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WORKSHOP

THE PRACTICAL HOBBY MAGAZINE

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Easily made tools
for special
purposes

GEAR SHAPING

Suitable for
lighter duties

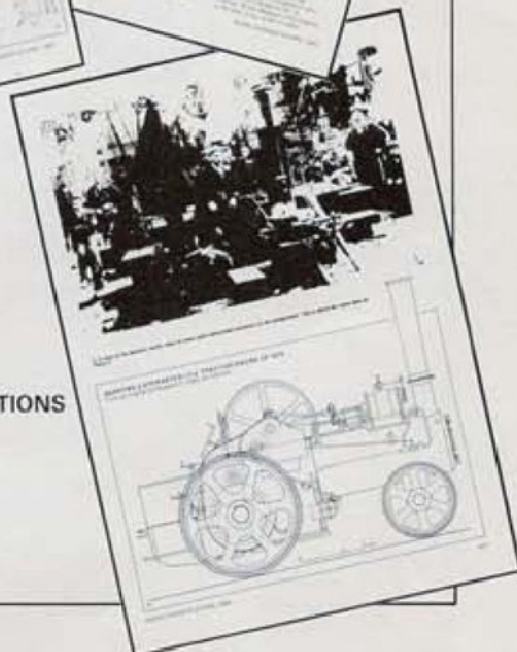
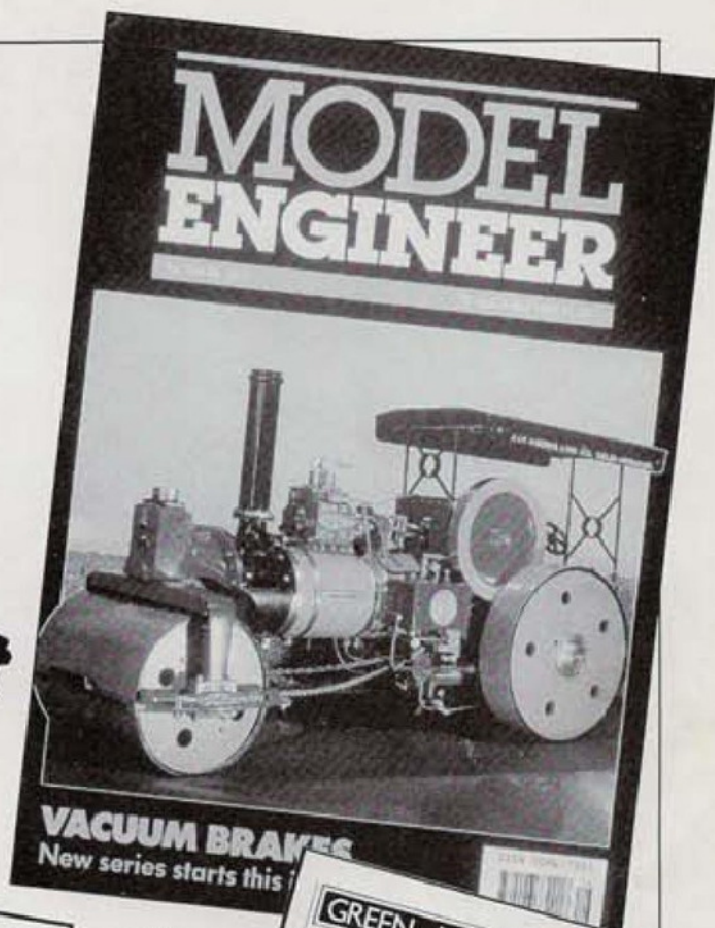
MILL KNEE MOTORISATION

Reduces manual
effort

THE 70th MODEL
ENGINEER EXHIBITION
Results and pictures
from Sandown Park



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



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

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On the cover

The clock maker's wheel cutting engine which won a Bronze Medal for its builder, Victor Cole, at the recent Model Engineer Exhibition. More results and a pictorial survey start on page 32



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Part of the busy scene at the Model Engineer Exhibition. This view shows the area which housed the Duke of Edinburgh Trophy contestants and some of the larger road and rail locomotives

CONTENTS

Issue No.
72

Editor: Geoff Sheppard

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- | | | | |
|-----------|--|-----------|---|
| 11 | ON THE EDITOR'S BENCH
Geoff Sheppard's commentary | 37 | HOME-MADE CUTTERS
Never be short of the right tool for the job |
| 12 | METHOD & SEQUENCE
Order rather than chaos | 41 | LINK UP
Readers' Sales and Wants |
| 17 | ADAPTING THE VERTEX HV6 ROTARY TABLE
Getting the best out of a milling accessory | 42 | MILL KNEE MOTORISATION
Easing the load when milling |
| 19 | YET ANOTHER KNURLING TOOL
A caliper type lathe tool | 46 | UPGRADING THE TAIG CNC MILL
Latest news from America |
| 24 | TRADE COUNTER
New items from our suppliers | 49 | A SAFETY INTERLOCK FOR A WARCO MILL
Contributes to safer working |
| 25 | GETTING STARTED IN MODEL ENGINEERING
Concluding the experiences of a new recruit | 50 | ELECTRO-MAGNETIC DEVICES - Part 7
Electric motor principles and theory |
| 28 | LATHE PROJECTS FOR BEGINNERS
Achieving precise diameters | 54 | SIMPLE GEAR SHAPING
Create internal and external gears for light duties |
| 32 | THE 70th. MODEL ENGINEER EXHIBITION
Reporting from Sandown Park | 56 | FINDING THE CENTRE
A refined version of a simple work setting tool |
| | | 58 | SCRIBE A LINE
Reader to reader |

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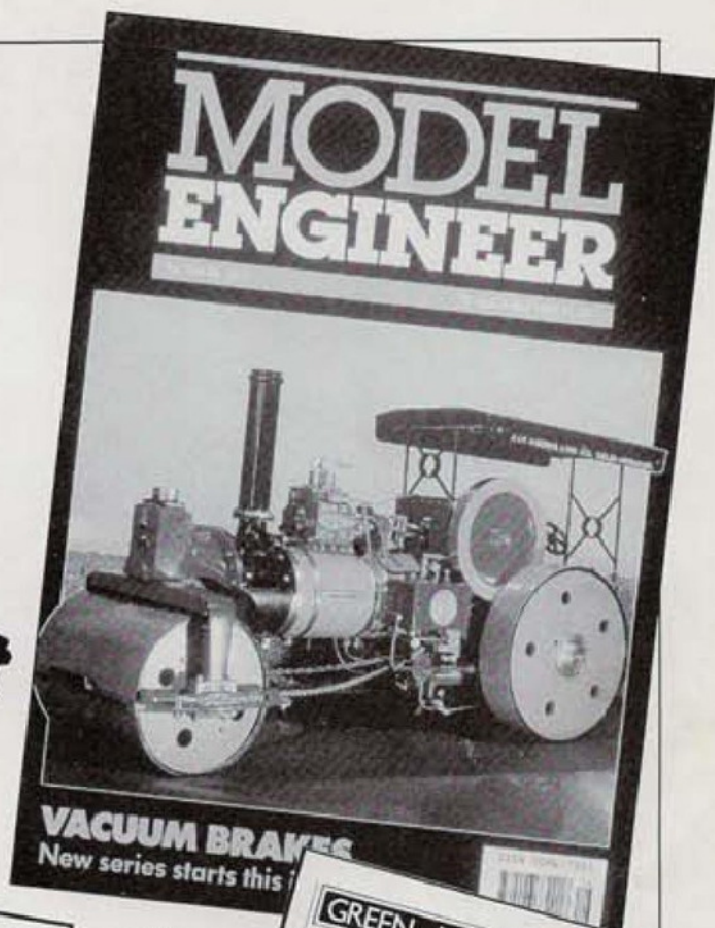
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ON THE EDITOR'S BENCH

Geoff Allen

The re-launch of the Model Engineer Exhibition and its relocation to Sandown Park proved to be an interesting and instructive exercise in many ways. There were bound to be many unknowns and we were prepared for some instant decision making, but the weather decided to be the 'joker in the pack'. Promptly at mid-day on Wednesday 27th. December people began to arrive with their entries for the Competition and Loan sections, so that Norman Phelps and his team of stewards were able to get the majority of the displays set up before we packed up for the day. The majority of those who had submitted entries were able to make it in good time, and the number that failed to make it was surprisingly low, most of these being from further afield. Some sent messages to say that travelling conditions were deteriorating, so we should have been warned!

The sight which greeted us on Thursday morning made our hearts sink. A liberal covering of snow was obviously going to make travelling difficult, and the news that other places were faring far worse than that particular corner of Surrey was not encouraging. Thursday was judging day, and it wasn't long before messages were being received from judges who were either going to be delayed or who had been forced to turn back because of the conditions. Fortunately, Chief Judge Ivan Law had set off from just south of Sheffield early enough to get ahead of the worst of the weather and arrived in time to be able to reorganise the team and to call on the services of experienced replacements who were within reach of Sandown Park.

We were not at all confident that we should see a reasonable attendance on the opening day, Friday, because the weather forecasts were horrendous and the advice being given on radio and television was not to travel unless absolutely necessary. Imagine our surprise when, well before opening time, there were queues forming at the doors and we were receiving news of long traffic tailbacks. Despite the forecasts, the day had dawned bright and sunny, so it appears that many who had perhaps planned to come on later days had decided to take the opportunity before the weather clamped in again.

The problem was now that the car park surfaces consisted of very slippery

frozen snow, which naturally slowed things down as drivers negotiated the access roads very carefully. An added difficulty was that the ground conditions were such that some of the areas which normally would have been used as overflow car parks were now inaccessible.

Visitor numbers on Friday were, in the end, far greater than we would have ever expected - getting on for double that which we had planned. Consequently, the strain on all the facilities made things uncomfortable, and we can only apologise to those who had their day spoiled by the difficulty in gaining access to the stands or getting served with food and drink.

Saturday was a quite different day. Still the weather was being kind and access was improving. As a result, a manageable number of visitors arrived and the Exhibition Centre could be described as being 'comfortably full'. The remaining days were somewhat quieter, but still slightly better than expectations. We can only hope that some who had not been able to see all they would have wished on Friday had a chance to return on one of the less-busy days.

Attendances at recent International Model Shows have been so disappointing that we were just not prepared for the numbers we saw on Friday. It was just like being back at Wembley where, at times, the only comfortable place to be was on a stand. The sight of queues in the snow also brought back many chilly memories!

The heartening thing about such support is that the event was a modest commercial success, hopefully sufficiently so to persuade our new owners to allow the event to be staged again next year. We have learned many lessons about organising a Model Engineer Exhibition at Sandown Park, and can only thank the exhibitors, the Clubs and Societies that put on displays, the traders and all our visitors for their support.

We have received many encouraging messages. It seems that this type of no-frills exhibition is what most model engineers want. Many were vociferous in their criticism of recent International Model Shows, having told us point-blank that they were intending, not only to stay away, but to encourage others to do likewise. These same people have now sought us out to offer congratulations on the latest event. As long as we recognise the teething problems inherent in moving to a new venue and take action to avoid them in future, I feel that the prospects for the Model Engineer Exhibition are much improved.

We have received a few critical letters from those who regret the move away from the IMS format, but these are very much in the minority. Although I have enjoyed many of the additional attractions, particularly the flying, there are those to whom such things are an anathema, believing that they are a distraction from the true purpose of the Exhibition. Unfortunately, to hire a venue

in which it is possible to stage such activities costs so much that the numbers of people prepared to support them are nowhere near sufficient to make them commercially viable.

Now that it seems that the Model Engineer Exhibition has been re-established in a format that most of our fraternity seem to enjoy, we look forward to a period of steady enhancement, until it again reaches the popularity it enjoyed in those far-off halcyon days.

The Chronos Unimat Millennium Lathe Prize Draw

Mark Smith of Chronos Limited of St. Albans has let us know that the winner of the Unimat Millennium Lathe Prize Draw competition held at Sandown Park was David Berreth of Uckfield, East Sussex.

Mark was extremely pleased with the interest shown in the competition and with the response from visitors. I have had the opportunity to speak to David, who has contributed to this magazine in the past and is delighted with his prize, which will make a useful addition to his new workshop. He hopes to tell us more about it when he has gained some experience in its use.

The Unimat Millennium lathe is mounted on its own heavy base unit, which gives it great stability, so that it can be used without having to be secured to a workbench, thus providing great flexibility of use, particularly for those with smaller workshops.

Geoff Allen's Tilting Compound Table

Pressure on space in this issue has meant that I have not been able to include the latest article on building the heavy-duty compound table. Apologies to Geoff and to anyone constructing the unit and waiting for more information. There is a prospective builder in America who has contacted Geoff, but to whom he has been unable to reply. Would this gentleman please make contact again.

MIG welding - a note of warning

I have received a number of appreciative comments from readers regarding the article on MIG welding by Trevor Marlow (Issue 71) as it approaches the process from the point of view of the amateur using it in his own workshop, rather than that of the professional who is using it every day. One reader has, however, suggested extreme care if attempting to weld such areas as car wheel arches where carpet, trim or other upholstery materials may be in the vicinity (page 48). He reminds us that any welding process involves a great deal of heat and should be kept well clear of any flammable materials. An additional point is that a suitable fire extinguisher should be kept to hand whenever any type of welding operation is being carried out.

METHOD & SEQUENCE

With the introduction of new equipment, work planning procedures used in industry are changing rapidly. Philip Amos looks back at some of the older routines and suggests that the use of some of them may be advantageous to the home workshop owner

I never cease to be amazed at the ingenuity of home workshop people in making all sorts of items with the limited tools and machines in their possession, but this is half the fun. To devise ways to achieve a result despite a lack of facilities is a great challenge, and also a source of considerable satisfaction when the result is achieved.

This article examines the procedure, and later discusses how the problems are addressed in commercial industry.

Design

While the principal aim in designing a part is to have it perform a particular function, it is desirable, right from the outset, to contemplate how it will be made. If this is not done it may make the manufacture more difficult than need be, or perhaps even impossible. As part of the manufacturing concept it is necessary to work out how to hold the material so that it can be worked on, either by hand or by machine, and often this will require

additional material for tooling purposes, which is cut off the finished part after having been used during manufacture.

'Chucking Pieces' are excrescences on castings which allow them to be held for machining - see example in **Drawing 1 (a)**. In some cases the excrescence is added to a part-finished piece to allow further work - see **Drawing 1 (b)**. The additional material may just be an added length of bar which will allow the part to be gripped in a region away from where it is being worked on. Tubal Cain in Reference 2 gives much useful advice in this regard.

As an example of a variety of possible manufacturing methods, consider the case of the special screw shown in **Drawing 2**. If the concentricity of screw, shaft and head are important, the part can be machined from bar stock in the lathe in one setting, as depicted in view (a). This would ensure that these requirements can be met to a high degree of accuracy, but the process involves a lot of turning, generating much waste - the volume marked XX.

However, much the same result can be obtained by starting from a thinner bar and attaching to it with adhesive a piece of thicker bar which has had a hole made in it - view (b). After the adhesive has set, the machining can be done - much as for case (a) including skimming both faces of the head. In this case much less waste occurs - volume Y. If the delay in waiting for the adhesive to set is unacceptable then silver solder or brazing can be used instead.

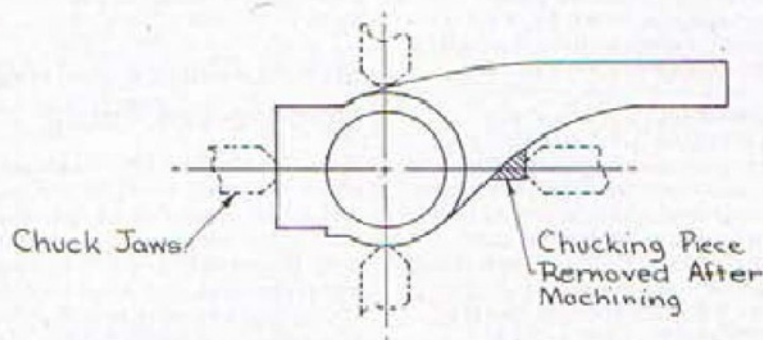
As the head has a knurled rim it is likely that its concentricity with the shaft is not of major importance. Also, if the shaft itself does not have to be a precise size for fitting into something else, then the shaft can be made from bar stock as in view (c) which further reduces the machining required and almost eliminates waste.

Finally, if there is no requirement for the shaft section to fit anything, a piece of threaded rod may be used as in view (d), which again reduces machining and simplifies manufacture while retaining the same functional outcome.

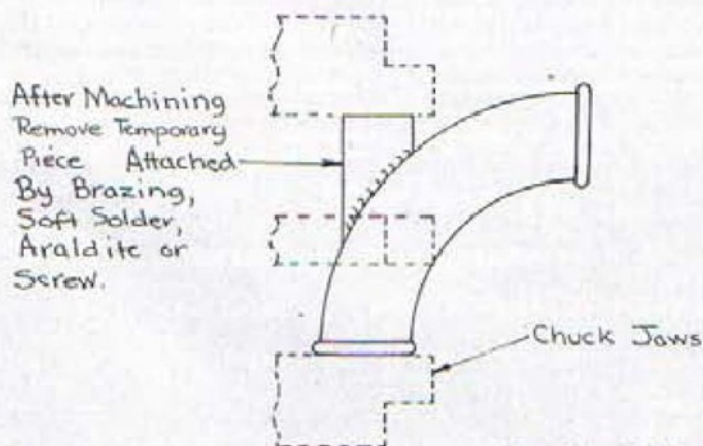
When all this cogitating is completed, the design is at last presented as an engineering instruction - the drawing.

Now it may be that the design is merely held in the mind's eye of the designer, but in all but the simplest cases some sort of drawing will be required. This could be only a dimensioned sketch - development workshops often work to these - but if there is any likelihood of a need to refer to the drawing at some future date, perhaps

(a) Quorn Example - (Rocking Lever)



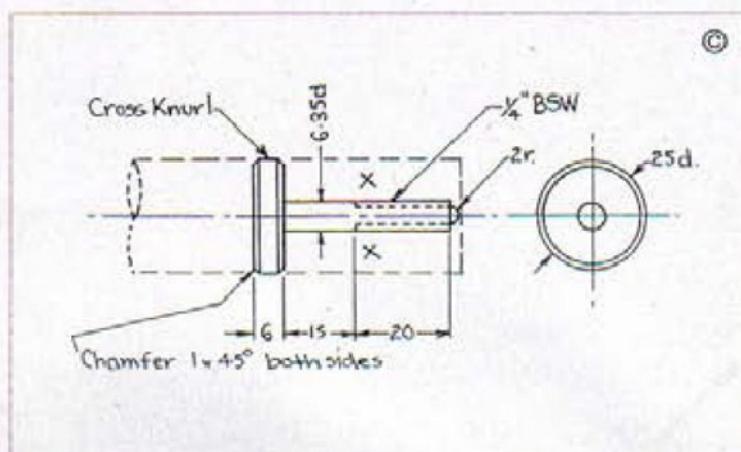
(b) Tubal Cain Example - Commercial Cast Iron Elbow.



Drawing 1 Chucking pieces

years later, it is probably worthwhile exercising the set squares and compasses (or the computer keyboard) to make a formal drawing. Such a drawing will be certainly be more easily interpreted by someone else if presented in conformance with the usual conventions, which are all well explained by Tubal Cain in Reference 3.

Drawings were originally ink on paper pictures to scale, often beautifully coloured, to show clients how the object was intended to be. This was particularly the case in architecture and in large sized machinery. These pictures were, however, unsuited to being handled in normal workshop conditions, and because of this it became common practice to make copies for everyday use, by tracing the drawing on translucent paper or linen. The tracing was placed in a frame over light



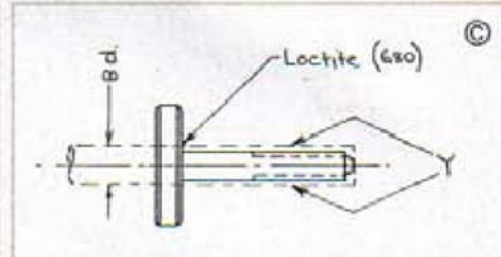
Drawing 2a - Special screw

Draw No	Description	Ref (C)
Material	Process	Finish
Revision	Date	Scale
A Original Issue	Drawn By	Dimensions in mm
	Test	Tolerance $\pm$
	Machined Surface	Unless Otherwise Specified
	Finish Number	
	Is machined in mill	
		(Company Name)
		(Drawing Title)
		(Drawing Number)

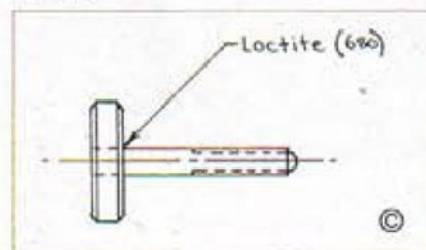
Drawing 3 - Typical printed drawing sheet

Draw No	Description	Ref (C)
Material	Process	Finish
Revision	Date	Scale
A Original Issue	Drawn By	Dimensions in mm
B Hole dia. 10.0	Test	Tolerance $\pm$ 0.5
C Hole dia. 10.0	Machined Surface	Unless Otherwise Specified
D Hole dia. 10.0	Finish Number	
	Is machined in mill	
		XYZ Limited
		Crank
		1088-E-65

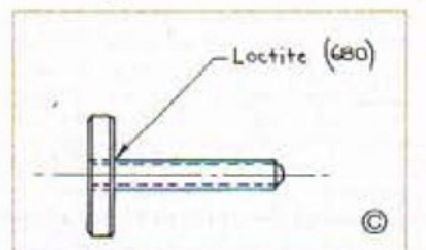
Drawing 4 - Typical detail



Drawing 2b



Drawing 2c

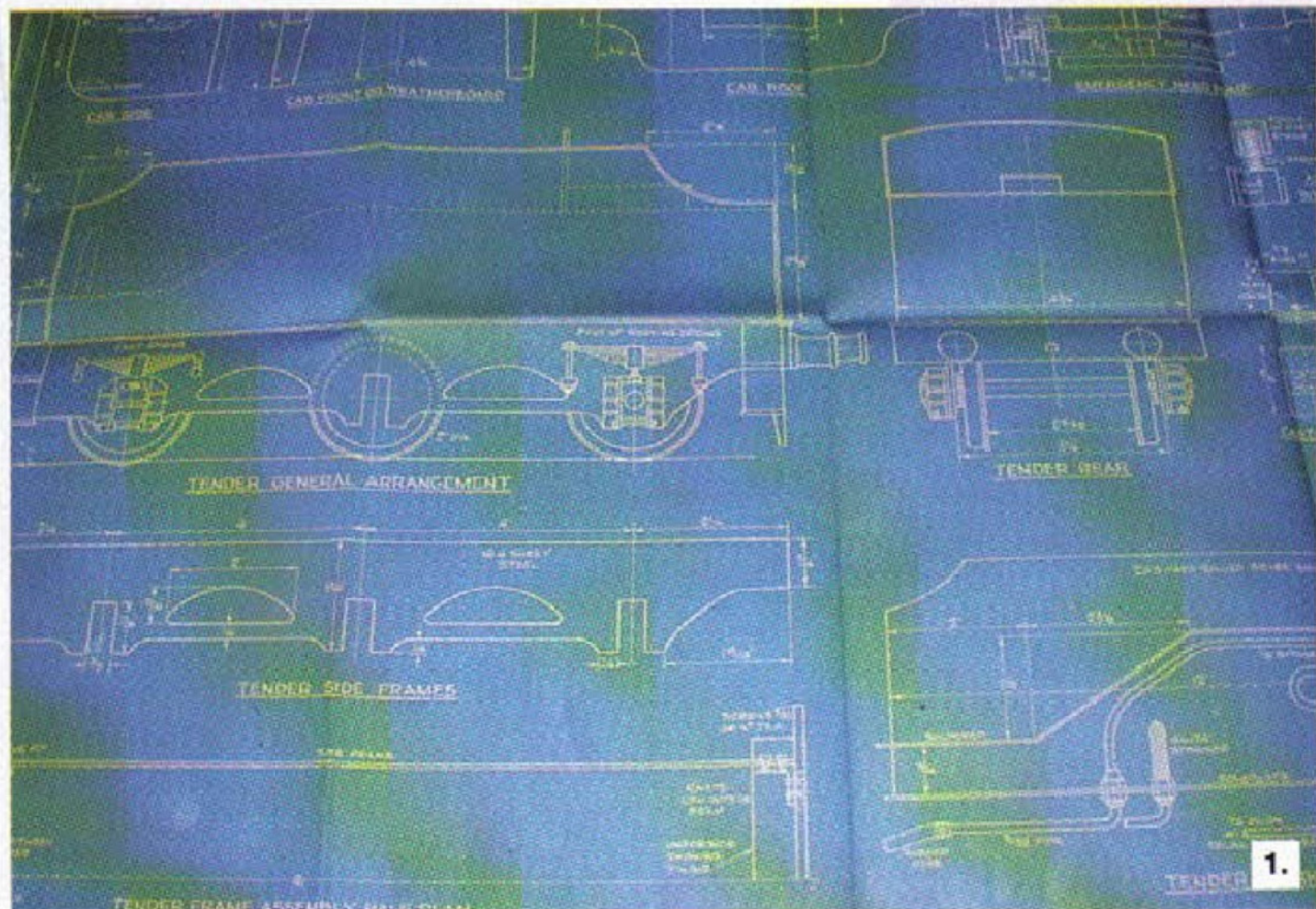


Drawing 2d

sensitive paper (sensitised with complex ferric salts) and exposed to bright light - usually sunlight but sometimes an arc lamp. After exposure the light sensitive paper was washed in water and then dried. The resulting impression was of white lines on a dark blue background - hence 'blueprint' (photo. 1).

In more recent times this process was replaced by a process in which development was by the use of ammonia vapour, and the impression became black lines on a white background, the print being called a 'dye-line' or 'azoprint'.

It became practical to use pencil-on-tracing paper drawings using this process for printing, and thus eliminating the tracing process in most cases, and so reducing cost. With the advent of office copiers, the smaller sized drawings are readily copied on these machines, and drawing offices are equipped with larger



cabinets, but sometimes arrangements to hang them vertically were used instead, particularly on construction sites. Next came the use of aperture punched cards, in which a microfilm copy of the drawing was set in place in the special punched card. These could easily be retrieved from store mechanically, but had to be used with a viewer, or else an enlarged print made.

These days most commercial drawings would be stored digitally on computer disk, and can be readily called up on screen or printed if a hard copy is desired.

Format

Commercial drawings have a title block - see **Drawing 3**. This block usually lists the company name, drawing title, number, date, scale, who drew it and possibly who traced it, checked it and authorised its release. It also may include projection angle, general statements on tolerances and machined surface finishes. There will be a column available for revision notes, spaces for material, process and finish requirements and column headings for a material list.

Considerable cost saving in draughtsmen's time results from having printed drawing sheets available with all this format information already in place, and it retains some order in the presentation. Similarly, such information can be included in a CAD program.

Drawing Number

The simplest approach is just to take the next number from the drawing register.

However, more sophisticated systems have evolved. In the days of cabinet storage there was merit in having the sheet size included in the drawing number to direct the searcher to the correct cabinet drawer (usually only similar size drawings were kept in the same drawer, or partitioned section of a drawer). Also, the use of a project number as part of a drawing number helped to pilot a course through the maze. Thus '4 Cylinder IC Engine' might be listed as project 1086 and a part carry the title 'Crank' and drawing number 1086-E-65 (see **Drawing 4**).

If a number of items appear on the same drawing sheet they are identified as 1086-C-29 item 1 etc., or 1086-C-29/1.

For an assembly, the items are shown in the material list, each with its own drawing number and the assembly designated, such as 'Group 1'. Thus 'Engine Crank Handle 1086-C-46 G1'. Several assemblies involving common parts can thus be depicted on the one drawing, each designated 'Group 1' or 'Group 2' etc. (see **Drawing 5**).

Material List

This usually has columns for item number, drawing number, description and number required for each assembly (group). Simple items may often be called up by description only, e.g. "45 of 6 dia bright mild steel", as a detail drawing would be superfluous in this case.

The best place for the material list is at the top left hand corner of the sheet, as then items are added in normal line sequence down the page, and assemblies

(groups) are added in conventional column sequence left to right across the page.

Revision Column

When a change is made to the drawing, details should be recorded in the revision column, together with the date and who did it. In some companies there is a separate document called for example 'Design Change Authority' which records why the change was made and listing all the consequences to ensure that these are all considered before the change is made. The revision note should be such that the change can be reversed if necessary e.g. "Hole 12 d. was 10 d."

The drawing can be identified in some way, such as 'Revision B' or 'Sub issue B'. It is good practice for the part to retain its drawing number if it can still be used in place of what went before. However, if the new part cannot be so used it should have a new number assigned.

Accessories

Another form of material list is variously titled "Accessories List" or "Tool List" or "Complete Equipment Schedule". This relates to parts which are required to service a main equipment or to enable it to be used for its intended function.

It may be simply a tool list such as:-

Hammer
Screw driver
13 x 11 open end spanner
Oilcan

or perhaps it might be:-

Left hand guard 1076-E-90/1
Right hand guard 1076-E-90/2
3 off M6 socket capscrews with
lockwashers
Socket wrench

or it may be much more extensive running into many pages of items.

An example of an Accessories List would comprise the chucks, steadies etc. for a lathe; or all of the special tools needed for servicing a commercial vehicle. Such lists may be illustrated with drawings or photos to aid identification of the items concerned, or to show how they are intended to be attached or to be used. They are not assemblies in the usual sense in that they are probably not joined together - more a collection of associated items. Nevertheless the conventional material list/ drawing format is often a convenient means of recording them.

Route Sheet

The information contained on the route sheet is usually compiled by industrial engineers who may be expected to be up-to-date on just what facilities are available in the establishment concerned. Over the years this function has been exercised by people with a variety of designations such as efficiency experts, time & motion study personnel, methods engineers, tooling engineers and so on. Industrial engineer seems to be the term most likely to endure.

The format is mostly as shown in **Drawing 6** and will usually have the same number as the drawing of the part. It

details the quantity of material needed to make the part (or 100 or 1000 or whatever) and the sequence of operations for its manufacture. Any jigs or fixtures required or available for any operation are listed with tool numbers, and the machine (or machine type) also listed. Set-up times and run times for each operation are shown - these and the material quantity allow the costing of the part into store and also allow calculations for machine and department loading, labour requirements and so on.

The times are usually in minutes but may be in decimal hours or in seconds - that will depend on each particular establishment and its way of operating. A revision space can be provided as on a drawing.

Typical route sheet information for differing types of establishment and production quantities are shown in Appendix A.

Conclusion

Much of the enjoyment of making things in the home workshop comes from considering just how to go about the task with the available tools and equipment in your own workshop. Often the methods you use will be quite different from those of the designer, as for example something that has been written about in ME or M.E.W., but you attain the same end result - to your great satisfaction.

It is a pity after all this thought if you have to put the work aside for some time and forget all the details of how you intended to go about it, so it really is worthwhile jotting down a list of method and sequence when you first think of it. This list doesn't have to be a formal

document, but perhaps it is sufficiently important to put it on a fileable piece of paper, and not just the back of an envelope or a bus ticket.

The discussion above about commercial drawings may help home workshop people find their way around such drawings if they haven't had previous experience with them, or suggest some features which it would be useful to include on drawings for a new project.

The only reason for home workshop people to make out job cards is to act as reminders of things to be made in the future, when time or need or cash will allow them to be brought to fruition. In this case the reference location - magazine article, book, advertisement or idea can be briefly jotted down on an index card - the set of which can be scanned from time to time to jog the memory.

Despite my progress in making things on my list, it always seems to get longer - but at least that means I don't have time on my hands!



References

1. The Quorn Universal Tool and Cutter Grinder D.H.Chaddock 1984
2. Workholding in the Lathe - Tubal Cain - WPS 15 1987
3. Workshop Drawing - Tubal Cain - WPS 13 - 1988
4. CAD for Model Engineers - D.A.G.Brown - WPS 29 1999

Appendix A

Route Sheet Information

For example, take the crank drawing number 1086-E-65 to be made in various types of establishment.

1. Local Jobbing Shop

Requirement 1 only

Operation	Machine	Tooling
Cut to length		Hacksaw
Mark out hole centres		Rule & scribe
Drill 2 holes	Bench drill	
Round ends		Filing buttons & file

2. Small Manufacturing Company

Requirement 100 items

Cut to length	Cold saw No. 2	
Drill holes & mill round ends.	CNC Machining Centre Centre No.3	Holding Fixture No.147. Program 1086-E-65

3. High Volume Large Manufacturer

Requirement 5000 items

Pierce holes & crop round ends	100 tonne Press #1	Punch & die set 1086-E-65 T1
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QUICK TIP

An Anti-corrosion formulation

I have one workshop indoors, with the heavier machinery installed in a detached garage. When the cold weather arrives, garage work ceases for a couple of months and rust sets in. The solution is to take a jam jar, partly fill it with petrol, and add a couple of tablespoons of Vaseline. This concoction is made about November time or earlier, and stood on a window sill, to be shaken every time I walk past. Although it takes a long time, the Vaseline eventually dissolves into an emulsion which is eminently suitable for brushing upon exposed metal surfaces. As the petrol evaporates, a thin film of Vaseline is left behind, and the machine is protected. The method is extremely effective; I treated my late Grandfather's workshop in this manner two winters ago and the film is still intact and the machines still rust free. As the formulation is liquid, it will 'wick' into gaps and so gets everywhere you could want it. It must be borne in mind, however, that we are using an extremely flammable solvent, and during treatment and subsequent evaporation there must no source of ignition!

'Monolith'

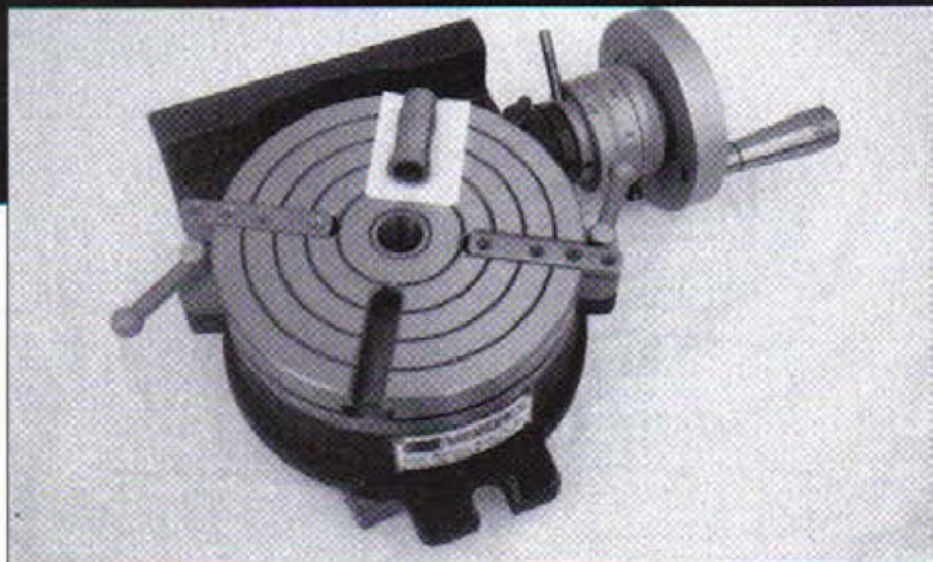
ADAPTING THE VERTEX HV6 ROTARY TABLE

Derek Oxley solved a couple of problems which he encountered when setting up this popular commercial milling accessory

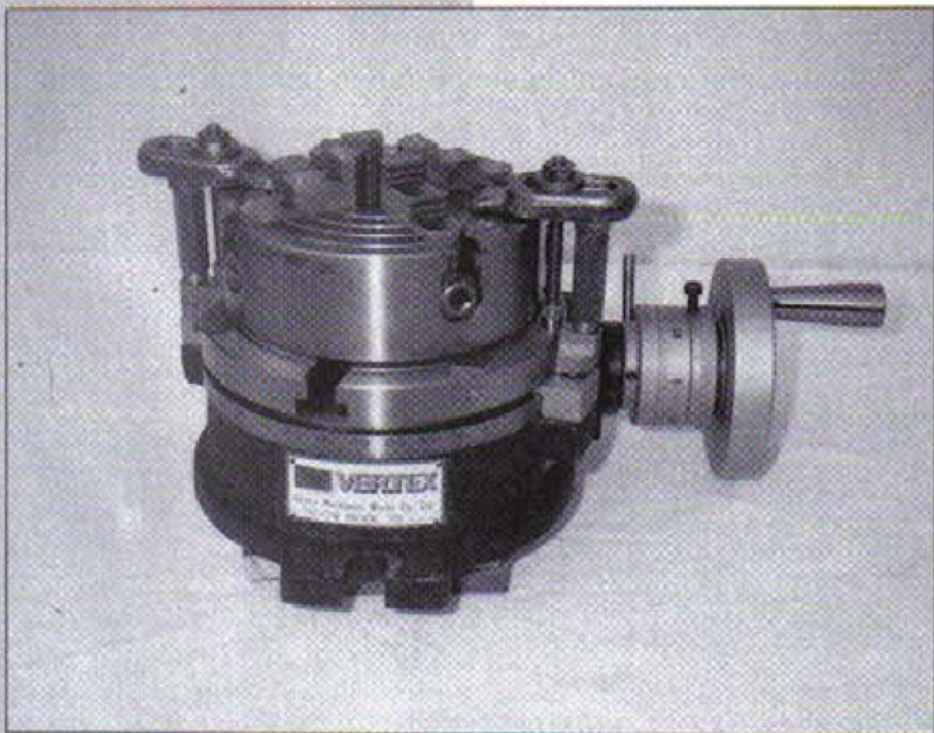
When my original pre-owned rotary table had to be replaced six or seven years ago, the Vertex HV6 was chosen. Although I deemed it unlikely that it would be used in the vertical mode, the short ground flange was seen as a useful aid for setting it square to the front edge of the milling machine table and then for setting the four grooves parallel to the 'X' and 'Y' axes when so required for special jobs.

It transpired that this model of rotary table had two disadvantages, both of which could be remedied:-

a) With long 'T' bars fitted as for strapping down a suitably arbores 5in. dia. chuck, rotation of the table was fouled by the as-supplied table clamping bolts and handles (Parts RT 18+19), as can be seen in



1. With long 'T' bars fitted for strapping down a 5in. dia. chuck, the rotation of the Vertex HV6 table is fouled by the original pattern of table locks. This photo. also shows the 2MT waisted non-split sleeve



2. A suitably arbores 5in. chuck strapped down after replacing the original table locks with 1/4in. BSW x 1in. capscrews, with the cast iron clamping pieces counterbored to accept their heads

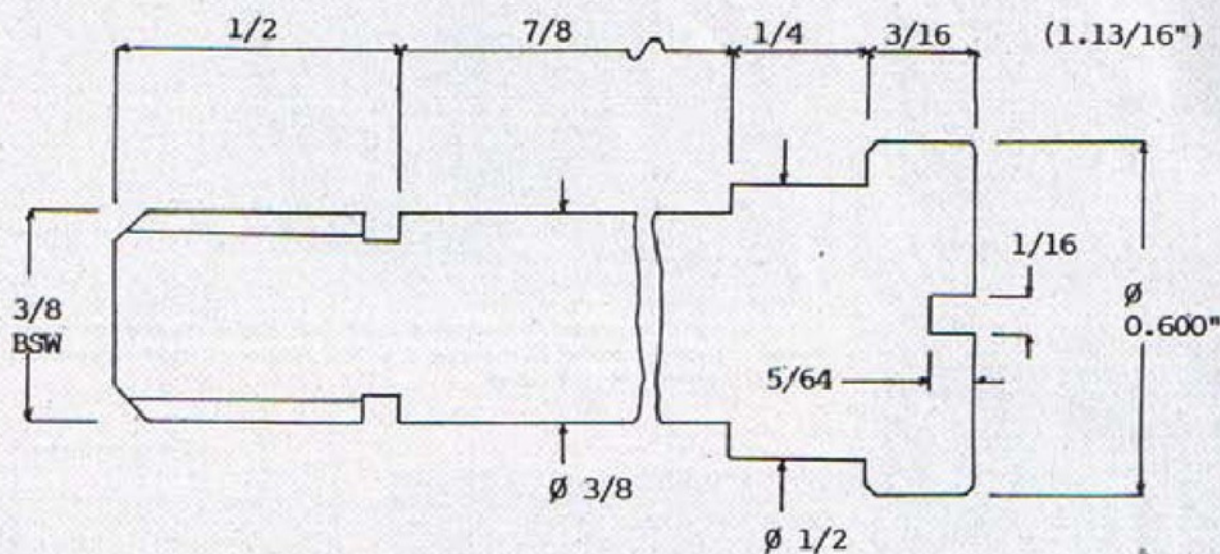
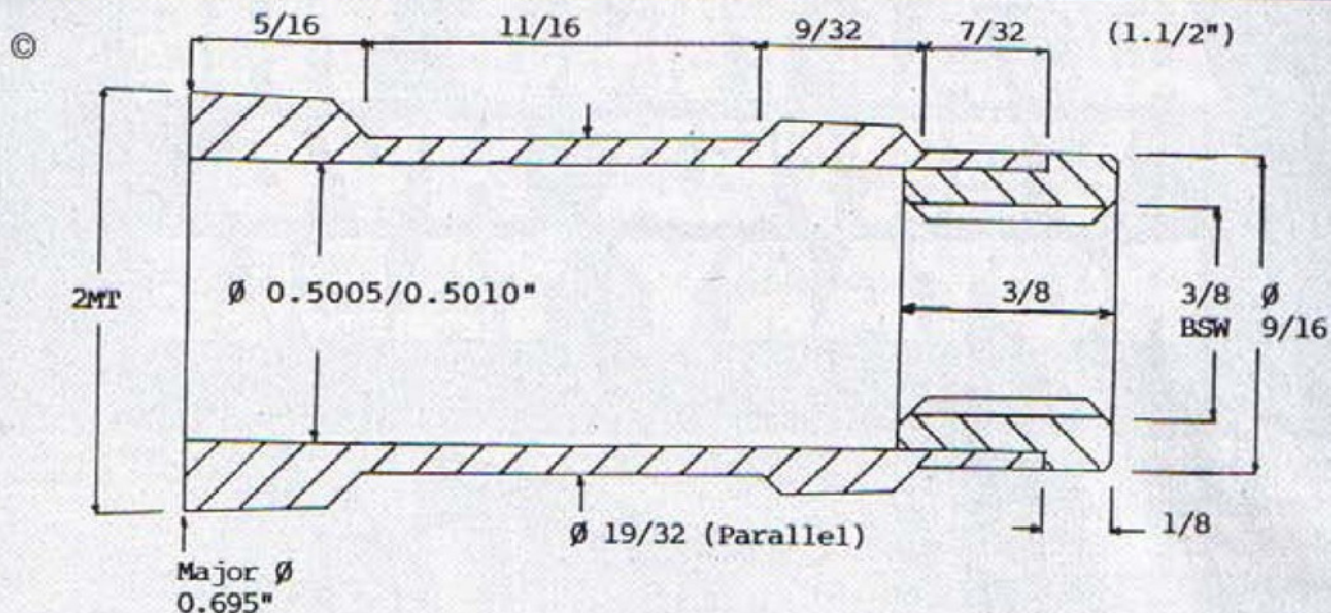
Photo. 1. This problem was easily remedied by replacing these components with 1/4in. BSW x 1in. capscrews after first counter-boring the clamping pieces RT 17 to 10mm dia. x 0.260 deep (**Photo 2**). The thread of the 'T' headed setting screw RT 11 was also shortened by 1/16in.

b) The 2MT central hole was of little use to me and complicated the procedure for centralising the rotary table under the quill of the vertical mill/drill and for making centrally positioned locating pegs when so required. Not wishing to destroy the 2MT facility, a 2MT waisted sleeve and retaining screw were made to the dimensions shown in **Fig. 1**.

As a matter of purely personal choice, the handwheel handle was removed and replaced by a shorter, freely rotating type of different form, for which my 'back of an envelope' sketch was not converted into a decent drawing.

It is worth mentioning that there is an error in the supplied 'Operation and Service Manual, which states, on page 3, that the micro-collar is graduated in steps of 1 minute of arc. There are only 30 graduations between the whole degree marks, and the entry in the manual should be corrected to read "steps of 2 minutes (002)". The error was acknowledged by Vertex Machinery in a telex dated 7 May 1999.





- Notes: (a) Major ϕ of 2MT sleeve restricted to 0.695" to ensure no projection above table surface.
 (b) 3/8 BSW flanged bush Loctited in situ.

Fig. 1 - 2MT waisted sleeve MS and retaining screw (MS)

QT QUICK TIP

A Quick Oil Can

An old shower gel bottle can be readily converted into a squeezable oil can: First discard the hooked outer cover and remove the inner screw cap. This is composed of three parts:-

The body
 A soft rubber seal with a cross-shaped cut
 A retaining ring

1. Cut a short length of 3mm diameter copper tube, clean up the ends and rub it with emery to remove any oxide.
 2. Scribe a 16mm diameter circle on a piece of thin (0.25mm) tin plate and punch a central hole in it.
 3. Cut out the circle and push the copper tube through the hole so that 4-6mm is exposed on the rough side of the hole.
 4. Solder the disc and tube together.
 5. Pry off the retaining ring with a scribe or short dental pick.
 6. Push the tube into the cross-shaped cut in the rubber seal, reassemble the cap and ...
- Voilà! One oil can!

Notes:-

a. Use only very light weight tin plate. The rubber seal must be capable of absorbing the thickness of the plate when the retaining ring is in place. Examine carefully the sections of the retaining ring and rubber seal. These are complex, and the sketches below are much simplified.

b. Don't drill the tin plate! The radiused distortion caused by the punching acts as a well for the solder, thereby strengthening the joint.

Paul Boothby, West Sussex

YET ANOTHER KNURLING TOOL

Gary Wooding of Leamington Spa describes his version of a caliper type knurling tool

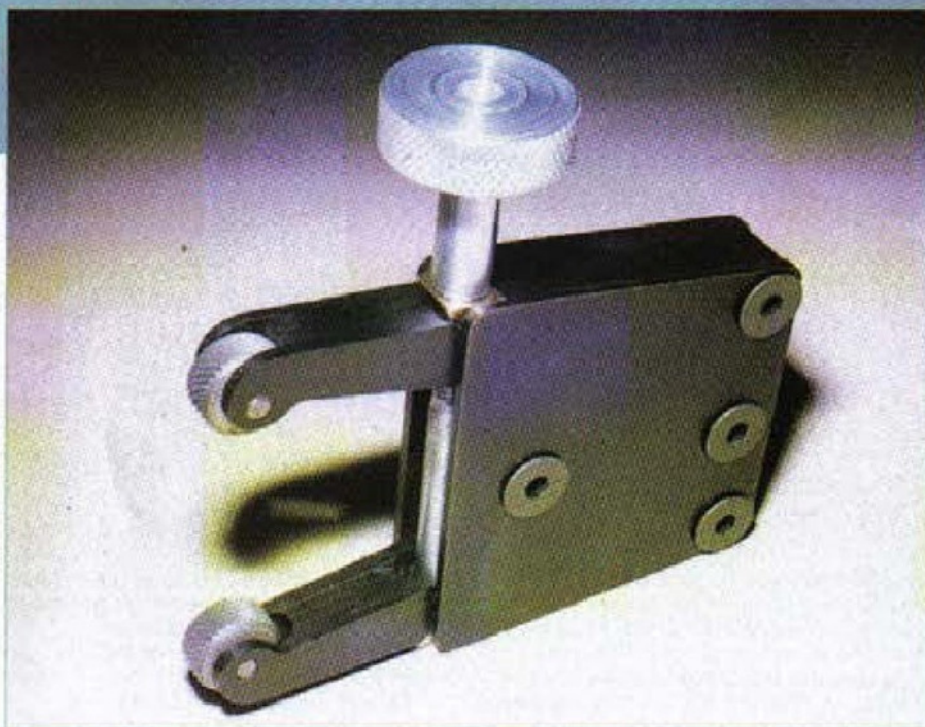
Although I have a reasonably robust lathe which accepts the normal side-push knurling tool without protest, there were times when the work itself was not rigid enough to withstand the requisite side pressure without bending - thus the need for a caliper type tool. Not being totally happy with the design or capacity of the normal caliper type, and prompted by the purchase of some inexpensive sets of knurls from Chronos, I decided to design a version that I thought more suitable. My main requirements were: easy changing of knurling wheels, ability to work close to a shoulder or the chuck, large capacity (it will accept 70mm diameter work), and it had to 'look the business'. **Photo. 1** shows the completed tool, and **Photo. 2** shows the component parts.

None of the dimensions is critical, except that the two arms should match and the joints should not be sloppy. Since I don't possess a milling machine I used the vertical slide of my Bofford. The materials I used were 5/16in. square BDMS for the arms and toolpost mount, and some 90mm x 3mm MS strip for the cheeks. Other material came from oddments. The tool was designed so that, when fitted into the toolpost of my lathe, its centreline was level with the lathe centre height. This determined the 13mm dimension in the 'General Arrangement', which in turn determined that the two horizontal holes in Items 9 and 12 were 3mm below the centreline. You should check your lathe to see if amendments are required.

One other point: the knurls as purchased are hardened steel with 1/4in. bores. I felt that it would be advisable to insert brass bushes so as to avoid a steel on steel bearing surface, and to allow the use of pins (Item 10) of smaller diameter. Since I had some 5.4mm silver steel from which to make them, the most appropriate thread size turned out to be 1BA. If you want to use a different sized pin, don't forget to change the sizes of holes A and B in the arms.

Item 1

This is a simple turning job using almost any odd piece of material in the scrap bin. I used a piece of aluminium rod rescued from a photocopier. True up the narrow end and cut away the section to make the stem, then drill 6.8mm for a depth of about 42mm followed by 8mm for a depth of 2mm and tap M8 as deep



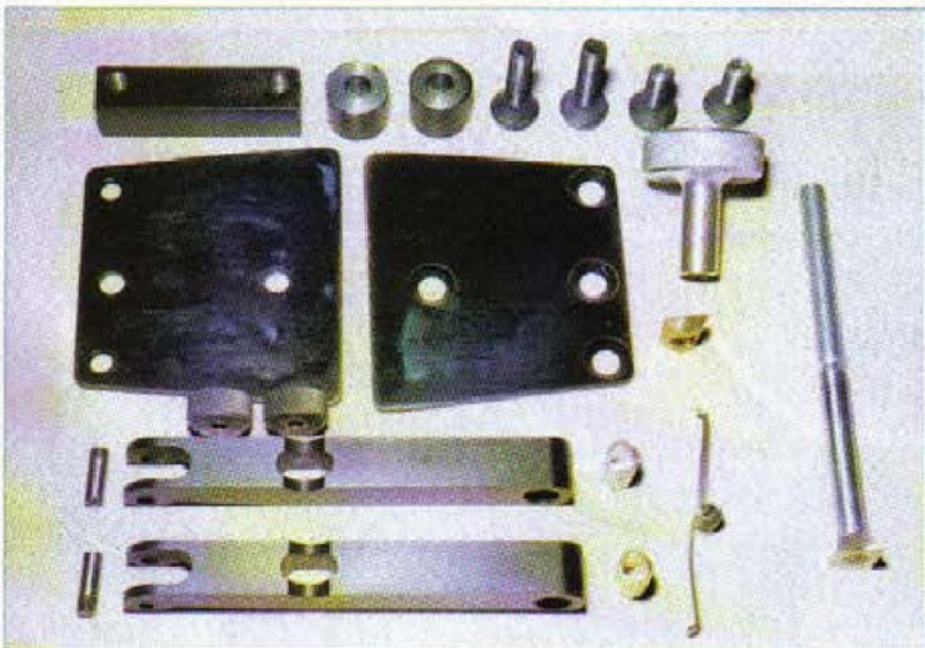
1. The completed knurling tool. The design provides a wide range of adjustment

as possible before parting off to a length of 41mm. Reverse in the chuck, tidy up the grip end and drill 8mm to a depth of around 15mm to leave approx. 23mm of thread. Final knurling can be carried out when the tool is finished as shown in Photo. 11.

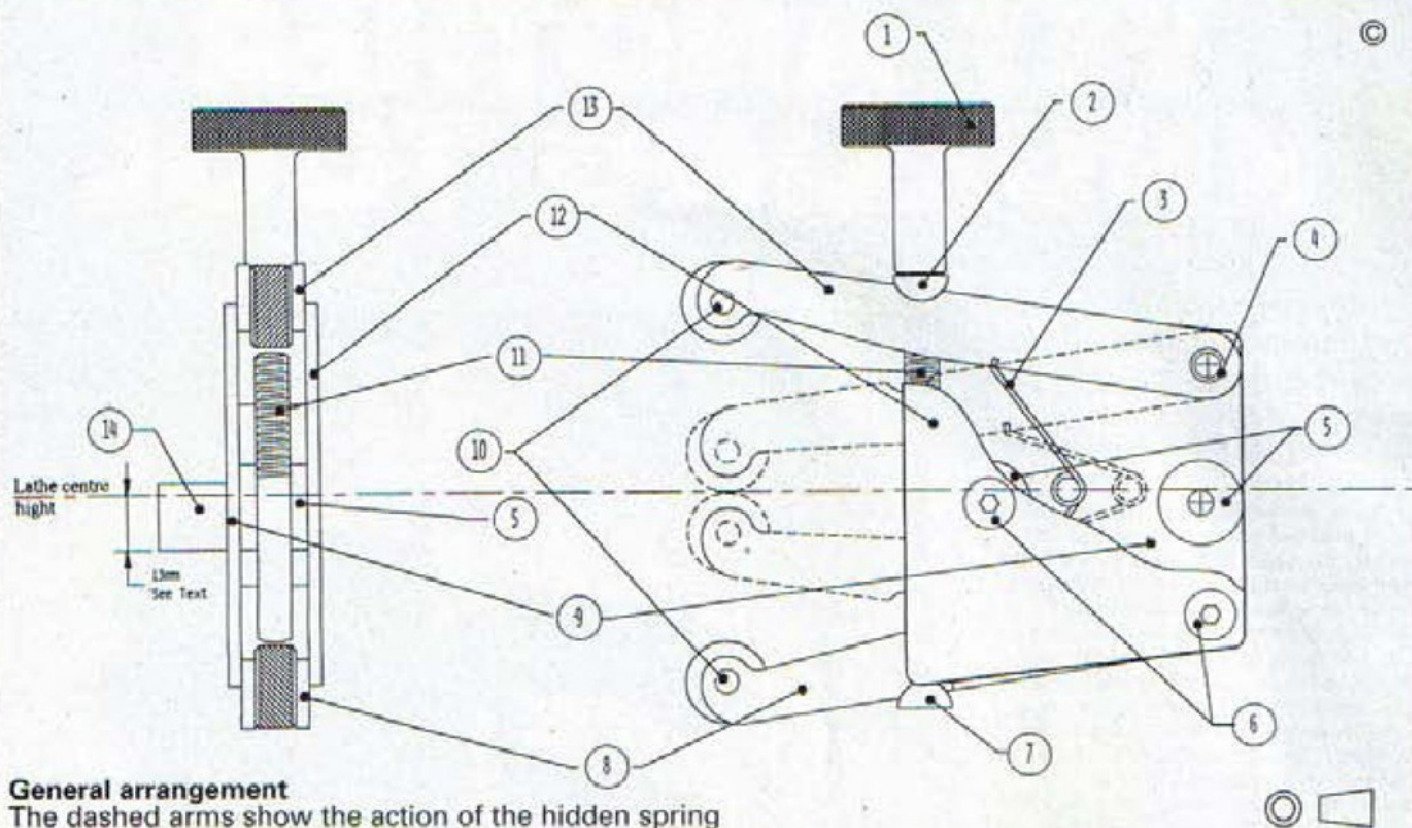
Items 2 and 7

These were made from a short section of 12.7mm (1/2in.) brass rod, cross drilled and cut lengthways to form the two items.

The cross drilling was accomplished by a remarkably simple, yet highly accurate method that I wish I had invented. The rod



2. The component parts



General arrangement
The dashed arms show the action of the hidden spring

was clamped in the vertical slide with its axis around lathe centre height, a small centre drill was placed in the 3-jaw and the slide moved to pinch a 12in. steel rule between it and the rod as shown in **Photo. 3**. The chances are that the rule is not held vertically because it is not resting on the widest part of the rod. Adjust the slide up or down until the rule is as vertical as possible and the rod will then be very accurately positioned for cross drilling. If the ends of the rule are as much as 0.1in. out of line, this corresponds to $\frac{1}{2}$ deg. off the vertical, and the error in the cross drill location will be around $0.004 \times$ diameter of the rod. Not bad for such a simple method.

Since 0.1in. is very easy to see, its quite feasible to aim for something closer to .025in., which corresponds to an accuracy better than $\frac{1}{1000}$ of the rod diameter.

I drilled the cross hole 6.8mm (M8 tapping size) approx. 8mm from the end, tapped it M8, sawed off about 16mm and transferred it to the 3-jaw for tidying up the ends to a 15mm length. **Photo. 4** shows the resulting piece, screwed onto an M8 bolt held in the 3-jaw, being scribed along its axial centreline. After being sawn in two, each part was then tied in the lathe whilst being held by the M8 bolt as seen in **Photo. 5**. The threaded hole in Item 2 was then redrilled and reamed to 8mm.

Item 3

I used a short length of 1.2mm stainless steel wire that I happened to have. Since Young's Modulus is more or less the same for all steels (its only the yield point that differs) you can use whatever you have. Giving it seven coils should ensure that it is never strained beyond its yield point.

Items 4 and 5

Two off each. These are simple turning jobs where the only comment to make is that their lengths should be approx. 0.02mm (0.001in.) greater than the thickness of the arms (Items 8 and 13).

Item 6

These are simply M6 socket head countersunk bolts, cut to length.

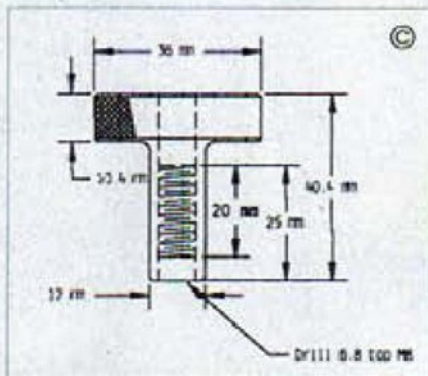
Items 8 and 13

Cut off two 130mm lengths of $\frac{5}{16}$ in. square BDMS for the two arms, and degrease them (washing-up detergent works well).

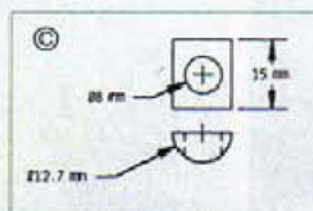
In order to simplify marking out, I drew the plan and side views of an arm, full size, onto some white paper and cut them out with about an $\frac{1}{16}$ in. border all round. I then stuck one of them onto an arm, allowed the paste to dry before trimming off the excess border and then stuck the other on as shown in **Photo. 6** (it is easy to align the paper with the metal if it is held up to the light). The photo. also shows the hole centres being centre punched. The two arms were then clamped together for drilling - **Photo. 7**. As it turned out, my drill-stand attachment was not rigid enough to drill the holes as accurately as I would have liked, so, rather than



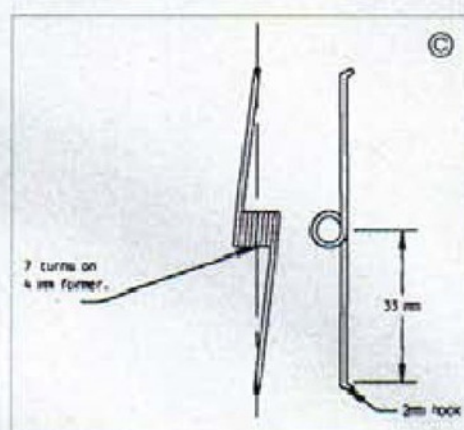
3. Setting the centre height in preparation for cross drilling



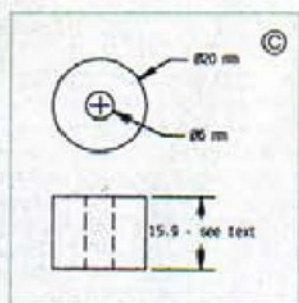
Item 1 - Mtl Aluminium



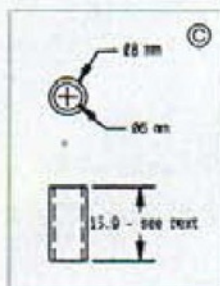
Item 2 - Mtl Brass



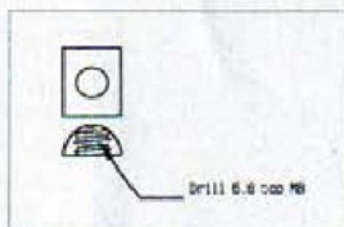
Item 3 - Mtl 18 swg steel wire (2.2mm)



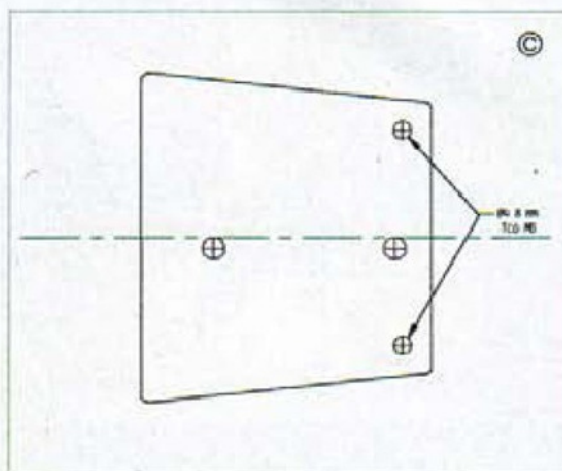
**Item 5 - Mtl Ms
2 off**



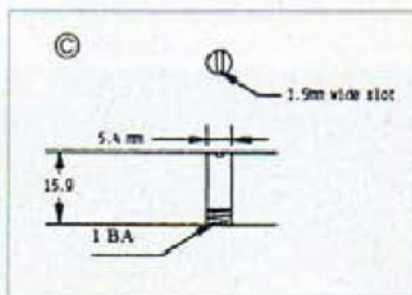
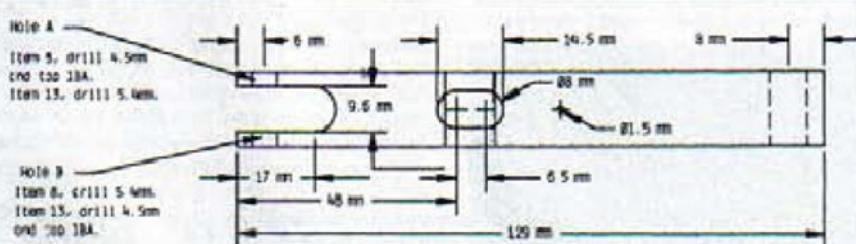
**Item 4 - Mtl Brass,
2off**



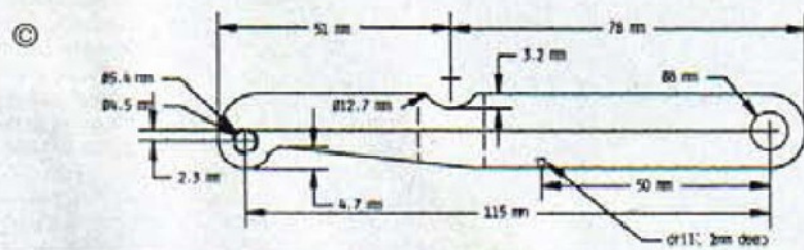
Item 7
As item 2, but hole
drilled 6.8mm and tapped
M8.



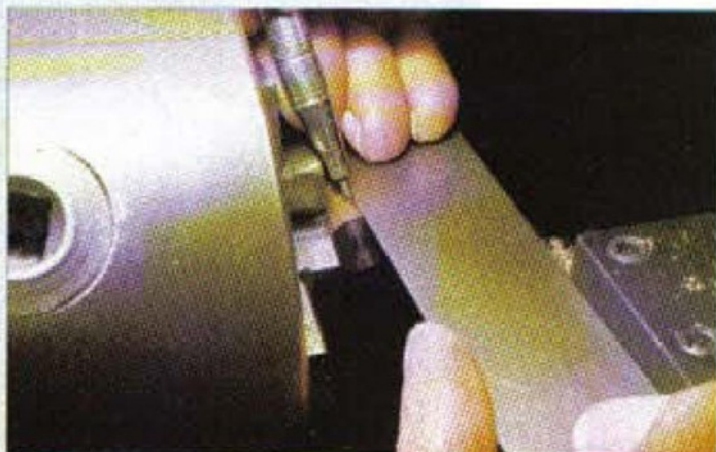
Item 9
Dimensions as item 12,
no countersinking, note tapped holes



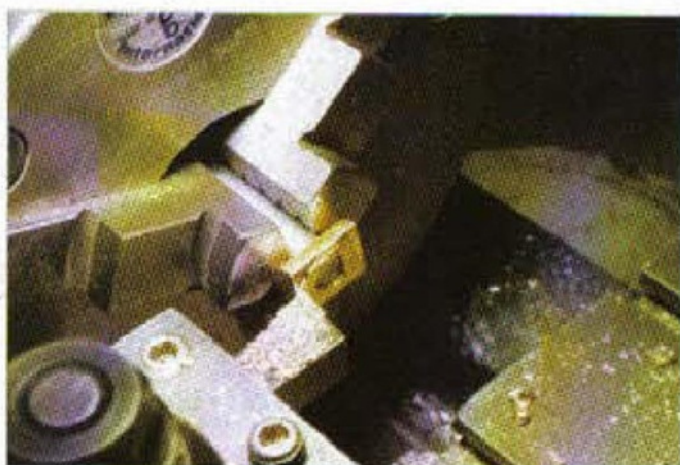
Item 10
Mtl Silver Steel, hardened and
tempered
2 off



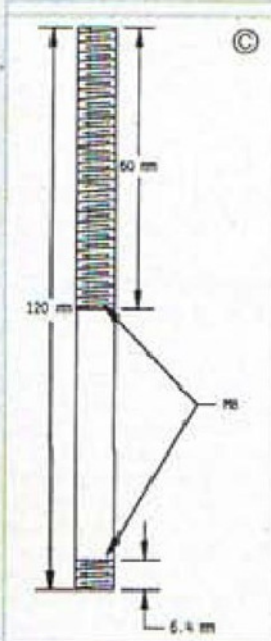
Items 8 & 13
Nominally 5/8" square BDMS. Both items identical, but note that
holes A and B are handed.



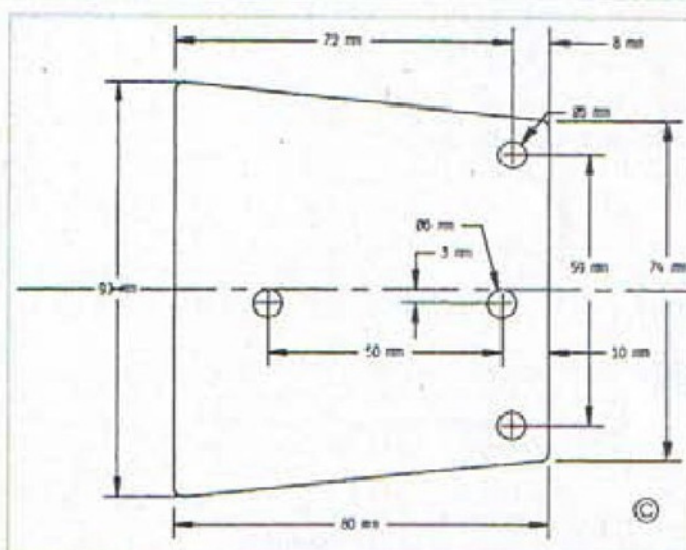
4. Items 2 and 7 were made from one piece of brass bar, slit along its length



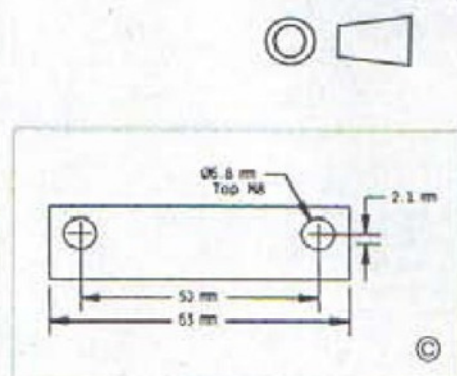
5. These items were then tidied up by facing while mounted on an M8 bolt



Item 11
8mm MS rod

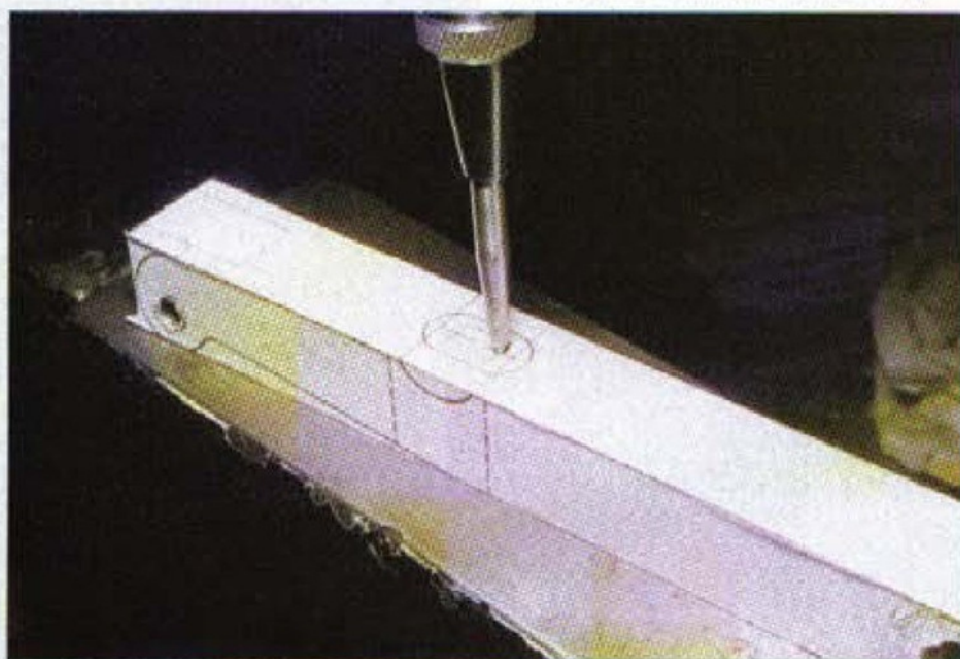


Item 12
3mm MS plate, all holes countersunk



Item 14
Mtl. $\frac{5}{8}$ " square BDMS

consigning the arms to the scrap bin I redrilled them oversize in the vertical slide (the eagle eyed will notice that I actually



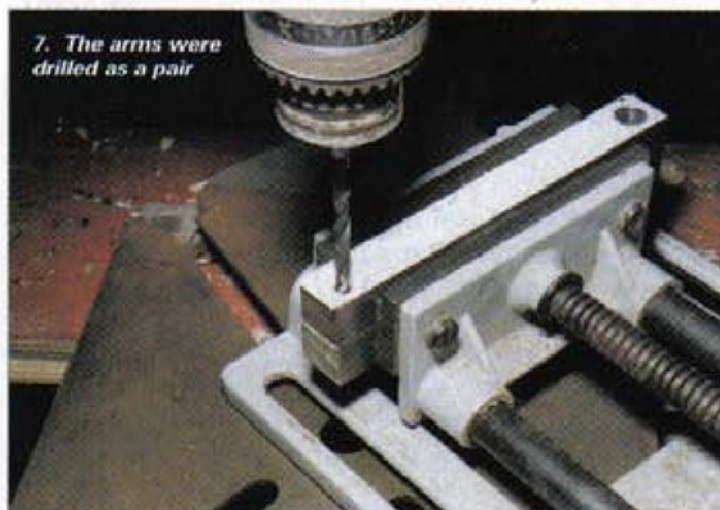
6. The marking-out of Items 8 and 13 was aided by gluing paper patterns to the stock material

used 8mm bolts rather than the 6mm ones specified).

After drilling the holes (don't forget the small ones that support the spring) I placed both arms in the vertical slide for milling the slots. Since the sizes are not too critical I had no qualms in using endmills instead of the preferred slot drills which I would have had to buy specially; and, to the certain horror of the purists, held them in the 3-jaw. Being fully aware of the possibility of them working loose with disastrous consequences I checked carefully after every few operations. I used a $\frac{3}{16}$ in. endmill for the 9.6mm slots and $\frac{1}{16}$ in. for the 8mm. Unfortunately, my endmills were not long enough to machine both arms at once, but, after setting up to centre height, the second one was easy. **Photo. 8** shows a 12.7mm endmill being used to machine the semi-circular recesses for the pinions. Again the endmill wasn't quite long enough to fully machine both arms, but it left enough of a witness mark on the second one to simplify setting it up by itself.

To cut the recesses on the undersides of the arms I placed them, face up, at an angle of 7 deg. on the vertical slide. **Photo. 9** shows the recesses being machined with a 12.7mm endmill, while **Photo. 10** shows the rounded ends being initially cut as a series of flats, later to be smoothed out by filing.

The two arms are handed so that, in use, the action of rotating the knurls tends to tighten the retaining bolts (Item 10).



7. The arms were drilled as a pair



8. Machining the semi-circular recesses in the arms

Open up opposite 4.5mm holes to 5.4mm and tap the smaller ones 1BA.

Items 9 and 12

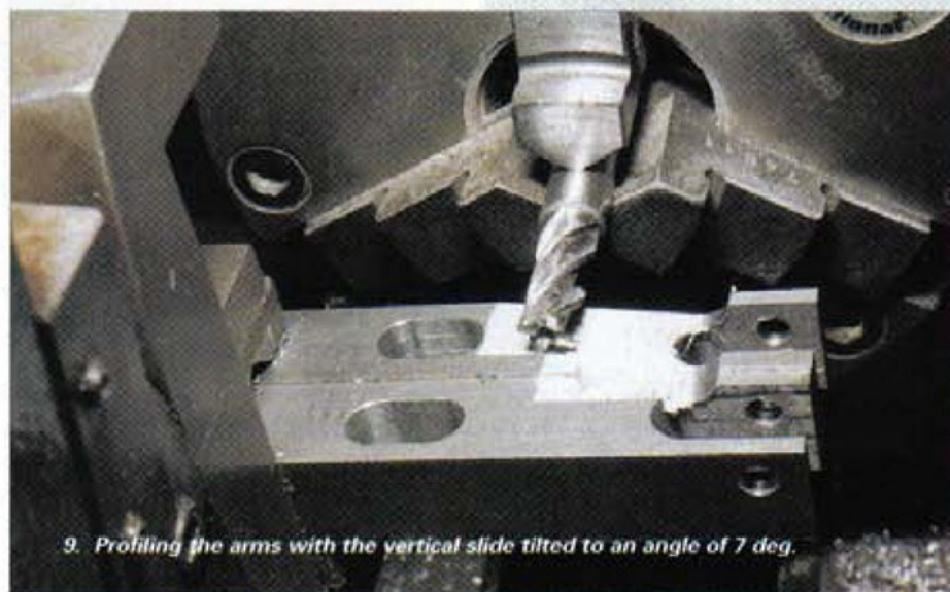
Cut off two 81mm lengths of 90mm x 3mm MS strip. I drew the plan of Item 9 on a sheet of white paper, cut it out with a $\frac{1}{8}$ in. border, and stuck it on one of the degreased lengths. The positions of the holes were then centre punched, the two pieces of strip clamped together, and the two 4.8mm and two 6mm holes drilled through both. The sloping sides were sawn off with a hacksaw and the edges filed true to the outline on the paper. The clamp was then removed and the two 4.8mm holes in Item 12 were opened up to 6mm before countersinking all four holes to take the heads of Items 5 and 6. The two 4.8mm holes in Item 9 were then tapped M6.

Item 10

Two off. These are made from silver steel. After cutting the 1BA threads and sawing the slots, they were hardened and tempered to pale straw (230 deg. C).

Items 11 and 14

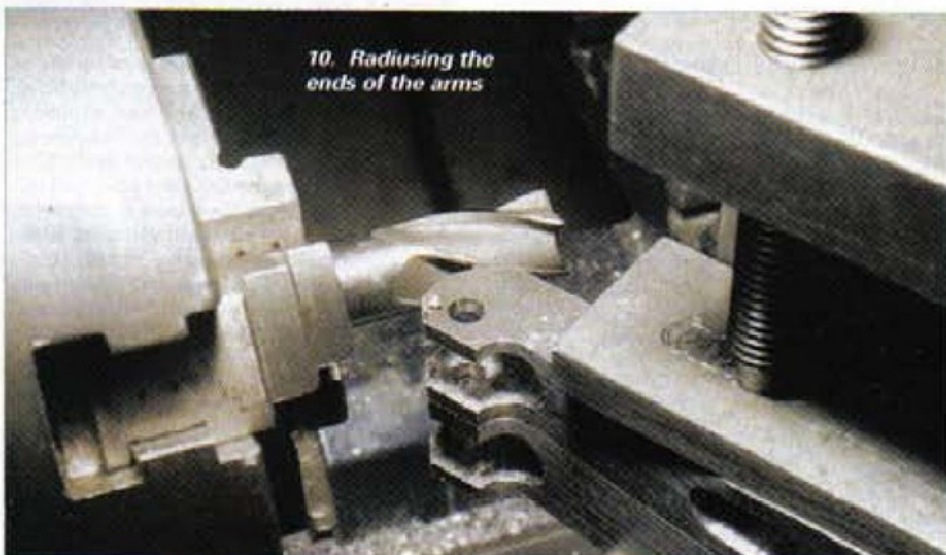
These should need no comment except that, in my case, my old but unused 8mm die turned out to be blunt (it was of Eastern origin and just goes to prove that you often get what you pay for) and incapable of cutting 60mm of thread without distorting



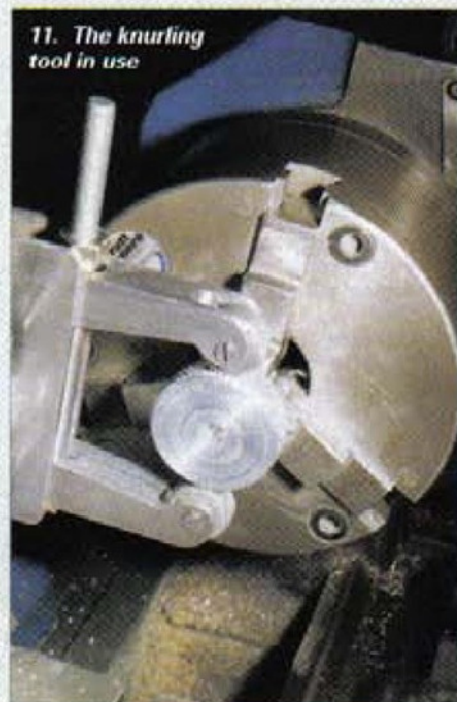
9. Profiling the arms with the vertical slide tilted to an angle of 7 deg.

the rod! I tried screw cutting the thread in the lathe but gave up after twice breaking the tip off of a carbide metric cutter (again of Eastern origin!) despite taking cuts of no more than 0.05mm. In the end I made Item 11 from a long M8 bolt cut to length with a 5mm x 15mm axial hole in one end, and a 75mm long 8mm MS rod with 15mm at the end turned down to a good but easy fit in the bolt. The joint was made with superglue. According to Tubal Cain's excellent Model

Engineer's Handbook, the joint should withstand almost $\frac{1}{2}$ ton of tension before failing: I was certainly unable to break it by clamping the finished tool as hard as possible onto a block of wood.



10. Radiusing the ends of the arms



11. The knurling tool in use

TRADE COUNTER

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

A. J. Reeves 2000 - Good News!

We recently received the following Press Release from Anker Towbars Ltd of Warwickshire.

"As you are no doubt aware, A. J. Reeves & Co. (Birmingham) Ltd. entered voluntary liquidation last October.

"We are delighted to announce that the company has been purchased and A. J. Reeves 2000 will be continuing largely as before. It will now be run by a new management team with a long and successful track record.

"The new owners are best known for Anker Towbars but have other interests as well. Bill Barton who will head the company, is a mechanical engineer with many years experience. He has owned several full-size steam locomotives and a steamroller. Currently he owns a collection of old commercials, mainly fire engines and Scammell mechanical horses. This background helps him to understand the product. We are not men in suits, we are engineers and will run the business accordingly.

"Geoff Stait has been employed to manage the new company. Geoff's years at Reeves have given him a wealth of experience; he will be joined by some other ex-Reeves employees.

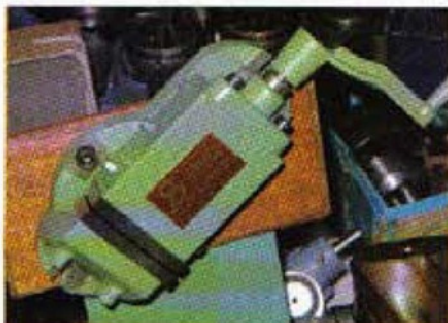
"Our immediate plans are to continue to trade at Marston Green until 20 January, we will then close temporarily. We will attend the Brighton exhibition and then move the company to our premises. Orders received by fax or by post during February will be processed at the earliest opportunity. We expect to have the whole ongoing range re-stocked during this period. From 1 March the company will then trade on a mail order only basis until a permanent new building is finished. We will then re-open the sales counter. The general range and scope of activities will be similar to that historically and the catalogue will be reprinted, first in abbreviated form, and then for next year much as before.

"From 1 March the new telephone number will be: 01827-830894 and the new fax no: 01827-830631. The web site will be functioning again as soon as possible. Meanwhile you can find out more about us, our products and take a factory tour at

www.ankertowbars.co.uk"

Judging from the number of telephone enquiries received at our editorial office, there are many readers who will be relieved to hear that the company is being re-launched. We wish Bill Barton, Geoff Stait and their team every success with A. J. Reeves 2000. As soon as we receive further news, we will pass it on.

Small machine vice from Home and Workshop Machinery



Readers in New Zealand often tell us of the difficulties of obtaining some engineering supplies locally, having to rely on European or American sources, with the attendant cost penalties. It is pleasing, therefore, to be able to bring news of what appears to be a high-quality product which emanates from that country and which has now reached the UK.

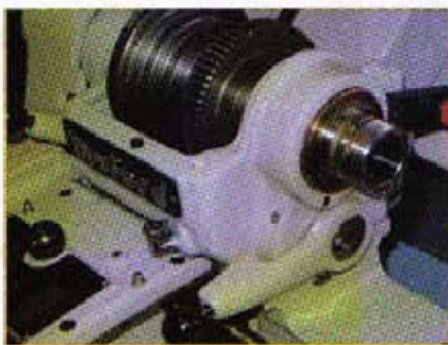
On show on the Home and Workshop Machinery stand at the Model Engineer Exhibition was a neat small machine vice produced by Stanier Engineering of Auckland.

The 55mm wide jaws are hardened and ground and open to 41mm. Jaw height is 19mm. The Acme form screw terminates in a squared end which accommodates a substantial removable handle. The body is of cast iron and incorporates an adjustable dovetail slide, a spanner and hexagon wrench being provided for adjustment. The unit is supplied in a substantial wooden box.

Home and Workshop Machinery, 144 Maidstone Road, Footscray, Sidcup, Kent DA14 5HS Tel. 020 8300 9070 Fax. 020 8309 6311

A new Super 7 lathe from Myford

Making its debut on the Myford stand at the Model Engineer Exhibition was the latest version of the Myford Super 7 - the Super 7 Plus.



Designed to overcome what was seen by some to be the major shortcoming of the old version, this one has a larger headstock assembly which houses a spindle featuring a through bore of 25mm clearance. This allows a No. 4 Morse taper socket to be incorporated, together with a larger nose thread and register. A No. 4MT to No. 2MT reducing sleeve is supplied to allow the use of many existing items of tooling.

While retaining the threaded chuck fitting, a security groove is machined in the register, into which chuck backplate safety clamp screws locate.

Adapter plates are being made available so that many of the items designed for earlier versions will be able to be fitted to the new lathe.

The larger spindle necessitates the use of redesigned back gear components, but a four-speed vee pulley final drive is retained, while the two-speed primary drive now features a poly-vee belt system. *Myford Limited, Wilmot Lane, Chilwell Road, Beeston, Nottingham NG9 1ER Tel. 0115 925 4222 Fax. 0115 943 1299*

Warco 3 axis digital read-out system



In addition to their wide range of lathe, milling machines and other equipment, Warren Machine Tools exhibited a low-cost, effective digital read-out package. This consists of rigid horizontal and vertical digital scales coupled to a 3 axis digital counter which features a magnetic mounting system. Installation of the latter is made easy because its magnetic backing simply attaches itself to any suitable flat area of iron or steel.

The scales are available in a variety of lengths from 100mm to 500mm and need only simple brackets, well within the capability of any model engineer, to mount them on the machine.

Warren Machine Tools (Guildford) Ltd., Warco House, Fisher Lane, Chiddingfold, Surrey, GU8 4TD Tel. 01428 682929 Fax. 01428 685870/685812

GETTING STARTED IN MODEL ENGINEERING

Part 3 concludes Loris Goring's tale of setting up a model engineering workshop and covers buying the basic tools for hand and lathe operations

A good way of achieving an apoplectic state is to visit a fellow engineer's workshop (and you will get invitations if you are wise enough to join a model engineering club) and realise you are going to see thousands of tools you have not got and cannot afford unless you win the lottery. Panic not. I rapidly found out that some engineers make tools to make tools. They never actually make anything for application outside the workshop. To placate a wife regarding the spending of much of the household wealth, I recommend making something that she who holds high office can appreciate.

You will be wise to start off with a bare minimum of tools and then experience the joy of adding to them when they are really needed. Many basic tools will already be in any practical man's workshop. A metal work vice (4in. jaws or thereabouts), hammers and drills and drill bits. If you have these, then concentrate in the first place on the tools you will need to set up the lathe.

My own weakness and strict policy is to buy the best I cannot afford. I detest cheap and inferior tools that become a pain to the user. They break and supposedly sharp ones do not hold their edge. While some may disagree with me, I believe that saving money on basic tools is a waste of time and quite often, money. When building up your collection of tools you will find advice from club members, professional engineers and of course, this magazine. I wrote off for catalogues (usually supplied free of charge) to Moore and Wright and Neill Tools of Sheffield. After a lifetime of using their tools in both motor and marine engineering, I know they are 'best quality' and many of them, after 40 years use, are as good as the day I bought them. You can get cheap foreign ones but they are often of inferior quality. You still get what you pay for!

For a beginner, buying second-hand tools can be false economy. You can find superb bargains, but you can find ones that have been badly used, badly sharpened and as useful as a headless hammer. Let's look at the basic tools for my new workshop. References are to Moore and Wright (M&W) or Neill Tools (NT)



1. A selection of good quality measuring and marking-out tools, without which no home workshop is complete

Measuring and Marking out Tools

Before you cut anything it will have to be measured and marked out. A couple of steel rules (M&W SEG-006E 6in. and ER-112 12in. graduated Imperial and metric) (Photo. 1). My old Myford was, of course, an Imperial one, so as far as practicable I will work in good old British Imperial, but do keep an open mind as regards using metric for some areas of your amateur engineering work.

We talked about failing eyesight earlier in the series, so a handy aid to using these rules is the M&W MAG-001 Mini Magnifier which has a magnetic base which just clips onto them. As ever in craft work, it is important to get your eye right over the mark area, so that you do not get parallax error.

Punches and Scribers

Punches - not the ones from the better half when you fail to emerge from the

workshop for dinner - but the ones used for marking the exact spot where drilling is to take place. A nice plastic case (Neill 351 W) contains four centre punches which will be used to indent workpieces prior to drilling. I chose two Neill scribers No E222 double ended (for marking out in confined spaces) and a Neill 225 pocket scriber with a tungsten carbide point. The double-ended one has a piece of de-wired plastic electrical cable to protect its very sharp point, while the reversible point of the latter tool prevents tearing and snagging of clothing when it is clipped in the pocket. However, the clothes I wear in the workshop are usually glue and paint reinforced, so that is not a bother.

Precision measuring

A question you must answer is how much precision you need for measuring your model engineering. If your work is to be simple then there is no need, in the first instance, for a micrometer, but if you decide to make precision scale



2. A digital vernier caliper is a versatile precision instrument which will suffice until more specialised equipment can be afforded

locomotives and internal combustion engines, then you will need these instruments. However, I was advised that a first purchase should be a 6in. Digital Caliper (M&W - EC5-015D - Swiss made) which features a clear display (Photo. 2). This device measures both internally and externally and both in mm and Imperial and is a beautiful tool that is very easy to read. Later I did a swap of a tool for a 1in. micrometer but, although it looks good, I will have to get it checked by a professional engineer who has micrometer setting gauges, and then learn to read it.

When work is in the lathe a Surface Gauge (M&W - E-107-9) stood on the bed can be used to mark out work in situ. Its

stand can also be used for holding a Dial Test Indicator (M&W - DIL-301 D). The E905WFMW 'Eclipse' magnetic base will also be used as a surface gauge as it is very handy to be able to place it on a lathe bed and know that, with the magnet turned on it is not easily going to be knocked off! I intend mounting a M&W DIL301 Imperial and Metric dial test gauge on it. Concentricity is an important part of lathe work. Eccentricity you will recognise in mel

Gauges

As a beginner, I experience a couple of problems which, luckily tool manufacturers like Moore And Wright are

able to solve. Firstly, I never know what size a drill is once the markings have worn off the shank, so their 1066M gauge will be a boon. Similarly I never know what kind of thread I am looking at - its always been a complete mystery to me how engineers can look at a thread and tell me precisely what it is. The M&W 804 screw pitch gauge should solve that problem. Threads are already the bane of my life for, although I have a nice set of metric drill bits in 1/16mm increments, I have yet to get some taps and dies. Will I have to get an Imperial set of drill bits for US and British threads to avoid confusion?

What on earth do I do for taps and dies? I was hoping that a set of ISO Metric would do, but there is a bewildering choice between 'Model Engineer', BA, BSF, Whitworth (which was supposed to be redundant in the 60's or was it 1970's?), as well as Brass and Cycle pitches, Fine Thread 60 tpi, to say nothing of UNC-UNF (SAE) and British Standard Pipe. As yet, I am a lost soul. As full sets are quite expensive, I intend to buy as I need them.

Finally I ordered a M&W 911 feeler gauge set for checking gaps between things.

Cutting Tools

Regarding files, it must have been said at least a thousand times over the years in these pages, but I still make no apologies for reminding readers that all files should be used in a proper handle, unless of course, you prefer the file tang to pierce the palm of your hand.

To save the bother of getting handles, I purposely chose four Spear and Jackson Polypropylene handled ones (Photo. 3). Their Square File (30-258R) for enlarging holes, Dual Cut (30-268R) for general flat filing, Half Round (30-328R) for general flat and curved work and their Round File (30-428R) for finishing or enlarging round holes.

There are thousands of kinds, cuts and size of file and the term 'Bastard' does not refer only to the ones that injure you. This table will help you to make your own decisions as to the type of cut you might need.

Type	Description of typical use
First Cut	Used with light pressure to produce smooth finish
Double Cut	Used with heavier pressure for fast removal of material where a rougher finish is acceptable

Four simple rules for filing any work are:-

1. Fix work securely to prevent chatter as you work on it
2. Maintain a steady rhythm, with constant pressure on the cutting stroke
3. Lift the file clear on the return stroke to save wear
4. File carefully with a new file and, after



3. Good saws and files are a good buy in the long run as they will out-last several sets of cheaper equipment

using it, brush it off and lightly oil it to prevent rust, which will dull any cutting edge.

A good hacksaw (Neill 70-TR) and some blades provide both a quick and cheap solution to the rapid removal of chunks of metal, but even hacksaw blades need to be understood. Neill, with a lifetime of experience behind them have developed better hacksaw blade cutting edges over the years.

Much of what I said about using files (1-3) applies to the use of hacksaw blades, which should be held in a proper frame and not simply between your fingers. Steady pressure on the forward cutting stroke and relief - just 'lighter' as it were on the return stroke will achieve maximum work with minimum wear.

For model engineering, it is sufficient to have spare blades of 32 teeth per inch to supplement the 24 tpi ones sold on the 633S. For thin section materials, the higher number of teeth must be used, while thicker ones will require the use of the 24 tpi blades. Both are well able to deal with all materials up to 1/4in. thick. The aim is to get as many teeth as possible in contact with the material being cut, so that it runs through smoothly without jamming.

The more flexible Eclipse Plus 30 high speed steel blades are ideal for an amateur, as they will not shatter as easily as rigid hard blades. For small work the Eclipse Junior Hacksaw, with metal cutting blades, is very inexpensive and works extremely well on small work or in a confined space.

Lathe tools

I found that Neill do a very neat pouch (E430) containing six of the necessary lathe tools (**Photo. 4**). Although a lathe cutting-off tool and holder (Neill 633S and cutter TJ123V) were ordered, judicious use of the hacksaw to cut the right length off the stock material first can save much time.

A lathe cutting tool must be precisely set on the centre line of the metal being turned - neither above nor below it.

Photo. 5 shows the strips of light alloy that I cut to place under the tools when clamping them into the tool post on the lathe, thus bringing them to the correct height.

Holding Tools

If you fail to hold thin pieces of metal securely while you saw or drill them they are likely to bite! A bit of thin plate swinging round on the end of a drill or a piece which slips when being sawn will often inflict a nasty cut. Unless metal is held firmly in the lathe chuck, on a face plate, on a drill stand or in a bench vice, there is serious danger of injury.

If I cannot clamp it, bolt or other wise hold it mechanically, then for light duty sawing and filing I wear a pair of tough leather gardening gloves (95p per pair). The thick leather will also prevent burns from hot swarf and splinters when you are cleaning down the lathe, as you should do after each use.

Woodworking 'G' clamps are pressed into service for holding plate work on a bench and toolmakers clamps like the one



4. A set of lathe tools will provide a good basis on which to build a comprehensive range as experience is accumulated

shown (Neill 411 - 3in.) are also essential.

Holding work on the lathe, I found, is an art in itself. I would recommend the Nexus publication "Work Holding in the Lathe" by Tubal Cain (£6.95) which is dedicated to recommending a thousand ways to hold workpieces on that machine tool. I consider it to be a vital publication for the beginner, to be studied before you go out and buy lathe carriers and face plate clamps.

The other items which have to be gripped securely during lathework are drills and other tailstock mounted tools. I already had a Jacobs chuck with a No. 1 Morse taper on it. However, there are

conversion sleeves that allow smaller shanks to be used in larger sockets, so as Myford lathes accept No. 2 MT in both head- and tailstock, I got a No. 1 to No. 2 MT sleeve.

Having visited other model engineer's workshops I have no doubt that I will have a lot more tools to buy, but for now, on with that candlestick!



Useful contacts

Neill Tools (Eclipse)	Tel 0114 281 4242
Moore and Wright	Tel 0114 225 0400



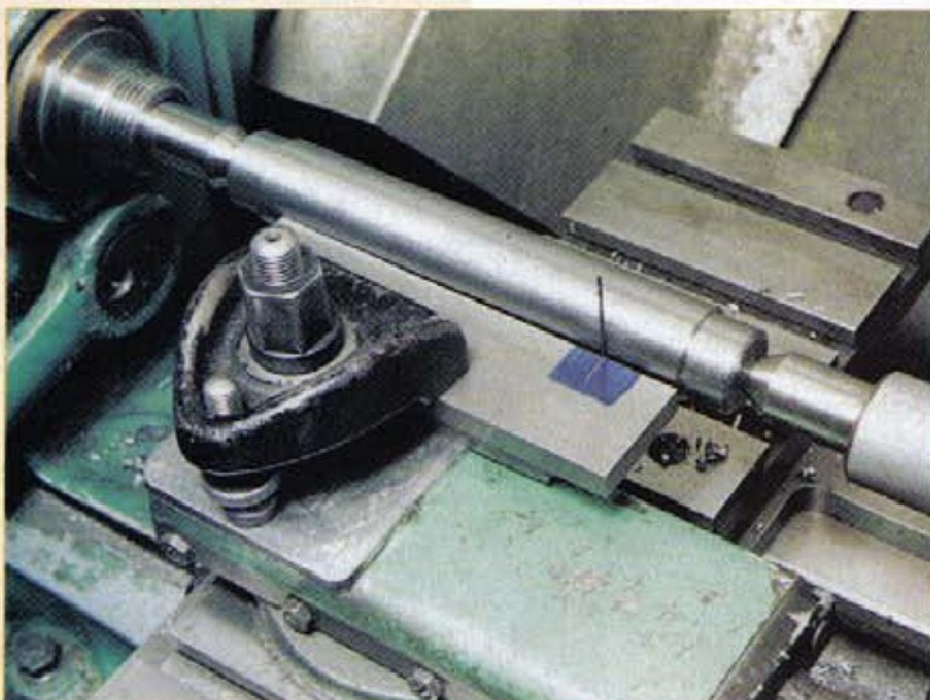
5. A sharp lathe tool set accurately to centre height makes turning a pleasure. Keeping a range of packing of a variety of thicknesses to hand aids the setting process

Lathe projects for beginners (6)

Precision Turning - Diameters



1. When using a tool with a very fine edge and a very shallow cut (in the order of 0.0005mm) grinding dust-like swarf is produced. The tool is in need of demagnetising



2. Setting the top slide to an angle of 1 in 100 enables fine cuts to be taken. Typically, a feed of 0.02mm on the top slide advances the tool radially towards the workpiece by 0.0002mm

Having covered basic lathe operations, Harold Hall now discusses techniques used to bring a component to size on diameter while achieving the required surface finish

We have so far concentrated on straightforward facing and outside diameter turning, where diameter and length have been relatively unimportant though, for experience, it has been suggested an attempt should be made to be very close to the dimensions given. In this part of the series the project aims for diameters and length (issue 73) to be virtually error free, at least within the capabilities of the measuring equipment to be used.

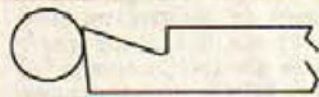
To provide the need for producing very accurate outside diameters, the article deals with hole gauges and, whilst it is a quick and simple project, it needs precision as great as any likely to be needed in the average home workshop.

Precision, the problems

Above all there are two situations that affect our ability to produce parts to a very precise diameter - being able to feed the tool into the work by very small and precise increments and the sharpness of the tool used. Whilst the lathe itself will play a part, even old and worn machines can produce accurate work, especially for smaller items. There is though one aspect of the machine's condition that is important, that is the adjustment of its bearings and sliding surfaces. These must be adjusted to be free of any play, as this would permit the tool to take up differing positions relative to the workpiece from cut to cut.

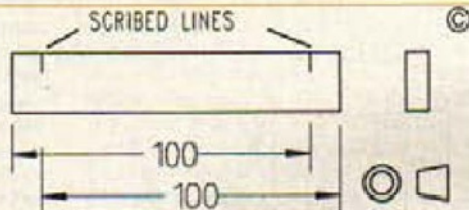
Tool

As we are endeavouring to make parts that have errors in diameter of no more than -0.0025mm to +0.0000mm, (better if possible), we will be taking some very shallow cuts to achieve the final dimension, typically, to reduce the diameter by 0.0025mm, so the cut will



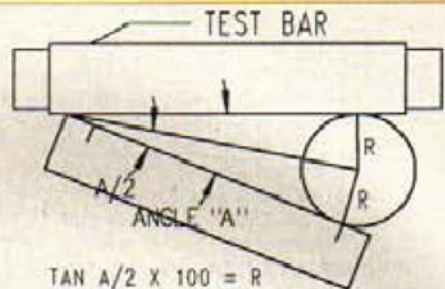
A TOOL SET TOO HIGH CANNOT TAKE A FINE CUT. EFFECT SHOWN MUCH EXAGGERATED. ©

SK1. Tool height setting



OTHER DIMENSIONS TO SUIT MATERIAL AVAILABLE SUGGESTED LENGTH 110mm

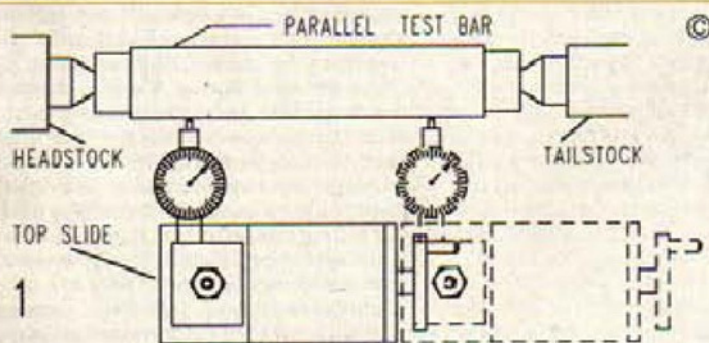
SK2. Setting Plate



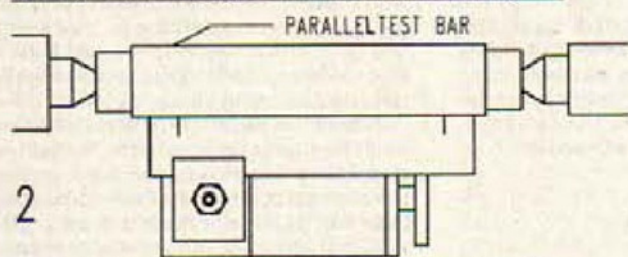
$$\tan A/2 \times 100 = R$$

$$\text{DIAMETER} = 200 \times \tan A/2$$

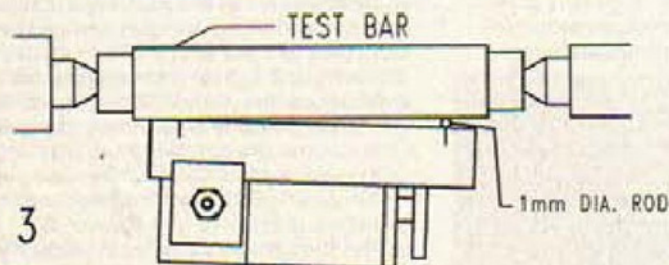
SK4 Calculation of diameter for angle "A"



SET TOP SLIDE PARALLEL WITH THE LATHE'S AXIS



FIT SETTING PLATE TO TOP SLIDE AND AGAINST TEST BAR



SWING TOP SLIDE, USING 1mm ROD AT 100mm MARK TO SET ANGLE

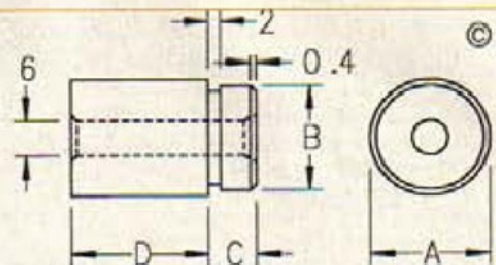
SK3 Setting top slide to an angle of 1 in 100

have to be set to 0.00125mm. The essential requirement for taking extremely light cuts is the appropriate type and state of the tool used. I think it is obvious that for a very shallow cut to be taken, the tool must be honed to have a very fine cutting edge. There will be no point in attempting a cut of 0.0012mm deep if the tool has a radius on its cutting edge of 0.005mm, as the tool will just rub, though it would happily take a cut of say 0.05mm. The tool I use is a round-nose tool ground from high speed steel, a material which I use as I am never able to get the cutting edge I

am looking for with tungsten carbide, though that may just be me.

An inexperienced lathe user could be forgiven for considering that a new tip for a replaceable tipped tool would be the answer. Some are though deliberately supplied with a minute radius on their cutting edges to give them strength for heavy duty production work. Finely honed tips are available, but these are rarely specified for home workshop use.

The tool I use is the finishing tool I first



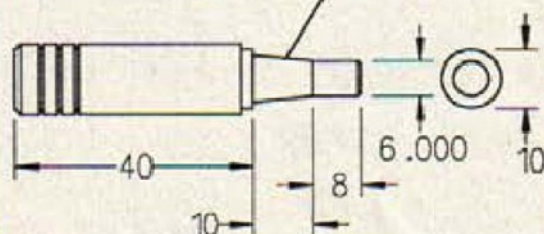
MAKE DIM "B" SMALLER THAN "A" BY PREFERRED AMOUNT, 0.2mm SUGGESTED

A	C	D
7.000	5	10
8.000	5	11
10.000	6	13
12.000	6	15
14.000	7	17
15.000	7	18
16.000	8	19
20.000	8	23

MATERIAL 230M07 STEEL, DIAMETER TO SUIT

Metric Hole Gauges

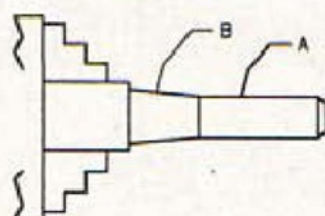
THIS SECTION SHOULD TAPER FROM 6.000 WITH AN INTERNAL ANGLE OF ABOUT 1 DEGREE. THIS WILL THOUGH DEPEND ON THE ACCURACY OF THE HOLES IN THE GAUGES WHICH SHOULD PREFERABLY BE REAMED.



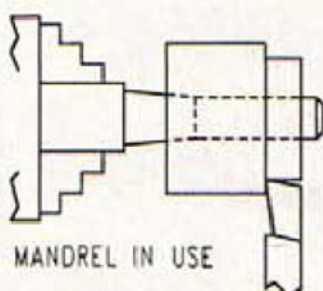
MATERIAL 10mm DIAMETER 230M07 STEEL

Handle

described in Issue 68, (Sk. 2, page 41). The essential factor is that the tool must have a very fine edge, but even with it sharpened and ready for use, its use should be limited to just the last few finishing cuts as such a fine edge can soon be lost. Because of this, all preparation work should be done with a conventional knife tool. It is worth noting that even though the finishing tool is fed right to left,



PREPARED MANDREL



MANDREL IN USE

NOTES

A. THIS SHOULD BE A VERY CLOSE SLIDING FIT IN, AND AS LONG, OR ALMOST AS LONG, AS THE LONGEST PART TO BE MACHINED.
B. THIS TAPER SHOULD HAVE AN INTERNAL ANGLE OF BETWEEN 1 AND 2 DEGREES.

WHERE MULTIPLE PARTS ARE TO BE HELD THEY MUST ALL HAVE THE SAME INTERNAL DIAMETER. HOLE, A REAMED HOLE IS PREFERRED.

PRECISE CONCENTRICITY CAN ONLY BE ACHIEVED IF THE MANDREL IS TURNED AND USED WITHOUT REMOVING FROM THE CHUCK.

THE MANDREL CAN BE REUSED WHERE CONCENTRICITY IS LESS IMPORTANT.

SK5 Making and using a taper stub mandrel

the rake on this tool is front to back and can, as a result, only take very limited depth cuts. It can, of course, also be fed left to right.

Another important requirement is that the tool must not be above centre height as, in this situation, the workpiece will just rub on the front face of the tool which will fail to cut. The reason should be obvious, but **Sk. 1** will help to make it abundantly clear. The outcome of having the tool only just too high is that the cut can be intermittent, the conditions changing from satisfactory to unsatisfactory as the tool traverses. Especially, this may develop

when machining small diameter items that are able to flex as a result of the cutting pressure. Because of this it is best to set the tool a very little below centre to be sure, say 0.05mm. A similar intermittent cut can result if the tool is in need of sharpening.

In-feed method

Having a tool that will take such a shallow cut serves little purpose if it cannot be advanced with certainty in equally small increments. This is impossible to do reliably by the use of the cross-slide and

its micrometer dials and some other means has to be used. The easy way of achieving this is to set the top slide at a small angle, such that a relatively large axial (*) movement of the top slide results in a much smaller radial (**) movement towards the workpiece. For a large magnification, an angle of 0.6deg. will apply a cut of 0.001mm for a movement of the top slide of 0.1mm, a factor of 100 times. As a metric dial is likely to be calibrated in increments 0.02, or 0.025mm, adjustments of 0.0002mm will be possible. In the case of an Imperial calibrated lathe, 0.001in. on the top slide will equate to an in-feed of 0.00001in. (one hundredth of a thou.). For a lower magnification, an angle of 6 deg. will give a factor of 10. If you are sceptical regarding the ability to take such fine cuts, I have included **Photo. 1** which shows fine fragments, more like grinding dust, adhering to the end of the tool that is in need of demagnetising.

If your top slide rotation is calibrated, this should be adequate for setting 6 deg., but setting the angle to 0.6 deg. by this method is impracticable. This is where our between-centres test bar (Issue 71), comes into play. Set this up between centres and, with a dial test indicator mounted on the top slide, adjust this until it runs parallel with the test bar. This is also the way to set the top slide accurately for normal turning and is much quicker than the trial and error method of turn, measure and adjust, turn, measure and adjust.

Now cut a piece of flat steel 110mm long, size not that important but would suggest 40 x 5mm, and scribe lines on the top surface 100mm from each end (**see Sk. 2**). Mount this on the top slide with its long edge against the test bar and clamp it in position using the tool mounting clamp. With this done, the top slide can be loosened and rotated such that one end of the bar is touching the test piece and the shank of a 1mm diameter drill is held between the flat bar and the test bar at the 100mm mark. This can easily be done by winding the cross-slide in until the drill becomes just captive, when the slide can be clamped in this position. **Sk. 3** illustrates the complete procedure and **Photo. 2** shows the top slide being set using the shank of a 1mm diameter drill. The procedure is not limited to setting the top slide to 0.6 deg. but could be used for any precise angle providing the diameter of the spacer is worked out accurately (**Sk. 4**).

Hole gauges

Photo. 3 shows the completed gauges which have diameters of 7, 8, 10, 12, 14, 15, 16 and 20mm. Front left is the handle on which they are mounted whilst being used, and on the right the mandrel on which they are turned. The gauges have a short reduced diameter portion, 0.2mm below gauge size, to give indication that the hole being made approaches the required size, with the front end also having a small chamfer for earlier indication. The chamfer is dimensioned at 0.4mm which, with the reduced diameter at this point, makes its leading diameter 1mm less than gauge diameter. The shallow groove between the two



3. The finished hole gauges which need to be made to very precise diameters

diameters ensures that the main diameter of the gauge has a clearly visible leading edge.

For economy of material and effort, the gauges are made to fit to a common handle, the fit achieved by the portion that goes into the gauge being very slightly tapered and a close fit in the hole. For this reason it is essential that the holes are all of the same diameter. A reamed hole would be ideal, but holes all drilled with the same drill should suffice.

Taper Stub Mandrel

Very similar to the handle, but rather more critical is the 'taper stub mandrel' on the right of the photograph. Various forms of work holding mandrel are used in lathe work, too many to discuss here, but the taper stub mandrel is probably the most useful and the most simple. Its essential features are (a) a parallel portion that is a close sliding fit in the hole of the part it is to hold and (b) a taper from this parallel portion to a slightly larger diameter. The part is pushed on to this taper, making it a tight fit and giving it the drive necessary for the required machining to take place. A suggested internal angle for the taper is 1 deg., though the angle is not that critical, but it should be noted that if it is made too shallow it may not cope with small variations in hole diameters when more than one part is to be held.

The main benefit of this mandrel is that if the part to be machined is fixed onto it as soon as it has been made (without it having been removed from the chuck), then any machining carried out on the workpiece will be precisely concentric with the bore. Similarly, work on the end face will also be true to the bore. Whilst removing and replacing the mandrel in a 4-jaw chuck will enable it to be returned with reasonable accuracy, it will never have the degree of precision of a mandrel turned and used at one setting. Where concentricity is important, a taper stub mandrel is frequently the only practical method to achieve the required result. In this case, concentricity is of no importance so the mandrel can be removed and returned.

Making the gauges

Like most machine shop operations, there are many ways of achieving the same result, and in this case it may appear a good approach to drill a hole in a piece of material, part it off and then doing all the remaining work whilst mounted on the mandrel. An accurately made mandrel is capable of providing a fair level of drive, making quite heavy machining operations possible. However, the requirement to make the groove in the outer diameter is likely to prove too much, especially as the mandrel is only 6mm diameter.

Place a length of material in the chuck and face the end, centre drill to a little over 6mm and drill and ream (or drill only) 6mm diameter to a depth of a millimetre or two longer than the gauge being made. If using a reamer, its taper lead will prevent the hole being reamed to its full depth, so it will therefore need to be finish reamed after parting off. Use the parting off tool to make the groove and follow this by parting

off to the required length. If the part is being made from bar that is appreciably larger than the gauge being made, then the outer diameter can also be reduced prior to parting off. Reverse the part in the chuck and face the end to give the finished length. Use the centre drill to make a small chamfer on the hole. The elimination of the sharp edge on the hole will assist in fitting the part to the stub mandrel. Make all the required gauge sizes to this stage before moving to the next operation.

Making the Mandrel

As the accuracy of the angle for this is not that critical, there is no need to go through the detailed process for setting the 100 : 1 ratio for accurate turning. Somewhere between 0.5 and 1.0 deg. (1 to 2 deg. internal) should suffice. If you are not too sure of your top slide's calibration then turn and measure the result before you arrive at the 6mm diameter to fit the gauges. An increase on diameter of around 0.2mm over a length of 10mm should be adequate.

Place a piece of steel in the chuck, say 8mm diameter, with some 35mm projecting. Having set the top slide angle, turn a short portion of taper, diameter of no importance, and measure to check that the taper falls within the above limits. Having done that, turn diameter 'A' say 25mm long (see Sk. 5) to a little over 6mm, then carry out preliminary work on the taper. Using the angle of the top slide to reduce the diameter, but winding it back, will enable small changes to be easily made until a very close sliding fit in the holes in the gauges is achieved. Of course, use the saddle for traversing the cutter. On the final cut, having achieved the fit and length required for 'A', continue by traversing the top slide to finish the taper 'B'.

With the mandrel having been made, it will be necessary to remove it in order to adjust the top slide to 0.6 deg., setting the angle such that the top slide is advanced to reduce the diameter, as seen in Photo. 2. Now return the mandrel and fit the largest gauge to it, using a twisting action as it is fitted to obtain sufficient grip. Machine the outer diameters to about 0.3mm above gauge diameter, doing this with a right-hand knife tool. Replace this with a finishing tool and, using the angled top slide to set the depth of cut, traverse the tool using the saddle, making repeated cuts until the required diameter is achieved. I suggest that you should aim at size $+0.0 - 0.0025$ mm, preferably better. The accuracy achieved will, of course, depend on the quality of the measuring equipment available, so do check that the micrometer zeroes correctly before taking any measurements.

With the outer diameter finished do not move the top slide, but feed the cross-slide by 0.1mm and finish the smaller diameter. This is less critical than the major diameter, so using the cross-slide will be sufficiently accurate. Providing free cutting steel is used, the finely honed tool should hold its edge long enough to machine the complete set of gauges. If in doubt however, do remove the tool and re-establish the edge before completing the batch.

As you are machining diameters from

7mm to 20mm, a ratio of almost 3:1, do take note that machine speeds should be varied accordingly. I will not quote any speeds as, by now, you should be getting to grips with the requirement, I will though comment that at these light finishing cuts, a slightly higher speed than for heavier cuts at the same diameter should be tried.

Finally, set up a chamfer tool and wind it into the outer edge of the smaller diameter until it just touches, note the cross-slide dial setting and continue feeding the tool in for an amount equal to 0.4mm. This ensures that the smaller diameter of the chamfer is 1.0mm smaller than the main diameter and can therefore be used as an early indication of the hole size.

The handle

The handle is made in the same manner as the stub mandrel, the 6mm diameter being made shorter so that it does not extend beyond the end of the shortest gauge. This will be advantageous if a gauge is ever used to check a blind hole.

Although you may have no immediate need for the gauges described above, I would suggest that you should have a go at making them as some of the sizes will be required when making a number of the projects to be described later in the series.

As I feel space will be available to included it I have also provided **Photo. 4** which shows dust-like swarf which fell onto a piece of card whilst finish cutting the outside diameter of a hole gauge. The larger specks seen on the photograph are made up of multiple fragments which illustrates that removing very small amounts is perfectly possible on a lathe.

Precision in length

In the next issue precision will again be the subject, but this time relating to length rather than diameter.

* Terminology

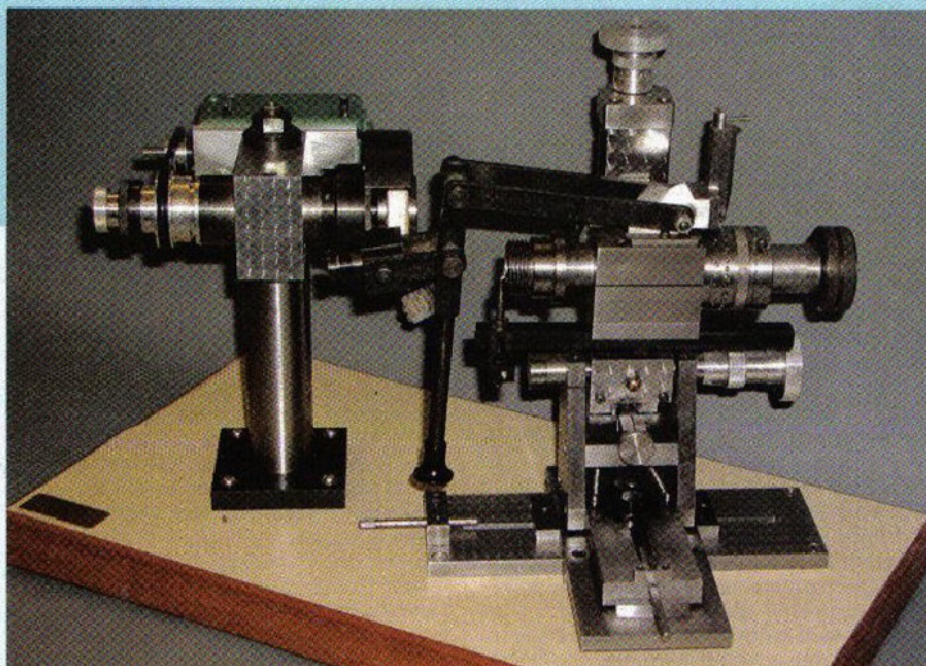
Axial. In line with the axis of a part or machine.

Radial. Items, or movement, radiating from the axis of a part of machine, typically the spokes of a wheel.



4. These dust-like particles were produced whilst reducing an outer diameter by a very small amount. The larger specks are multiple fragments.

THE 70th MODEL ENGINEER EXHIBITION



1. Winner of the major award in Class A5 - Tools and Workshop Appliances was Ray McMahon of Carrickfergus, Northern Ireland, who gained a Silver Medal for his 'Raymac' tool and cutter grinder. He was also presented with the Bowyer-Lowe Challenge Cup in acknowledgement of the ingenuity of its design (Photo. by Mike Chrisp)

Awards in Class A5 - Tools and Workshop Appliances

Silver Medal and The Bowyer-Lowe Challenge Cup

Raymond McMahon of Carrickfergus for his 'Raymac' Tool and Cutter Grinder

Bronze Medal

Victor Cole of Worcester Park for his Clockmaker's Wheel Cutting Engine

A Highly Commended Certificate

Peter Clark of Southwold for his group of Screw Finishing Tools

A Commended Certificate

Peter Clark of Southwold for his group of Accessories for the Clisby Lathe

Some of the awards in Class A2 - General Engineering

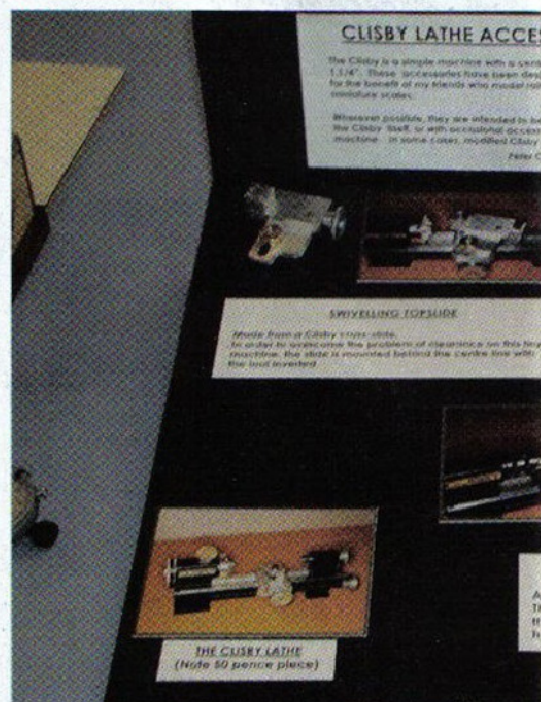
Silver Medals

Barry Jordan of Derby for his 1/5th. scale Dean, Smith and Grace Heavy Duty Gap Bed Lathe

Barry Jordan of Derby for his 1/14th. scale Bridgeport BRJ Milling Machine

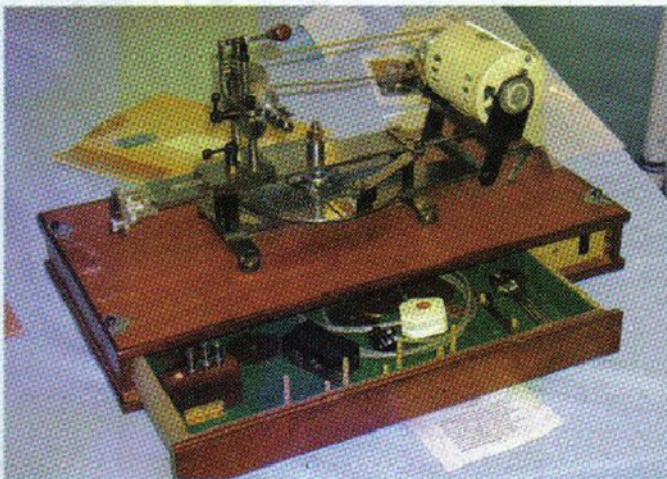
Bob Mellows of Romford for his 1/6th. scale Holbrook Model 'C' Lathe

Some results from the event held at Sandown Park over New Year, together with a selection of photos of workshop related items

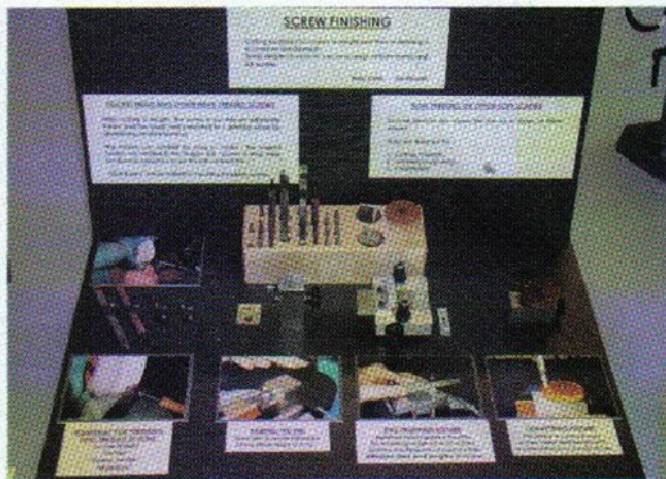


4. Peter's second group, of accessories for the small Certificate (Photo. by Mike Chrisp)

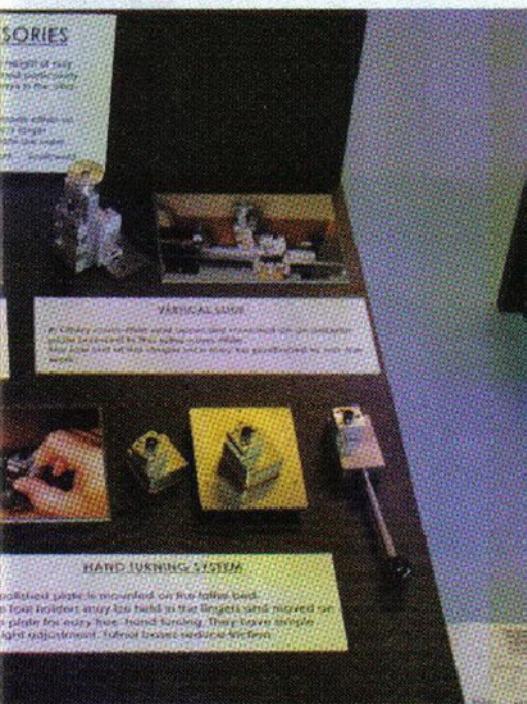




2. The clockmaker's wheel cutting engine by Victor Cole was built to a modified version of a published design, and won a Bronze Medal (Photo. by Mike Chrisp)



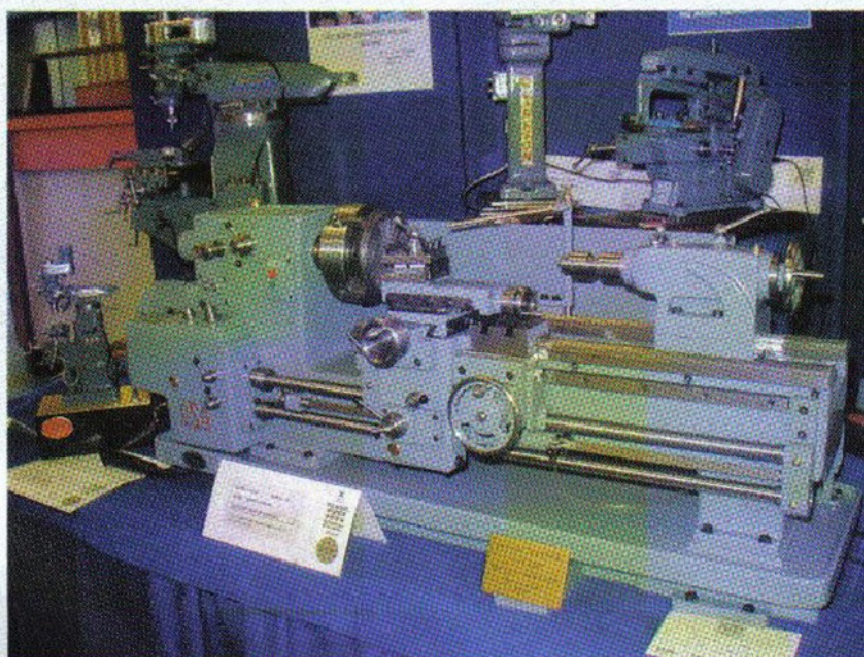
3. Peter Clark's two entries were as well presented as ever. His group of screw finishing tools was Highly Commended (Photo. by Mike Chrisp)



Clisby lathe was awarded a Commended

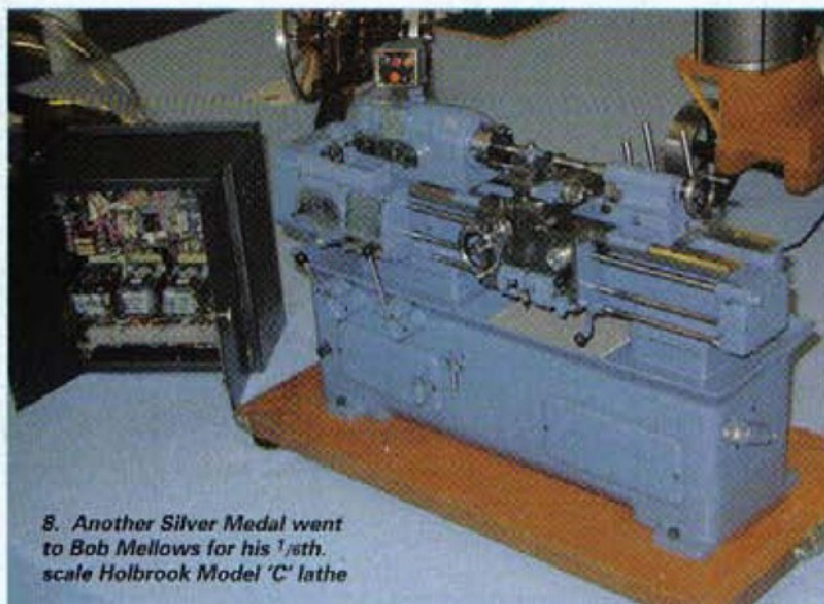


5. Barry Jordan's group of miniature machine tools makes an attractive display

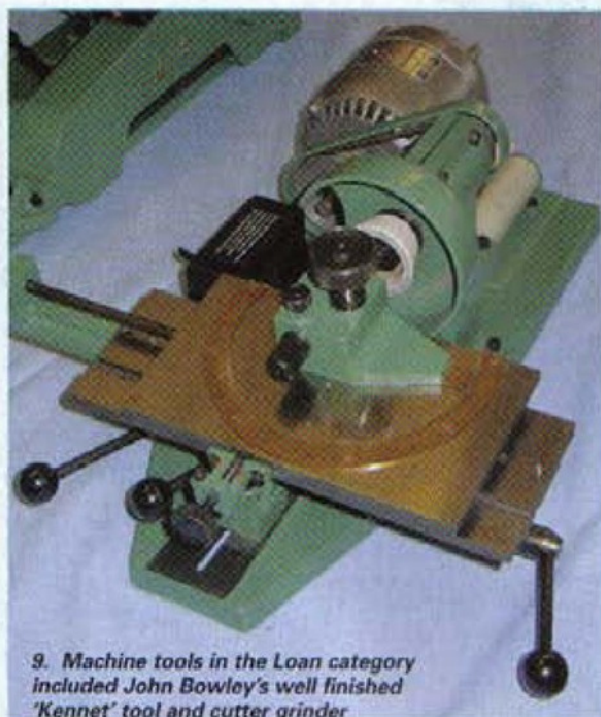


7. Although it is capable of serious work, Barry's 1/5th. scale Dean, Smith and Grace heavy duty gap bed lathe is classed as a model, rather than a machine tool. Entered, therefore in Class A2 - General Engineering, it won a Silver Medal

6. Barry gained a second Silver Medal for his smaller (1/14th. scale) version of the Bridgeport BRJ milling machine



8. Another Silver Medal went to Bob Mellows for his 1/8th. scale Holbrook Model 'C' lathe



9. Machine tools in the Loan category included John Bowley's well finished 'Kennet' tool and cutter grinder



10. An impressive version of the 'M.E.S.' abrasive belt machine was also on loan from John Bowley (Photo. by Mike Chrisp)



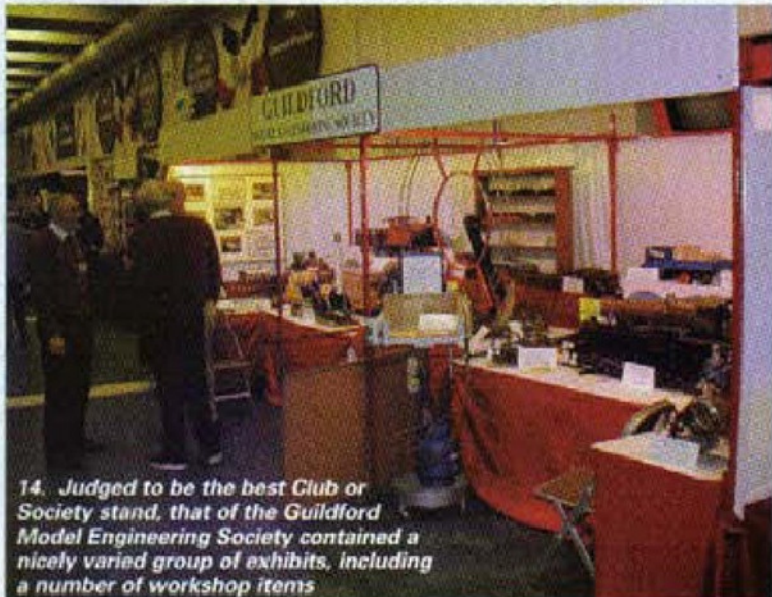
11. Much interest was generated by the complete set of items being described by Harold Hall in his current series 'Lathe Projects for Beginners' (Photo. by Mike Chrisp)



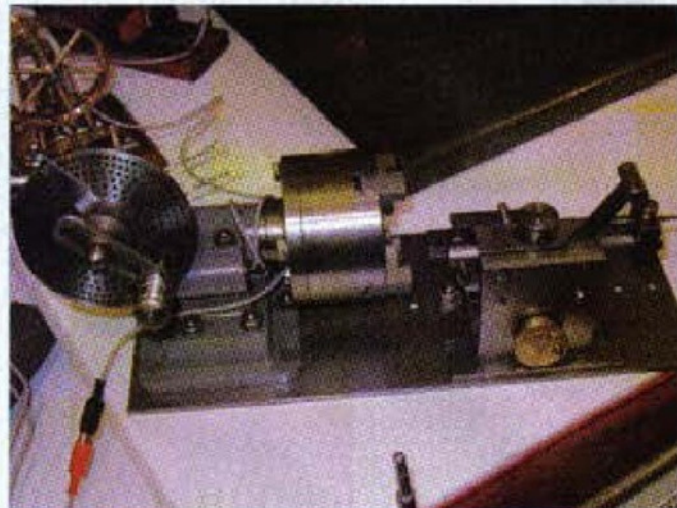
12. Regular supporter of the Loan section, Len Walker sent a group of smaller items as well as the latest modification standard of his small milling machine and his drilling machine with the simple but effective table location device (Photo. by Mike Chrisp)



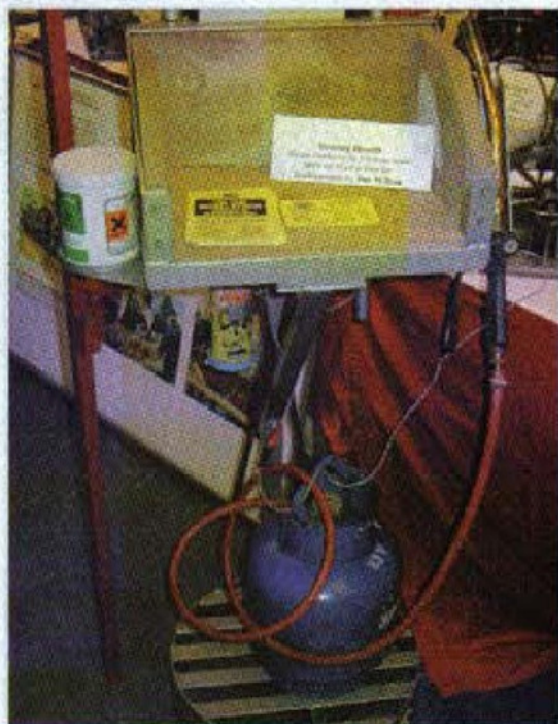
13. A general view of the stand containing some of the tooling items



14. Judged to be the best Club or Society stand, that of the Guildford Model Engineering Society contained a nicely varied group of exhibits, including a number of workshop items



15. This version of the Thomas Versatile Dividing Head, shown with a slotting attachment was by Guildford member Doug Peddie



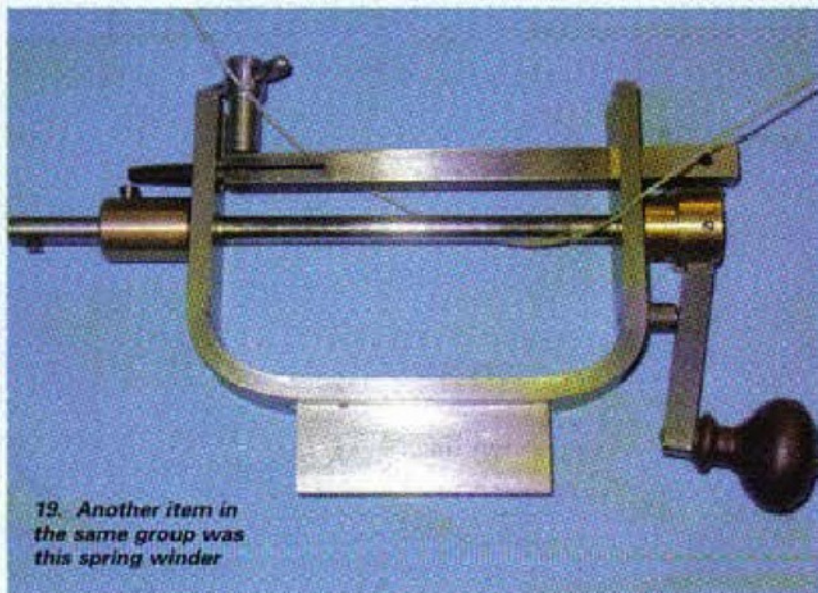
16. Guildford's Jim Wilson constructed this compact brazing hearth



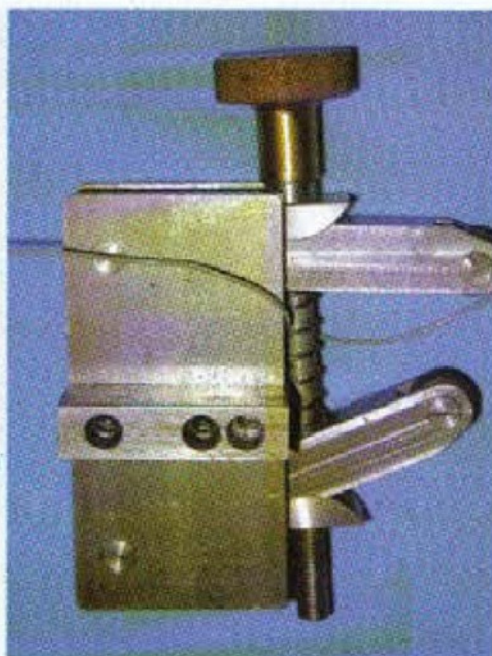
17. The Harrow and Wembley stand contained a nice group of small tools, including a lathe steady



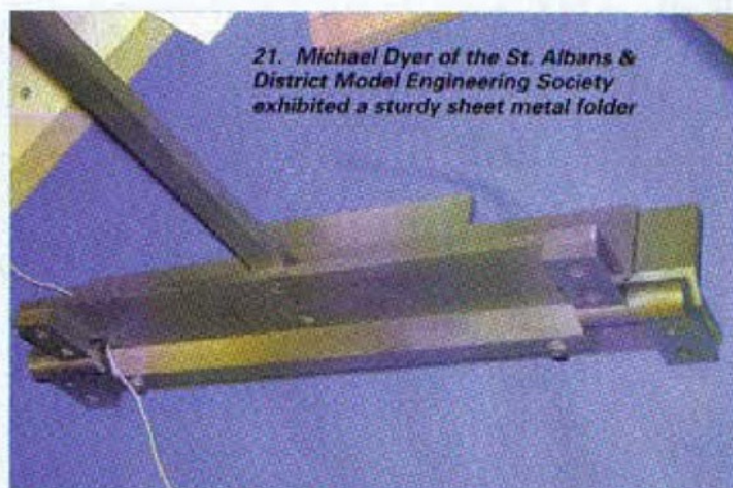
18. This group also featured some clockmaker's tools, among which was this preacher punch. The origin of the name caused some debate.



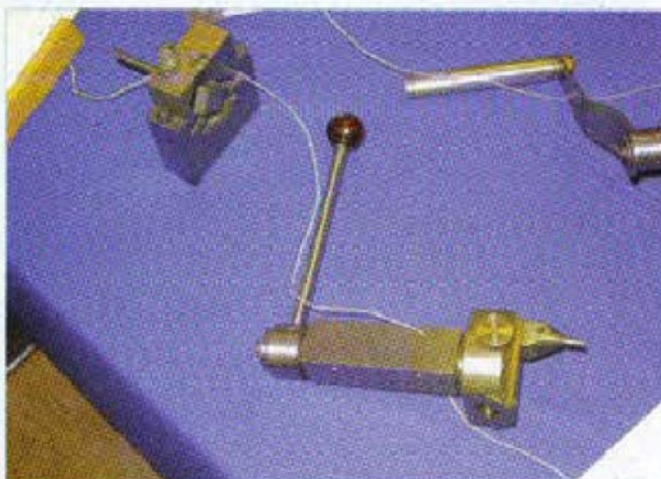
19. Another item in the same group was this spring winder



20. A caliper type knurling tool, similar to the one described in this issue, was also seen in the Harrow and Wembley display



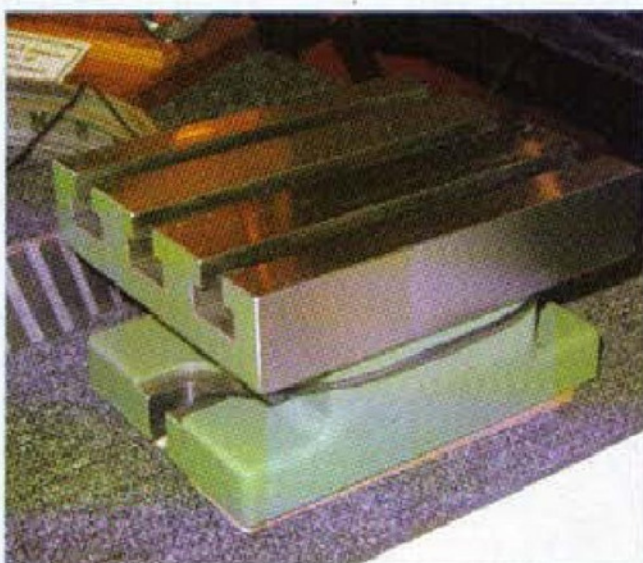
21. Michael Dyer of the St. Albans & District Model Engineering Society exhibited a sturdy sheet metal folder



22. A ball-turning tool and a cross-drilling jig were also by Michael Dyer



23. Another version of the Versatile Dividing Head was also to be seen on the St. Albans stand. This interesting variant, mounted on a swivel base was by John Caldwell



24. The stand of the Ickenham & District Society of Model Engineers was, for the second year running, Highly Commended, the judges being of the opinion that they had made excellent use of the space available. This slotted auxiliary table was one of the exhibits, having been made as one of a pair



25. Norman Phelps (at left) and his team of stewards did their usual superb job. Here they are gathered at the end of the magnificent display of clocks, just a few minutes before opening time on the final day

HOME-MADE CUTTERS

Many home workshop projects require the use of cutters which may not be available commercially. Bob Loader shows that making many of them need not be a daunting task

Quite often, when machining a component, a shape is needed which is not easy to cut with normal tools or with those which may be available. I found this out a long time ago, when I wanted to cut a 90 deg. included vee for a 0.003in. wire to sit in. The cutter in the stores was a non-starter; where there should have been a point there was quite a radius. The solution was to make a fly cutter with a nice sharp profile. I have made many more since, using high speed steel tool bits, standard punches, broken end mills and slot drills, silver steel, gauge plate and old files. I usually have one or two old files which have been softened ready for cutting suitable lumps off.

There are many different cutters which are not that difficult to make.

D-bits

These are an old favourite, available in many catalogues, but more fun and



1. A selection of D bits

relatively simple to make, being very effective, especially as reamers. They give superb finish and accuracy, especially useful when you have lost or broken the size you need, or when you have to machine a flat bottom in a drilled hole.

Fig. 1 gives typical dimensions and Photo. 1 shows a selection which I have used from time to time. Making one couldn't be much simpler - an

accurate and smoothly finished diameter is cut half away to make a cutting edge. It doesn't matter if it is a bit smaller than half, it will still have a cutting edge and the D shape acts as a guide. In fact, the geometry of the cross-section takes care of all but the grossest errors. I once did some experiments which proved that a D-bit would still cut accurately at quite a bit undersize, or a touch over, so I always aim to make them as close as possible to half diameter.

The lead shown in Fig. 1 does the same as the taper on a hand reamer, but if the cutter is to be used to make a square bottom, it can be left parallel.

Special D-bits

Photo. 2 shows some non-standard D-bits made for special jobs. The two plain radiussed ones were made by grinding the end shapes on $\frac{5}{16}$ in. high speed steel tool bits. When the shape was correct and smoothly finished, half of the cutting end was ground away and stoned to a fine finish. It is always good to remember the old engineering wisdom, "the finer the finish on the tool, the finer the finish will be on the job".

Making D-bits from the larger tool bits takes a lot of time and needs a free-cutting wheel. The other two were made from silver steel, hardened and tempered on the cutting part only.

Hardening

The temperature to aim for is bright red - easy to say, but bright could mean different things to different people, so a useful alternative is to wait for paler patches to appear on the surface (see Photo. 3), at the bottom left-hand corner

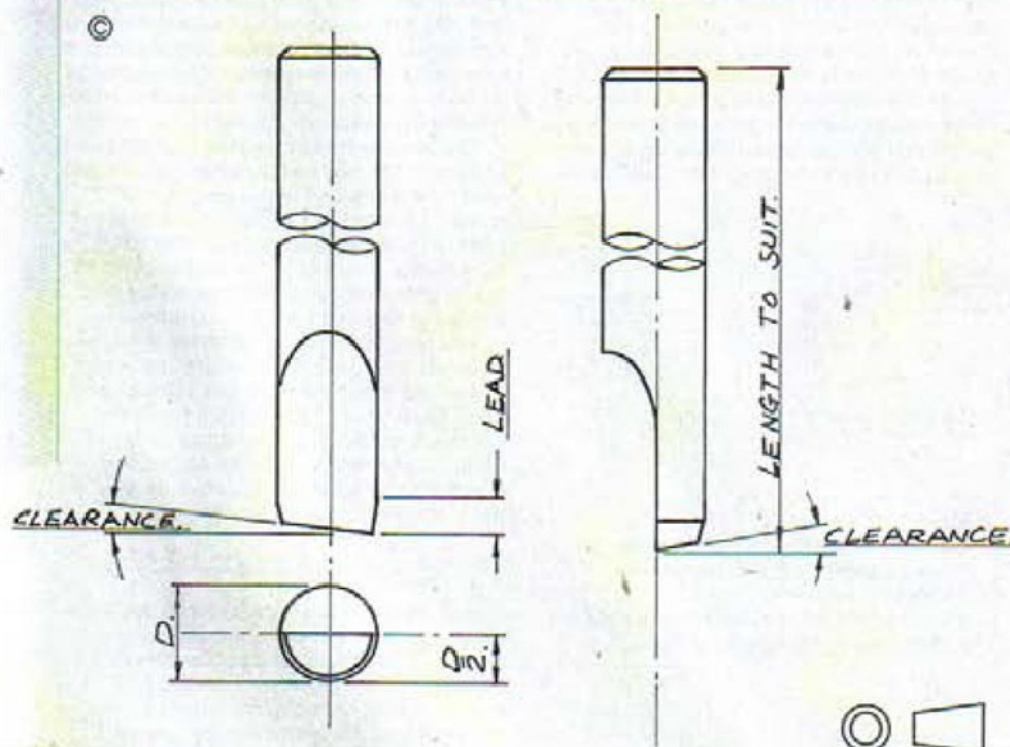
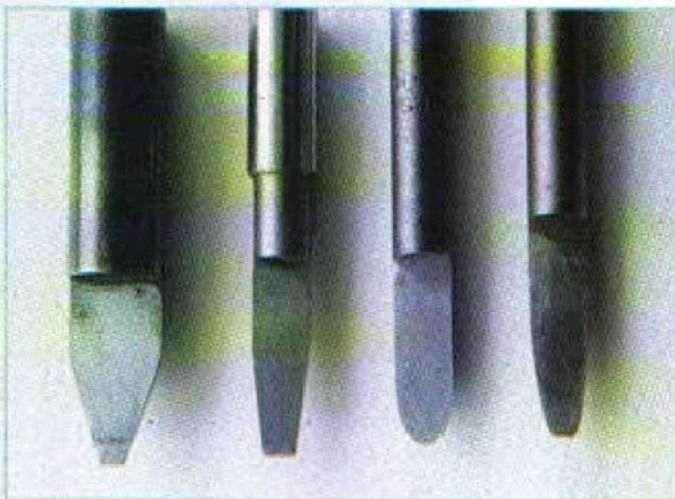


Fig. 1 - D Bit - silver steel



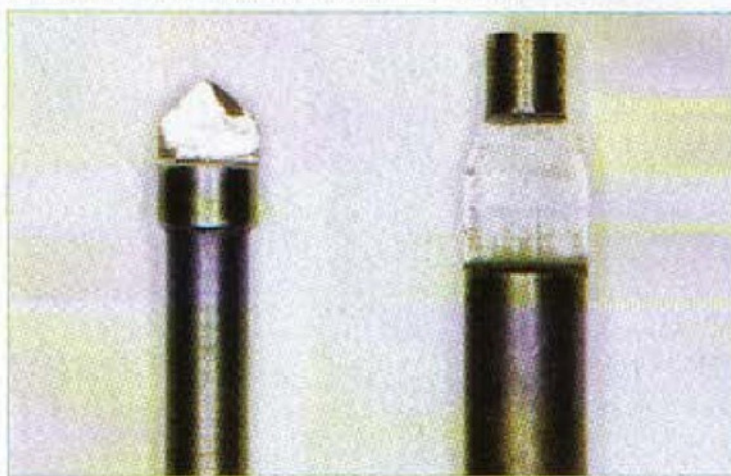
2. Some special D bits



3. The hardening temperature. Note the pale patch at the bottom left-hand corner. (Photograph by Pauline Loader).



4. Non-standard D bits for special shapes



5. A couple of D bit countersinks

of the workpiece. The patches will turn to blisters and when they do, it is time to quench in cold water. I don't use an oil quench for small work. After hardening the cutting surface can be polished and tempered to a straw colour.

Photo. 4 shows two of the jobs for which the non-standard D-bits were used, a venturi shape for a model engine intake and half of a moulding tool for making fishing weights.

Another two specials worth mentioning are those in **Photo. 5**. The smaller one is a countersink machined to 90 deg. included, not ideal for some jobs or materials, because it can chatter and vibrate a bit. The larger one avoids this by having a spigot to fit the hole being countersunk. It acts as a steady and gives a much better finish. As the angle is 60 deg. instead of the normal 90 deg. it must have been a special, but I cannot remember what for.

Counterbores

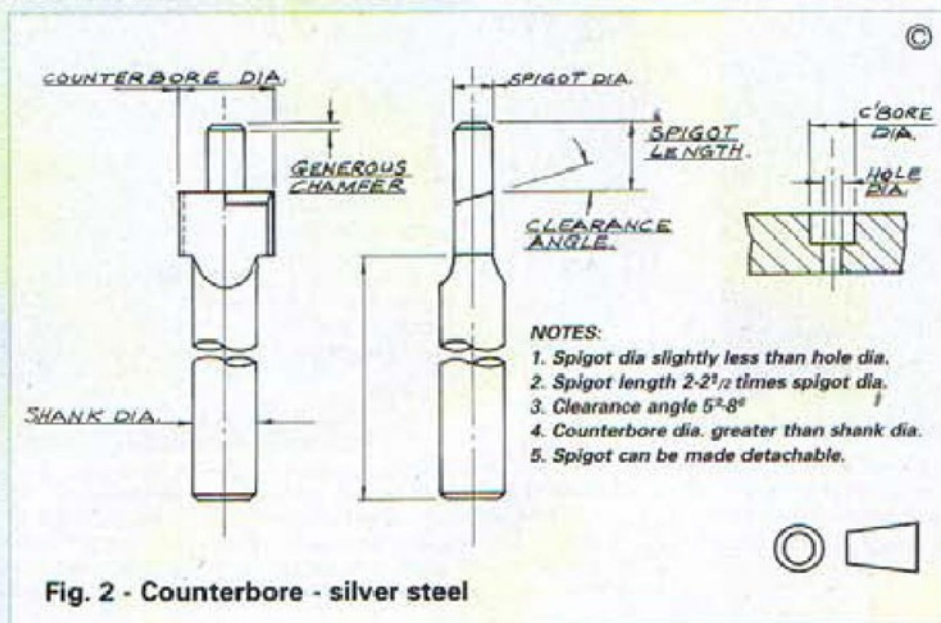
Fig. 2 shows a typical counterbore and **Photo. 6** a selection. Three of them are part of a set I made when I was an apprentice and the other two were quick jobs, roughly made in about 15 minutes, when time was short and the cutters needed urgently.

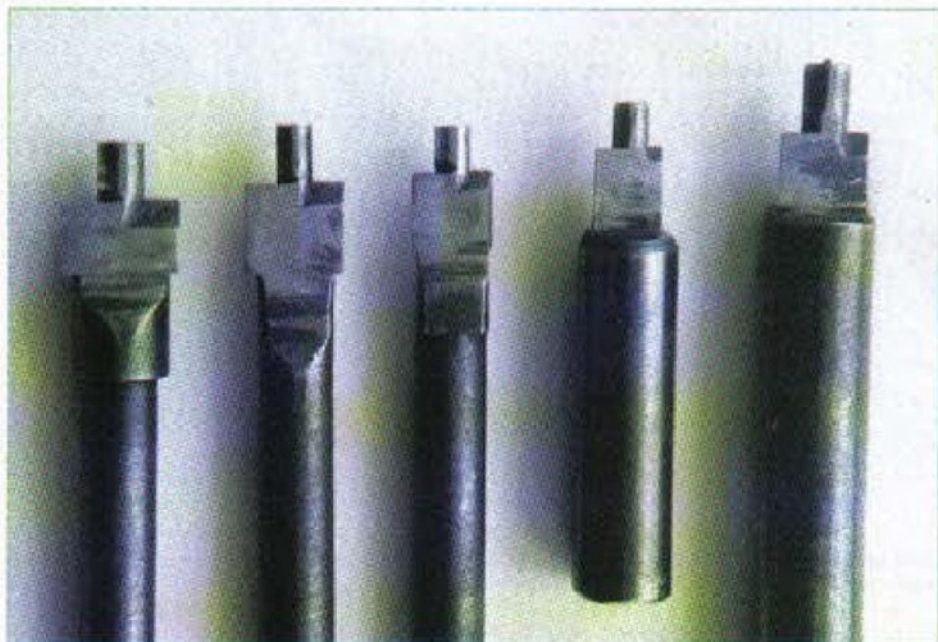
The spigots do not have to be made solid with the rest of the cutter and can be made detachable, it being possible to make a counterbore for several different sizes of hole by making a set of spigots. All it needs is a hole in the tool body to fit the spigots and a locking hole drilled and tapped in the shank to take a grub screw.

The two small ones in **Photo. 7** have pressed-in spigots, an arrangement which makes the filing of the teeth a lot easier. They were sizes I had to make to do the job I was working on. The other cutter in **Photo. 7** also has a separate spigot and was made for spot facing, which is why the teeth are on the face only.

Ring cutters

These (**Photo. 8**), are relics from the days when I worked for a hearing aid company and were used for cutting an annulus in some small components, I think ear pieces. A part of one is shown. The material was mu metal or radio metal, I forget which. Each was a pig to machine, which is why one cutter has three teeth





6. A selection of counterbores

but started out with four.

If I had to do the same job today, I would make them with six or eight much shallower teeth, or even make them as D-bits. They date from a time when I thought I was Jack-The-Lad and tended to over-engineer things, so that they looked lovely, but weren't always as functional as they could be.

Cutters from files

As mentioned earlier, I always have a stock of carbon tool steel from old files which have been softened by heating to scaling temperature (when the bright red has paler patches on it) and walking away, leaving it to cool. It needs a good heat source and the patience to make sure that all the file has reached scaling temperature. I have always left it to cool where it has been heated and not bothered to bury it in hot ashes or whatever the book says; it has always worked for me.

Files do not always need softening, small broken ones or worn-out ones of

suitable size can be used as they are.

Photo. 9 shows three made by grinding to shape and one which was softened, filed to shape and re-hardened. It was done that way because it was for gear cutting and the shape is not easy to make by grinding. The three which are ground are a turning and facing tool, a 60 deg. threading tool and a gear cutter for a rack or gears containing over 135 teeth.

All of these cutters work best on softer materials. They will cut some of the softer ferrous metals but the harder and tougher ones can be difficult, especially if the cutting process generates a lot of heat or is intermittent. They were made for quite small work and can be held in the standard Unimat tool post.

Cutters from broken end mills

Broken end mills or slot drills make excellent cutters, and **Photo. 10** shows three. They are, a grooving tool, one for



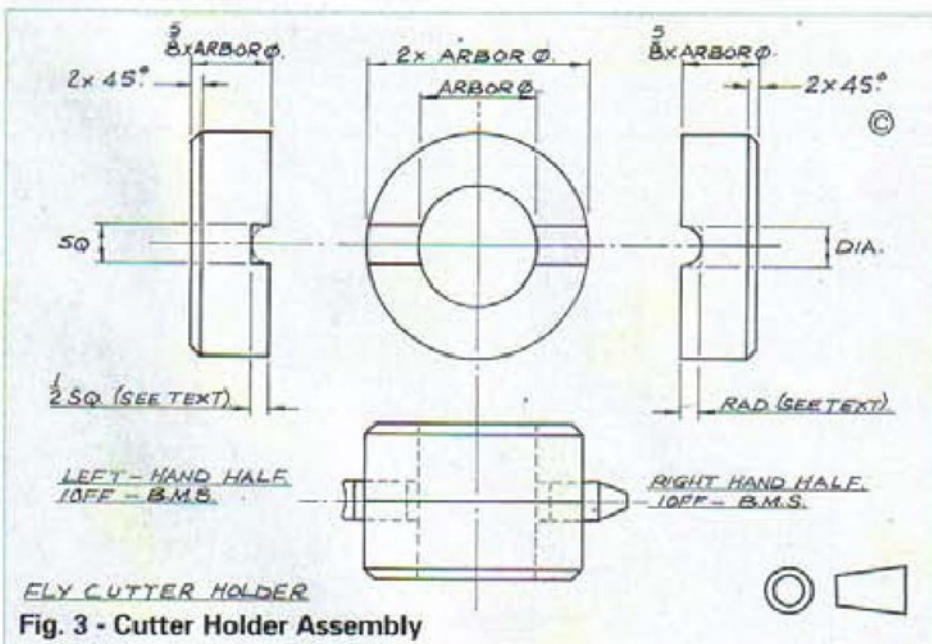
7. Two small counterbores and a spot-facing tool

engraving lines and one for squaring out a corner by using a vertical milling as a slotter. The machine is turned off at the mains and the cutting done by winding the quill down or the table up, taking small cuts each time. All of the cutters worked well.

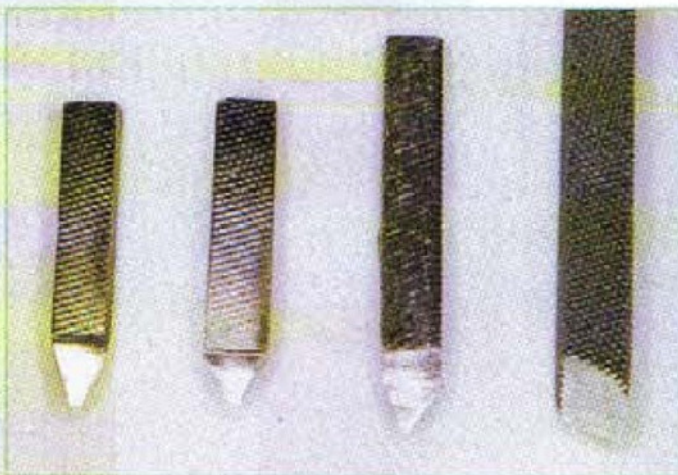
Taps

It is possible to make taps, especially for small sizes and soft materials. The first time I made one was when I had no choice. I lost the tensioning nut off a fixed spool fishing reel - it is still at the bottom of the Severn somewhere I expect. I tried to identify the thread and found that it was a bastard size, no reflection on its parentage or the difficulty of making it, merely a grauncher's way of describing a thread where the diameter and pitch are not related. In this case (the smaller tap in **Photo. 11**), it was $\frac{9}{32}$ in. diameter and 26 threads per inch. I couldn't find it in the tables, not even BSB. As the replacement nut was made from Tufnol, the one I made cut well, having fairly narrow flutes. The main problem with making taps is that it is not possible to machine the backing-off which commercially made ones have.

I did the best I could to avoid the



8. Ring cutters and the component cut by them



9. Cutters made from files



10. Cutters made from broken end mills



11. Two home-made taps

backing-off problem on the larger tap by filing more flutes, tapering it well and reducing the threaded part to leave a thin land. It is a roughing tap to use when tapping M14 x 1, the attachment thread for Unimat chucks and accessories. I made it slightly smaller in diameter and thread depth. It is not a pretty sight, but it works.

Both of the taps shown in Photo. 11 are made from silver steel.

Spade drill

Spade drills, like the one in **Photo. 12** are about the easiest of the lot to make; just a forged shape on the end of a piece of silver steel, filed to shape with a clearance angle on each cutting edge, and hardened and tempered. They can be used on the softer metals and wood, especially the latter. A pilot hole is useful to give it a start but it will vibrate a bit because the shank is smaller than the cutting diameter. For ductile metals, a rake angle can be ground as a lip on each edge. In the smaller sizes, spade drills cut very well on hard brass.

A long spade drill was very useful when my son-in-law's fence was damaged in a gale and a very long drill was needed to repair a fence post. It was much longer than a long series drill would have been, even if I'd had one. The answer was to make a spade drill and, as it was for wood, it was made from mild steel and could be sharpened by filing.

The other item in **Photo. 12** is a short broken drill which has been converted into a slot drill by grinding clearance on the flute faces and a small groove across the centre.

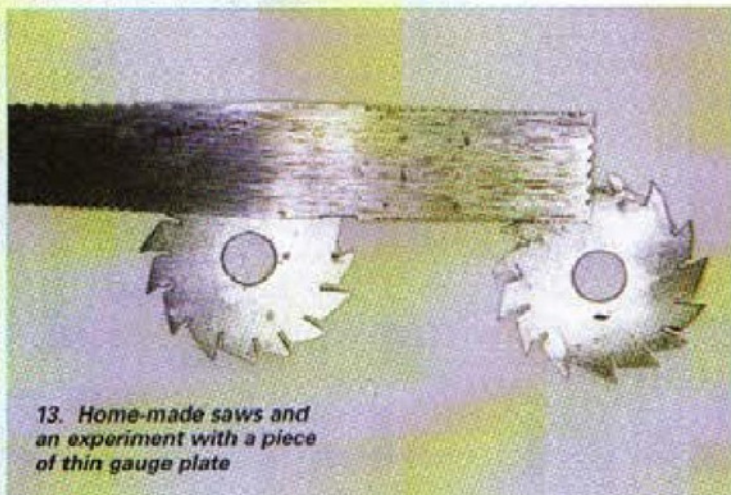


12. A spade drill and a slot drill made from a broken twist drill

Home-made saws

Photo. 13 shows a couple of 1in. dia. x 1/16in. thick saws and a piece of 1/32in. gauge plate with some teeth cut into the edges. The saws were made from discs

of gauge plate with very roughly cut teeth and were for cutting slots in wood. I have written about them in an article describing the making of a calivider, when one of them was used for slotting duralumin. If I had intended them for metal, I would have made the teeth a lot



13. Home-made saws and an experiment with a piece of thin gauge plate



14. Three special form cutters, see text

shallower and much more regular. Despite their appearance, the one I used did a splendid job, so perhaps there is something to be said for irregular teeth, like the 'incremental cut' files that were available once upon a time.

I won't dignify the piece of gauge plate in Photo. 13 by calling it a saw, but that is what I used it for, more as an experiment than anything else. When sawing thin slots using a saw with a set on the teeth, it is almost certain that it will wander. The best way of keeping the cut straight is to use a blade with no set. It is difficult to grind the set off a blade and a razor saw is not always to hand, hence the experiment. The teeth on the top edge worked best.

Odds and ends

The three cutters in **Photo. 14** don't fit into any neat category, the shape each one was used to cut can be seen by the component shown below the cutter. The two radius cutters were used as fly cutters in a holder similar to the one shown in **Fig. 3**. The small half-round one was for machining the tops of the hinge and hinge block. It was a little-by-little job, as was the small gear which was cut with the form cutter set on its side in the Unimat tool post (**Photo. 15**).

The large radius cutter was quite a head-scratcher and had to be very accurately shaped to make the dummy knob shown. I borrowed a drawing board and instruments from one of the draughtsmen, drew the cutter profile 25

times full size and projected the cutter on the inspection 'shadowgraph' at 25 times magnification. When the profile drawing was laid over the cutter profile, it was easy to see where an adjustment was needed. Some careful filing did the job. The only difficult bit was filing the ribs round the corner of the finished knob.

A fly cutter holder

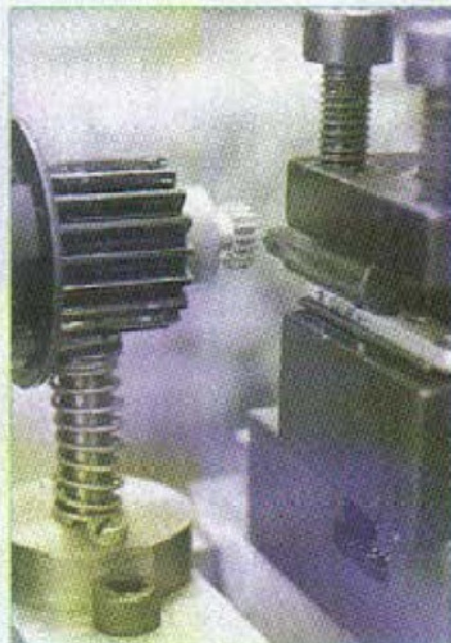
Small fly cutters can be held easily in a cross-drilled bar of a suitable diameter, locked by a grub screw. For larger cutters, like the ones in **Photo. 14**, a holder like the one in **Fig. 3** is useful, especially if a horizontal milling set-up is available. It is made in two halves and they clamp the cutters by having a very small gap which pinches the cutters when the arbor is tightened.

For the square section, the gap is adjusted by filing equal amounts off each half square until, when clamped, a feeler gauge of 0.002in. will just enter. To clamp the circular cutter, the two halves can be clamped together with a shim between them. There are all sorts of things which can serve as shims. One of my favourites is the aluminium cooking foil my wife uses. It is near enough 0.0005in. thick, so four thicknesses, a piece doubled and doubled again, will be 0.002in.

With the shim in place, the hole for the cutter can be drilled and reamed. 1/4in. or 6mm is a convenient size and a good way of using broken cutters. When the hole has been reamed and the shim taken out, the cutter should clamp firmly. If it doesn't, the

inside faces of the holder can be gently and accurately scraped, filed or otherwise adjusted. As shown in **Fig. 3** the dimensions are based on the arbor diameter.

Using home-made cutters is sometimes a necessity and it increases the enjoyment of getting an awkward profile or a non-standard size right. It is often a useful exercise in precision machining or hand work and sometimes heat treatment.



15. The gear cutter in **Photo. 14** being used

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John Hammond, 96 Moorcroft Road, Moseley, Birmingham B13 8LU
Tel. 0121 249 1520

- 8 End mills, Clare 18% Tungsten HSS. 3/8in. - 1in. dia. VGC. (I am standardising on screw shank) £25
Myford leadscrew handwheel & pointer (1430), as new & boxed. £20
Wood/metal hand turning tool rest. Adjustable height above cross-slide 1 7/8in. - 2 3/8in. £5
Tel. 0114 2366475 (Sheffield)

- M.E.W. Sixty-six issues up to No. 69. Unsoiled and complete with data sheets. Offers.
Tel. 01482 869818 (Beverley)

- Owner's Instruction Book for Rishton Promill 35, surplus to requirements. Free on request.
Tel. 01244 376164 (Chester)

WANTED

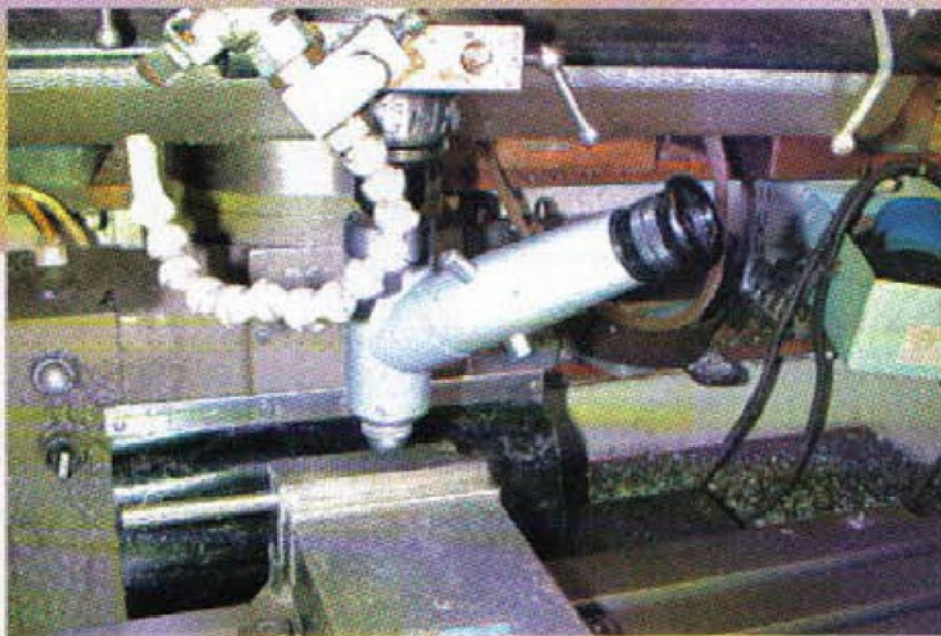
- Any information on a CENTEC 2A Horizontal Milling Machine. I have just bought a machine, Serial No. 1360 for restoration, with bits missing.
Tel. 01386 556578 (Worcs.) or mikehaughton@tinyworld.co.uk
Costs will be reimbursed.

- 'Simple Model Locomotive Building - Introducing LBSC's Tich' book to help with the construction of this model. Also full set of drawings.
Tel. 01274 882398 (W. Yorks) after 6.00 p.m.

EXCHANGE

- Boxford TUD, less tailstock, in sound clean condition, for set of changewheels for Boxford Model 'C'
Tel. 01387 810444 (Lockerbie)

MILL KNEE MOTORISATION



1. The Helger and Watts optical positioning device, the acquisition of which prompted the modification

This project has been in the pipeline for many years and it is only recently that I have decided to complete it.

The mill that I have at the moment is a unit similar to a Bridgeport in that it has a turret and a raiseable knee. This knee, however, is manually operated by a handle which protrudes from the front of the machine at an angle of 45 deg. and, because of the proximity of this handle to the bench at the side of the machine, the knuckles of my hand have been skinned on a number of occasions. This still happened even after the handle had been

modified by shortening and a ratchet fitted to ease the situation. The shortening has, of course, increased the effort required to raise the table and, when measured, required a force of 18 pounds to start the handle turning. A part of this is due to 'sticktion', and although the same effort is not required once the knee is moving, I had to take it into account when deciding on the motor size needed.

The need for the modification really became apparent when I acquired an optical alignment device manufactured by Helger and Watts of London. This device

Frustrated by the effort needed to raise and lower the table of his milling machine and by the occasional injury to his person, Peter Rawlinson decided that 'something must be done'

(Photo. 1) has a length some 90mm greater than that of an average end mill and also requires a distance of some 85mm between the object lens and the workpiece. This, of course, means that to use it the knee must be wound down and then back up over a distance of some 175mm each way - perhaps acceptable in normal circumstances, but with the onset of arthritis in my right hand and wrist, together with the occasional skinning of the knuckles, I finally decided that enough was enough.

The power requirement

My first consideration was the power requirement, and as mentioned above the load required on the handle was measured using a length of strong string and a mixture of cast iron box tables and angle plates as weights, adding them until the knee would move upwards when the weight was lowered. The handle radius was then measured and found to be 6in., so simple multiplication gave a torque requirement of 108lb.in. Now, up to date catalogues no longer give motor performance in these units, so conversion



2. The modified bearing retaining plate. The article was written and the photos taken some while after the modification had been completed and while another major project was under construction - hence the swarf!



3. The new back plate fitted by means of the four countersunk screws

was necessary. My book gives a conversion factor of $1 \text{ N.m} = 8.85 \text{ lb.in.}$, so my requirements in modern terms were 12.21 N.m.

As I would have to offset the motor, a chain drive was decided on and this would then allow a reduction ratio to be incorporated in the drive, thus allowing a smaller motor and gearbox to be used. As space was limited, this would be an advantage, but it would mean a reduced speed of traverse. The performance of the completed modification is acceptable, but it would have to be faster if this were an industrial application.

I found that what appeared to be a suitable motor/gearbox combination was available from Model Motors Direct (now just Motors Direct). Reference to a catalogue listing a popular range of small size motors and gearboxes provided a check on the torque figures for similar motors with the same reduction gearbox ratio and input power, and it seemed that if I used a reduction ratio of 3:1 in the chain drive, then ample power would be available from this motor.

This has proved to be the case as the motor and gearbox run without even getting warm.

The mechanical components

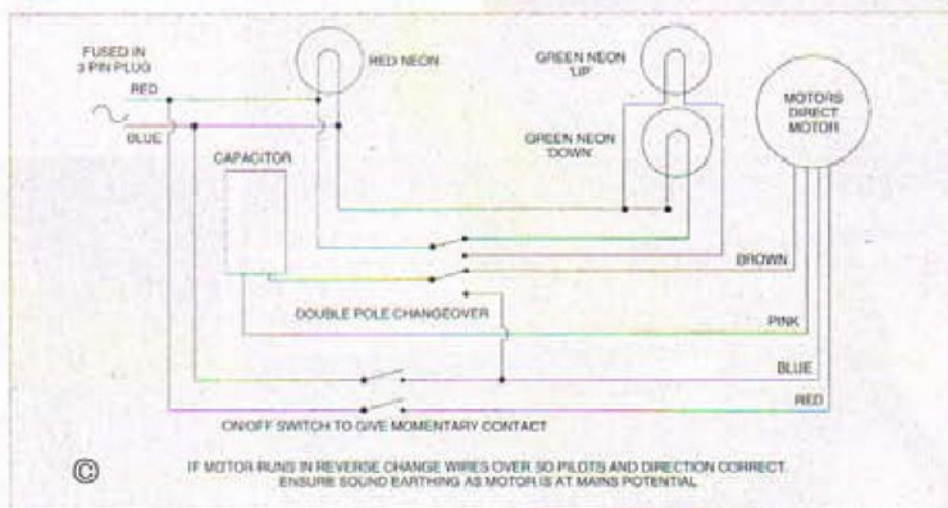
The mechanical side was quite straightforward, the components proving simple to machine or fabricate. The drive shaft to the knee mechanism on my mill is 18mm in diameter, running in ball bearings, the outer bearing being held in place by a retaining disc secured by two Allen screws (Photo. 2). The bearing retainer was modified and four extra tapped holes added to take the screws securing the motor mounting plate. These had to be countersunk into the mounting plate to miss the drive sprocket (Photo. 3). Similarly, the motor mount also required the front two holes for the motor screws to be countersunk to miss the chain run (Photo. 4).

The motor needed a cover (Photo. 5) to prevent the ingress of swarf and coolant, but this could be open at the bottom to improve cooling (Photo. 6). I have also incorporated a series of louvres

Parts list

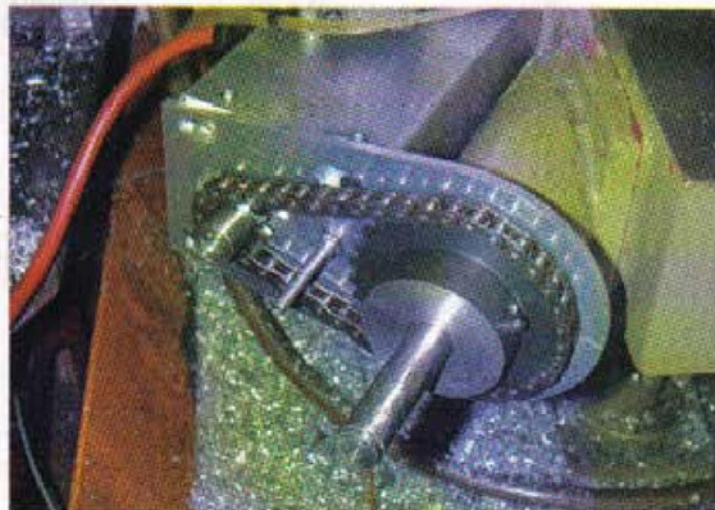
Motor/Gearbox (with capacitor to suit)	1 off	220V. 60 rpm.	Motors Direct
Sprocket	1 off	30 tooth x $\frac{3}{8}$ in. pitch	Farnell No. 713-3431
Sprocket	1 off	10 tooth x $\frac{3}{8}$ in. pitch	Farnell No. 713-3327
Chain		Roller chain $\frac{3}{8}$ in. pitch	Farnell No. 713-2591
Connecting link	1 off		Farnell No. 713-2633
Switch	1 off		Farnell No. 918-611
Switch	1 off		Farnell No. 918-600
Pilot Lights	2 off	Green	Farnell No. 140-253
Pilot Light	1 off	Red	Farnell No. 140-254
Neon Bulbs	2 off	Green	Farnell No. 140-278
Neon Bulb	1 off	Red	Farnell No. 140-181
Box	1 off		Farnell No. 462-305
Glands	3 off		Farnell No. 927-727

Mains plug, cable and 4 core cable to suit

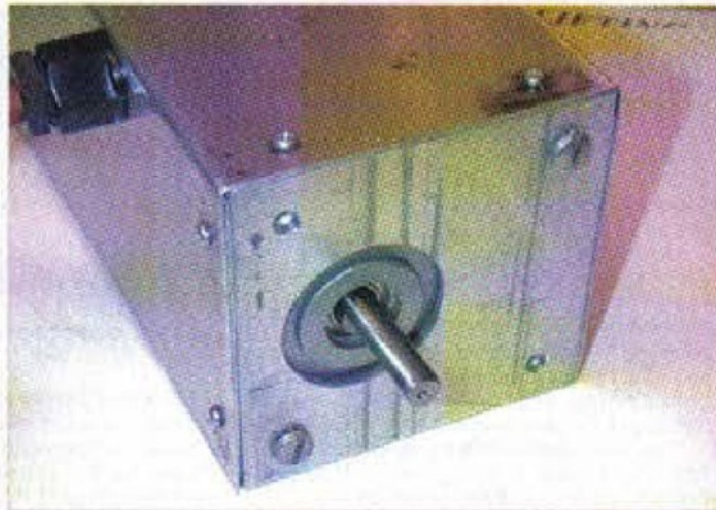


in the rear cover (Photo. 7) to allow the motor fan to work reasonably efficiently, and this cover also incorporates a full cable gland to ensure that the main cable

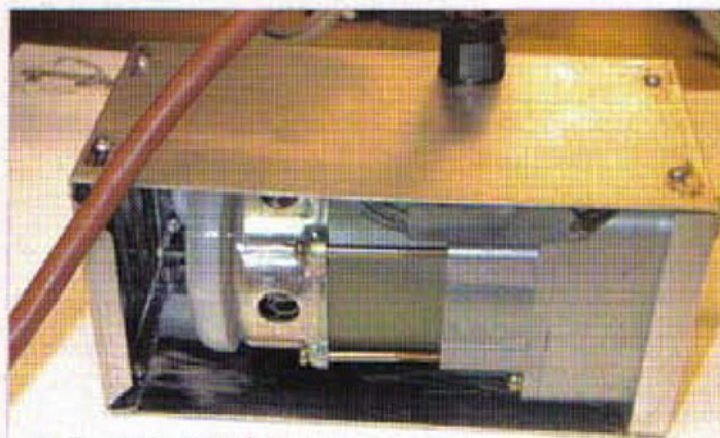
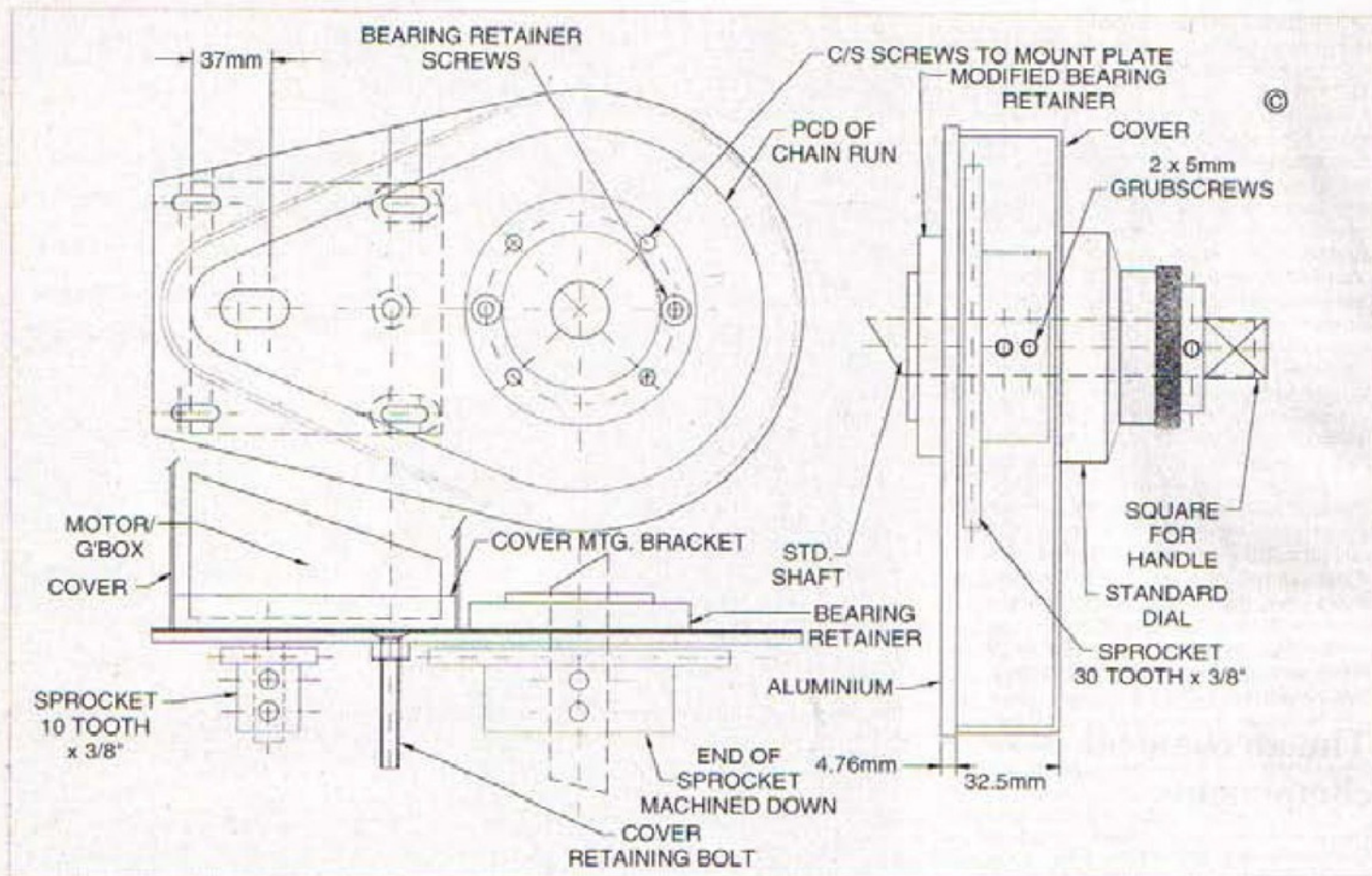
is securely anchored and properly sealed. Although anyone planning to fit a similar modification to their milling machine will have to tailor the components to suit, I



4. The chain drive added



5. The motor cover seen from the drive end.



6. The under-side of the motor cover is left open to facilitate cooling

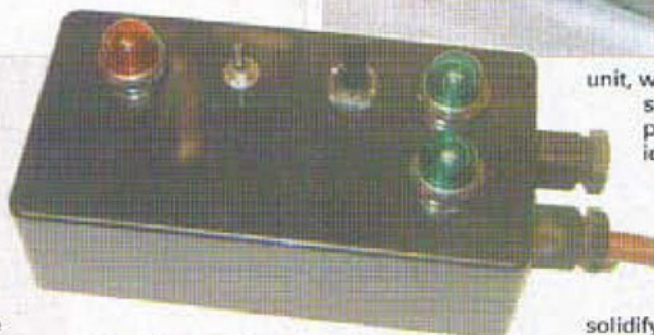
have shown detailed drawings of a number of them for guidance. The front chain guard is likely to be much the same if similar components are used, but I have not detailed the cover as the design of this will depend very much on equipment availability.

I provided a mounting bracket for the motor cover by machining a 90 x 90 x 12mm piece of aluminium to have a recess 80 x 80 x 9mm deep, thus allowing the motor to fit inside while still allowing the majority of the shaft to protrude. The cover is then screwed on to the outside of this mounting.

The chain guard (**Photo. 8**) was made from brass sheet, but only because I had it in the stock box. It is soft soldered together, the outer band being partly rolled and partly pressed. This was fitted



7. Louvres are incorporated in the end of the cover for a similar reason



10. The control system is housed in a handy plastic box

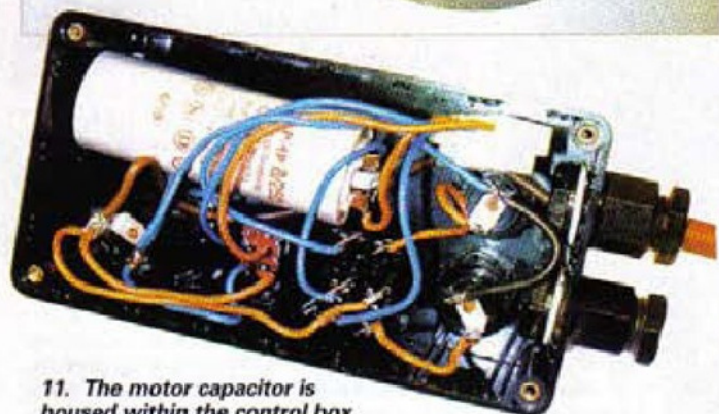
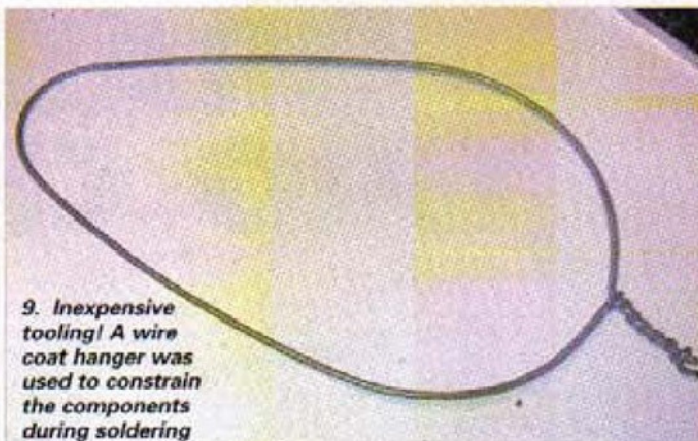
to the outer pear-shaped plate and held in position by using a wire coat hanger, wrapped around and tightened (**see Photo. 9**). Two small wooden wedges were also used to help push the sides hard on to the front plate, and it was then soft soldered using a Proxon gas torch. This

unit, which uses cigarette lighter gas, has a self ignition system built in and produces a very fine flame. I found it ideal for the task as it provided enough heat to run the solder (even considering the huge thermal capacity of the heat sink formed by the components), but the flame was fine enough to allow the solder an inch away to solidify.

Grub screws of 6mm dia. were used to lock the sprockets to the shafts and a thumb nut was made to hold the case in position.

The control system

The only other major part is the electrical control system, which is housed in a small plastic box (**Photo. 10**). As I always turn all my equipment off at the



wall switches when not in use, a red neon indicator is incorporated to show that the unit is plugged in and turned on. A spring-return mains switch is fitted (this could be a push button) and a further switch is used to select direction of movement, two green neon lights being added indicate whether this is 'Up' or 'Down'.

The motor starter capacitor is also fitted into the box (**Photo. 11**), the connection to the motor being made by means of a four core cable. It has no fuse, but relies on the fuse in the mains plug, although one could be incorporated if desired.

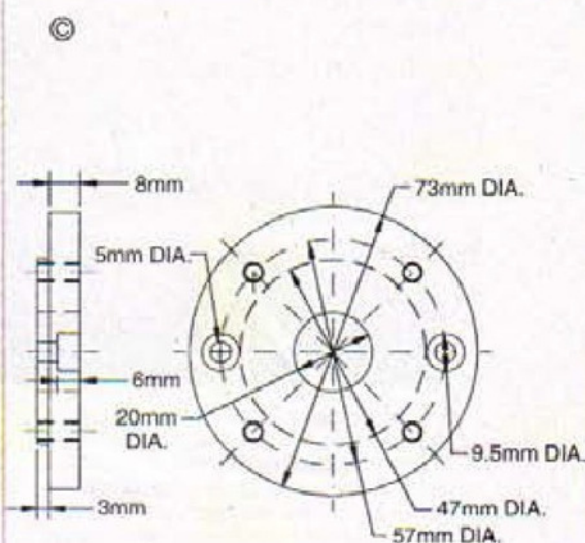
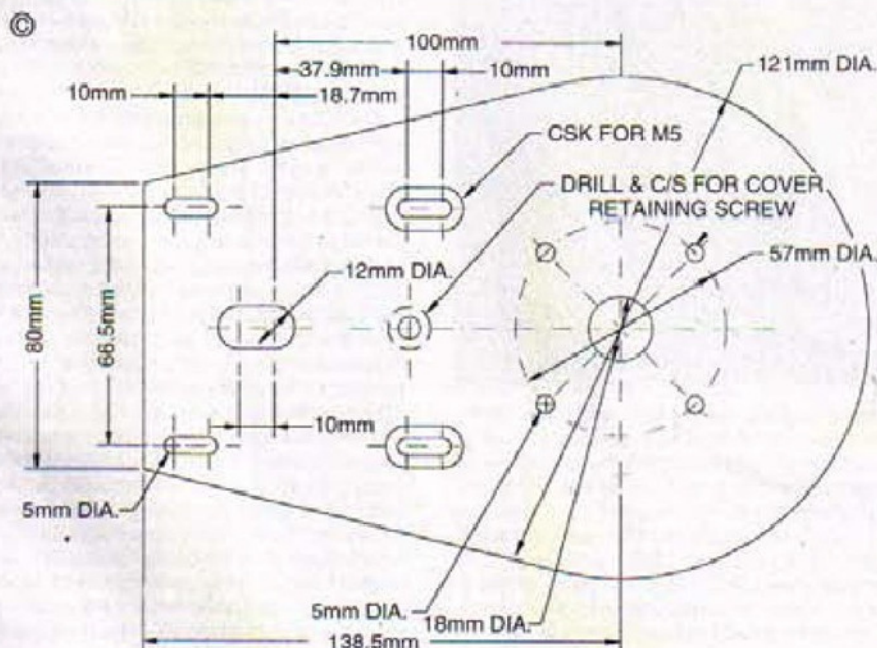
The unit is now complete (**Photo. 12**) and works very well, but I am now

wondering why I did not carry out the modification a long time ago as the effort it saves is well worth that required to make it. The bonus, of course, is that the saving in 'injury time' will certainly make up for the time expended.

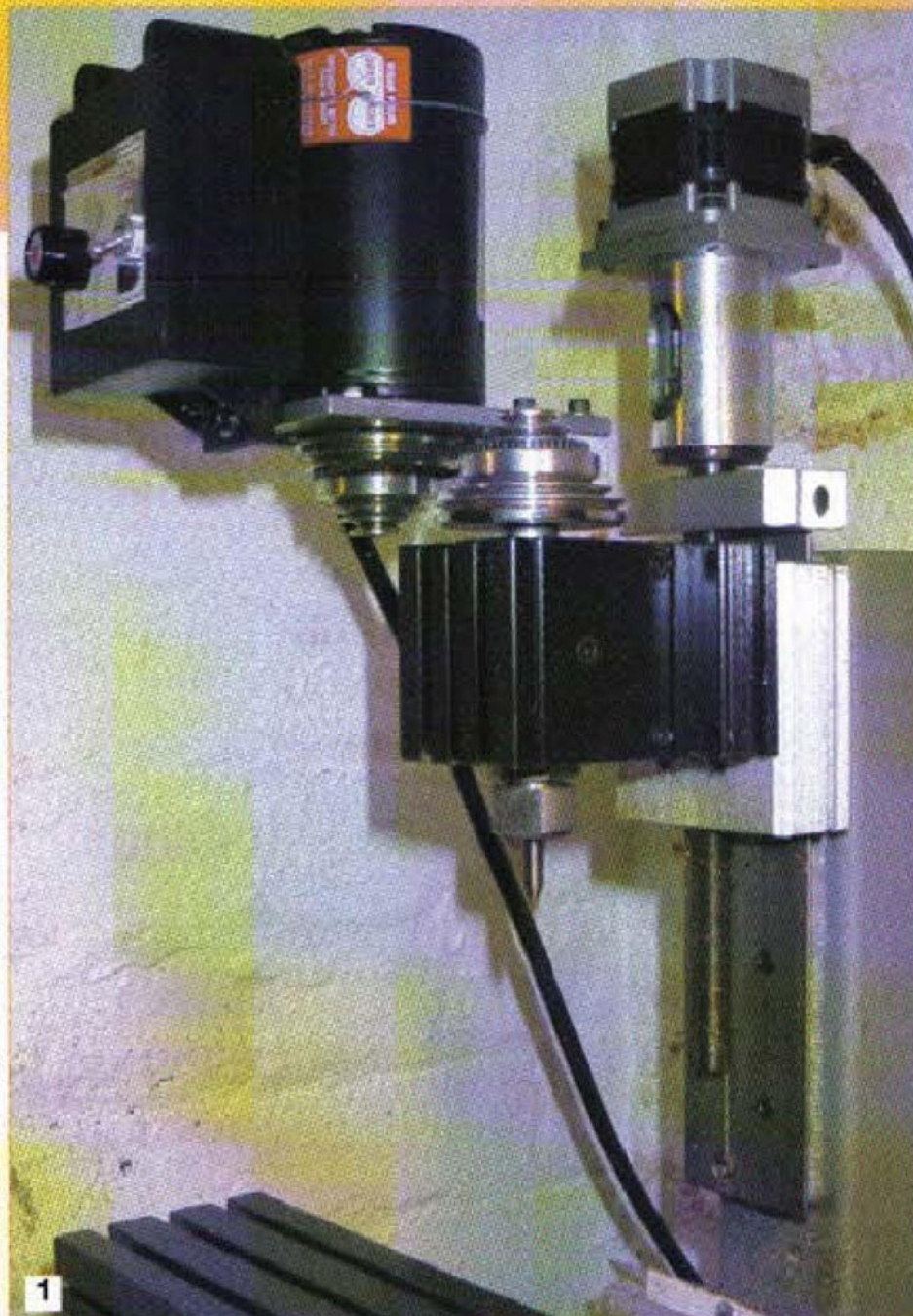
As with my previous articles, I am happy to answer any questions, but only by telephone please (Charing, Kent. 01712158).

Suppliers

Motors Direct Tel. 01749 860111
Farnell Tel. 0113 263 6311
Proxon Tel. 0845 6590000



UPGRADING THE TAIG CNC MILL



Tony Jeffree reports on modifications which have recently become available for this small American milling machine

and I was keen to see if there were opportunities to upgrade my machine.

The improvements to the mill range from cosmetic changes through to some more significant modifications:

Taig have decided to pay some attention to the appearance of the mill - the steel frame components are now powder coated in a pleasant blue, and some of the aluminium components are blue anodised to match.

The Y-axis ways, formed from square section steel bar, have been extended front and back. This does not change the Y travel at all, but ensures that the saddle is fully supported over the full range of Y-axis travel. The Z-axis ways have been completely redesigned to make them considerably more substantial. In the process, the usable Z travel has been improved; more about these changes below. A version of the mill is now available with a longer table, offering a full 12in. of X-axis travel.

The CNC version of the mill can now be supplied with more powerful stepper motors - 200oz.in. as opposed to 140oz.in. The range of software packages that Taig (and their UK/European distributor - Quantum CNC - Ref. 2) can supply for use with the mill has been extended to include 'MicroMill Dolphin' for conventional 2½D use and also 'Mill Wizard' for 3D engraving/modelling work.

The Dolphin package is a fairly conventional CAD/CAM package, sold in its full form for about three times what you will pay for the Taig version. It consists of a Windows-based CAD package that allows a part to be drawn, and also allows drawings to be imported in .DXF format, and a CAM 'back end' that will take components of a drawing and generate G-code programmes that define the toolpaths necessary to cut the contours and pockets defined by the drawing. The G-code output is compatible with the 'MaxNC' G-code interpreter software, which is also available through Taig or Quantum CNC. The package supports the use of a rotary axis, and will handle pocketing operations with up to nine islands. Mill Wizard allows a 3D model, created in an appropriate drawing package, to be converted into G-code, allowing roughing and finishing passes to be defined using different cutting tools - generally a ball-nose end mill for

A recent business trip to Phoenix gave me an opportunity to visit the Taig factory (Ref. 1). Taig is very much a family business; Forrest Daley, his wife Daisy, and their two sons all work in the business, and the manufacturing facilities are to be found in a series of workshops built in the grounds of the Daley residence in a small town on the outskirts of Phoenix.

Kurt Daley, who designed the CNC conversion for the Taig Mill, and who runs the CNC end of the business, showed me

round the factory; the vast majority of the components of the Taig lathe and mill are manufactured in-house, using a wide variety of machinery ranging from ancient automatic lathes that munch their way through long lengths of bar stock, through to modern pallet-fed CNC machining centres. He also showed me some of the recent improvements that have been made to their mill design. This was of particular interest to me, as I own the first Taig CNC mill to be imported into the UK,

roughing, followed by a finer V-point engraving cutter to give the final finish. The biggest limitation with this package will be the problem of having to create the 3D model in the first place; however, for anyone serious about this kind of milling work, it looks like a very useful piece of software.

After a very pleasant and interesting visit, I came away burdened with the components necessary to upgrade the Z ways and motors on my mill. The remainder of this article describes these improvements in more detail, and my experience of applying them to my machine.

Upgrading the Z-axis

Photo. 1 shows the mill before the Z-axis upgrade and with the original 140oz.in. motors fitted (only the Z-axis motor can be seen, at the top of the column). The Z ways are formed from a length of hard-anodised aluminium extrusion approximately 2.25in. wide, with 45 deg. dovetails; essentially the same cross-section as the steel bed of a Taig lathe. The Z slide block is also an aluminium extrusion (actually the same section as the riser blocks supplied for the lathe); this carries a rectangular mounting plate of the same aluminium dovetailed extrusion, which in turn carries the spindle assembly, which is identical to the headstock of a Taig lathe. The 'feed nut' for the leadscrew is tapped directly into the aluminium slide extrusion, offering no opportunity for adjustment or replacement, other than replacing the entire slide block.

Photo. 2 shows the new Z ways and slide. The new ways are made from hardened and ground steel bar stock; a 3in. x 3/8in. plate ground on its front and back surfaces controls 'pitch' of the slide, and a central rib of 1.25in. x 3/8in. stock ground on its outer edges controls 'yaw'. The slide itself is longer than the original and considerably more substantial, although still constructed from hard-anodised aluminium extrusions. Adjustable L-shaped cheeks bolt into the sides of the slide extrusion, providing the means of adjusting the fit of the bearing surfaces with the 3in. wide plate; a tapered brass gib allows fine adjustment of the bearing against the edges of the central rib. This gives the look and feel of a well-designed and well-engineered solution, in contrast with the crude appearance of the old slide.

The front surface of the slide is drilled and tapped to accept the rectangular mounting plate for the spindle assembly, as before. However, eight mounting holes are provided, allowing the spindle to be mounted at three different heights.

Photo. 3 shows the leadscrew for the Z-axis. This is essentially the same as the original leadscrew, only somewhat longer (about 10in. of thread as opposed to the original 8in.); however, a more significant difference is that now there is a proper bronze feed nut in place of the rather crude arrangement used on the old slide.

Removal of the old ways and fitting the new is straightforward; the old ways are held in place by nine UNF 10-32 socket head screws, and the mounting holes in the new ways follow exactly the same pattern, although longer screws are needed on account of the increased thickness of the new ways. The slide is

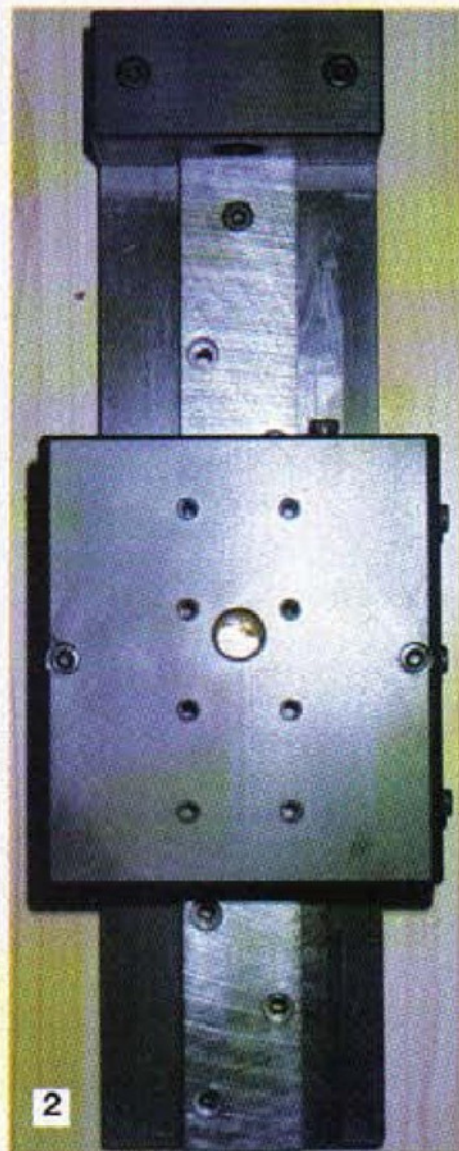
adjusted to remove any play; the tapered gib has an adjusting screw top and bottom, and the two 'cheeks' have adjusting screws at the front and sides. The new leadscrew assembly is fed into the mounting block at the top of the slide and into the feed nut; the bearing block for the leadscrew is threaded into the mounting block, and retained in place with the help of Loctite retaining compound. The stepper motor mount for the Z-axis motor was salvaged from the old Z-axis leadscrew assembly, and fitted to the new assembly; the motor mount tube screws onto the outer diameter of the leadscrew bearing block, providing adjustment for the resilient motor couplings. The Z-axis motor can then be re-fitted (or in my case, the larger replacement motors are fitted).

The headstock assembly can then be fitted to the slide, using four of the eight tapped holes in the front face of the slide, plus the rectangular mounting plate mentioned earlier. The spindle motor is mounted on a 1in. square section post that is held in a T-slot on the left hand side of the headstock assembly. I found that I needed to drill alternative holes for the T-bolts (see **Photo. 4**) as the original holes (drilled on the centre line) meant that the post would have prevented proper fitting of the headstock to the mounting plate. All that remains is to check the alignment of the column to ensure that the slide ways are perpendicular to the table, and that the spindle is mounted so that it is also perpendicular. The result can be seen in **Photo. 5**; the extra length of the more powerful steppers can be seen by comparison with **Photo. 1**.

One aspect of the new design struck me as being in need of improvement. Having assembled the new slide and adjusted the column, it occurred to me that although the eight mounting screws on the face of the slide (see **Photo. 2**) allow the spindle to be mounted at different heights, this arrangement also requires adjustment of the mounting plate whenever it is moved up or down on the slide. Far better to have a longer mounting plate, the full length of the slide extrusion. The obvious solution is to press the now redundant Z ways extrusion into service as a longer mounting plate. It was a simple job to use the mill to drill and counterbore eight holes in a 4 1/2in. length of the old ways material and to fit this to the slide as a long mounting plate. The result is seen in **Photo. 6**. Adjustment of the spindle height can now be achieved simply by loosening the two headstock clamp screws, repositioning the headstock and re-tightening, with a reasonable expectation that in doing so, the alignment of the spindle has not been affected.

With the spindle mounted at its highest, the spindle-nose-to-table distance is about 7 3/4in., and the Z-axis travel is about 6 1/2in.. Fitting the spindle at its lowest point reduces the spindle-nose-to-table distance to slightly less than the available Z travel, which can be useful if engraving on thin materials is undertaken with the work mounted directly on the table.

Although I have described these upgrades in the context of my CNC version of the mill, the improvements to the Z-axis also apply to the manual version of the mill (Ref. 3).

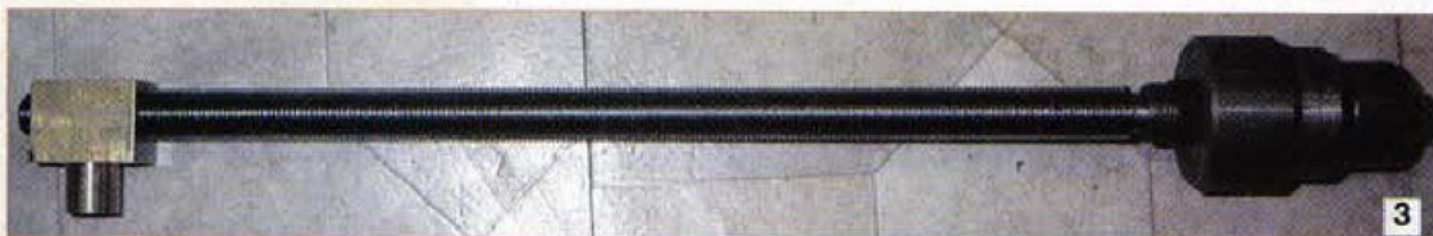


Upgrading the motors

The physical job of changing the motors is simple enough - undo the four motor mounting screws, drop the old motor out, fit the motor end of the drive coupling to the new motor, adjusting the position of the coupling on the shaft to match the position on the old motor, then re-fit the motor into the motor mount. However, it doesn't end there, as the new motors are the same current rating as the old ones, but require a higher drive voltage to achieve that current. Unless you are a competent (and confident!) electrician, I would not recommend attempting the modifications necessary to the stepper control circuitry in order to deliver the required voltage. The modifications involve re-wiring the existing power transformers, adding a variable voltage control, and changing one of the resistors on the circuit board. Kurt very helpfully supplied me with the necessary replacement transformers pre-wired in the correct manner so that I couldn't get it wrong, but I suspect that a more satisfactory solution for most people would be to return the unit for factory upgrading.

First impressions

It is early days yet - having only recently completed the upgrade, I have not tested



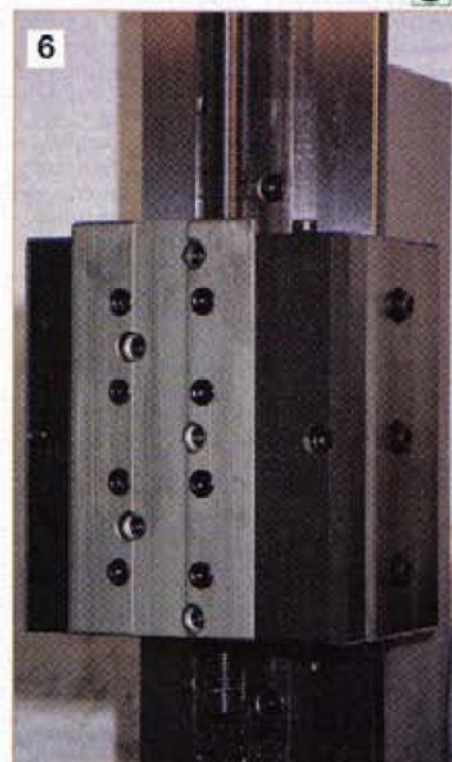
the machine to anywhere near its limits. However, it is very clear from the work I have done on it so far that the improvements to the Z-axis and the more powerful steppers have made what was already a very capable machine perform significantly better. There is a very noticeable reduction in vibration during cutting - this will inevitably be accompanied by an improvement in the surface finish that can be achieved with the mill. The more powerful stepper motors are capable of handling higher feed rates than the old ones; even so, I suspect that, with the improved stiffness of the Z-axis, the limiting factor on speed and depth of cut is now the steppers, whereas with the old Z-axis, the stiffness in Z (or lack thereof) was probably the limiting factor.

References

1. Taig equipment is manufactured by Taig Tools, 12419 E. Nightingale Lane, Chandler, Arizona 85249, USA Tel: (602) 895-6978. Website: <http://www.taigtools.com/>

2. The Taig MicroMill 2000 CNC Mill is distributed by Quantum CNC (Europe) Ltd, Wall End House, Moor Lane, Coleorton, Leicestershire, LE67 8FQ, UK Tel. 01530 834376. Website: <http://www.quantumcnc.co.uk/>

3. The Taig lathe and the manual version of the mill are distributed under the 'Peatol' brand name by Peatol Machine Tools, 19 Knightlow Road, Harborne, Birmingham B17 89S, UK. Tel/Fax: 0121 429 1015



A SAFETY INTERLOCK FOR A WARCO MILL

Dr. David Hall of Ipswich suggests a small modification to a popular milling machine

The following modification, for a Warco or similar mill, came about because I felt that there is a serious potential hazard for those, like me, for whom age has brought absentmindedness.

The problem

Two swinging arms lock the head of my Warco mill. If one forgets to lock the two levers before operating the mill, the head can swing sideways with possibly disastrous results. The first time it happened to me a $\frac{3}{16}$ in. cutter went flying horizontally - fortunately away from me. The second time a drill met its end. Having given the drill two opportunities to maim me, I didn't fancy giving it a third! As my lathe has several safety interlocks I felt that the mill deserved one. The solution was very simple: a cam clamped to the shaft of one of the swinging arms engages with a micro-switch, which controls the power supply to the motor. Now it is impossible to operate the mill without the lower arm being fully tightened.

The solution

The cam can be made from a piece of $\frac{3}{16}$ in. thick mild steel as shown in **Fig. 1** for a Warco mill; the dimensions may need modifying for other makes. An advantage of a long cam is that adjustment by means of the pinch clamp is ample, thus eliminating the need for critical positioning of the micro-switch or for providing the micro-switch with slots for adjustment. The cam could be cut with a hacksaw but I chose to take three tangential cuts with the mill and then filing to a smooth curve. The micro-switch can be secured by means of two threaded holes into the mill casting and a suitable bracket. No design for the mounting is included below, as that will depend upon the chosen micro-switch.

Electrical considerations

I found that the simplest way to couple up the circuitry (**Fig. 2**) was by use of a standard circular 20A junction box. This fits



The 20A junction box, the cam and the box containing the micro-switch are labelled. The swinging arms are in the unlocked (off) position to reveal part of the cam

neatly into the space between the locking arms and the feed handles and, with a coat of paint, looks like an original fixture and makes use of the existing route of the supply to the motor. Insulation of the micro-switch is important. I made a box - with back and bottom missing - out of $\frac{1}{2}$ in. thick plastic, which gives full protection. The workshop RCD provides overall cover.

Care has to be taken also that the micro-switch will cope with the maximum current drawn by the motor. My scrap-box provided one of the types with ample current capacity and a robust spring-loaded steel lever with a ball end, which rubs upon the cam.

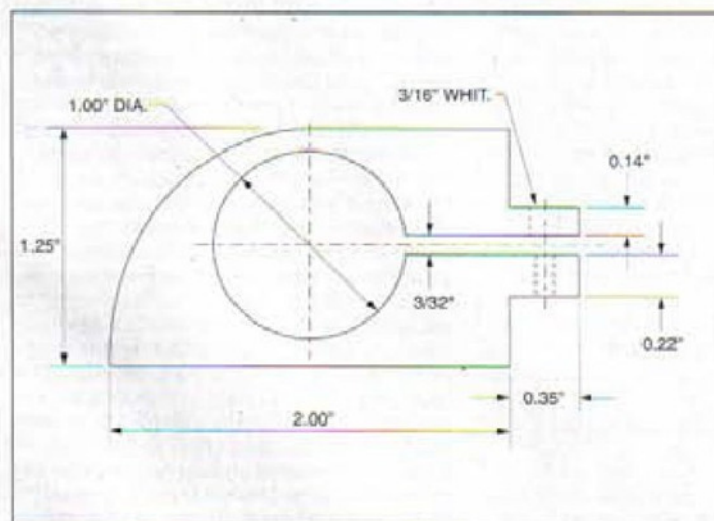


FIG. 1 The cam with pinch clamp

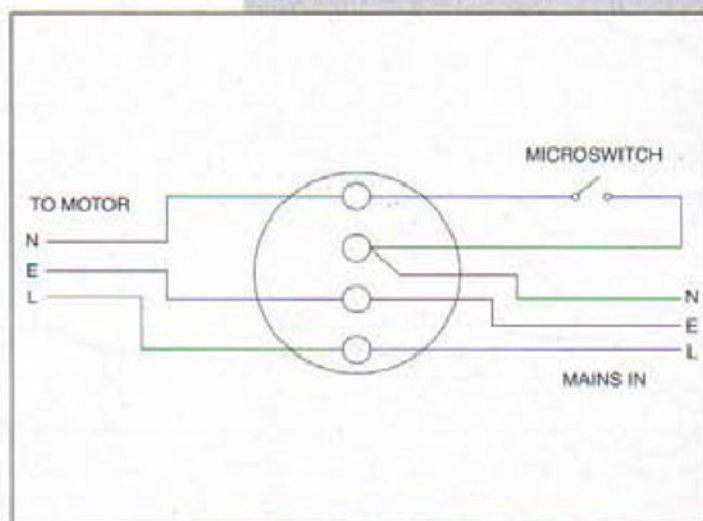


FIG. 2 Connections to the junction box

ELECTRO-MAGNETIC DEVICES - Part 7

Tony Claridge now moves the discussion from transformers to motors

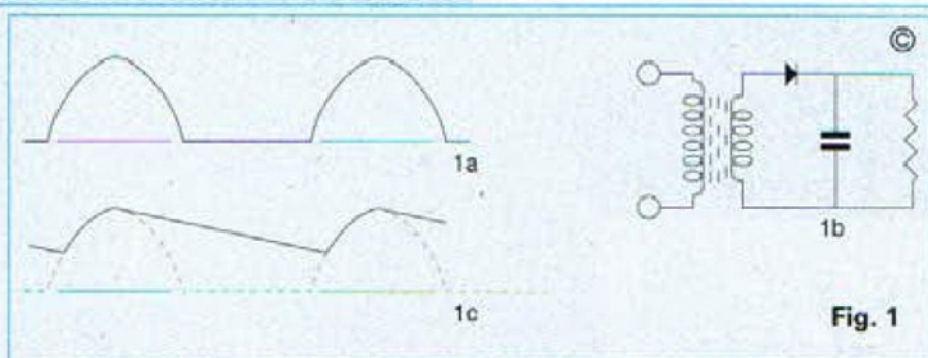


Fig. 1

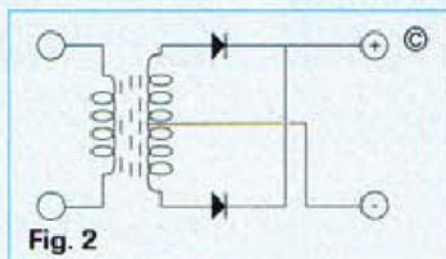


Fig. 2

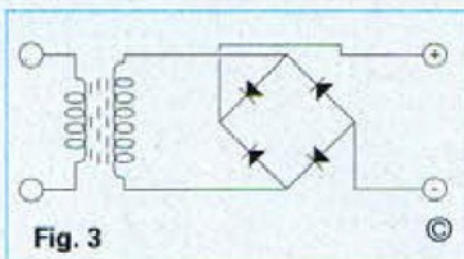


Fig. 3

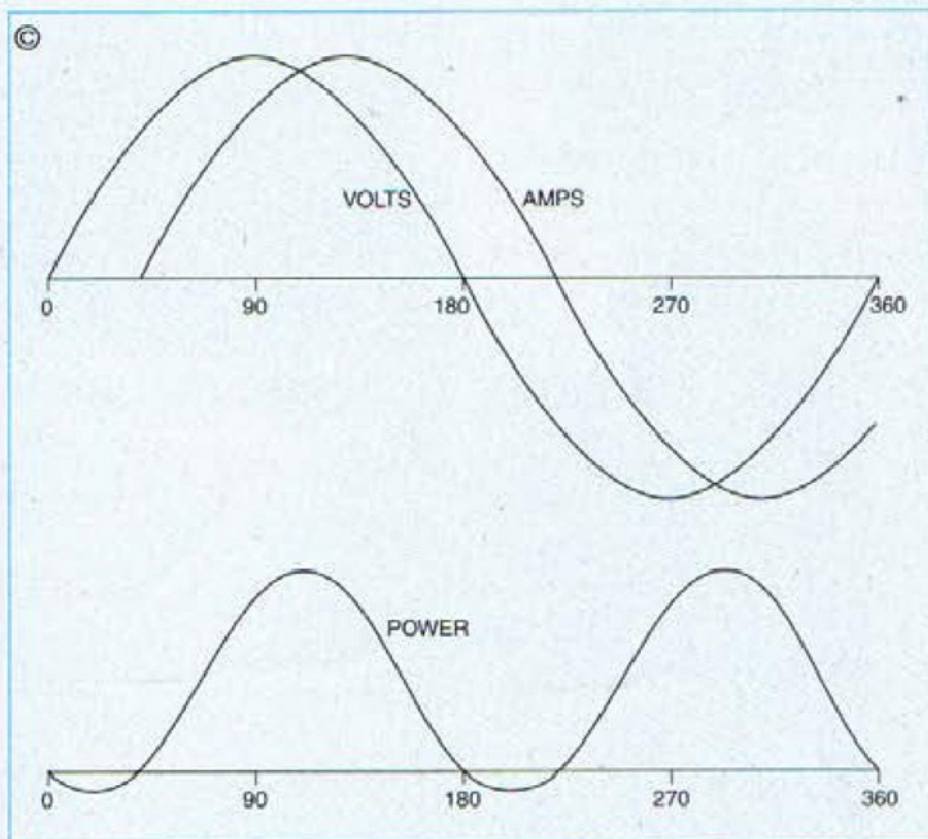


Fig. 4

There are a few points regarding transformers which should be cleared up before we go on to an unusual transformer - the induction motor.

We start by examining the use of transformers to supply DC loads via rectifiers. The simplest way to do this is to use a single diode in series with the transformer's output winding. Because this results in a DC output like that in Figure 1a, it is usual to add a sizeable capacitor to the circuit as shown in Figure 1b, which then changes the DC output to something similar to that shown in Figure 1c, the 'ripple' varying according to the size of the capacitor relative to the load. The capacitor acts roughly like a flywheel on a single cylinder engine.

There are several shortcomings in this circuit, whose only merit is its simplicity. First, the transformer has to deliver the average output current in short bursts, so that the form factor is very poor and the secondary winding's resistive loss is relatively high. Just as serious is that the secondary current consists of a DC component together with a complex series of harmonics. The DC component biases the transformer's magnetic field so that the core goes into partial saturation during each alternate half cycle of the supply. This circuit is very much the cheap and nasty one of the rectifier world and is fit only for such applications as battery chargers for shavers, mobile phones, etc. Even then it offends the pure in heart. For anyone who is interested, the definitive analysis of this and most of the other rectifier circuits is a paper by O. H. Schade in the Proceedings of the (American) Institution of Radio Engineers of July 1943.

The next circuit is shown in Figure 2. This was widely used in the days of valve circuits, which needed a high (250 volts and upwards) anode supply, often called the 'HT', but usually at a fairly low current. There were no high voltage semiconductor diodes at the time and so valve diodes (often two in a single valve) had to be used; they were expensive, and this circuit was attractive as it needs only two of them. The transformer uses a centre-tapped winding, and while the ripple is less than in the single diode case, the utilisation of each half of the secondary winding is still poor. A possible problem with both this circuit and that of all rectifier circuits which rely on a large capacitor for smoothing is that at the instant of switch-on the capacitor has no charge and acts like a short circuit. The inrush of current is limited only by the resistances of the transformer and the diodes, plus the leakage inductance of the transformer.

With the availability of cheap semiconductor diodes suitable for just about any voltage and current, often already packaged into four-arm bridges, the circuit shown in **Figure 3** is almost always the best choice. Ripple content is low, transformer utilisation is good, and having to use four diodes compared to two or even one is not a significant drawback. A point to bear in mind, though, in all rectifier circuits is that most diodes have a forward voltage drop of around three-quarters of a volt, so that they generate heat equal to this voltage multiplied by their through (RMS) current. For any substantial duty, they need to be provided with heat sinks, usually finned aluminium plates with an extended surface area.

There is one more point regarding rectifier circuits. When these are used to charge batteries, it is necessary that the output voltage is such that, when the battery approaches the fully charged state, there is still enough voltage to enable some current to be delivered, even though it will be in small pulses as the voltage touches its peaks. Care must also be taken that the current flowing into a 'flat' battery does not exceed the diode rating. A substantial series resistor, preferably a variable one, is the simplest answer, though there is a growing trend towards using an electronic regulating circuit to control the charging current. Do not be alarmed by this list of potential snags in building transformer/rectifier sets. It's not all that difficult!

Before starting on motors, there is one more detail which must be covered; it has relevance to the induction motor which we shall reach shortly. It is the property called 'power factor'. In any circuit which has inductance or capacitance in combination with its resistance, the current will not be in phase with the applied voltage. We are talking of AC systems and assuming sinusoidal wave forms of course. With an inductive load the current lags behind the voltage; capacitance results in the current leading the voltage (except for the instant of switch-on of course). Now power is the product of voltage multiplied by current, and in **Figure 4** are shown sinusoidal waves of voltage, a lagging current, and the resulting power. The most striking thing is that, for part of the cycle, the power is negative, i.e. is flowing from the load into the power supply. This comes from the stored energy of $\frac{1}{2} L I^2$ in an inductance or the corresponding energy stored in a charged capacitor. This is analogous to the situation when a spinning flywheel delivers rotational energy back into an intermittent driving source. We could explore the size of this effect by some trigonometrical calculations, but there is an easier way.

If we depict what is going on by means of the vector or phasor diagram, we can define a lagging current as being made up of two components. One is in phase with the supply voltage and the other lags this by 90 degrees. **Figure 5** shows this clearly (I hope!). The power is then calculated by multiplying the voltage by the in-phase component of the current. The voltage multiplied by the lagging current (sometimes called the quadrature current) is described as wattless power; this is a bit of a misnomer since there are no watts as such. In power engineering, the common

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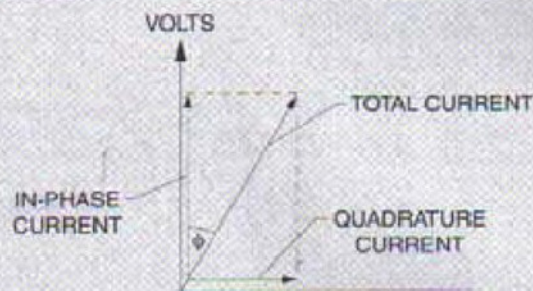
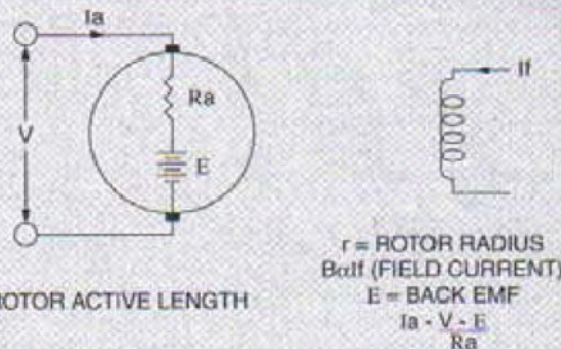


Fig. 5

©



MOTOR:

FORCE ON ROTOR CURRENT = $B \cdot I_a \cdot L$, SO TORQUE = $B \cdot I_a \cdot L \cdot r$ Nm

POWER = TORQUE x SPEED (RAD/SEC)

$$= B \cdot I_a \cdot L \cdot r \times 2\pi \times \frac{\text{RPM}}{60} \quad \text{WATTS}$$

GENERATOR:

$$E = B \cdot L \times 2\pi r \times \frac{\text{RPM}}{60} \quad \text{VOLTS}$$

$$\text{POWER} = E \cdot I_a = B \cdot L \cdot I_a \times 2\pi r \times \frac{\text{RPM}}{60} \quad \text{WATTS}$$

Fig. 6

designations are watts and KVAR, for kilo-volt-amps, reactive. The true power is referred to as KW. The two together are just called KVA. Keeping track of KVAR is important in the power world because the whole current has to be supplied, and this incurs heating losses in generators and cables etc.

To get back to power factor, we can see from our phasor diagram that, using the basic trigonometric definition that the cosine of any angle is the ratio of the length of the adjacent side to that of the hypotenuse in a right-angled triangle and using this relationship in our diagram, we find that the length of the in-phase current line equals the whole current multiplied by the cosine of the angle of lag of the current behind the voltage.

Power is thus defined as voltage times current times the cosine of the angle between the two. Electrical engineers use the Greek letter ϕ (phi) for this angle, and so the power is calculated as $V \times I \times \cos \phi$ and $\cos \phi$ is called the power factor.

Electric Motors

Now we can make a start on electric motors. Most motors work by exploiting a basic phenomenon, which is that an electric current flowing at right angles to a

magnetic field in which it is immersed will experience a force which is at right angles to both. Conversely, if the conductor carrying the current is moved through the field (cutting those imaginary lines of force we talked about early in this series), then a voltage will be generated in the conductor. In order to keep track of the effect, an early electrical scientist named Fleming devised his right- and left-hand rules, which are written on the heart of all magnetically oriented electrical engineers. They work like this. First, identify the 'F'orefinger as field direction, the 't'hu' 'M'iddle finger for motion (we could as easily use the 'T' for travel) and finally the 'I'ndex finger for current. We usually use this letter for current. If you hold out your hands and extend these digits, you will find that they are mutually at right angles, but of course are of opposite hand to each other. The only remaining trick is to remember which hand is for motors and which for generators. There are a number of ways to do this but I remember only one. I say to myself "generighter".

Now, in a basic electric machine, both force (in the form of torque) and voltage generation take place at the same time. Whether the machine is generating or motoring depends on which way the current is flowing relative to the applied

voltage. The internally generated voltage is usually called the back EMF in a motor because it opposes the flow of current from the supply. The basic relationships are given in **Figure 6**.

However, all this is an aside to describing the induction motor, so let's get back on track. Although we model engineers mostly use only single phase machines, the workings of induction motors are easier to grasp if we start with the three phase version, so that is what we will do. I must warn you that we have to deal with time-varying sine waves (the electrical inputs) and the spatially-varying sine waves of the rotating magnetic field which the windings produce in the motor. Here we go!

Starting once more with the phasor diagram to depict the electrical pattern of a three-phase supply, the phases are represented by the three lines, spaced 120 deg. apart, as shown in **Figure 7**. Conventionally we refer to the three phases as Red, Yellow and Blue, and take the phase sequence as being in that order. With the motor or any other load connected in 'star', each of the three coils is connected to one of the three phases of the supply, as shown. However, they can also be connected between the ends of the three supply phasors as also shown in **Figure 7**. This is known as 'delta' connection, and you will see that the actual voltage across each winding is a lot higher. It is equal to the 'phase' voltage multiplied by the square root of three, which is 1.732. It doesn't matter that these new phasors do not start from the diagram's origin and so long as the motor windings are designed to suit, motors can be connected in star or delta. A useful trick for larger motors is to wind them for delta connection, but start them while star connected so that the reduced voltage on each winding cuts down the standstill current, which can otherwise be as much as five times the full load value. As soon as the motor is up to speed, the windings are switched to delta connection.

Figure 8 shows a set of three-phase windings and their resultant magnetic fields, again in phasor format. Each of these varies as their respective phase currents vary and next we have to work out the resultant field which we get by combining the three. This is done by calculating the resultant fields along two axes at right angles to each other. Since the three electrical phases are usually called 'red, yellow and blue' I have called the two axes X and Z. By means of a page or so of trigonometrical manipulation it is found that both the X and Z resultant phasors are of magnitude equal to $1\frac{1}{2}$ times that of the field of a single phase, and that one is a sine wave and the other a cosine wave. The resultant total field is thus of constant size and revolves once per supply cycle for the two-pole winding we have examined. For other numbers of poles the rule is that the field rotates one pole pair for each supply cycle.

Now, in the middle of all this is a short-circuited winding. In most of the motors we deal with it is the kind called a squirrel cage, named after the rotating cage used in cages for gerbils and hamsters (but

rarely for squirrels!). Cylindrical in shape, it consists of two end-rings and an array of axial bars. The whole cage fits onto a slotted laminated iron cylinder and is often made by casting it in situ from aluminium. The cage must be an electrical conductor, but the iron plays no part in generating motor torque. It is there solely to encourage the magnetic field to go inside the cage. So we finish up with a rotating magnetic field coupled to a conducting cage. As the field sweeps past the cage's bars it causes a voltage to be produced in them, and thus to bring about a circulating current along each bar, round the end-rings and back along the diametrically opposite bar.

Applying the law that a current flowing in a perpendicular magnetic field experiences a mutually perpendicular force (see the statement earlier in this article), we can at last see how torque is developed. The really clever thing is that the induction motor can be seen as a kind of transformer in which the stator windings act as the primary winding and the rotor cage becomes a short-circuited secondary winding. The delivery of rotational power is almost a kind of bonus! This brilliant concept was the brainchild of Nicolai Tesla, a Yugoslav citizen who emigrated early in life to America, where, after a scintillating career during which he patented more than a hundred inventions, he died in 1943. After this digression we had better get back to how the motor works.

As the rotor begins to go round, the frequency of the supply to the squirrel cage falls and, remembering the formula for volts per turn which we used when looking into transformer design, we can see that the rotor voltage, and hence the rotor current, is reduced. In fact, if the rotor went round at the same speed as the rotating field from the stator windings, the rotor would see the field as a constant, rather than an alternating one, and there would be no induced voltage, no rotor current, and no torque! It is for this reason that induction motors can never reach the speed of rotation of the stator field, usually called the synchronous speed. In practice, induction motors normally revolve at a 'slip', which is the fraction of synchronous speed by which the rotor falls short of synchronism. On no load a slip of three per cent is typical, rising to rather more than seven per cent as the load torque is increased. If the load torque is progressively raised, the slip gets greater and if it is increased far enough, the motor stalls.

At this point we have to deal with a fundamental law which applies to induction motors. Its proof is rather too complicated for these articles, but it affects the behaviour of the motor. It is in the form of a three-way ratio and it goes like this:-

Input power to rotor : Mechanical power out : Rotor electrical loss
= 1 : 1-S : S

where S is the slip, expressed as a proportion of speed,

e.g. a slip of $\frac{1}{2}$ means that the rotor is revolving at half the synchronous speed and a slip of 0.1 means that the rotor is turning at 90% of synchronous speed.

Applying this to induction motors gives some surprising results. Firstly, as the motor always runs fairly near to synchronous speed and thus delivers close to full power, reducing the applied voltage causes the input current to rise, so as to maintain the input power approximately constant. Next, if the motor is overloaded, the slip rises as the speed falls slightly. In these circumstances the input power rises not only to supply the extra output demanded, but also to furnish the increased rotor loss. For example, if the output power demanded causes the slip to rise from 3% to 7%, say, the loss in the rotor goes up to well over twice as much.

If you must have a drive with a wide range of speed variation, then you must use either a DC motor or one of the electronic frequency changers which are now available. These work by altering the input frequency so that the synchronous speed is varied. However, if the frequency is changed, then it is important to vary the supply voltage in more or less the same proportion. Remember that this is a form of transformer, and the volts per turn formula includes frequency as a factor. Sometimes the fact that the output power of the motor varies with the shaft speed can offset the abnormal operating conditions to some extent. If you choose to go the frequency changing way, then think through how the motor duty varies with speed and make sure that your supplier is aware of your intentions.

There is another way to have a range of shaft speeds which can be built into a motor. It goes by the name of 'pole amplitude modulation' and it works like this. **Figure 9** shows the field pattern of a four-pole machine. For convenience it is drawn as if it were derived from a four-pole permanent magnet which is revolving at synchronous speed (this is more or less the pattern generated by the more normal windings). On a 50 Hz supply, this field revolves at 1500 rpm, one pole pair per cycle, remember? Now if we reconnect the windings to reverse the polarity of alternate poles, then the rotor sees a two-pole field, now revolving at 3000 rpm. There is a slight notch in the middle of each pole, but the rotor takes no notice of this, and we now have a motor which can run at either 1500 or 3000 rpm synchronous speed according to how external switches are operated. Such motors have to be specially wound for the purpose, and they can be arranged to give other combinations of speed if required. This scheme is used sometimes on motors for washing machines and the like, and if, like me you are a dedicated cannibal of discarded machinery you may come across this kind of motor, which can be very useful sometimes.

Single phase motors

Before getting down to understanding how these motors work, I would like you to carry out a simple experiment. Find a small weight, say your smallest change wheel or a one inch nut, and tie it onto the end of a piece of string about a half to three-quarters of a metre long. Now, holding the other end of the string in your hand, try to set the weight

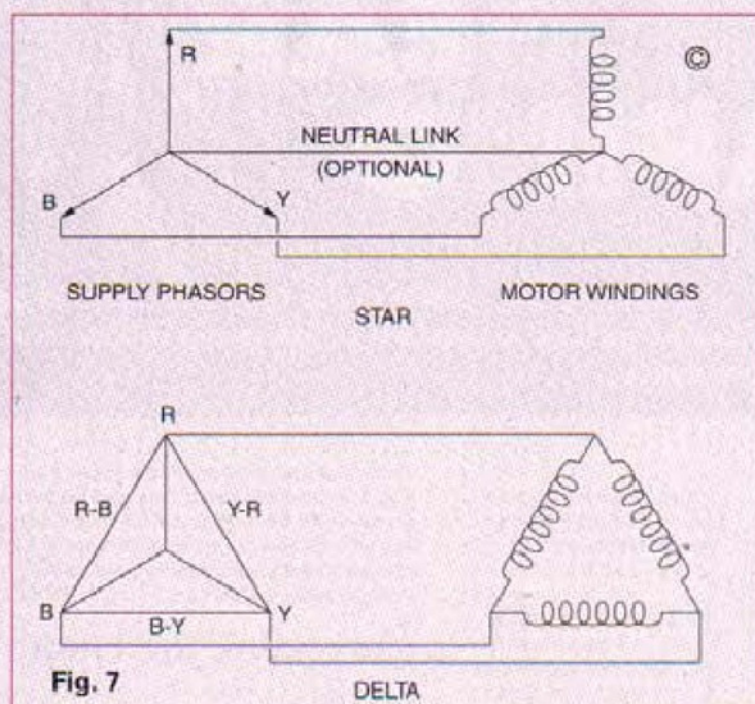


Fig. 7

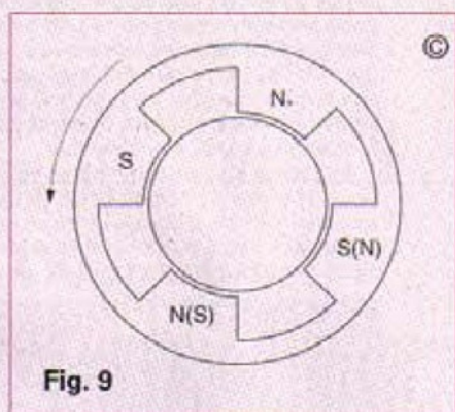


Fig. 9

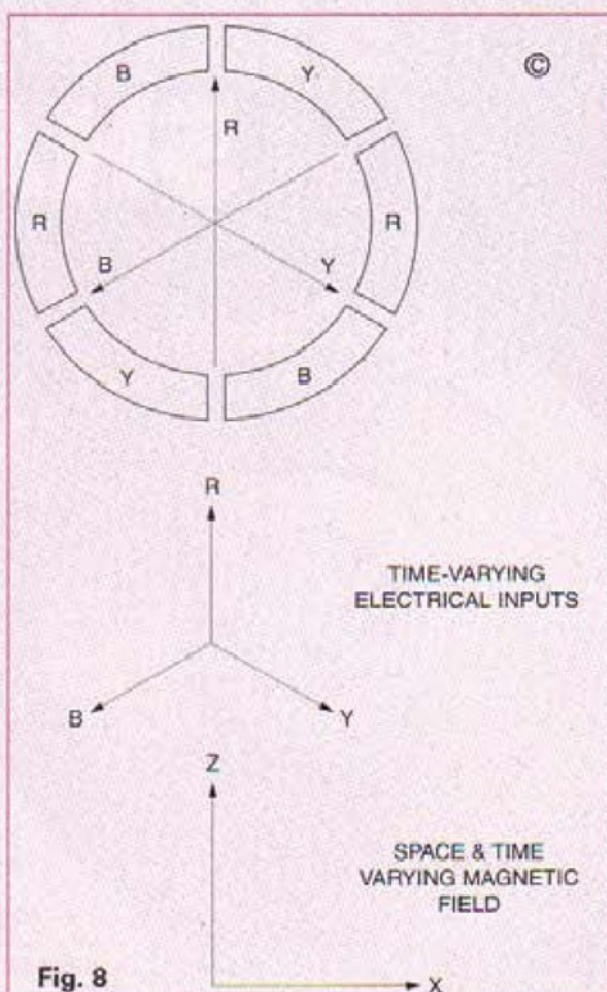


Fig. 8

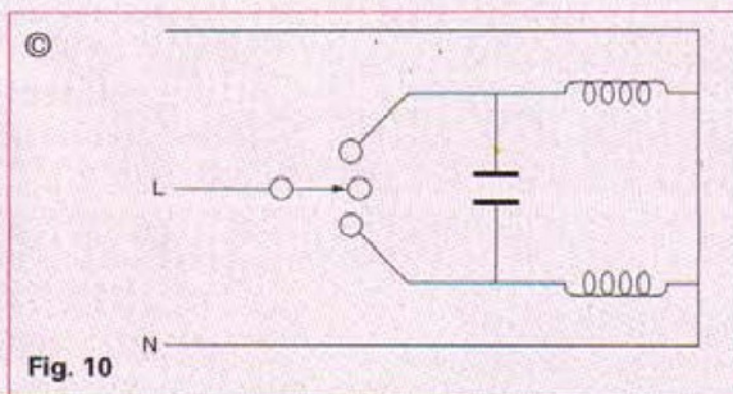


Fig. 10

swinging in a circular orbit, of 200mm diameter or so. You will have moved your hand in a circular orbit to get the motion started, or something close to circular at any rate. Next, having brought the weight to rest, try to set it on its circular orbit while limiting the movement of your hand to a straight line. It can't be done! But, if you set the weight in orbit again by using a circular hand movement, you will find, if you try it, that once the weight is in orbit it can be maintained indefinitely with your hand constrained to movement in a straight line only. This is an illustration of how a single phase induction motor can be started and run, even though a single phase supply cannot generate a rotating field. The secret of single phase induction motors is therefore to get

them rotating by adding a second phase, either just for starting or leaving it on all the time. The second winding can be rated for short time operation only if it is used only for starting, and this allows more space for the main winding as well as saving on copper costs. This last factor is offset however by the need to install a centrifugal switch to disconnect the starting winding as the motor gets up to speed.

There are two common methods of contriving a phase-shifted winding, which is usually called the quadrature winding. One is to deliberately arrange that its power factor (the amount by which its current differs in phase from that of the main winding) by adding an external resistor in series with it. The most popular method though is to connect a

capacitor in series with the quadrature winding. Remembering that a capacitor draws current which 'leads' the voltage, we can get a large phase shift in the current. Thus we arrive at the popular type called 'capacitor start' or 'capacitor start and run' according to whether or not the quadrature winding is kept on permanently.

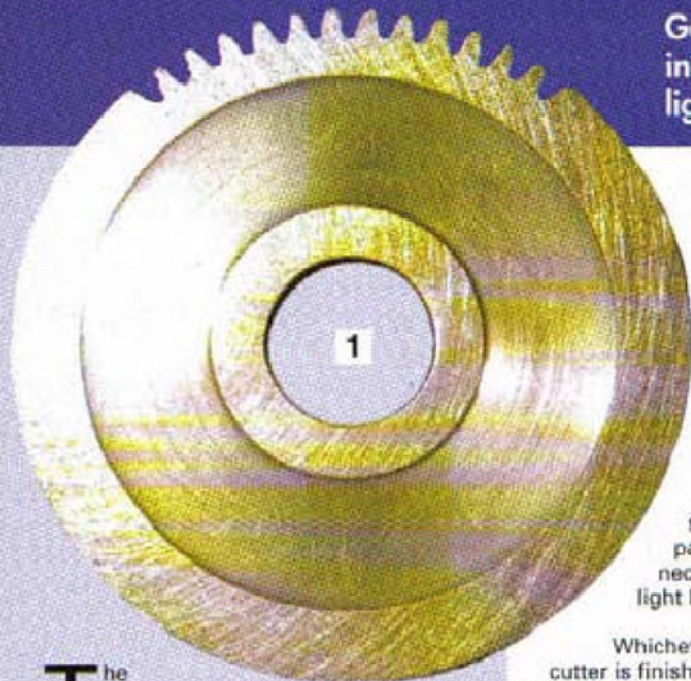
For motors which are subject to frequent reversal, the arrangement shown in Figure 10 has always appealed to me. The two windings are identical and the direction of rotation is controlled by the three position switch.

There are a few more details regarding induction motors which need to be covered, but they will have to wait till next time. Then we will continue by dealing with some other types of machine.



SIMPLE GEAR SHAPING

George Dimelow of Ashton-under-Lyne has adapted an industrial method to produce simple gears suitable for light duties



(1) By grinding a parting tool to 14.5 deg., with the usual clearance angles and top rake

(2) By making a silver steel 14.5 deg. taper D-bit. Setting the angle is a simple job and side clearance is put on automatically. The drawback is its lack of strength, so gashing with a parting tool will first be necessary with all but very light brass gears.

Whichever method is used, the cutter is finished off by grinding the tip to the width between the teeth at their root.

When made to cut a particular gear, it will cut any gears of the same pitch, regardless of the number of teeth.

Cutting the teeth

The gear blank should be set up on the lathe using a mandrel in the chuck. For dividing out, a division plate or the lathe's change wheels should be used. As an alternative I have used a miniature geared rotary table clamped on to the face plate with the spindle locked. An arrangement employing a dividing head if one is available would also be a possibility, but the methods described here have been chosen so that the work may be carried out using the minimum amount of equipment.

Now, with the cutter in the vice on the

vertical slide, set it exactly to centre height (Fig 1A). Light shaping cuts can be taken across until full depth is reached. Going round the blank, cutting each space between teeth, results in a gear with straight sided teeth.

Correcting the tooth form

Having found the circular pitch and raised the cutter by this distance above centre height (Fig. 1B), it is now in the same position as the next tooth would have been had a multi-tooth cutting rack been used. By repeating the shaping operation and turning the gear through one tooth at a time the tooth profile is brought nearer to the correct shape on one side.

Resetting the cutter by the same amount below the centre height (Fig. 1C) and again shaping across each tooth makes a correction at the other side. The slight corner where the flat surfaces meet

The cost of special

revolving cutters for making gears can be off-putting and although it is possible to make this type of cutter in the workshop, there is another method which can be used. The Sunderland Spur Gear Planing Machine uses a rack-shaped cutter moving backwards and forwards, taking repeated cuts from the blank. This blank revolves in time with the cutter head which gradually moves vertically by the same amount as if it were an ordinary rack meshing with a gear.

Making the cutter

The commercial machines use a multi-toothed cutter for speed, but it is possible to get the same result using one with a single tooth. It can be made by one of the following methods:-

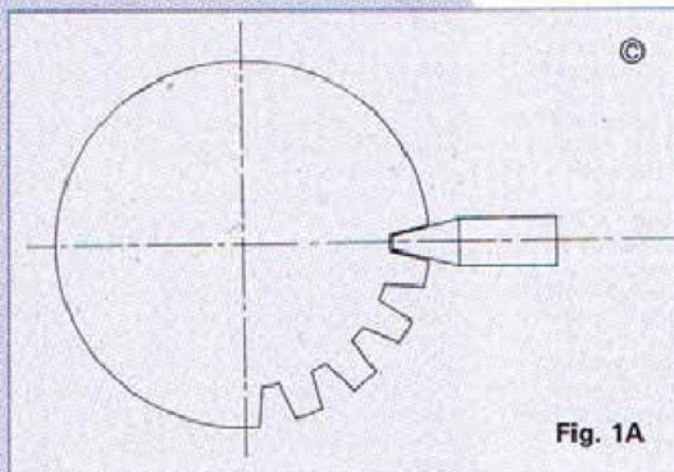
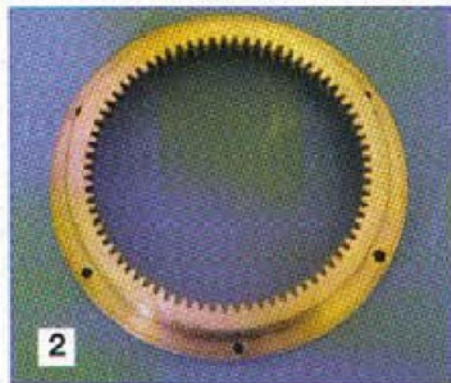


Fig. 1A

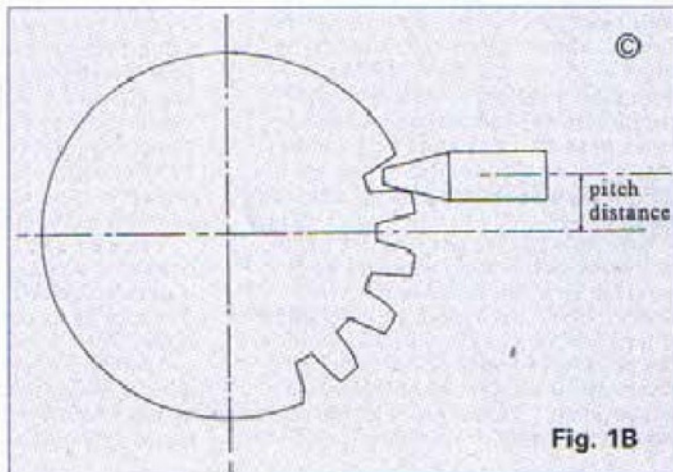


Fig. 1B

can be rounded off with a smooth file. This produces a spur gear (**Photo. 1**) which is perfectly adequate for low power applications where high efficiency is not needed. Although I have not found it necessary, it would be possible to generate an improved tooth form by making more shaping passes, using very small angular movements of the gear and matching height settings of the cutter.

Other applications

Some thirty years ago my father and I built a model of Murray's Hypocycloidal Steam-Engine and we used this technique to cut the epicyclic gears. Making a small internally cut gear (**Photo. 2**) would be difficult by any other method. A purpose-designed broach could have been used to cut all of the teeth at one go, but this would not have been practical when making just one. The author of a more recent article describing the construction of a similar model solved the problem by arranging to make available a set of laser cut gears.

Cartwright's Portable Engine used a rack on the piston-rod linked by a pinion to the rest of the engine. On a model the rack (**Photo. 3**) was made by the shaping method. This just required clamping the blank vertically on the face plate with the spindle locked and shaping the teeth one at a time with the height of the cutter reset by the pitch distance each time. The same cutter was used to make both the rack and its pinion.

A whole range of toothed wheels of

varying degrees of complexity can be cut using shaping methods, with a version of the Sunderland machine even having been made to generate the teeth on double-helical gears.

Most of the technical data required to calculate tooth proportions can be found in 'Machinery's Handbook', which can be consulted in the reference section of many public libraries.

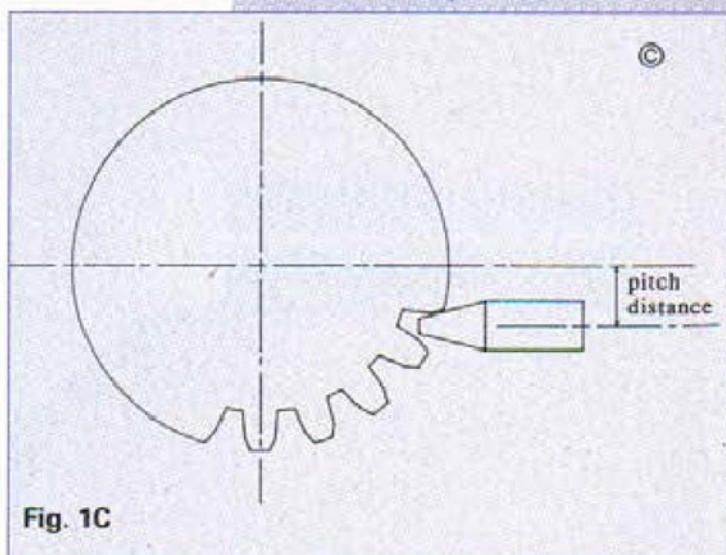
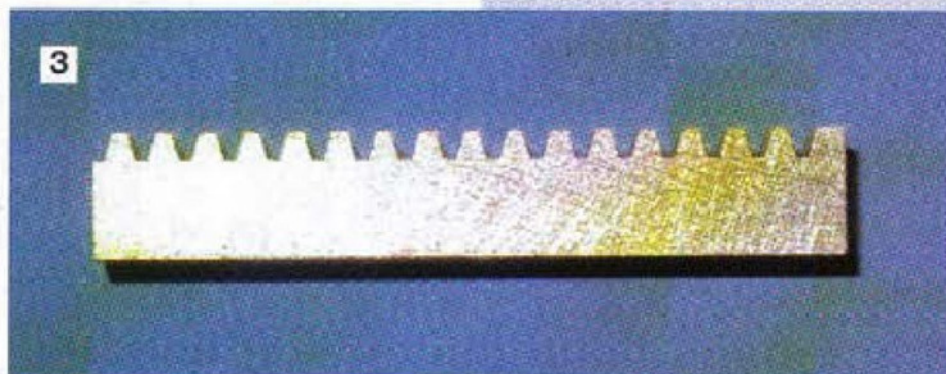


Fig. 1C

IN OUR NEXT ISSUE

Coming up in Issue No. 73 will be

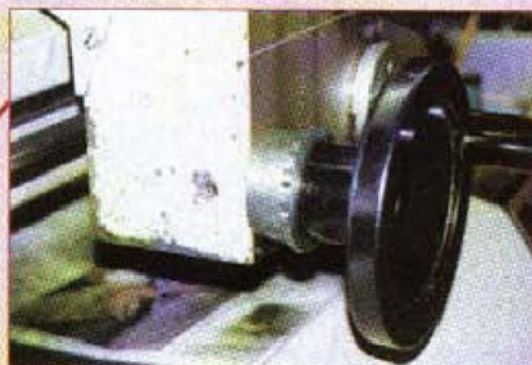
AN AUTOCOLLIMATOR FROM THE SCRAP BOX

Bill Morris shows how to construct a precision optical device which has many potential applications in the workshop



RENOVATING AN ATLAS HORIZONTAL MILLING MACHINE

Mike Thurgood gives a new lease of life to an elderly machine



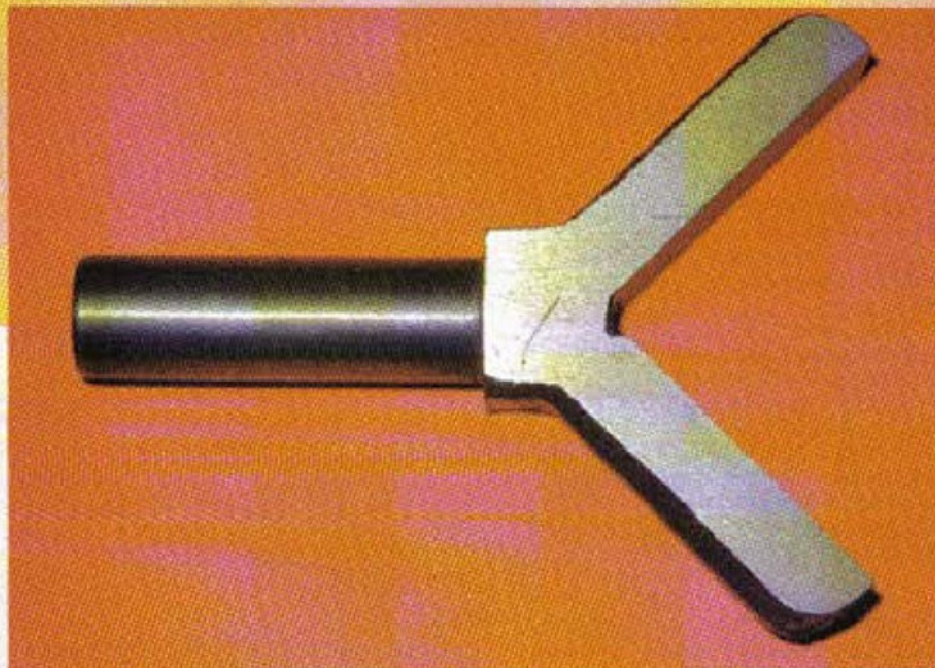
SADDLE AND TAILSTOCK HANDWHEEL DIALS FOR A HARRISON M250 LATHE

Additions to lathes not fitted with these items as original equipment, described by Shelley Curtis

Issue on sale 13th April 2001

(Contents may be changed)

FINDING THE CENTRE



1. The simple version of the centre finder which has to be set against the workpiece by eye or by adjusting the gaps using feelers

It is customary to find the centre of a shaft in the miller either by the use of a wobbler or by chucking a pin of known diameter, touching it to the side of the shaft and moving the Y axis by half the diameter of the pin plus half the diameter of the shaft.

When developing the Quick-Step Mill neither of these options could be used and an alternative was developed, as shown in Fig. 1. This simple tool (Photo. 1) is perfectly good, but its use depends on seeing daylight gaps, which is not always possible, or using feelers which is a bit of a fiddle.

A year or two ago, SMEE member Tony Philips found a centre finder in the USA and kindly made me a gift of it. Tool supplier Chronos now sell it and its novelty lies in the swivelling fork with an indicating arm which shows centre when two lines coincide. It is, however, only as good as one's ability to judge when two marks are in alignment and, as it is known that feel is more sensitive than eyesight, the design shown in Fig. II was made, wherein the indicating arm was contained within a housing of exactly the same size, pivoted so that any misalignment between arm and housing could be felt with great accuracy.

However, in use it was slow, as it was not possible to traverse the QSM or the milling table without withdrawing the centre finder from engagement, otherwise high thrust forces would be

developed and damage would occur. To overcome this drawback, the version shown in Fig. III was evolved, in which the fork, as well as being able to pivot, is free to move longitudinally over a short distance. It is spring loaded to keep in contact with the workpiece and it is now possible to engage the centre

John Payne, designer of the Quick-Step mill decided that existing designs of centre finder could be improved upon. This sprung version depends upon feel rather than eyesight

finder and traverse until truth is obtained, rapidly and without any risk of damage. The three stages of development are shown in Photo. 2. Consideration has been given to fitting the fork housing with a sliding sleeve which can only be slid home when all is true, but this was rejected on the grounds that, should it be left in the 'home' position, an attempt to use it could either cause damage or reduce its effectiveness to that of Fig. 1 design.

As the design of Fig. III seemed to have some merit, a patent has been applied for, and I would be pleased to find someone to make and market the device.

Readers who wish to make a centre finder for their own use may do so, and the following tips may be helpful.

Manufacture

The method of manufacture adopted entailed making the fork, finished in all



2. The three stages of development of the centre finder

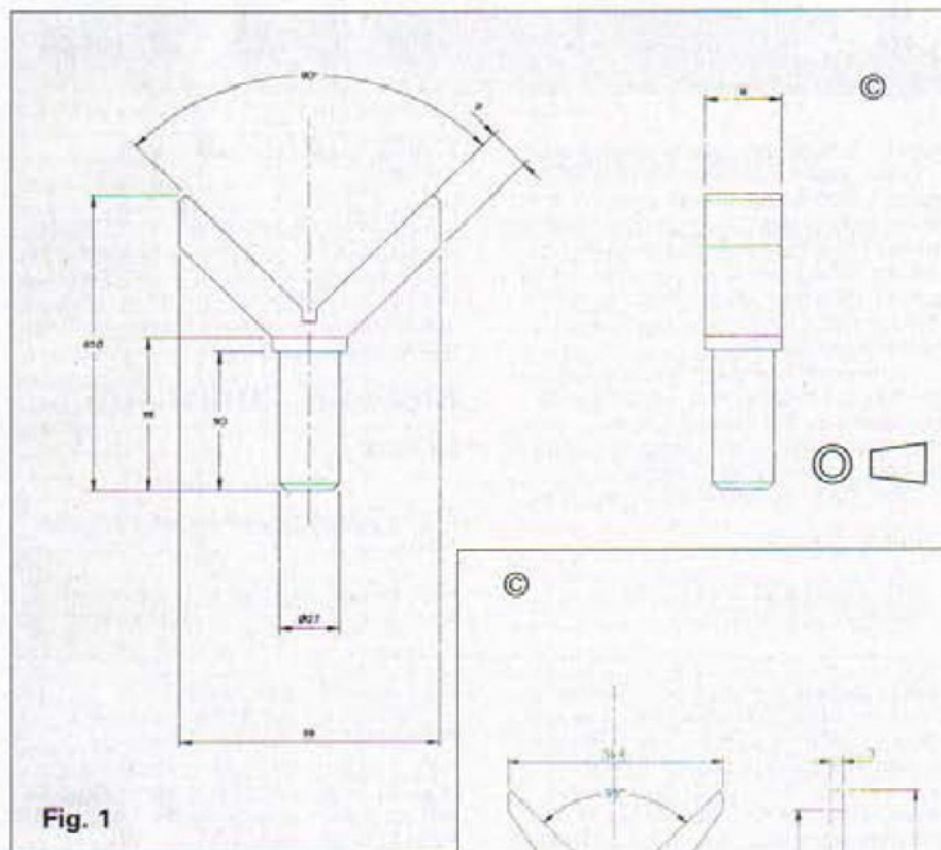


Fig. 1

respects except that no slots were cut in it, and the indicating arm was left 1mm over-wide. The fork housing was entirely finished except that it too was left 1mm oversize and with the 3mm pin hole undersize for reaming at a later stage.

A piece of material is held in the tailstock chuck and drilled $15/32$ in. with the drill in the lathe chuck and, if the 4-jaw is used for this, it can also be used to hold a boring bar to enlarge this hole, so that the shank or spigot of the fork housing is a perfect sliding fit. Having done this, do not remove the bush from the tailstock chuck or the chuck from the tailstock.

The 4-jaw is now used to chuck a piece of, say, $2\frac{1}{4}$ in. dia. aluminium which is then coned to agree exactly with the angle of the fork.

Enter the 12.7mm ($1/2$ in.) spigot into the tailstock bush, Loctite both the fork and its housing slot, assemble and advance the tailstock until the fork is engaged with the cone and allow to set off in this position.

When cured, remove and drill and ream for the 3mm pin and drill cap screw clearance size through the fork, then fit both the pin and the cap screw without disturbing the fork.

The assembly is now chucked by the spigot to turn both the fork and its housing to a good finish at 19mm (or $3/4$ in.) diameter. The fork is then removed from its housing (gentle heating to destroy the Loctite bond may be necessary) and set up in the mill to have both the slot and the box milled. It is important that the 3mm or $1/8$ in. slot is parallel with the edge, that the cutter cuts dead size and that the cutter is truly centred over the hole.

Parallelism is assured if the vice jaws

are checked to be truly over the hole. This will call for a very short pin to be fitted so that it can be clocked round. The only way to be sure that the slot drill cuts to size is to try it out first on a scrap piece of gauge plate.

After machining and de-burring, the components may be assembled. It will only be true one way, and the cap screw, with a little Loctite, is just firmed up so that the fork does not flop about. Fitting a $3/16$ in. bearing ball, a spring and a $1/4$ in. UNF grub screw into the centre of the spigot completes the job. If desired, two warning lines may be scribed across the fork, one on each side, just short of full engagement.

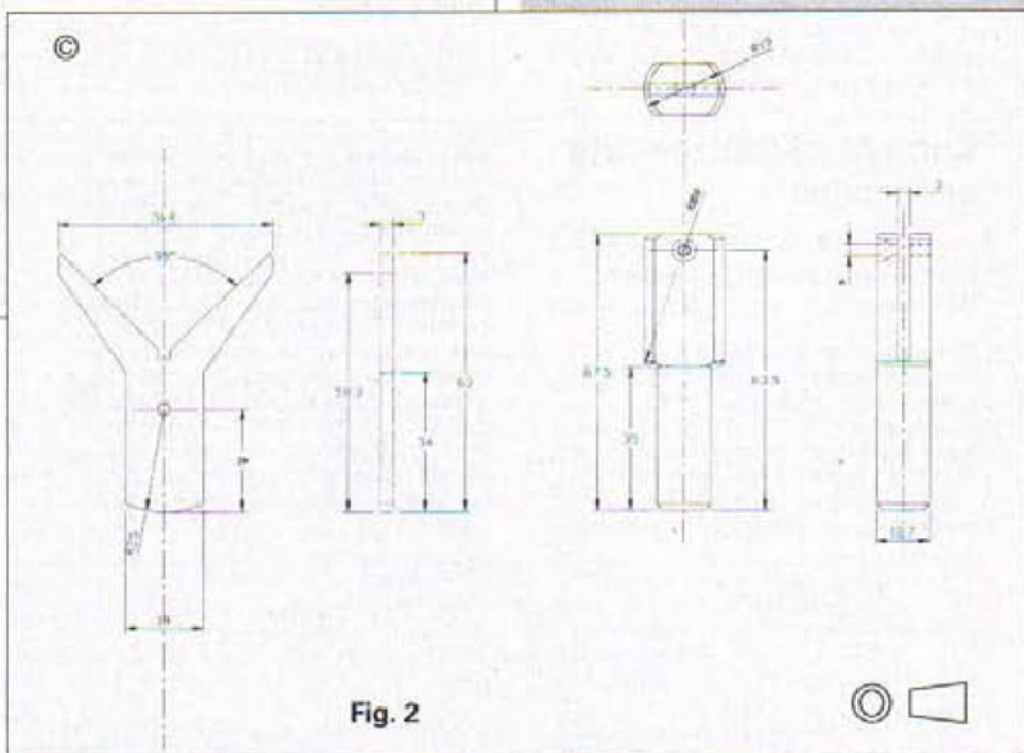


Fig. 2

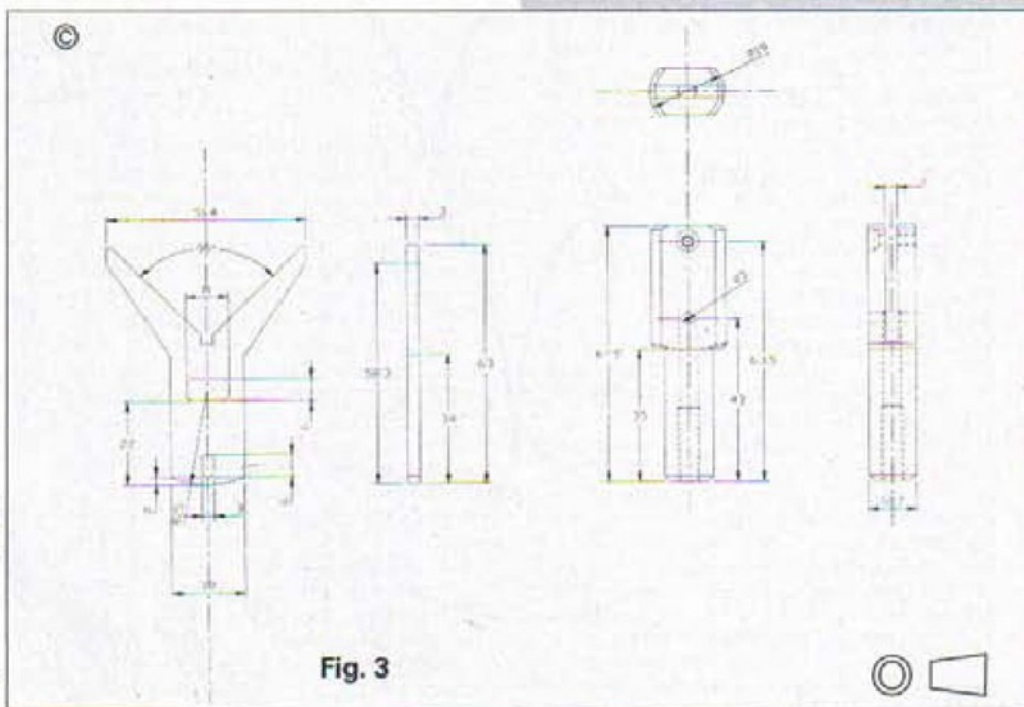


Fig. 3

SCRIBE A LINE

With a little help from the angels!

From J. R. Lait, Lincoln

The following will be very useful to model engineers and, from my own experience, all other sorts of engineers as well. It was given to me by an old workmate many years ago and has proved its worth over and over again.

I first met Sid when I joined a Research Laboratory. The work was very interesting and occasionally very difficult, made more so by the use of pure metals and weird alloys. Sid was a centre-lathe turner, as was I, but Sid was able to perform 'miracles' of surface finish, unobtainable by lesser mortals. Neither did he suffer

from broken drills or taps of small sizes.

Closer association with Sid revealed his use of a fluid which he kept secreted in his locker, only to see the light of day when a special job appeared (e.g. drilling and tapping 25BA holes in an extremely tough armour plate type alloy). Pleas by his peers to share this 'magic' fluid were refused point blank.

Some years later, I left that place to improve my chances and, on the day of my departure, Sid handed me an envelope, saying, "Don't open this till you get home, it will come in handy".

Later, I opened the envelope and read:

ANGEL'S BREATH

1 PART GENUINE TURPENTINE
2 PARTS WHITE SPIRITS

3 PARTS OLIVE OIL (SHAKEN OR STIRRED)

This 'formula' has been a tremendous aid to me in my work for many years, and I can strongly recommend it. Smokers beware as it is highly flammable, but it has proved to be 'angel's breath' on many occasions.

More on varnishing brass

From Edward Coady, Sevenoaks, Kent

I am only an amateur horologist and home engineer, but I may be able to

Current meter reading anomalies

From Frank Brown, Eastleigh, Hants

This is mainly a reply to Peter Rawlinson's question about why his current meter reads low (Further Experiments With CNC, Issue 70), but has some explanatory notes, which may be of interest to the general readership.

Peter is using a full wave power supply, supplying about 9 Amps. At this

sort of current, a smoothing capacitor in the order of 160,000 Micro-Farads would be required to reduce the 'ripple' on the supply to a value of around 10%. If the value is very much lower than this, the effect is that the 'DC' is actually just the rectified AC. If Peter was using a Moving Coil meter (a non-electronic 'AVO' or such like) it would be responsive to the MEAN of the wave form. For a rectified sine wave, this is its peak value multiplied by 0.637, i.e. $13.6 \times 0.637 = 8.66$ Amps. The 0.707 figure is to convert the peak voltages heating effect to that of DC, i.e. the heating effect of his 13.6A rectified current is the same as a DC current of

$(13.6 \times 0.707) = 9.62$ Amps.

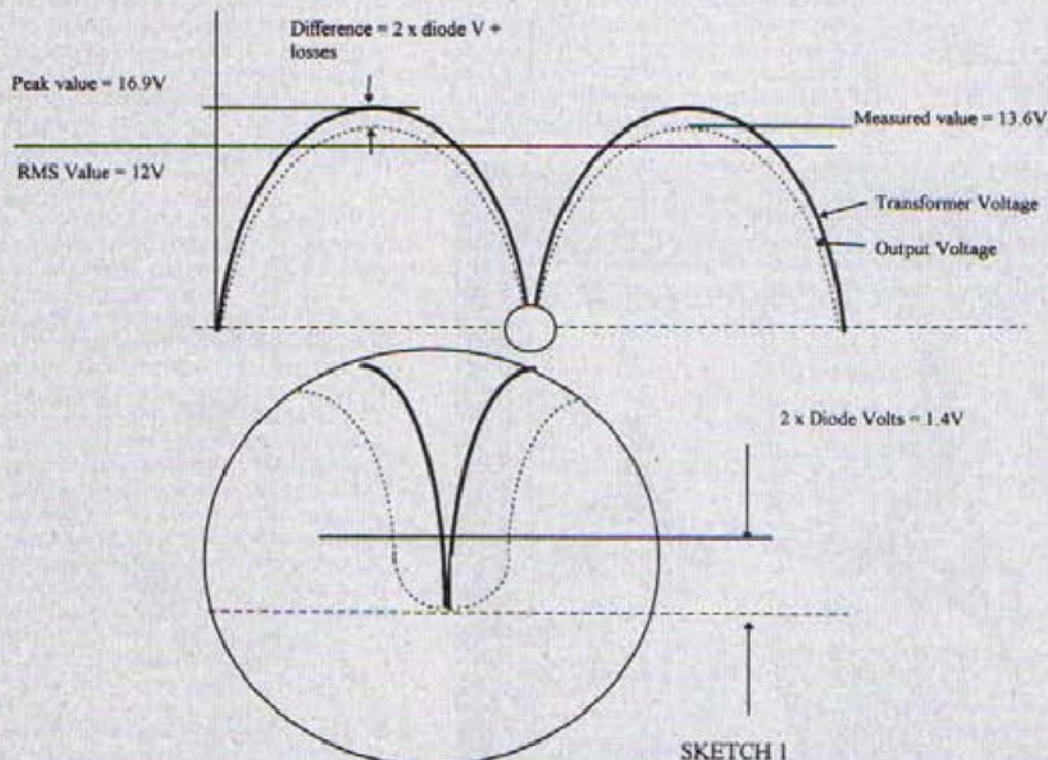
The ratio 0.707/0.637 is called the FORM FACTOR, and for a sine wave is 1.11. This form factor varies with the sort of wave form that is being examined and can produce very large errors if the wave form is pulsed on and off.

Example:-

Suppose we have a 12V battery feeding a load of R ohms for 100% of a time period. The average power is $12^2/R$ and the average voltage is 12V - no surprise here. Suppose we pulse the voltage on and off so it is on for only 50% of the time. The average voltage is now

6V, so let's get the average back to 12V by increasing our battery voltage to 24V. Right, the average (Mean) is back to 12V, BUT the heating effect is now $24^2/R \times 50\% = 288/R = 16.92/R$. So, while the MEAN has stayed the same, the Heating Effect (RMS) has increased by 1.41! In this case the form factor is $RMS/MEAN = 1.41$.

The Peter Rawlinson form factor also is even greater than the 'classic' 1.11 because the silicon diodes that convert the AC to DC do not conduct at all below a certain voltage (between 0.6 and 0.8V - depending on the type), as there are two of them in series in the power supply, it means that the power supply output is actually ZERO during the portion of the sine wave when the voltage is lower than $2 \times 0.7 = 1.4V$, and with a transformer secondary voltage of 12V, will cause additional distortion to the wave form and hence a higher form factor conversion number (see sketch).



help Dr. W. B. Amos, who's letter about protecting brass appeared in Issue 69.

Firstly, my experience of old (Victorian) scientific instruments is that the wonderful finishes on them were of a shellac varnish, which is similar to the French polish still available in certain woodworking and hobby outlets. It is, however, easy to make by dissolving shellac in methylated spirits. I have tried this on smaller articles with some success, by applying with a fine hair brush or cloth 'rubber', and it gives that old 'antique' look, but it is tricky to obtain a smooth and even appearance due to the fact that it is very quick drying. I would strongly advise experimenting with the strength of the mixture and trying to apply with a small air spray unit on larger pieces, but I would certainly give it a try on scrap first.

Modern synthetic finishes are also effective. I have used a cellulose (clear lacquer) spray made by Simoniz, which is good for protection on any metal, easily obtained from my local auto dealer for many years. However, caution needs to be exercised when contemplating using it on antiques. It is of a quite thick consistency and can easily be over-applied if too enthusiastic; again, experiment to aesthetic taste beforehand. I have used it successfully on old clock bezels; the trick being not to polish the brass to a high mirror finish beforehand (a light rub over with very fine wire wool is effective after polishing to take away that overdone look), but I would not use it on any working parts of a clock. It gives a quite authentic and lasting appearance. Trade-bought items are often treated this way but also often, I feel, they have a very over-finished look due to the high polishing previously referred to, and I have nearly always resorted to stripping and re-applying it myself, to achieve an acceptable result.

I hope this helps. Good luck.

From Howard J. Lister, Hemel Hempstead, Herts

I would like to suggest to Dr. Amos that he should try Furniglass 'Hardset' or possibly Ripmax 'Tufcote' (reference Ian Peacock's 'Air Brushing Manual' ISBN 085242 8022).

I have used both on wood; put on layer by thin layer, as in French polishing, with a 'rubber' (cotton wool inside a cotton covering - a handkerchief!). Both certainly give a first-class finish. Brass is difficult initially, but I believe that the success of the finish on old brass instruments was the multiple thin layers.

Formic acid is, according to Ian Peacock, a urea formaldehyde melamine-reinforced, acid-cured lacquer - I would like to know what the acid is.

On a different topic, may I ask if readers have any experience or suggestions about putting a clutch on a large lathe (Smart and Brown 10in. x 24in.), the electric motor of which is 2 - 3 hp.

I would like to make one on the lines of a Myford clutch, but the pieces of metal are very expensive in sizes of several inches diameter. I have tried (unsuccessfully) to obtain old clutches

from motor cars or motor bikes.

I would like to know of sources of magnetic clutches, and if they would be suitable.

Excellent service

From Dave Quartermaine, Kettering, Northants

I would like to advise readers of M.E.W. of the excellent service experienced from one of the advertisers, namely the Metal Procurement Company.

My latest project required a specific grade of steel in quite small amounts and various diameters. I contacted MPC and was given advice in a cheerful and well-informed manner. The small order required posed no difficulty, with next-day delivery promised. An apologetic telephone call was received the next day advising that, due to domestic difficulties, there would be one day's delay - which proved to be the case.

The icing on the cake was a Certificate of Conformity for each individual diameter, for the nitride hardener's needs.

In this day and age I believe that this type of service deserves support. The usual disclaimer applies.

Radiused centre drills

From Tony Beech, Church Broughton, Derbyshire

Readers may like to know that these are available in Britain from any branch of Cromwell Tools, under the name of HSS Combined Countersink and Drill, type Radius Form, in five sizes ranging from 1/8in. (BS1R) to 7/16in. (BS5R). Cromwell tools can be contacted on 0116 2546721 at their Head Office in Leicester or at branches around the country.

A little ingenuity taps an odd thread

From Ted Wale, Porters Lake, Nova Scotia

I bought a nice little tap from a plumbing range of items which was exactly what I needed for a project. It was only 1in. long and about 1/2in. square. It had a male thread at each end, with the little tap mechanism in the middle. It is made for compression coupling of 1/4in. copper pipe. I needed to screw it into a brass block, so I needed a female thread there. However, when I came to measure it, I found that the male thread was 7/16in. - 24! The standard fine threads are 3/8in. - 24 or 7/16in. - 20. OUCH! No such threading tap available. It was conceivable that, on the lathe, I could cut an internal thread into my little block, but it would not have been easy.

At this stage, I suddenly remembered a tip that one of the Club's grey beards had put in the Club news letter a few months before. The 3/8in. tap, the next size down, is the right thread. Take a small piece of hardwood with an approx. 90 deg. corner

and chisel a small piece off the corner so that the piece starts with about 1/8in. sides and tapers to a blunt point. Put this sliver into one of the flutes of the 3/8in. tap and put it all into the hole correctly drilled for a 7/16in. thread. The tap will be held off the hole wall on one side by the wood and it will cut on the other. Obviously, it will cut oversize, which is exactly what is wanted. After the first pass, slide the tapered wood down a bit and cut again. It is surprising how much it cuts, so it is necessary to keep checking after each pass, else it is very easy to finish up with a sloppy thread.

The system worked like a charm and, with only three passes, I had my thread. I was working in brass and, presumably, a steel block would have needed a few more passes. The bit of wood suffers, but who cares? When I mentioned it to another experienced machinist he said "Yes, but I use a piece of shim to do the same, by covering two of the four flutes." I tried that also, but I did not find it as easy as the wooden spill. It probably is a question of practice.

I hope that this is as useful to a reader as I found it when I needed it.

Oiling Myford Lathes

From Ray Noonan, Chester

Eureka! May this formerly oily Myford owner unreservedly recommend the Reilang pressure oiler (Part No. 017-283)?

It simply puts oil where you want it, and nowhere else. The downside is that one's left arm no longer slips effortlessly into one's workshop coat and the sleeves are now the same colour. (Those for whom this would be a deprivation may prefer to continue with the character-building pompom supplied by Myford).

Available from Blackgates Engineering for £15 plus p&p & VAT. (Usual disclaimer).

Turning tapers

From Simon Jackson, Nesoya, Norway

I read Doug Ball's article on his device for offsetting a tailstock centre. I already have such a device, cunningly disguised as my boring head.

'Smarty-pants' was very pleased with this idea: he could use the micrometer screw on the head to put on the offset, and could proceed to turn his tapers, knowing that they would be accurate, and without all the usual flaffing about making trial cuts, measuring, adjusting, new trial cuts, and so on.

Not a bit of it! Here was a heffalump trap for young players. The resulting taper was too steep (I was turning Morse Taper blanks). The problem is that when the workpiece is not parallel to the lathe axis, the centre no longer seats in the centrally in the centre-hole in the workpiece, but seats on the side of it. This effectively lengthens the workpiece, resulting in a steeper taper.

I wish I'd thought of Doug's trick of using the DTI to set over the tailstock centre. Now that really is elegant!



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