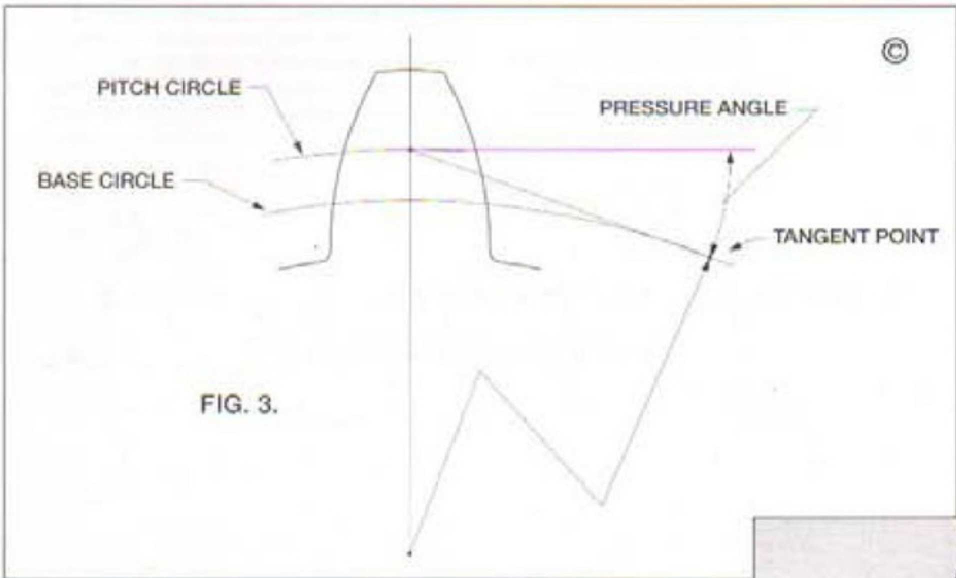
FIG. 1.

THE LINE OF CONTACT BETWEEN TWO INVOLUTE TEETH. CONTACT STARTS AT POINT 'A' AND ENDS AT POINT 'B'.



from the drum - the path followed by the end of the string will be an involute curve. The involute curve, in theory, goes on without end, but fortunately we are only interested in the small initial part of the curve, where the string leaves the drum. It can be seen from the above that the shape of the curve will vary with the size of the drum, a small diameter drum will produce an involute with a pronounced curve, a very large drum will result in an involute with a shallow curve and if the drum is of infinite diameter then the 'curve' will be a straight line. In gear tooth nomenclature, the diameter of the drum is called the base circle and is an important element in gear tooth profiles. When setting or laying out gears they are thought of as circles or discs and if the resultant gears are to run correctly, these circles, called the pitch circles, must touch each other. The actual tooth consists of two elements, the part above the pitch circle called the addendum and the part below the pitch circle referred to as the dedendum. The surface of the tooth above the pitch circle is called the face whilst the surface below the pitch circle is the flank. Since the involute curve is struck from the base circle then that is where the tooth profile begins, but as clearance in the bottom of the tooth is needed, the actual tooth profile continues for a short distance below the base circle. **Figure 2** illustrates a gear tooth and the relative elements so far discussed. It will be seen that about half of the tooth, the dedendum, is below the pitch circle and therefore the base circle must always be smaller in diameter than the pitch circle and also be concentric with it. Any pair of mating involute gears must have the same ratio between the radius of the base circle and the radius of the pitch circle. If this ratio alters then the diameter of the base circle for any given gear will alter and so will the resulting involute curve. It follows that, when considering gears, this ratio is an important element in determining the tooth profile - and so it is.

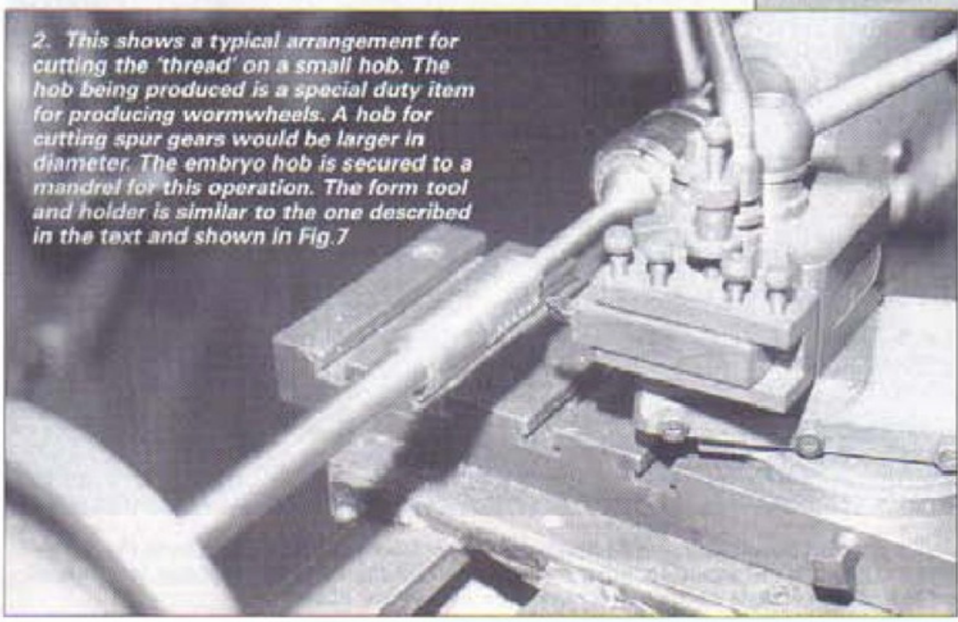




However, it is not expressed in the form of a ratio but as an angle, the pressure angle **(Figure 3)**. This pressure angle determines the relative size of the base circle in relation to the pitch circle, a factor which is most important when designing and making hobs.

1. This shows a group of hobs. The three large hobs are 'standard' hobs of differing D.P's and each can be used to produce a complete range of gears, both spur and helical.

The small hob is a dedicated one and was made to produce a special wormwheel for use in a dividing head.



2. This shows a typical arrangement for cutting the 'thread' on a small hob. The hob being produced is a special duty item for producing wormwheels. A hob for cutting spur gears would be larger in diameter. The embryo hob is secured to a mandrel for this operation. The form tool and holder is similar to the one described in the text and shown in Fig.7

Gear tooth size

We have now established the shape of a gear tooth, but not its size. A gear of, say, 3in. dia. could have 30 teeth cut on it - or even 100 teeth. Both sets of teeth could be of perfect involute form, but would not run together as their physical sizes would be considerably different. Some means or standard of determining tooth size is therefore necessary.

As was mentioned earlier, gears in the design stage are considered as rotating pitch circles and this pitch circle forms the basis when determining gear tooth size. There are three methods in use which the model engineer may encounter and the first is circular pitch.

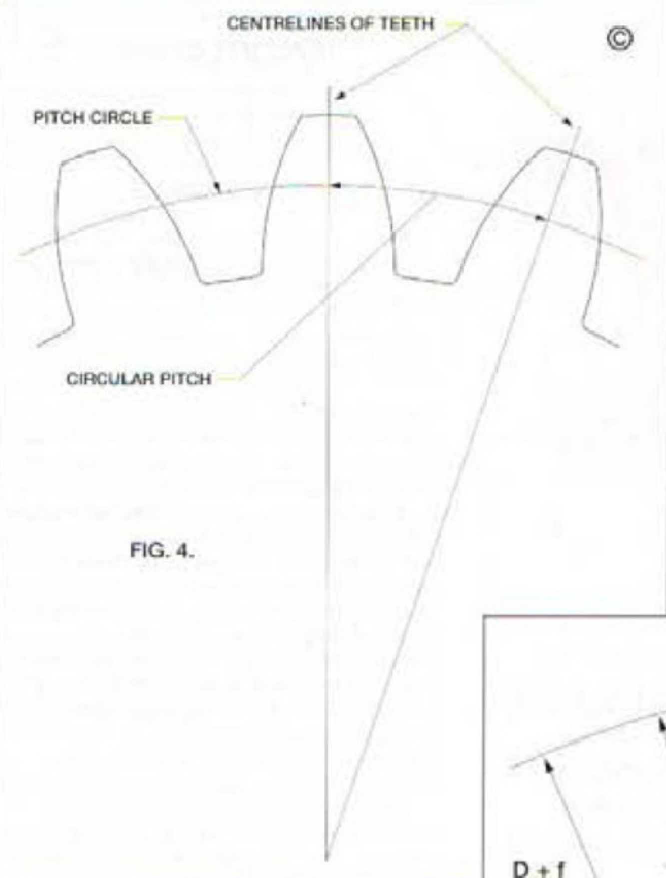


FIG. 4.

Circular pitch

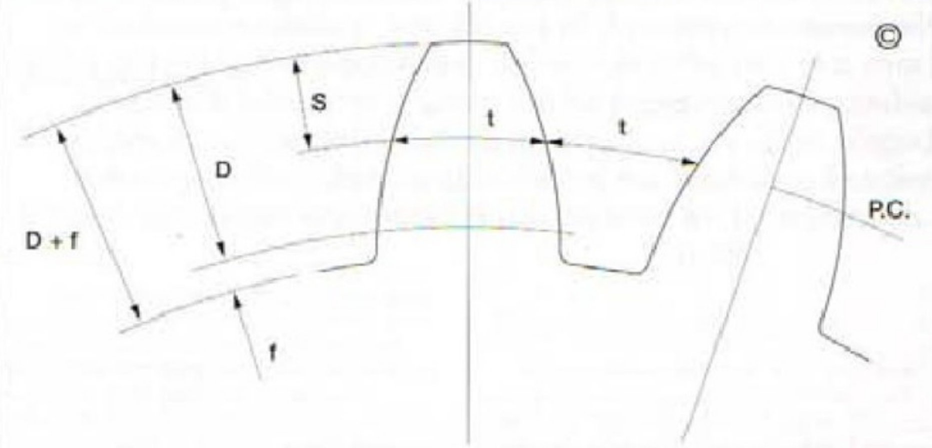
The circular pitch of a gear is the distance from a point on one tooth to the corresponding point of the next tooth, measured around the pitch circle **(Figure 4)**. This circular pitch is usually quoted as some friendly figure such as 0.100 or $^1/_{16}$ or $^1/_8$. In order to obtain the gear's basic datum, i.e. the diameter of the pitch circle, it is necessary first of all to multiply the circular pitch by the number of teeth in the gear. This must be a whole number and it will give us the circumference of the pitch circle. We then have to divide this number by pi to find the pitch circle diameter. As pi is rather an unfortunate number, it follows that the diameter of the pitch circle will be 'awkward' and therefore the centre distance between two mating gears will not be a round figure, but one quoted to at least three decimal places. It can be argued that this matters little as in the workshop an 'awkward' size is just as easy to obtain as a standard one. This may be so, but the problem is largely academic because unless the gear is going to be used in conjunction with a rack to measure linear displacement, such as down-feeds on milling machines, gears encountered by the model engineer will not be based on the circle pitch notation, but on a more popular method known as diametral pitch.

Diametral pitch

This method, usually referred to as the DP, is the most common of gear size notations, particularly when considering the size of gears likely to be encountered by model engineers. The diametral pitch is simply the number of teeth per inch of pitch circle diameter. For example, if a gear has a pitch circle diameter of 1in. and has 20 teeth, then that gear is referred to as 20DP. If, on the other hand it has 40 teeth, then the size is quoted as 40DP. A 40 tooth gear of 20DP. would have a pitch circle diameter of 2in. and so on. DPs are usually whole numbers and also even numbers, at least in the sizes that model engineers will encounter. The DP notation simplifies setting out a train of gears. For example, should it be desired to produce a pair of gears to give a speed reduction 3:1 and 20DP. was chosen for the gears, then two gears, one with 20 teeth and one with 60 teeth would give us the required ratio. The pitch circle diameter of the 20 tooth gear would be $^{20}/_{20}$ or 1in. whilst the PCD of the other gear would be $^{60}/_{20}$ or 3in. This would result in gear centres of 2in. - this being half of the sum of the two PCDs.

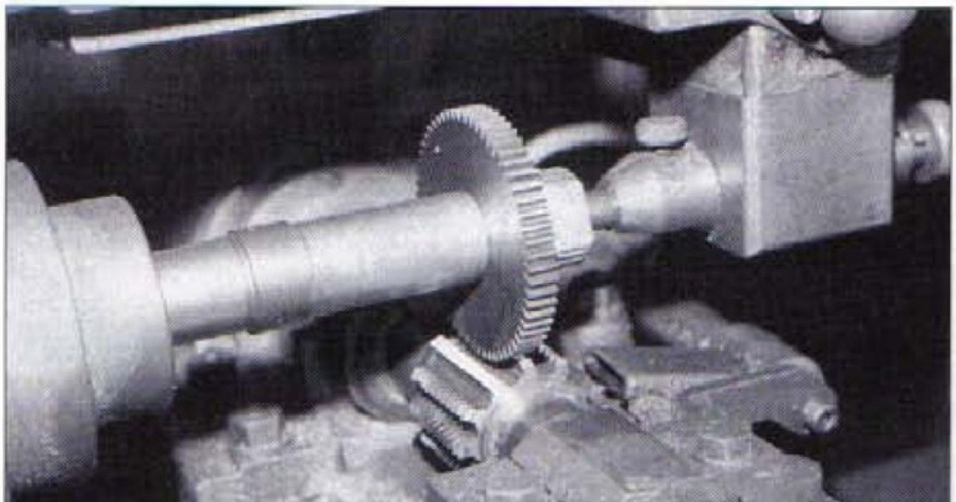
Module

Nowadays, as far as we are concerned, we can regard the module as a 'metric' way of noting gear sizes. The module is the pitch circle diameter in millimetres divided by the number of teeth, or to put it the other way round, the PCD. in millimetres is obtained by multiplying the module number by the number of teeth required. There are 25.4 millimetres to one inch so a number 1 module is the same as 25.4DP, a number 2 module would be 12.7DP whilst a 0.5 module would be 50.4DP. I believe that most of the machinery imported from the Continent has gears based on the module system.



t = TOOTH THICKNESS ON PITCH LINE = 1/2 C.P.
S = ADDENDUM = 1/DP OR .3183 x C.P.
D = WORKING DEPTH OF TOOTH = 2/DP
D + f = WHOLE DEPTH OF TOOTH = .6866 x C.P.

FIG. 5.



3. This shows the cutting of a 60-tooth spur gear. The mandrels driving both the gear and the hob are connected together by a gear box. In this case the gear box is arranged to give 60 revolutions of the hob for one turn of the gear blank

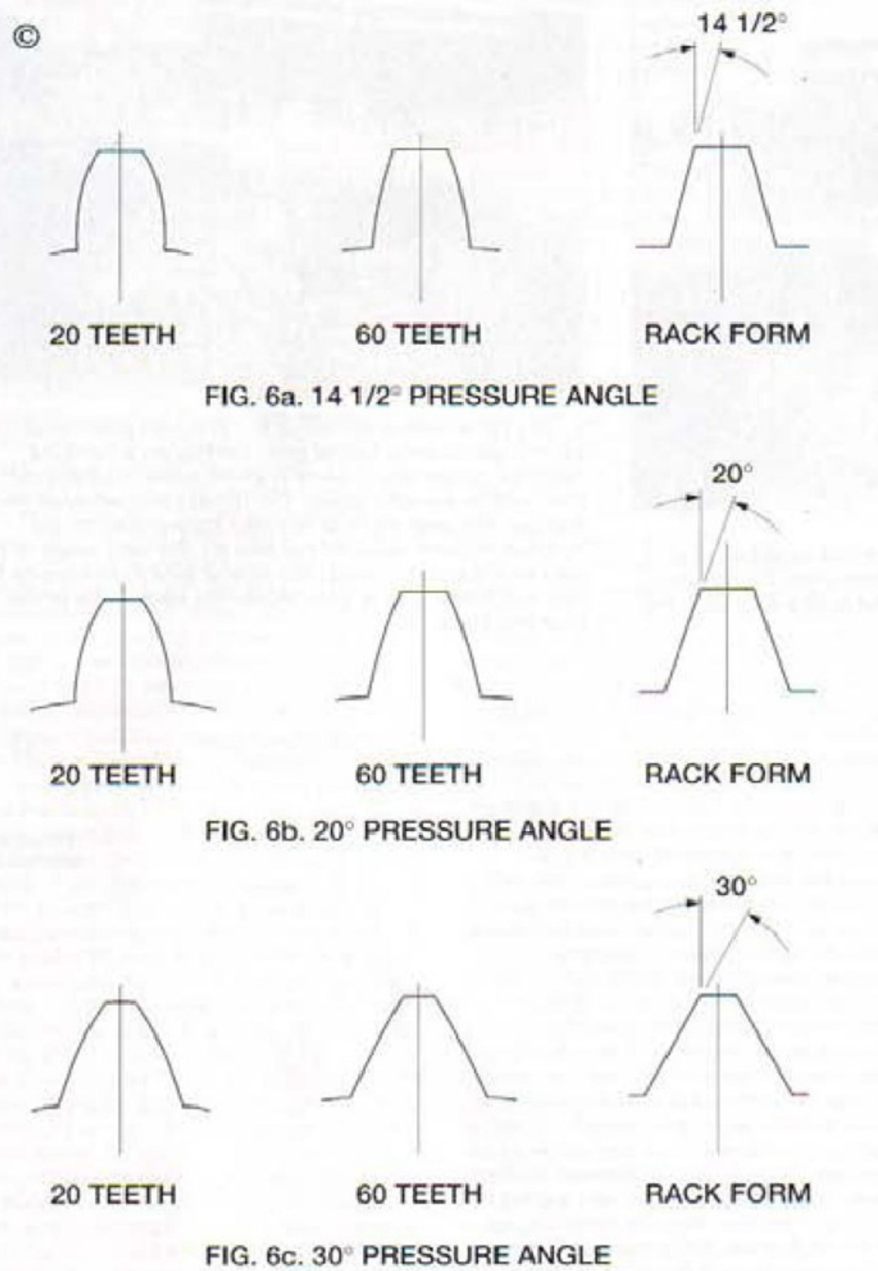


FIG. 6a. 14 1/2° PRESSURE ANGLE

FIG. 6b. 20° PRESSURE ANGLE

FIG. 6c. 30° PRESSURE ANGLE

SHOWING HOW THE SHAPE OF GEAR TEETH VARY WITH THE NUMBER OF TEETH ON THE GEAR AND ALSO THE EFFECT OF PRESSURE ANGLE.

FIG. 6.

Tooth proportions

It was stated earlier that part of the tooth was above the pitch circle and part below. Before we can determine the specific shape of any teeth, we must look at the proportions of the various elements that combine to give the complete tooth profile. These proportions are shown in **Figure 5**. The sizes quoted may be termed 'theoretically' correct and if followed exactly would not allow for clearance between the mating teeth. We know from general practice that size and size do not fit, and some small clearance must be provided. Precision gear manufacturers usually decrease the tooth thickness to about 0.48 of the circular pitch, thus making the tooth space 0.52 of the circular pitch. In practice, by our methods of production, I have found this complication to gear cutter calculation can be ignored. I usually cut my gears to the theoretical proportions shown and they usually assemble without difficulty. Maybe I inadvertently cut the teeth just fractionally deeper than theory suggests!

Some considerable time has now been spent and the word 'hob', the subject of the series, not even mentioned - but it is necessary to understand just what we are trying to achieve. You do not obtain a good tooth profile by chance! If all the above ramblings have been understood, then the rest becomes very easy.

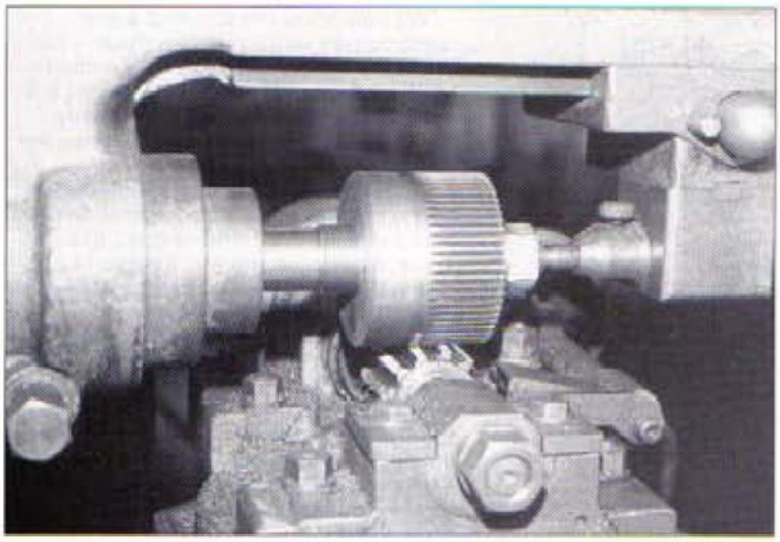
We now know the shape of a gear tooth, but we cannot cut this shape, only the space between the teeth. All cutting tools produce the same thing - swarf! It is the bit that is left behind that we really want. If we cut the teeth one at a time, the usual method employed by model engineers, then we require a form cutter that is the shape of the space between two adjacent teeth but, unfortunately, this space is not constant over a range of gears, even though they may be of the same DP and pressure angle. It follows from what has been said so far that the diameters of both PCD and the base circle from which the involute is generated will alter with the number of teeth on the gear. **Figure 6A** shows this change in shape although the same DP has been used for each profile and the same pressure angle, viz. 14 1/2 deg. The next two drawings **Figs. 6B & 6C** show the difference in shape when the pressure angle is increased to the popular 20 deg. and finally to 30 deg. It is now apparent that cutting gears one tooth at a time by form cutters can only give theoretically correct teeth if a form cutter of the correct pressure angle and specific tooth number is used. This would need a very large number of cutters and would make the process impractical. Fortunately, a small deviation from the theoretical form can be tolerated, and so one cutter may be used for a range of tooth numbers, provided they are of the same pressure angle. In fact, a series of eight cutters covers the entire range from a small pinion to a rack, but - to be pedantic - each cutter can only cut one tooth number to the correct theoretical shape.

Enter the hob

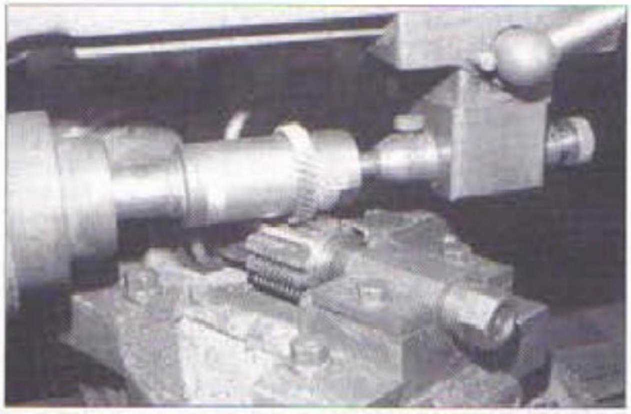
This is where the hobbing process enters the story. By this means, no matter what number of teeth are required on a gear, the correct involute form for that number will be automatically produced. It may be 20 teeth or 21 teeth or even 87 teeth, it matters not. The teeth will always be the correct shape as the appropriate involute curve is generated by the hobbing action. Only one cutter is needed for each DP and pressure angle, and all the teeth are produced with just one pass of the hob, thus making the cutting of gears much quicker and simpler, as no mis-count of the dividing head can arise because a dividing head is not needed.

The hob is a cutting tool in the form of a thread or single start worm. The shape of the 'thread' is the rack shape of tooth profile that the hob will eventually produce **(Figs. 6A/B/C)**. It should now be apparent why I have kept emphasising the importance of the pressure angle as this is the angle that determines the 'thread' form of the hob.

The hob is provided with a series of gashes or flutes that form the cutting edges of the hob where they meet the thread. In order for it to cut effectively, the teeth should be 'backed-off'. This process is outside my current ambit and will be dealt with by Dr. Parkes in the next stage of the hob story. Unlike general milling cutters, a hob can only be sharpened on its front or radial face, otherwise the tooth profile would be lost and the hob become useless.



4. *In this case six 60-tooth gear blanks are sandwiched together so that all six gears are produced at one pass. A typical time taken for this pass is about 15 minutes. The number of teeth produced is 60 x 6, or 360; this is equal to 2 1/2 seconds per tooth*



5. *The same hob as shown in the previous photograph is being used to cut a helical gear. Setting up a hobbing machine to cut helical gears is much more complicated than setting for spur gears. The speed ratio between the hob and the gear blank is not only determined by the number of teeth required but also on the helix angle of the gear and the rate of feed. The rate of feed in relation to the hob and blank speeds determines the helix angle of the gear produced*

How does it cut a gear? If the hob is secured to a rotating spindle and a workpiece is slowly brought into contact with it, the hob would (neglecting the helix angle) produce slots in the workpiece similar in shape to the teeth on the hob. Now, if that workpiece is replaced by a circular disc, viz. the gear blank, and that blank rotated, then a series of slots or teeth would be produced on the blank. The number of teeth produced on the blank would depend on the speed ratio between the hob and the blank. If the hob were to make 20 revolutions to one revolution of the blank, then 20 teeth would be formed on the blank. In other words, the number of teeth required on the gear is the same as the speed ratio between blank and hob. Now, and this is the most important function of hobbing, as the blank is rotating, the shape of the teeth produced is not the same as the straight-sided shape of the teeth on the hob. The teeth of the gear being cut gradually come into contact and out of contact with the hob teeth; in other words the gear teeth roll past and through the teeth of the hob and it is this rolling action that produces the correct involute curve that we desire.

As stated at the beginning of this article, commercial hobs are expensive, but making things is what model engineers like to do, so why not make your own hobs? It is, after all, only a screw-cutting exercise. The hobbing process has one great advantage - it is 'self-correcting'. If the angle of the tooth profile on the hob is not correct to drawing, or if the pitch is not quite what was intended, it does not matter, as all gears, regardless of the number of teeth on them, will mesh and run together perfectly satisfactorily, providing they are produced with the same hob. Another advantage is that we can, if we wish, produce our own standard. We need not keep to standard DPs or pressure angles. This could certainly be useful for anyone having trouble with high speed gear reduction boxes for use with steam or gas turbines. Increasing the pressure angle to about 30 deg. or so will result in a gear more suited to these arduous conditions and so prolong the life of the gears considerably.

Producing hobs in the lathe

As referred to earlier, making a hob or at least the threaded part is only like producing a single start worm or a coarse thread. A screw-cutting tool will be needed and this can be similar to a normal screw-cutting tool except that the shape must be similar to the gap between two adjacent teeth of the rack profile. The shape of the tool will, of course, be dependent on the DP and pressure angle required. The tools may be produced by skilful off-hand grinding but it is recommended that a tool and cutter grinder, such as a Quorn, Kennet, Stent or similar machine should be used. This special form tool is the start of the whole hobbing process and so it pays to produce it as accurately as possible. As shown in **Figure 7**, the cutting flanks of the tool are ground at the required pressure angle, thus the included angle of the tool is twice the pressure angle. If a cutter grinder is being used, then this angle can be obtained simply by using the protractor scales on the machine. It should also be possible to form the clearance angle at the same setting. The pitch of the hob (the distance from one tooth to a similar position on the next tooth - **Figure 8**) is usually very much coarser than that encountered in normal screw-cutting and this affects the side clearance. In order to cut cleanly and without rubbing, the leading cutting face of the tool must have the normal clearance angle of about 4 deg. or 5 deg. plus the helix angle of the 'thread'. The trailing cutting edge will be angled at the normal clearance minus the helix angle. This latter will result in what, with normal turning tools, would be called negative clearances. It is therefore necessary to determine the helix angle of the 'thread' before the form tool can be made, that is if the form tool is being produced from the normal rectangular high speed tool blanks. I find it easier to produce tools of this type from round material - in fact

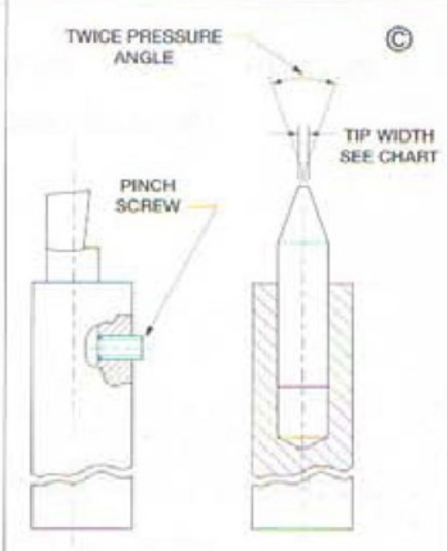


FIG. 7.
SUGGESTED TOOL AND HOLDER FOR PRODUCING THE HOB HELIX

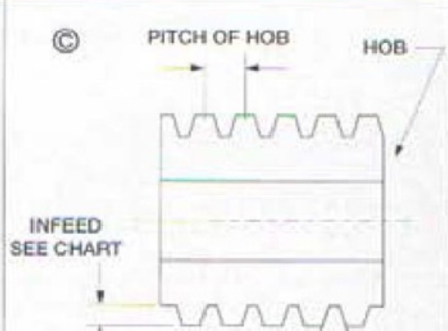


FIG. 8.
VIEW OF HOB SHOWING CUTTER, PITCH AND INFEED

this provides a use for broken centre drills! Form tools for DPs as large as No. 10 can be made from 1/4in. dia. material. It is necessary to have some form of holder when grinding small round tools. In the present case a piece of 1/2in. square mild steel about 2in. long is ideal. Drill a 1/4in. dia. hole in one end for the tool and secure it by means of a pinch screw. The helix angle of the hob can then be ignored and the tool ground, applying normal clearance and rake angles. The same holder can then be used for mounting the tool in the lathe tool-post for the screwing operation. As the tool is round, the helix angle can be obtained by rotating the tool in its holder. Using this method there is no need to worry about the true value of the helix angle; set the angle by approximation and start cutting. If the angle is incorrect you will soon find out as the cutter will start to rub on one side. Simply slacken the pinch screw, rotate the tool in the desired direction and try again. This round tool method allows the same cutter to be used for different helix angles, situations which would occur should hobs of the same pitch but different diameters be required.

When hobbing gears the only control we have in determining the tooth profile is the depth of cut, the hobbing process and the hob do the rest. It follows that, when cutting the hob, the only control we have on the hob tooth profile is the depth of cut applied to the form tool. From this we can see that the width of the tip on the cutting tool is important. The table **(Figure 9)** gives the tip width for a number of DP and pressure angles. Obtaining this tip width is not easy. There is nothing tangible to get the micrometer on to. If you have access to the equipment of a metrology department then go ahead and use it. I have not, and I am sure almost all my readers will not have either, so we have to do our best with what is available (isn't this the story of model engineering?). The method I use, and one that has proved satisfactory, is to set the micrometer a thou' or so greater than the required tip width and then, using a magnifying glass with a large magnification, grind the tool until it just enters the micrometer anvils - a slight resistance can also be felt to any movement of the cutter through the anvils. The method may not be scientific but it gives results perfectly satisfactory for our needs.

The next problem is to determine the pitch of the 'thread' and then the change wheels needed to produce that pitch. Should the hob be for gears based on the circular pitch notation, then there is no problem. The circular pitch of the gear may be regarded as being similar to the pitch required on the hob. This is not strictly correct as the true theoretical pitch of the hob should be the circular pitch of the gear divided by the cosine of the helix angle of the hob. In practice this makes little, if any, measurable effect and can be safely ignored. So, for example, if the CP is 0.100 then set the lathe to cut a pitch of 0.100 or 10 tpi. However, most gears that we encounter will be DP based and so we will have to convert DP to CP in order to obtain the pitch of the hob. It has been pointed out the advantages of the DP system compared with the CP for general gear calculation but there is a snag. To convert diametral pitch to circular pitch, we simply divide the DP into the function pi. Unfortunately pi is not what could be termed a friendly number and so any whole number divided into pi will result in an equally unfortunate number for the pitch of the hob. For example, to convert 20DP into CP divide pi by 20, which gives 0.1571 for the pitch and this, in terms of threads per inch, is 6.366! It is pointless looking at the lathe change wheel chart for 6.366, it won't be there. We have, therefore, to work out the change wheels ourselves in order to cut this strange pitch. There is a basic method of doing this termed continuous fractions. I am not going into this somewhat complicated process here, but if any reader wishes to pursue this line, then the method is described at length in 'Gears and Gear Cutting' which is No. 17 in the Workshop Practice series. A very close approximation of pi is 22/7 and we can use this to simplify our change wheels calculation. Paradoxically, using this approximation for pi can be used to advantage. It makes it possible to produce a hob that will cut a gear with a theoretically perfect pitch. If the number 35.2560329 is divided by the DP required and the hob then made with a pitch circle diameter to the number obtained, the gears produced with that hob will have a CP correct to within nine places of decimals; this, however, is of academic interest only. If we multiply both top and bottom of the fraction 22/7 by 5 we get 110/35. A 110-tooth wheel is not part of a standard set of change wheels but a 55-tooth wheel is, so the pi factor in our change wheel calculation can be 55/35 multiplied by 2. The chart **(Figure 10)** quotes the change wheels required for most of the standard DPs. These gear trains are based on a leadscrew of 8 tpi, such as the Myford 7 range. In each case the top numbers are the driving wheels whilst the bottom numbers are the driven wheels. I consider the quick-change gearbox fitted to the Super 7 series of lathes to be a tremendous time-saver as a large range of standard threads and self-act feeds are available at the flick of a lever. Unfortunately, it is of little help when cutting DP pitches. A quick-change box does not preclude the use of a normal gear quadrant or banjo. These are available from Myfords and can be fitted in a few minutes and so can suitable change wheels. It may be an added expense but it does increase the versatility of the lathe. When using any of the gear trains shown in the chart, set the gearbox to cut 8 tpi. When cutting non-standard pitches, it is not possible to disengage the feed screw half nuts at the end of each cut because it would be extremely difficult to pick up the pitch correctly for subsequent passes of the tool. The tool will have to be withdrawn at the end of each pass and the lathe reversed to the starting point before the next cut can be applied.

It is not advisable to use power when cutting pitches or threads greater than that of the lathe's feedscrew, otherwise the stress in the gear train becomes excessive. The 'power' can be easily supplied by fixing a handle on the end of the lathe mandrel and turning the lathe by hand; it will only require a few turns to cover the length of a hob blank. The handle can be made quite quickly from a few pieces of bar material, alternatively Myfords supply such a handle and it can be fixed to the mandrel in a few seconds - an accessory well worth having. It gives ideal control over the cutting process and is a great asset in general screwcutting, particularly when screwing up to a shoulder. For very coarse pitches, where the leadscrew may make several revolutions for each turn of the lathe mandrel, it is advisable to fix a handle on the end of the leadscrew. This will considerably reduce the stress in, not only the gear train, but also the elbow!. The depth of cut required for a variety of pitches is shown in the table **(Figure 9)**. This depth can be obtained by direct reference to the cross-slide micrometer dial.

The diameter of a hob (other than special hobs such as those used for cutting worm wheels) is in no way related to the diameter of the gear it can produce. For model engineers, the diameter may well be governed by the size of the material available for its manufacture.

When the threading is completed, the hob is ready for the next stage, gashing to form the teeth and for form-relieving to provide the clearance needed to obtain a satisfactory cutting action.

Another story teller, Dr. Parkes, will explain how this can be done.

D.P.	DEPTH OF CUT	WIDTH OF TOOL TIP 14 1/2° P.A.	20° P.A.	30° P.A.
16	.135	.061	.045	.015
18	.120	.054	.040	.013
20	.106	.049	.037	.012
24	.090	0.41	.030	.010
30	.072	.033	.025	.009
32	.067	.030	.023	.008
36	.060	.027	.021	.007
40	.054	.025	.019	.006

FIG. 9. CHART SHOWING DEPTH OF CUT AND TIP WIDTH

D.P.	GEAR TRAIN	D.P.	GEAR TRAIN
16	$\frac{55}{35}$ x IDLER	30	$\frac{55 \times 40}{35 \times 75}$
18	$\frac{55 \times 40}{35 \times 45}$	32	$\frac{55 \times 30}{35 \times 60}$
20	$\frac{55 \times 40}{35 \times 50}$	36	$\frac{55 \times 20}{35 \times 45}$
24	$\frac{55 \times 40}{35 \times 60}$	40	$\frac{55 \times 20}{35 \times 50}$

FIG. 10. CHANGEWHEEL CHART
UPPER WHEELS DRIVERS
LOWER WHEELS DRIVEN

AIDS TO MARKING-OUT

Len Walker describes two more useful items of workshop equipment which will soon repay a couple of evening's work

A glass surface plate (boxed-with lid)

A surface plate soon becomes essential if much model making is to be done. A true plane surface enables work to be marked out accurately and also tested for flatness. Unfortunately, it is rather a costly item.

The odd piece of 1/4in. thick glass is often pressed into 'make-do' service, but I felt that a thicker glass plate, evenly supported, in a proper wooden box with a fitting lid, would provide a much better permanent set-up.

I bought a 10in. square of 3/8in. thick glass from a local glassworks. They made a lovely job of it, finishing the sides and the corners smooth so that it could be handled safely. They must have taken pity on me as it only cost £1. Time and again, I have found that a mention of model engineering brings a positive response. Thank you, all my benefactors over many years!

To evenly support the glass, I used an odd piece of foam backed, short pile nylon carpet.

The box (Figure 1) is built around a square piece of blockboard (approx. 5/8in. thick), which is 1/16in. larger than the glass. Side pieces of 1/4in. thick ramin wood are screwed on as shown. Note that the thickness of the carpet plus the glass will determine the position of the top edge of the sides, which must be 1/8in. below the top surface of the glass. This allows work to overlap without interference.

Four plywood feet are nailed and glued to the underside of the box, as shown, then covered with 1/16in. thick rubber sheet, secured with Bostik.

The lid is made of hardboard or 4mm plywood, if you prefer, with a 3/8in. square ramin 'rim' nailed and glued on. The lid inside dimensions should be 1/16in. larger than the assembled box. Nominal sizes are given, but adjust to suit your assembly. In fact, the easiest way is to fix two adjacent sides of the rim (at 90 deg.) to the lid, offer up the box with the sides fitted, then pencil around the two remaining sides, allowing 1/16in. plus. Now fit the other two sides of the rim to your pencil lines.

A useful tip, when trying to glue up a lid or frame flat, is to build it on an odd piece of 'Contiboard'. I keep a piece 21in. square for this purpose. (It can

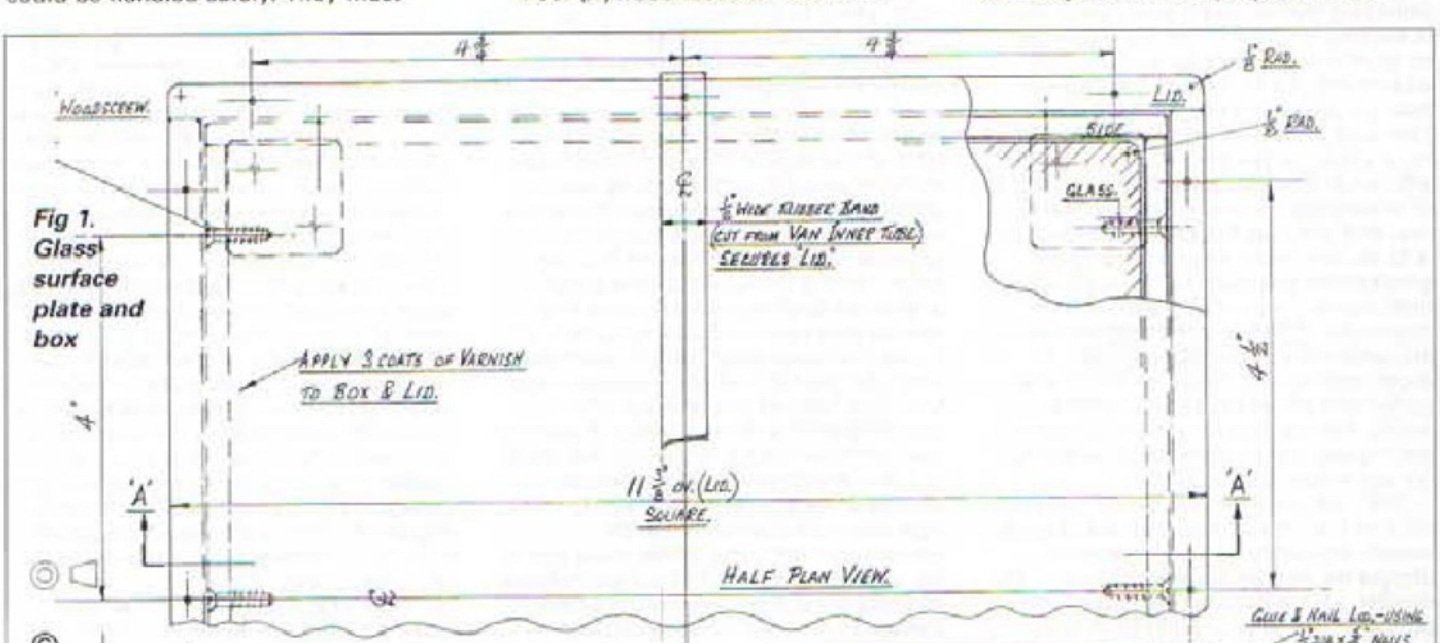


Fig 1. Glass surface plate and box

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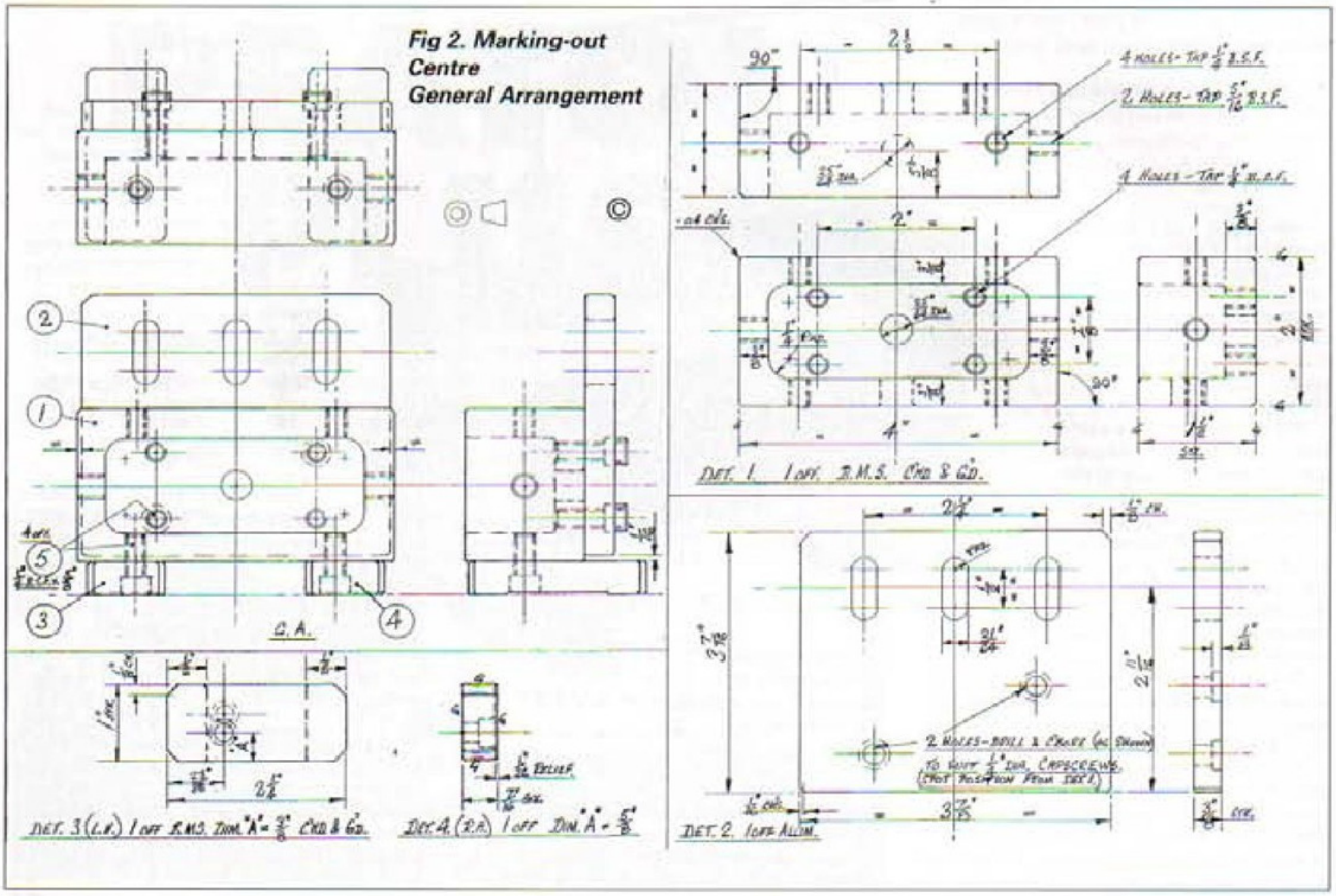


Fig 2. Marking-out Centre General Arrangement

also be pressed into service as a larger drawing board.) A layer of non-stick paper underneath the job - plus a few weights on top, and a really flat assembly is achieved every time. It avoids those strongly glued but permanently twisted creations!

To finish the job, apply three coats of polyurethane varnish to the box and lid. The result is seen in **Photo. 1.**

Keep a 10in. square of cloth between the glass and the lid when not in use in order to prevent scratching. (I used a piece of old pyjama trouser leg material!)

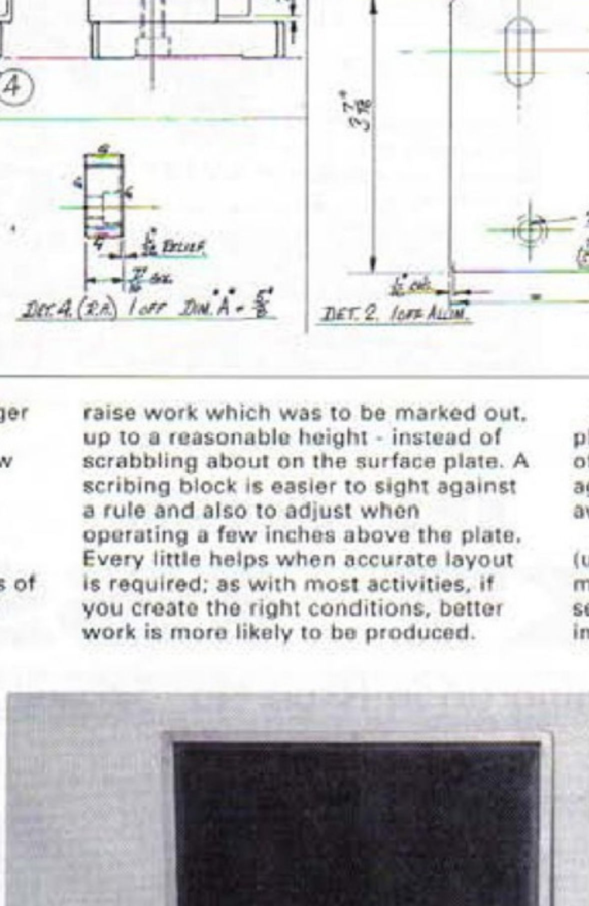
A rubber band, 1/2in. wide, cut from a van inner tube is ideal for securing the lid. Useful stuff, old tubes. They can be cut up to make strong securing bands, rubber feet, washers and the like.

Used with reasonable care, this glass surface plate will last a long time, then you can turn it over and start again. Keep it clear of any abrasive dust, to avoid scratching, as you would with a cast iron or granite plate.

So, for a pound or two, you can have an accurate plate, properly supported and protected, at a fraction of the cost of a cast iron one. As always, if you start with decent equipment, it encourages better quality work.

A marking-out centre

The versatile gadget shown in **Photo. 2** and Figure 2 (like Topsy) 'Just growed'. The original need was to raise work which was to be marked out, up to a reasonable height - instead of scrabbling about on the surface plate. A scribing block is easier to sight against a rule and also to adjust when operating a few inches above the plate. Every little helps when accurate layout is required; as with most activities, if you create the right conditions, better work is more likely to be produced.



1. A well protected glass surface will give good service for many years, then you can turn it over and start again!

The next stage was to add a back plate. Using the index finger and thumb of the left hand to clamp the workpiece against the backplate, you can scribe away with complete confidence.

A rule can be clamped to the plate (using a small toolmakers clamp), making it easier to pick up a scriber setting. The two 'feet' were added to increase stability and to give (free) extra height.

All this is very basic, but the overall effect did help to produce better work.

Other uses include:-

1. If the basic 'box' (Det. 1) is bolted to a suitable angle plate (using the 25/64in. dia. centre hole), it can be set to any required angle. This is very useful for drilling steam passages etc.

2. The box can also be used as a very rigid angle plate - either direct on a surface plate or clamped to the lathe cross-slide.

3. Again, the box (with a 5/16in. BSF x 2in. long capscrew screwed into an end hole) can be used as a small 'press', for assembling small pins, bushes and similar items, allowing accurate control over small jobs.

4. Finally (?) the two feet can be used as parallels, either 1in. or 7/16in. high.

It won't sweep the yard - you'll have to do that yourself!

Construction is simple but, as usual, a few words may help newcomers to the hobby.

Det. 1. Box

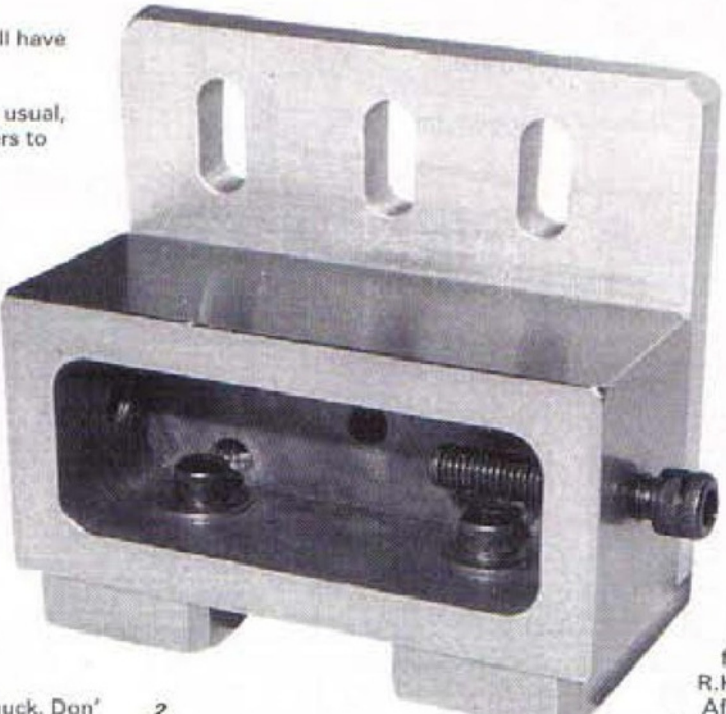
Use 2in. x 1 1/2 bright mild steel (BMS). The blank should be stress relieved, (heat to red, soak thoroughly then allow to cool slowly.) This will minimise distortion during machining and casehardening.

Machine the ends square and check that the sides are also square. The bulk of the centre material can be removed by drilling three holes 1in. dia. Alternatively, two holes can be bored, - say 1 1/8in. dia., one at each end of the pocket - with the job securely held in a 4 jaw lathe chuck. Don't go too deep.

Mill out the remaining material as shown. A magnetised screwdriver tip is useful for removing swarf WITH THE CUTTER STATIONARY.

Mark out, drill and tap all holes as shown, nice and square with the respective faces. Note that only two 1/4in. BSF tapped holes on the back face are needed to secure the backplate. The other two are spare for clamping work.

Add a chamfer, as indicated, to all edges and ideally, caseharden (local Tech?). Alternatively, leave soft and handle carefully. Make sure that all faces are parallel and square. If the facilities are available, surface grinding creates the ideal finish.



2.
A firm base and square, flat surfaces are a feature of this aid to marking out

Det. 2. Back Plate

I used an odd piece of aluminium 'because it was there', but BMS would do just as well. 1/4in. thick material could be used in place of 3/8in. if that's all you have.

The two fixing holes are transferred from Det. 1 (using a 1/16in. thick piece of packing under the bottom edge to provide the gap shown on the G. A. Counterbore to suit material used.

Mill (or file) the three slots, clean up and add chamfers.

Det. 3. Feet

Make from 1in. x 7/16 BMS. I used some of Whiston's 1 1/4in. x 7/16in. material which I had left (Come back Ken - all is forgiven!). Note that L.H. and R.H. are required.

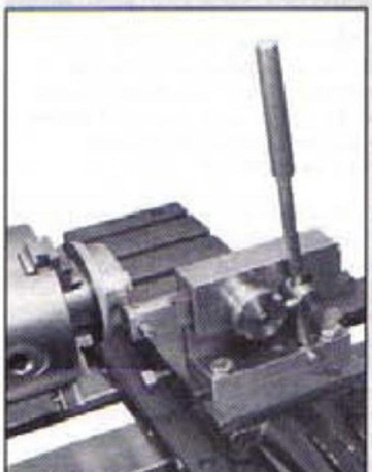
After machining, caseharden and grind parallel and square. These items can be used as parallels, so grind as a matched pair.

In use, this gadget has proved its worth, providing a solid, stable support for accurate marking out. The other uses, mentioned earlier are a bonus.

Store (well oiled), along with a strip of anti-rust paper, in a strong plastic bag, ideally protected by a wooden box.

IN OUR NEXT ISSUE

Coming up in Issue No. 57 will be



A GEAR HOB RELIEVING DEVICE

Following Ivan Law's introduction to gear hobbing, Giles Parkes describes his lathe attachment which facilitates the backing off of an axially gashed hob

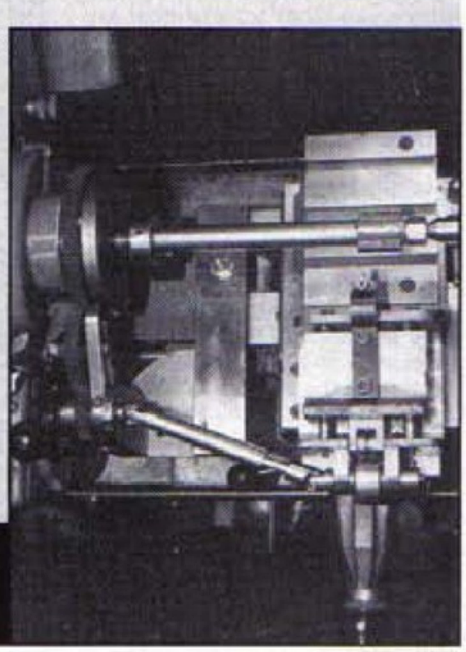
A LINE ENGRAVING TOOL

Harold Hall's design for an accessory which produces neatly engraved lines when graduating machine dials

BOW MAKING PLANES

During a violin-making summer school, George Swallow was called upon to use his model engineering skills for a novel purpose

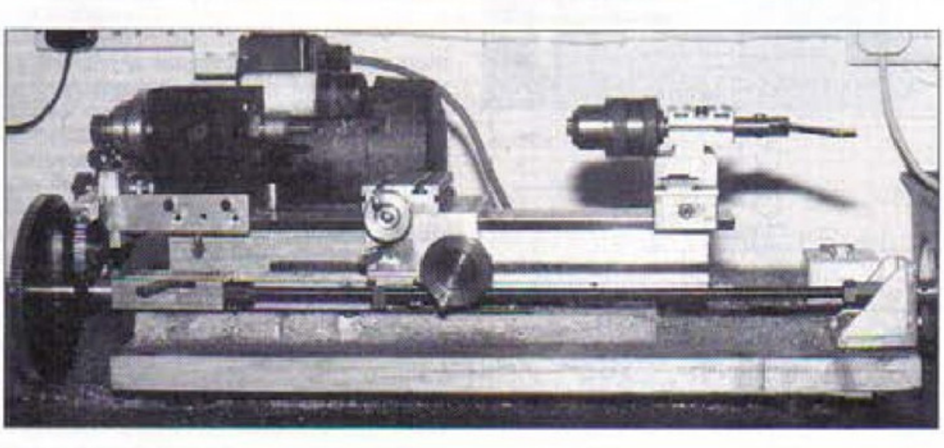
Issue on sale 16th April 1999



(Contents may be changed)

PEATOL PLUS

The Peatol lathe is popular with the owners of smaller workshops, but its capabilities are restricted by the lack of a leadscrew. Tony Jeffree has addressed the problem and, in a two part article, describes how has grafted on the components from another small lathe.



1. The Peatol lathe, now equipped with leadscrew, dog clutch and screwcutting gear train

Introduction

The Peatol micro lathe (Ref. 1), manufactured in the USA as the Taig lathe (Ref. 2), provides a very cost-effective means of entering the world of metal turning, for clock making or other light model engineering uses. One of its limitations, as the uses to which it is put become more sophisticated, is that it has no leadscrew; hence, it cannot be configured for fine feeds, or change wheels fitted to allow it to be used for cutting threads.

Other lathes of a similar size have leadscrew and screw cutting ability; notable among these is the Sherline (Ref. 3), which also allows fine feed to be obtained via a supplementary motor attached to the leadscrew. An accessory kit is available for the Sherline that adds the screwcutting capability; this consists of a suitable selection of change wheels, sector arms, and a handwheel which allows the lathe spindle to be driven by hand during the screwcutting process rather than by the lathe motor.

The thread cutting capability of the Sherline kit is fairly comprehensive. The Imperial version of the lathe has a 20 TPI leadscrew, and the kit allows most useful Imperial threads to be cut. The kit includes a 127T wheel to allow Metric threads to be cut as well. This introduces one of the curiosities of the Sherline change wheel set; the majority of the wheels are 24DP, however, there are a small number of 60DP wheels; two 100t wheels, one 127T and one 50T. These are used exclusively as the first driver and driven wheels in the Sherline set-up, using the smaller tooth pitch in order to include the magic 127T wheel for metric conversion without the wheel size being ridiculously large. The 24DP wheels are bored $^3/_8$in.; the 60DP wheels are bored $^9/_{16}$in.

Reading through the Sherline product literature, it struck me that their screwcutting kit might be a useful starting point for building similar capability into a Peatol lathe. I went ahead and bought the kit, to see if I could then think through a suitable design using some or all of its components. Clearly, it would be necessary to improve on the 'hand cranked' approach of the Sherline kit, as this would be desirable for providing a sensible fine feed. Including a tumbler reverse would also be an essential part of the design, as this would allow forward / reverse / neutral drive to the leadscrew. Similarly, incorporating a dog clutch to allow the leadscrew to be disengaged from the gear train would be essential; otherwise, fine feeding the carriage by hand would become a little strenuous. This will be apparent to anyone who has tried this on a lathe with no clutch, with a fine feed gear train engaged. Also, I considered the ability to disengage the saddle from the leadscrew (not possible on the Sherline) to be highly desirable, thus allowing the Peatol's existing rack & pinion to be used for fast saddle traverse. So these features formed the initial 'shopping list' for the project, along with the very basic requirement to be able to configure the lathe for a sensible fine feed, which on a lathe of this size means a very small number of thou of saddle feed per spindle revolution.

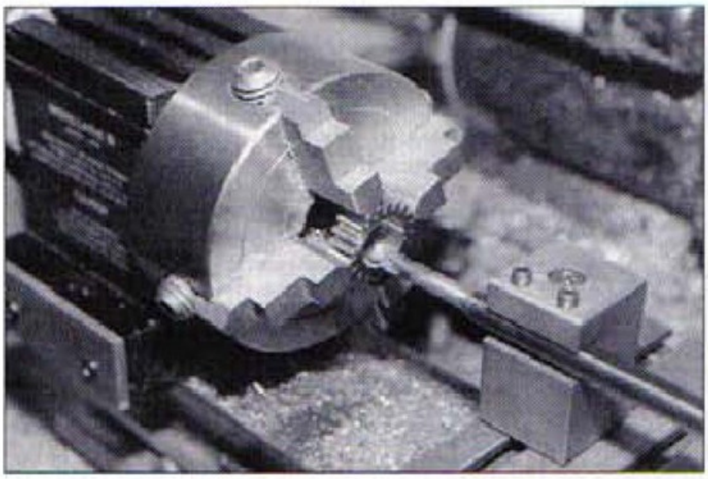
Attaching the drive to the spindle

The first problem, that of obtaining a sensible drive to the gear train from the lathe spindle, took considerable thought, particularly given the intent of including a tumbler reverse. The lathe uses a stepped pulley as its primary drive from a similar stepped pulley on the motor shaft. There is little space between the pulley and the headstock, and the pulley overhangs beyond the end of the lathe spindle, so direct attachment of a gear wheel to the spindle itself did not look like a good option. Besides, I already had that particular space earmarked for permanent attachment of a dividing plate at a later date.

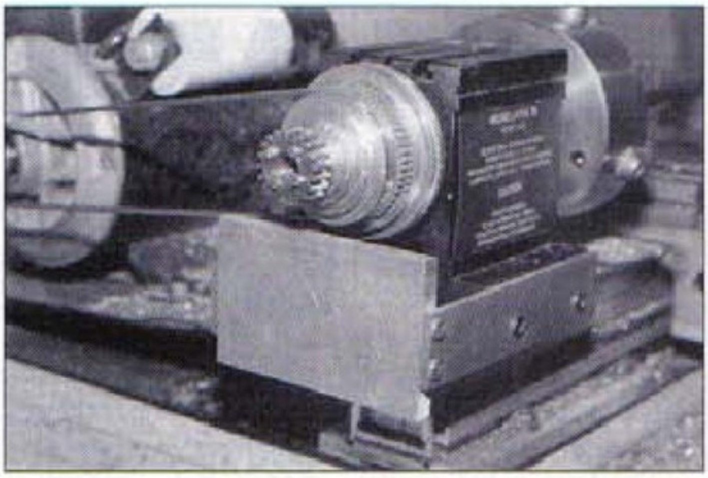
I considered making an adapter that could be inserted in the bore of the pulley, held in place by a drawbar through the spindle from the spindle nose. While this would be workable, it would have the obvious disadvantage that it would remove any possibility of using the spindle bore, for collets and so on, so I abandoned this idea as unsuitable. A close examination of the pulley itself revealed that there is just about enough metal at the tail end of the pulley (the smallest diameter end) to make it possible to attach a small gear wheel directly to the body of the pulley using longitudinal screws through the gear wheel, threaded into the body of the pulley itself.

The Sherline gears are aluminium, and around $^3/_{16}$in. thick; I figured that while these might be OK for light, occasional use, cutting threads for example, I would need to use something more robust as the basis for the tumbler reverse arrangement and for the gears used in the fine feed configuration. All of the additional gears that I used are chosen from the 24DP range manufactured by HPC Gears (Ref. 4). These gears are $^5/_{16}$in. thick; bore diameters vary according to the wheel size. The ones I used are steel; however, HPC offer the same range in Delrin, which, while I have not attempted to try them, may well prove to be a viable and cheaper alternative.

I used a 20T 24DP wheel, HPC part number G-24-20-PG, as the primary drive wheel attached to the spindle. The 20T wheel has a $^5/_{16}$in. bore; this needs to be opened out to the same diameter as the pulley bore, nominally $^3/_8$in., in order for the lathe spindle bore not to be obstructed. Opening out the bore retains the ability to fit the standard drill chuck spindle to the headstock, and also to use the full diameter of the spindle bore when turning small diameter stock. I found that it is straightforward to hold these gears in the 4-jaw chuck. By locating the tapered ends of the four jaws in the gaps between opposing pairs of teeth, the wheel can be 'automatically' centred to a workable degree of accuracy, assuming that the 4-jaw is itself accurate. Obviously, if inspection with a dial gauge shows that the wheel is not centred, this can be remedied using packing shims as necessary. The bore can then be opened out using a suitable boring bar – in my case, a $^1/_4$in. boring bar fitted with a Sumitomo titanium carbide insert (Ref. 5), which cuts very nicely indeed at these diameters. **Photo 2** shows one of the



2. Opening the bore of the gear which will be attached to the mandrel pulley



3. The new gear, now attached to the mandrel pulley, and the tumbler support bracket

Figure 1: Tumbler Support Bracket - Front and rear arms

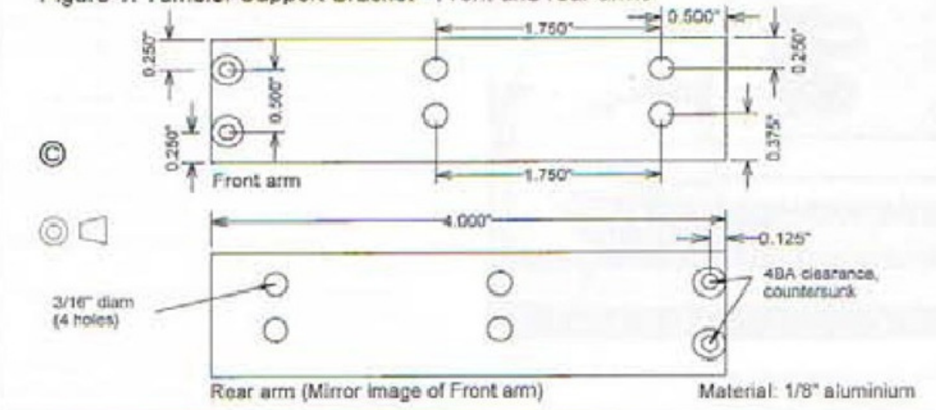
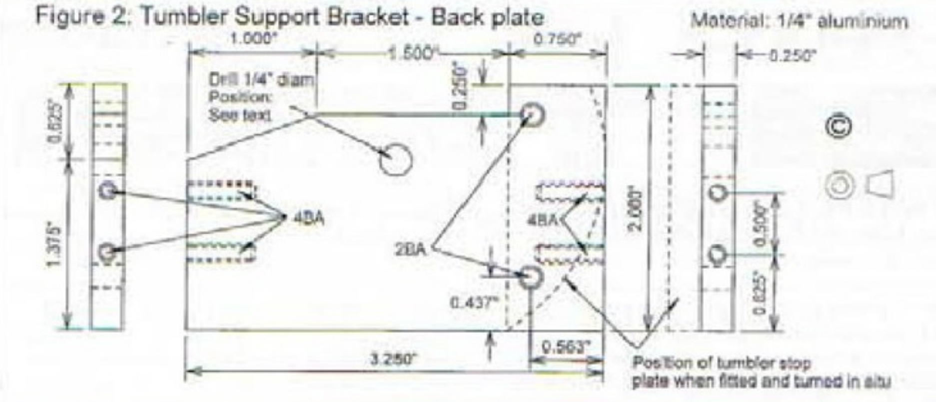


Figure 2: Tumbler Support Bracket - Back plate



tumbler gears having its bore modified by this means. At first sight, this technique for opening the bore of a gear wheel sounds as if it will damage the gear teeth. However, the wheel is very well located by the tips of the four jaws and therefore only needs to be held with light pressure. A boring bar of this size cannot take heavy cuts; it is therefore apparent that not very much force is applied to the teeth in this machining operation - and considerably less than they are designed to handle. My own gears showed no evidence of tooth damage after being modified in this way.

The groove of the smallest drive pulley is approximately 0.66in. diameter at the base of the V; this means that there is a wall thickness of approximately 0.14in. to play with, which is enough thickness to take an 8BA screw. While the wheel is still in the chuck, it is a simple matter to scribe a circle at a diameter of 0.51in. on the face of the wheel for later marking out the drilling positions for the screws. Then mark the four hole positions on this circle, 90 degrees apart. The pulley is then removed from the lathe spindle so that the wheel and pulley can be drilled in a single operation. I found that the wheel and pulley could be held in position during drilling with the aid of a 3/8in. steel dowel and the use of Superglue as a temporary adhesive. Drill through the wheel into the end of the pulley using an 8BA tapping drill, then open out the holes in the wheel to 2.2mm to clear the screws. Disassembly of the wheel from the pulley can be achieved by drifting the dowel out and splitting the components apart after drilling; if you avoid cleaning the parts too thoroughly before Superglue application this helps the disassembly process! Cleaning the glue residue off after disassembly completes the drilling operation. The four holes in the pulley are then tapped 8BA, allowing the gear wheel to be fixed in position using suitable 8BA screws. I used cheese-headed screws and found that the heads were just slightly too large to clear the 3/8in. bore, so turned them down to a more suitable diameter. Accuracy of assembly of the wheel to the pulley can be ensured by re-application of a 3/8in. dowel prior to tightening the screws, ensuring that the bores of the pulley and wheel are concentric. The end result can be seen in **Photo. 3**, which also shows some of the partly machined tumbler support bracket components in position.

At this point, it is possible to re-fit the pulley to the lathe, which is just as well, as many of the subsequent operations require the lathe to be operational.

The Tumbler Support Bracket

Photo. 4 shows how the tumbler reverse is assembled onto the lathe. Construction makes use of the fact that the lathe headstock has longitudinal T-slots running along its base at each side; these provide a temporary fixing method that allows the position of the mounting bracket to be adjusted before final fixing. The mounting bracket is a simple U-shaped frame attached to the headstock; this will hold the tumbler gears in position below the drive gear that is now firmly attached to the lathe's drive pulley.

Construction of the tumbler support bracket is straightforward. The two longitudinal arms and the rear plate are shown in **Figures 1 to 3**. The front and rear arms are mirror images of each other **(Figure 1)**; both are 4in. x 1in. x 1/8in. aluminium sheet, although the length may be trimmed after final fitting. Drill and countersink the 4BA clearance holes, and the two lower 3/16in. holes in each plate; at present, do not drill the upper 3/16in. holes. The lower holes are used to take T-bolts and nuts that will slot into the lower T slots on the headstock. 3/16in. Whitworth works quite well for this.

The back plate of the support bracket **(Figure 2)** is made from a 3 1/4in. x 2in.

rectangle of $^1/_4$in. aluminium plate, with one corner and some of the top edge sawn off as shown in Figure 1. This material is removed to ensure that there is no chance of the bracket fouling the drive belt or pulley when the unit is finally assembled.

The 3 $^1/_4$in. dimension of the back plate should be adjusted to the exact width of the headstock base. Each end of the plate is drilled and tapped 4BA to take the screws to attach the front and rear arms of the bracket. An additional tumbler stop plate **(Figure 3)**, formed from a rectangle 2in. x $^3/_4$in. of $^1/_4$in. thick aluminium is attached at the right hand side of the back plate (as viewed from the rear of the lathe) by means of two 2BA countersunk screws. This stop plate will eventually be turned to an arc on its outer edge, centred on the tumbler pivot pin, as shown by the dashed arcs in Figures 2 and 3, but not before the remainder of the tumbler has been constructed and test fitted in its final position. Similarly, the $^1/_4$in. mounting hole for the tumbler pivot pin is not drilled until later.

The two arms can now be assembled with the back plate, the additional rectangle for the stop plate screwed in place, and the whole bracket temporarily fitted to the headstock by means of T-bolts through the lower pairs of $^3/_{16}$in. holes.

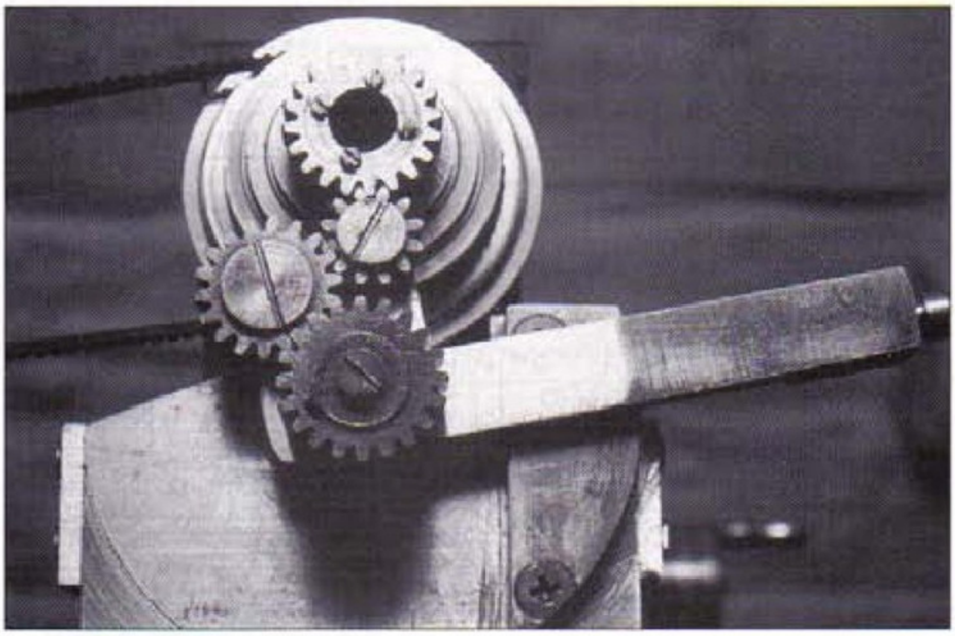
The Tumbler Assembly

The tumbler assembly is carried on a $^1/_4$in. thick brass tumbler plate, as seen in **Figure 4**. As the drive wheel attached to the spindle is 20T, the final drive gear from the tumbler reverse is also 20T; the two intermediate wheels are 18T (HPC part number G-24-18-PG) and 12T (HPC part number G-24-12-PG). The difference in diameters between the intermediate wheels is rather greater than is strictly necessary for operation of the tumbler, so a larger wheel might be substituted for the 12T wheel if desired, with suitable dimension changes elsewhere.

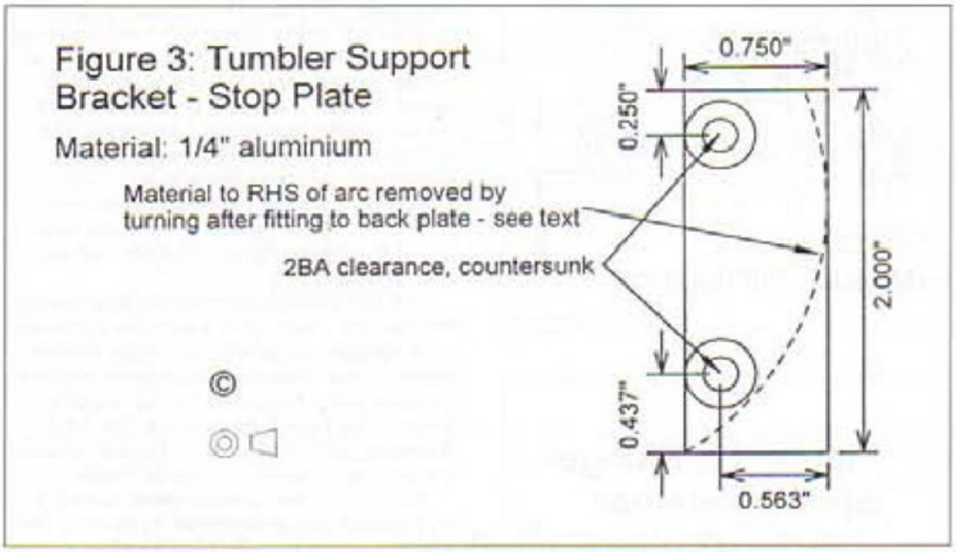
The dimensions shown for the relative positions of the gears are based on the Pitch Circle Diameters (PCDs) quoted by HPC for the gears used, and should result in free running of the gears. Clearly, for safety, it is advisable to check that these dimensions will be appropriate for the particular gears used, and adjust if necessary. The calculation is simple; the 0.7915in. dimension is half the sum of the PCDs of the 20T and 18T wheels. The 0.625in. dimension is half the sum of the PCDs of the 18T and 12T wheels. Finally, the 0.9165in. dimension is half the PCD of the 20T wheel, plus the PCD of the 18T wheel, less half the PCD of the 12T wheel.

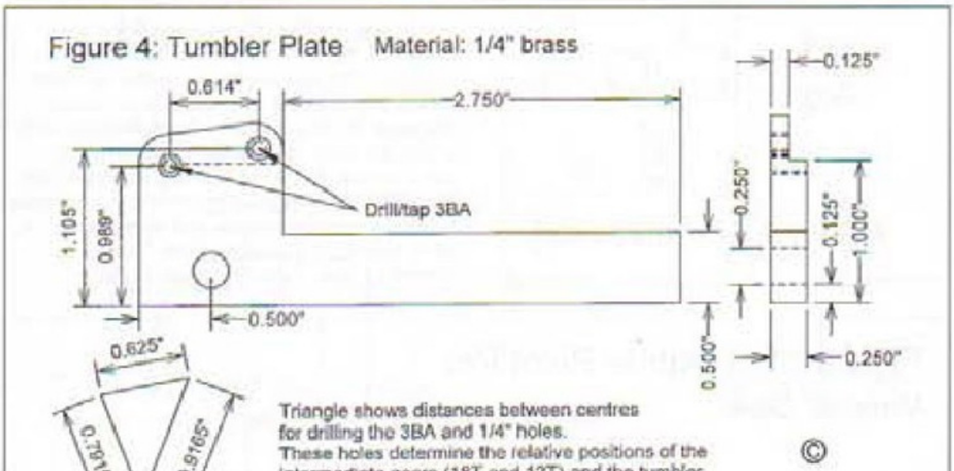
The two 3BA holes will hold the intermediate wheel studs; the $^1/_4$in. hole will fit over the pivot stud for the tumbler which also carries the tumbler output gear and the first driver wheel of the change wheel train. The 6BA holes are used to attach the operating arm for the tumbler **(Figure 7)**.

The plate is cut to size and the three holes drilled and tapped as indicated; then the recess on the rear face is milled or filed out. The recess at the back is necessary in order to avoid the plate fouling the lathe drive pulley. An alternative to using $^1/_4$in.



4. The tumbler assembly





sheet is to fabricate the plate from two pieces of $^1/_8$in. thick sheet, soft soldered together. An advantage of the latter approach is that the hole positions for either of the two 3BA holes can be adjusted more easily if they turn out to be incorrect for the gears to mesh nicely. Remove part of the front face by cutting to $^1/_8$in. depth with a hacksaw, and unsoldering it from the rest of the plate. It is then a simple matter to solder in a fresh piece of $^1/_8$in. thick brass in its place and

Figure 5: 18T Intermediate Wheel Stud

Material: steel.

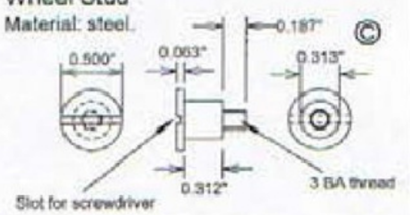


Figure 6: 12T Intermediate Wheel Stud

Material: steel.

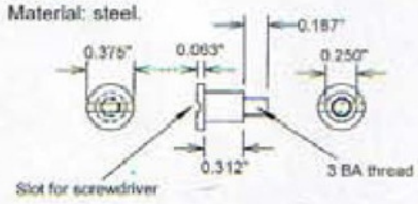
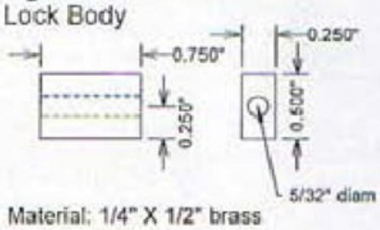
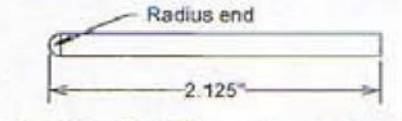


Figure 7: Tumbler Lock Body



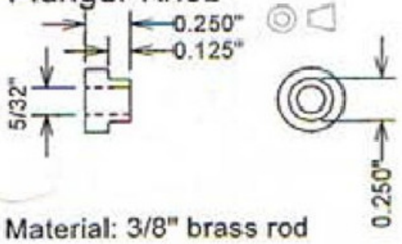
Material: 1/4" X 1/2" brass

Figure 8: Tumbler Locking Plunger



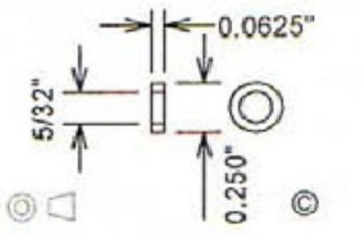
Material: 5/32" diam silver steel rod

Figure 9: Plunger Knob



Material: 3/8" brass rod

Figure 10: Plunger Spring Retainer



Material: 1/4" brass rod

re-drill/tap the hole in the correct position. It is advisable to make the arm of the tumbler plate slightly over length to start with, and to adjust it later as described below.

Two steel studs are turned to carry the 18T and 12T wheels. The 18T stud **(Figure 5)** is turned from 1/2in. diameter steel rod; the 18T wheel has a 5/16in. bore, so the stud is turned down to this diameter, leaving sufficient length to be further turned down and threaded 3BA for the last 3/16in. of its length. The 5/16in. diameter portion is nominally 5/16in. long to match the thickness of the 18T wheel; however, this should be left a few thou over length to ensure that the wheel will run free when screwed onto the tumbler plate. The stud is then parted off to leave a screw head about 1/16in. thick and a screwdriver slot cut across the head with a hacksaw. The 12T stud **(Figure 6)** follows the same procedure, this time starting with 3/8in. stock and reducing to 1/4in. for the bore size of the 12T wheel. In both cases, the aim is for a free running fit of the wheel onto the stud.

The two wheels can now be attached to the tumbler plate, with a suitable diameter steel washer under each wheel to prevent direct contact between the wheels and the tumbler plate. Note that the 12T stud is fitted in the hole furthest from the 1/4in. diameter hole. If all is well, the two wheels should mesh nicely and rotate freely.

The arm of the tumbler plate carries a locking plunger attached at its far end. This plunger will eventually locate in three holes in the curved edge of the tumbler stop plate, giving locking positions for Forward, Neutral and Reverse for the tumbler. The plunger runs in the tumbler lock body, a block of 1/4in. x 1/2in. brass **(Figure 7)**. The Tumbler Lock Body is soft soldered onto the end of the operating arm, on the side that has the recess at the top edge. It is aligned so that the axial hole points along the centre line of the arm; i.e., on a line to the centre of the 1/4in. diameter hole in the tumbler plate.

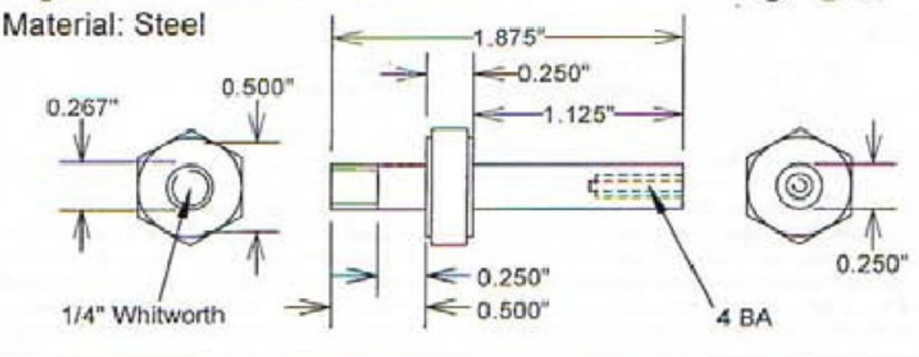
However, this is not soldered in position until the radius is cut on the stop plate as described below. Once soldered in place, any excess length of the operating arm is trimmed off flush with the end of the tumbler lock body, and the locking plunger fitted. The locking plunger is a simple length of 5/32in. diameter silver steel rod **(Figure 8)**, turned to a radius at one end. A simple brass knob cut from 3/8in. diameter rod **(Figure 9)** is attached at the square end using Superglue, and a thin brass washer cut from 1/4in. brass rod **(Figure 10)** acts as the retainer for the return spring at the radiused end. The knob is glued in place, the radiused end is passed through the axial hole in the lock body, a length of spring from a ballpoint pen serves as a return spring, and the retaining washer is Superglued in place about half way along the exposed length of the plunger. Again, the final gluing of the retaining washer is left until the lock body is soldered in place and the arm has been trimmed to length.

The Tumbler Pivot Pin **(Figure 11)** is cut from a length of hexagonal steel stock, nominally 0.56in. across flats. Face one end and reduce its diameter to 1/4in. over 1 1/4in. of its length. This length will need to be adjusted down later, once the rest of the assembly is complete; for the moment leave it over length. Reduce the diameter to 0.56in. for about 1/32in. in order to present a circular shoulder. Drill and tap axially 4BA for the screw that will act as the retainer for the final drive boss and the tumbler plate. Reverse the component, face the end, and reduce the diameter to 1/4in., leaving a shoulder 1/4in. wide, again turning off the hexagon for about 1/32in. Thread this end 1/4in. Whitworth and reduce the threaded portion to about 1/2in. long. This acts as the mounting stud for the pivot pin, and will be fitted through the 1/4in. hole in the support bracket back plate.

The tumbler final drive gear (a 20T gear – see above) is carried on a bobbin that also carries the first driver gear wheel of the changewheel gear train. The bobbin is shown in **Figure 12.** The Sherline 24DP gears have a 1/8in. wide keyway cut into the bore; the bobbin has an integral key to match, hence allowing any of the Sherline 24DP gears to be used, unmodified, as the first gear in the changewheel geartrain. The 60DP gears can also be used once modified to reduce the bore to 3/8in., as described later in this article. Construction of the bobbin starts by increasing the bore size of a second 20T gear (HPC part number G-24-20-PG) to 1/2in. diameter, using the technique already described, illustrated in **Photo 2.** Then chuck a suitable length of 5/8in. round steel bar; turn down the last 5/16in. to be a press fit into the bore of the 20T wheel. Leave a

Figure 11: Tumbler Pivot Pin

Material: Steel



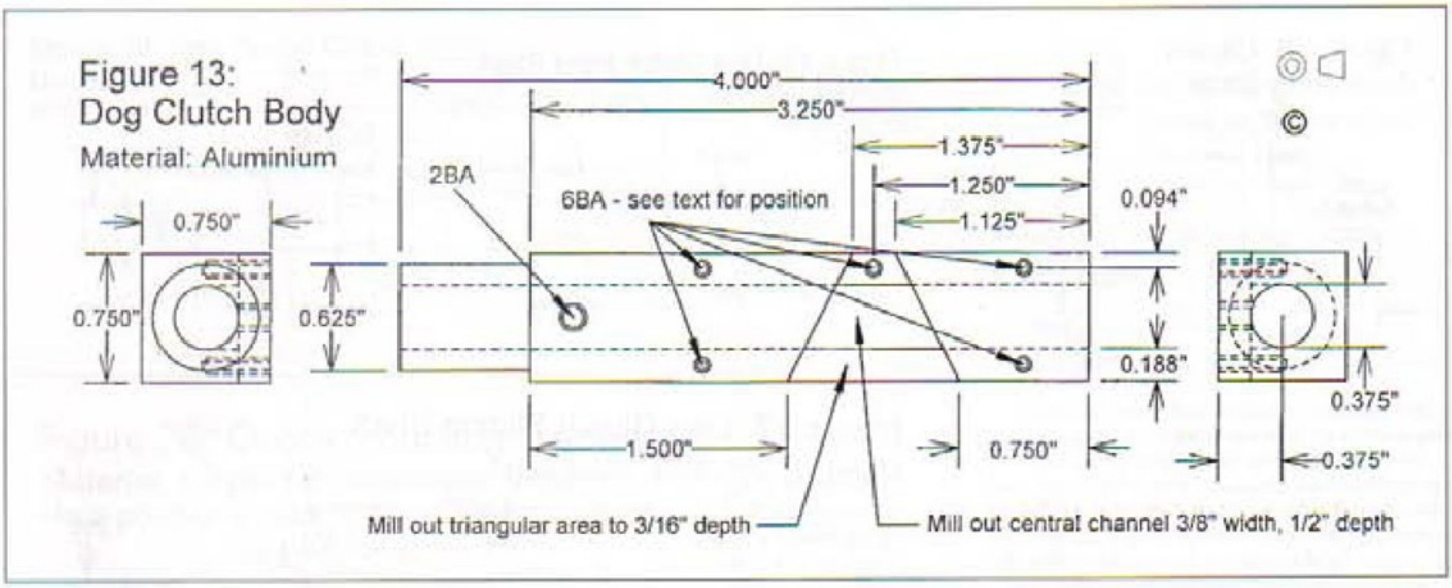


Figure 13: Dog Clutch Body
Material: Aluminium

$^{3}/_{16}$in. shoulder at full diameter, then turn down a further $^{5}/_{16}$in. length to $^{3}/_{8}$in. diameter, bore the piece $^{1}/_{4}$in. diameter and part off to length. The channel for the keyway is milled (or very carefully filed) to $^{1}/_{8}$in. wide along the entire length of the part, taking care not to cut too deeply into the $^{3}/_{8}$in. diameter portion. Milling is definitely to be preferred – the Peatol/Taig milling slide is invaluable for this kind of operation. A length of $^{1}/_{8}$in. square brass bar is then cut and soft soldered into the milled channel. Return the part to the lathe to clean up the ends of the key, and also to trim the excess that will protrude from the $^{1}/_{2}$in. diameter end. Press the 20T gear into place, securing with a suitable adhesive if necessary. The remainder of the brass key may need some final adjustment in order to fit the keyways in the Sherline gears. Leaving the keyed portion of the bobbin at $^{5}/_{16}$in. length will allow either Sherline gears or further HPC 24DP gears to be used in the changewheel train.

Now that all the components for the tumbler assembly have been made, the final machining and setting up of the support bracket and the tumbler can be completed. First, machine the pivot pin to its final length. Place the tumbler plate over the pivot, followed by a suitable washer (of the same thickness as those used under the idler wheels) and the completed final drive bobbin. The pivot pin should just slightly protrude from the bobbin; i.e., when a 4BA screw and washer is screwed into the end, it will retain the components in place while allowing the bobbin to run freely.

With the bobbin and plate assembled on the pin, check that the lower three gears of the tumbler now mesh correctly. Assuming all is well, mark the position of the hole in the back plate of the support bracket that will take the pivot pin. This should be vertically below the centre of the lathe spindle, and should be positioned to allow the tumbler's idler wheels to mesh correctly with the pulley's drive gear. The position of the support bracket should be adjusted on its T bolts to ensure that all the gear wheels end up in the same plane. Drill the hole in the back plate $^{1}/_{4}$in. diameter, fit the pivot pin in the hole with a suitable nut and washer, and check that the gears still mesh correctly in both forward and reverse positions. If

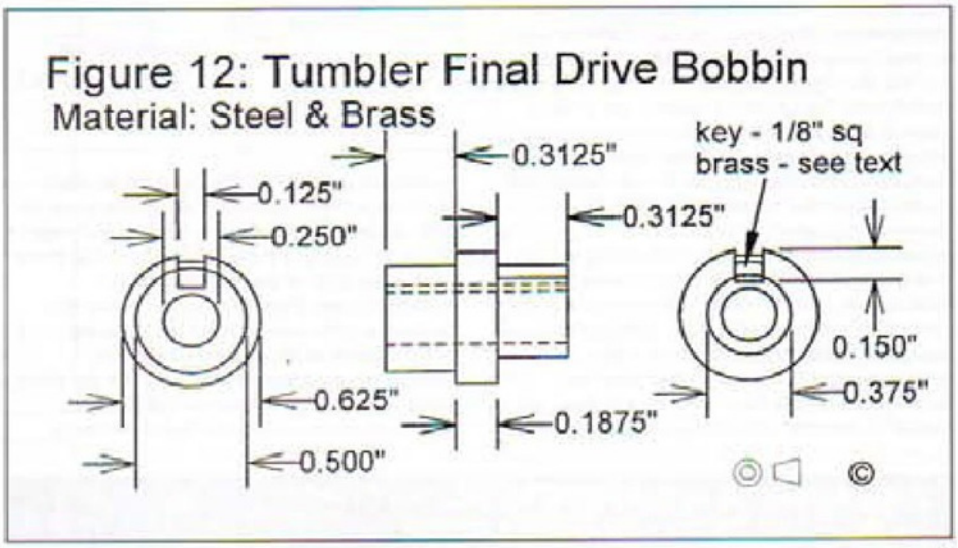


Figure 12: Tumbler Final Drive Bobbin
Material: Steel & Brass

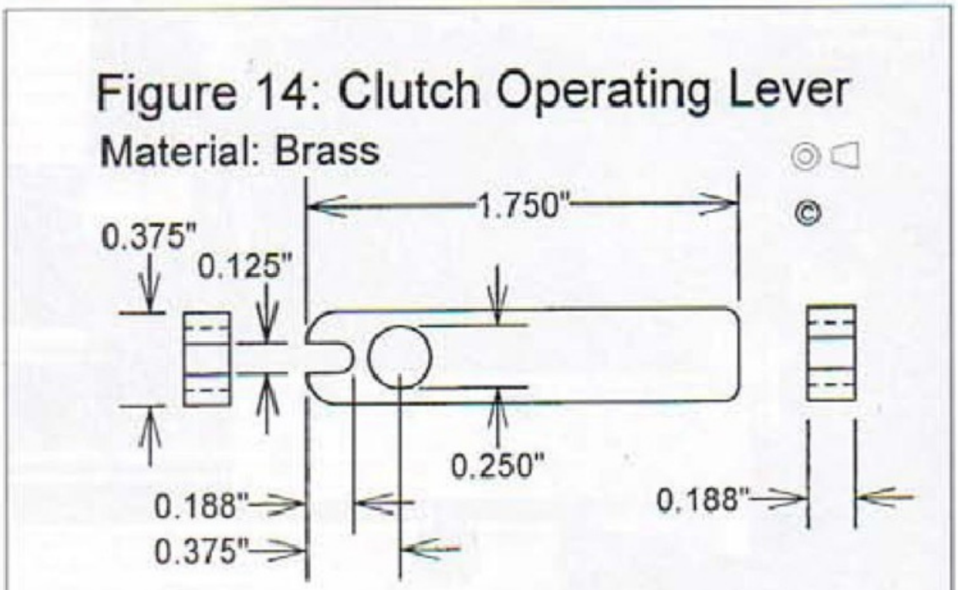


Figure 14: Clutch Operating Lever
Material: Brass

necessary, the hole in the back plate can be enlarged slightly to get proper alignment.

Remove the back plate from the support bracket, screw the stop plate in place, and mount the assembly in the 4-jaw chuck to turn the arc on the stop plate. It will be necessary to reverse two of the jaws to achieve this feat; the plate is centred so that the pivot pin is on the centre line. While the back plate is removed, spot through the upper pairs of holes in the side arms of the bracket, drill and tap into the headstock extrusions for suitable $^{3}/_{16}$in. bolts to act as the permanent fixing method for the bracket. The temporary **T**

Figure 15: Clutch Operating Shoe
Material: 3/8" sq Brass

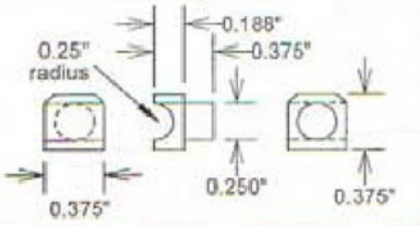


Figure 16: Dog Clutch Input Shaft
Material: 3/8" diam. Silver Steel

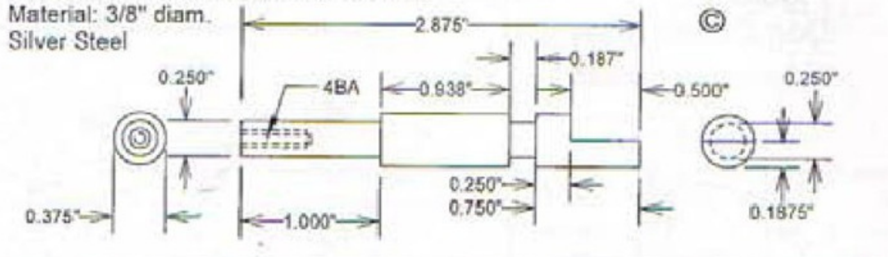
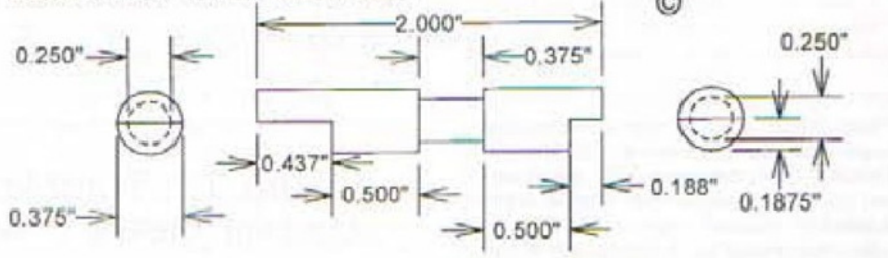


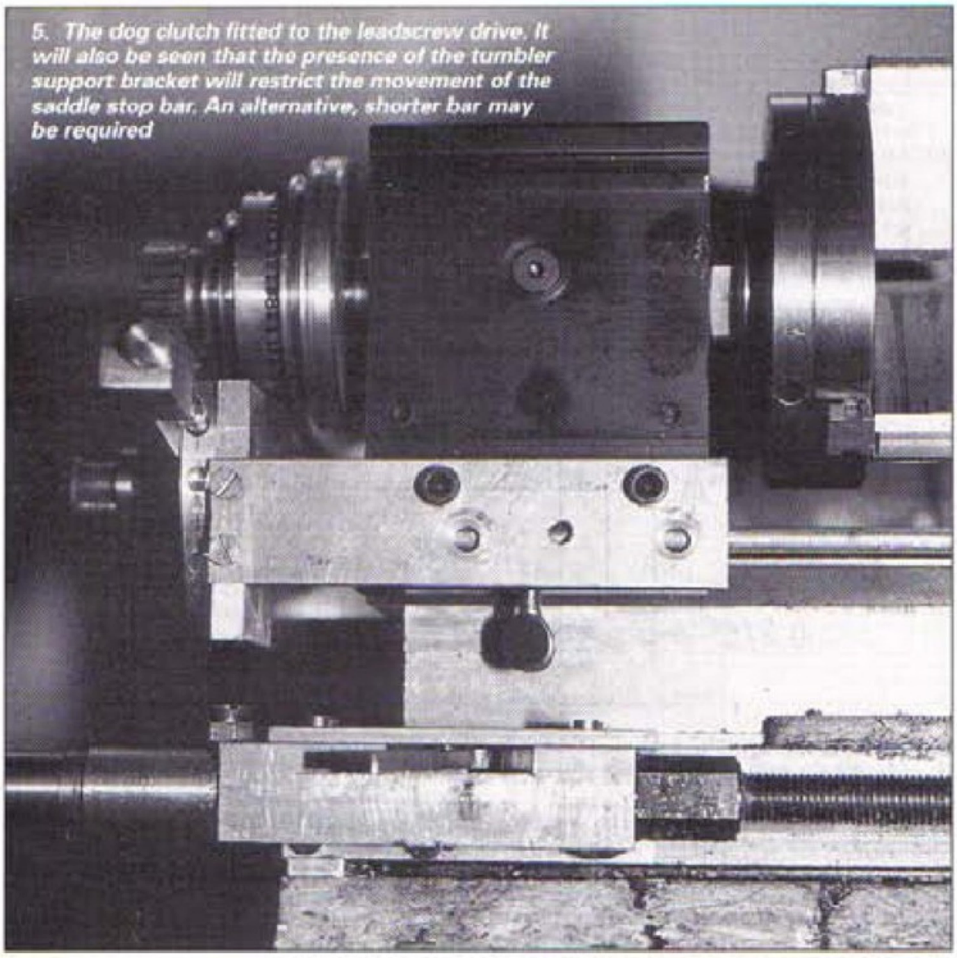
Figure 17: Dog Clutch Sliding Shaft
Material: 3/8" diam. Silver Steel



bolts can then be removed, thus allowing the saddle stop to be used once more.

Re-assemble the back plate and pivot pin in position, checking that alignment is still good. Re-fit the operating arm to the tumbler plate; assemble it onto the pivot, followed by the washer and bobbin. Retain the components in place with a 4BA screw and washer (if you are feeling very energetic, make up some 4BA screws with suitably large heads as an alternative that avoids the perennial vanishing washer problem!). Temporarily clamp the locking assembly in position on the tumbler plate, adjusting the position of the lock body so that, when the locking pin is fully retracted, it just clears the edge of the stop plate. Remove the tumbler plate from the assembly, soft solder the lock body in place, finish the arm to length, re-fit the locking pin, spring and retainer, and fit the complete tumbler plate and locking assembly back onto the pivot. Mark on the stop plate the position of the tumbler locking pin when the tumbler is in the forward, neutral (disengaged) and reverse positions, and drill a centre hole at each position with a centre bit in preparation for drilling the locating holes for the locking pin. Drill locating holes at each of the three positions. These are ideally $^5/_{32}$in. diameter, and deep enough to allow the locking pin to extend fully into the locating hole. If your drilling is accurate (i.e., exactly on a radius centred on the tumbler pivot pin), then $^5/_{32}$ may work fine; for lesser mortals, enlarging these holes to $^3/_{16}$in. or $^7/_{32}$in. may be necessary for easy operation of the tumbler lock.

At this point, you should have an operational tumbler reverse drive in position, capable of taking gearwheels of up to $^5/_{16}$in. in thickness, without disturbing the original functions of the lathe. One minor detail here is that the steel rod used as the saddle stop will now be too long for operations close to the chuck as it fouls the support bracket's back plate. This can be remedied by cutting a second, shorter, saddle stop bar to be used under these circumstances, retaining the original one for working further from the chuck.



5. The dog clutch fitted to the leadscrew drive. It will also be seen that the presence of the tumbler support bracket will restrict the movement of the saddle stop bar. An alternative, shorter bar may be required

The Dog Clutch

Photo 5 shows the general positioning of the dog clutch body; the clutch is supported on a simple aluminium angle bracket (**Figure 20**) that is bolted into the aluminium foot of the lathe. The clutch mounting bracket also provides a convenient retaining cover for the operating components of the clutch. The brass operating lever can be seen protruding from the clutch body, in the disengaged position.

The clutch operation is very simple indeed. The shaft into the clutch (**Figure 16**) has a groove cut in it into which a 2BA bolt (seen on top of the clutch body) locates, thus ensuring that the shaft stays in its correct lateral position but can rotate freely. The visible end of the shaft is a bobbin similar to the one used for the output gear of the tumbler assembly (**Figure 19**); the main difference is its length and the fact that in this case it is an integral part of the shaft. A suitable gear wheel can be placed on the bobbin, along with spacers to line it up with its driver wheel; another 4BA screw and washer retain these in position.

The opposite end of the input shaft (the end within the clutch body) is filed to a D section over the last $^1/_2$in. of its length.

Figure 18: Dog Clutch Output Shaft

Material: Hex section Steel

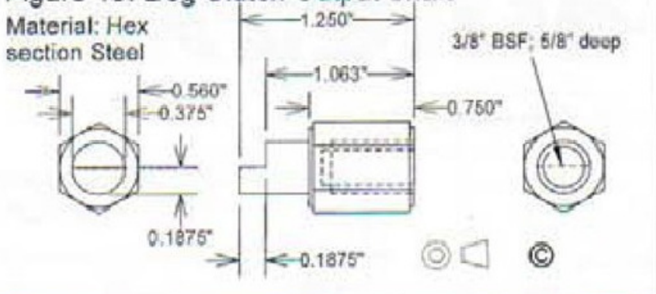


Figure 19: Dog Clutch and Stud Bobbins

Material: Steel & Brass

Quantity: 3

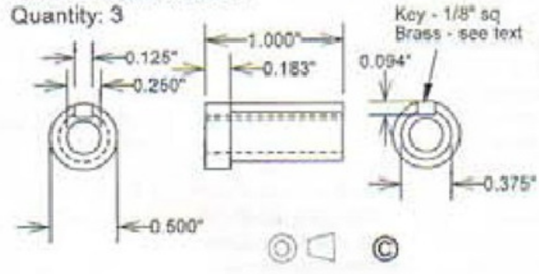
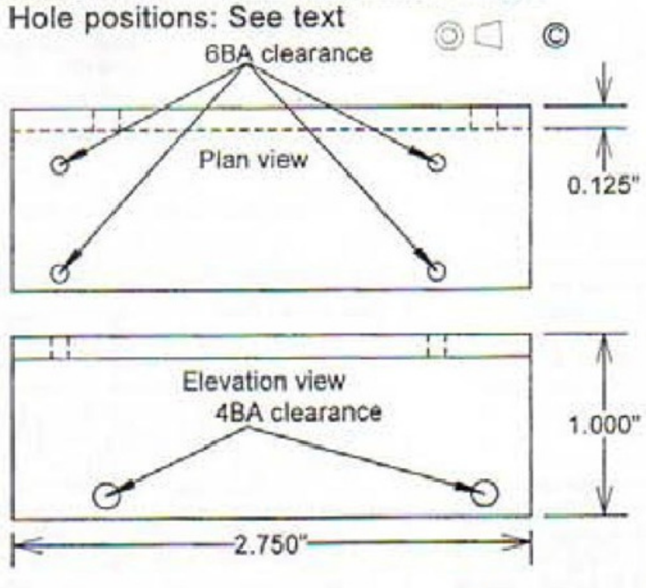


Figure 20: Clutch mounting bracket

Material: 1"X1"X1/8" Aluminium angle

Hole positions: See text



This D section constantly engages a short sliding shaft **(Figure 17)**, which has a similar 1/2in. D section at its near end, and a shorter, 3/8in. long D section at the other. A groove in the centre of this shaft carries the clutch operating shoe **(Figure 15)**, which in turn is pivoted in a hole in the clutch operating lever **(Figure 14)**. Hence, as the operating lever moves to the left or right, so does the sliding shaft. The output shaft **(Figure 18)** from the clutch has a 3/8in. long D section at its near end. The lengths of the components have been chosen such that, regardless of the position of the operating lever, the sliding shaft's D section always engages the D section of the input shaft. However, the D section of the output shaft is engaged only when the lever (and the sliding shaft) is moved to the right. This is crude but effective, and above all, fairly simple to make.

The output shaft from the clutch is threaded 3/8in. BSF (20 TPI) to take a suitable length of BSF studding for the leadscrew (Ref. 6). Clearly, this means that the 'sense' of operation is the reverse of most leadscrews (conventionally, leadscrews use a left-hand thread); if this is a problem, it may be possible to obtain left hand BSF studding (or have it cut) and left handed taps. You will have detected by now that this did not worry me sufficiently to do anything about it! The choice of 20 TPI for the leadscrew was made in order to keep the thread cutting capability essentially the same as the Sherline lathe. As 3/8in. BSF studding, taps etc. may not be readily available outside the UK, it may be appropriate for some readers to choose a different thread. A suitable alternative here would be 7/16in.-20TPI (UNF). There should be sufficient room in the design to accommodate the extra diameter without too much difficulty.

Construction starts with the clutch body **(Figure 13)**; this is a 4in. length of 3/4in. square aluminium. Centre it accurately in the 4-jaw chuck, face off the ends to length, and turn down 3/4in. of its length to a diameter of 5/8in. This circular section will carry the Sherline 'banjo' parts, after modification as described below. It is then necessary to bore the entire length to 3/8in. diameter. This is a non-trivial exercise in the Peatol lathe, but it can be done – very carefully and with lots of lubrication – as the prototype proves. Alternatively, careful set-up on a stand drill might prove more satisfactory – it is not essential that the bore is accurately concentric with the 5/8in. diameter portion. Mark out, drill and tap the 2BA hole that will carry the input shaft retaining screw. On the same face, mark out and mill the triangular shaped recess for the operating lever to slightly deeper than the thickness of the lever (nominally 3/16in.) to ensure that it will operate easily when the clutch body is screwed to its bracket. You know when the right depth has been reached, as the cutter will just start to break into the top of the bore. The final milling operation is to open out the bore immediately below this recess to form a slot 3/8in. wide to halfway across the bore (1/2in. below the surface of the bar). This slot carries the clutch operating shoe, located in the groove in the sliding shaft. Drill and tap the 6 BA hole as marked; screw a short length of 6BA studding into the hole for the slot in the rear end of the operating lever to locate onto. Leave the remaining holes for the present; these are marked and drilled later on in conjunction with the mounting bracket.

Next, the input shaft. This is fabricated in two parts. The main body of the shaft **(Figure 16)** is made from 3/8in. silver steel rod (chosen because of the surface finish, not for any other reason; BMS would do fine). Face off a length to 2 7/8in. long. Reduce the diameter over a 1in. length to 1/4in., drill and tap 4BA for the gear retaining screw & washer. Cut the groove for the 2BA retaining screw – this groove starts at 15/16in. in from the shoulder, 3/16in. wide and reduces the diameter to 1/4in.. Remove from the lathe, mark out and mill or file the 1/2in. long flat at the thick end of the shaft. The second part is a bobbin to carry the gearwheels **(Figure 19)**. Three of these are needed in all; one is fabricated and then soft soldered in place on the 1/4in. diameter portion of this input shaft, the other two are free running gear carriers for use on the intermediate studs in the gear train. Fabrication is similar to the tumbler output bobbin; turn down a length of 1/2in. diameter stock to 3/8in. diameter over a length of 13/16in., axially drill 1/4in. diameter, and part off to leave a 1/2in. diameter shoulder 3/16in. long. The groove for the 1/8in. square brass key is milled as before, and a 1in. length of key soft soldered in position. Clean up the ends and any solder excess, return to the chuck and turn down the key to the 1/2in. diameter; i.e., there should be 1/16in. of key protruding above the surface when completed. Solder in place on the input shaft, taking care not to disturb the key in the process, and clean up again. Make the other two bobbins while you are at it!

The sliding shaft **(Figure 17)** is very straightforward – again, silver steel was used; this time the groove is 3/8in. wide, and there are two flats to mill/file.

The clutch output shaft **(Figure 18)** is slightly more involved. Chuck a suitable length of hex section steel bar – the one I used measured 0.56in. across the flats, which is slightly smaller than a standard 3/8in. BSF nut. Face off, axially drill and tap 3/8in. BSF (20TPI) to a depth of 5/8in.. Cut a small shoulder, about 1/32in., to the inscribed circle diameter of the hexagon (0.56in.). Remove from the chuck, screw the piece onto a short length of 3/8in. BSF studding, and use this as a stub mandrel to hold the piece for the remaining machining operations. Mount the mandrel in the chuck so that the end of the hex rod buts against the chuck jaws; the turning action will tend to tighten it against the jaws. Turn down and face off to leave a $^{3}/_{4}$in. long hex shoulder, and a $^{1}/_{2}$in. length of $^{3}/_{8}$in. diameter. File or mill the flat for the last $^{3}/_{16}$in. of its length. Using the studding as a mandrel in this way ensures that the $^{3}/_{8}$in. bearing diameter will be as near as possible to being concentric with the leadscrew.

The remaining components of the clutch are the shoe, the lever and the bracket. The lever **(Figure 14)** is straightforward – cut a 1 $^{3}/_{4}$in. length of brass, $^{3}/_{8}$in. x $^{3}/_{16}$in.. Radius the ends. Drill a $^{1}/_{4}$in. hole through $^{1}/_{2}$in. from one end. Cut a $^{1}/_{8}$in. wide slot in the same end, to engage with the 6BA pivot pin in the clutch body.

The shoe **(Figure 15)** is cut from a length of $^{3}/_{8}$in. square section brass. Centre a 1in. length in the 4-jaw chuck, turn down one end to $^{1}/_{4}$in. diameter over a length of $^{3}/_{16}$in. (this fits in the hole in the lever). Remove from the chuck and cross-drill the bar $^{3}/_{8}$in. from the end of the turned section. Carefully cut and file across this hole so as to leave a semicircular bearing surface that will engage with the slot in the sliding shaft. File the two bevels – these are necessary to allow full left and right travel of the shoe in the slot in the clutch body.

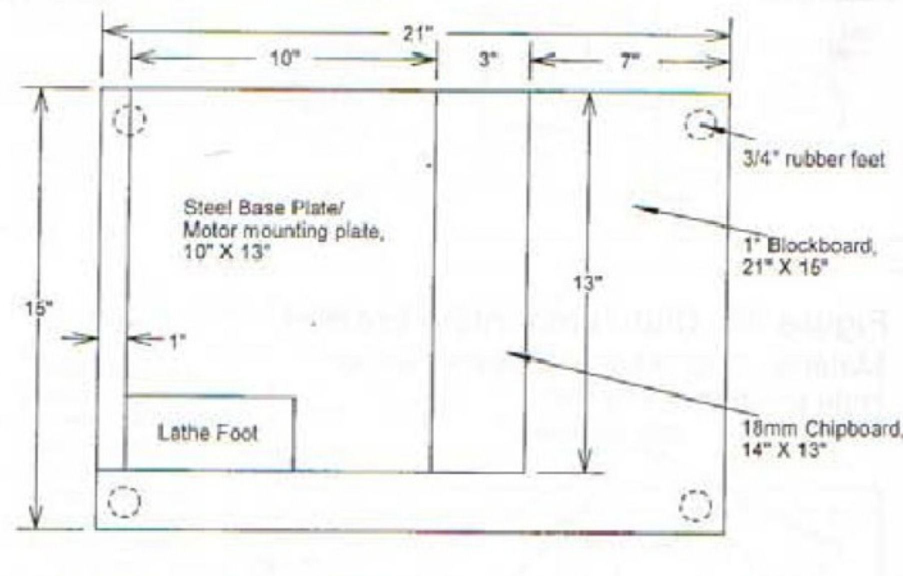
Finally, cut a 2 $^{3}/_{4}$in. length of 1in. x 1in. x $^{1}/_{8}$in. aluminium angle to form the support bracket. The clutch can now be assembled and tested for correct operation. Insert the clutch components, fit the 2BA retaining screw, locking it with a nut so that the input shaft is captive but can rotate freely. Make sure that the clutch will engage and disengage correctly, adjusting if necessary.

Fitting the Clutch

The next stage is to fit the clutch to the lathe. The objective here is to end up with the axis parallel to the axis of the lathe, and the shoulder of the input shaft bobbin in the same plane as the corresponding shoulder of the tumbler output bobbin. i.e., if a gear were to be placed on each bobbin, butting against the shoulder, both wheels would be in the same plane. For reasons that will become apparent later, a secondary objective is to allow the input shaft bobbin to overhang any mounting board or bench, to make room for large gears. A word about lathe mounting is therefore appropriate at this point.

My lathe is mounted on a 10in. x 13in. steel base plate approximately $^{1}/_{8}$in. thick that also carries the motor hinge plate; the foot of the lathe is placed in the near left-hand corner of this plate. In turn, the plate is screwed to a 14in. x 13in. piece of chipboard and nominally 18mm thick. The left-hand edge of the plate is about 1in. in from the left-hand edge of the chipboard. In turn, the chipboard is screwed/glued to a 21in. x 15in. piece of 1in. thick blockboard, leaving a 2in. apron in front and about 7in. to the right of the chipboard. The whole assembly is mounted on $^{3}/_{4}$in. high rubber feet. See **Figure 21** for a rough plan of the baseboard. The net result is that the metal base plate for the lathe is raised by

Figure 21: Baseboard Layout

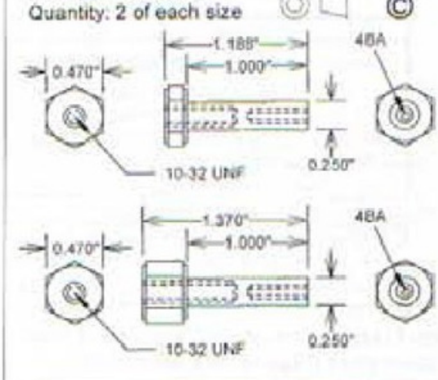


about 2.5in. above the bench top on which the lathe sits. This gives ample overhang at the left hand side of the lathe to accommodate the change wheels, and provides a useful base for mounting the right hand end leadscrew bearing in a position that will allow the saddle to be removed without disassembly of the leadscrew components.

Mounting the clutch is a matter of careful measurement and marking out. Firstly, determine the lateral distance between the left hand end of the lathe foot and the plane of the shoulder on the tumbler output bobbin. This gives the desired position of the shoulder of the input shaft bobbin relative to the lathe foot. The support bracket should be placed so that its right-hand end will match the position of the right-hand end of the clutch body. Place it in position, with its lower edge resting on the mounting plate under the foot of the lathe. Mark out and drill the 4BA clearance holes; spot through these onto the foot itself, drill & tap the foot 4BA. The bracket can now be screwed into position. The clutch body is then clamped temporarily to the bracket, leaving $^{1}/_{8}$in. clearance at the back of the clutch between it and the bracket – carefully checking its alignment relative to the tumbler output bobbin. Place register marks on the clutch and bracket, unscrew the bracket, clamp the clutch and bracket together so the register marks match, and drill clutch and bracket in one operation for the four 6BA mounting screws. Use the tapping drill to the full depth through both pieces; then at the same setting, open out to 6BA clearance through the bracket. This ensures that the components will re-assemble in the right place.

The bracket can then be replaced in its final position, and the clutch fitted to it with suitable screws. If desired, the free end of the bracket at the left-hand side can be supported further by means of a simple angle bracket screwed to the baseboard.

Figure 22: Short and Long Studs
Material: Hex Steel
Quantity: 2 of each size



The concluding part of this article, to be published in Issue 57, will give details of the leadscrew, the saddle split nut assembly and the banjo for the gear train.

References

1. Peatol Machine Tools, 19 Knightlow Road, Harborne, Birmingham B17 8QS, UK. Tel/Fax: 0121 429 1015

2. Taig Tools, 12419 E. Nightingale Lane, Chandler, Arizona 85249, USA. Tel: (602) 895-6978

3. Sherline tools and accessories can be obtained through Millhill Supplies, 66/68 The Street, Crowmarsh Gifford, Nr Wallingford, Oxon, OX10 8ES, UK. Tel: 01491 838653

4. HPC Gears, Foxwood Industrial Park, Chesterfield, S41 9RN, UK. Tel: 01246 260003 Fax: 01246 260003

5. Sumitomo inserts and tools are obtainable from Penco, 3 Greenfield Close, Sheffield, S8 7RP, UK. Tel/Fax 0114 237 7716

FIRESIDE READING

- A review of books which may be of interest

WORKSHOP TECHNIQUES by Geo. H. Thomas

Revised and Edited by William Bennett

In the early 1980s, George Thomas was working on a book which would be a compilation of articles on workshop practices and equipment which had appeared in Model Engineer magazine over about an eight year period, augmented by some new material. After a while, it became evident that this new publication, to be called 'The Workshop Manual' would be too big to be published as one volume, so two of the major topics were brought out, in advance, as stand-alone works under the Model and Allied Publications and Argus Books banners. These were 'Building The Universal Pillar Tool' and 'Dividing and Graduating', covering subjects which had appeared in instalments in M.E. over the years.

In the event, 'The Workshop Manual' never appeared in his lifetime, and we are grateful to Mr. Bennett who, supported by a number of GHT's friends, finally brought that project to a successful conclusion and to TEE Publishing who published it in 1992.

In the intervening years, the two original books went out of print and have not been available for some time. Mr. Bennett has now turned his attention to them and has revised and edited them in a masterly fashion, combining them into one work, entitled 'Workshop Techniques' and again brought to us by TEE Publishing.

The text is largely as GHT originally wrote it, but has been updated in a number of areas to reflect changes in the supply of castings and materials and to introduce modifications and additions devised by builders of some of the items. So skilfully has this been done that it is only on close inspection that it becomes evident that some of the words were not in the original version and indeed, were unlikely to have been written by GHT. Three new chapters have been introduced, covering 'Making Use of The Myford Dividing Head', 'Clock-plate Bushing Tool' (an attachment for the Universal Pillar Tool developed by Mr. Jim Batchelor of Leeds) and 'Making the Pillartool on the Myford ML10 Lathe'. Some topics which were covered in 'Dividing and Graduating' have been omitted, including 'Worms and Worm Gears' and 'Thoughts on Deep Drilling', but this material is now in The Model Engineers Workshop Manual.

My only real criticism of the new publication is that many of the drawings which have been copied from the original 'Dividing and Graduating' have deteriorated in quality, having suffered line break-up, particularly on dimension and leader lines. One drawing has suffered from the loss of its left hand edge.

That apart, I welcome the re-appearance of this material. The Universal Pillar Tool is a piece of equipment which is still being built in substantial numbers and deserves to be better known. 'Dividing and Graduating' is, to my mind, the standard work on the subject for the home workshop enthusiast, whereas most text books look at the subject from an industrial point of view. The Versatile Dividing Head, the construction of which is detailed in this section of the book is, if possible, more popular than the Pillartool. No model engineering exhibition is complete without one, some bearing the scars of honest toil in some home workshop, others immaculately maintained in 'concours' condition, but none the less welcome for that.

Many of the accessories and attachments described by GHT were devised in support of the construction of his 3 1/2in. gauge LNER Pacific locomotive which I suspect was never finished. There, on page 244 of the new work is a photograph of George's workshop and the chassis of that celebrated engine.

'Workshop Techniques' by Geo. H. Thomas, Revised and Edited by William Bennet (300pp) ISBN 1 85761 106 3 is published by TEE Publishing, The Fosse, Fosse Way, Radford Semele, Leamington Spa, Warwickshire CV31 1XN Tel. 01926 614101 Fax 01926 614293 Email: 100544.1675@compuserve.com
The cost is £24.95 plus £1.70 p&p.

Improvements and Accessories for your Lathe by J. A. Radford

From the same publisher and in the same vein is this collection of articles which was also originally published in Model Engineer, but covering a slightly earlier period, that from 1967 to 1971. The late Jack Radford was based in Diamond Harbour, New Zealand, and contributed about two dozen articles to M.E., mainly covering attachments and accessories for the Myford Super 7. Some of these were substantial devices, particularly the elevating heads which were inspired by the 'Bormilathe'. These heads, mounted on specially designed vertical slides provided a horizontal milling facility, the drive being taken by chain from a sprocket mounted on the lathe mandrel nose. Some hefty castings and formidable machining were involved, but it must be remembered that, at the time, the lathe was more frequently the only machine tool in many workshops, so it was worth making a major effort to extend its capabilities.

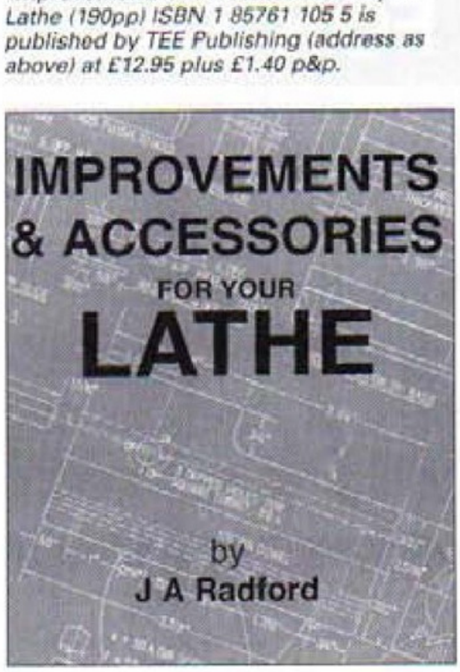
A number of the items described in these articles were the inspiration for George Thomas's later efforts, as he freely acknowledged. It appears that they corresponded frequently and GHT visited Radford on at least one occasion.

The book contains many useful items, the majority of which would be of use to the owner of any type of lathe. These range from ball bearing cone centres to a toolpost grinder. Some processes, such as gear cutting in the lathe are also dealt with, these chapters describing items of tooling which facilitate operations.

There is one intriguing chapter towards the end of the book which includes a photograph and a mention of a gear hob relieving device, but no further details are given. Interestingly, this attachment is also referred to by GHT in the chapter in his book which describes the Radford Dividing Attachment. He states that when he visited Radford, he was given a complete set of drawings and m.s. (mis-translated as 'mild steel' rather than 'manuscript' in this revised version), to use as he wished. Did any further details of this ever appear? Do those drawings still exist? It would be interesting to know.

Perhaps some of the devices described by Radford have been overtaken by history, but 'Improvements and Accessories for your Lathe' gives a new lease of life to some interesting articles and will be of use to anyone contemplating adding to the capability of the Myford 7 Series and similar lathes

'Improvements and Accessories for your Lathe (190pp) ISBN 1 85761 105 5 is published by TEE Publishing (address as above) at £12.95 plus £1.40 p&p.



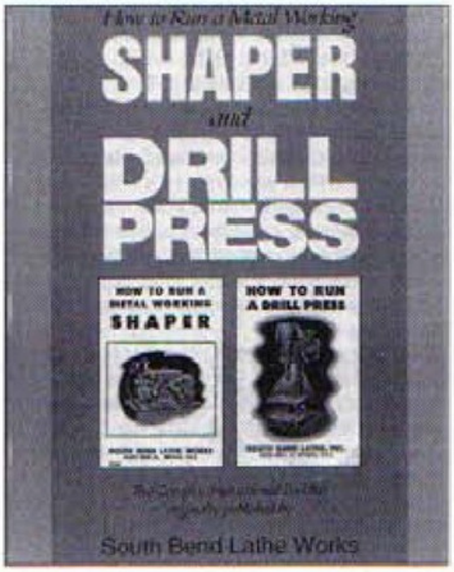
How to Run a Metal Working Shaper and Drill Press

From Lindsay Publications Inc via Camden Miniature Steam Services comes this handy little 50 page booklet which is, in fact an amalgam of two Instructional Booklets originally published by the South Bend Lathe Works of Indiana.

Both take the form of concise instructions and notes accompanying a multitude of photographs. Each machine is fully described, then instructions given on installation and commissioning before, moving on to deal with the many and various operations which can be carried out on each machine. Marking out, work holding, tool shapes and sharpening are well covered as are maintenance and adjustments.

For each machine, special accessories and attachments are described, with hints on how to use them.

The photographs and drawings (all in black and white) have reproduced well and the two booklets have been well combined into a handy reference work, particularly for those encountering these machines for the first time.



How to Run a Metal Working Shaper and Drill Press (ISBN 1 55918 213 X) is reprinted by Lindsay Publications Inc. and is available from Camden Miniature Steam Services, Barrow Farm, Rode, nr. Bath, Somerset BA3 6PS Tel. 01373 830151 Fax. 01373 830516 at £5.10 plus 80p postage within the UK or £1.30 overseas world-wide by surface mail.

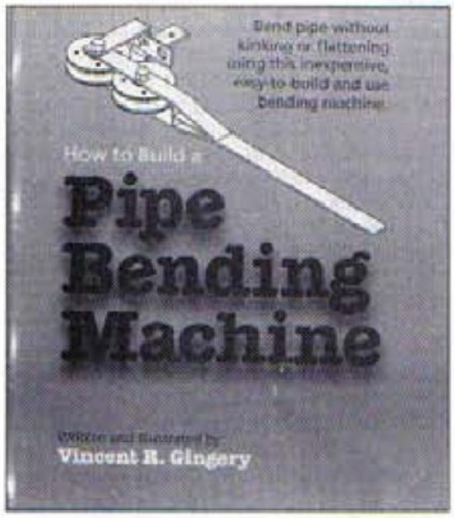
How to Build a Pipe Bending Machine by Vincent R. Gingery

Another slim (50 page) volume available through Camden, this book describes in detail how to make an inexpensive and easy to build device which will bend pipe without kinking or flattening. Of conventional design, the machine uses two dies, one fixed and the other mounted within a hand lever which can be rotated around the axis of the fixed one. The size is based on that needed to bend 1/2in. electrical conduit, the dies being made from hardwood with sheet steel end cheeks.

Text, photographs, drawings and diagrams are clear, with step by step instructions on how to make each part. Tool and material requirements are detailed and operating instructions are given, complete with the formulae needed to calculate pipe lengths.

This is not a complex piece of workshop equipment, but one which is invaluable when that particular job comes along.

How to Build a Pipe Bending Machine by Vincent R. Gingery (ISBN 1 878087 21 5) is published by David J. Gingery Publishing, P.O. Box 75, Fordland, MO 65652, USA and available from Camden Miniature Steam Services (address above) at £6.60 plus 65p. post and packing.



LINK UP

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FOR SALE

● 1hp electric motor,2800 rpm, continuous rated, foot mounted, 1/2in. shaft, pulleys available, money refund guarantee.
Tel. 01253 354478 (Blackpool)

● Model Engineer magazines 1977 - 86. Three complete volumes 1979 - 81 Offers
Tel. 01909 489259 (Notts)

● Build instructions from Model Engineer 1961 - 62 for 5in. gauge 'Firefly', a G.W.R. 2-6-2T, £15. Also Myford swivelling Imperial vertical slide to suit 7 Series lathe.
Carter, Tel. 01432 820081 (Hereford)

● Manchester Rapidor Hacksaw. Complete but requires cleaning. Exactly the same as the unit shown in M.E.W. Issue 31 page 35. £50. Buyer must collect.
Wright, Tel. 01524 822082 (Lancashire)

WANTED

● £50 offered for the complete set of MEW Issues Nos. 1 - 36 in good condition.
N. R. Collins, 18 Ashwell Close, Wealcot West, Swindon, Wilts SN3 1DY Tel. 01793 524153

● Model Engineer magazine back issues from 1938 (Volumes 78 and 79) covering Edgar T. Westbury's i. c. engine driven 1 1/2in. scale Aveling Type DX road roller.
H. M. Turnbull, 14 Long Lane, Killamarsh, Sheffield S21 1BT Tel. 0114 2486168

● Good price paid for Hardinge Spherical and Radius Turning Tool, to fit narrow bed (5in. dovetail). Also, has anybody the half millimetre 5C collets for this machine?
Tel. Nick Edwards on 01234 359392 (Bedford)

● Best price paid for M.E.W. 1 - 41.
Malcolm Barnett, 12 Halecroft Ave., Wednesfield, West Midlands WV11 1TS Tel. 01902 727143

● Milling machine with compound table having 400mm table for light machining and accurate drilling. Also a collet chuck for accurately holding 16mm dia. tool steel bar in my 150mm centre lathe. Also metal/wood bandsaw for re-sawing walnut 150mm x 50mm section to 150mm x 9mm section
John Summers, 26 Kilmory Road, Lochgilphead PA31 8SZ Tel/Fax. 01546 602827

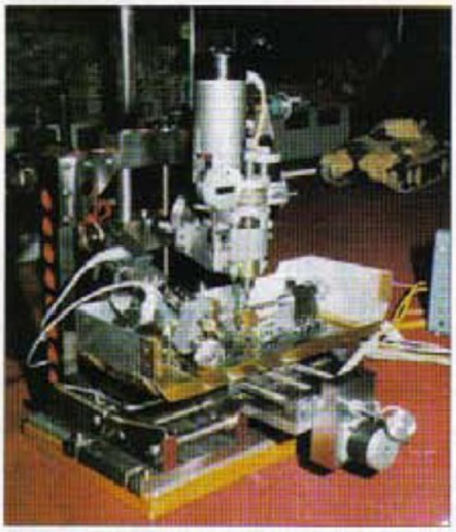
● Model Engineers' Workshop magazines, Issues 1 - 30 or will buy any longer run. Good price paid. Can collect.
D. Collins, Tel. 0181 348 5045 (London)

● I have recently obtained a 4 1/2in. x 24in. bench mounted lathe by Mellor & Sons of Huddersfield. Although non-screwcutting, the lathe boasts a very substantial six port turret on the cross-slide, the ports of which are 1.25in. diameter. I need any details/literature and a tailstock. I am also interested to know of any parts interchangeability with other lathes. Costs reimbursed.
Alan Wilson, 1 Katherine Close, Rayliegh, Essex SS6 8UH Tel. 01268 775184

● User manual for Schaublin SV12 milling machine, also any other relevant information. Expenses paid.
L. van der Aa, Rue du Printemps 25, 1380 Ohain, Belgium
Fax. 00 32 26 52 10 71

The 68th Model Engineer Exhibition at the International Model Show

Results and photos of some of the machine tools and equipment seen at Olympia this year



1. Peter Rawlinson's CNC milling machine took the premier awards in Class A5, a Gold Medal and the prestigious Bowyer Lowe Trophy

2. As always, Dr Peter Clark's entry was immaculately and imaginitively presented. This ingenious Versatile Pantograph Engine and Accessories gained him a Silver Medal

Among the award winners were:-

Class A2 General Engineering

Gold Medal

Barry Jordan, 1/5th. scale Archdale HM50 Radial Arm Drill

Silver Medal

Barry Jordan, 1/5th. scale Clarkson Mk. 1 Tool and Cutter Grinder

Very Highly Commended

John Walton, Steam driven Heavy Duty Large Scrap Cutting Guillotine

Class A5 Tools and Workshop Appliances

Gold Medal and The Bowyer-Lowe Challenge Cup

Peter Rawlinson, CNC Milling Machine

Silver Medal

W. Geoffrey Allen, Tilting Compound Table and Patterns

Dr. Peter Clark, Versatile Pantograph

Bronze Medal

Maurice H. Turnbull, Toolpost Milling Attachment

Highly Commended

Paul Bowler, Tool and Cutter Grinder

Thomas Husband Dividing Head and Rotary Table

Class J2 Juniors (under 16 years)

Gold Medal and 2nd Prize, Brunell Models 'Junior Engineer' Award

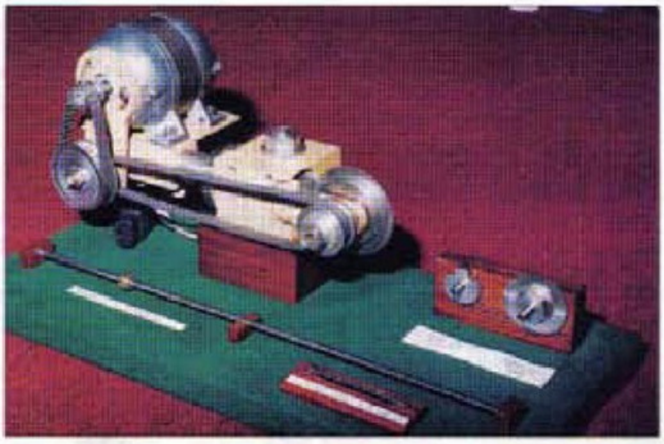
Edward Proffitt, Rotary Table and Pattern

Class F 1 Scenic Diorama, Architectural and Representational Models

Highly Commended

Mrs May King, 'Model Engineer's Workshop 1998'

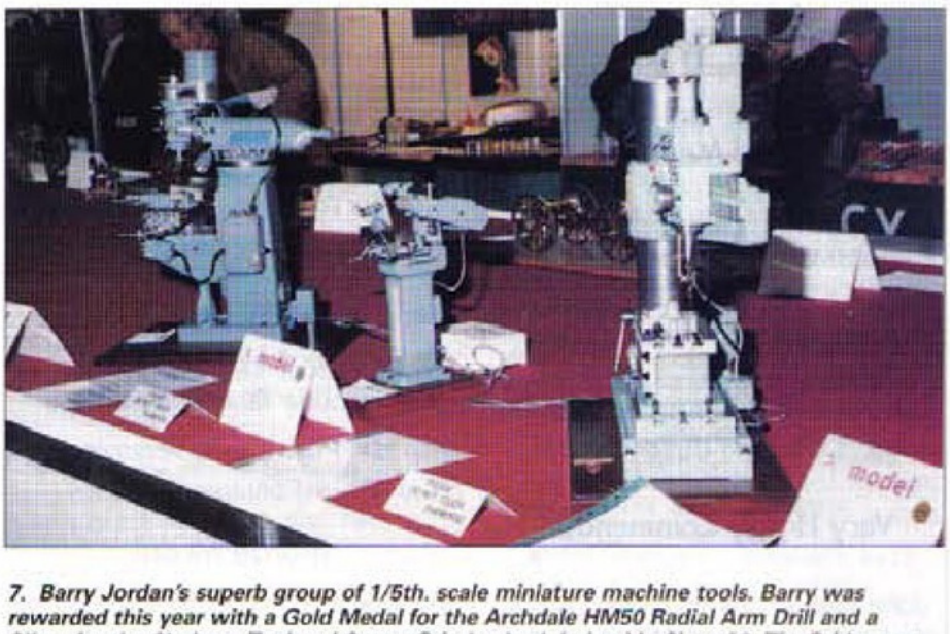
3. Another Silver went to Geoff Allen for a cast iron version of his tilting compound table. This one was shown complete with patterns. (Photo. Jon Jolliffe)



4. Maurice Turnbull's Toolpost Milling Attachment was awarded a Bronze Medal. The judges were impressed by the long slender leadscrew machined with its help

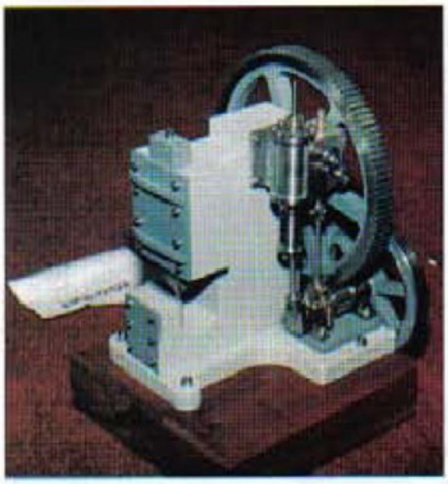
5. An interesting group of accessories and attachments by Thomas Husband was given a well deserved Highly Commended Certificate

6. Outstanding in the Junior Class was this small Rotary Table, designed and made by 15 year old Edward Proffitt, which was judged to be of Gold Medal standard. He was also awarded the second prize in the Brunell Models 'Junior Engineer' competition

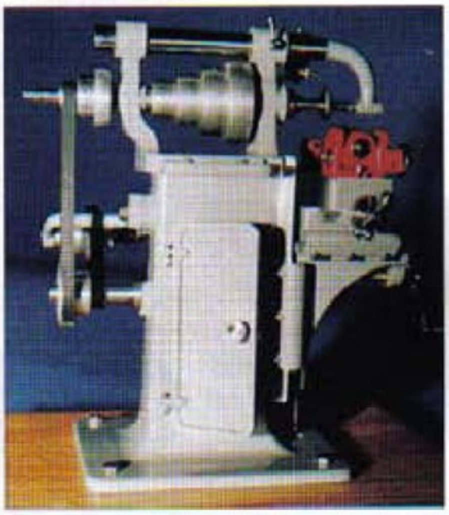


7. Barry Jordan's superb group of 1/5th. scale miniature machine tools. Barry was rewarded this year with a Gold Medal for the Archdale HM50 Radial Arm Drill and a Silver for the Clarkson Tool and Cutter Grinder, both judged in Class A2. The Bridgeport Milling Machine was entered in the Duke of Edinburgh competition.

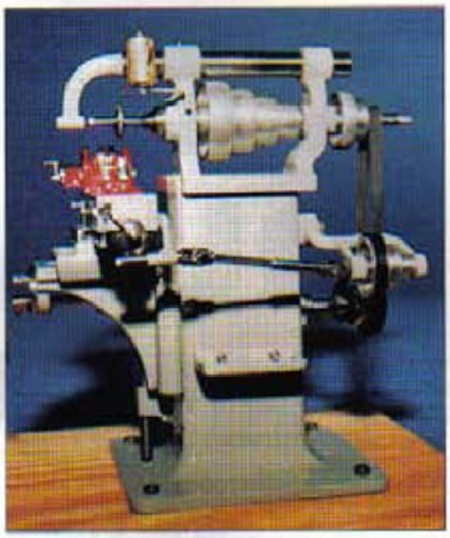
8. Another view of the Archdale Drill



9. An unusual prototype was John Walton's steam driven Scrap Cutting Guillotine which was Very Highly Commended in Class A2. (Photo. Jon Jolliffe)



10. Not entered in competition, but seen on the Mill Hill Tools stand was a collection of sub-miniature models by American modeller Jerry Kieffer. This Brown and Sharpe milling machine is built to 1/12th scale, which makes Barry Jordan's efforts look positively enormous! (Photo. Jon Jolliffe)



11. Another view of the B & S. During the Exhibition, Jerry and Barry were seen comparing notes. There was talk of a very interesting challenge. More news as it becomes available. (Photo. Jon Jolliffe)

13. Alec Price had his own stand, machining components for an open crank engine on machinery provided by Chester UK

12. A popular attraction was the Club Village, which featured a number of stands on which a variety of demonstrations were in progress. On the Society of Model and Experimental Engineers stand, Ian Cornish and Herbert Stumm are busy on machinery loaned by Myford. Other equipment was supplied by Rexon.

14. The equipment on the Society of Ornamental Turners' stand was a trifle older. A lot of low-level setting seemed to be involved. Michael Wright and colleagues are seen here getting down to it.

15. Back on the SMEE stand, Tony Philips contemplates Dr Giles Parkes' gear hobbing machine which was seen cutting a Tufnol gear. We hope to bring you a constructional series on this machine in the near future

16. Just to make us feel at home, Mrs May King entered her idea of 'The Model Engineer's Workshop 1998'. The panel at the front of the base covers the switches which set the machinery in motion! This delightful model was awarded a Highly Commended Certificate. Her 'Potting Shed' did even better, winning a Bronze Medal. (Photo. Jon Jolliffe)

A CHANGEWHEEL QUADRANT FOR THE MYFORD 7B

Harold Hall describes a new changewheel quadrant for Myford 7 Series lathes which are equipped with the quick change gearbox

I will now describe three of the minor items made for the purpose of producing new micrometer dials for my Hobbymat milling machine. I will also give some detail regarding the method I use for setting the top slide when turning Morse tapers. This was explained more fully in Issue 6 of MEW (Reference A)

The quadrant

Whilst describing the dividing head I explained that, having a lathe fitted with a quick change gear box, complex pitches such as that required for the 20DP worm were only possible by the fitting of a special quadrant.

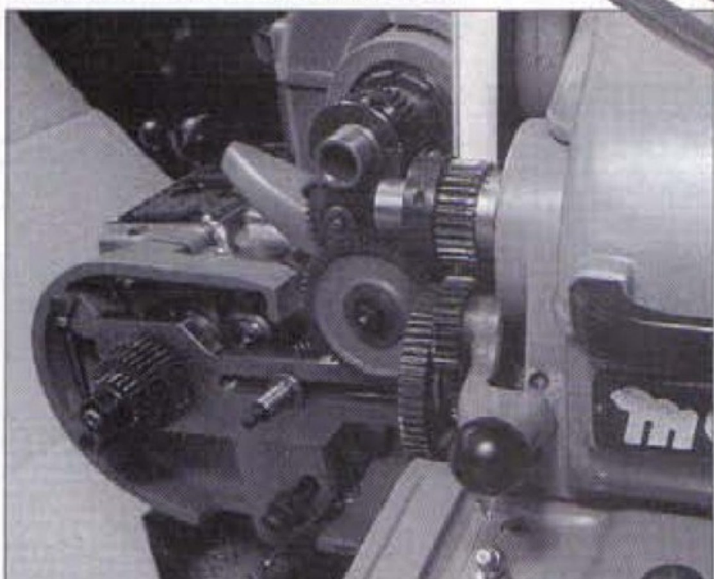
Having fitted the gearbox myself, I have the changewheels supplied with the original machine, but the quadrant removed when fitting the gearbox was not suitable to be returned to the lathe. I had therefore to purchase or make a special quadrant and I chose the latter course. Readers who have purchased a lathe complete with gearbox would also require to purchase gears, though only those needed for the applications as they arise, rather than the complete set.

The finished quadrant (**Figure 1**) can be seen in **Photo. 1**, but observant readers will note that I have not fully shaped it as detailed in the drawings. This was with the object of saving a little time. Those who wish to save even more time could leave the main arm (1) at 60mm wide throughout its whole length. I must though say that I have not fully checked to see if this would cause any problem with fouling. Without doubt though the shaping detailed could be reduced even further than I have done.

Photo. 2 shows the quadrant fitted, but with the idler gear removed so as to show more of the quadrant itself. Access to the end of the lathe is limited, so a mirror was used to gain an adequate view, hence the rather odd looking lathe.

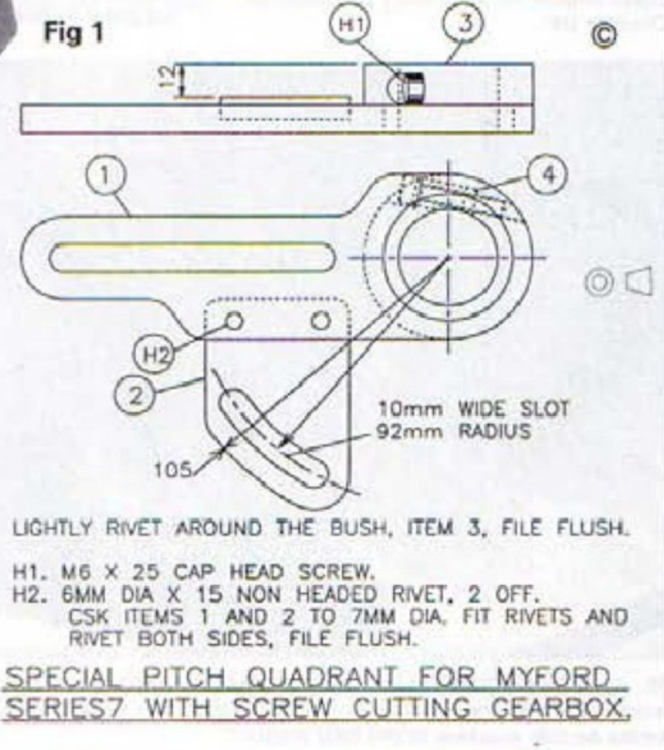
The quadrant is held in position mainly by the stud in the curved slot, the clamp on the boss on the end of the gearbox requiring only the lightest grip. Myford's quadrant has a split end as

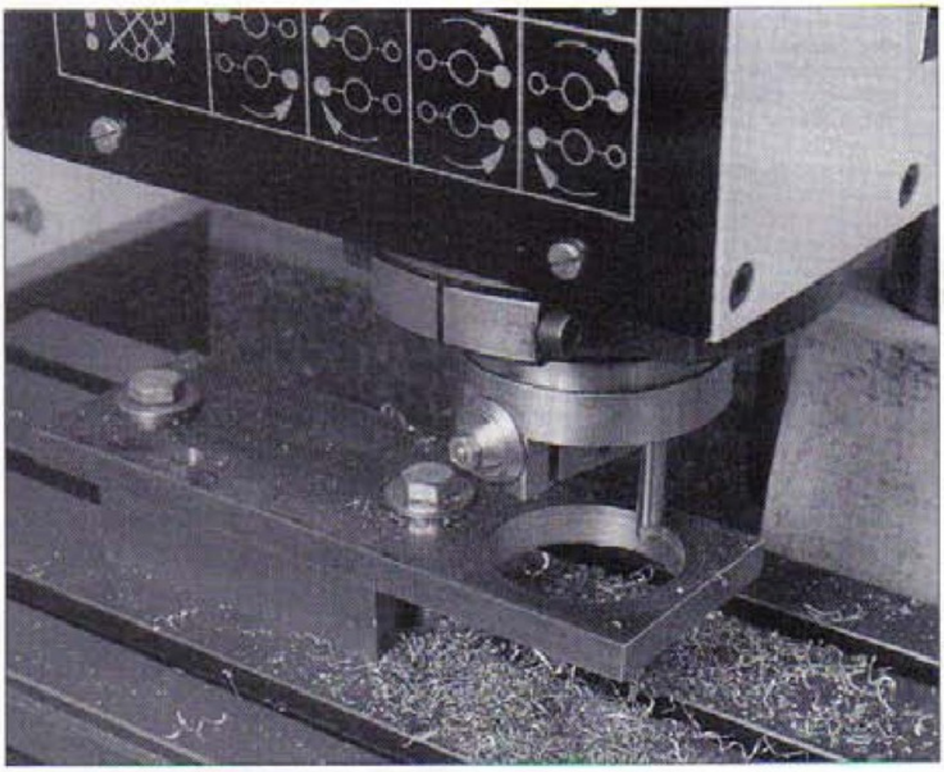
1. The completed quadrant



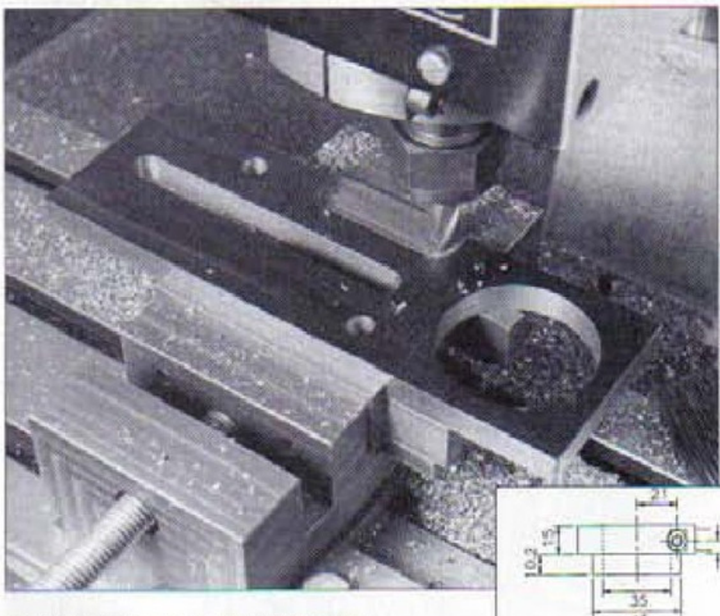
2. The quadrant fitted to the lathe but with central idler removed for an improved view of the quadrant. Limited access necessitated the photo being taken via a mirror

Fig 1





3. Using a small boring head to make the large hole in the quadrant main arm



4. Milling the recess for fitting the secondary arm

opposed to the method I have adopted, and Myford warn against over-tightening as apparently it can cause the bearing to tighten.

Manufacture

Manufacture of the quadrant is a simple process so I will not go into lengthy detail. The main arm is too long to swing on the faceplate for boring the 46mm diameter hole, so I used a small boring head in the milling machine **(Photo. 3)**, this though after chain drilling a circle of holes to remove the bulk of the material. Those not having a boring head could bore the hole on the lathe, with the arm mounted on the cross slide and a small boring tool mounted in the four jaw chuck to provide size adjustment. Photo. 5 on page 13 of Issue 55 shows the general idea. **Photo. 4** (this issue) shows the recess being made for the secondary arm.

Most of the bulk of the metal to be removed for shaping the quadrant was done on a bandsaw, with the cut edges finished on the milling machine.

I produced the curved slot in the secondary arm by drilling a series of holes, finishing it by filing. I could have made a rotary table for this operation but decided that this at least should be one project left for the future.

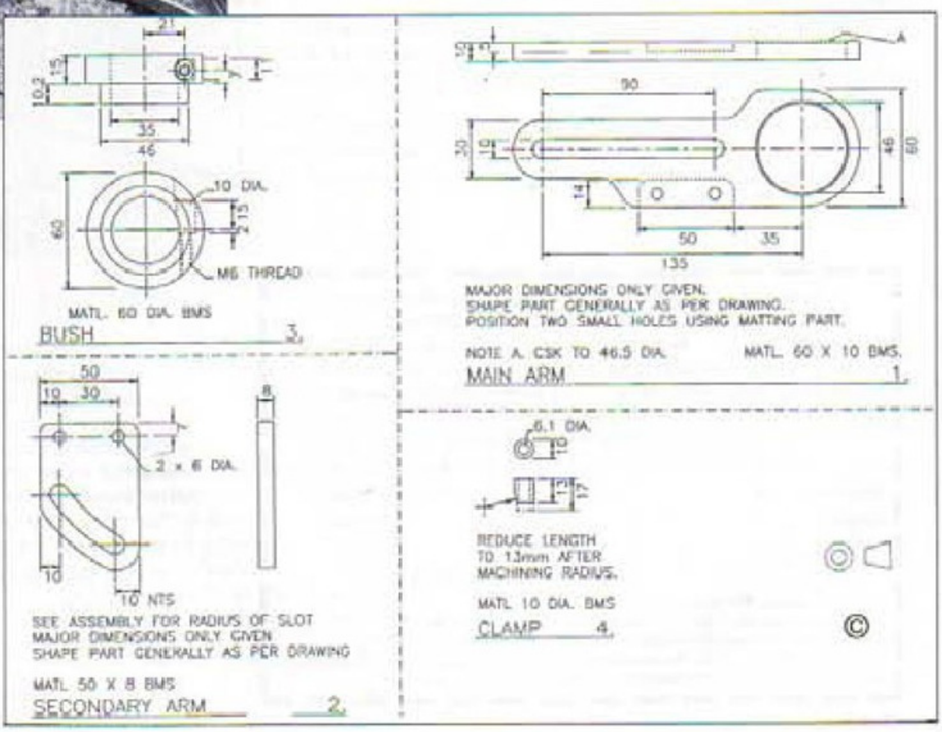
After making the clamp (4), initially 17mm long as shown on the drawing, the bush was the next item. This was first turned to be a very close fit in the 46mm diameter hole in the main arm and 10.2mm long. The extra 0.2mm length was an allowance for riveting the bush into the main arm. It was then parted off at around 25.5mm long. Next the recess, hole and tapped hole for the clamp were created and the clamp fitted. The bush was returned to the lathe, holding it on the 46mm diameter, and the through hole bored. The boss on the gearbox had previously been measured and a plug gauge accurately made to this diameter for checking the through bore. The clamp was then reduced in length, ensuring that it would grip the gearbox boss.

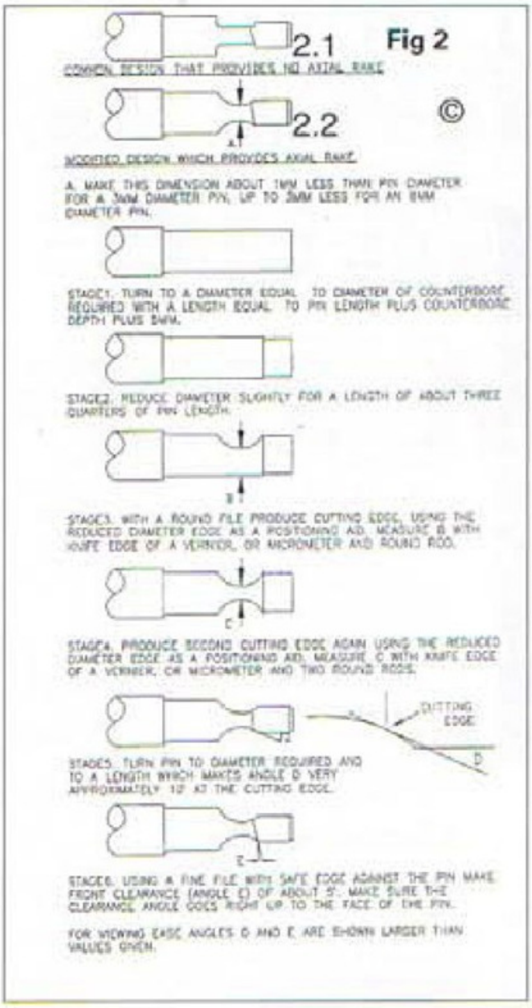
The bush was riveted into the main arm, and filed flush, followed by riveting the secondary arm to the main arm and the rivets similarly treated. The quadrant was now finished.

Counterbores

The most commonly published design for home-made counterbores provides no axial rake, as illustrated in **Figure 2.1.** This would be ideal if counterboring hard brass, but as these cutters are intended to produce counterbores for cap head screws, almost without exception they will be used on steel workpieces. The design shown in **Figure 2.2**, which also shows the manufacturing process, incorporates a measure of axial rake and were made to cover a size range of M3 through to M10, as can be seen in **Photo. 5.**

The stages of manufacture are clearly detailed in the sketches, but one





point worthy of further mention is the method I used for holding the counterbores whilst filing. This is shown in **Photo. 6**. By securing the material in the vee block, it could be held firmly in the vice in order to file the first side, then by turning the whole assembly through 180 deg. it was in the right position to deal with the second side. Thus it was relatively easy to make the two sides parallel within reasonable limits. After application of the round file, which of course needs to be smaller in diameter for the smaller sizes, the finish of the filed surface was improved by the use of a half round needle file. This improved the cutting edge which was eventually stoned after hardening to give that final keen edge. As a guide, the files ranged from around 6mm diameter for the smaller counterbores to about 9mm diameter for the larger ones.

Hardening followed standard practice which has been detailed in MEW on many occasions (References B, C, D), so I will not detail the process yet again.

Die head chaser holder

Another small item made whilst making the dividing head was a holder for a die head chaser (**Figure 3**). The design is straightforward and the only point worthy of mention is that the clamping force for holding the chaser in the assembly is created by the lathe's own tool clamping arrangement. The countersunk screw is only for holding the parts together whilst being brought to the lathe or in storage. For this reason it is essential that the screw head is well below the surface. If not, the bending of the clamp (2), under pressure from the lathe tool holder, may cause the clamping load to be taken by the screw head and not the chaser itself. **Photo. 7** shows the finished holder.

The 6.5mm distance between clamping faces (2.5mm on the clamp plus 4mm on the base) must be greater than the die head chaser thickness, 6.35mm (1/4 in.) in this case, in order to ensure that the pressure is applied at the outer end of the clamp, essential for satisfactory working. Do note this requirement if deciding to make a similar clamp for chasers of other thicknesses.

Morse tapers

Both the dividing head and the faceplate balancing fixture feature Morse taper sockets in their spindles. It may therefore be timely to re-iterate the method which I use when setting the angle of the top slide prior to turning such a taper. I make a test piece which allows the diameters at two precise points along the taper to be measured with a high degree of accuracy. With the distance between them also able to be

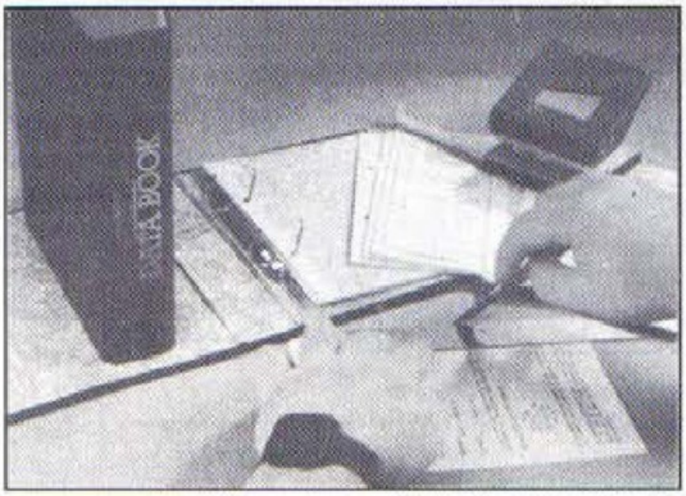
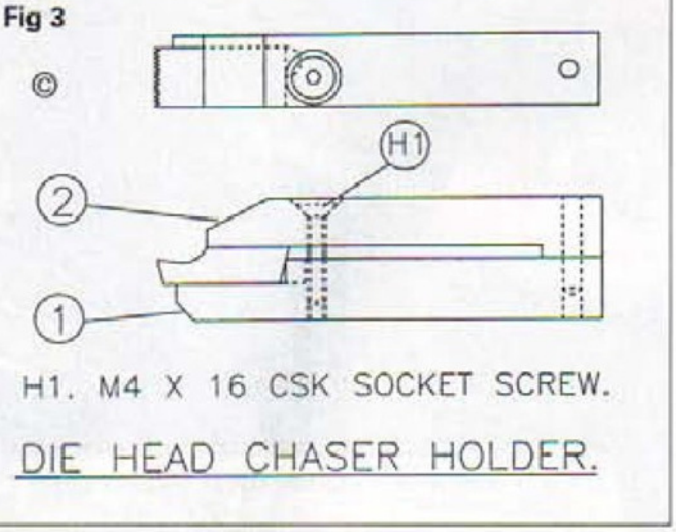
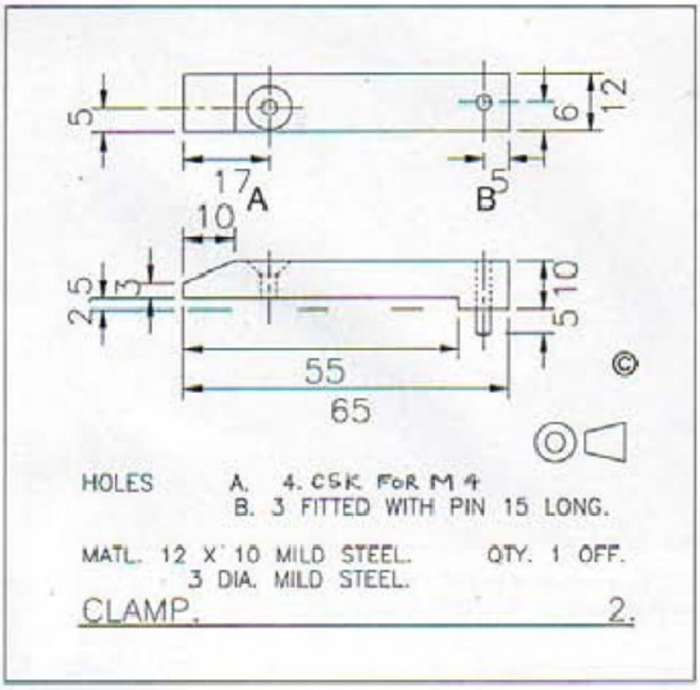
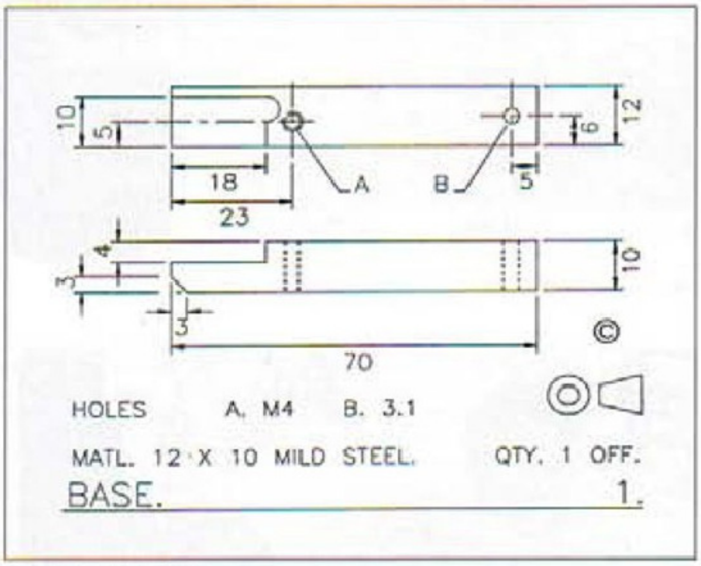


Fig 3







5. Counterbores to suit cap head screws from M3 to M10

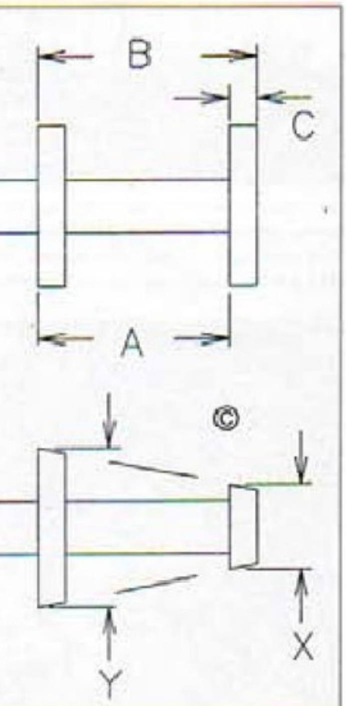
determined with precision, the angle of the taper being produced can be calculated.

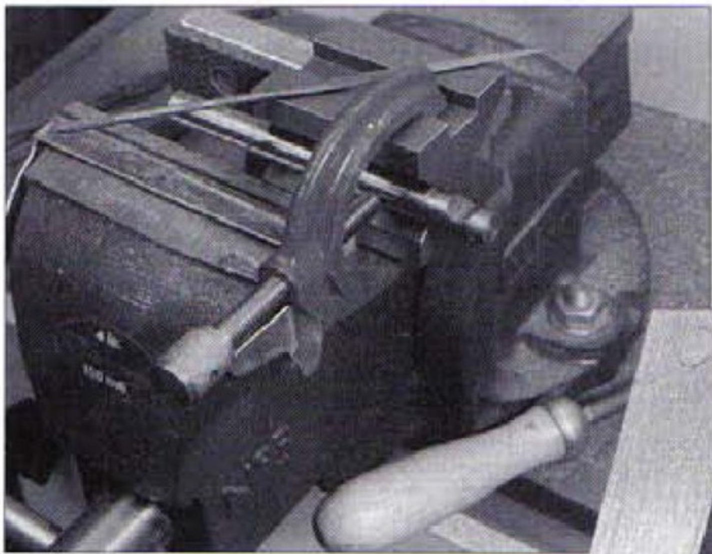
A test piece with two flanges is made as shown in **Figure 4**, with dimension A being the important value. As direct measurement of A is not easy, I measure both B and C with a micrometer and subtract C from B to arrive at dimension A. The two flanges are then turned with the top slide set as near as possible to the angle required, as shown in **Photo. 8**. When measured and the resulting taper angle calculated, it is a simple matter of adjustment of the top slide and repeat machining until the required difference between X and Y results. With this achieved, the top slide has been set to the correct angle.

I check the Morse taper which I have made against a mating taper, but this should be a formality as it should be OK first time. The sketches relate to turning an external taper, but the principle still applies when creating internal tapers such as those required for the two devices recently described.

The following table gives the value of dimension A for a difference between diameters X and Y of 0.04in.

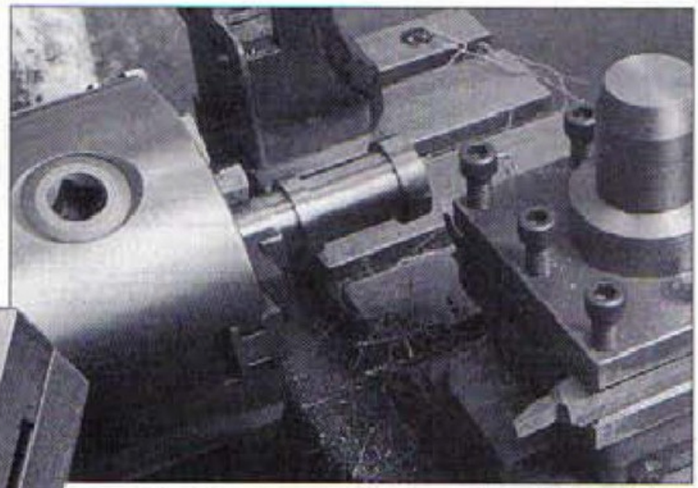
Fig 4





6. The method of holding the counterbore for filing the cutting edge

Morse taper	Taper per foot on diameter	Dimension A
1	0.59858in.	0.8019in.
2	0.59941in.	0.8008in.
3	0.60235in.	0.7969in.
4	0.62326in.	0.7701in.



8. The Morse taper setting test piece being turned

If a 2in., or even a 3in., micrometer is available, the dimensions can be doubled or trebled for added precision.

7. The die head chaser holder, for use when cutting threads on the lathe

If you have Issue 6 of the magazine do return to the article as it has greater detail than is given in this shortened explanation.

References

A. Turning a Morse taper. August/September 1991, Issue 6 page 28

B. Drills from flat stock. Issue 12 page 70

C. Rotating Centre. Issue 20 page 21

D. A plain man's guide to materials. Issue 20 page 32

MORE SCENES FROM OLYMPIA

Just a few of the people present at the Model Engineer Exhibition at the IMS caught on camera by Mike Chrisp, Technical Editor of Model Engineer

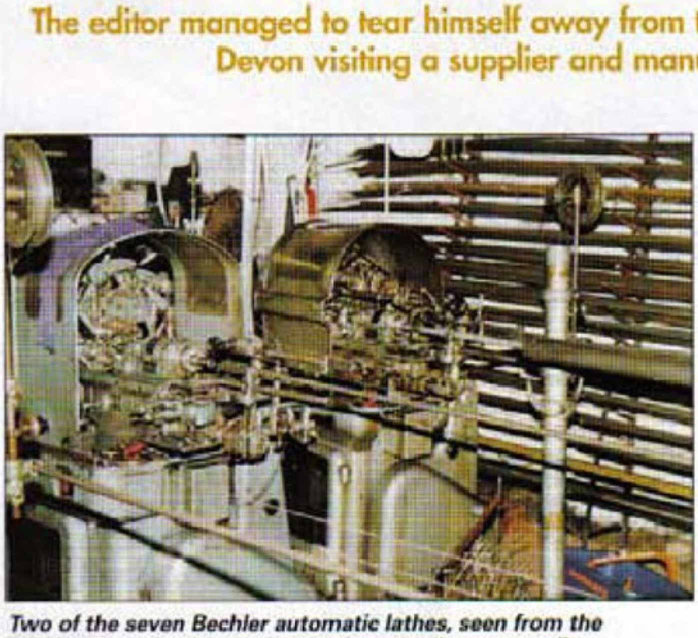
Jerry Kieffer of Wisconsin, USA and SMEE Secretary, Ron Hough look on as Barry Jordan uses a magnifying glass to study one of Jerry's miniatures. The challenge has now been issued and Barry has acquired a fully equipped Boley lathe with which to defend the honour of the British craftsman.

Above: Having both been brought up on 14 cylinder radials, the Editor and former colleague Doug Tritton are intrigued by David Boote's single cylinder sleeve valve engine which performed reliably in the i.c. engine demonstration area. As always, the Editor is having trouble finding somewhere to put his specs!

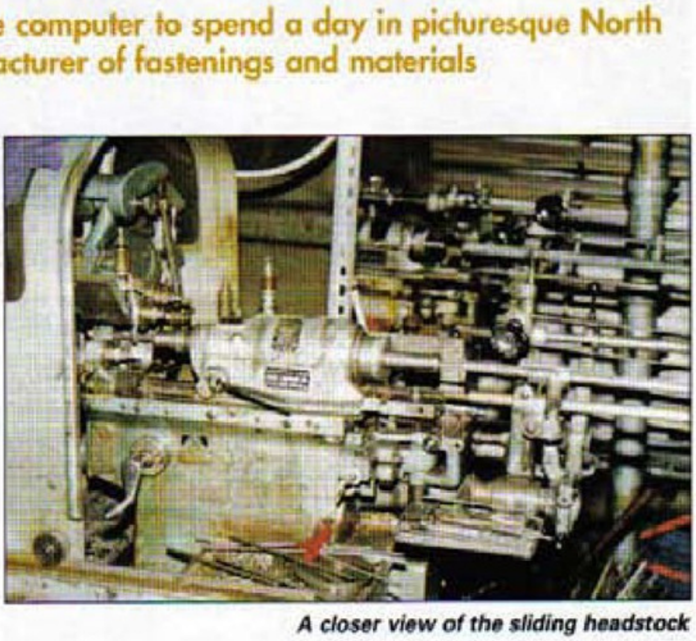
Left: Future readers of M.E.W. get down to some serious model building in the K'nex competition area. Many impressive projects were completed, allowing Dad plenty of time to study the exhibits or to spend his money on the trade stands.

WE VISIT EKP SUPPLIES

The editor managed to tear himself away from the computer to spend a day in picturesque North Devon visiting a supplier and manufacturer of fastenings and materials



Two of the seven Bechler automatic lathes, seen from the headstock end, with the bar feed mechanisms extending to the right



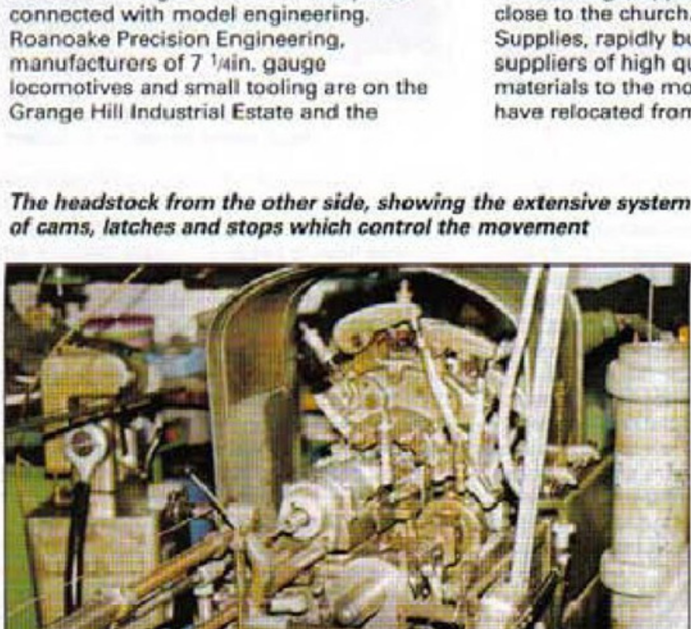
A closer view of the sliding headstock

Bratton Fleming is one of those North Devon villages which doesn't appear to have changed in decades. A few miles inland from the more popular coastal resorts, it is still very much a working village and still boasts a garage with filling station and a butcher, as well as the local pub. Interestingly, it now seems to be becoming a centre for enterprises connected with model engineering. Roanoake Precision Engineering, manufacturers of 7 1/4in. gauge locomotives and small tooling are on the Grange Hill Industrial Estate and the Exmoor Steam Centre, a 12 1/4in. gauge railway with a mile of track is at Cape of Good Hope Farm, just a little way from the village. Perhaps being on the route of the former Lynton and Barnstaple railway has something to do with it!

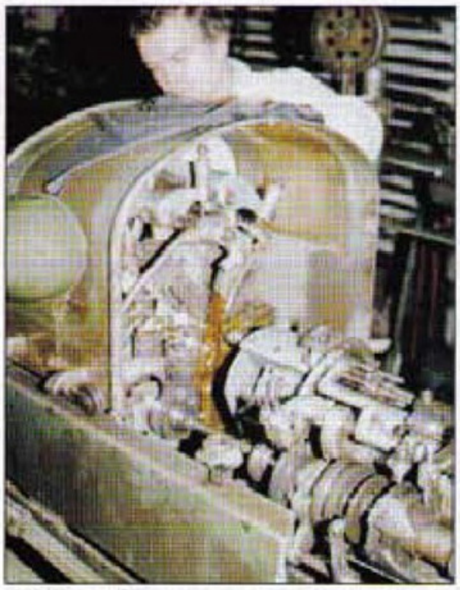
Our destination, on a very wet day in December, was located right in the centre of the village, opposite the butcher's and close to the church. It is here that EKP Supplies, rapidly building a reputation as suppliers of high quality fastenings and materials to the model engineering world, have relocated from their Coulsdon, Surrey premises.

This business, run by Lyn and Alan Pocock, with assistance from Alan's father, John, came into being because of frustrations and delays experienced when attempting to obtain supplies to support model engineering activities. Having built a number of models in previous years, John was engaged in constructing a 7 1/4in. gauge 'Bridget', while Alan had a 'Romulus' on the stocks. Having had a stream of orders returned with items marked 'to follow', Alan went looking for alternative suppliers who could meet their

The headstock from the other side, showing the extensive system of cams, latches and stops which control the movement

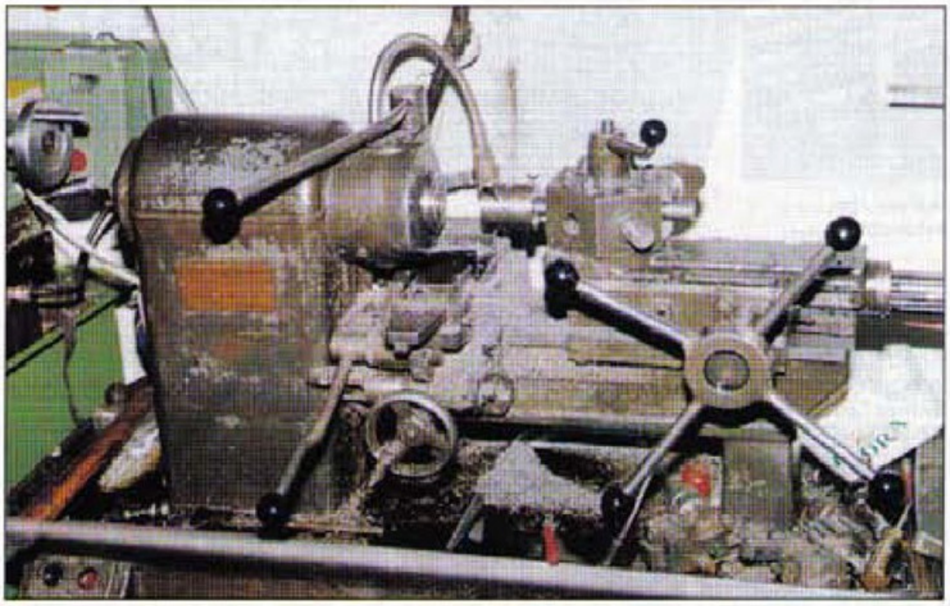


The five tool slides, each of which can accommodate a square high speed cutting tool. The powered tailstock is in the foreground



Alan Pocock makes an adjustment at the headstock end. The flood of coolant to the workpiece can be seen, as can some of the cams and tappets adjacent to the tailstock

The next-door workshop is the oldest section of the building and used to house a forge



The small capstan lathe is useful for making studding

This nut tapping machine is fascinating to watch in action

needs, and found a local manufacturer who had significant stocks in the required sizes. When this became known, other modellers asked if they could purchase small quantities, convincing Alan that there was a gap in the market which needed to be filled.

At this time, he was running his own building firm, so a part time enterprise was set up, with Lyn playing a major role.

All went well until existing stocks held by the manufacturer began to be exhausted. An enquiry about new production brought the unwelcome response that prices would have to rise considerably, in fact to levels which Alan decided would be prohibitive.

Although currently still engaged in the building trade, Alan had been brought up in an engineering environment and had experienced some formal training.

Originally an engineering machinist, John had later become responsible for running his company's training school and had also taught at a local college. At the time of his retirement, he held the post of Chief Engineer in a brewing company. Alan was allowed to 'help' in his father's workshop from an early age, becoming familiar with the rudiments of hand and machine work, building small models of his own, including a stationary steam engine. At the age of sixteen, he enrolled for a City and Guilds course in Engineering at a local 'Tech.' before embarking on his career in building.

With this experience behind him, he decided, with Lyn's support, to acquire the means to manufacture the replacement supplies of screws for himself. A second-hand bar feed automatic lathe by the Swiss machine tool manufacturer Bechler was purchased and Alan set about learning how to set and operate the machine to produce the items he knew were required. Once confident of producing components to a consistent quality, Alan was able to offer a wide range of fasteners to meet the demands of the model engineering world, to such an extent that a second Bechler was needed to keep pace with orders.

Early in 1997 it was becoming evident that the business was outgrowing the Coulsdon premises, so a search for a new base was started, a suitable house with a workshop attached being the objective. Although the Bratton Fleming house is not that old, the workshop has a very long history, at one stage having housed the village forge and also a farm waggon building shop. Evidence of both former activities can still be seen, a number of the

Some of the stock materials which can be seen on the EKP stand at exhibitions

Just part of the back-up stock of ferrous and non-ferrous materials, some in Imperial sections which are now difficult to obtain and have to be produced to special order

Alan sets up the bandsaw to cut one of the larger sections

wood working tools having been found. Alan says that, although he and John are building a 4in. Burrell, after a full day in the machine shop, he needs a rest from engineering so, reverting to his old skills, he enjoys the odd hour restoring parts of the old building. Incidentally, John has also moved to a village about 20 minutes drive away, where he has re-established his own workshop and is enjoying getting involved with the social life of the village, including art classes. He still provides active support to the business, and came to join us during our visit.

The extra space has allowed additional machinery to be installed, and there are now seven Bechlers sitting 'head to toe' to make maximum use of the space. Three more are held in reserve with one more used as a source of spares. These machines are now all hard at work producing all manner of screws, nuts and washers, both ferrous (including stainless) and non-ferrous. Standard headed and 'one size down' hexagon bolts, popular with model engineers, are regular production items, as are unslotted round head screws, which can be used in place of rivets where access is restricted.

It is fascinating to watch the Bechlers in action, but visibility is somewhat restricted due to the generous flow of coolant used when machining. The Bechlers are sliding headstock machines, with the 10ft. length of stock material entering through the hollow mandrel to be gripped by a collet. Cutting operations are carried out by high speed tools mounted in a bank of five tool slides and by drills, taps and button dies fitted to the powered capstan tailstock.

All movements are mechanically controlled, so the skill in using one of these machines is in the setting of the many cams, trips and micrometer stops and in grinding the necessary tool shapes. I expected to see some sophisticated means of tool grinding, but Alan gave us a display of the art of off-hand grinding, producing a perfect tool for a complex profile in a matter of minutes. As tool steel is used in significant quantities, it is also a catalogue item!

A more recent acquisition is a nut tapping machine which accepts pre-drilled hexagon blanks, feeding them along a long tap which features a curved end which allows it to be rotated by means of a slotted yoke. The threaded nuts are pushed along the tap by those following behind until they drop off the curved end into a hopper.

A conventional screwcutting centre lathe, a small capstan, a horizontal/vertical bandsaw and a home-made screw slotting machine (capable of being operated by younger members of the family) complete the inventory.

Difficulties experienced in obtaining Imperial size stock, particularly in hexagon form, prompted Alan to seek material suppliers who would be prepared to manufacture to special order. Although the minimum order quantities are substantial, production levels of fasteners are now sufficient to justify this major investment. A number of the other model engineering retail suppliers are now purchasing from EKP, both fasteners and raw material, so Alan is able to offer an increasing range of BA hexagon and Imperial section material, as his catalogue will indicate. With the versatile machinery and wide range of materials to hand, it is now possible to manufacture to meet special requirements, so if you have a particular need, give him a call.

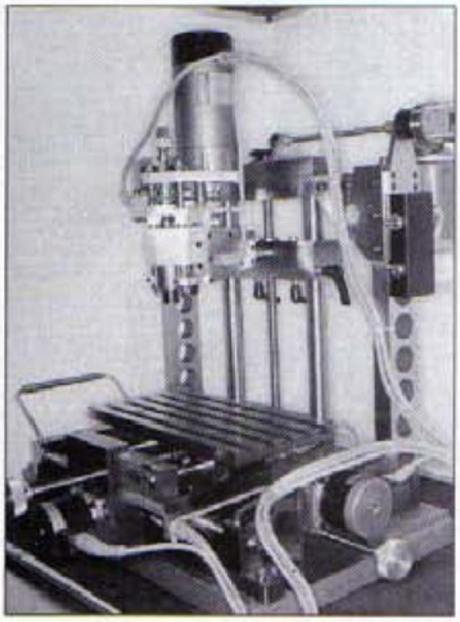
Other items listed include cutting and lubricating oils, and Alan has now located a source of case hardening compound. Some small tools are also carried as stock, some of these being manufactured in-house, including BA box spanners and a multi-size sliding die holder.

The majority of the business is, of course, carried out by mail order, a service mainly operated by Lyn, who also looks after the administration of the company. Alan, often supported by John, tries to appear at the majority of the major exhibitions, and also supports some of the smaller, local ones. We met him earlier in the year at the week-end event organised by the Taunton Society.

Our brief visit to North Devon was a most enjoyable affair, my wife, Gill taking the opportunity to explore the church and the rest of the village while we talked of things mechanical. There then followed a sociable gathering with Lyn, Alan and John for lunch in the 'local' while we filled in the background details. Unfortunately, we were unable to meet the children as they were attending the local school. I did, however, sense that history is repeating itself, as nine year old Michael already has his own small lathe and is busy making a (non-working) traction engine, while the family's pet rabbit looks on.

Given an average amount of good fortune, EKP Supplies is an organisation which should go from strength to strength as it tries to understand its customers' needs and to meet them in a dependable manner. Their comprehensive catalogue is available in return for four first class stamps.

EKP Supplies, The Old Workshop, Bratton Fleming, nr. Barnstaple, North Devon EX31 4SA Tel./Fax 01598 710892



A CNC MILLING MACHINE

Having completed the main structure, Peter Rawlinson concludes the description of his Gold Medal winning machine with the details of the control system. He also adds a number of accessories, including a CNC dividing head and steadies.

Electrical control equipment.

Safety

First off let me say that electricity in any form is dangerous and should be treated with the utmost respect, especially anything over 50 volts. I have heard of an accident where an electrician received a shock from 110 volts, centre tapped to earth, so only 55 volts above earth He recoiled and fell to his death from the top of a tower. Do be very careful. If any builder has the slightest doubt about his ability to handle the electrical modules, then please consult a competent electrician.

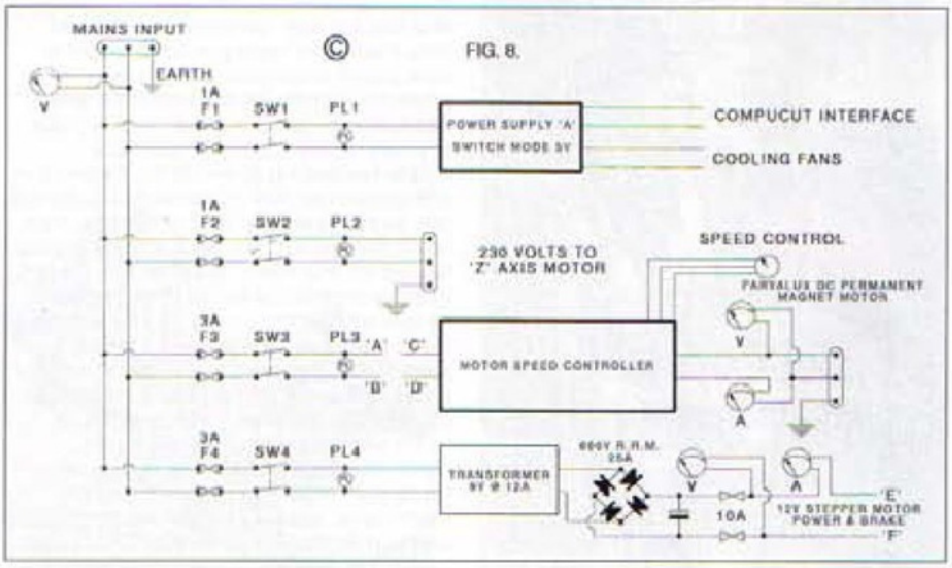


FIG. 8.

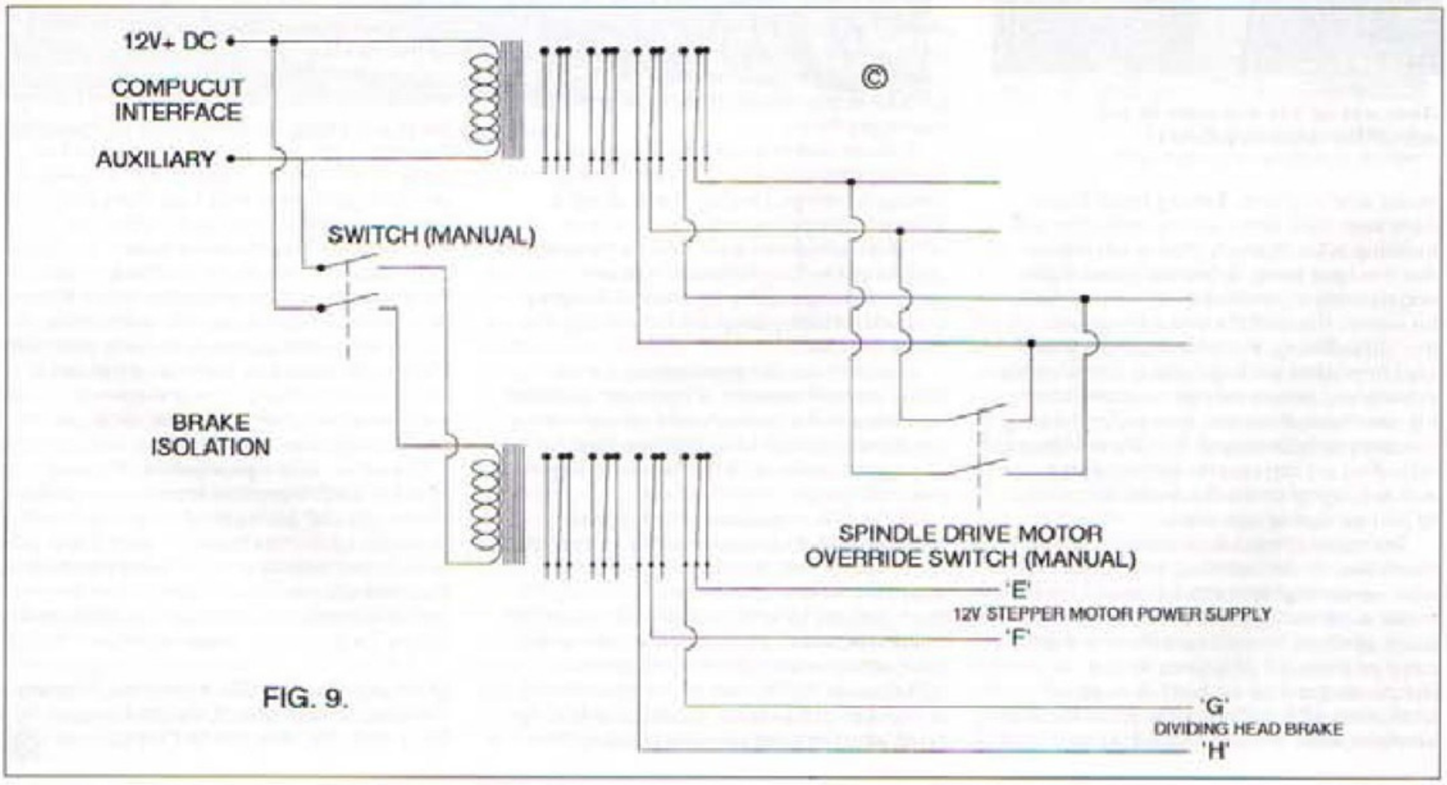
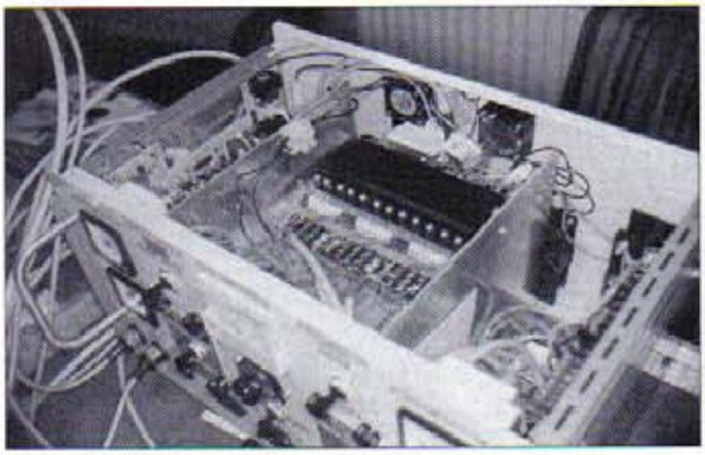
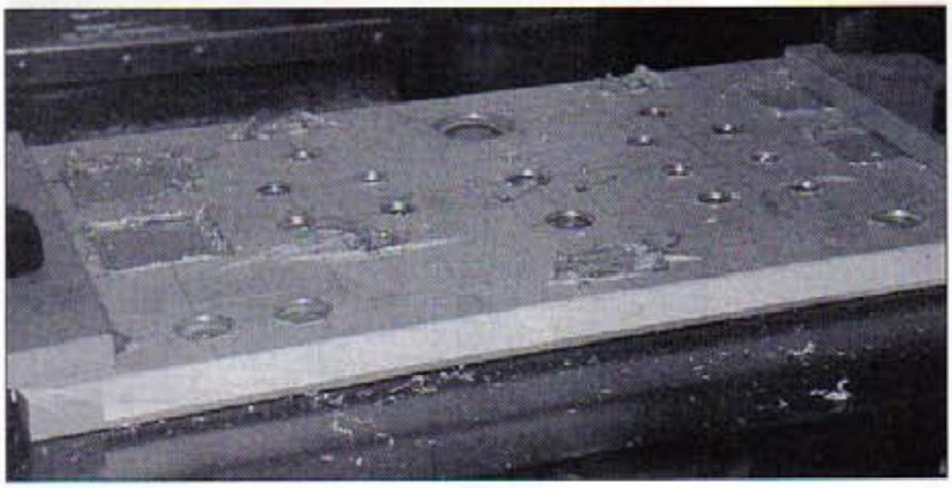


FIG. 9.



35. The electrical control equipment, showing how the cabinet has been partitioned to reduce the possibility of interference between one system and another. the 'Compucut' interface is mounted on pillars in the centre compartment

36. The front of the case, illustrating the comprehensive metering arrangements



37. Machining the front panel

Control system functions

The electrics are fairly straightforward, most of the electronics being dealt with in the 'Compucut' Interface. The control unit is fully switched and fused and features power input, spindle motor output, simulator output, stepper motor output (3), limit switch inputs (3), together with brake switches and spindle motor speed control. The circuit block diagrams are shown as **Figures 8 and 9**.

All stepper motors used are very low voltage DC, but of course mains voltages have to be fed to the various power supplies, these devices then supplying the required lower voltages, as follows:-

A. 5V for the interface.

B. 12V for the stepper motors.

C. DC Voltage as required for the spindle drive motor (60-100V).

Also, depending upon the motor being used:-

D. 230V. A.C. supply for the 'Z' axis drive.

Taking these in turn:-

A. This is best bought on the surplus market from a company such as Greenweld. Known as a Switch Mode Power Supply Unit (PSU), a suitable unit can be bought for as little as £3 - £4.

B. This can be built up from components. The current requirements are quite high (e.g. 3 off. Type 23 motors from Model Motors Direct requiring 10.2 Amps when running), and it is best to have some capacity in hand in case more powerful motors are used in the future. This Linear PSU is quite simple, using only a few parts. A circuit diagram is covered in the drawings.

C. This unit is best purchased as it is will be required to match the motor. The supplier of the motor should be able to advise on this and ought to be able to provide one which will match.

D. No problems here except the need to incorporate the appropriate fuses and to observe the normal safety precautions.

Control cabinet layout

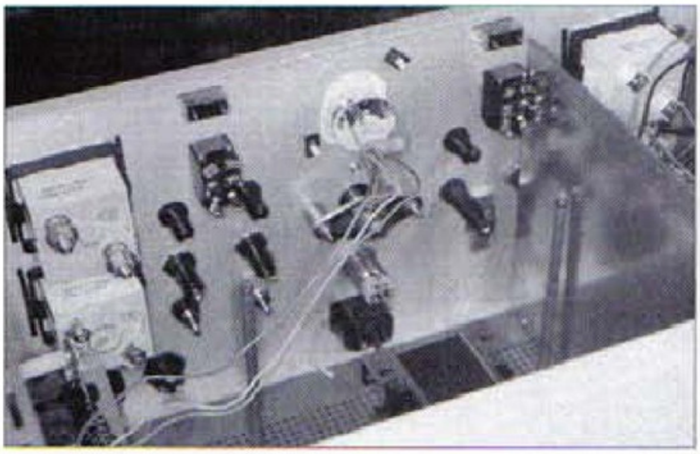
All of the above parts must be built into a cabinet, for safety reasons if nothing else. If the 'Compucut' interface to be fitted in as well as the power supplies, a reasonably large cabinet will be required. It must be fully ventilated and the one I used is readily available commercially and shown in the parts list, although home construction should present no difficulty to anyone contemplating making the machine. It is 430mm wide x 230mm high x 280mm deep and accommodates all the above parts, but there is very little excess room, one reason being that the Type 'A' power supply is about six times larger (physically) than is required.

Photo. 35 shows the internal arrangement of the cabinet, and it will be seen how the area has been divided up into three sections to reduce the possibility of cross interference. On the left we have the Type 'A' PSU which is mounted vertically on the left outer wall of the case. The centre area is sub-divided into upper and lower. The lower (not visible) contains the transformer, rectifier and capacitors for the stepper motor Type 'B' Linear PSU.

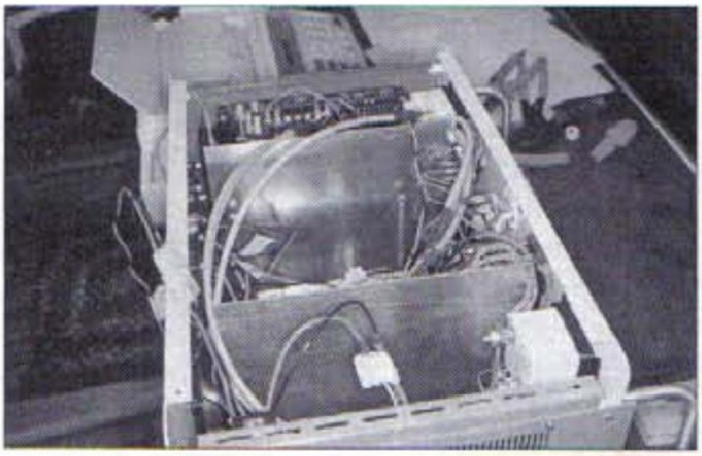
Over the top of this equipment and mounted on pillars is the 'Compucut' interface. Richard Bartlett recommends that this unit should be mounted in free air, but this does not suit my workshop due to the large quantities of coolant that I use and I also find that swarf travels well, so I take extra care. I have therefore fitted a series of fans in the rear of the case in order to force cool all the electrical and electronic components. This may look a little 'over the top', but to ensure that all the parts are covered, taking into account the dividing screens, I found it necessary to fit two larger ones in the bottom (I had them in stock) and two small ones in the top. These work well and I feel that I could have got away with fitting four small ones. Those fitted are all 12V but are run on 5V and then can hardly be heard.

The right hand compartment contains the spindle motor control with its associated relay and also the relay for the dividing head brake solenoids.

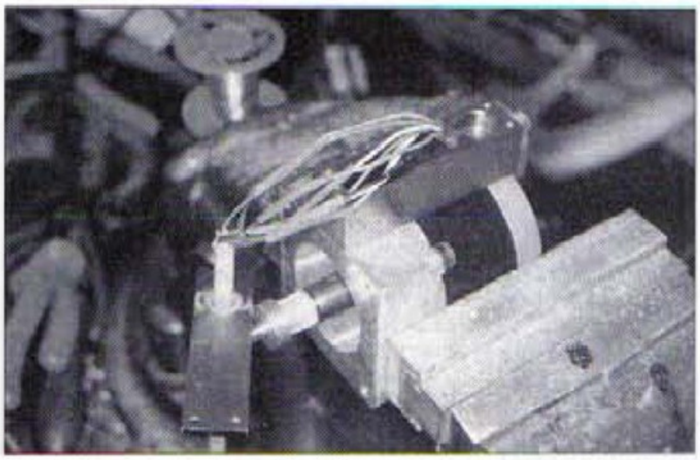
Photo. 36 shows the front of the case and, as can be seen, it is fully metered, having instruments to indicate the following:-



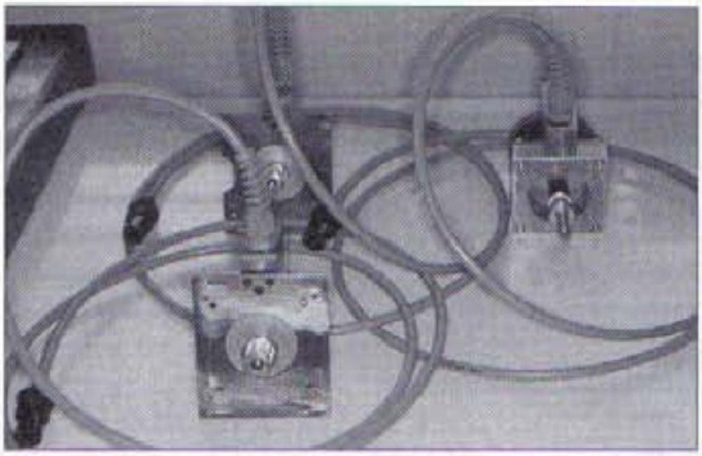
38. With the components in position, wiring has commenced in a methodical manner



39. A further view of the compartmentalised control cabinet



40. Wiring a stepper motor, showing the use of the specially made conduit box



41. The three stepper motors and their wiring, ready for installation

1. Mains input voltage
2. Stepper motor voltage
3. Stepper motor amperage
4. Spindle motor D.C. voltage
5. Spindle motor amperage

It is also fitted with four pilot lamps to indicate the 'On' condition of the following circuits:-

1. 5V regulated supply
2. 12V stepper motor power
3. Spindle motor power
4. Manual over-ride of spindle motor power.

Not all of these are absolutely necessary, so a decision should be made as to which ones are to be included before construction commences and the panel layout finalised before cutting metal. **Photo. 37** shows the machining of this panel. How much easier this would have been if the CNC mill had been available, even if the material had to be moved between cutting groups of holes due to its size.

The rear panel is the location of the four fans and the socket for the dividing head brake. It also has an extra mains input and an aperture which allows the input to the 'Compucut' interface to be attached without removing the top.

Wiring

A few tips which will go a long way to ensuring safe working:-

1. Have all parts available before starting.

2. Lay out all parts on the inside before mounting.

3. Make sure all parts are accessible before fixing.

4. Start with the mains supply side first and check each circuit as you go.

5. Always wire a circuit to completion and in that way you are not likely to become muddled at a later date. Check the circuit through immediately on completion of wiring.

6. Make sure that the motor and mains leads are long enough.

Always use a meter to check continuity and to see if there are any earth shorts. If a meter is not available then a simple battery and bulb will cover 90% of the checks but, whatever method is used, always do them before plugging in to the mains and switching on. When you do get to this important stage, always remove both hands from the 'innerds' of the box. As I have said before, if you have any doubts then I recommend that you recruit the services of a friend or colleague who is confident (and competent) to do the wiring or to check your work.

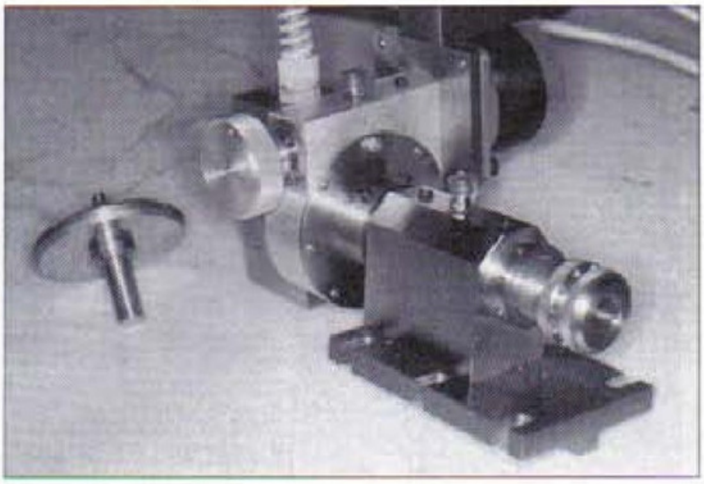
Photo. 38 shows the start of the fitting of the components into the case, particularly those on the front panel and **Photo. 39** shows another inside view of the finished control box.

Stepper motor wiring

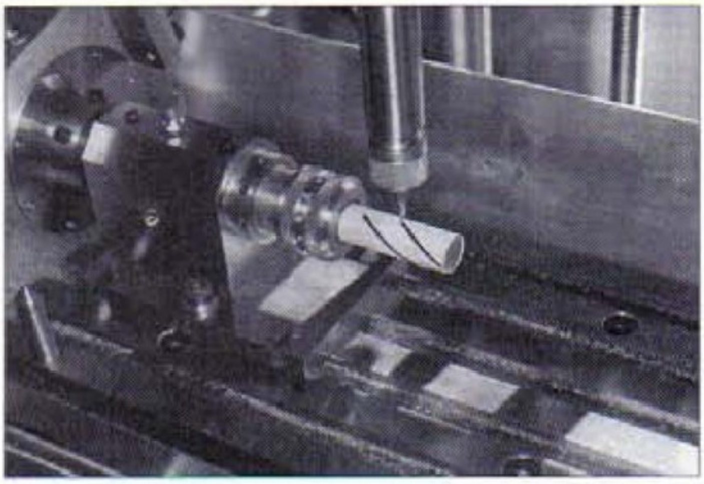
Photo 40 shows the connecting of the shielded multi-core cable to the stepper motor, connections being made in the special conduit box. **Photo. 41** is of all the stepper motors prior to mounting on the machine.

Interference problems

The only area where I experienced trouble was when some interference occurred between the 'X', 'Y' and 'Z' axis stepper motors, and this only happened when I modified the circuit to use a different voltage motor on the dividing



42. The CNC dividing head



44. The spindle flange and the collet closing ring are drilled to accept 'C' spanners. In this view a plotter pen is being used to check a spiral fluting program

43. The camshaft for a 30cc four cylinder i.c. engine produced with the aid of the dividing head

head. Each motor which uses a different voltage and current will require a different size of current limiting resistor, and I decided that, as I have plans to add other types of equipment, I would have these additional resistors built into the control cabinet and that I would have them switched for ease of converting between one type of motor and another.

It was here that I found that 'cross channel' interference was being caused and that the answer to this problem was to mount the switches and resistors in an aluminium box which was earthed to the case and to keep the leads from the interface as short as possible. From the outset I had used multi-core shielded cables in an attempt to minimise this problem. No other problems were experienced in the wiring, so without this additional feature, I would not anticipate that constructors should have any difficulties.

Dividing Head

The Dividing Head **(Photo. 42)** will, I am sure, be a very worthwhile addition to the milling machine, since although it cannot be used in the manner of a manual dividing head, it will facilitate the machining of complex components which are difficult by other means. A prime example is the camshaft for a 30cc four cylinder i.c. engine which can be seen in **Photo. 43**. The Head would also be useful for simple workholding tasks and it would be possible to sharpen spiral flute end mills and taps, it will of course entail sorting out the program, but this will just require a little work.

I built a dividing head many years ago, but that was larger and used Timken taper roller bearings, but I decided that this one was to be much smaller and very simple as it was to be

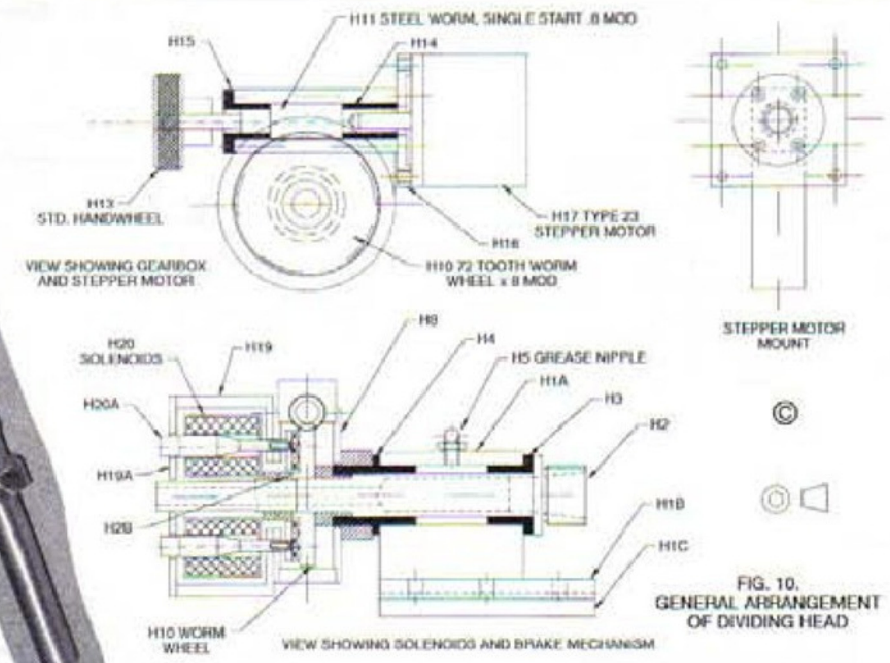
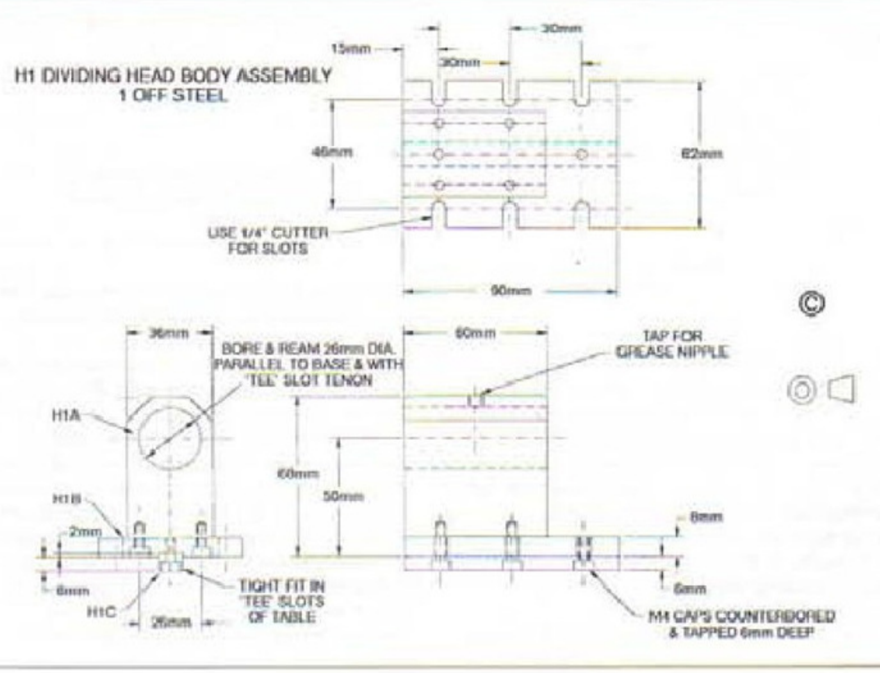
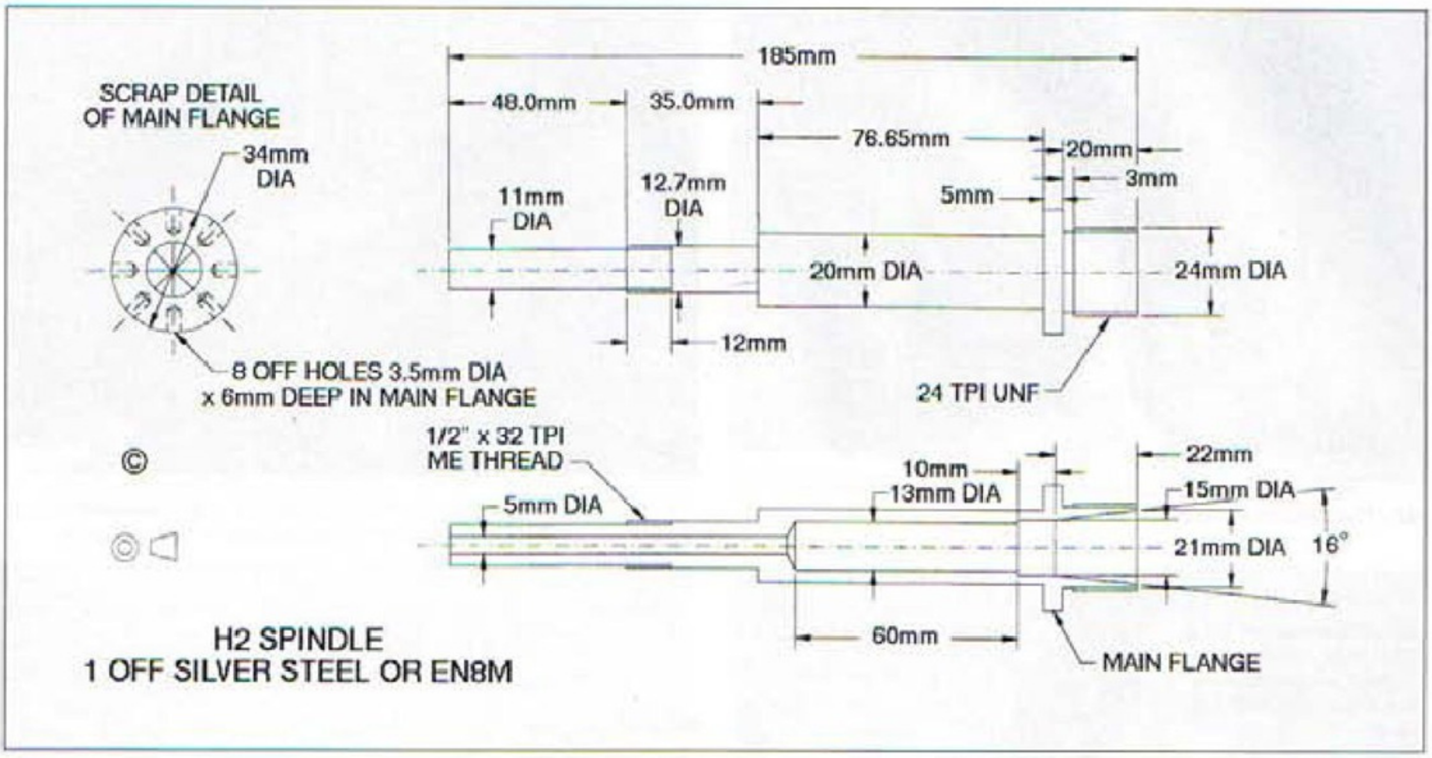
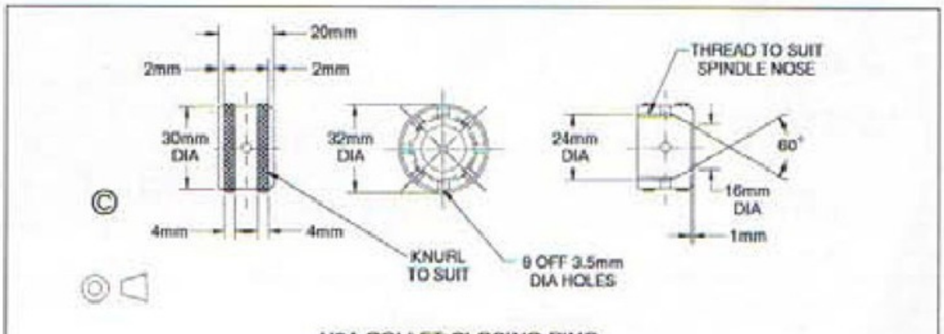


FIG. 10.
GENERAL ARRANGEMENT
OF DIVIDING HEAD

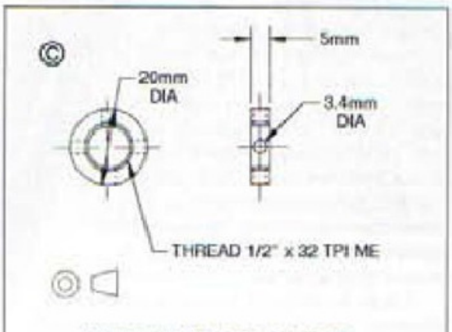




H2 SPINDLE
1 OFF SILVER STEEL OR EN8M

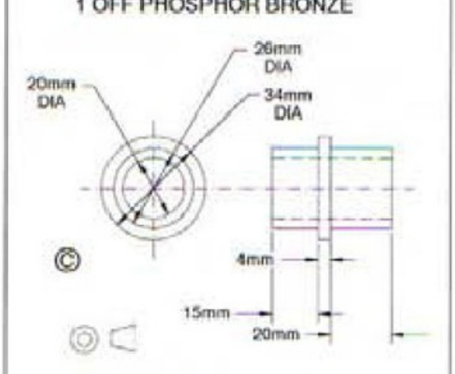


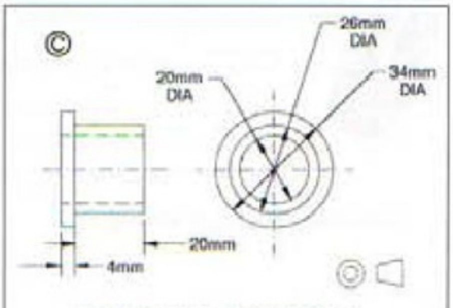
H2A COLLET CLOSING RING
1 OFF STEEL



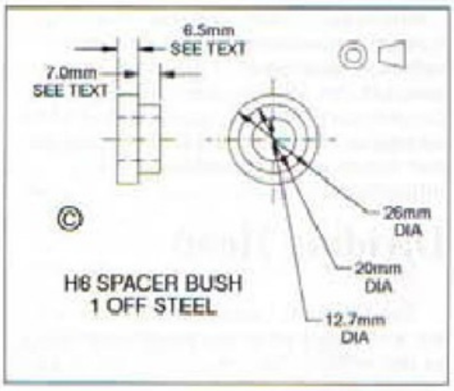
H2B SPINDLE LOCK NUTS
2 OFF STEEL

H4 SPINDLE BUSH (REAR)
1 OFF PHOSPHOR BRONZE





H3 SPINDLE BUSH (FRONT)
1 OFF PHOSPHOR BRONZE



H6 SPACER BUSH
1 OFF STEEL

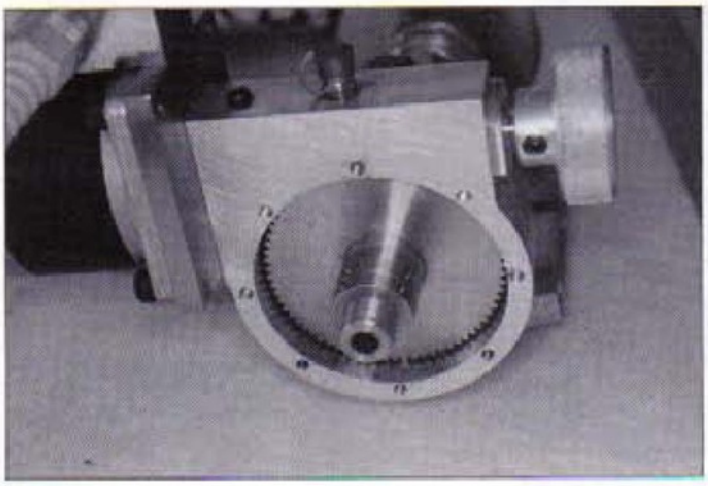
used on a machine with only a 1/10th. of the power. It is therefore equipped with plain bronze bearings and a soft shaft. The maximum diameter it will hold was set at 100mm and, as I mentioned in the description of the turret head, I have some ER collets which it was possible to fit directly in the nose of the spindle, with a closing ring to hold them in position (**Photo. 44**).

The General Arrangement of the head in its final form is shown in **Figure 10**. It was originally built without the brake, this being added later.

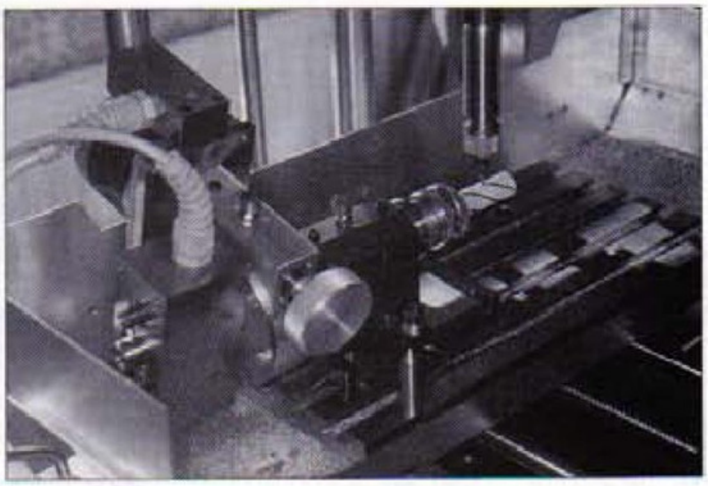
The body assemblies for the head and the tailstock (**Items H1 and T1**) are very similar, the main difference being in the diameter of the main bores. It will be obvious that it is necessary to ensure that the centres of these are at the same height above the base in order to be able to set work parallel to the machine table.

I have, over the years, fitted tenons to the under side of all of tooling which I plan to mount on the table of my milling machine, so I have carried on the 'tradition' on this piece of equipment. If properly made and fitted, these tenons eliminate the problem of having to clock up the piece every time it is fitted to the table.

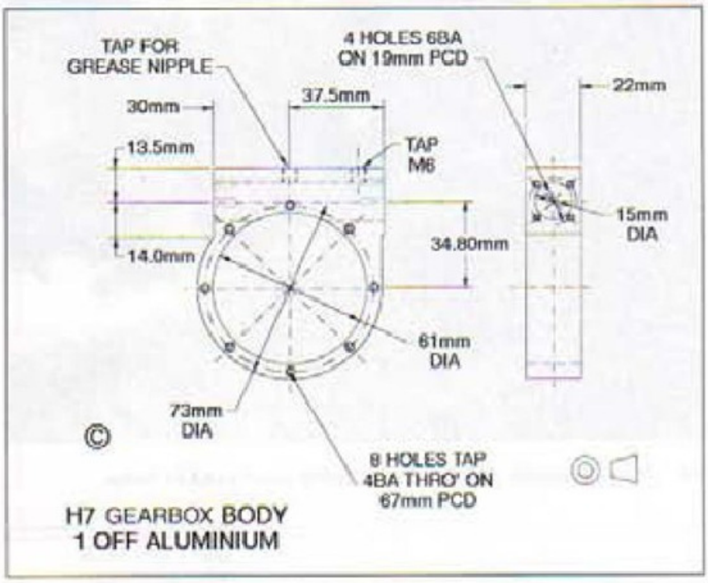
All the bushes fitted to the head must be concentric and a very accurate fit into their mating parts. The rear spindle bush could pose a problem as it is best to machine the outside diameters on both sides of the flange at the same setting. A tool similar to a parting tool will deal with this, but if you are not happy, then leave the flange off and adjust the position of the components accordingly.

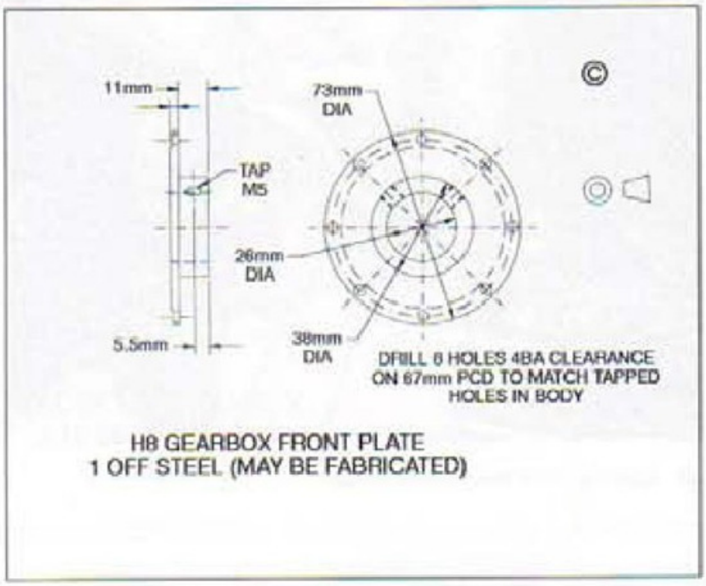


45. The gearbox showing the worm gear and the stepper motor



46. This view shows the stepper motor conduit box and the brake gear housing





On all parts which have to be concentric, I find that it pays to chuck an over-length piece of material, bore and ream then turn the outside and finally part off. I do realise that some people find problems when parting off on a small machine, but I suggest that the cost of an removable tip parting tool will be well repaid. A word on coolant; if you use a tipped tool then either use no coolant at all or swamp the job and tool with a continuous supply, as recommended by the tool manufacturer (or was 4-5 years ago). I would also not recommend running in back gear as the increased torque can cause problems - I would rather have the belt slip in the event of a 'dig-in'. If the tool starts to chatter, then increase the feed rather than decrease it. I played about with small tools for years before solving my problems. The use of a rear tool post can be advantageous.

The bushes should be a press fit in the body and the shaft a nice sliding fit within them, with no play. I have not given tolerances on the dimensions as we are not in an industrial manufacturing situation where any piece out of a possible batch size of 10,000 must fit with any another piece. The time available to the amateur and the skills which can be developed can often result in the achievement of a better fit and finish.

The main spindle and associated components

This is machined in the way I have described for similar items described in the past (see the articles on the cutter spindle and the right-angle drive unit). First machine the nose and the collet recess. Next chuck a piece of bar in the lathe and turn this down until it is a good fit in the recess. Using an adhesive such as Loctite, attach the embryo spindle to the stub mandrel without removing the latter from the lathe. With support from the tailstock centre, the spindle can now be finished machined with confidence.

This type of collet uses a closing ring **(item 2A)** on the nose of the spindle. The same comments apply to this as to the similar ring described for the alternative design of cutter head spindle. Both this closing ring and the flange of the spindle are again drilled radially so that 'C' spanners can be used. A similar arrangement is employed on the spindle lock nuts. Drawings of suitable spanners are provided.

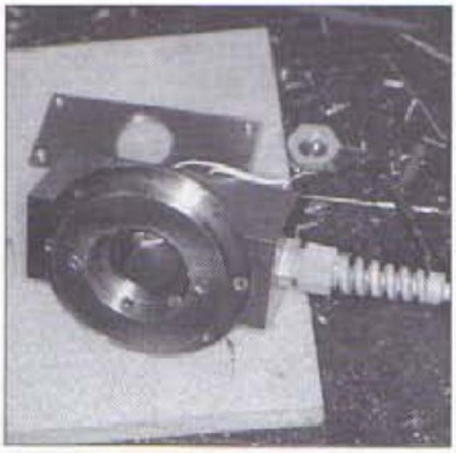
Gearbox

Item H7, the gearbox body was machined from aluminium **(Photo. 45)**, but could be made from any material to hand. It is important to maintain the dimension of 34.8mm as this is necessary to ensure the correct meshing of the worm and wheel. The machined faces must be square to the bores and at right angles to each other.

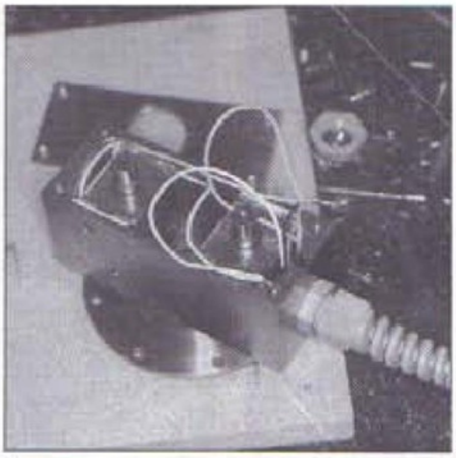
The motor mounting plate is common to all makes of motor of the Size 23 variety and incorporated in this are two 6BA tapped holes for mounting the conduit box which can be seen in **Photo. 46**. (Note comments in previous articles).

The front and back plates of the gearbox require no special machining instructions, but they must be concentric and faced parallel. The front plate must also be a very good fit on the rear spindle bush.

Drawing **H11** shows the modifications which must be made to the worm gear. These must be carried



47. The brake disc is seen here before the cork facing has been applied



48. Brake solenoids and plungers before fitting the cover plate

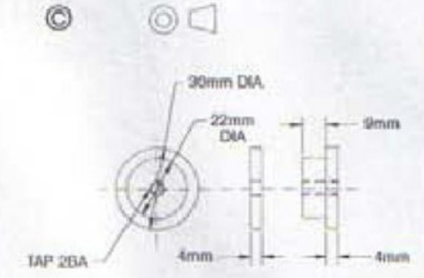
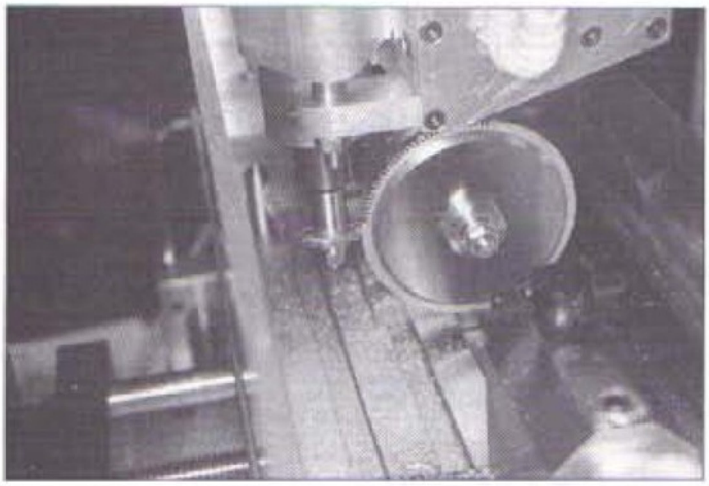
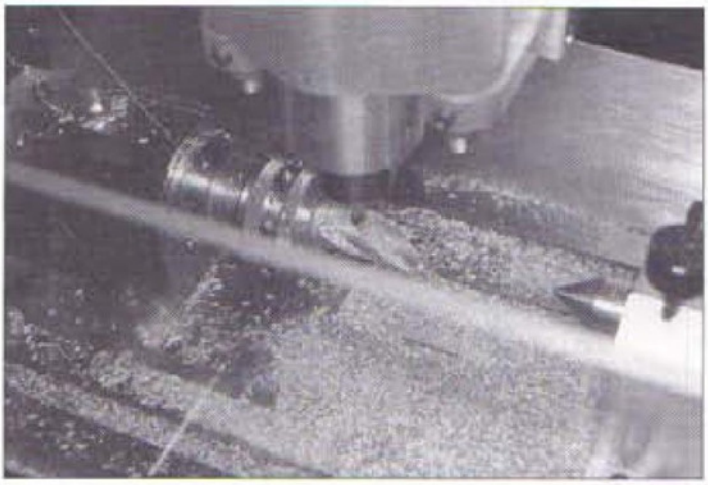


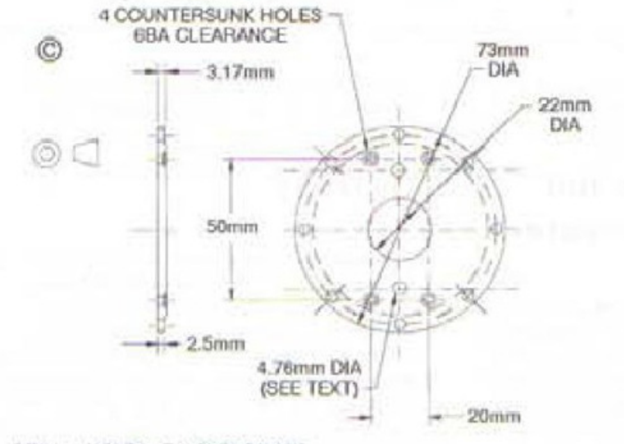
FIG. 11 SETTING TOOL FOR USE WHEN DRILLING SOLENOID PLUNGER HOLES IN ITEMS H9, H19 & H21



49. Cutting a 120 tooth clock wheel

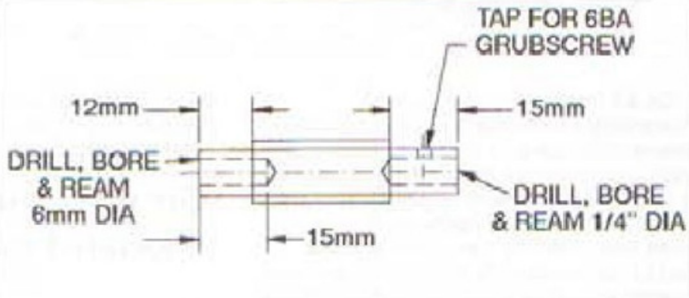


50. The previously plotted spiral being machined in brass

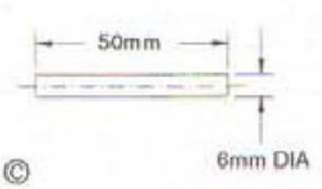


DRILL 8 HOLES 4BA CLEARANCE ON 67mm PCD TO MATCH TAPPED HOLES IN BODY

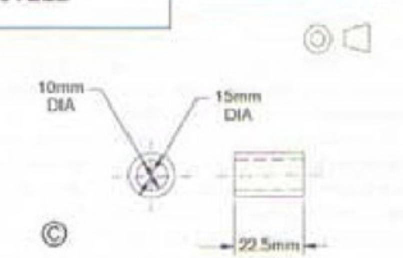
H9 GEARBOX REAR PLATE
1 OFF STEEL



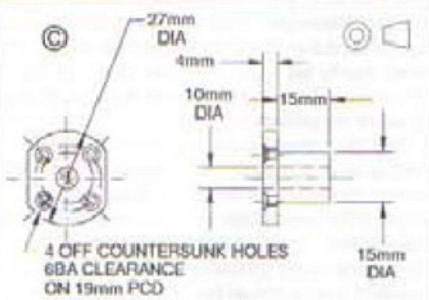
H11 WORM GEAR
SINGLE START .8 MODULE
1 OFF STEEL



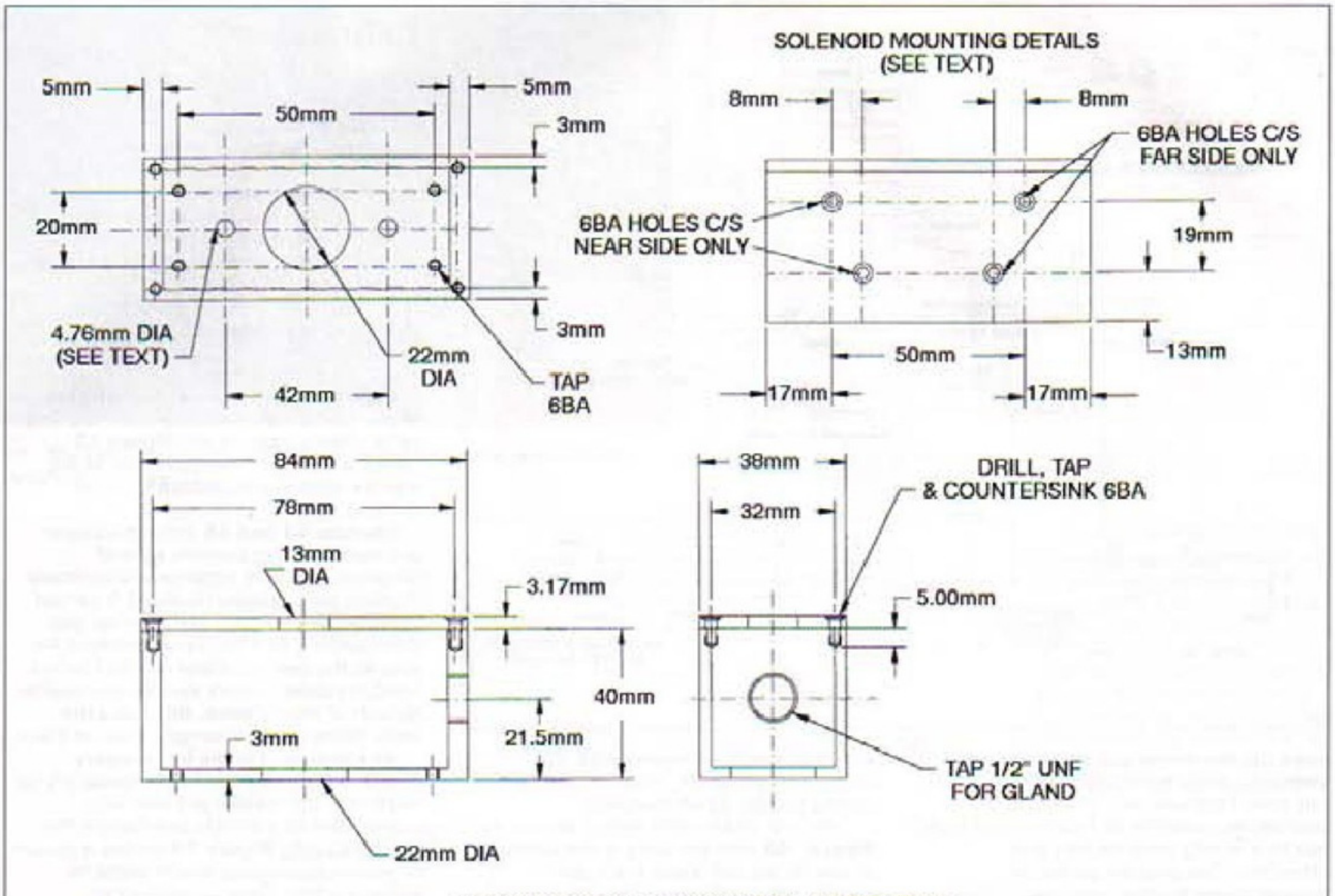
H12 WORM SHAFT
1 OFF SILVER STEEL



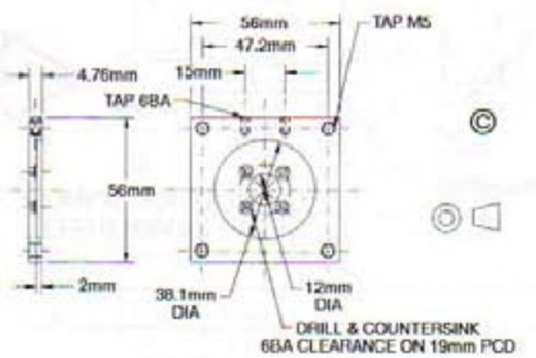
H14 WORM BUSH (FRONT)
1 OFF PHOSPHOR BRONZE



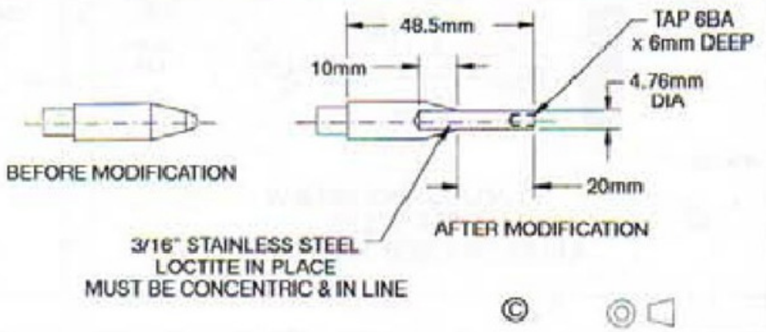
H15 WORM BUSH (REAR)
1 OFF PHOSPHOR BRONZE



H19 BRAKE SOLENOID BOX ASSEMBLY
1 OFF STEEL



H16 STEPPER MOTOR MOUNT
1 OFF STEEL



H20A SOLENOID PLUNGER
2 OFF CAST IRON

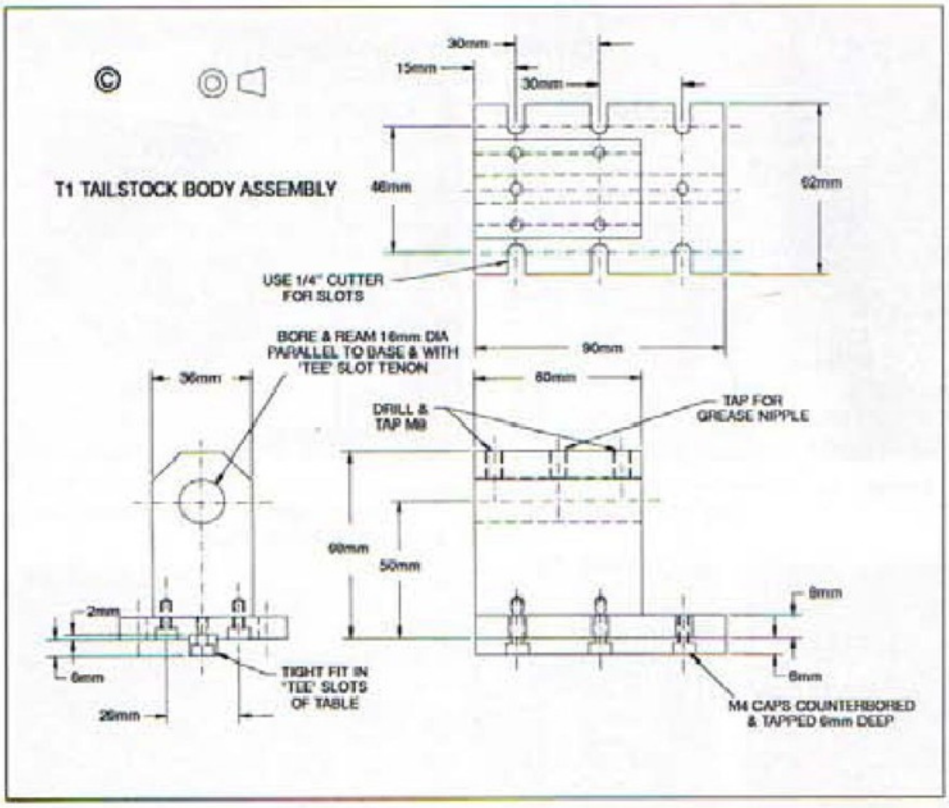
out accurately in order to maintain concentricity and alignment, so take your time when setting up.

We now come to the brake **(Photo. 47)** which uses two surplus 12 volt solenoids **(Photo. 48)**. These are obtainable new but you need to check the sizes before cutting material. It is likely that the mounting system may be different.

The brake itself consists of a disc faced with cork sheet approx. 3mm thick. This is pressed on to the face of the worm wheel by the action of the solenoids. There is no positive release mechanism, such a feature not having been found necessary as the shaft is quite free as soon as the solenoids are de-energised.

The brake box was first machined and bolted to the rear gearbox end plate, then the solenoids mounted in place. With the brake plate located in position using the setting tool shown in **Figure 11**, the solenoid base, the box and the brake plate were drilled through and reamed to accept the solenoid plungers. By first drilling 6BA clearance (2.9mm), the holes in the brake plate could then be countersunk and counterbored as shown on the enlarged view of drawing **H21**, to locate the ends of the plungers. The plungers were then modified as shown and all assembled, the parts all having been position marked as they were drilled in situ.

The brake was first tried in free air and found to be satisfactory. It retracted under its own weight, so it was fixed in place and tried again, by holding the head in a vertical plain and



nose up, the brake still released itself. It seems to have sufficient power to hold, but only time will tell. It would, of course, be possible to fit a manual lock, but this would require frequent attention. The system could be programmed to stop and report each time this action is required, something which is easily achieved with the Compucut program, requiring little typing (about 12 characters).

The 120 tooth clock wheel shown in **Photo. 49** was cut before the addition of the brake and even then, no significant backlash or double cutting was experienced.

Tailstock

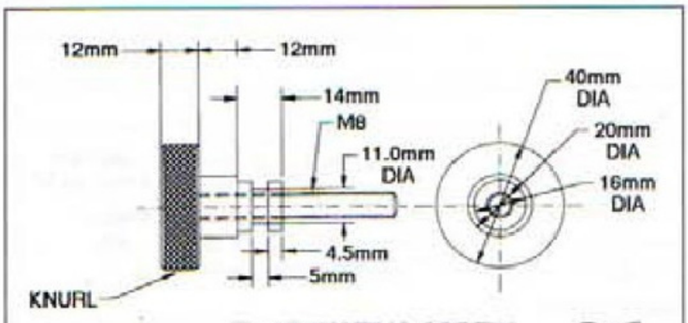
As mentioned previously, the tailstock body is similar to that of the headstock. As drawn it is slightly different to that seen in some of the photos, having an extended base, similar to the headstock. This allows the tailstock to be set further back along the bed, increasing the 'between centres' capacity.

Accessories

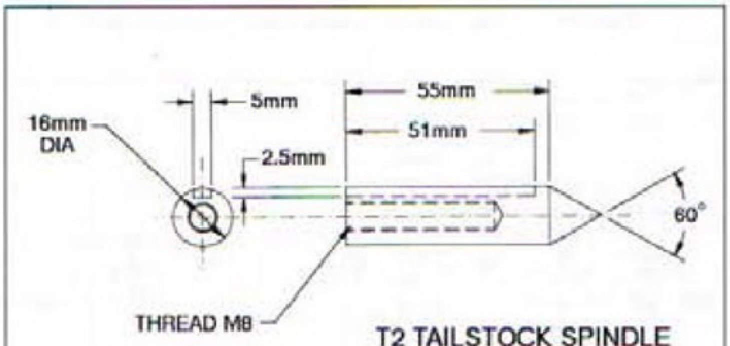
Figure 12 shows a set of 'C' spanners which will fit the various spindle nuts and collet closing rings, while **Figure 13** details a couple of fixed steadies which may be used in conjunction with the dividing head.

Photos. 44 and 46 show the plotter pen being used to confirm a spiral program. This item consists of a standard drawing pen, suitably modified. It cannot however be given the 'H.P.' pen up, pen down orders, so it has to be watched. As long as the pen is full and checked before hand, it seems to work well for reasonable periods of time. **Photo. 50** shows the spiral being cut on a sample piece of brass.

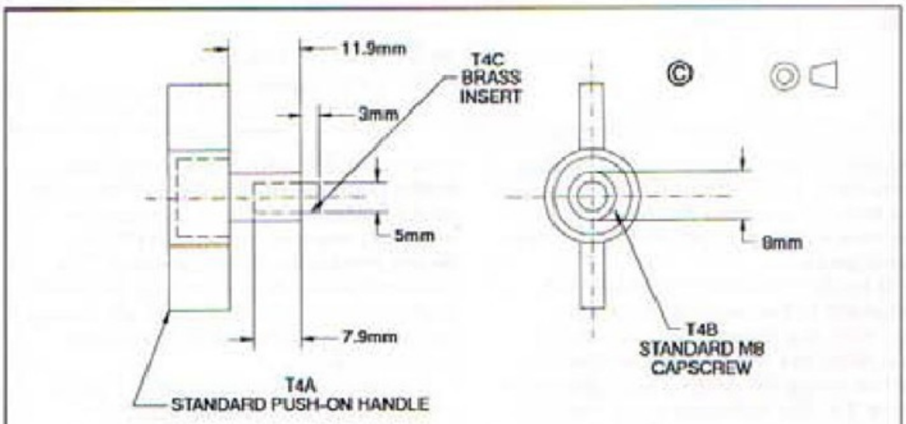
As mentioned in the introductory article in Issue 52, it is often necessary to relate the '0,0' datum position of a component to a similar position on the machine table. **Figure 14** shows a couple of useful accessories which assist in achieving this. They are shown in operation in **Photo. 51**.



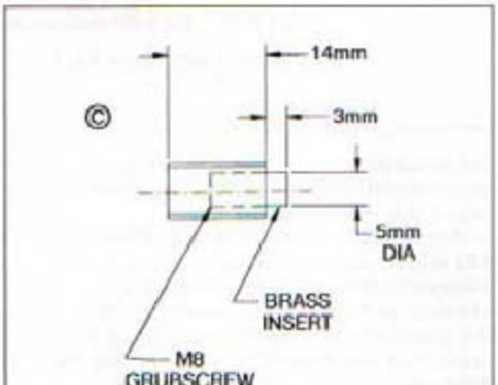
T3 ADJUSTING SCREW
1 OFF STEEL
KNURLED KNOB ALUMINIUM



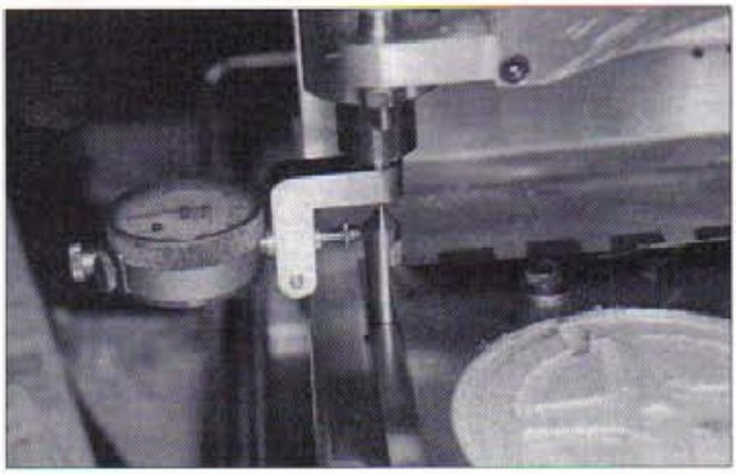
T2 TAILSTOCK SPINDLE
1 OFF SILVER STEEL



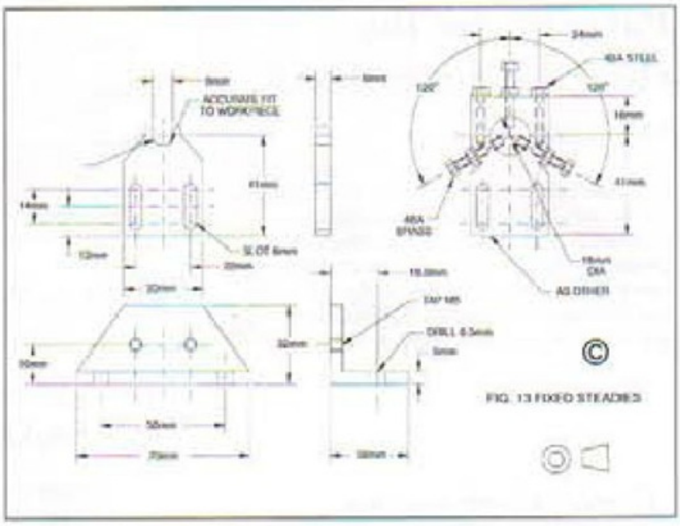
T4 CLAMP SCREW ASSEMBLY
1 OFF

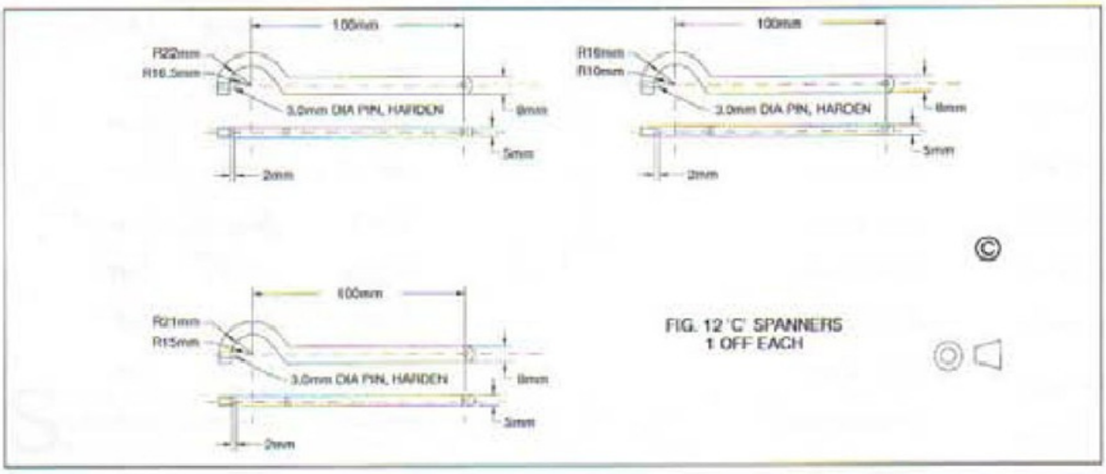


T5 GRUBSCREW
ASSEMBLY
1 OFF



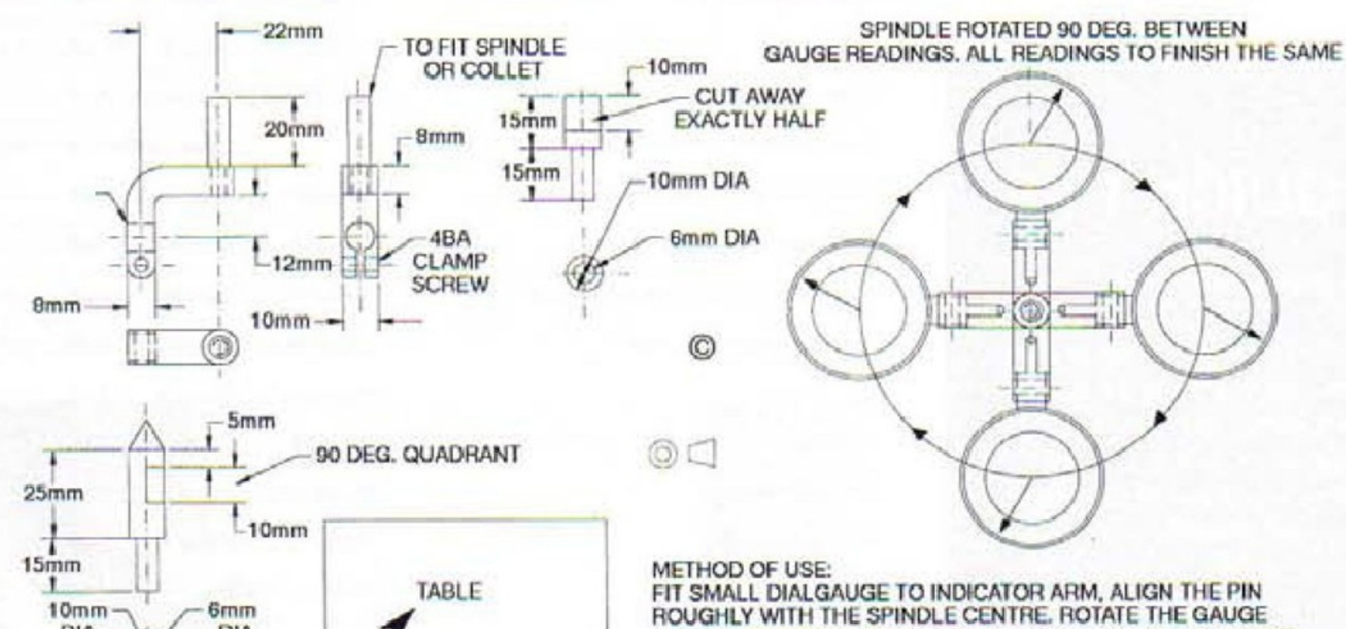
51. The table being set to the zero datum using the components detailed in Figure 14.





A short series of trials has confirmed that it should be possible to sharpen spiral flute taps and milling cutters, as mentioned earlier. I have an air driven grinding spindle, capable of spinning a small mounted point at some 10,000-20,000 rpm. It will be interesting to adapt the milling machine to accommodate this tool.

As I have mentioned before, I am willing to try to answer questions on the project, but by telephone only (01233 712158).



METHOD OF USE:
FIT SMALL DIALGAUGE TO INDICATOR ARM, ALIGN THE PIN ROUGHLY WITH THE SPINDLE CENTRE. ROTATE THE GAUGE AROUND THE PIN AND ADJUST THE 'X' & 'Y' AXIS UNTIL THERE IS NO MOVEMENT OF THE NEEDLE ON THE DIAL. THIS INDICATES THAT THE SPINDLE AXIS IS DIRECTLY OVER THE 'CENTRELINE' OF THE TABLE PIN. PROGRAMS DRAWN IN CAD WILL NOW BE POSITIONED FROM THIS POINT, IF THE PART IS ALSO DRAWN FROM THE 'ZERO-ZERO' POSITION ON THE CAD PROGRAM. THIS ALLOWS A SIMPLE METHOD OF SET UP AND CAN ALSO BE USED ON A TYPED PROGRAM.

FIG. 14
DATUM POSITIONING SYSTEM

Parts list for the electrical control system

Listed below are the components used in my system, together with suggested sources of supply. Other than Model Motors Direct and Richard Bartlett, the companies listed are not aware of this project or of the components listed. Wren Engineering are also planning to supply some parts.

Cabinet	480 x 230 x 280mm	224-032	R. S.	1 off
Meter	0 - 10A	108-449	Farnell	2 off
Meter	0 - 150v	312-763	R. S.	l off
Meter	0 - 300v	108-455	Farnell	1 off
Meter	0 - 30v	259-583	R. S.	1 off
Pilot lamps Mains	–		J & N	4 off
D.P.S.T Switches		FH39N	Maplin	4 off
D.P.C.O. Switch		JK30H	Maplin	1 off
Vernier dial 50mm		RX40T	Maplin	1 off
Fuse Holders		DA59P	Maplin	8 off
Fuse Holders		KC01B	Maplin	2 off
Input Socket		HL15R	Maplin	1 off
Output Socket		MK17T	Maplin	2 off.
6 pin socket		HL36P	Maplin	3 off
3 pin plugs		JU67X	Maplin	3 off
6 pin plug		HL37S	Maplin	3 off
3 pin socket		HL20W	Maplin	3 off
4 pin plug		HL33L	Maplin	1 off
4 pin socket		HL34M	Maplin	1 off
Mains socket		MK20W	Maplin	1 off
Motor output		FT64U	Maplin	2 off
Brake Switch		JK30H	Maplin	l off
Relays		DE08J	Maplin	2 off
Bases		SD77J	Maplin	2 off
5v Regulated Power Supply Unit			Greenweld	1 off
Transformer (Secondary 9V at 12A)		696-948	Farnell	l off
Rectifier (600V, 25A)		371-877	Farnell	1 off
Capacitor (10000 Êfarad, 63V DC)		491-032	Farnell	1 off
Motor Speed Controller		Parvalux/R.S./Farnell		l off
D.C. Motor		Parvalux/R.S./Farnell		1 off
Handles		861-297	Farnell	2 off
100mm Fans 12v		Model Motors Direct		2 off
60mm Fans 12v		Model Motors Direct		2 off
Compucut Interface		Richard Bartlett		1 off
Printer Cable		202-600	R. S.	1 off
Resistors (25 Watt or to suit motors) (See Compucut instructions)		R.S./Farnell		6 off
D.P.C.O. Switches		R. S. / Farnell		3 off
Screening Box		Greenweld		1 off
Micro Switches		J. A. Crew		3 off

As required:- solder, connecting wire, nuts, bolts, self tappers, connectors, glands, cable ties, labels, fuses, shrink sleeving, sleeving, insulating tape, fan guards, mains plug

Contact telephone nos.

R. S. (Electromail)	01536-204555
Farnell	0113-263-6311
Maplin	01702-554000
Model Motors Direct	01458-850061
J.A.Crew	01386-841979
Greenweld	01703-236363
J & N	01444-881965
Richard Bartlett	01203 473851
Wren Engineering	0181 312 0413

QUICK TIPS

A moveable vice

If you're short of bench space, bolt your vice on to a piece of steel plate, countersunk underneath, and fix it to the bench with a pair of G clamps. For a 4in. jaw vice, a plate 8in. x 6in. x 1/2in. will be about right, and a pair of 5in. clamps will hold it almost as securely as bolting it down. The vice can then be re-positioned or moved out of the way altogether in just a few seconds.

Ian Baggett

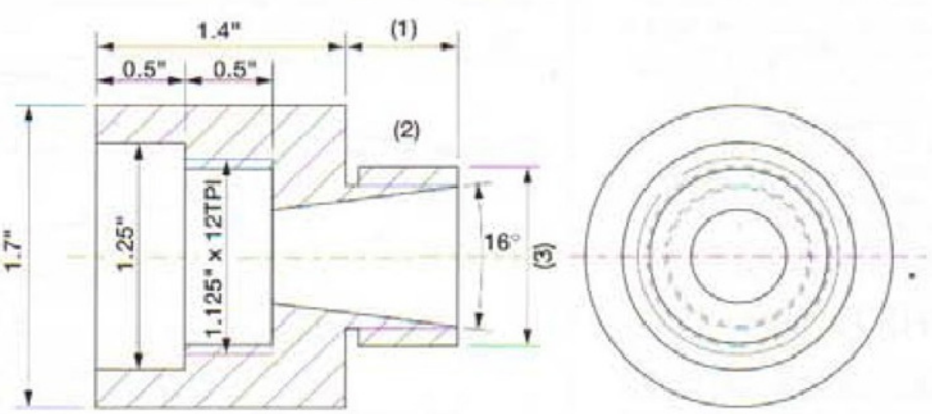
A MYFORD NOSE COLLET ADAPTOR

Dr. Giles Parkes has devised a simple method of fitting spring collets to the Myford S7 Series lathe

MYFORD COLLET ADAPTOR

FOR ER20 COLLET
(1) 0.65"
(2) M25 x 1.5
(3) 25mm

FOR ER25 COLLET
(1) 0.8"
(2) M32 x 1.5
(3) 32mm



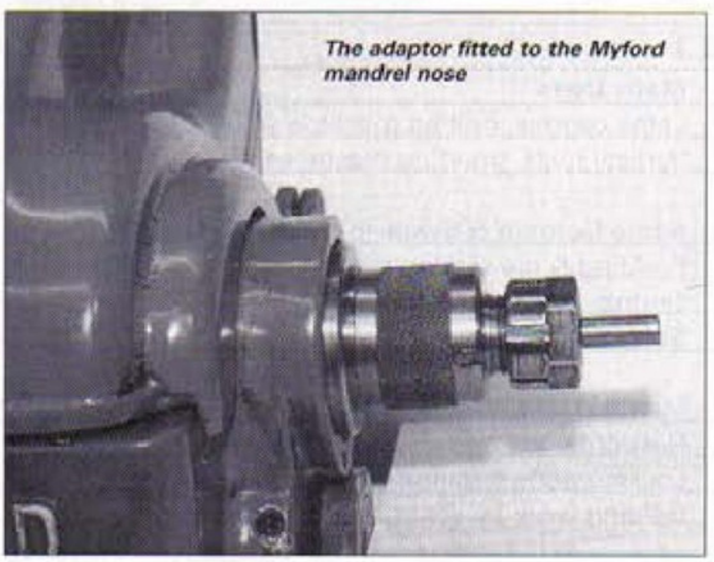
Spring collets are much more adaptable than fixed diameter collets and generally each size will hold round material over a range of 1mm. The device described enables the collets to be used on a Myford lathe nose and, as no drawbar is involved, the workpiece can pass through the mandrel. I made the adaptor for ER20 (range 1 - 13mm) collets which are what I had, but the range can be increased from 1 - 16mm by making the adaptor to take ER25 collets.

The manufacturing process is simple turning and screwcutting and the collet taper is bored after the register, with the workpiece screwed on to the lathe on which it is to be used. A go/no go plug gauge of 1.248/1.25in. is very useful for getting the register bore accurate.

Place 55mm (or 60mm for ER25) of 45mm bar in the chuck and carefully face off one end. As this face will be the register face, do it to a good finish. I find it best to drill the blank right through 0.5in. diameter and then bore the register and thread to a depth of 1in. at 1.108in. diameter. The register part is then very carefully bored to 1.250in. for 1/2in. with a 1/32in. chamfer on the outer end of the bore, after which a groove 0.125in. wide x 0.0625in. deep is cut at the deepest part of the 1.108in. bore for the screwcutting tool to run into. The thread is 12tpi Whitworth form and 0.0534in. deep. The chuck can be unscrewed from the mandrel and turned round to try the thread and register on the lathe nose. When it fits, leave it on the register, face the end to length and turn the end to diameter for the appropriate collet. Next, bore the taper and screwcut the collet nose - M25 x 1.5 for the ER20 collets and M32 x 1.5 for the ER25. The register end can then be tidied up and knurled, slots being milled to allow the Myford 'C' spanner to be used on it.

Setting the tool for boring the taper is very well described in MEW Issue 52, page 54, Fig.3 and page 56. A drawing for the ER20 collet nut is in MEW Issue 53, page 55. The ER25 is similar but scaled up. Both are available as separate items from Rotagrip, as are the collets.

Rotagrip Ltd, 16-20 Lodge Road, Hockley, Birmingham, B18 5PN.
Tel: 0121 551 1566
Fax: 0121 523 9188



The adaptor fitted to the Myford mandrel nose

A variety of spring collets, a spare closing ring and gauges used when making the adaptor

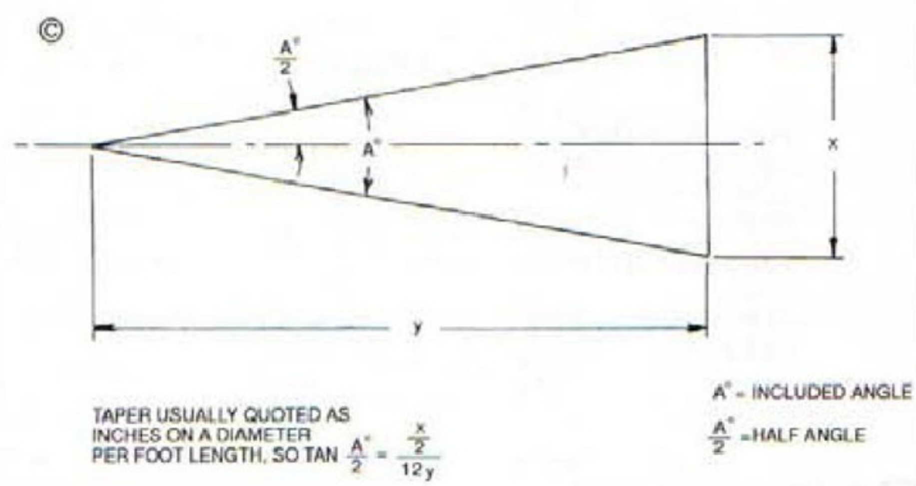
MACHINE TAPERS

Philip Amos surveys the types of machine taper which are likely to be encountered in the home workshop and gives advice on their manufacture and measurement

Introduction

Tapered plugs and sockets are widely used in industry, particularly in machine tools, as a means of accurately centralising and locating parts in relation to one another. They come in two flavours - 'self holding' and 'self releasing' - more on which topic is discussed later. For industrial use various systems of standardised tapers have evolved and these are set out below. This article addresses the nature of tapers, their manufacture and their measurement, as applying in the home workshop.

DRAWING 1.
SPECIFYING TAPER



Standard Tapers

The general characteristics and uses of various standardised systems of tapers are shown in table 1 - detailed dimensions are to be found in References 1, 3 and 4. See **Drawing 1**.

Except for the International system (*), all are self holding and, when used with drills and reamers, drive the tool through friction between the taper plug and socket only.

Note that when drilling, if the drill moves forward faster than the feed rate (for example if it 'digs in' on breaking through), it may be pulled out of the socket, releasing the plug/socket grip and allowing the plug to rotate in the socket with possible consequent damage to both. To guard against this there are usually flats on the end of the drill shank which can engage (loosely) with a rectangular hole at the bottom of the socket in a drilling machine spindle, which prevent any continuing rotation of the plug within the socket.

Likewise, the side thrust on vertical milling cutters can loosen the cutter shank in the socket, resulting in the shank rotating in the machine spindle with possible damage to either or both. In such cases a draw bar is necessary to ensure the maintenance of positive contact and drive to the tool.

The International system (*) must always have a draw bar to keep the taper plug end engaged in the taper socket. In addition, the drive is transmitted by a pair of dogs on the spindle nose which engage matching slots in a flange on the plug/mandrel.

The turning mandrel system (**), used to mount work between centres in the lathe, differs from all the others in that it comprises a tapered plug (the mandrel) in a parallel socket (the hole in the workpiece). When the workpiece is pressed or jarred into position on the mandrel, it is held in place by minor distortion of both parts (not unlike a force fit) which also increases the axial friction forces. The workpiece must be pressed or knocked axially out of engagement to separate the parts when the machining process has been completed.

Self Holding Tapers

Drawing 2a represents any axial plane section of a taper plug and socket. The surfaces of the plug and socket are shown separated for clarity but are in fact to be considered in contact. 'A' is any point on the plug surface and 'A[1]' is its mirror image on the opposite side of the plug.

The static coefficient of friction between

TABLE 1

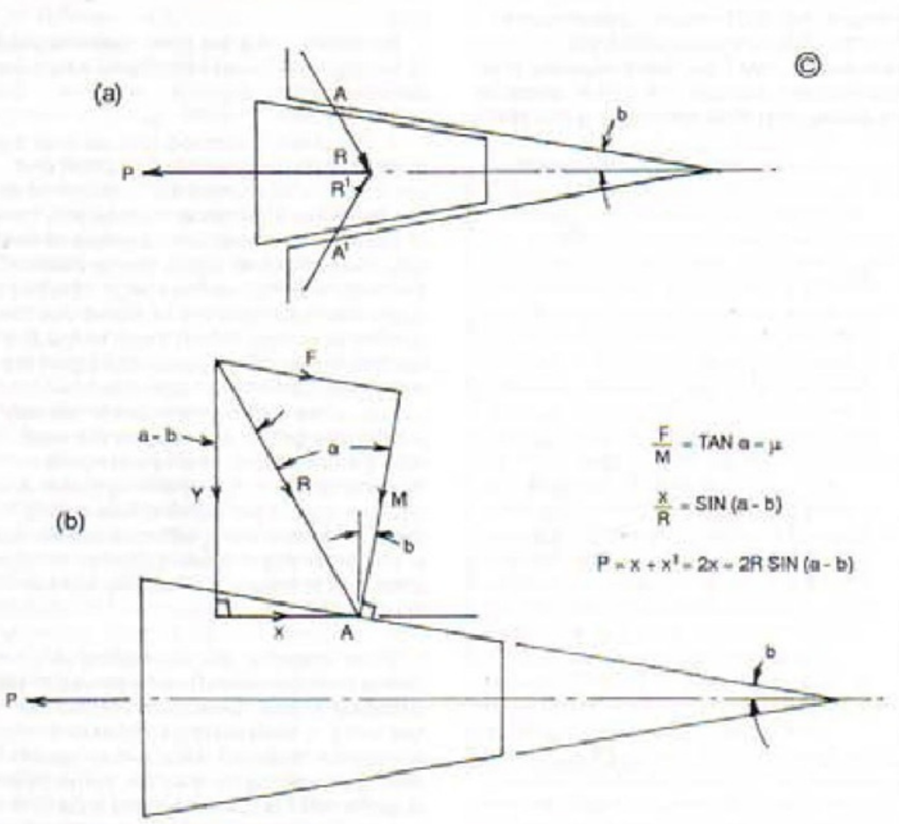
System	Taper	Main Uses
Morse	Approx. 5/8in. per foot	Lathe centres, drilling machine spindles
Brown & Sharpe	0.502in. per foot	Vertical mills, grinding machines
Metric	50 mm/metre (0.600in./foot)	Some German & Swedish machine tools
Jarno	0.600in./foot	Profiling & die sinking machines, some old lathe centres
Reed	Short Form of Jarno	Some lathe centres
Jacobs	Various 0.591 to 0.978 in./foot	Mounting drill chucks on shanks
* International	3.500in./foot	Horizontal mills
BS & US Taper Pins	0.25in./foot	Locking parts together
**Turning Mandrel	0.006in./foot	Holding work by central bore

TABLE 2

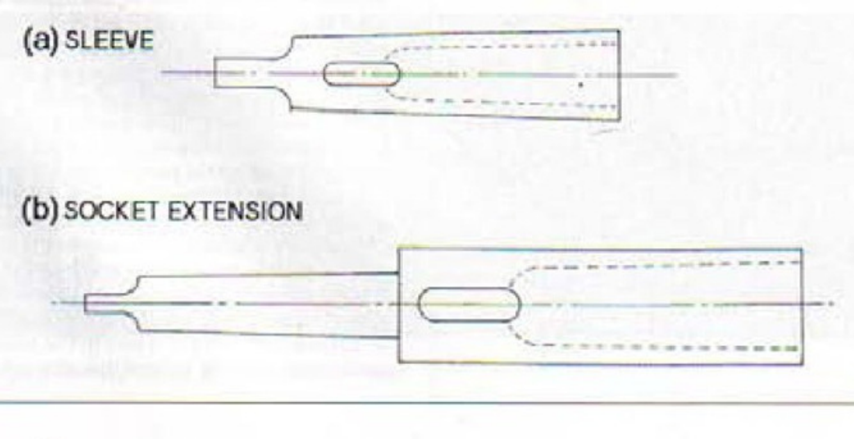
	Cast iron	Wrought iron	Steel	Brass	Bronze
Cast iron	0.162	0.19 0.166	0.155	0.147 0.21 0.19	0.16
Wrought iron		0.11 0.152	0.194	0.172 0.136	0.19
Steel			0.15 0.149	*	*
Brass				*	*
Bronze					*

Note * - No figures available.

DRAWING 2
SELF HOLDING TAPER



DRAWING 3
ACCESSORIES



the two materials forming the plug and socket is μ and is the value of the tangent of the angle 'a'. 'b' is half the taper included angle.

If a force 'P' is applied to extract the plug from the socket, then at the instant of separation this is opposed by friction forces 'R' and 'R^1'.

These forces at 'A' and 'A^1' comprise one along the surface (F) and one normal to it (M), such that F/M = tan a = μ

Force 'R' can be resolved into two forces at right angles, one 'X' parallel to the applied force 'P' and one 'Y' at right angles to it - see **Drawing 2b**.

Then 'P' is equal to the total of 'X' and its mirror image 'X^1' = 2X ; and 'Y' and 'Y^1' balance each other out.

By inspection: P = 2X = 2R sin(a - b)

If 'b' is less than 'a' then 'P' is positive and so the taper is self holding. If 'b' is greater than 'a' then conversely 'P' is negative and the taper is self releasing.

This criterion is as stated by G.Lautard in Reference 5.

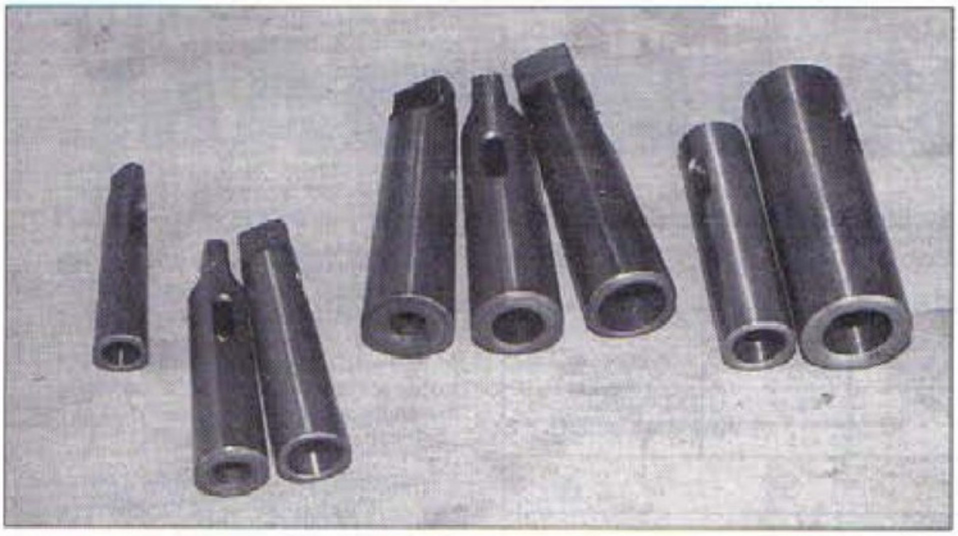
Coefficient of Friction

Coulomb, in 1821, put forward the empirical law of friction whence the notion of friction coefficient is derived. These coefficients for various combinations of materials were determined experimentally over the years by many workers of whom Coulumb, Rennie and Morin were the major contributors. Two figures are given for each pair of materials - static and moving. The static coefficient is that which applies just when the two materials are on the point of moving - this is the one which is required for our purposes. Once movement starts, the other (lower) value applies, but this is not of interest in our case. Also, separate figures are often given for clean and for lubricated surfaces; in the latter case it is possible that the figures are more representative of the oil film than for the materials themselves.

Table 2 is a matrix tabulation showing figures for static friction between pairs of materials in a dry condition, which has been extracted from a number of sources, but principally from Reference 7, which is essentially information from the Kingsbury Machine Works USA in the early 20th century. As pointed out by G.Lautard in Reference 5, the figures given in Reference 1 are quite at variance with just about all other sources - these anomalous figures should be ignored.

Coefficients of Friction (Static)

By inspection of the table, the lowest coefficient is 0.11 for wrought iron on wrought iron. This is the tangent of 6 deg. 17 min., so as a rule of thumb it would seem that, for all common material combinations, a taper plug and socket with a half angle of 6 deg. or less will be self holding.

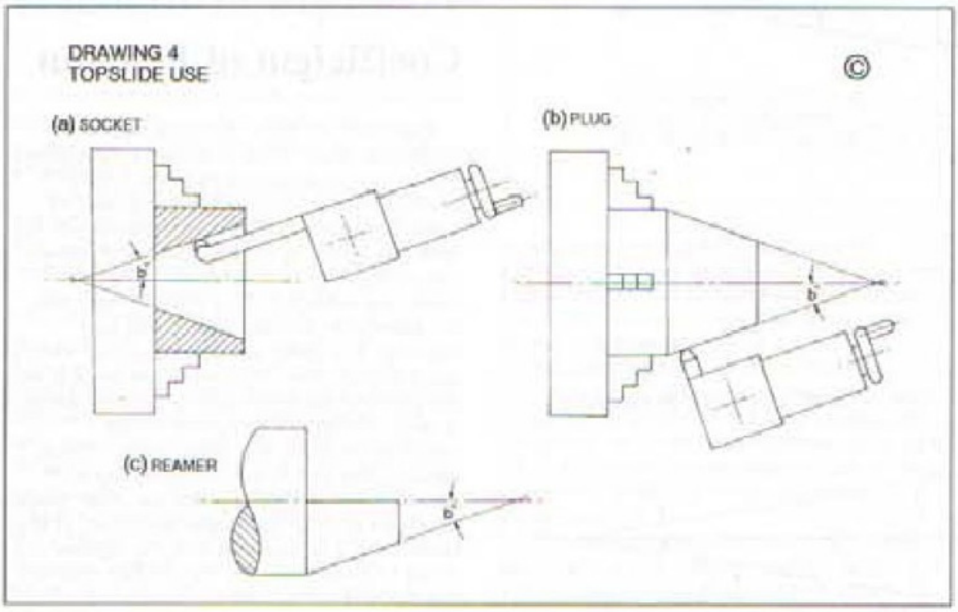


1. MT Sleeves - left to right - No. 1 to No. 2; No. 1 and No. 2 to No. 3; No. 1, No. 2 and No. 3 to No. 4; No. 2 and No. 3 to parallel

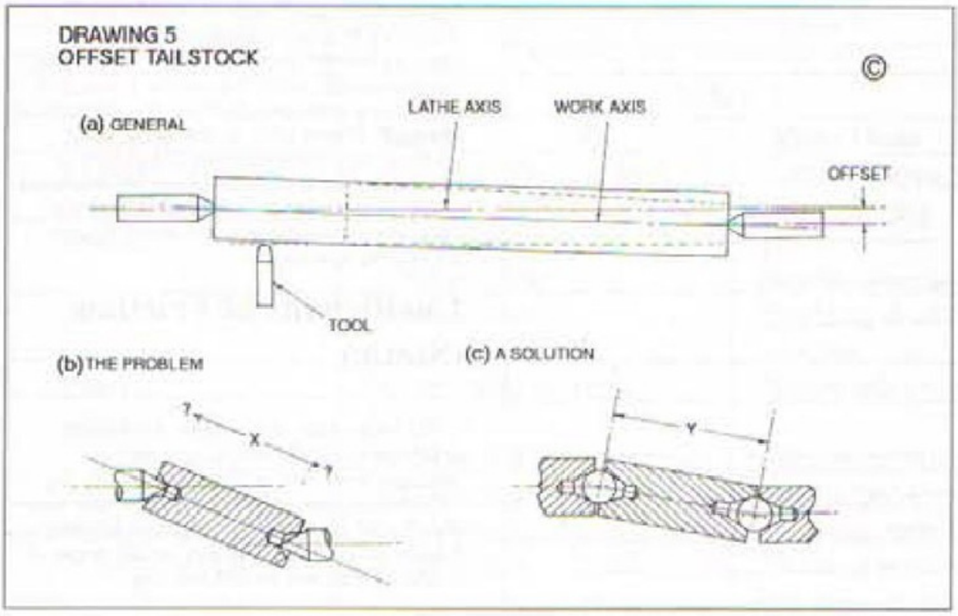
Standard Accessories

The Morse taper shanks on drills are made to appropriate sizes for the drills themselves, e.g. from 1/16in. to 35/64in. diameter, No. 1MT is used; from 9/16in. to 57/64, No. 2MT and so on up to 3in. diameter, No. 5MT. So, what happens if we wish to use a drill with a No. 1MT shank in our drilling machine which has a No. 3MT socket in the spindle? The answer is a drill sleeve **(see Drawing 3a)** having a No. 1MT socket inside and No. 3MT outside. Several such sockets are depicted in **Photo. 1**.

Sometimes the problem is that the drill shank is larger than the spindle socket. In this case, a drill socket extension is used, where the internal socket is larger than the external taper, as shown in **Drawing 3b**. While these are satisfactory in drilling machines, they are less useful in the lathe because of the long overhang produced. I do not own any such extension sockets.



DRAWING 4
TOPSLIDE USE



DRAWING 5
OFFSET TAILSTOCK

Manufacture

Having established the design criteria for a particular taper plug and socket, the next matter to be addressed is how to make them.

Taper Plugs

Essentially there are three methods used in turning taper plugs in the lathe which are discussed below:

1. The simplest method is to set over the topslide to the appropriate half angle and use it to directly produce the required taper - see **Drawing 4**. Because the available travel of the topslide is limited (in my case 90mm), only relatively short tapers can be made in this way, but they can have large included angles. Sometimes it will be found that the topslide operating handle tends to foul the tailstock if this is being used to support the workpiece. Often this problem can be overcome by rotating the topslide 180 deg. - but beware getting your fingers involved with the lathe chuck when winding the topslide handle in this operating mode. A disadvantage of the topslide approach is that it is manual feed - self act is usually not available for this motion - so it may be more difficult to achieve a high quality surface finish.

2. For longer tapers, the method of setting over the tailstock is much used - see **Drawing 5**. Most lathe tailstocks include two parts - a base casting machined to engage the lathe bed ways and an upper casting containing the tailstock barrel. In my case the latter is clamped to the base casting, but is machined so that it can slide transversely to the lathe axis by the use of two screws in the upper casting engaging a tongue projecting up from the base casting. Thus, by slackening one and tightening the other, the upper casting is moved and consequently so is the tailstock barrel axis relative to the lathe axis. At the handle end there is a small scale plate set on the base casting, with an index on the upper casting. On my lathe this plate is calibrated in 0.5mm steps for 10mm either side of centre. While useful as a starting point, this arrangement is not nearly sensitive enough to set the tailstock for accurate parallel turning or for tailstock offset for specific tapers. This setting process can however be effected by the use of a dial indicator fixed to the lathe bed (or saddle or toolpost) and bearing against the side of the tailstock barrel. If a dial indicator is not available, it is possible as a makeshift to have a tool in the toolpost positioned near the side of the tailstock

barrel and progressively check the gap with feeler gauges as the adjustment proceeds.

It will be evident that only tapers with small included angles are suitable for this method, as otherwise the action of the centres becomes unsatisfactory. This method does allow power feed. Many operators are loath to move their tailstock adjustment after having spent a lot of time and effort getting it just right for parallel turning. Tubal Cain solved this problem by employing his boring head in the tailstock to effectively offset the centre relative to the tailstock axis while leaving the adjustment of the tailstock itself untouched - see Reference 8.

It might be thought that great accuracy could be obtained by moving the tail centre the exact amount to produce a taper of the required inches per foot or whatever. The problem, however, is to identify exactly the length between the centre supports. It can be approximated, but is really indeterminate - see **Drawing 5b**. Nevertheless, with some trial and error, good results can be obtained.

In Reference 4, George Thomas described an elegant approach using female centres and supporting the work on balls at each end; in this case the length can be accurately ascertained (see **Drawing 5c**).

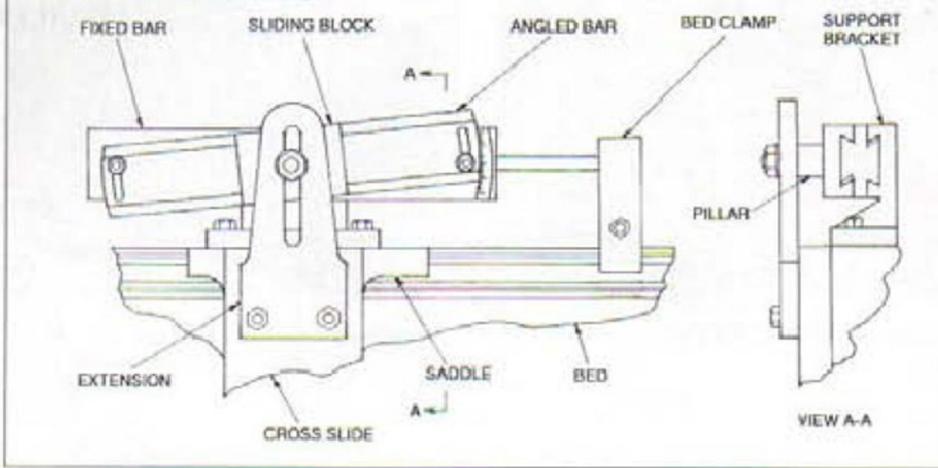
3. Where a lot of taper turning is likely, it will be found that a taper turning attachment made by the lathe manufacturer will be a great acquisition. The detailed design varies from one manufacturer to another, but in essence each comprises a block sliding along a bar set at the required half angle to the lathe axis; the block is rigidly attached to the cross-slide which is disconnected from the cross-slide feed screw. Thus, as the carriage is traversed along the lathe, the cross-slide is caused to move inwards or outwards in conformity with the angle of the bar - See **Drawing 6**.

As the cross-slide is disconnected from its feed screw, it becomes necessary to rotate the topslide 90 deg. and to use the topslide feed to adjust the tool position.

In some designs, the bar is supported on a bracket fixed to the lathe bed, while in others (on my lathe for instance) the bar is carried on a casting which slides on, and is supported by, an arm attached to the rear of the carriage and set in longitudinal position by a rod clamped to the lathe bed towards the tailstock end - see **Drawing 6**. On my lathe, the effective longitudinal travel for the attachment is 335mm; this can be arranged more or less wherever required along the lathe bed by fixing the bed clamp at an appropriate position.

Usually, the end of the angled bar carries an index which can be lined up

DRAWING 6
TAPER TURNING ATTACHMENT ©



with a calibrated scale on its support. This scale may be in degrees included angle or half-angle; mm per cm; inches per foot - sometimes degrees at one end and linear measurement at the other end. On my lathe the calibration is 12 deg. either side of centre in half degree steps. Whatever the scaling, it will still be found necessary to use the dial indicator method to accurately set the taper angle.

There are clamping screws at each end of the bar to fix it in position once set. Changing the setting is by gentle tapping - this is difficult to effect consistently. A more satisfactory arrangement is to provide a tangential screw to make this adjustment - as described by George Thomas in Reference 4, and my own emulation of his design in Reference 9. In my case, one revolution of the screw moves the bar 1.1 deg., so if the screw has 11 divisions, each represents 0.1 deg. - see **Photos. 2 and 3**.

Irrespective of the method used to machine a taper plug, it will usually not be possible to finish the whole axial length in one setting. If there is a non-tapered part of the workpiece on which the driving dog may engage, then no problem exists. For turning parallel between centres, a similar difficulty is overcome by reversing the workpiece end-for-end to gain access to the unmachined portion. This can be done for a tapered workpiece only if the tailstock centre is now moved in the opposite direction to its original displacement (or the taper turning attachment angulation is reversed) This readjustment can be done using a dial indicator in the toolpost to check that the new position is exactly correct. Great care is needed for a satisfactory result.

Taper Sockets

Again there are three methods of making these. The methods described above for use of the topslide and for the taper turning attachment apply equally well for turning taper sockets. Self evidently, the offset tailstock method cannot be used. However, a taper reamer is a convenient tool to use to accurately finish a taper socket which is already roughly machined towards its desired shape.

Procedure

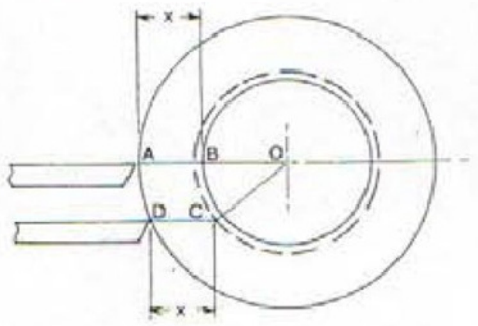
It will generally be found easier to make a taper socket first and then make the plug to fit it than vice versa, if one has to make such a pair. If standard tapers are to be made, then existing 'bought' standard plugs and/or sockets can be used to gauge one's efforts.

The first thing to get right is the angle; when this has been achieved, the actual diametral size can then be effected. Probably the most common taper attempted in the home workshop is a Morse taper. To set over the topslide or the taper turning attachment to the exact angle required, a lathe centre can be used as a convenient pattern. As each Morse taper differs very slightly from the next size, it is necessary to have a centre of the appropriate size e.g. No. 2MT. Using a female centre to accommodate its point and a normal male centre at its blunt end (which almost always is centre drilled) the pattern centre can be held in the lathe pointing either towards or away from the headstock. With a dial indicator attached to the toolpost and bearing on the pattern centre at centre

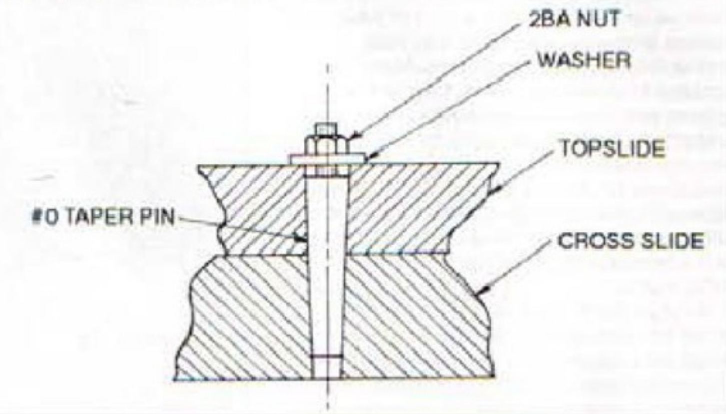
2. Angled Bar for Taper Turning Attachment

3. Tangential Worm Drive Detail

DRAWING 7
TOOL HEIGHT ©



DRAWING 8
TOPSLIDE LOCATION ©



height, the topslide can be traversed back and forth and the topslide angulation adjusted until the dial indicator shows no movement i.e. the topslide is then at exactly the same angle as the pattern centre surface. A similar process can be used in setting the angle of the taper turning attachment.

The plug can now be machined to shape. If a number of axial lines are marked on the plug with chalk or pencil or bearing blue and the plug inserted in the socket, given a quarter turn and withdrawn, the marks will be found to be smeared. From their appearance it is possible to assess where there is contact and where there is not. This will guide corrections to the angle being machined (and may also indicate a bulge or constriction in the axial length of the plug or socket). With some trial and error it will be found possible to arrive at a situation where the markings are uniformly smeared along the length of the plug and socket, thus indicating that both have the same angle.

Later in this article, information is provided on accurately measuring angles and diameters, but for most purposes, if the angle is right it may be sufficient to measure the large end diameter of the plug directly with a micrometer. If this is found to be too large, further material must be machined away; but note that very small diametral changes result in large axial changes of the position of the plug in the socket. For example, with Morse tapers a reduction in diameter of 0.1mm is equivalent to an axial change of 1.9mm, so proceed carefully.

If a plug and socket are both to be made, it is desirable to do both with the same setting of the topslide or taper turning attachment. To achieve this it will be necessary to bore the socket with the boring tool inverted, and working on the back of the hole i.e. away from the operator. The tool for turning the plug is set normally and works on the operator side of the plug. Again see **Drawing 4**.

Some people may prefer to make the plug first and then make another of silver steel, mill exactly half of it away to the diameter, harden and temper it and then use it to finish ream the socket to size. This should certainly yield a socket more precise than by just boring it, as it can eliminate the "spring" of the boring bar. I have not tried this technique myself.

It is important to set the tool accurately at centre height, as otherwise the expected taper angle will not eventuate, as shown in

DRAWING 9
TAPER PLUG MEASUREMENT A ©

Drawing 7. At correct centre height, the tool movement 'x' will reduce the radius from OA to OB. If set too low (or high) this same movement 'x' will only reduce the radius to OC, so that the taper will be too big at its small end.

If it is believed that many tapers of the same type will be made in the future, then it may be considered worthwhile providing a taper pin to exactly locate the topslide for this work. This concept is proposed by L. H. Sparey in Reference 10 and is shown in **Drawing 8.** A number 0 taper pin has its end turned down for about 1/4in. and is threaded 2BA. When the exact setting of the topslide for (say) No. 2MT has been found by trial and error, a suitably positioned hole is drilled and taper reamed through the topslide and cross-slide, and to such depth that the pin shoulder is below the surface of the topslide. The 2BA nut and washer then allow easy withdrawal when its use is not required.

Measurement

Although it is possible to directly measure the diameter at the large end of a tapered plug, the finite width of the micrometer anvils or caliper jaws makes the measurement at the small end inaccurate. Similarly, axial length between these two diameters is hard to determine accurately. Hence special procedures are required which are relatively simple but involve balls, rollers, blocks and some trigonometry - see References 11 and 12. **Photos. 4 and 5** show sets of balls and rollers which can be used in this regard.

Taper Plug

It is possible to ascertain both the small end diameter and the included angle of the taper with the aid of two rollers and two parallels (or equal stacks of slip gauges) as shown in **Drawing 9.** The plug is stood on its end (which must be machined perpendicular to its axis) with the rollers placed beside it and the measurement M1 made across the two rollers. The rollers are then placed on two equal blocks and the measurement M2 made. Knowing the radius of the rollers and the height of the blocks, the small end diameter D and the included angle 2α can be calculated as set out on the drawing.

Taper Socket

Three methods may be used; the choice depending on which is the most convenient in the particular case.

Case I. Using two balls and a stack of slip gauges as shown in **Drawing 10**, the measurement M1 is determined. The balls are then placed on equal blocks (or one large block) and the process repeated to obtain measurement M2. With known ball radius and block height, the large end diameter D and the included angle 2α can again be calculated as set out on the drawing.

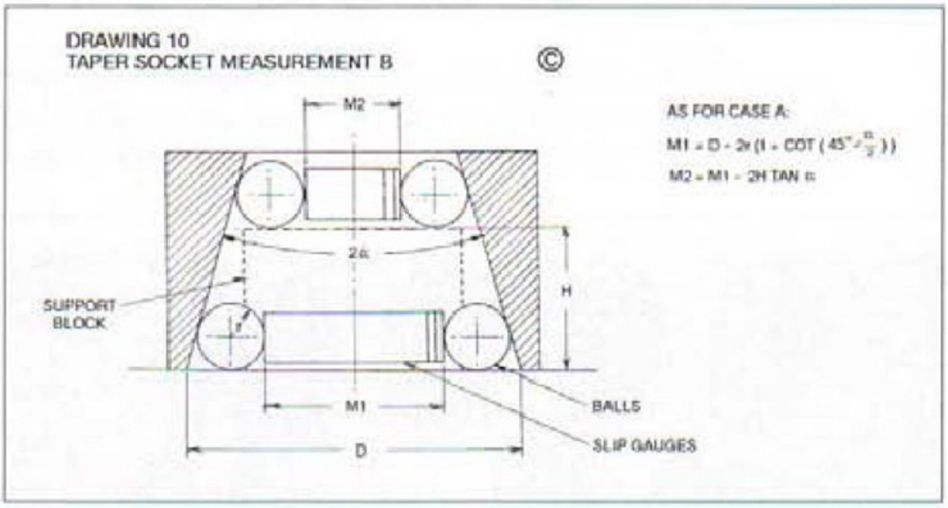
Case II. For smaller sockets, two balls of differing dimensions may be used as shown in **Drawing 11**. The heights H1 and H2 are determined with a depth micrometer or a vernier height gauge. With known ball diameters, the larger end diameter D and the included angle 2α can again be calculated, as shown on the drawing.

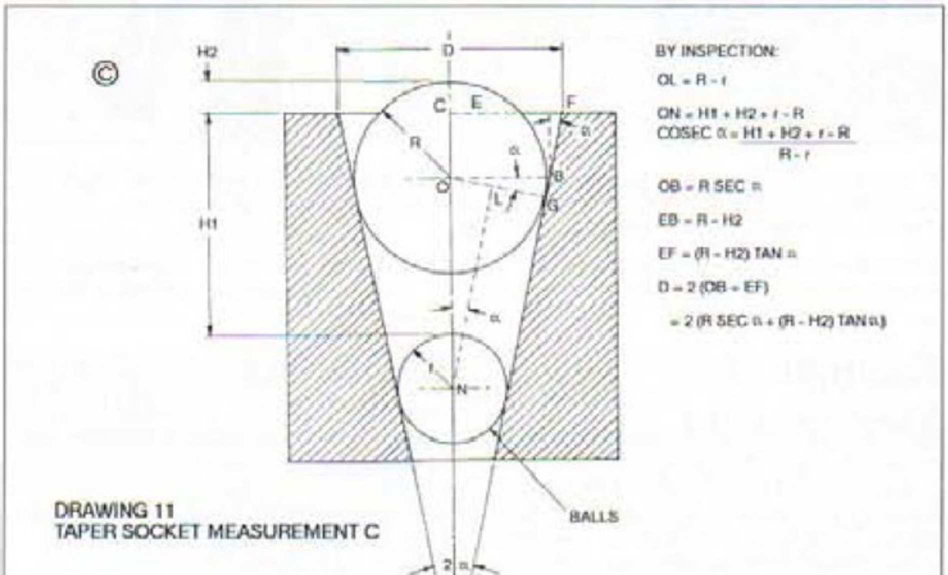
Case III. If the angle of the taper is very small, it may not be possible to use two balls as in Case II. As shown in **Drawing 12**, one ball is used here successively with two different size rollers, and measurements H1 and H2 determined. Following this, the large end diameter M and the included angle 2α can be arrived at as set out on the drawing.

While the above theory is quite straightforward, it will be found in a practical case that it may be difficult to obtain balls and rollers which conveniently fit near each end of the tapered hole. However, drill shanks form an excellent series of closely spaced diameters from 0 to about 13mm. If the largest available ball which will fit through the hole is used then the diameter rollers (drills) needed will probably be found to fall within this range. Drill shanks are usually just a little smaller than nominal, so the actual diameter must be measured for accurate work.

4. Ball Set, four each in 1/8in. steps from 1/8 to 1in. plus 3/16 and 5/16in.

5. Roller Set, four each - sizes as for balls





Example of Manufacture

My Taiwanese lathe has a No. 2MT tailstock socket and my Taiwanese drill/mill has a No. 3MT spindle socket. The lathe headstock has a non standard socket described by the manufacturer as No. 4 1/2MT! The lathe is provided with a sleeve with a No. 2MT bore to carry its soft centre.

The headstock sleeve outside taper is shown on the manufacturer's drawing as having a half angle of 1 deg. 29 min. 21.5 sec. This corresponds to a taper of 0.052in. per in. and is to be compared with No. 4MT of 0.05193 and No. 5MT of 0.05262in. per in., so it seems to be 'sort of' Morse if not really standard.

In order to be able to use drill/mill attachments on the lathe, a sleeve with No. 4 1/2MT outside and No. 3MT inside tapers was needed. While I was at it, I decided to make two of them and, for good measure, a duplicate of the 'bought' No. 2 / No. 4 1/2MT one.

Procedure

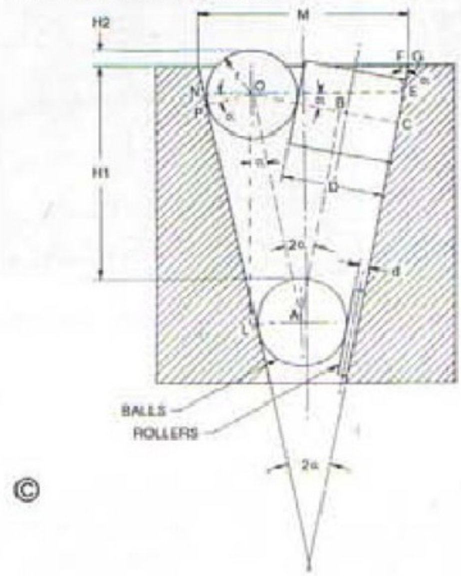
Firstly, a No. 4 1/2MT socket was made from 1 3/4in. diameter bright mild steel bar for use as a gauge (using the lathe spindle as a gauge would also have been possible but certainly not convenient). Next, tapered mandrels of No. 2MT and No. 3MT were manufactured. Blanks for the sleeves had variously No. 2MT and No. 3MT holes drilled, bored and reamed. Each was then in turn mounted on the appropriate mandrel and had its outside turned to No. 4 1/2MT, thus ensuring concentricity between inner and outer tapers; the outsides were checked against the No. 4 1/2MT gauge.

For reasons which I can no longer remember, the two No. 3MT sleeves were made shorter axially than the 'bought' sleeve, although the No. 2MT sleeve matched it in length. These various items are shown in **Photo 6**.

These items were made in 1986 when my measuring equipment was minimal. However, the results were acceptable for practical use and the accuracy checks made recently show that they were not too bad an effort in the circumstances.

My only other major taper turning activities have been the manufacture of

DRAWING 12
TAPER SOCKET MEASUREMENT D



BY INSPECTION:

$$OL = r + H1 + H2 - r = H1 + H2$$

$$OA = \frac{OL}{\cos\alpha} = \frac{H1 + H2}{\cos\alpha}$$

$$OC = r + D \quad BC = r + d$$

$$OB = OC - BC = r + D - r - d = D - d$$

$$\sin 2\alpha = \frac{OB}{OA} = \frac{D - d}{H1 + H2} \cos\alpha$$

$$\text{AS } \sin 2\alpha = 2 \sin\alpha \cos\alpha$$

$$2 \sin\alpha = \frac{D - d}{H1 + H2} \text{ so } \sin\alpha = \frac{D - d}{2(H1 + H2)}$$

$$OC = r + D \quad OE = (r + D) \sec\alpha$$

$$OP = r \quad ON = r \sec\alpha$$

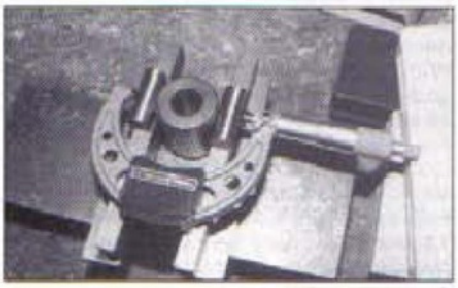
$$NE = OE + ON = (2r + D) \sec\alpha$$

$$FE = r - H2 \quad FG = (r - H2) \tan\alpha$$

$$M = NE - 2FG$$

$$= (2r + D) \sec\alpha - 2(r - H2) \tan\alpha$$

7. Measuring sleeve small end



8. Measuring sleeve large end

6. Left to right - 'Bought' sleeve No. 4 1/2 / No. 2MT with No. 2MT soft centre; 'Made' sleeve No. 4 1/2MT / No. 2MT; No. 4 1/2MT gauge; No. 2 and No. 3MT mandrels. Foreground 'Made' sleeves No. 4 1/2 / No. 3MT

9. Measuring depth of ball at small end of gauge

10. Measuring projection of ball at large end of gauge

a set of collets and their chucks (see Reference 13) and those required in the building of the Quorn.

Example of Measurement

As a trial, it was decided to check the outside taper of the 'bought' No. 2 / No. 4 1/2MT sleeve and the inside taper of the 'made' No. 4 1/2MT gauge. Using the roller and parallel method described above **(see Photos. 7 and 8)**, the outside taper was found to be 1 deg. 30.3 min. as compared to the manufacturer's drawing 1 deg. 29.3 min. - quite close.

For the gauge, the Case III approach was used as shown in **Photos. 9 and 10**, using a 1in. diameter ball (25.39mm actual) and drills 13mm (12.94mm actual) and 15/32in. (11.84mm actual). The inside taper was found to be 1 deg. 41 min. - just under 11 min. too great.

Conclusion

There is nothing mysterious about tapers. They can be readily designed, made and measured in the home workshop, provided that some care and thought is invested in the process.

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THE MODEL ENGINEER AND THE INTERNET

Stan Bray suggests that it is never too late to embrace new technologies. He has found that the Internet contains much to interest the model engineer and home workshop enthusiast

As a comparative newcomer to the use of a computer, having reached the traditional 'allotted span' before I even thought about having one, it followed that I would not be one of the earliest to embrace the Internet. I suppose, like most older people, I wondered whether I could ever learn to use the computer and my feelings were much the same when I kept reading and hearing about the Internet. Several friends finally persuaded me that joining the happy band of 'surfers', which is how Internet devotees are often referred to, would be well worth while and so I took the plunge. As with starting with the computer, once I had taken the first steps, it did not take long to fathom out how things worked and to realise that there wasn't all that much to it. It also made me realise what a lot of interest and knowledge, not to mention fun, people without these facilities were missing. I thought it might be worth while relating a few of the advantages one can get from a connection to the Internet and the World Wide Web.

What it's all about

The Internet (or Net) is the name given to the network of connections which carries the data between computers. The Web is a simple way of navigating through the data stored on these computers. Thus they form a vast open system of communication and information covering the world, and in Britain alone there are over two hundred thousand computers connected to it. It is possible to communicate with any other computer that is connected and this, of course, means that people involved in a hobby like ours are able to get in touch with others of a like mind which, in turn, allows an exchange of ideas. It is possible to look up information on a particular aspect of the hobby, ascertain where to obtain supplies and even to order them if one so wishes. So, for the benefit of anyone who has never used the system or perhaps even for some who have and have not yet discovered all that is available to help them, let me explain some more. It is broken into a number of sections, each of which allows a different aspect to be used, these are detailed below. All in all it is a system tailor made for our hobby.

E-mail

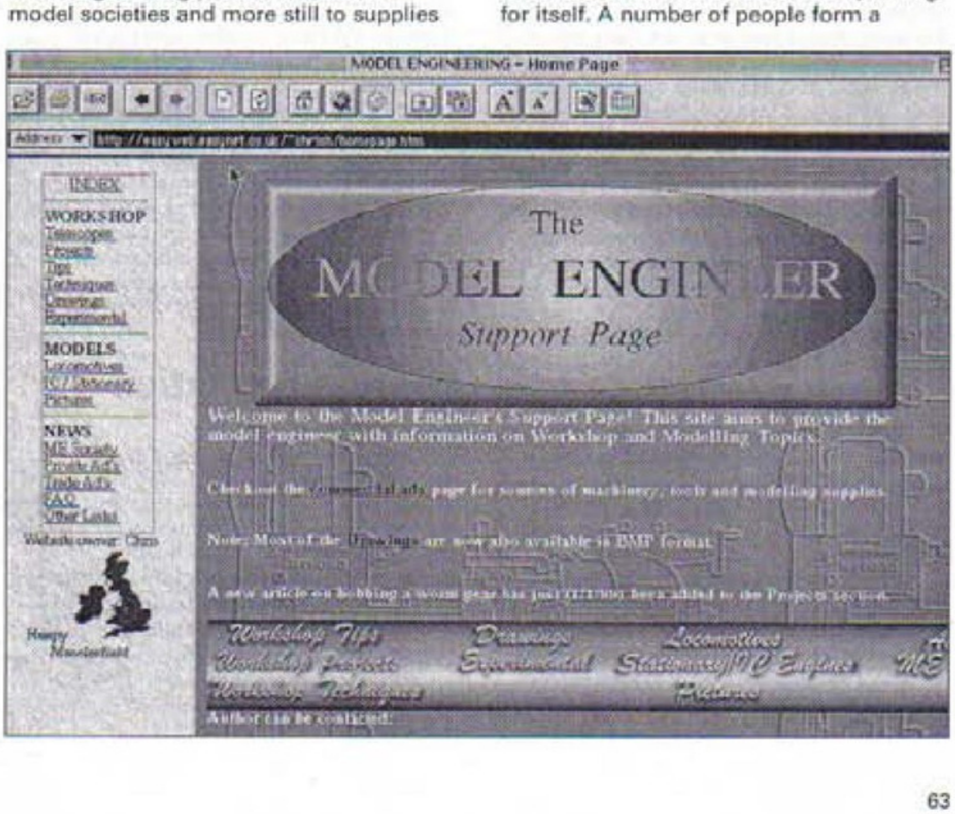
E-mail is short for electronic mail, which is a means of sending letters to other people, and it has a number of advantages over the more normal mail system, unkindly referred to by e-mail users as snail mail. What then are the advantages of the system? The main one is its speed. One person can send an e-mail communication to another on the other side of the world and it will be there in a few minutes. I have in fact sent them to Canada and had a reply in a matter of half an hour or so. Of course, using a telephone is even quicker, but with e-mail I can include drawings and photographs if I so wish, which cannot be done on the telephone. It means of course that I can also receive them. It is also far cheaper. The cost of sending an e-mail is just the cost of a local telephone call. These are charged in the UK at a cost per minute which varies with the time of day, but there is a minimum charge of 5 pence. Particularly at the most economic periods, three or more e-mails could be sent, all for that single local call cost. Another advantage is that I know that the correspondence has reached its destination, as its receipt is confirmed, something of which we cannot always be certain in the case of ordinary mail. Special addresses are supplied for use with e-mail and at first they seem confusing, but in fact they are quite logical when broken down.

The Web

E-mail is only one aspect of the system; the use of the Web itself really opens up a new world. It is divided into 'sites' and as far as our hobby is concerned, there are a large number of these which are run by clubs or individuals, some referring to full sized engineering practices, others to model societies and more still to supplies of materials and tools and where to get them. Through these sites it is possible to obtain information on a whole range of things. We can get details of the clubs, what they do and where they are. There are any number of drawings of various pieces of equipment that can be made. Photographs of engineering and model engineering artefacts are there by the thousand, to be seen at the press of a button, and there are many tips and ideas with which to make life easier in the workshop. It is really quite fantastic, as no matter what your particular interest, there seems to be a site to cater for it. Furthermore if you have some particular aspect of the hobby you think might be of value to others, it is possible to post it on to the Web for people to read.

News Groups

There are any number of news groups available, the name more or less speaking for itself. A number of people form a



group and it becomes rather like an intimate club meeting. Tell the group the problem you are having and in no time at all, you will have people offering advice and assistance, and remember that the group will consist of people from all over the world, giving the benefit on International ideas rather than parochial ones. A variation on the news group is the mailing list, in which case an individual copy of every communication is passed direct to everyone on the list, whereas in a news group it appears on the group site for each individual to take it or leave it as they wish.

How the system works

At first sight the system appears to be very complicated, but it is actually very simple. An interfacing device called a modem is used to connect your computer to a normal telephone line. The modem can either be a separate plug-in unit or be fitted inside the computer, depending very much on the machine itself. It is then necessary to find what is known as a 'service provider' and there are any number of these (e.g. Compuserve, AOL, force9, zetnet) who connect your system to the Internet when required. Most charge a small fee for so doing, some charge not such a small one, but more and more are appearing who let you use the service free. It is because you are connected to a service provider that the use of the system is only charged at local telephone call rate. You only pay for connection to them, the connection to the rest of the Web being free.

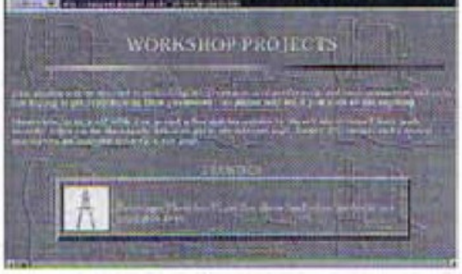
The software you need to install on your computer also usually comes free, often in the form of a floppy disk or CD attached to a magazine or in a mail shot, more often than not with a 'free trial' offer of 50 hours or so. This, of course, is an attempt to get you to sign up with a particular service provider for an extended period. It is far better to find out about the available service providers, select the one which suits you, then get the software from them.

If it is e-mail you are using then the service provider passes it into the system for direct transmission to the recipient. If you wish to use the Web and you know the Internet address of the site you wish to visit, then again you will be connected directly to the site you require. Like e-mail, each site has it's own individual address, and keeping a record of these makes it quicker to get to the one you want. It is not necessary to make a physical record of these, as a programme will be included in which you store your favourite addresses.

Surfing

Of course, when you first get involved, there is little chance that you will know the addresses you require. Even if you know some, it will not be possible to know everyone relating to the hobby, and so it will be necessary to go looking, a process frequently referred to as 'surfing'.

There are two techniques involved 'browsing' and 'searching'. Browsing software is now frequently included with computer operating systems, so you may already have a browser on your machine. The two well-known ones are Netscape Navigator and Microsoft Internet Explorer, both given publicity by a recent high-profile court case in the USA. For more specific questions, a 'search engine' is required and may be included in the system supplied by your service provider. Don't start getting excited because it is not an engine at all, but a part of the system into which you type the subject in which you are interested and up on the screen will come a list of sites dealing with your subject. The more information you give the search engine the better the result will be. For example type in 'home workshop' and up will come a list relating to all types of home workshops, many of which may not relate to our hobby at all. Type in 'engineering home workshops' and the search will be narrowed right down to topics relating to that. It will cover the world and so if you want to narrow it still more, give more information, say, 'engineering home workshops, UK'. The results will be limited to the United Kingdom. Whilst many sites will be available via any search engine, sometimes each will have its own list, so it is worth trying more than one. Almost certainly you will be asked if you require related topics and if the answer is yes, then model engineering, clock making and other such subjects will be given.



Equipment

It is not necessary to have the latest computer in order to make use of the Internet. Whilst a modern system will make things move faster and store more information, providing one is willing to be patient, quite an old machine will do the job. Old computers are now available very cheaply as many people like to keep up to date and dispose of their machine when it is a couple of years old. The result is that there are many good second hand machines available. It would take many pages to go through what type to buy, so unfortunately that information cannot be included in this article.

More information

There are now many good books describing the Internet and the Web. Most bookshops have extensive sections dealing with computer matters and will give advice on the choice to suit your needs. One of the best books we have found is in the Rough Guide series, distributed by The Penguin Group, and is simply called 'The Internet & World Wide Web - The Rough Guide' and is by Angus J. Kennedy from Internet (ISBN 1-85828-216-0).

Take the plunge

Don't be afraid to start computing. At first sight these machines seem to be very confusing things, but in fact are very simple. The people that design and sell them use a complicated language that is difficult to understand. I am sure it is just for them to sound clever that the language has been invented, but with a little thought, one soon realises what the various terms mean. So get on the Internet and open up to yourself a vast range of engineering and model engineering topics and perhaps pass some of your own tips on to others.

Some useful addresses

By now there must be many hundreds of Web sites which are of interest to model engineers and home workshop enthusiasts. Listed here are just a few to get you started. Many of these have links to other sites, and it is just a matter of 'point and click' to take you into them, starting a trail which will keep you interested for hours! All you have to do is to keep an eye on the phone bill, but as its a local call, the cost at cheap rate times is not too horrific.

http://easyweb.easynet.co.uk/~chrish/homepage.htm

One of the better known UK sites, known as The Model Engineer Support Page, is administered by Chris Heapy of Macclesfield. It covers both models and workshop topics and includes drawings and instructions for a growing range of projects. Reproduced here are screen prints from a couple of the introductory pages.

http://www.modeleng.org/

The Model Engineering Clearing House has been set up by Andy Clark as "a service to the model engineering hobby, with particular focus on live steam and model railway engineering". Topics covered include 'UK Clubs and Societies', 'Suppliers', 'Bookstore', 'Publications' and 'Discussion Groups', but particularly useful and commendable is the 'Lost Models Directory', which contains details and photographs of stolen models.

http://www.mindspring.com/~wgray1

Entitled 'Metal Web News - A Virtual Newsletter for the Online Metal Enthusiasts', this site is edited by William Gray. It includes 'chapters' on such topics as 'Metal Removal', 'Metal Fabrication', 'Blacksmithing' and 'Forge and Foundry'. A dip into Metal Removal reveals such diverse subjects as 'Instructions for making a lathe backplate' and 'Building the Quorn Tool and Cutter Grinder'.

SCRIBE A LINE

Face geared indexing table

From Colin Porter, Blackpool

R Bentley's suggestion in the November issue of making a face geared indexing table by having a three layer table with 90 teeth on one interface and 120 teeth on the other one was interesting.

It reminded me of a device marketed by Paul Dunstall during the 60's in order to adjust the timing on Norton motorcycles in increments of one degree. Instead of the standard chain driven cog being fixed directly to the distributor/points shaft, a replacement cog was attached to a disc which was then fitted to the shaft concerned. From memory, I believe the cog had 20 holes on a circular pitch whilst the disc had 18 holes, or vice versa. there was some sort of pin which could be moved one hole at a time in either component, thus giving a vernier type of adjustment.

My memory or arithmetic may be wrong about the number of holes and whether or not they gave the required 360 divisions, but I expect one of our readers will provide the necessary correction if required - and might even have used such a device in his (wild?) youth.

Perhaps the above is a suitable thought for future indexing movements other than division plates, although calibration would still be a problem.

Soldering aluminium

From Ted Wale, Nova Scotia

I was very interested in the article by T.S.Christian in M.E.W. Issue 53 on soldering aluminium.

I had been taught over 60 years ago that one could not solder aluminium. That statement, in the mechanical environment of the time, meant that one could not solder aluminium using the lead/tin solder and flux of the time.

I remember being fascinated when my boss said that this was not quite true and showed me how it was done. The problem was that the flux did not remove the very thin layer of oxide which forms instantly on aluminium , particularly so when warmed. One only has to try to solder tin, copper or any other 'solderable' metals without using flux to have this clearly demonstrated. My then boss took a piece of aluminium and melted a blob of solder onto it with a small torch underneath. He then took out his penknife and scratched the aluminium UNDER the solder by putting the blade THROUGH the solder blob while keeping the whole heated. Where he had scratched, the solder adhered. No flux was used.

While this demonstrated the cause of the trouble it did not produce a workable solution for general application, particularly for other than a flat surface. I never followed this up by trying to clean and solder aluminium in an inert atmosphere using tin/lead solder. This would have been the obvious next step. I was too busy on other things.

Clearly, since then, the solder manufacturers have investigated the problem clearly and scientifically, for now there are solder alloys specially made for joining aluminium properly, as T.S.Christian stated in the referenced article.

I tried Christian's method as soon as I could and found that it worked very well. I was particularly pleased with the low heat needed which, as he said, prevented the aluminium sheet from buckling. I first tried it in a workshop away from home and had to use a wire brush that was not stainless. The contaminants from the brush metal meant that I had to brush several times before a good wet was obtained. Back home, a used and dirty stainless brush produced much better results. A new brush, now dedicated to this process, is the answer. Works like a charm, as they say. This is not really surprising, as we all know that dirt and contaminants are an anathema to 'ordinary' solder, so why should they not be so here also.

I would be interested to know what the lead free plumber's alloy is. Perhaps a reader who is 'in the business' could let us know?

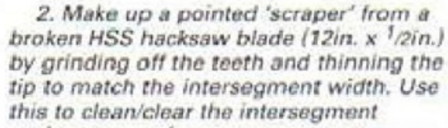
Motor Problems

From George Mills, Southampton

I fear that Bob Loader may be having more motor problems sooner than he expects. His method of 'hand filing' a commutator is far from satisfactory. Worn commutators should always be skimmed; the 'electric drill' drive method might have been a better idea after all!

1. Mount the armature between centres (or between chuck and centre). Check that the shaft (i.e. bearing surface) is running more or less true.

2. Make up a pointed 'scraper' from a broken HSS hacksaw blade (12in. x 1/2in.) by grinding off the teeth and thinning the tip to match the intersegment width. Use this to clean/clear the intersegment undercuts - make sure you scrape vertically and gently.



scraper shape

3. Now skim the commutator using (preferably) a tipped 'point' tool with a top rake of about 20 deg. - take minimum cuts until the surface is just clean.

4. Wrap a piece of 400 silicon carbide paper (wet and dry) around a 6in. dead smooth file and, with the armature spinning, lightly 'file' the newly turned surface. One or two strokes will be sufficient. This will remove burrs and cut down any intersegment material that your scraper has missed. Never, ever, use emery abrasive as this will cut the copper more than the intersegment and the new brushes will 'bounce', inducing arcing, and increasing both brush and commutator wear.

This was the method we used when I worked for a commutator manufacturer some years ago - it has always worked well for me since.

From James Lait, Branston, Lincoln.

The principles described were spoiled by the use of emery cloth to polish the commutator. Emery is a conductor and the particles cause untold damage when current is applied. Glass cloth or paper in ever decreasing grades down to 'flour' is best. The use of a file to remove the worst is O.K., providing it has been cleaned first with a strip of copper which drags out steel particles which would damage the surface of the comm. segments.

To get a rotation for filing, one could resort to the old army dodge of holding the drive end of the armature in a drill chuck, (powered or hand) and rotating thus against a file, subsequently with glass paper.

Inexpensive motors and other topics

From L. B. Wagstaff, Congleton, Cheshire

I have, like many others, surely, been intrigued by and grateful to your contributor, Bob Loader. In the '60s we lived in Malvern Link, which I am sure he knows - we had friends at the R.R.E.

One of the approaches I share with Mr. Loader - of necessity as I am a widower pensioner - is of finding ways to keep costs manageable, i. e. within my ability to pay!

One of my essays has been in the area of sewing machine motors. Even the older ones are rated at 65 watts; my first Unimat S.L. had only a 40 watt motor, but the sewing machine motors have the advantage of continuous rating, and with the foot control giving speed variation, can eliminate some belt changes. More importantly, this can help you to get the feel of the feed required on the material being machined. Perhaps one of your cleverer subscribers could work out optimum sizes of pulleys that would give the best results with the variable drive.

The downside is that these motors run counterclockwise, so to use them to power the lathe, they need to be positioned with the motor pointing away from the headstock, thus giving the correct direction. They can be positioned in front or behind the machine. The direction of the motors can be reversed. Singer centres will not do this, but a competent maintenance electrician can do it. As these motors can be bought cheaply enough, several could be used to set up accessories such as jig and *fret saw items as independent machine tools, always ready to use.*

Obviously, if you use one of them to power the lathe, the original Unimat 3 motor can be used as the mill/drill power unit, thus enabling more complex operations to be performed. Incidentally, when the position 2 is used on the Unimat switch (motor then 65 watts), a thyristor control can be inserted in the cable, thus giving variable control. A dimmer switch will suffice.

I am puzzled by the difficulty some people find with missing change wheels. Gears of the same DP are not essential throughout the gear train, as long as meshing gears match. If you make some longer studs, it is possible to use different DPs on the same stud. All you need is the ability to be able to calculate the chain of wheels required to produce the thread or divisions required. There is a marvellous chapter on just that process in L. C. Mason's excellent book 'Using the Small Lathe'. Pitches such as 38.5 tpi (4BA) and 52.9 tpi (7BA) can be produced without difficulty using his methods. Although I believe his book to be out of print at present, it is worth looking for on the second-hand market.

One of my treasured tools is the Eclipse Toolmakers Vice, which swivels 360 deg. vertically and horizontally. Before I acquired it - and sometimes since - I have used a photographic universal clamp with a home-made adapter to accommodate either a pin vice or a pin chuck depending on the type of clamping required. Try it.

Clock Pinion Milling Attachment (Issue 52)

From V. Varga, Oakville, Canada

I have made 16 clocks and had no end of trouble with pinions - that is until I made Doug Ball's design. Thanks very much.

It is a case of "Why did I not think of it?" It works extremely well with minor modifications - I would suggest that those who make small pinions:-

1. Make the V groove a bit smaller

2. Provide an extra hole to position the clamp plates nearer to each other.

For 0.3 Module pinions, the cutter centre height is critical. I produced several 'leaning' ones. To set on dead centre, clamp a $^3/_{16}$in. brass rod to stick out about $^3/_8$in. from the front clamp. Set to centre as best you can, then cut two leaves, examine the result then adjust as required.

Note:- when both ends are clamped and the pinion is cut somewhere in the middle, it is difficult to detect a small 'lean'.

Correcting lathe taper

From Pat Twist, Winchester, Hants

I bought my Myford Super 7 some forty years ago and not surprisingly it was not as accurate as it was originally. The wear on the bed at the mandrel end resulted in turning a taper instead of turning parallel. In fact a 4in. length would be roughly 0.002in. taper.

Once this was realised, I overcame the fault temporarily by setting the topslide over to neutralise the taper, promising myself that I would get around sometime to dealing properly with the problem, as has so often been described in 'Ours'.

Having at last decided that the job must be done, but being unhappy about removing the saddle from the apron, I slackened off the four gib screws on the front of the saddle and inserted a $^3/_8$in. strip of 0.005in. wide brass shim, 8in. long between the rear of the saddle and the back edge of the rear bedway, readjusted the gib screws and found that the lathe now turns parallel again, as far as I can tell as accurately as it ever did. In fact, the last gib screw on the right wing of the saddle is now effective, whereas before it seemed to serve no purpose. The brass shim stays in place by just bending the ends over; it has never moved.

The whole job took no more than five minutes at the most and the lathe has not been irreversibly tampered with in any way.

If you are unhappy about the accuracy of your lathe, try the 0.005in. shim / 5 minute cure.

A Failed Attempt

From Norman Hurst, Woodford Green, Essex

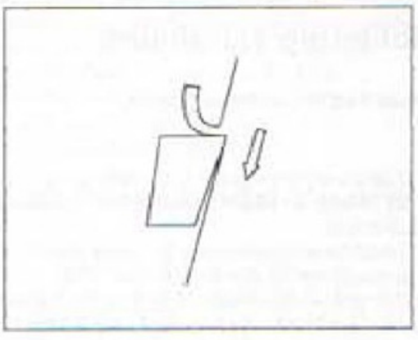
Sketch 3 of Harold Hall's dividing head article (M.E.W. No 54, page 37) shows the tool bit rotated to the helix angle. When using this method, the tool will (at some part of the work) be cutting with a negative rake. In my opinion, the correct method would be with the tool positioned as shown on the right of the sketch, but with the top face horizontal. Assuming that the thread is not made by 'plunging', but by feeding in at the required angle, the tool would then have a zero rake when on the initial cut, or when the tool meets the starting edge of the work, but would have a positive rake effect when on subsequent cuts - see diagram.

On page 40 of the issue, some dimensions and other details of the worm are given. I do not agree with these. The pitch of a worm to engage with a 20 DP gear cannot be the same as the gear's circular pitch. As the figures shown are to five decimal places, it is reasonable to assume that we are working to this accuracy.

I agree that the 'pitch' of a 20 DP gear is 6.36620 tpi ($20/\pi$) but the 'pitch' of a worm with an OD of 24mm will be 6.35504 tpi. This is not an error of 0.04% as stated, but is - in fact - an error of 0.14%. Without going deeply into the mathematics of the system, the worm pitch is a function of the cosine of the helix angle.

Why have an error with the change gear combination? Just change the OD to suit the gear ratios that you have. For this worm, these are arbitrary figures and it will not matter if the diameter is varied a few thou', or the helix angle a quarter of a degree; so work backwards from your gear train ratio. Unfortunately, some 'maths' will be necessary for this procedure and it may be helpful to use trial-and-error figures for the new diameter until you arrive within (say) four decimal places of the actual tpi.

I give below two examples for the worm in question; there will be others, but I haven't looked any further. These examples are for an 'English' lathe with an 8 tpi leadscrew; change wheels for an 'American' machine will be different. As stated, the figures are based on change gear combinations, so the resulting OD and helix angle will be correct to within the limits of your equipment.



DRIVERS		DRIVEN		TPI	OD in.	HELIX ANGLE deg.
40	55	38	46	6.3564	0.9999in. (25.398mm)	3.185
60	75	55	65	6.3556	0.9652in. (24.516mm)	3.313

QUICK TIPS
Application of cutting fluid

A disposable plastic syringe of 20 or 50ml (see your friendly local doctor or dentist) will conveniently supply cutting fluid when performing milling operations, especially with small diameter cutters. Attach a three or four inch length of small bore flexible tube as supplied for car windscreen washers. It is much better than a brush as gentle pressure will help to flush away the swarf.

If washed after use in warm water and a little detergent the syringe will last for a long time. It is also ideal for applying oil or thin grease to all those difficult to lubricate places such as car door hinges.