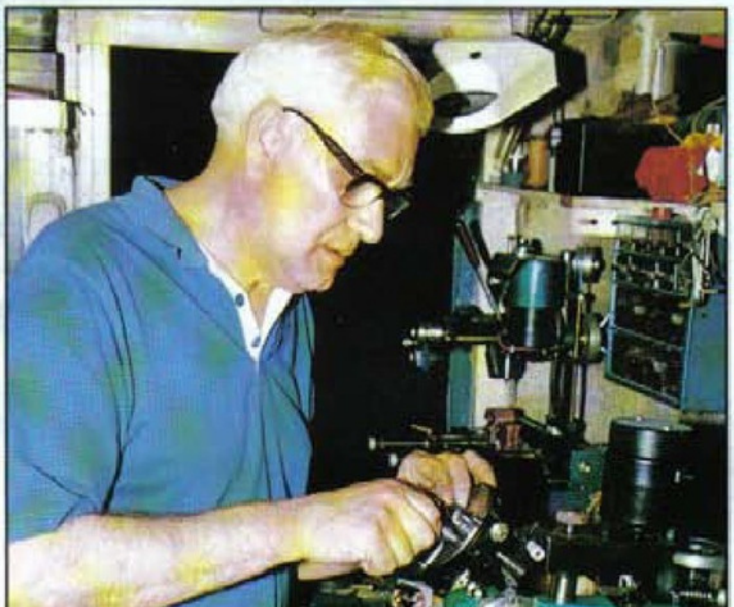
No. 14

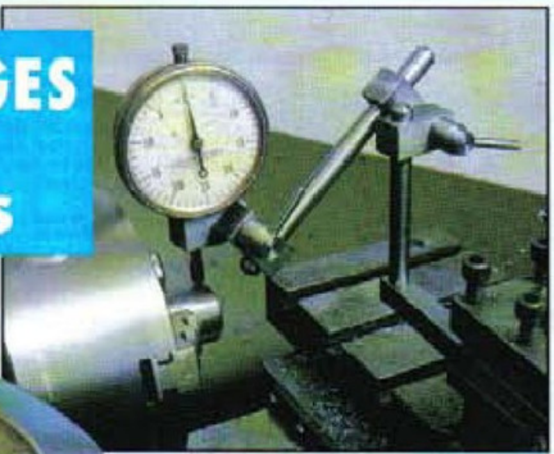
DECEMBER/JANUARY 1993 £2.50

MODEL ENGINEERS' WORKSHOP

62nd MODEL ENGINEER AND MODELLING EXHIBITION
OLYMPIA LONDON JANUARY 1-9 1993

THE PRACTICAL HOBBY MAGAZINE





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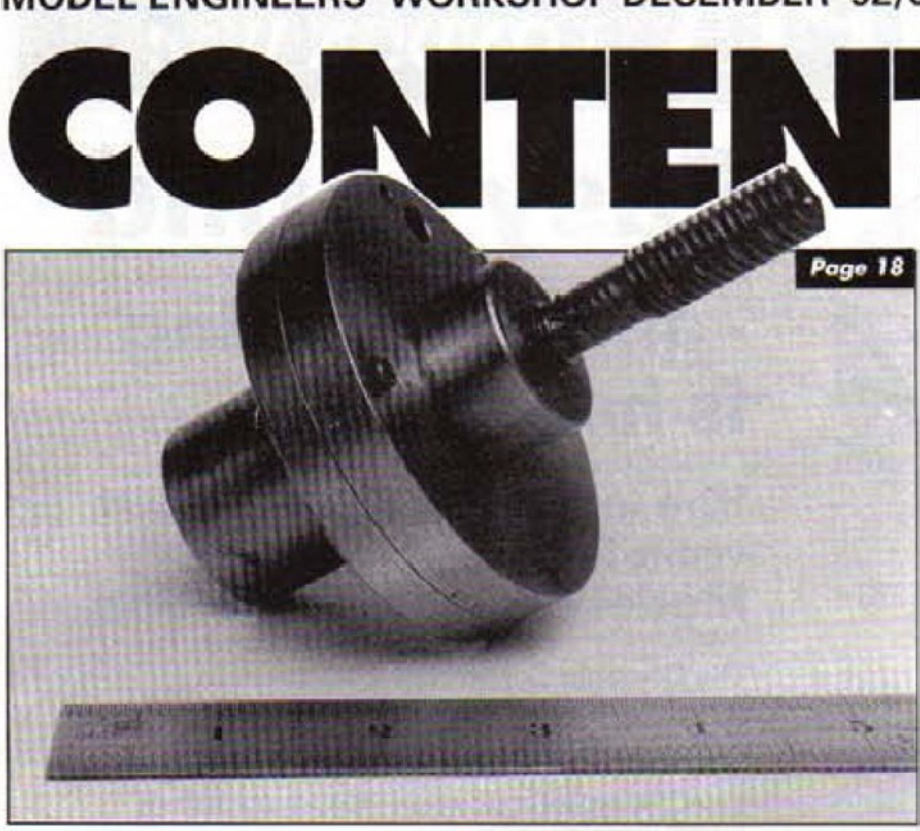
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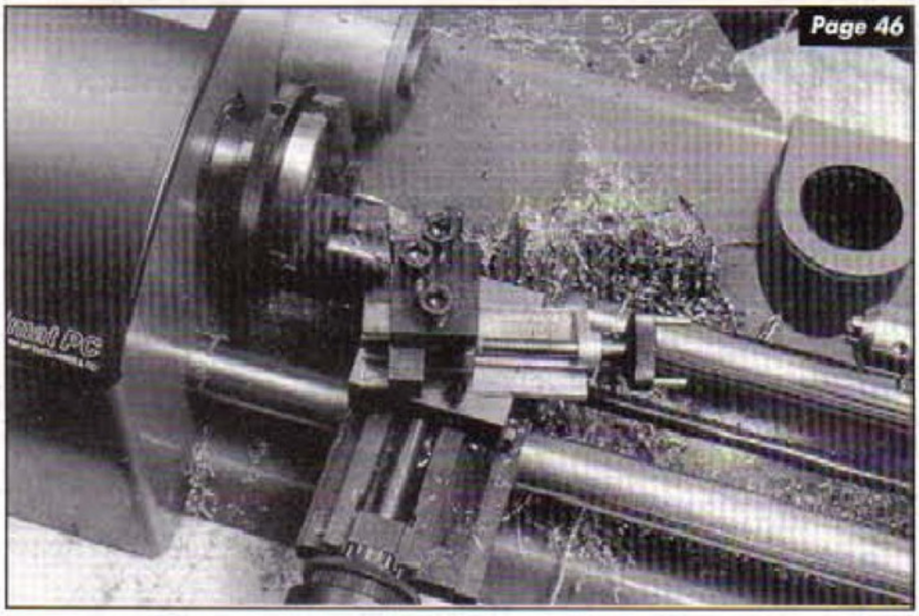
Workshop user on the cover is Geoff. Bartlett of Birmingham.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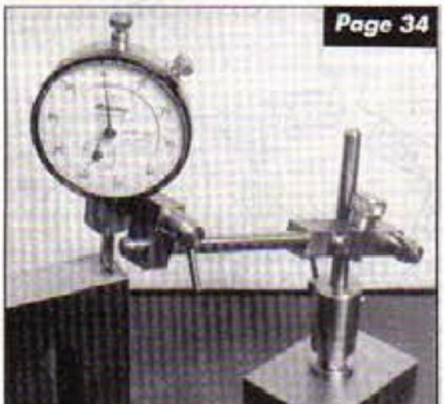
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Harold Hall

ON THE EDITOR'S BENCH

62nd International Model Engineer and Modelling Exhibition

Being the last issue of *MEW* prior to the 62nd International Model Engineering and Modelling Exhibition I would like to make a few comments regarding this event.

First, the venue which will be the Grand Hall, Olympia, Hammersmith Road, Kensington, London W14. It will be held from the 1st to the 9th January 1993 open every day 10am to 6pm, Thur 7th 10am to 8pm.

I have to confess that a few years back, and not being a regular reader of *Model Engineer* at that time, (shame on me), I duly turned up at Wembley as I had done for a number of years and found there was not a steam engine to be seen. I was told by the security guard that the exhibition had been moved to the Alexandra Palace, apparently there had been quite a few like myself, I do hope not too many will make a similar mistake this year. Whatever your interests, we hope that you can attend the exhibition, if it is within reasonable travelling distance. See the advertisements for more details regarding the exhibition, travelling and car parking facilities.

There are always a wide range of trade stands selling workshop equipment, with many bargains not likely to be available anywhere else. On the other hand, if you would like to be an exhibitor, displaying a model or some item of workshop equipment that you have made, there is still time. In many cases arrangements can be made for the collection and return of exhibits where exhibitors are unable themselves to deliver to the exhibition hall.

Changes have also been made to this provision this year which should be of benefit to exhibit and exhibitor alike. These changes are as a result of more transport and personnel being made available for this task. For the exhibitor this means that the item will be picked up just a day or two prior to the exhibition and taken directly to the exhibition hall, after the exhibition the same will apply but in reverse.

As a result the exhibit will be away from the exhibitor for considerably less time than previously, and this, together with there now being no requirement to off load into store before and after the exhibition, will considerably reduce any possibility of damage occurring. For further information and entry forms contact Argus Specialist Exhibitions, Argus House, Boundary Way, Hemel Hempstead, Herts, HP2 7ST. Tel. 0442 66551. Fax 0442 66998.

I hope to be in attendance at the exhibition on at least some days and would like to meet up with readers of *MEW.* If you have some point to make, or question to ask, do attempt to made contact with me on the Argus stand.

C.A.D.

My request in the June/July issue for details of members experience in using CAD in the home workshop environment (not professional use) has provided some interesting information. There is still some time for readers to send in details of the system they use together with examples of its capabilities. I am particularly interested in CAD packages in the few tens of pound price bracket, and also the use of the facilities provided with desk top publishing packages and the like.

Correspondence

Readers may be aware from comments in previous issues of *MEW* that the position of editor is not based at the office of Argus Publications. In view of this, all correspondence has to be forwarded on to me at my home address, as a result there is some delay in my receiving it. This rarely causes a problem but in some situations may cause unnecessary delays, I am thinking of instances where the requirement is for the correspondence to be dealt with by some other department at the office and I have to return it. This will place a delay of probably 4 or 5 days at best, maybe a few weeks at times of holidays.

I would therefore request that as all mail just addressed to *MEW* is forwarded to me, that should the subject relate to non editorial matters the envelope should be very clearly marked accordingly. Examples of this are orders for back issues or subscriptions, or readers offers. In these cases please clearly make your envelope "Back Issues", "Subscriptions", "Readers Offer" etc. and not mentioning *MEW.* This will save me a little involvement, but more important, will avoid unnecessary delays in your request being actioned.

History of machines and materials

As a result of much prompting by readers of *MEW* to include some items on the history of machine tools, we start in this issue with an item on the history of iron and steel, without which machine tools would not have developed. The series is being provided by Don Unwin who has provided much material for publication in both *M.E.* and *MEW* over the years. He has a considerable interest in the subject of the history of machines and I feel his contributions will be a worthwhile inclusion in the magazine.

Stan is back

I am pleased to say we have an article in this issue by Stan Bray, as most of you will know, the original editor of *MEW.* Stan did much to get us started and well and truly off the ground, before I took over, when all the hard work had been done. He is reviewing the new Warco 220 lathe, which he enthusiastically endorses.

Drilling square holes

For many the possibility of drilling square holes would seem a non starter. In this issue Derek Winks provides the answer that it can be done. It is interesting to read how he was prompted by a letter in *The Guardian* newspaper to write the article.

Availability of materials

Whilst considering the supply of goods and services, I feel that many readers overlook the fact that there are many very small sub-contract machine shops, who, like the home machinist require materials in relatively small quantities. As a result, it is not as difficult to purchase certain materials locally as is often suggested.

Typical of this is a requirement to purchase a short length of a relatively large size bright mild steel bar, say a 3in. length of 3in. diameter. It should be obvious that rarely will a small firm, or frequently even a larger one, be in a position to purchase a full length bar of such material, and will need to purchase just the amount required.

A similar situation occurs with another request from readers, this being for facilities for sharpening tools, particularly end mills and similar. Many small firms again will not have their own cutter grinders and will rely on specialist firms, usually themselves quite small, to provide this service.

The lesson to be learned from this brief comment is not to assume that, just because the item is not listed in the catalogue of a supplier to the home worker, it will not be purchasable by the private individual from a supplier who normally supplies the trade.

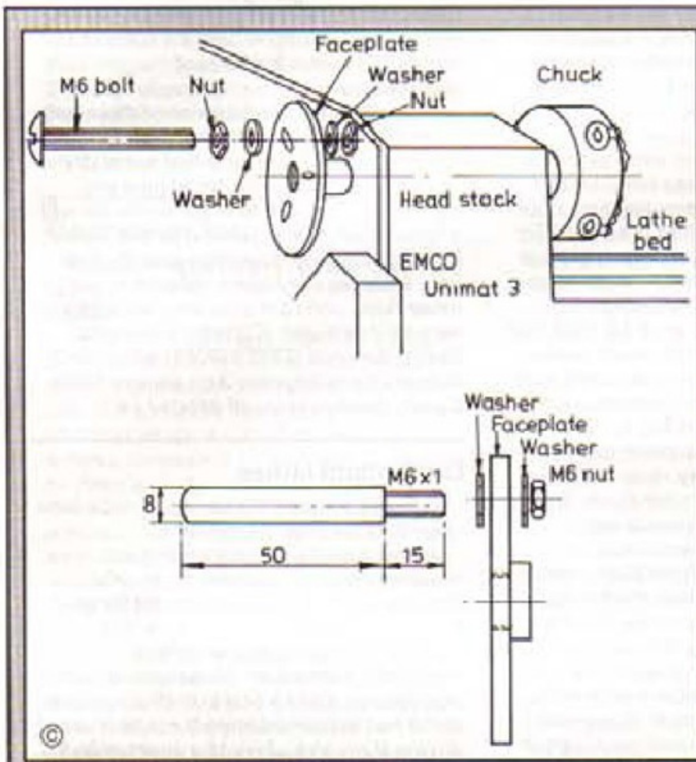
Firms specializing in providing such services can be located in *Yellow Pages,* British Telecom's directory of industrial organisations. No doubt readers outside the UK will have similar lists available. Look under headings such as "Steel stockholders" "Tool and cutter grinding" "Grinding and sharpening services" "Electrical wholesalers" "Engineering fasteners" etc.

Copy turning, request for an article

Is there any reader who has experienced in copy turning in the home workshop, and who could provide an article on the subject for publication in *Model Engineers' Workshop?* If so, please write to me first with your offer before proceeding. If on the other hand, you have some involvement with copy turning, simple or complex, and yet feel unable to provide an article, then do please at least send me a letter with brief details of your experience of this technique which may then be published in Scribe a Line. A photograph or two of the process taking place, or of the finished product, to go with the letter would also be useful.

SCRIBE A LINE

Your views, your pages! Your opportunity to make your point, ask the question or simply pass on a snippet of interesting advice to others. Your letters for publication in Model Engineers' Workshop are always welcome



Unimat Ideas

Anton Vella of Birmingham sends in this idea for manually operating the Unimat 3.

I have just finished reading the thirteenth issue of Model Engineers Workshop. *I would like to join the other many readers in congratulating you on such an interesting (and as evidenced by the several correspondents from abroad) 'international' magazine. I myself, at the time when I received the second issue, introduced it to my cousin in Malta who immediately took on a subscription.*

I myself am not an engineer by profession but like others I would like to make my contribution to the magazine in sharing a few ideas with others.

The article by Mr D.J. Scoggins on the dividing attachment for the Unimat 3 is very interesting and his way of cutting the M14 x 1 thread is a clever idea indeed. He suggests that the screw cutting be done by 'turning the mandrel by means of grasping the pulley and imparting motion'. He also suggests 'not to take too large a cut thereby making turning the machine by hand uncomfortable.' So here is my first quick tip to Unimat 3 owners:

As the pulley end of the Unimat 3 is also threaded M14 x 1, remove the drive belt and the mandrel pulley and fit the face place at this end. Attach the end of a 50mm to 60mm bolt with two washers and nuts as in the diagram. This makes an excellent handle to drive the chuck manually without much effort or discomfort. I claim this to be the cheapest accessory to the Unimat 3. However if one wants to make the handle look professional, I enclose drawings for a handle that can easily be made on the Unimat 3 itself.

Filtering suds oil

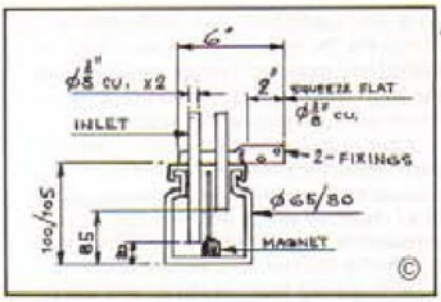
Derek Walters of Tetbury suggests this little filter for your suds system

I refer to M.E.W. *No: II June/July 92. Page 23.*

This super cheap way of delivery shows the set up with the drip tray and collecting bottle with a nylon stocking in the neck, which is perfect for this set up.

However if you have a recirculating pumped system, after a period of time it is possible to be troubled with the micro fine metal particles which get through so many filters of home construction, to abrade the seal in your centrifugal pump and cause leakage which allows air in and stops the pump self priming.

If you use a nylon filter at drain entry and follow this by a gravity and magnetic filter you collect almost all the particles, the pump seal's life will be considerably lengthened.



It's so simple to make. Take a small jam bottle with a 4 tab screw on METAL lid (don't be tempted to used plastic and Araldite the pipes, as the plastic will almost surely be attacked by the coolant), size about glass dia. 65/80mm and height about 100/105mm (Tesco or Wilkinsons), soft solder in two ⅛in. dia. copper pipes and between them another pipe with its ends squeezed up to mount the filter. A small magnet is Araldited onto a handle to just come short of the lid as shown on the sketch.

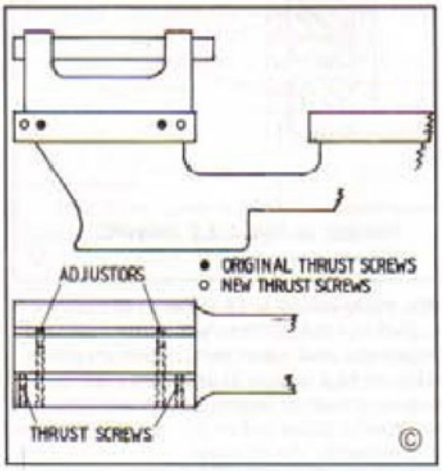
Operation is obvious, the amount of metal dust adhering to the magnet is a real eye opener, sludge is deposited in the jar.

This filter can be used with a neat cutting oil or common suds.

An ML7 modification

This modification, to improve accuracy of his ML7, has been sent in my Mr J Hickson of Newton Abbot. Do though read the article on lathe alignment, in the Feb/Mar '92 issue, before making such a modification.

I am enclosing the details of a modification which I made during the course of the restoration of my Myford ML7 lathe. I thought perhaps this modification could be of value to other ML7 owners and be passed on to them by means of your journal.



I had been aware of the fact, for some time, that the headstock of my well worn ML7 was badly out of line with the bed, i.e. it was impossible to turn a spigot truly parallel. I set out to remedy this when I came to restore the lathe.

On stripping the machine down I discovered that there was no means of adjusting the alignment of the headstock. What I thought were adjusting screws, in the front shear, were merely thrust screws forcing the tenon of the headstock against the back shear.

Using the two tapped holes for the thrust screws in the front shear as pilot holes, I drilled right through the tenon

4mm and tapped for 2BA grub screws. These are the adjusting screws. I then drilled two new 4mm holes, as shown, in the front shear and tapped these 2BA. These are for the new thrust screws.

After re-assembling the lathe, I turned two collars on a short test piece and measured them with a micrometer. From this I deduced which adjuster had to be screwed in to give the desired effect. After tightening the thrust screws and four clamping bolts I turned the collars again and repeated the whole process, until I was satisfied the two collars were the same diameter, thus putting the headstock back in line with the bed.

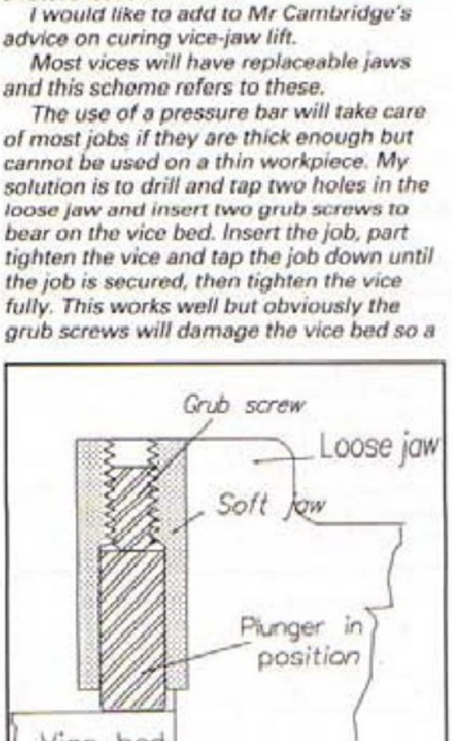
Limiting jaw lift

Frank Tobin of Staines has an idea for living with jaw lift. Also indicates he is happy at 70 to learn new things, in this case CAD. An article on CAD. is planned for a future issue of *M.E.W.*

I would like to add to Mr Cambridge's advice on curing vice-jaw lift.

Most vices will have replaceable jaws and this scheme refers to these.

The use of a pressure bar will take care of most jobs if they are thick enough but cannot be used on a thin workpiece. My solution is to drill and tap two holes in the loose jaw and insert two grub screws to bear on the vice bed. Insert the job, part tighten the vice and tap the job down until the job is secured, then tighten the vice fully. This works well but obviously the grub screws will damage the vice bed so a



little more needs to be done to avoid this.

Drill out the bottom half of the hole to a larger size and insert two pieces of round material to a sliding fit and with well radiused bottom edges. These will have to be fitted in place before the replaceable jaw is screwed to the vice jaw.

I think the drawing should be self-explanatory. I hope you are not too critical of my very first piece of CAD drawing. There are lots of nice new things to learn, even at 70! (Jolly good. Ed.)

M.E.W. aids in boat building

Peter Hutchings of Crawley provides this letter, it serves to indicate the wide range of activities undertaken by readers of this magazine.

As a reader of M.E.W. *from the first issue, I was beginning to think that I should write to let you know that I enjoy reading the magazine and always look forward to the date of the next one. However I am prompted to write at the present by the possibility that I may be able to help with a request for information. (Published elsewhere Ed.)*

Your request for an article on metal spinning reminds me that I have only ever done one job. However when I bought my Myford in 1951, almost the first large job I did was to make the Busy Bee cyclemotor described by Edger Westbury in Model Engineer.

This required a petrol tank which had spun ends in brass of about 5½ in. diameter. They were domed and flanged and despite never having made anything like it before, his instructions were so good that I recall that I had no trouble at all. Perhaps reference to E T W's article of 1952/3 might be of help to get someone started. (Article coming soon Ed.)

It was during my apprenticeship that I managed to build a small boat which I sold for, what was to me, a small fortune. From this I was able to purchase the Myford brand new. I still have it and it is used as much as ever as I am presently making a 25ft. sailing boat. This has taken me ten years so far, in between working and other things that take up one's time.

Having retired now I am expecting to get the boat finished before too long. Unless you are in the rich category, building a boat brings up a lot of interesting problems. For instance, I have made a lot of special tools for making parts, some simple form tools for hatch slides and rigging fittings etc.

But stainless steel has to be hit hard and a few times only if it is not to work harden. Also I have made more involved tools such as a tube bender for stainless tubes up to 1in. diameter at radii from 4in. to 10 inches. Also made a mini cement mixer to mix one ton of iron shot and epoxy resin and pour straight into the keel from the drum. This had a spin drier drum, a Vitesse car flywheel and a lawn mower motor.

I buy most of my bits from boat jumbles but could not get a ¾in. prop shaft long enough. I had therefore to make one from a worn 1in. one I bought for £3. As it was twice as long as the lathe I had to alternate every few thou. doing half at a time with the steady fixed to the bench. At present I am making rudder shafts and couplings in 2½ in. stainless, and an anchor capstan.

I was very interested in the article on MIG welding. I have had my welder for some years now, but find that I have to do a lot of practice each time as I do not use it often enough. I have a lot of stainless to weld i.e. tabernacle, pulpit, pulpit rails (sounds like a 21st century church to me Ed), *silencer etc., etc. I am waiting till most are ready, when I intend to hire a bottle of Helium from BOC for a year only. Helium gives a nice bright weld on stainless without the need for polishing.*

Hardened steel – another turning solution

This letter comes from Alan Jeeves of Meltham

I have pleasure in writing to you again. I read with interest the article on turning hardened steel in issue 13. You may like to know that I have in my possession a tool holder of the 'T-Max' type and in it I have a throw away top which is marketed under the brand name **Amborite.** *Using this tool in the centre lathe I have reduced the diameter of bearing outer races (Rockwell 60 C) by large amounts (3mm). The tool is, of course, designed for this purpose. I am told tips cost two arms and two legs plus.* (Typically around £100.00 Ed). *I enclose a page out of the Seco (tel. 0789 764341) tool insert catalogue of 1987 which lists Amborite tips available. Whilst it is successful in removing hardened material I cannot envisage much use for it in the average home shop. However the fact is that they are available if required.*

Videos as learning aids

In this letter Robin Smith of Lynwood, Australia replies to my prompting in Scribe a Line for your comments, for or against, re the content of *M.E.W.*

In the Aug/Sept 92 issue you asked for some ideas.

I would like to see some videos on using lathes, mills etc. I am sure that with new techniques being taught in schools etc. i.e. CNC tools there must be many of these videos available from both the education authorities and machine tool manufacturers.

Could M.E.W. *obtain some of these and have them copied and made available for a reasonable fee? I am sure that some of the big tool manufacturers might give you copies with consent to copy for the benefit of your readers and as most of this would be obsolete, they may even give them to you. Most people have a video at home these days, and I am sure they would be very well received. (Camden Miniature Steam Services (0373 830151) advertise 2 videos on welding and 3 on using a lathe. Do any readers know of others? Ed.)*

Drummond lathes

Can anyone help Mr Swingler of Ludlow regarding his Drummond lathe.

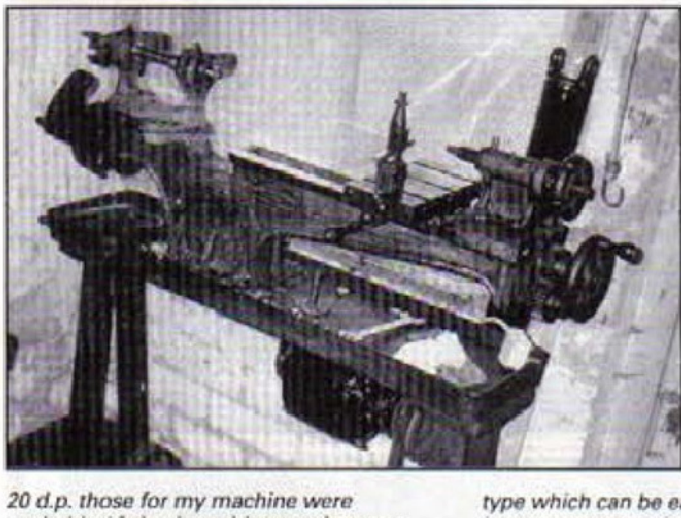
I have a well equipped workshop, however I had no machine tools until recently when I purchased an old 3½ in. Drummond lathe.

In the photographs the lathe is practically dismantled for restoration. As you can see it has a cast iron drip tray and stand and (a later addition?) a ¼ hp motor driving through pulleys to a countershaft and these to the lathe spindle by leather belt. The motor has 4 pulleys and there is also a bike gear so I have 8 speeds in all.

The feedscrews for the cross slide ran directly in the cross slide casting and the threads in the casting were virtually non-existent. A local engineering firm modified the cross slide for me and made a phosphor bronze feed nut to suit. The cross slide now works well. I have successfully carried out cutting operations using the lathe but have two problems:-

1) The leadscrew as you will note runs between the slide-ways and is prone to getting covered in swarf and is consequently badly worn at the end nearest the chuck. Can any reader recommend a firm that could manufacture me a new leadscrew or does anyone know of a leadscrew from another machine, e.g. Myford, that could be readily modified to suit? It is ⅝in. dia. and is threaded 8 TPI for the first 18.5 inches then is plain ⅝in. diameter for 4⅝ inches.

2) My lathe has no change wheels. Someone suggested that I might adapt Myford change wheels to suit. Myford informed me that their change wheels are



20 d.p. those for my machine were probably 16 d.p. I would appreciate any advice from your readers. Could I use change wheels for Boxford or Harrison machines. I have seen these advertised in your magazine by G&M Tools.
3) Lastly, does any reader have a manual for my Drummond they could either photocopy for me or loan to me to photocopy.

Electric Furnaces

We have three letters regarding electric furnaces. The first from C.S. Drake of Ropley.

Before attempting to make an electric furnace consider a new or even better a secondhand small enamelling or pottery kiln. The cheapest enamelling kilns have a chamber of say 4 x 5 x 3 in. and will achieve between 900-1000 deg. C. They can be fitted with Pyrometers and/or 'Simmerstat' controller. Starting prices around £100. A number of specialist craft suppliers stock them but a major stockist for the jewellery trade is: H.S. Walsh and Sons, 243 Beckenham Road, Beckenham, Kent BR3 4TS.

If DIY is still the aim then you will need Kanthal A1 element wire which operates reliably at 1300 deg. C as used in pottery kilns. It is not likely that this can be obtained from home made elements in small quantities and a reel would cost the earth. However, a few years ago the following company advises that they would wind an element for any kiln given the basic parameters, e.g. wattage and total length of slot space available for wound element:-

Gomartie Kilns Ltd, Park Hall Road, Longton, Stoke-on-Trent ST3 5AY.

For the insulation you can most readily build your furnace from the lightweight Aluminio-Silica Bricks used by kiln makers. These are readily drilled, sawed, filed, for example to make channels for the elements. Available from many local pottery material stockists or by Potterycrafts Ltd, Campbell Road, Stoke-on-Trent ST4 4ET. Alternatively board or blankets of similar material is available from MPK Insulation Ltd, Hythe Works, Hawkins Road, Colchester, Essex CO2 8JU.

It will be evident that I've passed this way myself but for £25 bought a second-hand Pottery Test Kiln complete with controller. This will melt brass, aluminium, and silver for casting, so my problem has been solved.

Vic Barratt of Medira Art Castings Ltd makes some useful comments regarding making and using an electric furnace.

When constructing an electrically heated furnace I suggest using much thicker wire than that found in a domestic electric fire. For example 1 or 1.5mm nickel/chrome resistance wire specially made for the purpose.

Constructing the inner lining of such a furnace with a soft refractory brick. The type which can be easily cut to shape and have grooves made in the sides to hold the elements. Always of course (Repeat Always) ensure that any furnace has a safety cut out device so that power is fully disconnected before the door can be opened.

Ideally also use a low voltage transformer to supply the element windings.

On another tack, with regard to the Quick tip, page 15 of issue 13, one should be wary of putting carbon containing materials into an electric furnace. This is especially so with open element furnaces where the heater wires are exposed. The carbon can in certain conditions chemically combine with the element wire causing it to become very brittle and break. This is important when heating wax like materials.

Mr MacEke writew of his experiences in making a small furnane.

On the subject of muffle furnaces, kilns etc. Some twenty years ago I made a small kiln for lost wax casting in silversmithing. I use it now, still with its original element for small jobs like tempering piston rings. The drawings for it were in an American publication on lost wax casting. The element suggested was the type I used. It was sold as a replacement for the type which goes inside a quartz tube in an infra-red wall heater. It was a 750 watts and the controller was a hotplate type. It could easily overheat I believe, and has stretched somewhat over the years! As a temperature marker I cut a small piece of aluminium and bend it into a V, place it on its side and when it collapses I have a good temperature indicator.

At the time of making it, the biggest problem was finding a source of refractory brick. I managed to trace an old chap, long retired, who had some blocks in his garden left over from his days as a kiln maker. Apparently it used to be mined in this area (diatomaceous earth) and is easily cut with a wood saw and grooves scraped out for the element. To make one now would present the same problem of finding this material. If anyone knows of a source I would be happy to redesign and rebuild a similar furnace. The one I have only has a 4in. cube interior which is a bit small but was governed by the bricks available.

Many years before that I was involved in my student days with the making of one of the first pottery kilns for colleges. These have a very high temperature and the elements were made from "Kanthal" wire. Unfortunately, I no longer have any information on this. I remember, however, that we were warned not to touch the elements after firing as it developed a crystal surface which if damaged, would shorten the life of the element.

Dropping chucks!!

Terry Ives of Abertridwr has a problem with his new pillar drill, do any readers have the same situation, and if so, what is the cure? I have my theories, Ed.

I recently bought a new pillar drill and find that on odd occasions, the chuck has dropped out of the Morse taper spindle hold when drilling steel.

Both Morse taper surfaces are clean, (no oil, no grit) and seem to be a perfect fit!

The manufacturer's instructions were followed to the letter, i.e. with the chuck fitted, wind down onto a block of wood to ensure a tight fit.

Incidentally, two other friends have the same problem, and both have new drills.

Could you please tell me what can be done to cure the problem.

Breaking blades

Ernie Hodgson from the Isle of Wight writes, amongst other things, regarding a problem he has with a Naerok band saw, can any reader help.

Concerning your magazine, I think it's the tops. I think I have made something from every issue. My latest project is from the June/July issue, the fretsaw. I made everything at the time of issue but couldn't get the 1in. al. angle.

I have just acquired some 2in. al. angle which I am now reducing to complete the project.

Although I have a small universal milling machine, my lathe is just a toy really and any biggish work I have done by going to the local Technical College evening classes. Up to this year, retired people got the classes for half price, which was nice, but this year there is no half price and the price they want for the session has put me out of the running. I suspect a lot more people will be missing too, since most of the class were retired.

One of my tools is a Naerok band saw (I believe they have since gone out of business) and it has a big problem. The saw blades keep on breaking. I have checked the wheels for alignment and they are within about ¼ inch. Whether they are wide or narrow, the blades break in a very short time. Have any of your readers experienced this and what have they done about it?

Cheap benches

From Roger Sykes of Bristol an idea for economy benches.

Having subscribed to M.E.W. since the launch I find the magazine is most enjoyable, it is widely read amongst our Bristol Model Engineers and those at the local evening classes.

The Milling for Beginners is particularly useful. A brief comment on the Milling Machine stand (No.12 p.33). The design was elegant – but it is cheaper to build out of standard angle steel – obtained from old bed frames at the local tip! All my benches are made in this recycled way!

Nameplates etc.

From Ms Darryl Anne Welborn of Auckland, New Zealand comes an interesting letter. It is nice to know we have at least one female reader. I do hope there are many more. Ed.

I noticed your request for details on the manufacture of small metal nameplates in the June/July 92 issue of M.E.W.

I don't know if my method is worthy of mention, but as a professional builder of locomotives in the scale range '0' - ½ inch scale, I often have need for builders plates and nameplates that are decidedly unusual and not available from commercial sources.

My method is based on photo engraving and is decidedly 'low tech'. I firstly obtain a photograph, copy of works drawing, copy of an engraving from a reference book, whatever, as long as the plate details are a good clear copy. I then photocopy them as large as possible without losing the form and detail of the lettering, i.e. I don't let it get too fuzzy.

The next step is to attack the photocopy with indian ink and photocopy correction fluid (not ordinary correction fluid as it dissolves the photocopy ink making a mess) the object being to produce a good clear black and white reproduction of the plate. It can end up being a bit lumpy but so long as all edges are sharply defined it doesn't matter.

Once this stage is reached another photocopy is taken, and the detail checked. If all is well measure the longest side of the plate in millimetres (photocopy) and note down the required size the finished plate has to be. Armed with this information, another trip to the photocopier and if the photocopier operator is as clever as the very helpful lady at our local commercial stationers you will end up with a piece of paper with a black and white representation of the needed plate the correct size. This is your artwork for photo engraving. The only important thing to note is that everything black on the paper will be raised, everything white will be etched. So if your plate has raised lettering, draw these in black, if the opposite is the case draw them with the correcting fluid.

As to getting the plates etched, many of the operators of part time businesses producing photo-etched components for model railways are often happy to include an odd piece of artwork amongst a production run. This is how I get mine done.

I hope my method is of use, I've found it very quick and cheap and the results are good too. Obviously it is no good for the bigger scales as the etching is not deep enough, but up to 16 mm scale it is good. A 'Garratt' plate I had done in this scale turned out very nicely.

Congratulations on a very good magazine, my little business is not well endowed with funds, so I have to make most tools etc I need, a good many ideas in M.E.W. *have found fertile soil.*

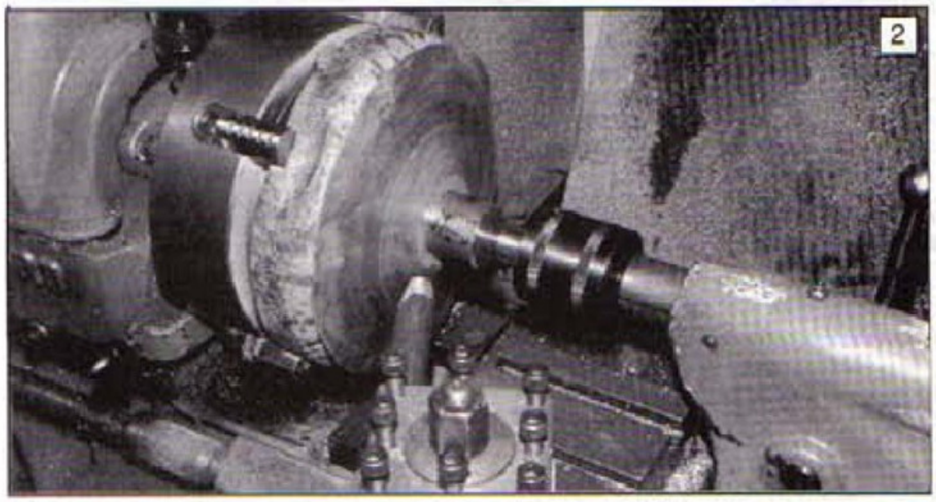
Spinning

Mr R. Jeffery of Hornchurch sends this letter to encourage us to have a go at metal spinning.

Following a recent chat re spinning. I enclose three photographs. No.1 shows the hardwood former being shaped in a four jaw chuck on my ML7 lathe. No.2 shows the spinning of one or two Brass discs 6in. in diameter. Each disc was 16 SWG, and was annealed about eight times during the operation. No.3 shows the reason for my venture into spinning a pendulum for a longcase clock.

I will offer some tentative words of encouragement to anybody contemplating spinning on the lathe by simply saying; "have a go".

1



2

3

Arkansas stones

Mr G R Barker of Grays, Essex raises these questions regarding Arkansas stones.

Having read with great interest the article about the Universal Milling Attachment in the October/November issue of the Model Engineers' Workshop No.13, I am wondering if you can tell me what an "Arkansas Stone" is. This is mentioned on page 87 2nd paragraph on bottom right.

1) *How does it compare with India stone?*
2) *What size can they be bought?*
3) *Where can they be purchased?*
4) *What is the price?*

The following comments have been taken from the Shesto catalogue (tel 081 451 6811). Prices for Arkansas stones are a little higher than for India stones.

Water of Ayr Stones

Called Scotch stone in the United States and Water of Ayr stone in Britain, this is literally a very soft stone. It is used wet for the final smoothing and as it is softer than the metal, it wears away, leaving a muddy residue. Wash the residue off occasionally so you can check your progress. You can file the stone into any shape to reach into awkward contours.

India Stones

Made of rough aluminium oxide abrasive. The India is unequalled for its long sharpening life, durable shape and smoothness of cut. Oil filled at the factory, these stones are ready for long and continued use with only a few drops of oil applied occasionally.

Genuine Hard Arkansas Stones

These stones are cut from the finest deposit of Novaculite known to exist. The extreme firmness of grit and close density give Hard Arkansas Oilstones their quality as the supreme sharpener of fine, delicate tools and instruments.

A blast from the past

Some recollections and ideas from the past, sent in by John Lord of Cheadle Hulme.

As a new reader of M.E.W. *and a returnee to model engineering I was reminded of my apprenticeship (1952) in your article in the June/July issue on drilling.*

The old tradesman who I was put with said that the first thing I had to learn (after brewing up) was to hand grind a drill, this I had to learn quickly as Arnold smoked a foul mixture of Bruno Flake and Thick Twist. This he would breathe over you whilst telling you what a pain you were for not getting it right.

It was amazing how many tradesmen came to him to ask if he would grind drills – he gave them a hard time and as I had picked up the skill would pass the job over to me with the comment that even an apprentice which he had could grind them so why couldn't they do it!!

One tip which he showed me was to hold two hex nuts together to check the drill angle. He had a pair riveted together to act as a gauge and made me construct a similar set, which I still have, and use.

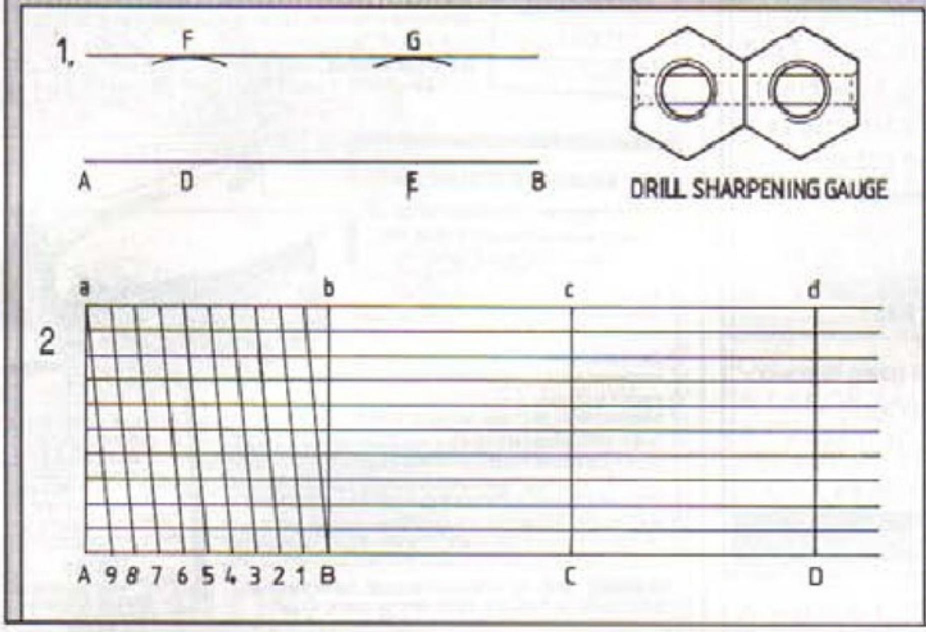
The article on workshop geometry, example 3, is a common way by which draughtsmen have in the past constructed a rule to a given scale. This is useful as it means that if a drawing was to a scale for which no proper scale was available in the office one could be made using this method on white card.

*I also enclose copies of part of an old book which I have (*Mensuration for Beginners *by I Todhunter, first published by* Macmillan *in 1869, the edition I have is 1901) which shows the following:*

1) How to draw a straight line parallel to a given straight distance from it.

2) To construct and use a decimal diagonal scale. With the latter it is surprising how accurate you can measure using a good pair of dividers or compasses. It is essential that the points on the dividers or compasses are kept well sharpened and that the pencil lead is made into a chisel point.

I hope that the above is of interest and I look forward to the next issue.



A book wanted

Can any reader suggest a book or books to help Donald Murphy of the Irish Republic.

Would you be so kind as to let me have the name of any current comprehensive "Machine Shop Mathematics" book or books. Author and Publisher.

I am on your mailing list for Model Engineers' Workshop. *It is an excellent magazine.*

The fully floating chuck

Guide plate

Slip bushing

Guide holder

We are grateful to Messrs. Drill Services (Horley) Ltd. for permission to include these illustrations from their catalogue.

Square drill

Hexagon drill

DRILLING SQUARE HOLES

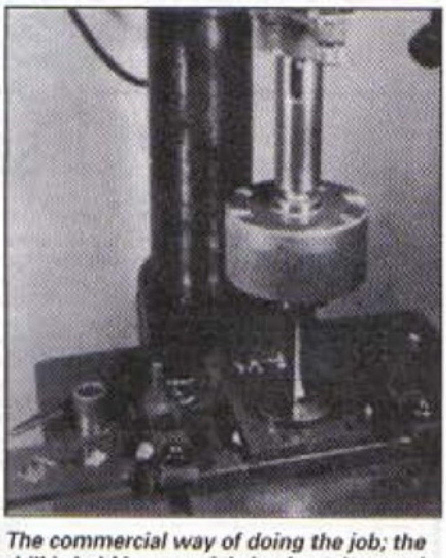
Drilling a square hole may sound an improbable proposition. This article by Derek Winks explains how this seemingly impossible job can be done quite simply.

My interest in this somewhat odd subject was prompted by a letter in the *Notes and Queries* column in *The Guardian*, in which the writer expressed disbelief in the possibility of producing a square hole by a rotary drilling process. This rang a bell, as I could remember a reference to a method for doing this in an old issue of *Model Engineer* as well as some other old books. A look through Volume 2 of 1904 unearthed an article by Charles Cook in which he described a method using a triangular drill with a guide plate containing a square aperture. I made a drill and plate to try out the system, and found that it works quite well. I hope that it will be of interest to *M.E.W.* readers as it has practical advantages as well as being of historical interest. Note that it will easily make blind holes which would be difficult to produce by drifting, broaching or filing.

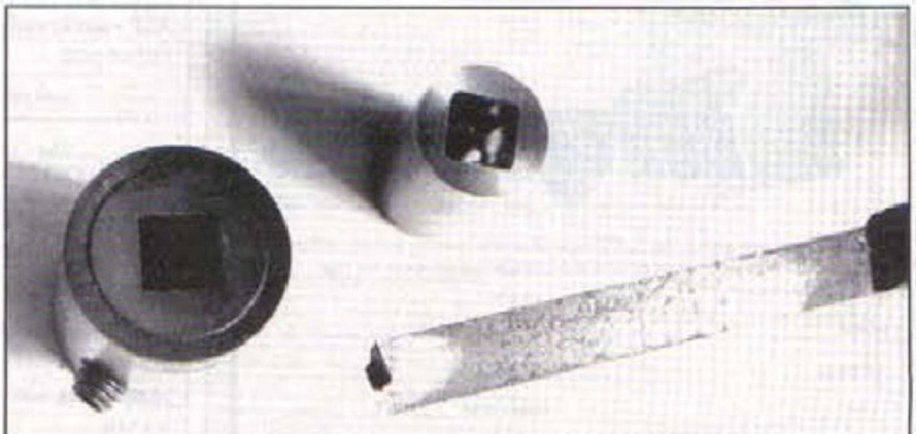
Construction

The cross-section of the drill is an equilateral triangle with sides equal to the sides of the hole to be drilled. **Diagram 1** shows how to calculate the diameter of the blank which works out at 1.155 multiplied by the size of hole required. My drill was for a ¼in. hole so a blank 0.289in. dia. was needed. A length of free-cutting silver steel 5/16in. dia. was held in a collet, centred and turned down to this size for the length of the triangular section which should be about ⅛in. longer than the maximum depth of hole to be drilled. The method for cutting the triangular section will depend on the equipment available; I used a dividing head on the milling machine. Diagram 1 also shows that the amount of metal to be machined off each side is equal to one quarter of the blank diameter. A small land a few thou. wide should be left on each corner as a dead sharp corner would wear very quickly. The overall length of the drill should be enough to allow a little flexibility as it makes a sort of orbital movement in use.

After machining the section, the cutting edges are formed and backed off using a fine file with a safe edge. The drill is now ready for hardening and tempering in the usual way. The whole of the triangular section must be hard or it will wear very quickly in the hardened guide. Temper to light straw, then polish the faces and cutting edges on an oilstone.



The commercial way of doing the job; the drill is held in a special chuck, and passed through the guide plate which is mounted as a drill bush would be. (Courtesy Drill Services (Horley) Ltd.



The drill and guide plate made by the author, together with a square hole drilled in a piece of brass.

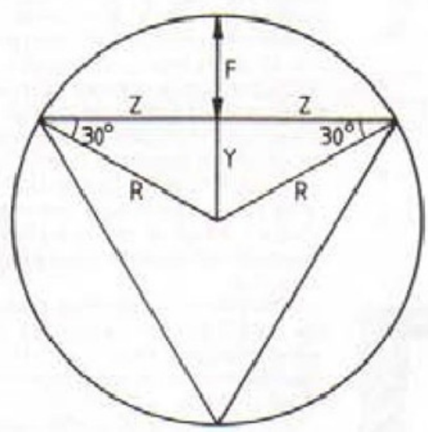
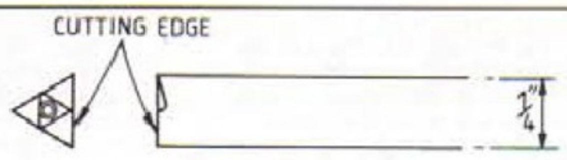


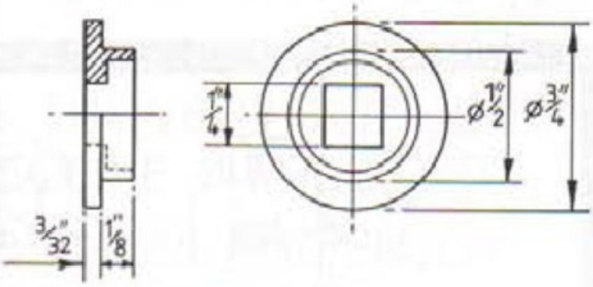
DIAGRAM 1

$Z/R = \cos 30^\circ$
$Z = R \cos 30^\circ = R \times 0{\cdot}866$
$\text{SIDE} = 2Z = \text{DIA.} \times 0{\cdot}866$
$\underline{\text{DIA.}} = \text{SIDE} / 0{\cdot}866 = \underline{\text{SIDE} \times 1{\cdot}155}$

$Y/R = \sin 30^\circ = 0{\cdot}5$
$Y = 0{\cdot}5R$
$\underline{F = \text{DIA.} \times 0{\cdot}25}$



DRILL TIP



DRILL GUIDE

MAT. SILVER STEEL, HARDENED
DIMENSIONS FOR 1/4 INCH DRILL.

Drill guide

This is a hard steel piece with a square aperture the same size as the hole required in the workpiece. I made it in the form of a flanged button which can be stuck into a holder of softer material to suit the work in hand, thus making it more adaptable. It was turned from ¾in. silver steel as in the drawing. After drilling the centre hole it was marked out and filed square as shown. This should be done as accurately as possible, leaving a minimum clearance for the drill. The piece was then hardened and tempered to straw colour, as with the drill.

The guide needs to be clamped or otherwise fixed to the work so that it cannot move, the means will of course depend on the shape of the workpiece.

Method of use

After fixing the guide to the work, drill a hole through the aperture in the plate, slightly smaller than the square hole wanted, to remove the bulk of the waste. Replace the drill with the triangular one, and pass the point through the guide *before* starting the machine. Lubricate the drill and guide to reduce wear. Feed the drill through in the usual way. The result should be a respectable square hole. The drill point should not be allowed to emerge from the guide while it is revolving or the edges may be damaged. The corners of the hole are slightly rounded, but this does not matter for most purposes.

The photograph shows the tool, and a bit of brass rod drilled as described.

As far as I know, there is no commercially-produced equivalent. Perhaps some enterprising manufacturer would like to have a go. It would cost a bit to make, but broaches are not cheap either.

In fact drills for square and hexagon holes are supplied by Drill Service (Horley) Ltd 0293 774911 and probably one other supplier in this country. These drills and their accessories are not cheap and possibly outside the price range of most home machinists. Drills are available from ¼in. to 2in. in 1/64in. steps and cost from around £30.00 to £300.00.

We are indebted to Drill Service (Horley) Ltd for permission to print the following extract from their catalogue.

Polygon Hole Drilling

The system for drilling square, hexagon and polygon holes was developed in 1891 and has been in continuous use since. It is a practical and inexpensive system which may be used on a drill press, centre lathe or capstan, but not on an automatic or multispindle due to the necessity for the tool to enter the guide plate with the spindle stationary.

Uses

Drilling rather than broaching polygon holes has advantages in the manufacture of many items. Stronger and better components can be made, as well as smaller quantities. Broaching undercuts are not needed and the hole will have a flat unimpeded bottom.

These advantages show themselves in the manufacture of stamping dies, socket head screws, socket head wrenches, collets, etc. Another typical application is on outboard motor propellers. Square boring tools may be mounted in boring tool holders, hexagon head bolts may be countersunk and made captive, square sections may be joined as for stair rails, etc.

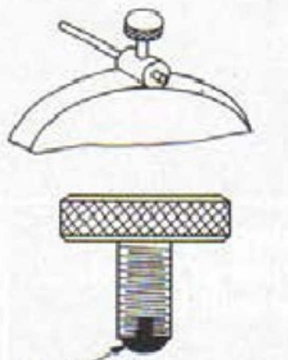
Equipment

The drill is a special cutter with one less flute than the number of sides of the hole. The drill is rotated and also allowed sideways motion whilst held axially aligned. Its action is to lodge one cutting edge in a corner and to 'sweep' round with another edge until this one lodges in a corner. The drill must only be sharpened on the end so that the outside form continues to fit the guide plate. In free cutting mild steels as many as several thousand holes may be made by one tool kept in good condition. On high carbon steels for dies several hundred may be expected. The drill is clamped in the holder by a grub screw for which flats are provided. One cutting edge will tend to 'lead out' and from time to time the drill should be indexed to the other flat to ensure equal wear of the cutting edges.

The drill is held in a special fully floating chuck. This chuck positively drives the drill in rotation, holds the drill accurately aligned axially, but allows sideways float in order to follow the hole form. The chucks are available in several sizes to contain the full range of drilling.

The guide plate is a bush of the form of the hole to be made. It is mounted in the

QUICK TIP



Any locking screw of the type shown in the drawing will tend to burr the spindle on which it is being tightened. To overcome this, a brass insert is fitted into the end of the screw. This will still provide positive locking but will not damage the shaft in any way.

J.M. Gurr

same way as a drill bush, but does have to absorb radial thrust and should be held firmly. The drill has to enter the guide plate while the spindle is stationary. A guide plate will usually outlast 3 or 4 drills.

For drilling bar stock in a lathe, the guide plate is held in a guide holder which is in turn clamped to the bar by a grub screw.

Predrilling is generally recommended. This reduces wear on the tooling and the amount of swarf to be cleared. It also relieves some of the drilling pressure. On some of the softer materials the cutting forces may become inadequate to hold the tool to the profile and a lump may appear on the hole face. This can usually be eliminated by reducing the size of the pre-drilled hole, or in the case of brass and some copper by not predrilling at all. This problem can also be eliminated by using a fully profiled tool which restricts the flute area. For predrilling a slip bush can be provided which drops into the guide plate. This also helps to align the spindle and guide plate so that the float of the chuck is symmetrical to the centre of the hole.

Quality

Square holes are produced with corner radii. The tools could be made to make the corners square but would have too short a life to justify their use. hexagon, octagon and other polygon holes have sharp corners. A short stubby broach can be used to clean out the square corners, but would not normally be required.

Holes follow the form in the guide plate with a tendency to open out slightly, about .001in. - .003in. at depth. As the tool wears the hole will become a few thousandths oversize.

The maximum practical depth that can be drilled is twice the distance across flats. Over this depth swarf disposal is a problem and the hole can become spoiled. Also the form will open out.

For best results flood coolant is recommended, particularly to help chip disposal. Light cutting oil is preferred. Also the chuck must be kept running free, and requires lubricating from time to time with a light lubricating oil.

Post Script

In fact drills for square and hexagon holes are supplied by Drill Service (Horley) Ltd 0293 774911 and probably one other supplier in this country. These drills and their accessories are not cheap and possibly outside the price range of most home machinists. Drills are available from ¼in. to 2in. 1/64in. steps and cost from around £30.00 to £300.00.

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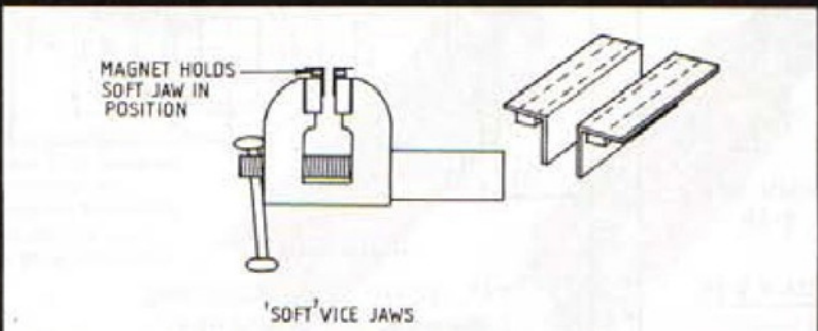


'SOFT' VICE JAWS

QUICK TIP

To retain your vice soft jaws in the vice whilst opening and closing, fix a length of magnetic strip under each half. This can be obtained from the door seals of old refrigerators and held in position using suitable adhesives.

J.M. Gurr

IN OUR NEXT ISSUE!

More parts for the Super adaptable DTI/Work holding device. Using it as a robust helping hand, a machine guard holder and small vice for minute work, etc etc.

An article on Files and Filing, learn how its done.

The principles of AC induction motors. The first of a series on electric motors, AC and DC. This will include such things as their theory in simple terms, reversing and speed control.

Coming up in the February/March issue will be:

How to carry out metal spinning operations, without getting into a spin.

A Super new wooden workshop, very functional inside, very attractive outside.

Coming Soon

A mill/drill spindle, smaller and simpler than that in issue 13.

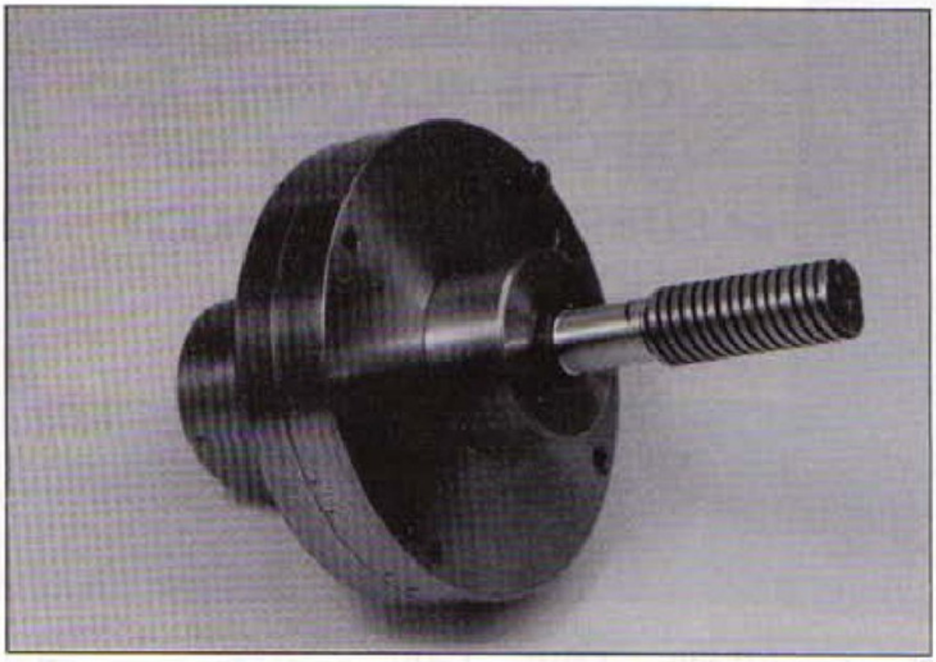
And much more

Issue on sale 8th January 1993

Contents may be changed

AN INDEXING CHUCK

George Eveniss describes the manufacture of an indexing chuck which allows the cutting of multi-start threads on any screwcutting lathe. This article is published posthumously, when this was written the author was almost blind and unable to prepare drawings. The tool was therefore stripped and drawn up by our staff.



The completed chuck, seen here with a three start workpiece, in bronze, secured in the workholding section.

Many people, even quite experienced model engineers will tell you that they have never seen or used multi start threads. How wrong can you be? They even fit them on such commonplace objects as the humble screwtop jam jar! If you don't believe me, go out to the kitchen and have a look.

Perhaps the most common use for multi-start threads to us as model engineers is that of the reverser screw, especially if this is on a locomotive.

Terms and Definitions

Before we can deal with the manufacture of multi-start threads it would be as well to define some of the terms used in relation to screw threads:-

1) **Lead,** this is the distance that the nut will move along the screw when it is turned through one complete revolution.

2) **Pitch,** the distance between adjacent crests of the thread, usually stated in threads per inch (TPI).

With a single start thread the nut will move through one pitch per revolution of the nut, i.e. the lead and the pitch are the same. This is true of the vast majority of bolts, screws and nuts in common use as fastenings. For a multi-start thread however the case is different, in the case of a two start thread one revolution of the nut will move it twice the pitch, i.e. the lead is equal to 2 times the pitch of the thread, for a three start, 3 times and so on.

Accepted methods of cutting multi-start threads

The classical method of cutting a multi-start thread is:-

1) Set the lathe to give the required lead of the screw. A complete thread is then cut at this setting.

2) Withdraw the tool and using the top-slide index advance the tool by ½, ⅓ or ¼ of the lead according to whether a 2, 3 or 4 start thread is to be cut. At each of these settings another complete thread is cut, tracking down the uncut metal surrounding the already cut thread.

In theory this will produce a multi-start thread of the correct dimensions. There are snags in this method of working; one may move the top-slide index inadvertently and lose one's place as it were, making it difficult to pick up from the first thread cut and leading to machining errors. Even if all is successful and one then screwcuts a nut to suit, if it will not fit well at the first try then one does not know which of the various threads already cut is in error, so correction is difficult.

Having tried this several times and scrapped a few carefully made parts I determined to do something about it; the result is the indexing chuck which forms the subject of this article.

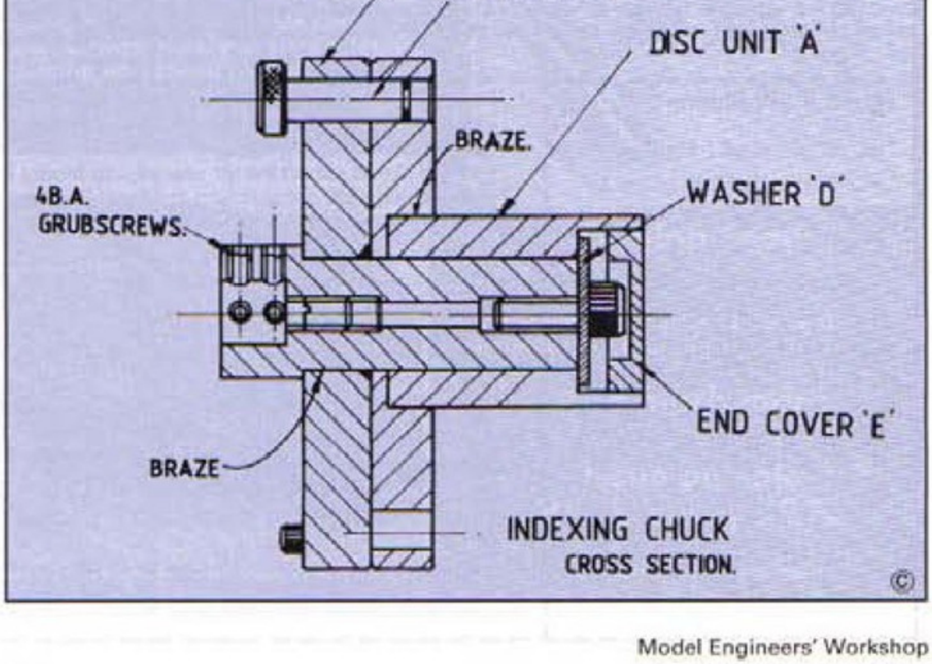
A request and a solution

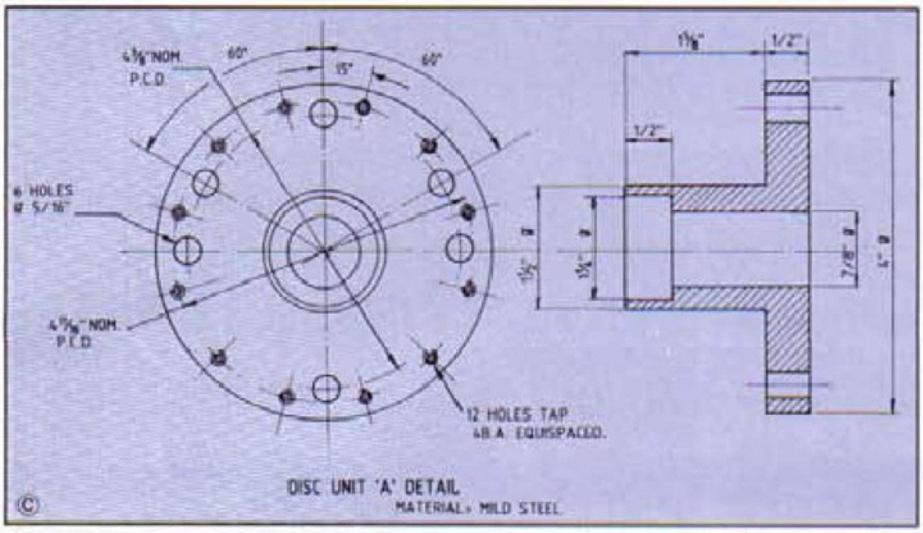
Having been asked to make a number of components which had three start threads, I decided the easiest method was to make an indexing chuck. I knew that it would be used again, so decided to make it for ½in. diameter, reasoning that the odd job over this size could have a shoulder to fit, and that anything under this could be gripped in a fitted bush soldered, "glued" or screwed in, if that were needed.

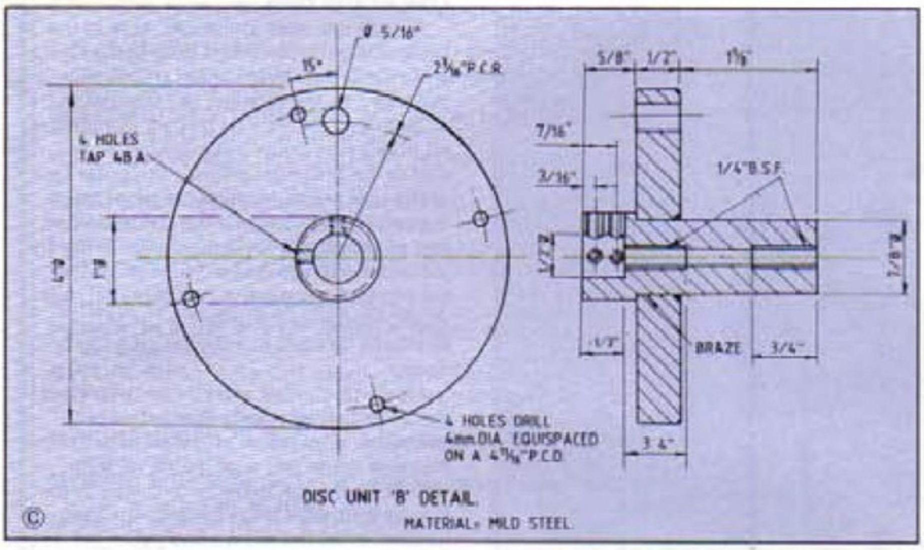
My practice, and one which I strongly recommend is that one makes a tap to suit the thread for each group of parts made in this way. It only takes a few minutes extra, being made at the same setting. It is a very good way of tackling the nut problem.

Construction

Start by studying the Cross Section drawing. Materials required are:-







2 discs m.s., 4 in. dia. x 5/16in. thick,
1 off 3 in. x 1 in. dia. m.s.,
1 off 2 in. x 1½ in. dia. m.s.
1 off 1½ in. x ¾in. dia. m.s.

Screws to suit, (Imp. shown, metric can be used).

15/16in. o.d. "O" ring.

We start on Unit **"A"** Face and chamfer one end of the 1½ in. dia. bar, clean up with emery cloth for about ¾in. from this end, score the first ½in. with a scriber to allow the spelter to flow.

Hold a large disc in the chuck or faceplate, face it, and bore the centre to a depth of ¾in. to a wringing fit on the prepared end of the 1½ in. bar.

We are going to silver-braze these components together, using pre-placed spelter. For this area we need about 4 in. of 1/16in. dia. rod, we cut this into 1 in. lengths and place them in the bottom of the hole. For silver solder we use Tenacity 4A flux, which will stand the prolonged heating we shall be using. Place the prepared sections of disc and bar together after liberally annointing with flux, heat from the disc side and eventually the bar will drop into the disc and a ring of spelter will show at the joint. Allow to cool and clean off the flux. Put to one side for the moment.

Now make a start on Unit **"B"**. Chuck the 1 in. dia. bar, centre and turn down about 2¼ in. to about ¾in. dia. Now lightly face the other disc, both sides, bore this to a close fit on the ¾in. portion of the bar. On what will be the outer edge of the hole chamfer deeply to form a reservoir for the silver brazing material. After fluxing liberally with Tenacity 4A, place this over the ¾in. portion, with the chamfer uppermost, you can pre-score if you wish. Wind about 1½ turns of Easy-flo silver solder around the shaft, pushing it into the 3/32in. chamfer, and heat from the underside till it flashes through. Allow to cool and clean off any residual flux.

Chuck by the 1 in. dia., drill and tap the other end ¼in. BSF or similar, to a depth of ¾in. This will be used for the locking screw on assembly. I placed a ¼in. BSF screw in the hole, centred this and used it with a centre for the next operation. Next operation at this setting is to turn the ¾in. dia. to a fine finish, and face off the back of the disc, and the end of the ¾in. dia. shaft. Finally turn the o.d. of the disc to bring it to size. Chamfer all corners.

Re-chuck by the freshly turned end, protecting the surface with slips of brass or copper. Face the outer edge of the disc and the end of the shaft so that this latter part stands ⅝in. proud of the disc. Centre, drill for ¼in. BSF tapping, about 1⅜ in. deep. Open this out using progressively larger drills to around 7/16in. dia. to a depth of ½in. At this setting bore the hole to ½in. dia., finishing with a reamer or D bit, or with a good finish from the tool. The remainder of the hole, can now be tapped ¼in. BSF, and a brass grub screw made up to fit. The tapped hole is to aid workholding on small diameters later, the grub screw protects the threads against grit or swarf.

Mark out on the outer surface of the 1 in. dia. section for the four 4BA securing grub screws, these are positioned at 90 deg. as per drawing. Remove from the chuck, drill and tap the holes, return to the lathe and clean up the o.d. of the 1 in. section.

Before removing from the chuck we require two lightly scribed rings spaced on the outer face of the disc. One of these is 5/32in. in from the edge, the other 9/16 inch.

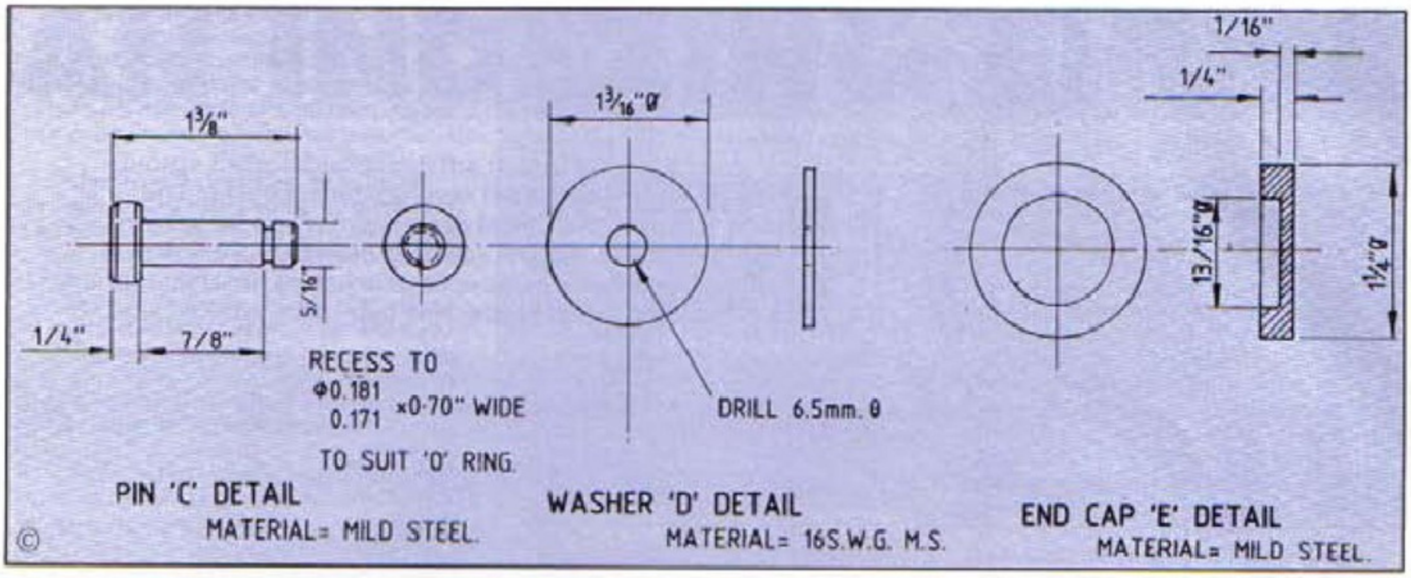
Now we can return to **Unit A.** Chuck this by the o.d. of the disc, turn the stub to a nice finish, about 1½ in. o.d., face the end and bore, using the ¾in. portion of **Part B** as a plug gauge. Aim for a free running fit without perceptible shake. Chamfer the corners. Now enlarge the outer end of the bore to 1¼ in. dia., ½in. deep. This will accept an end cover and permit the ¼in. BSF locking screw to be fitted later. Turn in the chuck, checking with a d.t.i. to ensure that the finished bore is running concentrically. Face off the outer face of the disc and put a small chafer on the outer edge of the bore. At this setting re-insert **Part B** and check that the o.d. of the two discs are identical. If not note this for correction later.

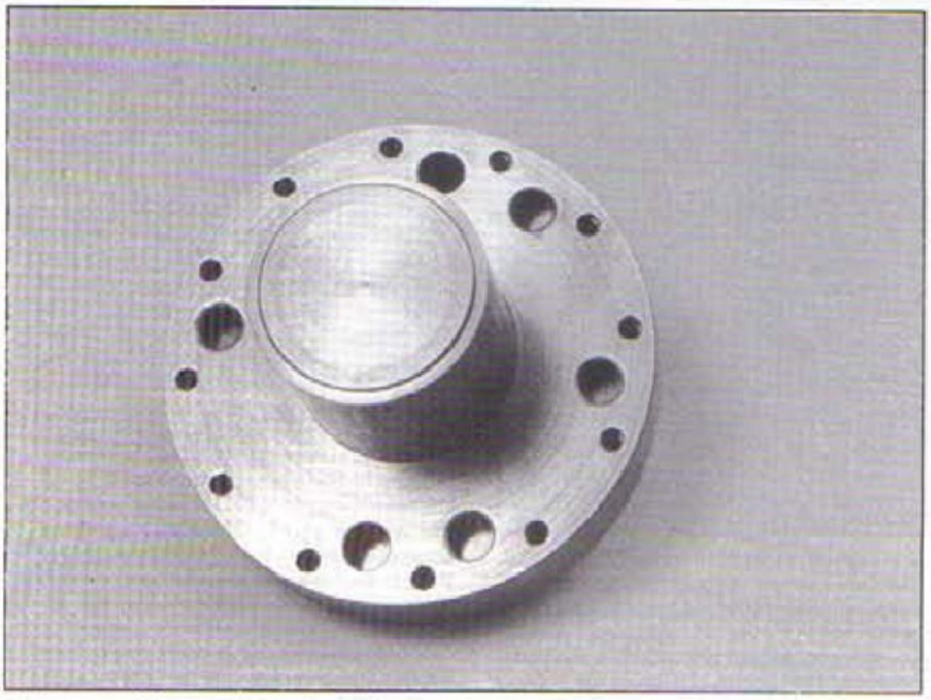
If you have means of drilling from the toolpost the next stage is easy. We require on **Unit B** four equi-spaced holes at *exactly* 90 deg. on the outer of the two scribed rings, and just one hole on the inner ring at 15 deg. from any of the four. At this stage keep the drill size to a common size, less than 4 BA tapping. If you can select a drill the same size as a stock piece of silver steel this will help. Drill through at each position, remove the part from the chuck and debur the holes. Now rejoin **Units A & B,** clamp them together firmly, drill through from the holes already drilled on the outer ring, using these holes as drilling bushes.

Place a couple of dowels through two opposite holes and move the drill to go through the hole on the inner ring. Next remove the dowels and clamps, swivel the outer plate through 90 deg. reset the dowels and drill through again. Repeat for each of the 90 deg. positions. Without disturbing the setting of the drill remove the outer plate and drill through again at a position 60 deg. to the left and right of any of the four holes on this circle. Replace the outer plate and check that the drilling has been carried out accurately. Check this by means of a dowel. If all is well go back to the outer ring of holes, pick up the pitch

QUICK TIP

A useful supply of copper sheet can be created by splitting down a length of ordinary domestic copper water pipe then hammering it flat. The finished sheet will be just over 3 times the diameter of the pipe e.g. 1in. pipe = 3½ in. wide sheet. The older Imperial size pipe is thicker walled and is available up to 1½ in. diameter waste pipe giving a 5in. wide sheet. A local plumber will often supply old offcuts f.o.c.





A close-up of the rear of the chuck showing the holes which are used for the various advances according to the number of starts required.

circle, and using whatever dividing method you choose, drill through a ring of holes all at 30 deg. apart on this pitch circle.

Having again checked that all is well separate the two pieces, and enlarge the holes. The outer circle on **Unit B** is drilled 4 BA clearance, the single hole is drilled and reamed 5/16in. diameter.

On **Unit A** the outer ring of holes should be relieved from both front and rear so that only about ¼in. of 4 BA thread has to be cut, this will be amply strong for our purposes. Again, having picked up the inner ring, these should be drilled and reamed 5/16in.

All that remains to be done is to make a suitable washer to fit under the head of the ⅜in. BSF screw at the rear of **Unit B** and clamp these two parts together as shown. I went all posh and made a push-in dust cover for mine, I recommend it, but it is optional. All you need now is the locating pin made as shown on the drawing. A simple job, and the screws.

Final cosmetic job is to ensure that the two discs are of equal diameter, and to lightly face the outer of **B** to remove the scribed rings, which have served their purpose.

Graduation of the tool

Set the completed tool up in the lathe, with all securing screws removed. Place the register pin through the outer and any of the 90 deg. spaced holes. Have a pointed tool sideways in the holder, exactly on centre height. Directly above a screwhole scribe a mark across both discs. Stamp this thus **1**, 3, 4. This indicates the start point for one, three or four start threads. Withdraw the register pin, ensure that the mandrel does not move. Move the outer disc round to the next hole, clockwise. Again scribe a line, stamp this **2**, 4, continue to the next, mark and stamp **2**, 3, then **3** ,4, then **3**, 3 then **4**, 4. The bold number indicates the start, the smaller no. the number of threads, easy isn't it? I have not troubled to mark for a two start, any two at 180 deg. apart will serve for this.

Use of the tool

Mount the work in the ½in. hole in the front of the tool, which is held in the chuck and checked for true running. Give tailstock support if this is needed. Set the tool to **1, 3, 4** and cut the first thread. Depending on how many starts are required, at the end of the first thread move the outer face of the tool around, whilst keeping the mandrel still. Withdraw the pin to do this, and of course the locking screws. Bring the job around to the desired position, reset the pin and screws, cut that thread to full depth, repeat as required for other positions, *et voila* as they say, the job is done.

I know that multi start thread cutting is not a job that we tackle every day, but when the need arises you will bless the day that you made this useful little gadget.

One final note: there is no magic in the figures and sizes that I have given, they happen to be the stock I had when the need arose. If you have one of the smaller lathes you could make just as useful a tool, provided that the angular relationships of the holes remain the same. If you do reduce the size remember that the tool needs to be strong to be rigid, so keep the metal used as generous as possible.
GOOD MULTI-STARTING!

QUICK TIP

When using a circular die it is a good idea to prepare the rod for threading by chamfering the end at about 45 degrees. This will allow the die to start cutting gently; failure to do so will put a sudden load on to the cutting edge and can result in chipping. Always ensure that the die is concentric and square on to the rod when threading is about to start. If this is not done the die will not cut evenly on all legs. Whenever possible, avoid opening a split die as this causes rubbing on the workpiece. When closing in do not put all the pressure on one position. Adjust both "closing screws" on the die-stock evenly.
Remember that hexagonal die nuts are designed for re-threading worn, damaged or rusty threads. They should not be used to make new threads on plain bars.

Doug Cooper

STEEL, HEAT AND CRYSTALS

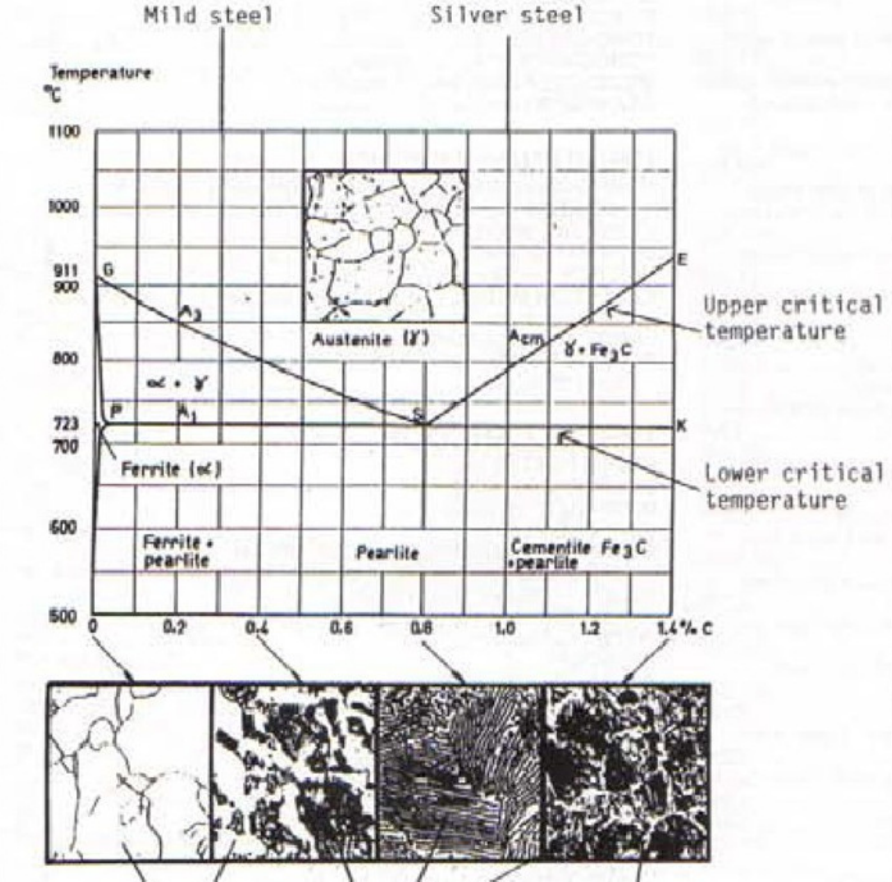


Fig 1 IRON-CARBON EQUILIBRIUM DIAGRAM

Bill Morris discusses the theoretical and practical aspects of modern day steels. Even if the theoretical aspect is a little hard going, the practical aspect of their uses in the home machine shop will make studying this brief article very worthwhile.

Generations of engineering students and interested amateurs like myself must have looked at equilibrium diagrams like that shown in **figure 1**, mentally put them in the "too hard basket" and moved on to things that looked more interesting. In fact, a few minutes spent studying figure 1 will add interest to the materials that we as model engineers use most: mild steel and high carbon steel in the form of silver steel.

Equilibrium diagrams

First a few preliminary remarks. It is called an iron-carbon *equilibrium* diagram because it represents the composition of steels containing various proportions of carbon (horizontal axis) when held at the temperatures shown (vertical axis) long enough for no further change to take place. We are used to thinking of solutions as being liquids in which molecules of, say, sugar quickly diffuse or disperse themselves throughout a cup of tea, but to understand what follows it is necessary to accept that molecules of other substances, carbon in the case of steel, can diffuse and disperse themselves in solid steel which is not only not molten, but may not even be red hot. The process may take time, typically of the order of a few seconds to a few hours, and this introduces a fourth element, that of time. Finally, iron and iron-carbon compounds are in the form of crystals, something that will already be known to anyone who has looked at the fractured surface of a piece of steel or cast iron through a hand lens. One form of pure iron called ferrite has its atoms at the corners of cubes that make up a lattice with a further atom at the centre of the cubes. This type of crystal lattice is called *body centres* (**figure 2**). Another type, called Austenite after Sir William Roberts-Austen also has its atoms at the corners of the cubes, but additional atoms are at the centre of each face and the lattice is known as *face centred* (**figure 3**). The size of the austenite cube unit is bigger than the ferrite cube, but austenite contains more atoms and has a slightly greater density.

Mild steel contains about 0.3% carbon. Let us follow on the equilibrium diagram what happens to it as it cools down slowly from its freezing (i.e. melting) point at about 1500 deg.C. Until it reaches the *upper critical temperature* at about 830 deg.C it is all in the form of austenite. All the carbon is dissolved and evenly distributed throughout the austenite with the carbon atoms in the edges of the cubical crystals as shown in **figure 4**. As it cools below 830 deg. C the form of the crystals begins to change to the ferrite form which normally cannot hold much carbon and, provided that the cooling is slow enough, the surplus carbon atoms released diffuse to areas where the iron-carbon crystal lattice is still in the face-centred form. When the temperature reaches 723 deg.C, the *lower critical temperature*, all the remaining iron is in the body centred ferrite form and the carbon is no longer in solid solution. The end result is a mixture of two thirds ferrite and one third a layered substance called pearlite. The pearlite is in turn made up of alternating layers of ferrite and cementite. Cementite is iron carbide, Fe_3C, and as you might expect from its name, it is extremely hard. We normally expect metals to expand as they get hotter and contract as they cool, but during the cooling transformation from austenite to ferrite the steel actually expands because of austenite's greater density. One cc of austenite weighing 8.22g becomes 1.037 cc of ferrite.

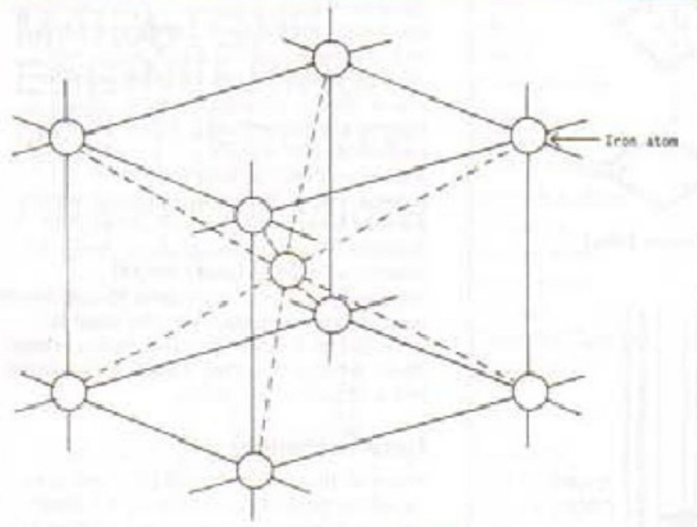


Fig 2 FERRITE CRYSTAL LATTICE(Body centred)

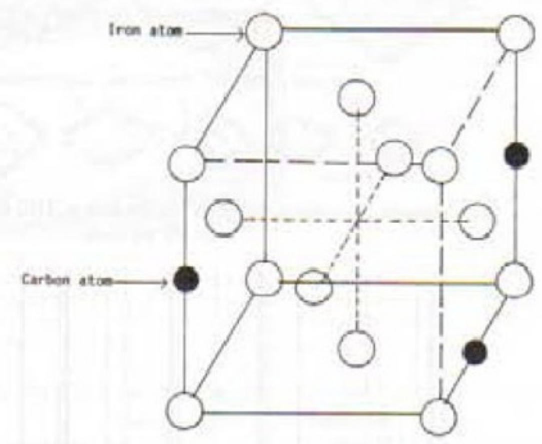


Fig 4 ARRANGEMENT OF CARBON ATOMS IN AUSTENITE CRYSTAL

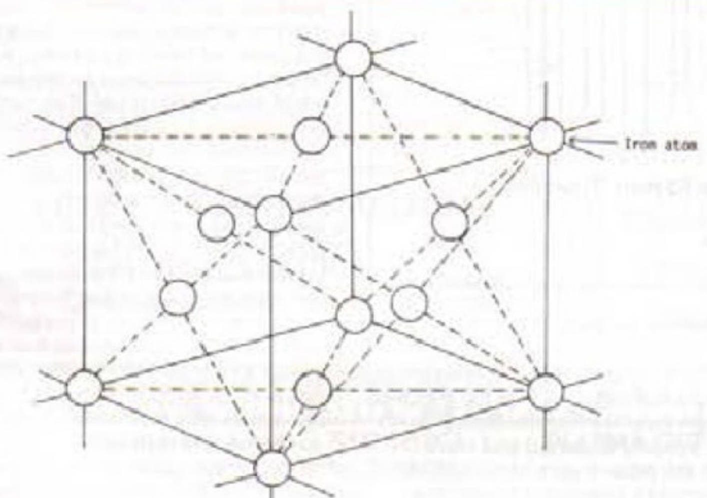


Fig 3 AUSTENITE CRYSTAL LATTICE(Face centred)

When steel containing 0.87% carbon is cooled, the transformation all takes place at 723 deg.C and the resulting steel is all pearlite. When silver steel containing 1% carbon cools below about 800 deg.C carbon gets forced out of the lattice to form pearlite and the excess carbon forms free cementite which can be seen at the grain boundaries or as crystals. Ferrite is soft and weak. Cementite is hard, but brittle and weak, while the composite pearlite is hard and strong. As you might expect, mild steel is a good compromise of strength and hardness. Maximum strength is reached when the steel is all pearlite at 0.87% carbon; and hardness increases with the total cementite content.

All the above assumes slow cooling. If cooling takes place rapidly, austenite starts to transform to ferrite, but there is not enough time for the carbon atoms to migrate and the carbon atoms remain in solid solution in the ferrite. Since there is less space in the crystal lattice of ferrite for the carbon atoms, the carbon expands the crystal lattice and the stress that results hardens the steel. The outer part of the steel cools first and expands then contracts. The interior does the same, but later and so expands against a hard, brittle skin before contracting, sometimes causing cracks in the process.

The new, supersaturated solution of carbon in ferrite is called martensite after the German metallurgist Adolf Martens. The amount of martensite that forms depends on how quickly the steel is cooled and, as you might expect, up to a point how much carbon there is available to expand the crystal lattice (**figure 5**). Quenching mild steel in this way results in only a little martensite being formed so that although it will be a little harder, it does not harden in the usual sense of the word. In a high carbon steel, however, there are many irregular plates of martensite in a matrix of austenite, resulting in a very hard but brittle steel. If this is then heated slowly to a temperature well below 723 deg.C, typically from around 230 deg.C for turning tools to 300 deg.C for springs, some of the martensite transforms to pearlite, resulting in a steel that is less hard but tougher.

Most amateurs probably quench small tools of "straight" carbon steel in water. If oil is used, the cooling process is slower and, while less martensite is formed, internal stresses are also reduced.

Quenching in brine or, historically, in urine, results in a more rapid cooling because the salt crystals that form on the surface reduce the insulating effect of the steam that forms. In the case of urine, the nitrogen compounds in the urine form crystals of hard iron nitride, Fe_2N, though of course the iron has to be hot for this to occur and dogs do not harden lamposts!

A similar process occurs when arc welding, the intense heat causing the nitrogen in the atmosphere to combine with iron to form crystals similar to martensite (nitro-martensite) and to pearlite (braunite). These can make a weld brittle as well as blunting tools, so electrodes are coated with a flux which helps to minimise the problem.

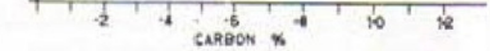
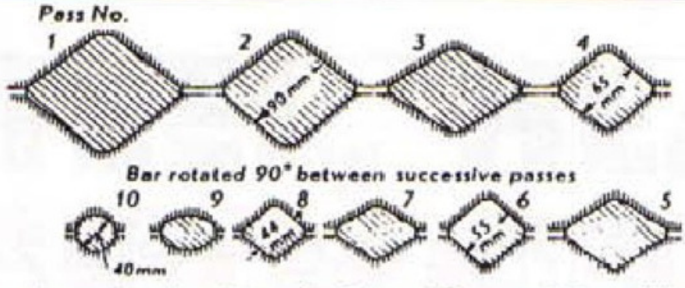


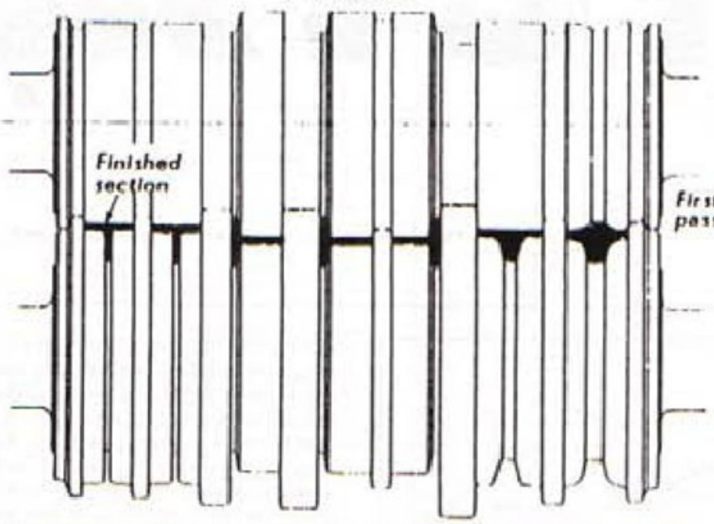
Fig 5 HARDNESS OF QUENCHED CARBON STEEL

Mild steel

Mild steel, the model engineer's standard material, starts life as molten steel of the correct composition, which in a traditional steel mill is then cast into ingots to solidify. The ingots are kept at white heat (about 1200 deg.C) in underground furnaces until ready to be rolled. The ingots which are about 1500mm long and 500mm square in cross section are then passed between rollers of chilled cast iron or steel, the thickness and shape of the steel section being altered with each pass (**figure 6**). In a modern continuous casting mill, the molten steel is poured into a sort of funnel which directs it into a tubular water cooled copper mould. The mould moves down with the steel stream for about 25mm as



(a) Stages in rolling 40 mm bar from a 100 mm x 100 mm billet in 10 passes



(b) Pair of rolls for producing a 100 mm x 75 mm T section

From figure 39 of Chapman, W.A.C.
Fig 6 *Workshop technology, Part 1*. London, 1972.

the skin solidifies and then moves abruptly upwards to break free from the steel and to repeat the cycle. The now solidifying strand passes through a water spray and between water cooled guides which bring it to a horizontal position by the time that it is fully solidified. The resulting continuous billet is then rolled in the usual way.
Since the rolling process takes place at well above the upper critical point and cooling takes place relatively slowly under controlled conditions, with time for any deformation of crystals to reform, the finished product is usually of uniform and predictable composition. As cooling has taken place in air, the surface is covered with a blue-black oxide scale with contains hard nitrides so that scribers tend to skid off it. However, the scale is fairly corrosion resistant. It can be wire brushed off with patience, though a paste of domestic Harpic powder will remove it with less effort, leaving a pale grey surface. Large or complex sections may have stresses locked in them since the outer layers cool first and compress the inner layers, so that, for example, removing part of the flange of an H-section will result in warping because of the residual stresses in the edges, but simple sections are fairly trouble free. If you look at the freshly sawn end of a round steel bar, you can very often see traces of these residual stresses as curved lines which look like ridges but cannot be belt as such. In square bar they are seen as straight lines at right angles to the direction of the saw cut.

Bright mild steel

The model engineer's bright mild steel is cold rolled steel. It starts life as hot rolled steel close to the size and section of the desired finished product. The brittle scale is removed by pickling and the rod or bar passed through highly polished rollers to reduce it to the finished size. In the process, the metal crystals in the outer layers especially become distorted and *work harden*, so the outer layers of cold rolled steel are not only somewhat harder than hot rolled steel, but also contain tensions. Many a model engineer must have been distressed to mill one side of a connecting rod, only to find it take on the shape of a banana when removed from the machine table. Cutting a long keyway in a round shaft will have a similar result. However, these residual stresses and increased hardness and strength in the skin are desirable features in shafts that transmit power.
The distorted crystals can be encouraged to take on a more normal shape by heating the metal to 650 to 680 deg.C and in general, the more severe the coldworking, the lower the temperature at which this *sub-critical annealing* takes place. *Full annealing* refers to heating the steel to about 50 deg. above the upper critical temperature (somewhat lower for high carbon steels) and allowing it to cool very slowly so that it passes through approximately the same stages that the equilibrium diagram summarises. The process of *normalisation* again takes the steel to above the upper critical temperature, but it is allowed to cool faster so that finer crystals form, the steel is stronger and it can take on a finer surface finish when machined. **Table 1** compares hot and cold rolled steels.

Case hardening

From all this you will probably realise by now that both cold and hot rolled steels may be *case (or surface)* hardened. In this process, a relatively low carbon steel is heated to above the upper critical temperature in the presence of carbon, usually charcoal combined with various additives, so that carbon atoms can diffuse into the surface austenite crystals, even to the extent of forming carbides. Kasenit is a favourite product used by the amateur for small items. The carbon first combines with atmospheric oxygen to form carbon monoxide which then combines with more oxygen to form carbon dioxide. This breaks down at the steel surface to form atomic carbon which easily diffuses into the hot steel. In general, the longer the temperature is held, the deeper the carbon will penetrate. About five hours is necessary to get 1mm of carburisation, but with the small components that the amateur uses the process for, 0.1mm or less is often enough so that 10 to 20 minutes suffices. When the steel is then quenched, the high carbon outer layers harden in the usual way while the low carbon interior retains its previous qualities of toughness and moderate strength. Both hot and cold rolled steels can be case hardened though the scale should be removed from the hot rolled steel first to allow better penetration of the carbon. Free cutting steels can also be case hardened and I have successfully case hardened free-cutting stainless steel in making small reamers for piston rod glands.
Interestingly, silver steel can benefit from the process when making small tools as the grain structure of the surface is refined, increasing wear resistance and decreasing the tendency to crack.

Table 1
Properties of rolled mild steel

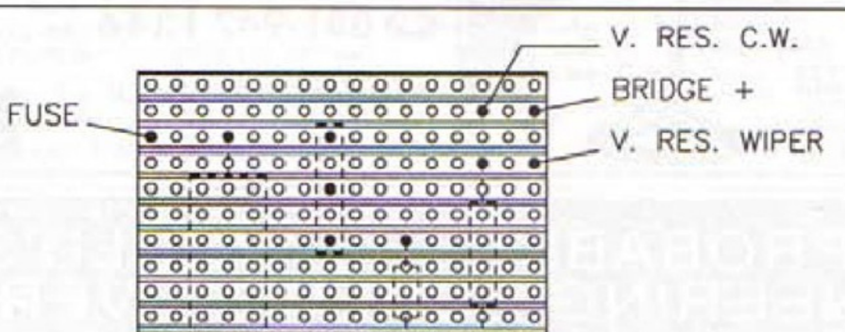
Hot rolled	Cold rolled
Blue-black scaly surface	Bright smooth surface
Difficult to scribe	Easy to scribe
Corrosion resistance	Corrodes easily
Rectangular bar has radiused corners	Rectangular bar has sharp corners
Dimensions variable	Dimensions constant over short lengths
Annealed as supplied	May have relatively hard skin
Bends easily	May crack if bent parallel to rolling direction
Less likely to distort as a result of machining	More likely to distort as a result of machining
Relatively cheap	More expensive

The cooling fan motor mounted in position on the milling machine. The mechanical reversing switch can just be seen at the top left hand corner of the picture.

David Machin details this excellent little variable speed drive controller, which he developed for use on the table feed on his milling machine. (The start of a series on this subject appears elsewhere in this issue.) The controller could be be used in many other applications.

I was planning to add a power feed to the table of my small milling machine. A major consideration at this stage was the choice of motor. My first idea was to use a car heater blower motor which I had in stock but, after some experiment, including rewiring the field windings to allow reversing but rejected it on the grounds of too little power, and lowering of power when end pressure is put on its shaft. The latter would be a problem since the worm gear system I was proposing would put end pressure on the shaft.

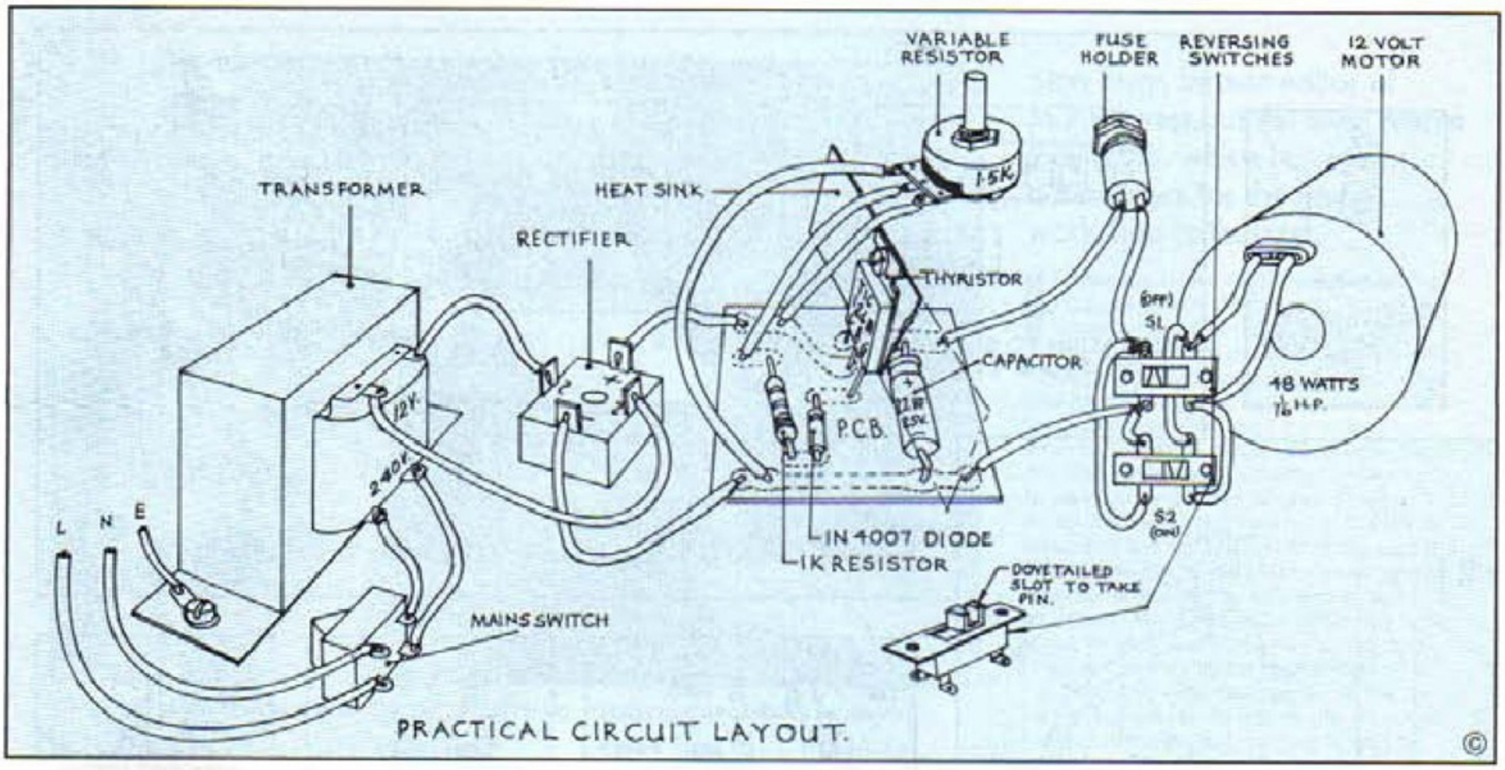
A SMALL VARIABLE SPEED DRIVE CONTROLLER



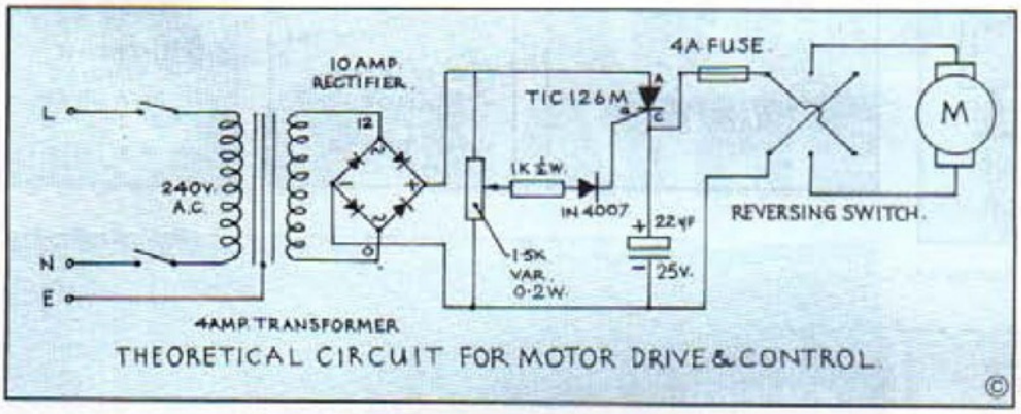
The motor

Finding a suitable (controllable) motor was becoming a problem until one day, when checking the oil level on my car, I spotted the cooling fan motor. Could this be the answer? Since the fan puts considerable end load on the motor bearings, and absorbs quite a lot of power in wafting the air through the radiator, it seemed a good solution, and later proved to be so. Enquiring at the local breakers yard, I found that the most powerful motors were fitted to continental cars so, on the principle that a little too much power is better than too little, I bought a cooling fan motor originally fitted to an Audi Avanti. (Its power I later calculated to be 48 watts – about 1/16 H.P.) I was charged £5 for this which I considered to be a bargain. It was of Bosch manufacture, and its "crimped" construction would not allow easy dismantling. I was glad to find that it could be reversed by changing over the leads. I would have liked to have dismantled it to check it over, but didn't because of the construction.

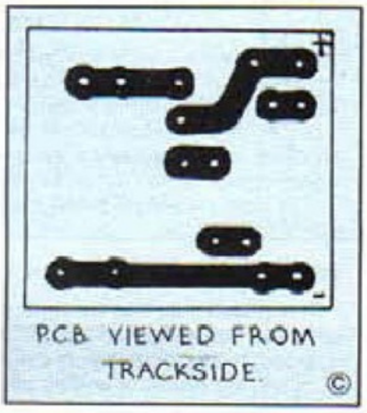
However, when I thought about this, I realised that most of the time when using a car, *this* motor isn't turning; it only swit-



PRACTICAL CIRCUIT LAYOUT.



THEORETICAL CIRCUIT FOR MOTOR DRIVE & CONTROL.



P.C.B. VIEWED FROM TRACKSIDE.

ches on very occasionally when in traffic jams etc. Certainly no wear could be discerned from handling the main shaft.

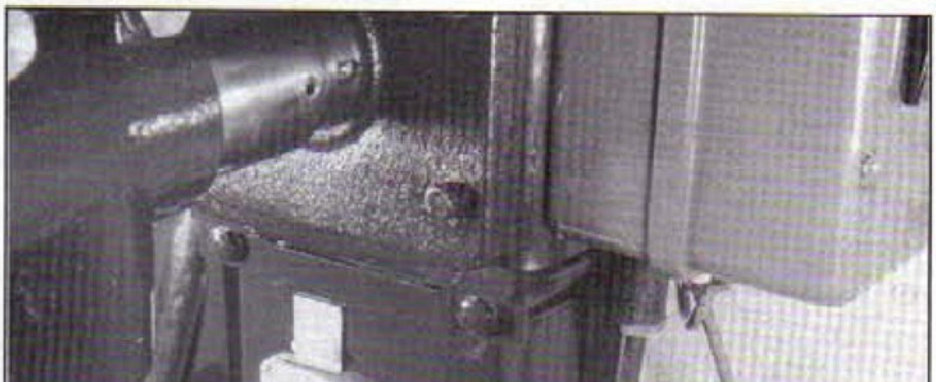
Eventually the motor was assembled between gearbox and cross-slide, and a trial run attempted, after oiling round.

I used the car battery for this, and was able to measure the starting and running currents on load – 5 amps and 4 amps respectively. I therefore bought a 4 amp 12 volt transformer on the principle that the small starting surge – far less than a second – wouldn't be a problem. However, for the rectifier, being a solid state device I decided to double the starting current and bought one of 10 amps.

The controller

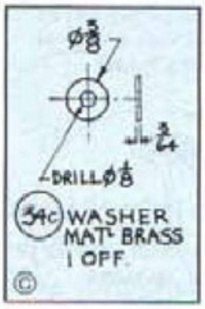
Controlling the motor speed was a greater problem than I anticipated. Eventually, after many "wet towels round head" sessions, I ended up with the very simple thyristor control seen on the drawing. The secret, as I later found, was to double the load current (8 amps) and fit a thyristor of this value. This has worked well.

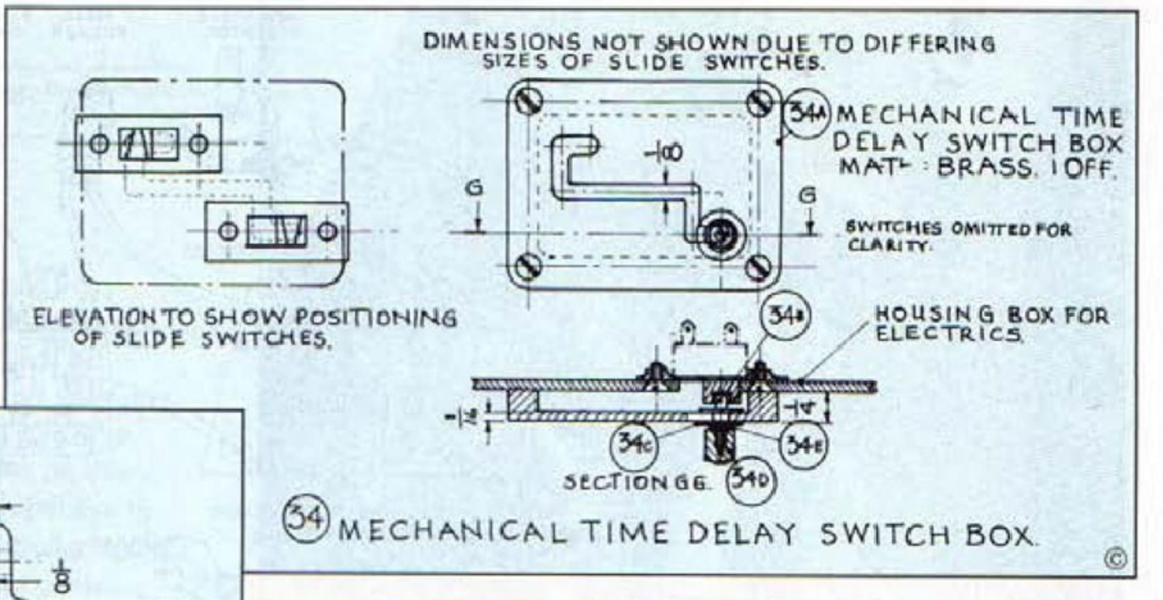
For the electronically minded: The output from the rectifier has no smoothing capacitor and although the output is d.c. it is actually pulsing at 100 Hz. With variable resistor set to the more positive side of the circuit, a triggering current is obtained early in the cycle, giving a long pulse at the motor. As the V.R. wiper is moved to the

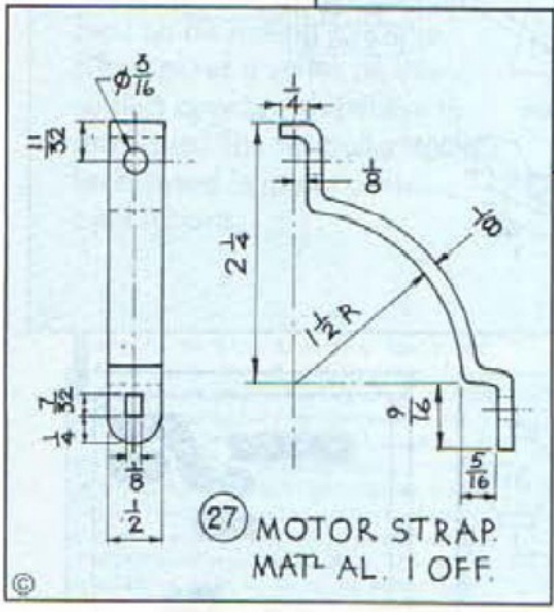

The controller showing the reversing switch and speed control knob.

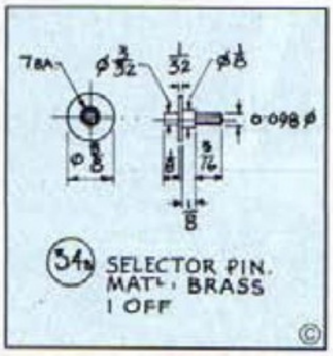
negative, triggering is delayed. This gives shorter pulses at the motor. So pulse length controls motor speed, but even at the lower speeds, good torque is still available. The same effect can be obtained with a pair of 555 I.C.'s but this is a much more complex circuit.

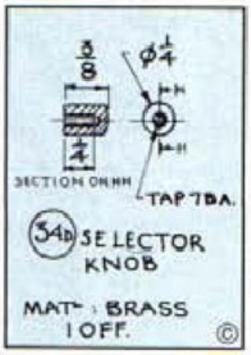
The control box was originally wired with a single D.P.D.T. switch for reversing. Using the reverse switch before switching off at the main switch – on moments where my attention was on the machining – caused some blowing of thyristors due to back E.M.F. Various electronic expedients (mostly time delay) were considered and rejected on the grounds of complexity, so I eventually ended up making a "mechanical time delay". This can be seen in the photographs.

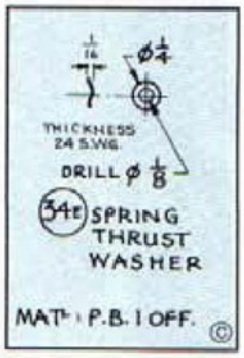












This makes sure that the motor has come to a complete standstill before being reversed. It uses double pole single throw switches, the plastic operating parts of which have to be notched so that a pin can enter to control them. Hopefully the drawing will make all clear. Of course many applications do not require reversing and will not require this added complication.

The practical wiring layout is also shown on the drawings, together with a suitable P.C.B. layout for the thyristor control. You could, of course, use stripboard (*see postscript, Ed.*). At the time of writing, the firm of N.S. and A. Hemingway are looking into the possibility of a complete electrical package (*apparently almost ready, Ed.*) for this project, for those readers who are not confident of their electronic abilities. Watch this space! On my version, the electrics were fitted in a box, made from 14 SWG sheet aluminium, with suitable air vents for cooling. The box was then fixed to a backplate hung below the main motor bracket. The mains input lead is fed from the main motor switch so that feed can only be applied with the milling machine spindle running.

Postscript

This unit will only suffice with two terminal DC motors, that is either series wound or with permanent magnet field. I would not know which type of motor the fan motor would be, does any reader know which type? Ed.

For those readers not experienced in purchasing electronic components, the following will enable them to be purchased mail order. To enable them to all be purchased from one source, some items differ from those detailed by the author, this will not effect the functioning or construction of the unit.

Some items have a minimum order quantity, these are indicated. As these are mostly just a few pence each they do not greatly affect the overall cost which is around £30.00. Cost could be reduced by shopping around, not a good idea for the inexperienced. Materials obtainable from: Electromail, PO Box 33, Corby, Northants. NN17 9EL. Tel. 0536 204555.

Component		Electromail part number	Qty req.	Order qty.
Thyristor 7.5A 600V TIC126M		649-453	1	1
Transformer 240v prim 2 x 6v 4A sec	note 1	208-771	1	1
Potentiometer 5K 0.2W Log Track	note 2	168-083	1	1
Diode 1A 1000V IN4007		261-980	1	10
Bridge Rectifier 25A 200V KBPC2502		265-033	1	1
Capacitor 22µf 25V		107-000	1	5
Slide Switch DPDT		337-986	2	5
Toggle Switch DPST	note 3	316-541	1	1
Strip Board 95 x 292 x 1.6mm		433-826	1	1
Resistor 1K ½W	note 4	132-494	1	10
Fuse holder 20mm		414-134	1	1
Fuse anti surge 5A 20mm x 5mm		415-626	1	10
OR Fuse anti surge 3.15A 20mm x 5mm		415-610	1	10

Note 1. This transformer has two 6 volt secondaries. Connect these in series to achieve 12v. Do also connect the end of one secondary to the start of the next. If connected start to start, or end to end, voltages will subtract to give zero volts.

Note 2. The value of 1.5K is now a non-preferred value, the increase to 5K will not greatly affect the operation. A resistor between the bottom end of this potentiometer and the negative line, could ensure that it was not possible to leave the motor powered, but in a stalled condition. The value would require to be chosen by trial and error, use the surplus 1K resistors. In this case probably a 1K potentiometer would be preferable, 173-811 is this value but more expensive.

Note 3. This type of switch, chosen by the author, is unlikely to be rated for 4 amps continuous. If it is probable that the system is to get continuous use over a few hours, some higher rated switch should be considered. The mechanical arrangement should be adaptable for other types. Even if its use is continuous, each switch will only be used part time as the table has to move alternately, in either direction.

Note 4. This is much larger than required. An alternative would be to construct on a small portion of insulating material, fitted with pins and wire links to give the required circuit.

The photograph shows the headstock; the dividing attachment can clearly be seen.

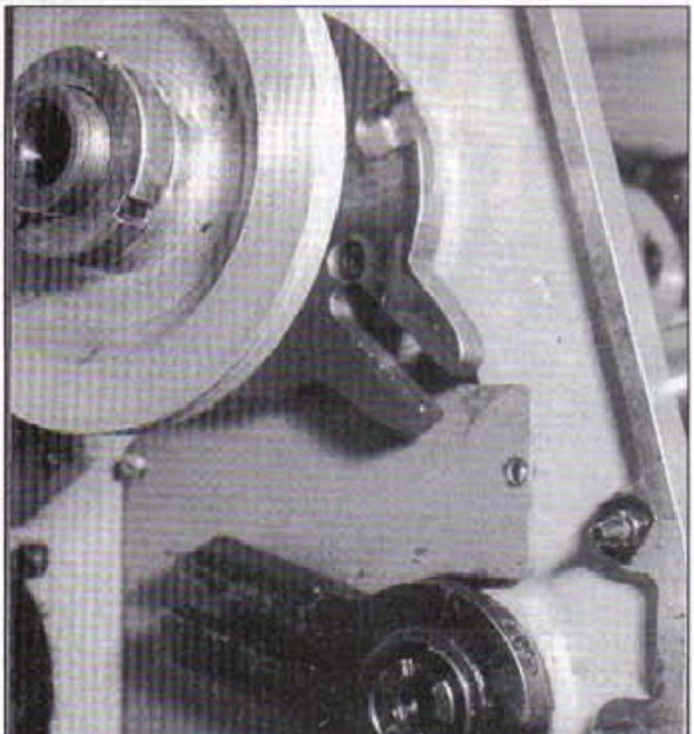
THE WARCO 220 LATHE

Stan Bray, former editor of M.E.W. tries out the new Warco 220 lathe, which has many advantages for the home workshop enthusiast.

It does not take long to realise that this new lathe from the "Warco" range is something out of the ordinary. The massive, rigid form of construction is more in keeping with an industrial machine than one for the hobbyist, with the result that the home machinist gets the best of both worlds. The lathe was well and truly put through its paces for a period of several months, during which time all types of materials were machined on it. It was not spared in any way and it came through the test with flying colours. The exceptionally rigid construction has a further advantage as it means that no special effort has to be made to level it, although of course one must not be silly about such things. The rigid box bed with heavy ground, flat carriage slideway do however ensure that there is no untoward twisting is likely to take place.

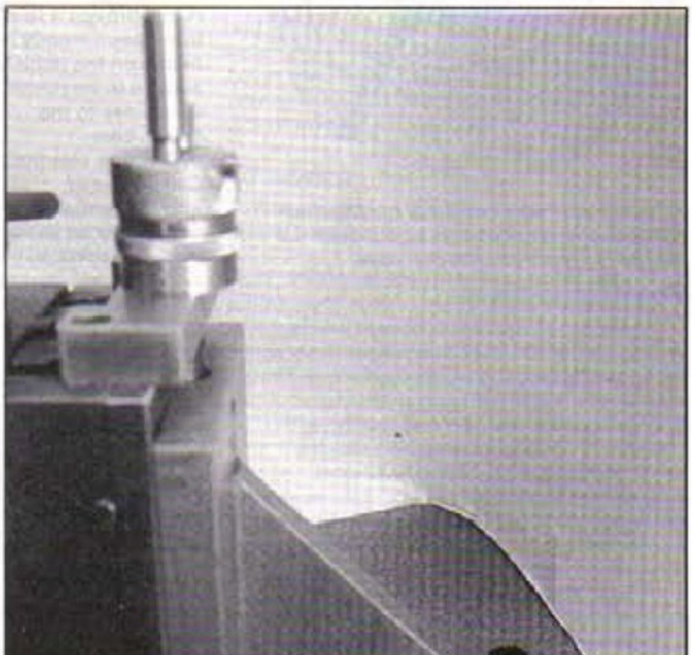
Accuracy

Every machine is issued with a test certificate and this gives tolerances etc. Each certificate is individually prepared at the factory and signed by the inspector. The obvious start was made by checking on the figures quoted and these proved to be as near correct as was practical to measure. Particularly impressive in these



These quadrants are used to set up the gear chain for screw cutting. The lever at the bottom engages in three grooves. Depending on the selection this gives a range of fine feeds.

The rear view of the vertical slide gives some idea of the massive construction.



checks was the mandrel run out and the slide movement. If confirmation was required then this was later obtained during machining operations. Because of the very rigid construction incorporated in the manufacture of the machine there was an absence of chatter, and vibration was nearly zero. A normal check for vibration is to place a coin on edge on the lathe bed and see if it falls over when taking a fairly heavy cut. This test was passed with flying colours, indeed it was found to be possible to put the coin on the saddle and it would still pass the test.

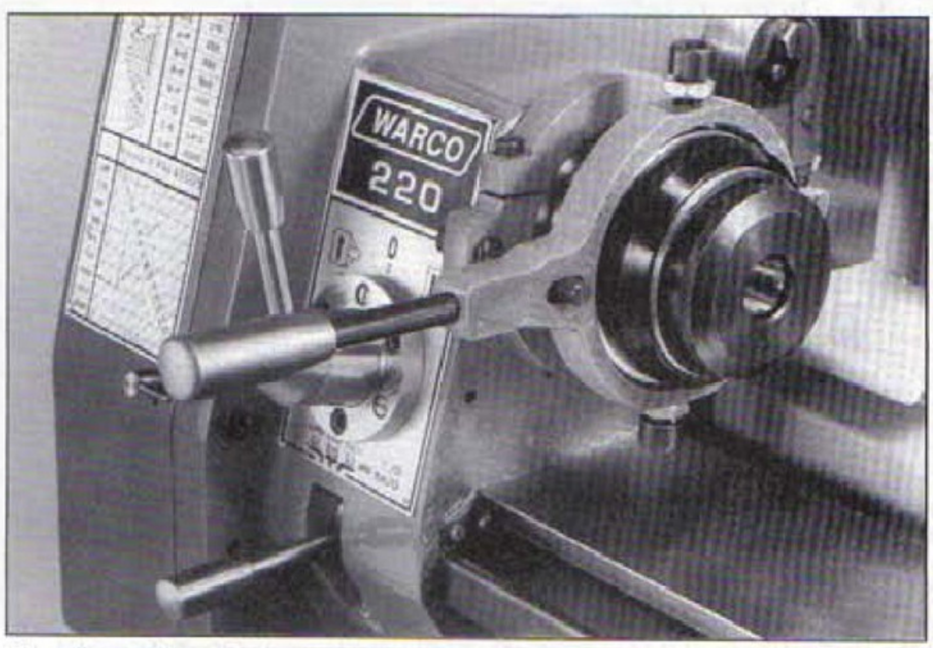
Measurement

The lathe has a centre height of around four inches and about nineteen inches between centres. There is adequate cross and top slide travel and movement on the tailstock. The latter can be set over for taper turning if required. The handles for all movements are nice and large and all slides are smooth in operation. The tailstock takes a No.2 Morse taper and has a hole through the centre of about ¾ in.. diameter. An additional bonus is an indexing device which consists of a series of holes round the mandrel and a bold-on detent which is sprung loaded.

A heavy balanced faceplate means that really heavy work can be coped with. Of particular value are the tee slots.

Speeds and feeds

There is a range of rotational speeds which should cover all operations likely to be undertaken in the home workshop. The machine is belt driven and changing speeds is made easy by one cam lever slackening and tightening the belts, the lever being situated on the headstock casing. The feed arrangement is through a permanently engaged lead screw. Normal fine feed is via a friction drive and there are three feeds to select from which allow sufficient range for roughing and finishing operations. Screw cutting is via the normal type of gear train and the gears supplied will give a very wide range of metric and Imperial threads. There is no thread dial indicator. The permanently engaged lead screw means that the tools is withdrawn at the end of the cut and the machine put into reverse to get back to the start position. A successful enough system once one gets used to it. The handwheels on the model supplied were graduated in metric divisions. Production models will have both metric and Imperial graduations. All dials can be zeroed.



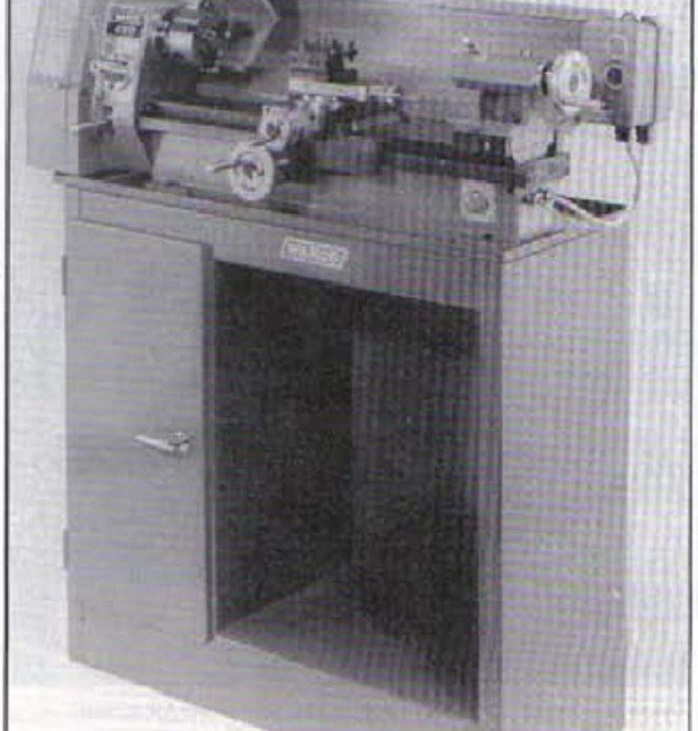
The collet attachment is lever operated and allows rapid work changing. On the headstock will be seen the speed chart for the lathe.

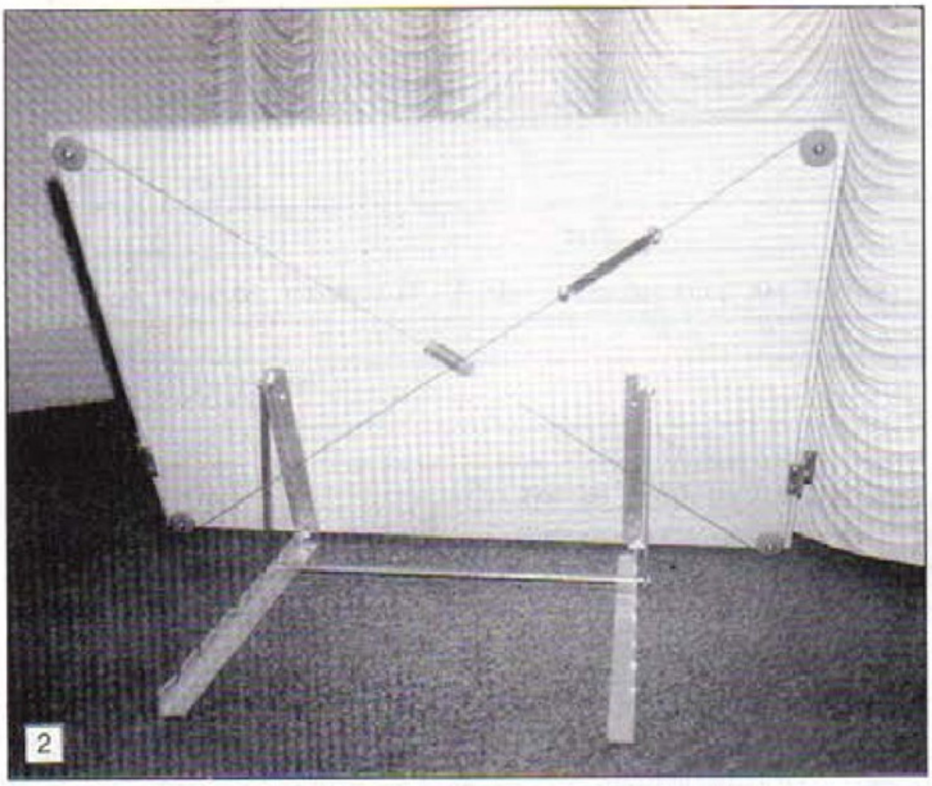
Fittings etc.

Chucks etc are fitted to the mandrel by locating on a spigot and bolting up with six cap head screws. A very sound system which avoids the possibility of the chuck coming off when operating the lathe in reverse. The faceplate is particularly solid and has three normal type slots plus three proper tee slots which make positioning the work very simple. The plate has been balanced at the works to prevent vibration and the possibility of it running out of true. A test proved it to be perfectly accurate. A three point steady is supplied. This fits neatly on the lathe bed and is angled to allow it to be placed very close to the chuck. Like everything else the structure is of above average rigidity. As an extra there is a vertical slide with an arrangement which incorporates a vice which accepts round or rectangular work, as well as allowing the work to be bolted direct to the vertical slide if the shape does not permit it to be put in the vice. Needless to say the vertical slide is again a massive chunk of metal. Another extra is a collet attachment which will accept a range of metric and Imperial collets. This is a bolt on attachment which is easily fitted. A lever arrangement opens and closes the collet making it an ideal tool for rapid work changing operations.

The lathe brings a new concept to machines for the home workshop and because of its form of construction is ideal for the less experienced worker as well as those who are well versed in machining techniques. It is anticipated that other attachments will be available, but anyway the machine just lends itself to making those extras that convert a normal model into a customised version. With a price tag considerably under £1000 it is probably less than a second hand equivalent and really must be around the best buy on the market for anyone looking to make a start, or to update an existing workshop.

An overall view of the lathe on its cabinet.

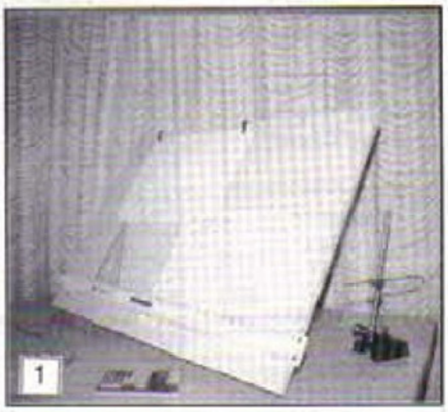




2: *This view of the rear of the board shows the crossed wires and sturdy supports.*

A FABRICATED DRAWING BOARD

Putting your ideas on paper before starting to make some items to one's own design is a very worthwhile approach. It will probably save time and, more important, may also prevent expensive failures. The drawing board design in this article has been provided by Stephen Vagg. This would be an excellent and relatively inexpensive addition to any home workshop.



1: *The complete board, ready for use.*

The idea

The criteria for the design was to produce a board of reasonable size with parallel motion and to be able to pack it into a very small space i.e. on top of a cupboard or under the stairs when not in use, hence the weight must also be kept to a minimum. The seed was sown when browsing around the local destroy it yourself store where a plastic 36in. stick (rule) was purchased.

The design

The drawing surface and the base (*not to be seen in the drawings or photos. Ed.*) are cut from a sheet of 24in. wide Contiplas, the stuff used for shelves and homemade furniture, this material was chosen because its surface is smooth and free from grain line. These latter, if drawn on directly can leave an unexpected imprint on the paper. The parallel motion is easily provided by four pulleys turned from aluminium and a length of thin Bowden cable routed as per **photograph 2**. The rule attaches to each side via a pair of brackets and modified bolts.

The tilt and folding mechanism is provided by four lengths of 25x25x3mm aluminium angle made as shown in the drawing and pivoted at one end. To enable the angle of the work surface to be adjusted two support bars are fitted, spaced out with a length of aluminium rod. The bars being pivoted at the other end of the board pivot enables it to swing into any of the 45

3: *Drilling the base angles.*

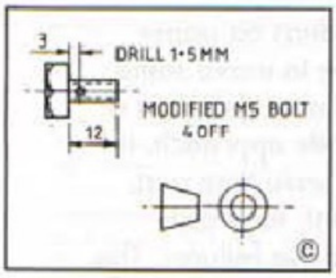
deg. slots in its other angle. This gives seven gradients for working upon. When not in use this rod swings up out of the way to allow the board to be closed and stored away.

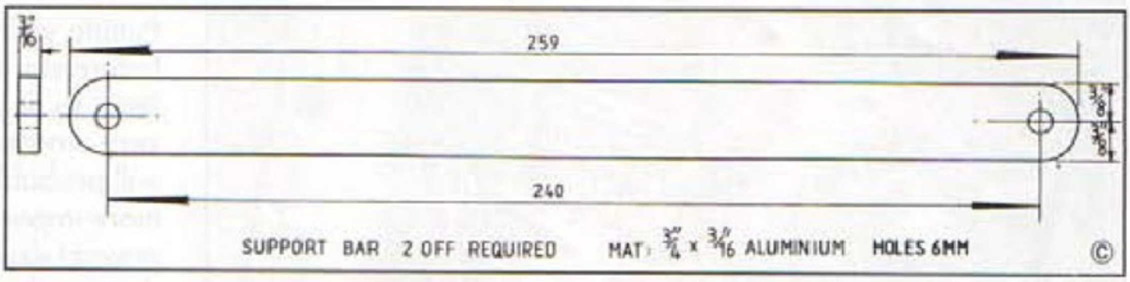
To work ...

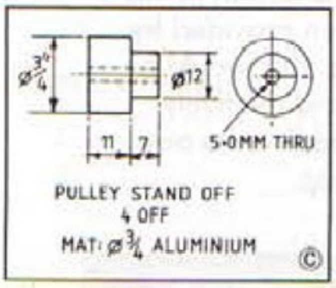
First a word on the drawings. I've used metric because it's a lot easier to take 3mm from 19mm than to mess about with fractions, for those of you that haven't tried metric try it now – you've been using decimal for over twenty years now in your coinage without realising it! (*Your 24in. Contiplas will be 600mm according to my catalogue. Ed.*)

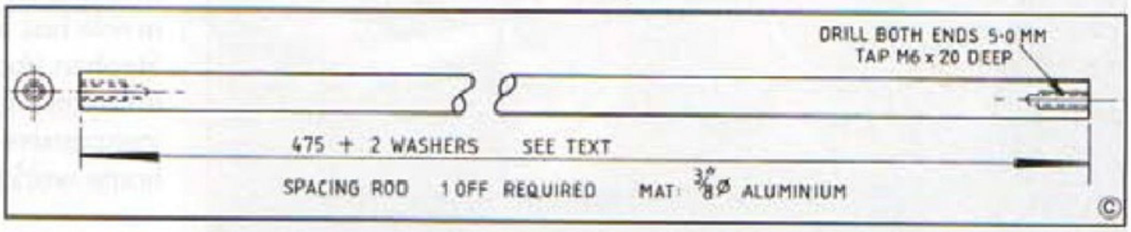
To the work ... The board and base are both the same size from 24in. wide Contiplas as I've said. The critical thing is to get the centres right for the pulleys to ensure true parallel motion, check this by measuring the diagonals of the centres, if both diagonals are the same then it can be assumed that they are square. The pulleys themselves need no explaining as they are a straightforward piece of machining. The diameters in the grooves should be checked to ensure they are all alike, again to ensure true parallel motion. These are then simply fixed on with suitable screws and washers (to stop the pulleys falling off). A smear of vaseline on the bearing surfaces will stop them galling when in use.

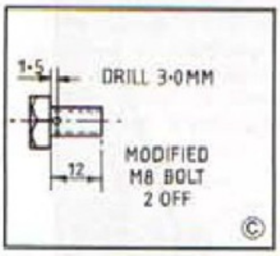
Now the angles. The 25x25x3 aluminium for these is available from Maidstone Engineering Services (Tel. 0622 691308) as is all the other metal (*not Bowden cable, I think; try J.A. Crew and Co. 0908 583252.*

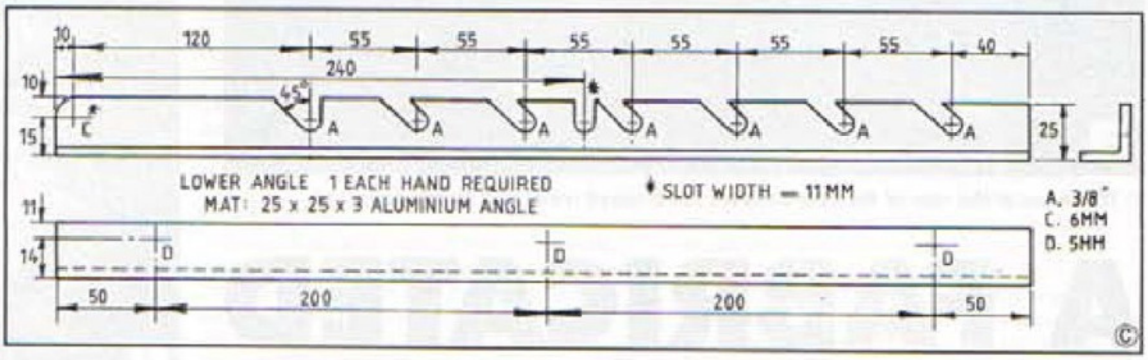


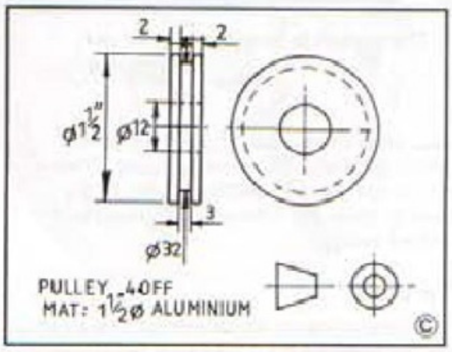


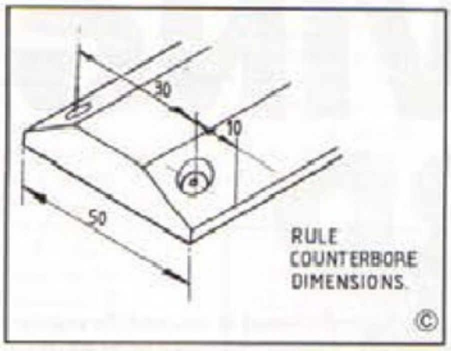


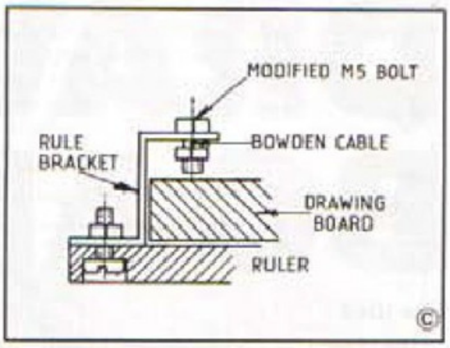










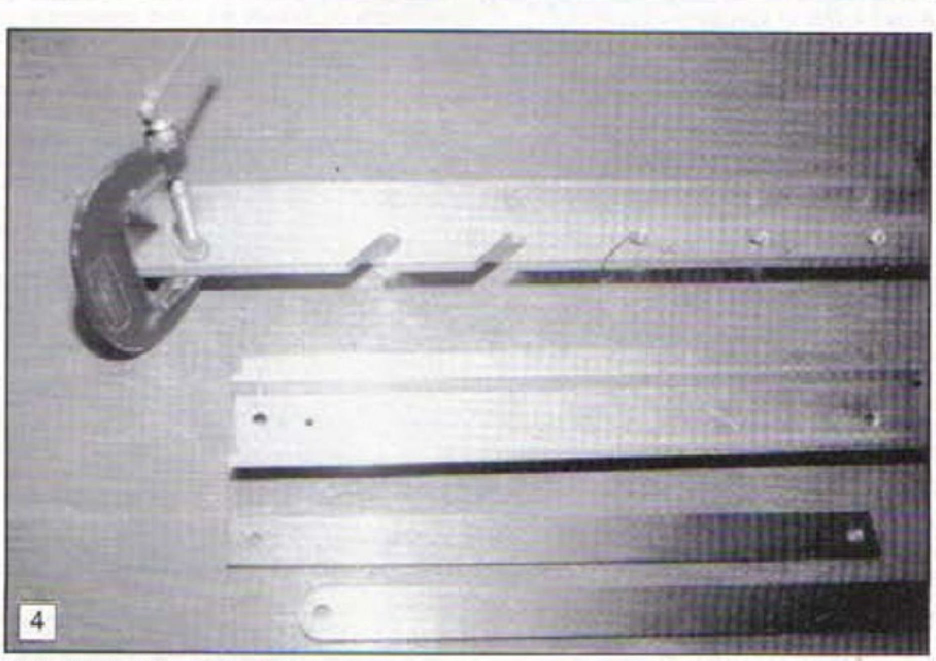


Ed.). The only point I need to make about the angle is to make sure you actually produce a handed pair of each! Clamp together as in **photograph 3** to produce a pair without thinking, also only one of each type will need marking out. This method can also be used to saw the 45 degree slots in the long angles as seen partly completed in **photograph 4**.

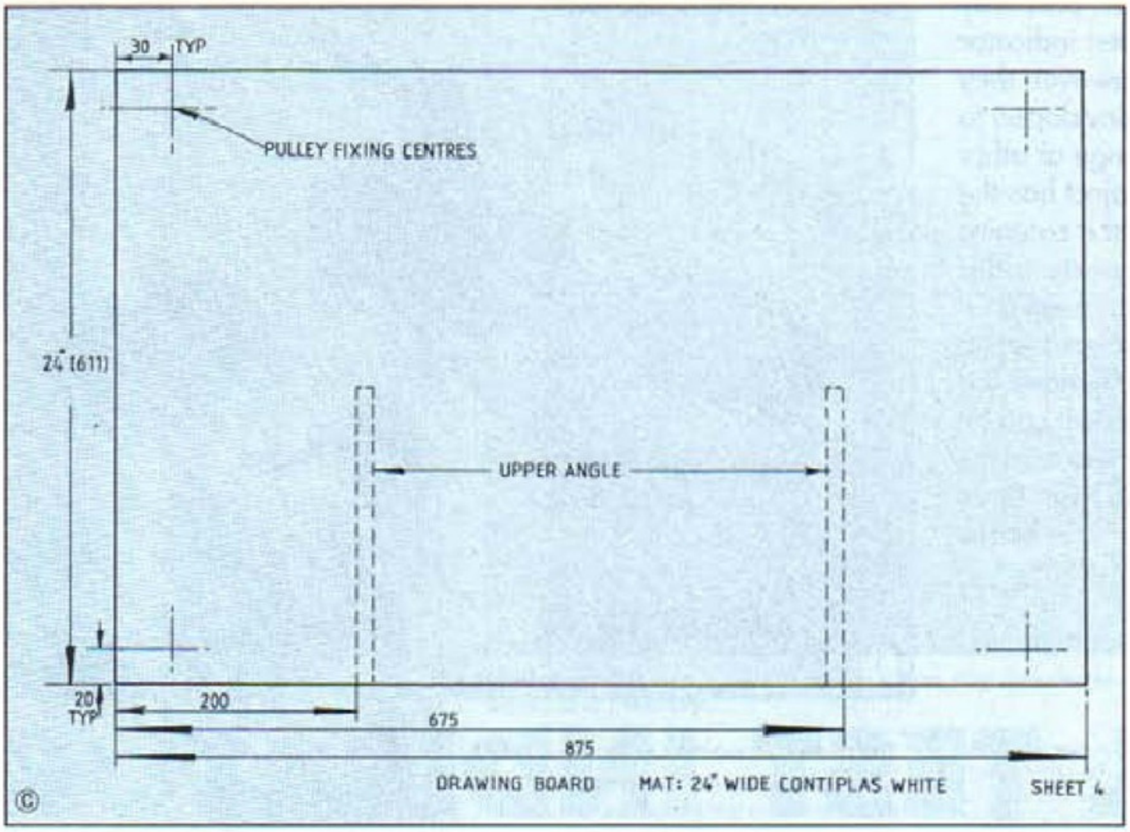
Assemble the pair using M6 x 20mm bolts and Nyloc nuts, or equivalent, not forgetting a washer between the angles, through the 'C' holes marked * to form a channel when closed with the short angles on the outside. Next perform a mirror operation.

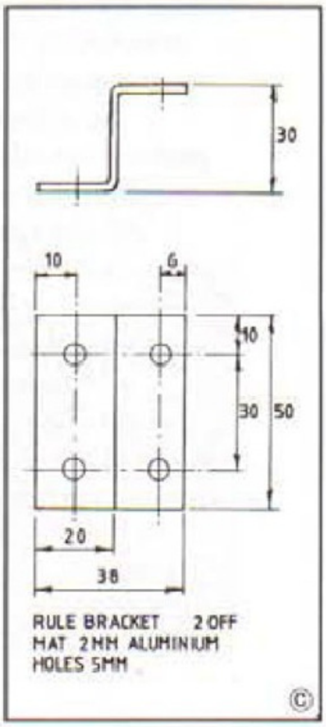
The aluminium support bars located in the remaining 'C' holes in the short angle on the outside. Fixing is by a M6 x 25mm bolt and Nyloc nut in each, with a washer between the two parts. These washers have to be of known thickness and added to the length of the ⅜in. aluminium rod, it seems trivial, but if ignored the holes that the cable passes through could finish up in the wrong place. The spacing rod is then simply bolted between the support bars with M6 x 20 bolts.

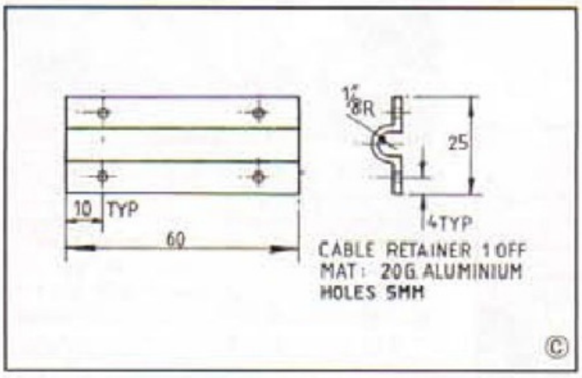
This angle sub assembly is then fixed to

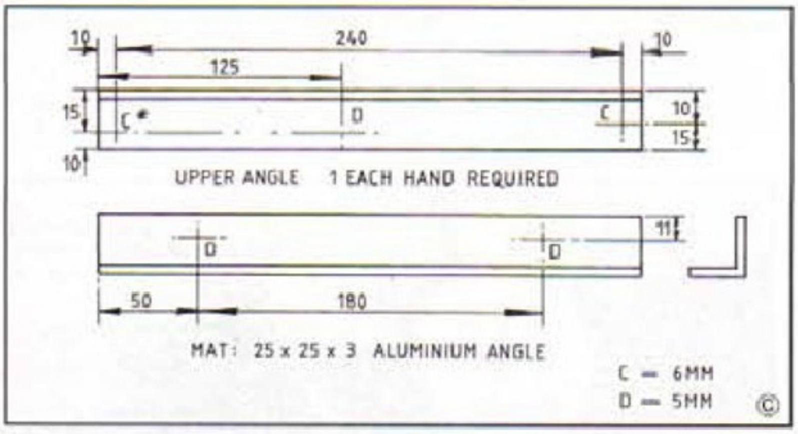


4: *The various parts of the frame.*









the reverse of drawing board in the position drawn, the same side as the pulleys, via the two 'D' holes in each of the short angles. Ensure that this is kept square while fixing. Check also that the length of the screws will not bulge out of the drawing side of the board.

Place two of the four modified M5 bolts onto the Bowden cable with a rule bracket as in the cross section drawing, (the thinner the cable the better, as it will "roll" around the pulleys easier). Thread the cable through one of the angles from the outside, place the other two bolts and rule bracket on, thread through the other angle, again from the outside. Then the cable can then be attached as seen in photograph 2, join the two ends together with a suitable expansion spring (most small car accessory shops have good selection if you haven't) and two modified M8 bolts, this is where the "missus" will come in handy, to stretch the spring out while tightening the second bolt. Don't be surprised (or angry) if it takes more than one attempt. Take note: the join is on the top diagonal.

The next step is to attach the rule with the counter-bored holes. See sketch for dimensions. This can be fixed on firmly. A tip for counter-boring: start the counterbore with a conventionally sharpened drill until just after full diameter has been obtained, then resharpen the drill similar to a slot mill i.e. flat, 180 degrees, and bore to required depth. Now the rule is securely fixed to the brackets, move and hold it parallel near the top of the board. Before tightening the bolts check that the spring will not crash into a pulley on its travels, adjust accordingly, then tighten the bolts gripping the brackets to the Bowden cable, check for parallelism with the top of the board and re-adjust if necessary, incidentally if it is askew it will still produce parallel lines, but on a slope.

The purpose of the cable retainer is to hold the cable out of the way of the spring when it crosses the intersecting diagonals. This is made from a thin piece of aluminium or tin can. This shape is easily formed with the use of a vice opened 8mm, the rectangle of material placed centrally over the gap, a piece of ¼in. rod placed on top over the opening and a stout piece of flat bar balanced on top and given a clout with a hammer until the flat bar touches the material being formed. Drill four holes and attach over the lower Bowden cable, the one without the tensioning spring, with short self tapping screws.

After checking that the tilt mechanism functions correctly and also folds flat without crushing the Bowden cable it can be placed, folded, onto the base board. True the top up with the base, mark the positions of the angles unfold them, drill and fix down with suitable screws.

This I think you will agree is a simple little project that takes less than a day to complete but over the years will prove to be worth its weight in gold.

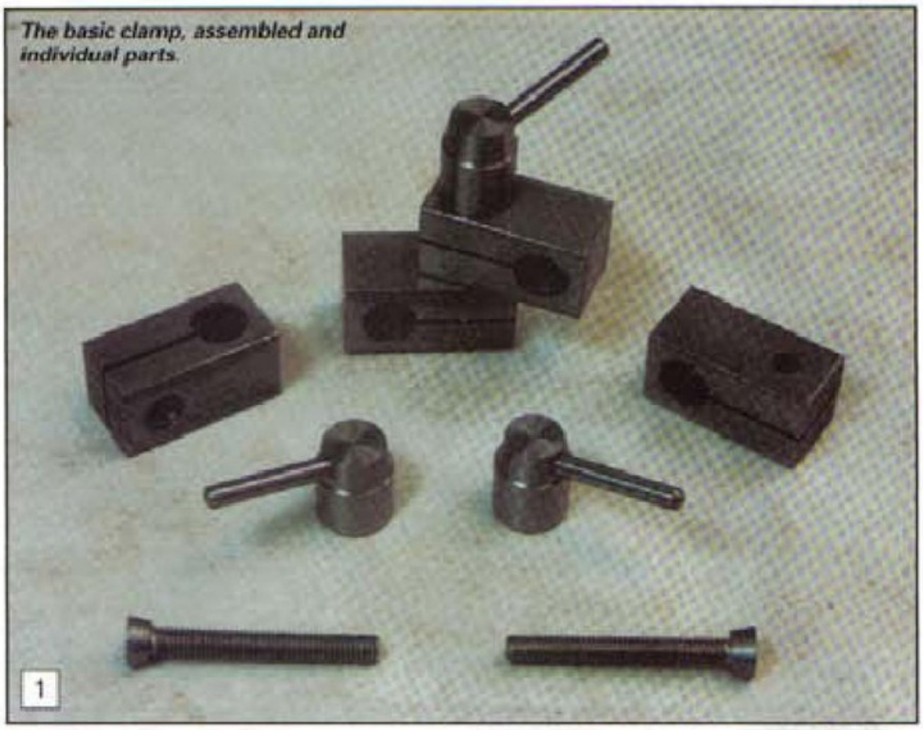
Another little extra that can be added is a rule grip, whether it is full length, of wood or metal is up to you and what you have available, but some people might feel that this gets in their way so therefore no drawing is shown.

I'm sure you realise that the full length of the rules doesn't have to be utilised or the board as large as the one shown, but if reducing the sizes, the holes in the upper angles will have to be redefined. Of course the parallel motion part remains the same only using less Bowden cable.

Here is a kit of parts, primarily intended as dial test indicator accessories. However, they have been developed to perform a wide range of other duties. The project has the advantage that it contains many quite simple parts and is an ideal job for the beginner. It's varied applications when finished will make it a worthwhile project. It can be made in total, or selected items only. The article will be in three parts.

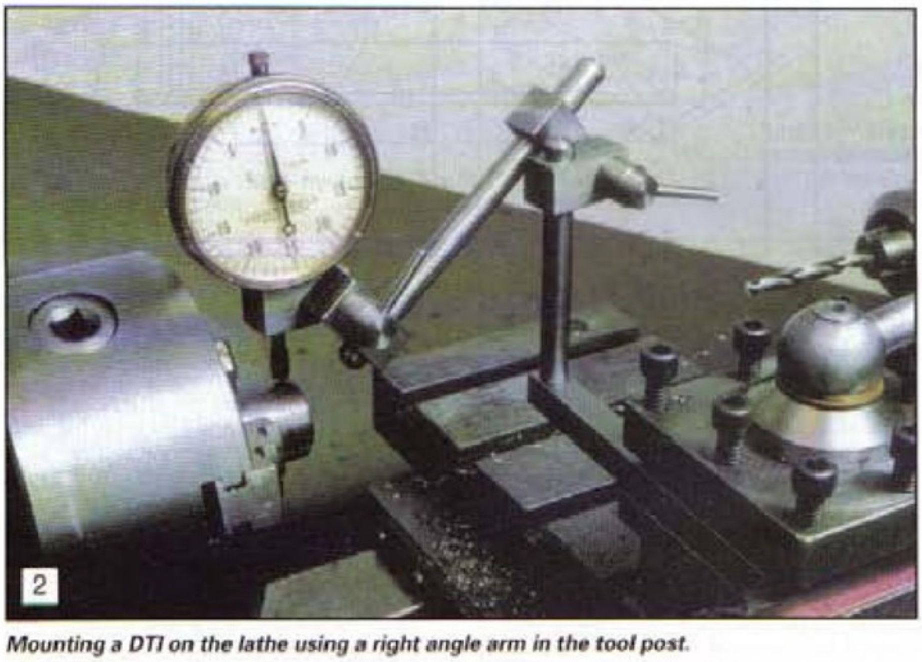
Part 1

The basic clamp, assembled and individual parts.



1

DIAL TEST INDICATOR ACCESSORIES



2

Mounting a DTI on the lathe using a right angle arm in the tool post.

I was becoming unhappy with the amount of time taken to set up my dial test indicator, when using it on either the lathe or particularly the milling machine. This led to my adopting other methods which avoided its use, these were frequently not totally adequate for the task being performed.

The problem was greatest on my mill/drill when invariably the indicator was required to be mounted remote from the table. This was so that the position of items mounted on the table could be checked for location as it was moved and the indicator remained stationary.

Mounting the indicator from the chuck was the normally adopted approach, but this had two major weaknesses. First the tool mounted in the milling machine may have to be removed to enable the correct chuck to be fitted. With this done, the range of attachments provided with the indicator frequently made it difficult to position adequately.

An adaptable helping hand

Because of these problems, it was decided to make some attachments to improve the situation. It soon became apparent that the scope of the items as they were being envisaged, could be extended well beyond that of just a dial test indicator carrier. As a result, what started as a small project became quite a major exercise, quickly developing into a very adaptable helping hand.

Any reader could just make one or two items from those about to be detailed, whilst others may even develop the idea further.

Some of the tasks performed, are:

A Dial test indicator carrier.
A Coolant nozzle carrier.
A machine guard carrier.
A Helping hand.
A Mini vice.

The basic design

The basic design was considered and existing indicators inspected. It was found that there was no standardisation between the indicators in terms of diameters of the various attachment points. In view of this it was decided to make all the arms which made up the set, $\frac{5}{16}$in. diameter, and to adapt only at the point where the various devices would be fitted.

The method of holding the arms together also had to be decided. One possibility was that found on many commercial units. These comprise a split clamp onto one arm, with the other arm passing through holes in an assembly having an inner part and an outer tube. This method was discarded in preference for two split clamps, it was considered this system would be better all round and easier to make. These can be seen in **photograph 1**.

One disadvantage of using two split clamps is that the clamping screw will easily rotate when being tightened, this cannot happen with the common commercial system. To overcome this the head of the screw is made with a taper, this goes into a corresponding tapered hole in the clamp. When being tightened the head is drawn into the tapered hole and becomes captive, thus preventing it rotating.

Whilst this tapered hole is only required in one of each pair of split clamps, it has been included in each half. This will prevent the necessity of searching out the correct clamp half as the system is assembled in its various combinations.

4

Mounting a DTI on the milling machine. This uses the arm holder which is intended to be permanently fitted to the bottom of the down feed stop bar assembly.

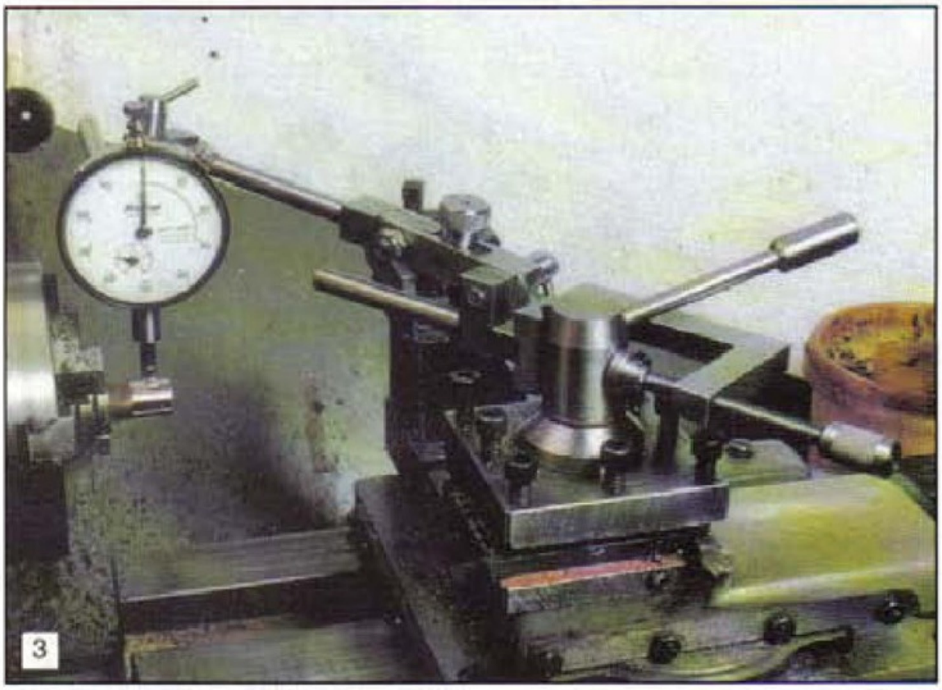
In this the first of a three part series the basic items of equipment are being described. These will permit the mounting of the dial test indicator to both the lathe (**photographs 2 and 3**) and the milling machine (**photograph 4**).

Additional methods of mounting the dial test indicator will be included in part two, together with additional items to permit other uses of the system.

Fine adjustment attachment

This is seen in photograph 3 showing the equipment being used on the lathe as a fine adjustment attachment. This fits onto a clamp half and with the dial fitted onto the other end gives adjustment over a range of about ½in. travel.

This has been made with a fixed arm, about 4in. long. With the experience gained in its use, it is now considered preferable for this to permit the fitting of differing length arms. Any reader making this would be advised to consider making this change to the design.



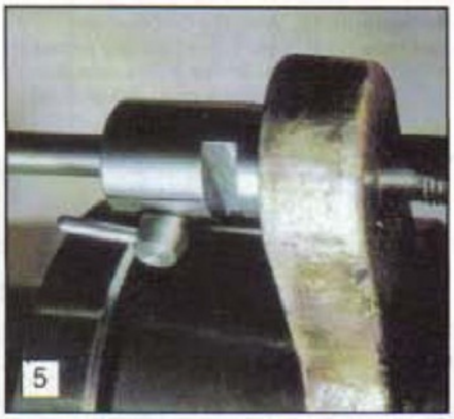
3

Mounting a DTI on the lathe using the clamp. Also included in this arrangement the fine adjustment assembly.

The milling machine attachment

To avoid the requirement to mount the indicator from the milling machine chuck, some other method would have to be established. This could be from the machine column but would have a rather large overhang, and also require a large clamp.

At first there did not appear any place around the spindle area, where a fitting could be accomplished without major modification. It was then noticed that the down feed stop bar was fitted with a nut underneath the bracket carrying it. If this were removed then there would be a stud onto which some form of mounting could be fitted.



5

Close up of the fitted arm holder referred to with photograph 4.

This would appear to be an arrangement common to many of the mill/drills, so should be equally appropriate to most other machines. No doubt machines without this arrangement, would have some other suitable point for attaching the system.

The stud was a little on the short side but was just adequate for the task, being ⅜in. BSW and with ⅜in. length showing when the nut was removed. To mount an arm from this, a boss tapped at one end to fit onto the ⅜in. BSW thread was decided on. This would have a 5/16in. diameter axial hole in the other end, being split and with a clamp screw. By this method, arms of differing lengths could be fitted and removed with ease, with the boss remaining on the machine at all times. This can be seen in **photograph 5**.

6

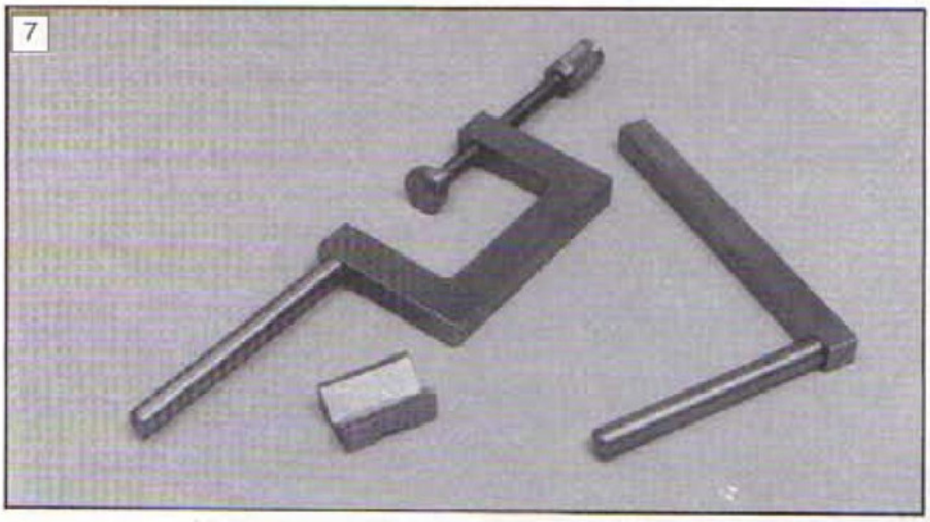
A range of bar sizes.

A range of different arm lengths (**photograph 6**) together with sufficient split clamps would complete the basic system for the milling machine. These would enable the indicator to be moved into position with relative ease to suit a wide range of applications.

The lathe attachment

When being used on the lathe the basic arrangement of arms and split clamps would again be adequate. As the arms etc. would not remain on the milling machine, the same items could also be used on the lathe. It is proposed that, to obtain maximum adaptability, a range of arm lengths would be made with sufficient split clamps to complement these. The total requirements will probably be best envisaged when the full capability of the system is realised in part two, in the next issue.

The only part additional to those already seen as required in the case of the milling

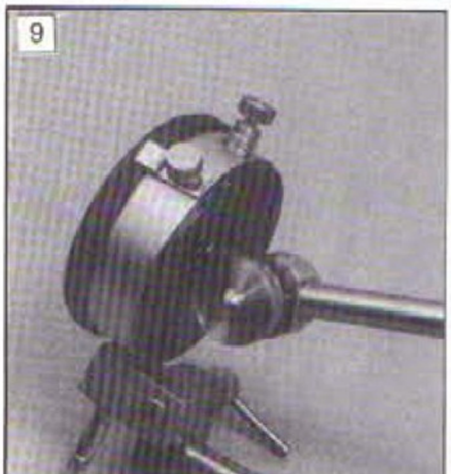


The right angle arm and the clamp with arm. The clamp will be detailed in the next issue.

machine, is the right angle arm (**photograph 7**). This can be mounted in the top slide tool post, and will permit the indicator to be mounted from this, using additional arms as necessary.

The universal clamp

Also to be seen on the lathe, in photograph 3, is a universal clamp, this is for use, as and where it proves useful. Included with this is a small add-on vee block (photograph 7), this permits it to be clamped securely onto round items. Details for constructing this clamp will be included in part 2 in the next issue.



This shows the two alternative methods of mounting a DTI.

Making the parts

Manufacture of the parts should present very few problems, even for the inexperienced.

Arms

Decide on the range of sizes and the quantity of each to be made. Two of each length should be considered a minimum. Cut just over length using a hack saw and radius the ends in the lathe, use a radius form tool as seen in **photograph 8**. (*See article on form tools in issue 13. – Ed.*)

Arm clamps

Make sufficient with 5/16in. dia. holes (to fit the arms) to ensure there will be enough to maximise use of the system. Other sizes can be made as required, typically to mount onto the barrel of your dial test indicator as seen in **photograph 9**. It will be easier to make a few extra at the start, rather than requiring to make a further batch at a later date.

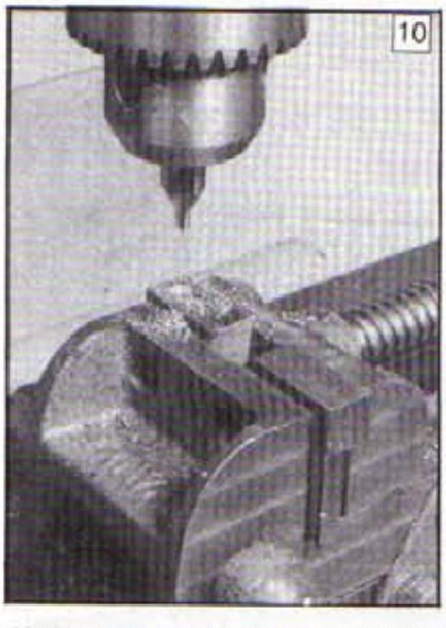
Cut the number of pieces required of ½in. square bright mild steel and face one end in the lathe. Fit a lathe mandrel back stop if available. (*If not, why not make one to the design in the April/May '92 issue page 22 – Ed!*) return the parts to the lathe and face the other end to the required length.

Set up the milling machine with a drill chuck and fit a centre drill. Clamp a vice to the machine table, fix a clamp in it with the one end flush with the end of the jaw. To avoid straining the vice, it will be necessary to place a part at the other end of the jaw.

Move the table into position so that the part is centred in the correct position, see **photograph 10**. With the first clamp satisfactorily centred, the remaining pieces can be placed one at a time in the vice with their ends against the jaw end, and centred in the same way. Using this method, individually marking and centre punching each part will be avoided.

With the clamp screw hole also being ¼in. from the end, this can be marked in the same way. Line up the other end of the part as previously, note the part must also be rotated through 90 deg., centre each part as before.

Replace the centre drill with one suitable for reaming 5/16in. diameter. Drill the quantity required at this size and similarly, with suitable size drills for other sizes required. Follow this by either hand or machine reaming. If a reamer is not available a drill can be used, providing it is not cutting too much over size. Due to the

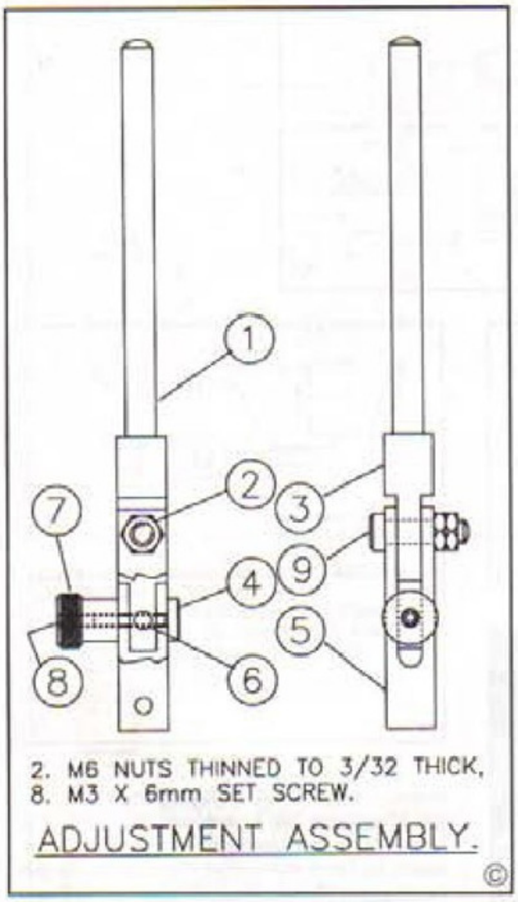


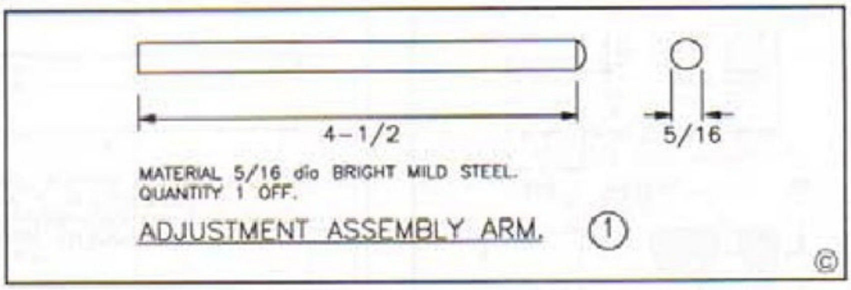
Marking with a centre drill the position for drilling the clamp pieces.

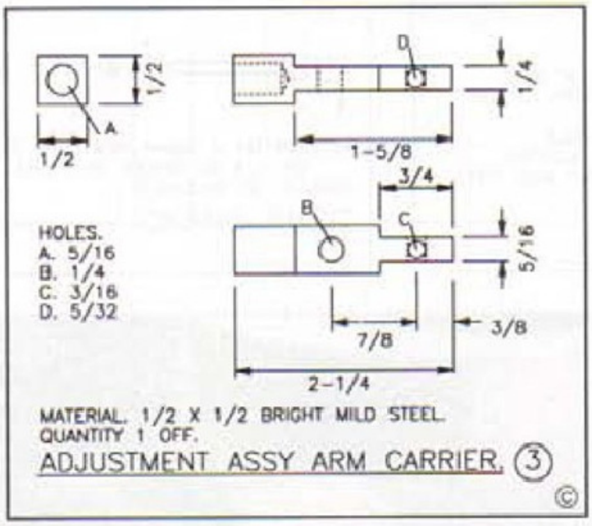
arrangement, only a thou. or two clearance over the bar will cause the clamp to close disproportionately.

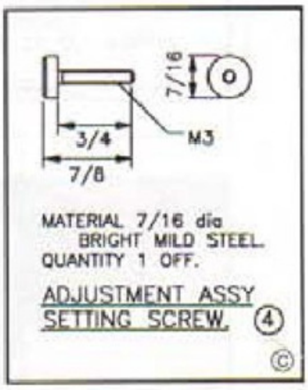
To produce the hole for the clamp screw a special taper bit will be required, as shown in **photograph 11**. This should be made from silver steel and hardened in the normal way. (*See item on making drills from flat stock in issue 12 should you*

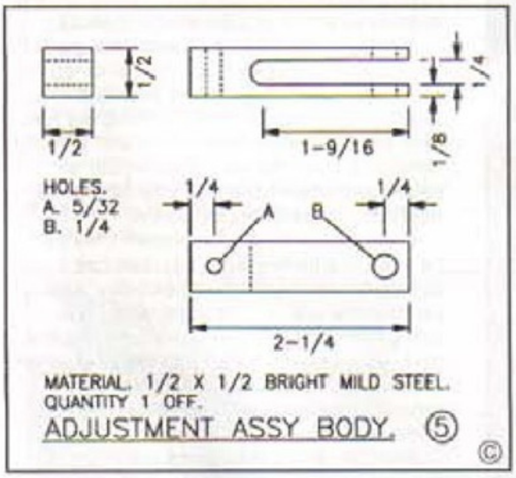
Turning the radii on an arm.

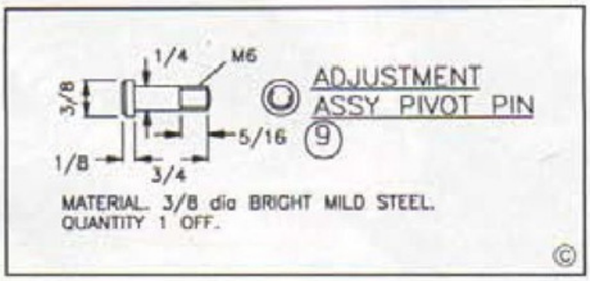


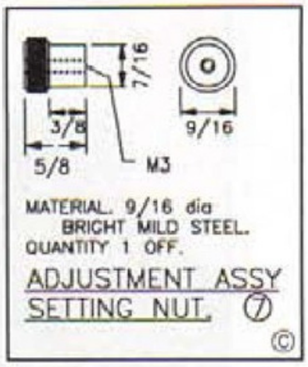


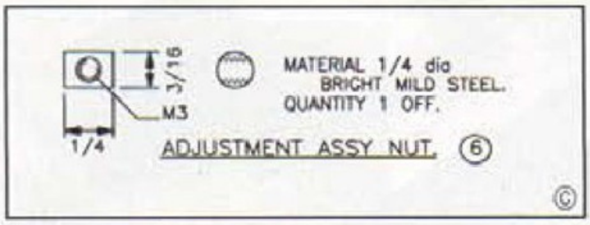






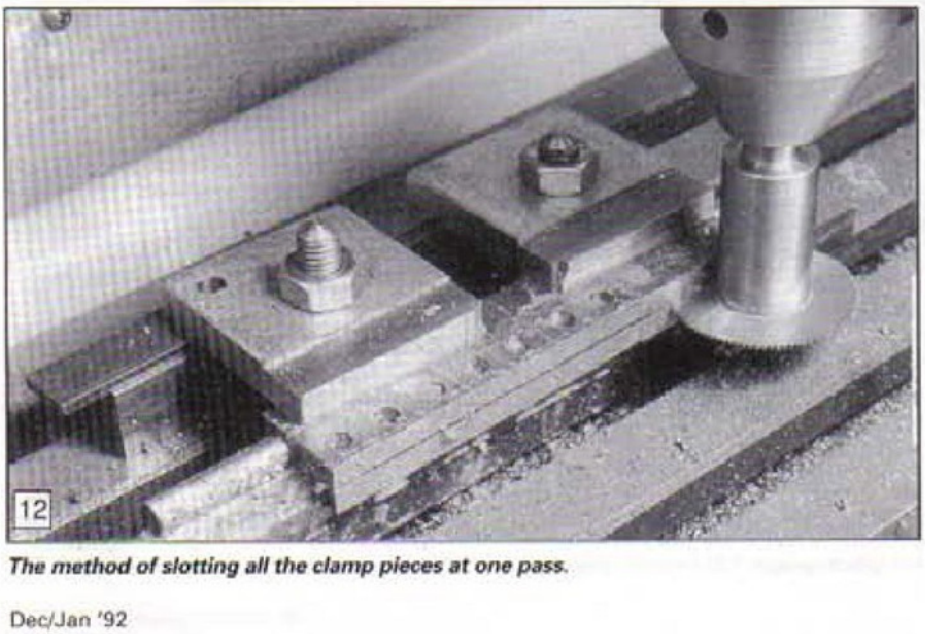






11

The D bit for making the tapered counterbores in the clamp pieces.



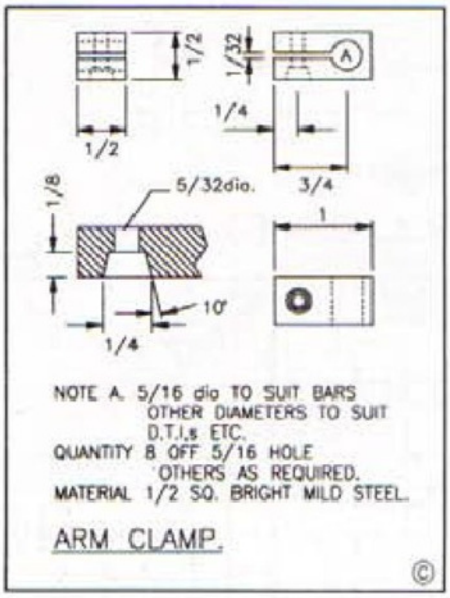
12

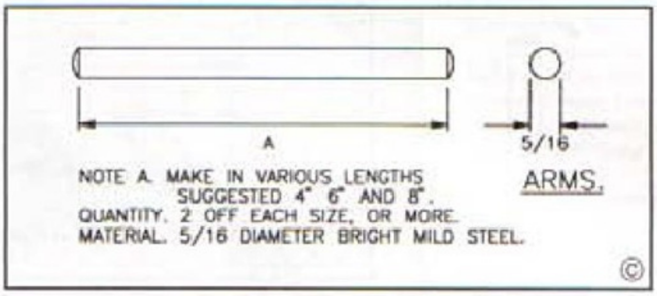
The method of slotting all the clamp pieces at one pass.

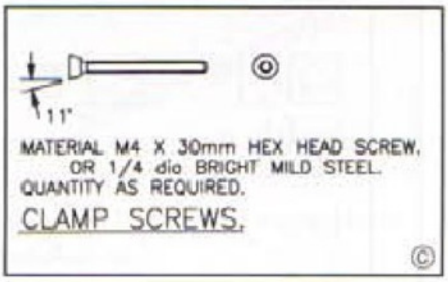
require help on the subject of hardening. – Ed.) The holes could be tapered by boring on the lathe but this would be a slow process.

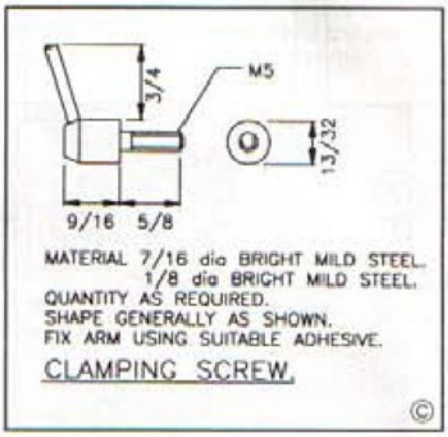
Now in the second position drill through 9/32in. diameter for the clamp screw, and counterbore 5/16in. diameter 1/8in. deep, finish this with the taper bit.

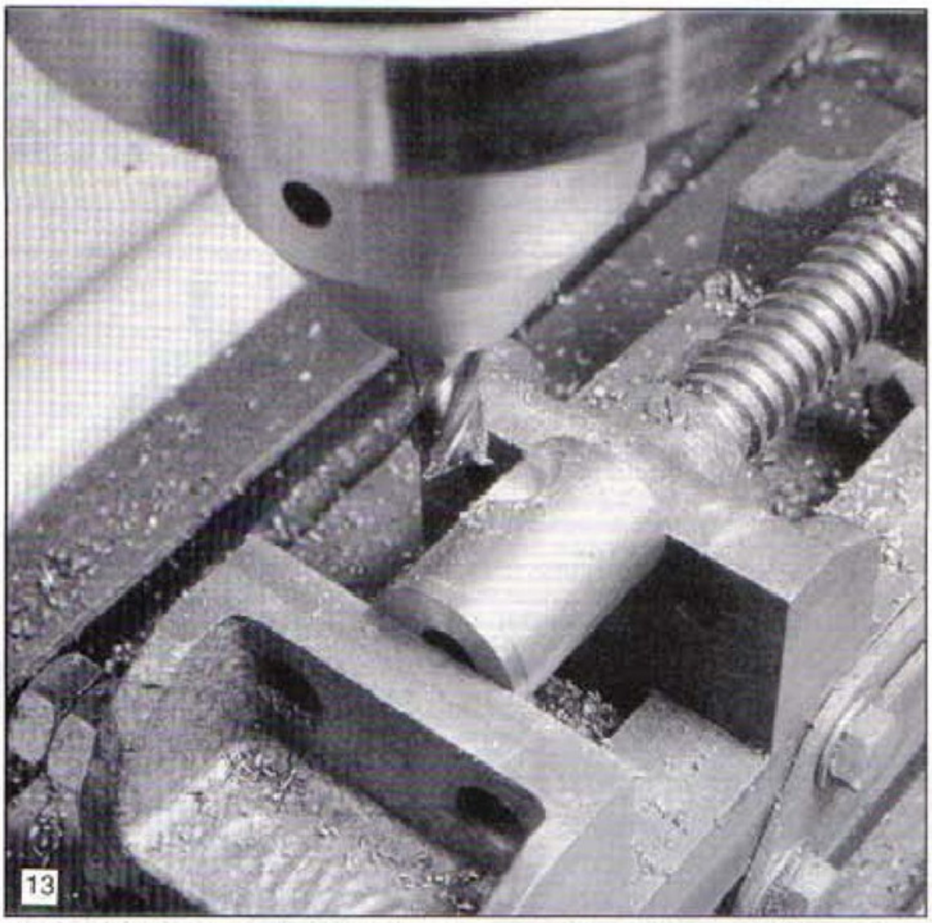
It now remains to slit the clamp. To do this place a piece of 5/16in. dia. material through the parts, and position on the milling machine table as shown in **photograph 12**. Slit to within a few thou. of the











Making the flat on the arm holder for the clamp screw. See text for proposed alternative method.

bar, remove from the machine and finally complete the slit in each clamp piece with a hacksaw. Using this method the bar will not be spoilt, preventing its future use. Lightly remove all sharp edges with a fine file and the clamps are complete.

The screws for the clamps are made from M4 x 30 Hex. head steel screws. Hold the screw lightly, so as to prevent damage to the thread, in the three jaw chuck and turn the taper. Note that the angle has been increased to 11 deg. for this part, this to ensure that the parts grip at the largest part of the head. If screws are not available, then they will require to be made from scratch.

The clamping nuts for this assembly are quite straight forward and require no explanation. They can be seen in photograph 1.

Milling Machine Arm Holder

Place a piece of 7/16in. dia. bright mild steel in the lathe three jaw chuck and drill and ream 5/16in. diameter, machine over surfaces as required and part off. Reverse in chuck and thread to suit thread on end of down stop bar, 3/8in. BSW in the case of the prototype.

Return now to the milling machine, place the holder in the vice and make the flat (**photograph 13**) for the clamping screw. Follow this by making the slit (**photograph 14**) to achieve flexibility. If a larger diameter saw is used then it will not reach so far down inside the holder. As the holder is only just flexible enough, in this case it will be required to cut further on the outside to arrive at a satisfactory result.

Photographs 13 and 14 show the part having been removed and repositioned for making the slot. It would be preferable, to position as in photo 14 for making the flat, then proceeding to making the slot without removing from the vice. This would be easier and ensure the slot was parallel to the face for the clamping screw.

Produce the single flat shown (this can be seen in **photograph 15**), this has a two fold purpose. It increases flexibility, also permits the use of a spanner when it is being fitted to the milling machine. As the part requires to be fitted just the once, then remaining on the machine, it was considered unnecessary to go to the added effort of making this a hexagon.

The clamping screw for this assembly requires no explanation, and can be seen in the complete assembly shown in photograph 15.

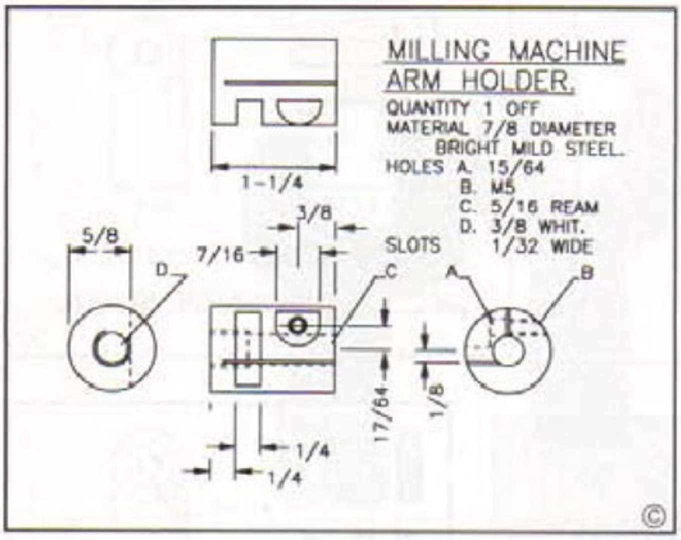
Right Angle Arm

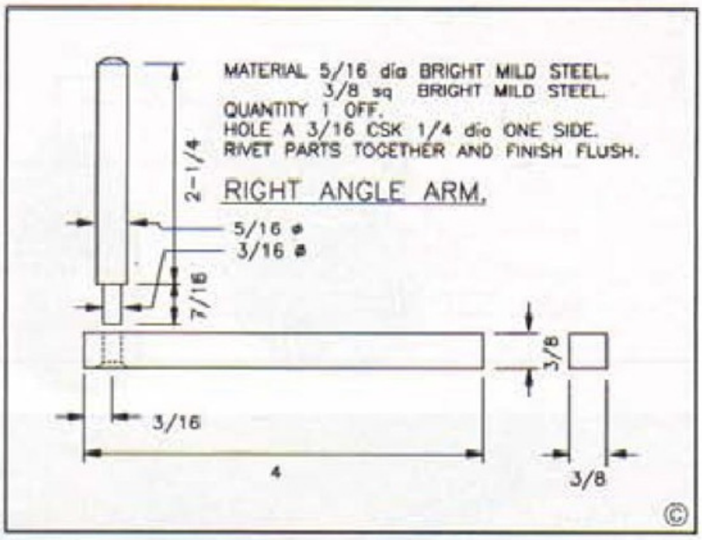
This is very straightforward and should present no problem in manufacture. The two parts are made and riveted together, then machined flush. Alternatively the parts could be fixed using adhesive.

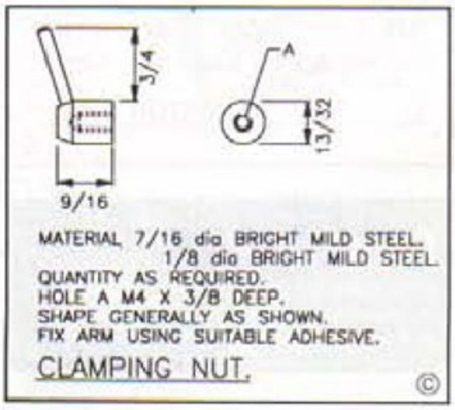
Dial Test Indicator Arm

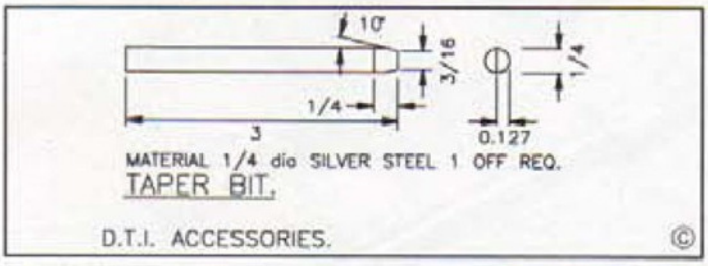
In addition to the special diameter clamp suggested above for holding the dial test indicator, an arm with a boss for fixing to the rear of the indicator is also detailed. The two alternative methods of mounting the DTI can be seen in photograph 9.

This again is very simple to make. It is probably preferable to make the 5/16in. diameter on the end of the arm longer than indicated on the drawings. Then to fix this into the boss with adhesive before the boss has its central hole drilled. By this method maximum strength will be achieved.









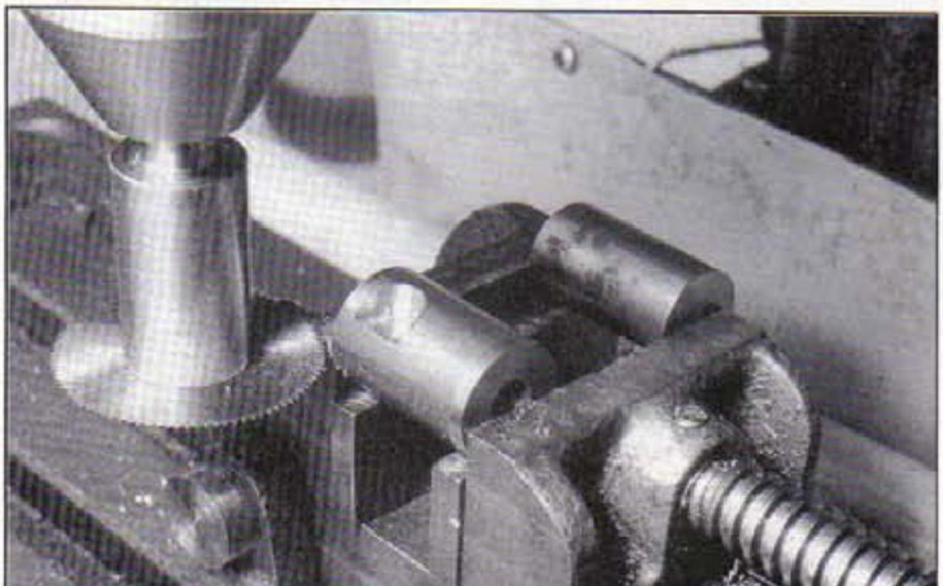
Manufacture of the screw and nut to complete this part of the equipment really require no explanation. The 40 TPI M.E. thread makes for a nice feel to tightening the nut, which will be improved still further if a suitable size disc spring is included in the assembly.

Fine Adjustment Unit

This unit can be seen in **photograph 16** and is the part which requires the most care in its manufacture. Ideally the item should be free of play or backlash. This should be quite easy to achieve as it is permissible for the parts to be made a little on the tight side. Having said that, when making the prototype the M3 die used to make the setting screw, refused to do anything other than make an undersize thread. The result of this was backlash, no doubt another die is called for.


15

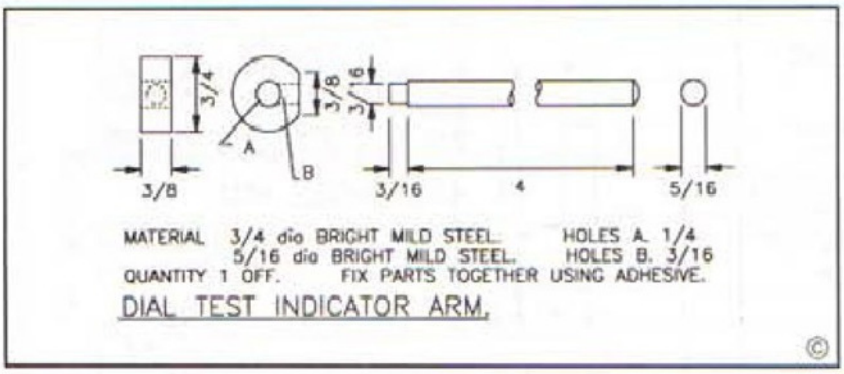
The finished arm holder.

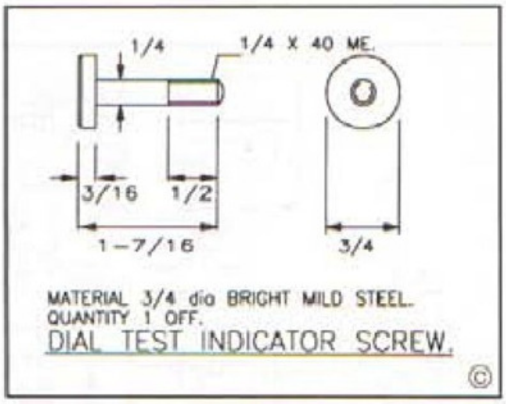

14

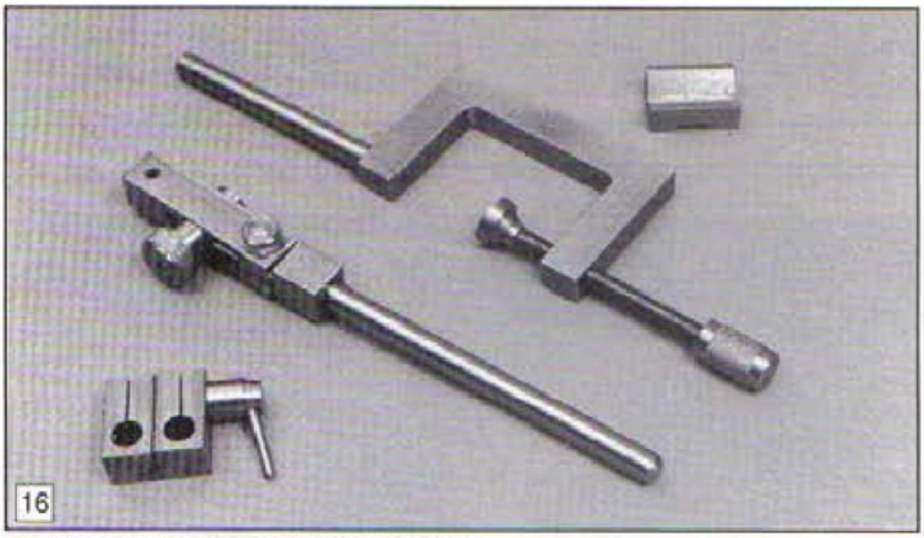
Slotting the arm holder.

QUICK TIP

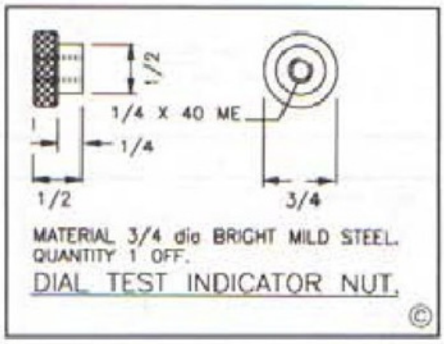
Modern photocopiers not only print on paper or card but also onto a special, very thin, clear sticky-backed plastic costing only a few pence for an A4 sheet. Your local 'copy-shop' should have this in stock. Simply draw or print your design or labels on plain white paper, if necessary have that enlarged or reduced by the copier then copy onto the clear plastic. Cut out the shape, peel off the backing and hey-presto a professional looking finish to any project. If a solid colour rather than a clear background is required simply stick the printed sheet onto plain white or coloured sticky-backed plastic before cutting out.
Don't forget copies can now be made in full colour so it is possible to make a label from a photograph.







The fine adjustment assembly with other items.



QUICK TIP

If the balls are removed from a ball race by breaking the cage, then the two rings make excellent ring parallels.

First cut the two pieces of ½in. square mild steel for the body and arm carrier. Place these in the four jaw chuck, face the ends of both parts to the required length. Whilst one piece is in the lathe, drill one end for the arm to eventually be fitted as drawn, using a suitable adhesive.

Do consider though, as mentioned earlier in the article, the possibility of making the arms removable, maybe by the use of suitable socket head grub screws.

Place the body in a vice mounted on the milling machine for milling the ¼in .wide slot. Position the part with the portion not to be slotted in line with vice screw, this should help to avoid the slot closing at its mouth and becoming tapered. If an expensive, good quality vice is being used and there is no possibility of its jaw pivoting, then this precaution will be unnecessary. With the part in position mill the slot using a slot drill or, failing this, an endmill.

Now place the arm carrier in the vice, reduce its width to be a close fit in the slot produced in the body. Place the two parts together and drill through both for the pivot pin. Drill to a suitable size and finish with a 3/16in. reamer, also drill the remaining hole in the body. Now make the pivot pin to go through these holes, do ensure that the diameter is such that a light push fit results.

Separate the parts and mark out and drill hole **C** in the arm carrier, drill this and ream 3/16in. diameter. Make the nut item **6**, again ensuring that this is a light push fit in the body. Part off such that its length is only a thou. or two less than the width of the body.

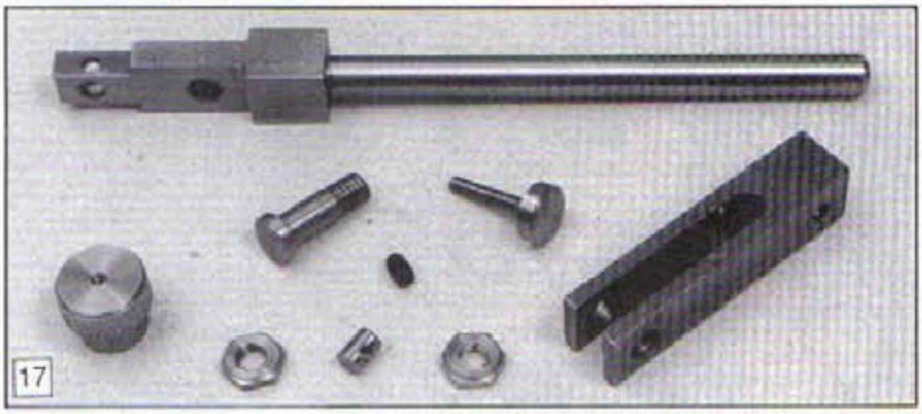
Place the nut inside the body and mark in a manner that will ensure it is always returned in the same position. Drill hole **D** through both, but initially at a size suitable for tapping M3. Remove and tap the nut, open up the hole in the carrier to 5/32in. as indicated on the drawing. Push the nut back into the carrier.

Return the carrier to the milling machine and reduce the end to 5/16in. as per drawing. Remove all sharp edges using a fine file, then fit the arm using a suitable adhesive.

Next make the setting screw ensuring the thread is a very close fit in the nut so as to avoid any backlash. Follow this by making the setting nut which should present no problems. Take two standard M6 nuts and reduce their thickness to 3/32in. to give a compact assembly. This now completes the parts for the Adjustment Assembly which can all be seen in **photograph 17**.

Place the carrier **3** into the body **5** and fit the pivot pin **9**, fit the first nut and tighten until the carrier just pivots, but stiffly. Fit the second nut and lock the two together.

Run the setting nut onto its screw until it is lightly tightened across the width of the body. With it in this position screw a M3 x 6mm set screw into the nut, then tighten it to maintain this adjustment. It should now be possible to make adjustment to the assembly position, albeit a little stiff, without any play or backlash being present.



The complete set of parts for the fine adjustment assembly ready for assembly.

In part two, next issue

This completes the basic items required for the initial purpose as a DTI carrier, for use on the lathe or the milling machine. Items to extend their use will be covered in part two in the next issue.

Copies of articles previously published and mentioned above can be obtained at a cost of £1.50 for UK readers and £2.00 overseas readers. Request should be sent to the Photostat Service, Argus Specialist Publications, Boundary Way, Hemel Hempstead, Herts HP2 7ST.

2: Four cutter chucks, one not yet fitted with its flange.

A SHARPENING JIG
FOR SLOT DRILLS AND END MILLS

A. Longworth describes a method of sharpening the end faces of end mills and slot drills for those who have no access to a tool and cutter grinder

Sharpening end milling cutters, whether they are the two flute slot drill type or multi flute end mill type, is a very difficult, if not impossible, operation to carry out by hand.

For those who do not possess a special cutter grinder, such as a Quorn, a Stent, or a Worden, the jig described here will produce quite acceptable results. The construction is well within the capabilities of the average home machinist, there being no really complex machining operations to carry out.

The design has the benefit of being made from standard materials, there are no special castings required. Materials are easily obtainable, being mainly bright mild steel and free cutting aluminium. Other materials could be used such as cast iron for the vee blocks, or aluminium for the cutter chucks. The design is not critical as far as dimensions are concerned, so could be changed to suit material sizes already available in the workshop if desired.

1: Two Vee blocks with other small parts.

Vee blocks

There are two Vee blocks, seen in **photograph 1**, one having a 90 deg. groove and is intended for two and four flute cutters, the other has a 120 deg. groove and is for three and six flute cutters. Cut two pieces of material from 2 x 1in. and machine the ends. Being relatively short the grooves can be rough cut by hand to minimise the time consuming and tedious milling operation. Hand cut the grooves leaving about 1/16in. to be removed by milling. With the main machining operations complete, drill and tap all holes and fit stud as shown in the drawing.

Cutter chucks

The number of cutter chucks (**photograph 2**) required will depend on the number of cutter shank diameters to be accommodated. There will be one chuck to suit each 2 and 4 flute cutter shank size in the square material chuck, and similarly one for each 3 and 6 flute cutter in the hexagonal material.

3: A Vee block mounted onto the special grinder table.

If, like the author, your milling cutters are a mixed bag of inch and metric sizes, it is probably better to make two chucks, one square and one hexagon, for each of the two types. These can be bored out to accept the largest diameter cutter one is likely to use, and split sleeves made to suit the smaller cutters.

If the largest bore is such as to result in sleeves with the walls too thick to deform when gripped by the grub screws in the chuck body, then it will be necessary to make the sleeves without the slit. In this case the sleeve will also be fitted with grub screws and the cutter will be locked into the sleeve prior to being fitted into the chuck.

Start by making the 2in dia. end flanges. These are straightforward and require no explanation as to their manufacture.

Cut off the required lengths of square and hexagon bright mild steel. These will require little in the way of surface finishing, except for the removal of burrs and blemishes. If a sufficiently large lathe with suitable size chucks is available to adequately hold the rather large size materials, (in particular the 1⅜in. hex.) then the chucks can be made exactly as shown in the drawing. If in doubt regarding the capacity of the lathe, then the following procedure may be worth considering.

First centre drill one end, either in the lathe or the drilling machine, and set up in the lathe with this end supported by the tailstock centre. Turn the ½in. dia. portion for the end flange, testing with the flange to ensure a close fit is achieved. Now remove the tailstock centre and support the part with a fixed steady, this bearing on the portion just turned for the end flange. The part can now be drilled and tapped 5/16in. BSF as indicated.

Remove the part from the lathe and centre drill the other end. In this case, as will be seen, this centre will determine the concentricity of the bore with the outside faces, it must therefore be done with care and this fact in mind. It is true that absolute concentricity is not that important and an error of two or three thou. will not be totally unacceptable.

Again support the end with the tailstock centre and turn a short (say ¼in. long) round portion on the end, this to as large a diameter as the material will accept. This can then be supported again using the fixed steady and the bore made using a deep boring tool. This bore should be a close fit on the shank of the milling cutter for which it is to be used.

This turned portion will reduce the length being supported by the Vee blocks but should not affect the working of the device noticeably. Finish the chucks by the addition of the tapped holes and the slot for the locating plate. It will be realised as the article is read further, and the method of working understood, that the locating plate and the slot for it can be omitted. In this case the positioning of the cutter in the chuck would be done by eye. This would probably be acceptable but the additional accuracy achieved by its use, I feel, makes the effort in providing the facility worthwhile.

4: Two chucks fitted with cutters and shown with the locating plates being used to position the end mill/slot drill.

The smaller components

All the smaller components as drawn are very straightforward to make and require no explanation. In addition to the parts indicated on the drawings, some adaptation of the bench grinder table will be necessary, details of which are not included as they are bound to differ considerably from case to case. Inspection of the assembly drawing will give a good indication of what is required.

The bracket required to adapt the bench grinder to accept the sharpening jig, may be able to be left in position whilst other tasks are performed. It is more likely, that it will prove necessary to remove the bracket, and will therefore be of benefit if this action is made as easy as is possible. Provide tapped holes in the bracket so that it can be fitted with a hex head screw and spanner, (or socket screw and T handled Allen key) without the need for loose nuts and washers.

With all the parts complete it is now time to put the jig into operation. I am confident that once its use is mastered that it will find frequent use. The short time it will take to sharpen a cutter will be considered very worthwhile, when the improvement in cutter performance has been experienced.

Putting the jig to use

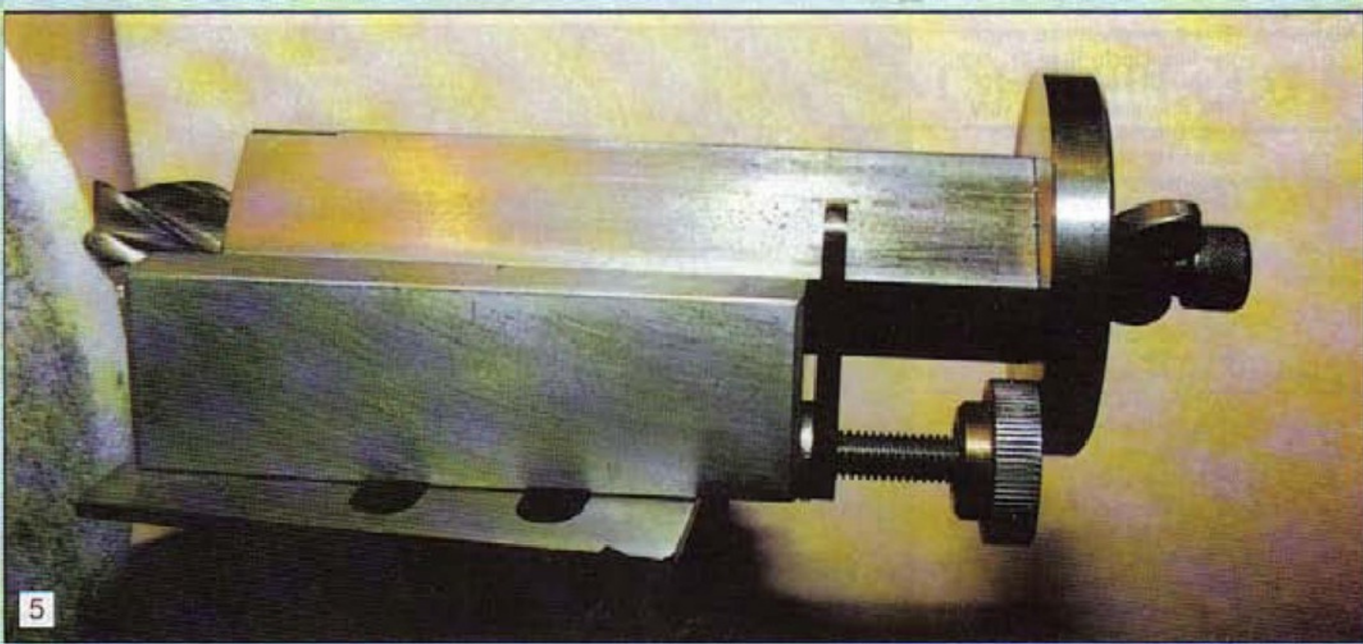
The first essential of any precision grinding operation of this type is the condition of the wheel. Dress the wheel to ensure that it has a good front face and that the right hand corner is sharp and square, especially if it has been used for other heavy duty use.

With the wheel in good condition and the special bracket fitted to the bench grinder, the next consideration is to set the bracket at the correct angle to the horizontal. Suggestions for making this operation as easy as is possible will be discussed.

Setting the angles

It will be seen from the list of recommended clearance angles (as specified by S K F Dormer Ltd.) included with the drawings, that the sizes of end mills of most interest to our fraternity only require single clearance. In the case of slot mills double clearance is listed for ¼in. dia. and above.

Setting first the angle to the horizontal, and without the Vee block fitted at this stage, will perhaps not be so easy as first envisaged. The reason for this, is that the angle ground will be dependent not only to the angle set to the horizontal, but also the height of the grinding position above the wheel centre line. This will be determined by the thickness of the material used for the Vee block and the across flats dimension of the chuck itself. The effect will be the



5 and 6: Showing the square chuck (5) and the hexagonal chuck (6) in position and the depth stop set against the chuck flange.

greatest for smaller diameter wheels.

With the horizontal angle set, that relative to the face (left to right) of the wheel also requires setting. With the Vee block at the correct angle (**photograph 3**) lock it in position using the Tee bar clamping nut. This again is not that straightforward. For not only must theangle be set, but the Vee block must be

positioned such that the full cutting edge is ground without touching the other teeth.

Probably the easiest method of setting the angles would be by comparison to a new or unsharpened cutter. To ease subsequent settings a range of templates/ protractors could be made. For the angle to the horizontal, a plywood template/ protractor could be made to stand on the bench in such a way as to be close to the angled table. This could then be marked or cut to the angle established, then used for reference when setting the angle on subsequent occasions. Some form of template/protractor could also be made to record settings for the angles required in the other plane.

Fit the cutter required to be sharpened into the chuck and position using the appropriate locator plate as seen in **photograph 4**. This plate will position the cutter both for its projection from the chuck, and for rotational position. Tighten the grub screws to fix the cutter into the chuck, also bring the depth setting screw into contact with the end of the cutter and lock its position, this will give added positional security whilst the action of grinding the cutter is taking place.

The sharpening operation

Now with the grinder stationary place the chuck in the Vee block and slide it along until the cutter contacts with the wheel. At this point, again check to see that the wheel will not touch any teeth, other than the one being ground. Whilst in this position wind out the setting screw until it touches the flange of the chuck; this can be seen in **photographs 5 and 6**, lock it in this position using the locking lever. (It is probable that when assembled for the first time, the lever will not rest in a suitable position when locked. To overcome this, place a suitable thickness of washer or washers between Vee block and lever.)

Remove the chuck and loosen the lever slightly and wind in the setting screw sufficient to permit a few thou. to be removed when sharpening the cutter. Start the grinder and place the chuck with cutter into the Vee block, slowly move it into contact with the rotating wheel. Do make sure that only a thou. or two are taken off at a time to avoid overheating of the cutter and the consequent softening of its cutting edge.

With the first edge ground, rotate the chuck in the Vee block and grind the remaining teeth, all at the same adjustment setting. Inspect the cutter to see if all cutting edges appear sharp. If any sign of bluntness remains, adjust the setting screw to permit a further few thou. to be removed, regrind all the cutting edges once more. Continue this process until a satisfactory result is obtained.

Where the cutter requires a double clearance, the angle can be reset for this and each tooth ground in the same manner as already explained. This will of course be less critical than that for the actual cutting edge. Having sharpened a few cutters the operation of the jig will become an easy operation to perform, and keeping ones cutters in tip top condition will present little difficulty.

The following extract is taken from 'Model Engineers Handbook' by Tubal Cain.

WHEELS FOR TOOL-GRINDERS

In general, hard materials should be ground on a relatively soft wheel, and vice-versa. Hard and brittle materials require a finer grade of wheel than softer or more ductile materials. Aluminium oxide is used for the majority of steels; silicon carbide (of appropriate grade) is better for cast iron, non-ferrous materials and, of course, for very hard alloys such as tungsten carbide.

The most frequently used designation for wheel specifications is that of the American Standards Association, as follows.

Prefix	A number, often being absent, being the maker's abrasive record.
First letter	Type of Abrasive; A for aluminium oxide, C for silicon carbide, GC green silicon carbide.

A Number	This is the grain size, in grits per lineal inch, 10 to 24, very coarse; 30-60, medium; 70-180, fine; and 220-240, very fine. Grades up to 400 can be had to order).
Second Letter	Hardness grade of the grit; ranging from A = very soft, through LMNOP = medium to Z = very hard.
A number	(Not always present) indicates the 'openness' of the structure, 1 = dense to 20+ = open.
3rd Letter	Type of bonding. V = Vitrified, S = Silicate, R = Rubber, B = Resinoid.
Final number	May be absent - the maker's private marking.

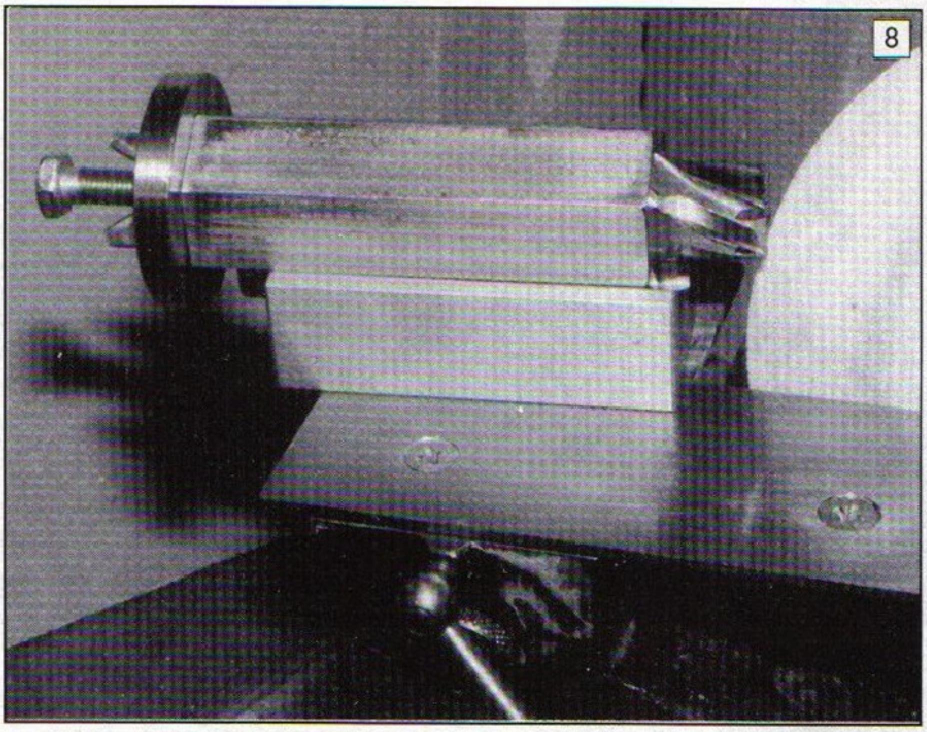
Thus 58-A54-L8-V1306 means maker's grit bin No.58, Aluminium oxide, No.54 grit, Medium hardness, medium dense face, Vitrified bond, maker's catalogue number 1306.

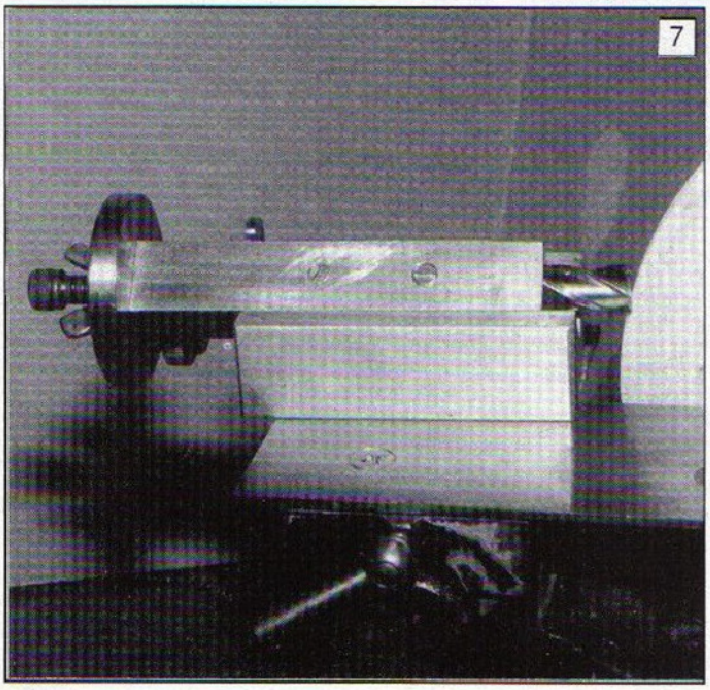
The Carborundum Company have kindly supplied the following data on suitable wheels for model engineer's tool-grinders, assumed to be 6in. wheels running at 2545 rpm or thereabouts.

Those using home-constructed grinders should note that every wheel is marked with a 'Maximum safe speed'. This should *on no account* be exceeded, and special care should be taken with small wheels mounted on series wound or 'universal' motors, the no-load speed of which can be very high indeed.

The ONLY safe speed for second-hand wheels of unknown provenance is *ZERO*.

For single-ended grinders,	a general purpose wheel	A46-O5-V30W
For D.E. Grinders.	One wheel coarse	A36-O5-V30W
	One Wheel Fine	A60-O5-V30W
	or, a wheel for finer work	A100-O5-V30W
For Carbide Tools,	General Purpose	GC80-K11-VR
	ditto (D.E.Grinder) Coarse	GC60-L11-VR
	ditto (D.E.Grinder) Fine	GC120-J11-VR

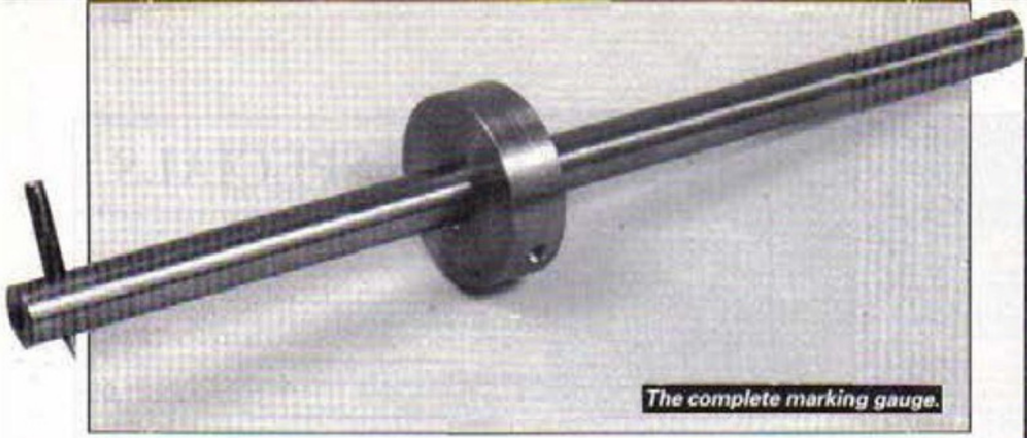


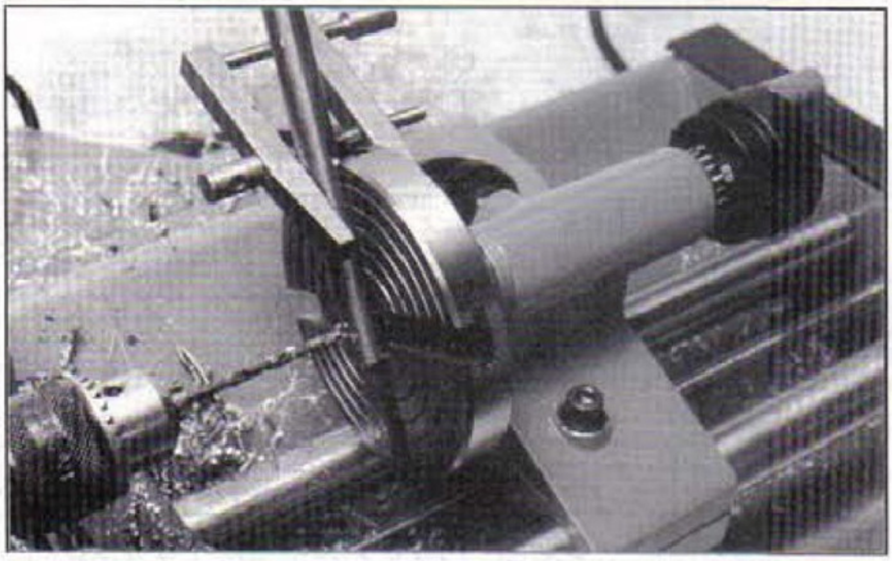


7 and 8: In use, grinding a slot drill (7) and an end mill (8).

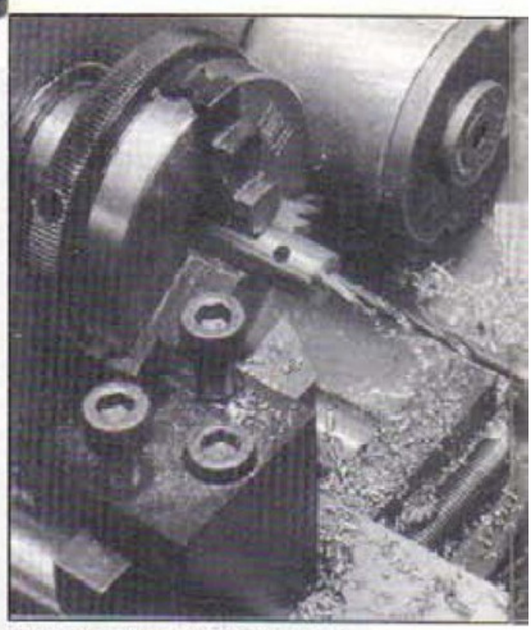
'Model Engineers Handbook' can be purchased from Bailey Distribution Ltd, Units 1a/1b Learoyd Road, Mountfield Road Industrial Estate, New Romney, TN28 8XU. Tel. 0679 66905. Price £6.95 + £1.00 post and packing.

(Readers who make and use this equipment, indeed any grinding equipment, are strongly urged to ensure that they are wearing adequate eye protection during use. To ensure that you get the best from this method of sharpening tools, position the Vee block carrier with great care in relation to the wheel, any contact between the wheel and adjacent teeth could well destroy an otherwise serviceable cutter.)

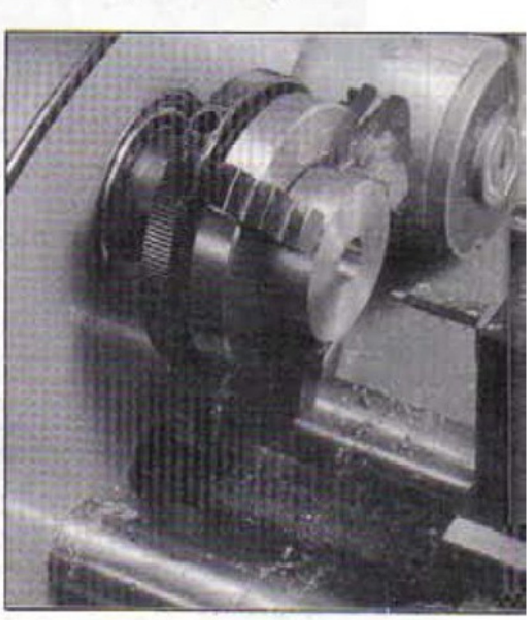




Cross drilling the shaft using the faceplate mounted on the Unimat tailstock.



Drilling for the scriber fixing screw.



Boring the slider to give a close fit on the 8mm diameter shaft.

MARKING GAUGE

This simple marking gauge has been provided by Mr Langham and is seen in this article being made on the Emco Unimat lathe which was reviewed in the Oct/Nov '92 issue of *M.E.W.*

The most common method of marking out in metalworking from the edge of a plate using hand tools, is by the use of odd leg dividers. Whilst this is an acceptable method for many applications it does have some limitations. As an example, unless the leg intended to run along the metal's edge has a stepped end, and many do not, then this can be a problem if the tool is being used with thick components.

This marking gauge, based on the type used very frequently in carpentry, can overcome many of the failings of the odd leg divider.

The proposed method of manufacture assumes that the only machine available for making this is a small lathe, and all machining operations are completed on this machine. This includes activities which would normally be carried out on a drilling machine.

The shaft

Cut a length of 8mm dia. bright mild steel to length, face and slightly chamfer both ends, do not at this stage drill for the M3 hole in one end. Now with a drill pad (or in this case with the Unimat, the face plate, see photograph) cross drill and ream the end for the scriber.

With the cross hole done, return the shaft to the chuck and drill and tap the cross drilled end M3 for the scriber fixing screw.

Slider

Take a bar 30mm diameter and saw off a piece about 12mm long. Place in the three jaw chuck and face the end. Drill a little under 8mm and then bore to be a close fit on the 8mm diameter shaft.

Reverse the piece in the chuck and face the second side to make the part 10mm thick. As the jaws are likely to project from the chuck by more than 10mm it will not be possible to place the part against the chuck face to ensure the slider faces are parallel.

To overcome this situation place a piece of thin flat material (maybe a wide steel rule) against the chuck face and position the slider against this when tightening.

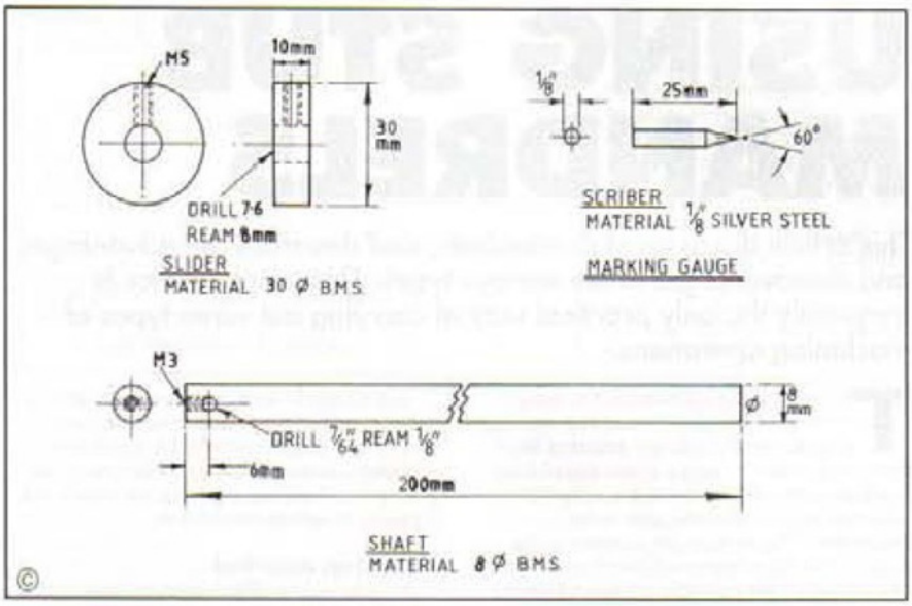
With this done the flat material can be slid out from beneath the slider which should now be satisfactorily positioned for final machining.

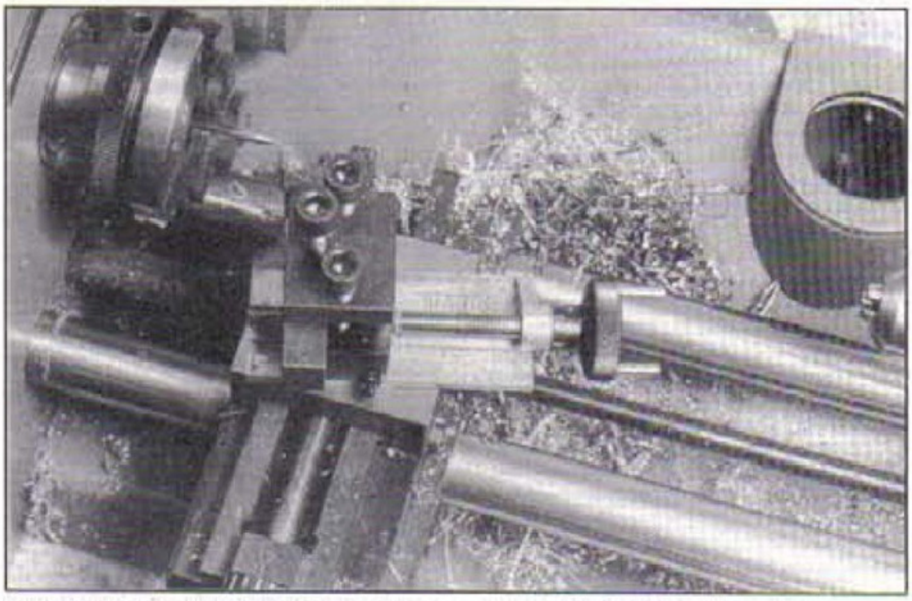
Now place in the four jaw chuck with two jaws on the flat faces and the other two on the outer diameter, as can be seen in the photograph, drill and tap for the fixing screw. If you consider it worth machining the outer diameter to improve appearance, mount on a stub mandrel and lightly machine to give a good finish. Make a slight chamfer on both edges at the same time.

The scriber

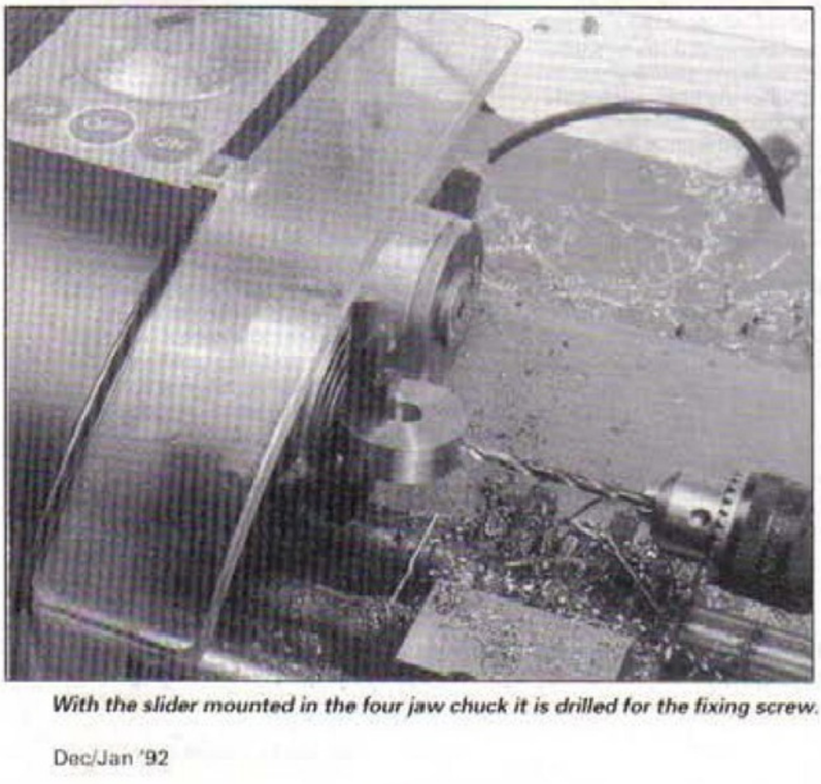
Set over the top slide to 15 deg. and make the scriber from a length of ⅛in. dia. silver steel, harden and temper. (*See Quick Tip Dec.91/Jan.92 page 49. Ed.*)

If frequent use of the marking gauge is envisaged a thumb screw can be made for fixing the slider, otherwise a socket grub screw can be used.



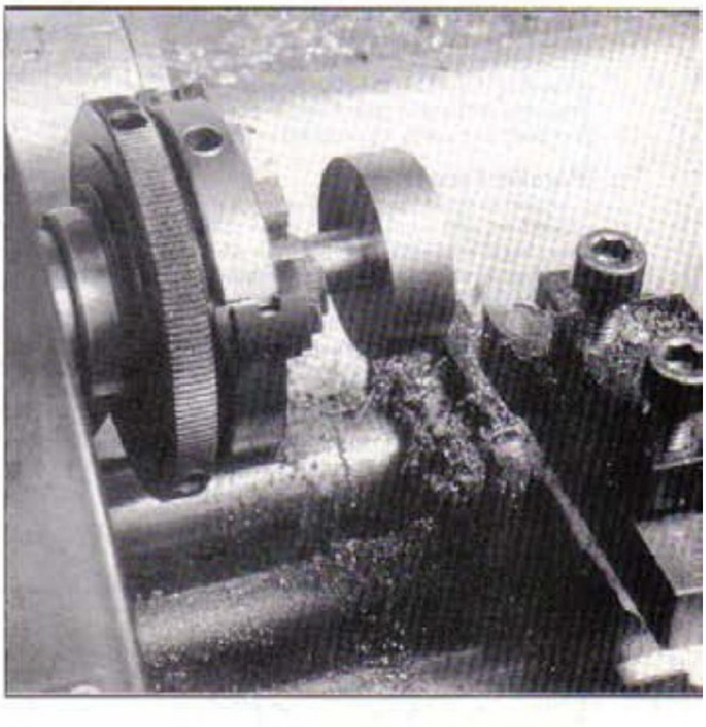


With the top slide accessory fitted to the Unimat the scriber point can be made.



With the slider mounted in the four jaw chuck it is drilled for the fixing screw.

Machining the outer diameter of the slider whilst mounted on a stub mandrel. (See article regarding mandrels elsewhere in this issue. Ed.)



USING STUB MANDRELS

This article discusses stub mandrels, and describes the advantages and disadvantages of the various types. This simple device is frequently the only practical way of carrying out some types of machining operations.

The uses of stub mandrels for work holding in the lathe are many and varied, and the system benefits from being very easy to apply. In principle, the method is to turn, on the lathe, a spindle, which is a close fit in the part to be machined. This is then left in place in the chuck, and the component fitted onto it by one of a number of methods, to enable the part to be machined.

Concentricity

The reason for employing the stub mandrel can be one of a number. Probably the most common is to maintain concentricity between the inner bore and the outer parts of the component. This is necessary when these cannot be turned without removing the part from the chuck.

Typical of this is when the part needs to be machined and bored from one end, and then requires to be reversed to be machined from the other, and where it is essential to maintain concentricity between the two stages of machining. There have been a number of examples of this in *MEW* in recent issues.

A similar case, which had the part been turned completely from scratch, would have presented no problem, would be the requirement to reduce the outside diameter of an existing sleeve bearing. This for use in an application, for which it had not originally been intended.

Irregular Components

Sometimes it will be required to machine a component which it is impracticable to be held in a chuck. As an example, a gear with integral boss may require the boss to be reduced in length.

Whilst with much care if it were a large gear, it may be possible, this is an instance where the stub mandrel approach is so simple, it is not worth attempting to fit the gear into the chuck directly. With the mandrel made and gear fitted in position, the boss can easily be reduced in length.

Parallel Faces

Another situation may be when a part is quite thin, and if fitted in the three or four jaw chuck, may take up a position which is not exactly at right angles to the lathe spindle axis. This results in the bore not being at right angles to the face when turned, or maybe of more importance, the face on one side not being parallel to the face on the other.

The use of a stub mandrel here may be of help, but it will depend very much on the relative length of the bore to its diameter. As a rough rule the diameter should be no greater than the length of the bore. If it is then an exactly similar problem may exist, that is, with the part not sitting squarely on the mandrel.

In a situation such as this, where the proportions of the bore are satisfactory, one side of a disc can first be machined, and then reversed for the other side to be machined. This ensuring the two sides are parallel, to within close limits.

Two step mandrel

An interesting application of stub mandrel, is to produce a two step mandrel. Typically the diameter nearest to the chuck holds a gear used for dividing, and on the second diameter is mounted the component, which requires to be indexed for some reason.

The photograph shows a dial being created, with the gear next to the chuck, and the dial on the outer end of the mandrel being engraved with the marks required. It is of course essential that neither gear nor disc move on their respective mandrels, as then an error will result, but with care this should not really be a problem.

Take note, in this application, not only would the lines be created whilst the disc is fitted to the mandrel, but also the outside would be turned. This ensures it is running true, as otherwise the lines will not be of equal intensity around the circumference.

One limitation with this arrangement is that should the item to be worked on have a larger bore than the gear, then the largest portion would have to be on the outer end.

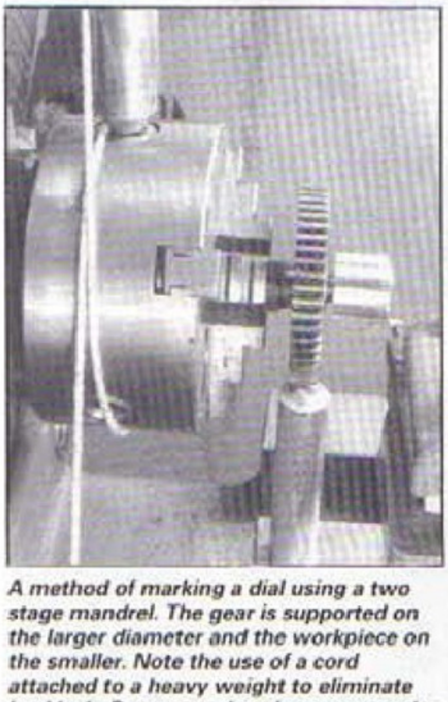
Obviously this is not practicable, so to overcome this a bush is first made with a bore smaller than that of the gear and an outside diameter larger than that of the component to be machined. Following this a normal two step mandrel is made with the one diameter to fit the gear and the other to fit the bore of the bush previously made.

The gear is then fitted followed by the bush, with the bush very firmly in place, this is then machined to fit the internal bore of the component. This arrangement can be seen in the drawing (**Fig. 1**).

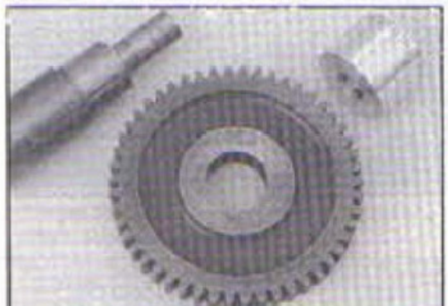
The internal mandrel

One other point to consider is that a similar but much less used arrangement, is to create a bore in a piece of metal mounted in the chuck, and to use this for holding a component on its outside diameter.

It is not intended to go into this in detail, but as a simple example, a short spindle, already existing, may require to be turned down over part of its length to a smaller diameter, and to be concentric with the larger diameter to a very tight tolerance.



A method of marking a dial using a two stage mandrel. The gear is supported on the larger diameter and the workpiece on the smaller. Note the use of a cord attached to a heavy weight to eliminate backlash. Do ensure that the power to the lathe's starter is switched off to avoid the lathe being started inadvertently.



The two stage mandrel used in the first photo, together with the completed dial and the gear wheel used for indexing.

The internal mandrel would suit this requirement very well.

A major benefit of this approach, is that it would avoid the laborious trial and error method of setting the component up in the four jaw chuck. This is particularly beneficial if a number of identical parts are to be made, providing their outside diameters were sufficiently identical for all to be held adequately.

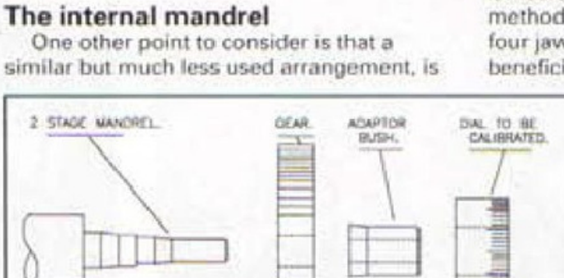


Fig. 1.

TWO STAGE STUB MANDREL WITH ADAPTOR FOR LARGER OUTER DIAMETER

©

Construction

Having considered, but by no means exhausted the uses to which a stub mandrel can be put, we now have to consider its construction. Also considered the method of securing the component to the mandrel, to enable the required operations to be carried out.

The parallel mandrel

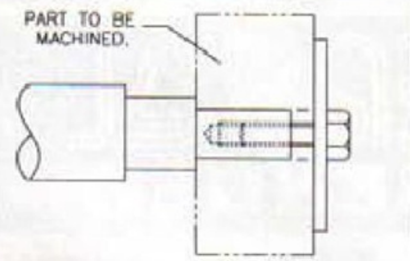
In its simplest form the mandrel is just a parallel portion, turned in situ in the lathe, and being a very good fit. The fit being one which permits the part to be placed on the mandrel, and removed without the need for force.

With this approach some method is required to hold the part rigidly onto the mandrel. Typically in the case of the gear mention earlier, the boss may have a grub screw fitted for fitting the gear in its final location, in which case this could be used. As a precaution, a flat for tightening the grub screw onto would be advisable.

If machining the end of the component is not required, then the mandrel can be made with a suitable flange, and a thread made in the end. The part can then be held with a screw and washer, used to clamp onto the end of the part, this is shown in **Fig. 2.**

If the part requires substantial machining, then a more robust fitting may be required, to avoid the necessity to take many light cuts. One method used but one that I have no first hand experience, is to fix the component with one of the adhesives which weaken when heat is applied. The part is machined, and following this is heated up to enable it to be removed.

Whilst this would be suitable for the single component, it would have to be removed from the lathe to apply the heat, so that the part can be removed. If concentricity were important a new mandrel would require to be made, or alternatively reset in the four jaw chuck.



STUB MANDREL – PARALLEL WITH FIXING SCREW Fig. 2. ©

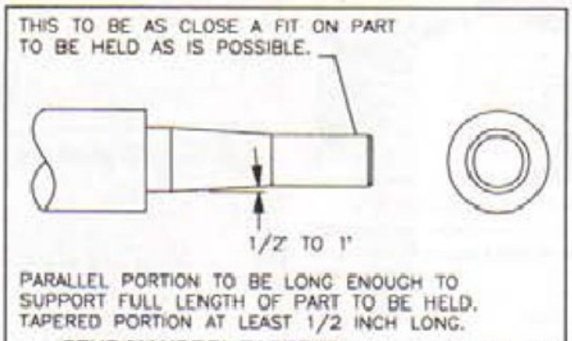
The tapered mandrel

Whilst this is a little more complex to make, it is the most easy to use. The principle being, that a parallel portion is turned to a very close fit in the bore of the component required to be held, yet still allowing for the component to be easily fitted without force.

The length of this parallel portion, would be about the length of the bore in the part to be machined. Beyond the parallel portion the mandrel would gradually increase in diameter, with a total internal angle of say between 1 and 2 degrees. That is, set the top slide between ½ and 1 degree, this method can be seen in the accompanying drawing (**Fig. 3**).

To use the mandrel, the component is slid onto the parallel portion, and then forced onto the taper with a slight turning motion. Provided only light cuts are taken, the grip should be sufficient.

Making the mandrel to the degree of accuracy required is very simple, if the following procedure is carried out. The top slide is first set to an angle of ½ degree, and the parallel portion commenced.



STUB MANDREL TAPERED Fig. 3. ©

When the diameter arrives at a point near to its final diameter, and only a few thou. have to be removed, setting the diameter can now be carried out by turning the top slide back.

A 10 thou movement of the top slide, will reduce the radius by only 1/10 thou, whilst still using the saddle for turning. By this method very small adjustments to diameter can be made, and a very close fit easily arrived at.

When the desired result has been achieved, the tool can then be run along the parallel portion still using the saddle, until it starts to cut again. At this point the top slide should be used to create the required taper portion.

A split mandrel

For heavy duty requirements, and particularly for instances where a number of components are to be produced, a split mandrel will be the most convenient. A typical example can be seen in the drawings (**Fig. 4**).

This requires little explanation, but take note the split mandrel does not require to be very flexible. This should first be made a few thou. oversize and then split, finally reduced to the diameter required.

This method may not be so repeatably accurate as the rigid types, but it does have some distinct advantages over the others (see also other comments at end of article).

The rigid types will only work satisfactorily, if the proportions between the bore diameter and length, are adequate for the operation to be carried out.

For example, it would not be appropriate to try to face a washer, with a bore of say ½in. dia. and only ⅛in. thick. But with some care the same washer could be reduced in outside diameter, so there is no hard and fast rule on proportions. Each application would require considering in the light of experience.

Now if the split mandrel were produced with an integral flange, this would ensure the washer took up the correct position. (In this case it would be satisfactory to face the washer, where the rigid types it would not be, see **Fig. 5.**

Limitations and care in use

Solid type with taper

The stub mandrel with taper section, and intended for the part to be a push fit, is the one with the greatest limitations. Whilst this type is preferable for achieving concentricity, it does have its limitations, depending on the following factors:-

1) The condition of the bore in the part being held.

2) The machining load and whether the cut is continuous or intermittent.

3) If more than one part is to be fitted the consistency of the bores particularly on diameter.

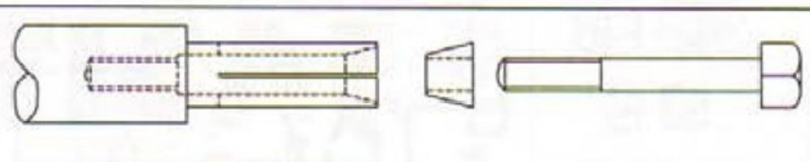
The condition of the bore is the greatest problem particularly with the tapered mandrel. Whereas the split mandrel will be able to cope with errors, providing the bore is parallel to within a few thou, in the case of the tapered mandrel the bore must be parallel to within a fraction of a thou, at least over most of its length, or else this method will not be practical.

If the hole is a drilled one, and the drill is cutting oversize, it will be found that as the drill breaks through, the hole will normally reduce over the last few thou. to exact size.

This can confuse the situation, and if when the mandrel is made, its fit is tested on this end only, it will be found to be too small, do check both ends as the mandrel is being turned.

If this is found to be the case, the slight reduction in diameter at the end, can easily be removed with a taper reamer, or a suitable round file.

The machining load: whilst this can be a problem, providing the work is approached



TYPICAL SPLIT MANDREL Fig. 4.

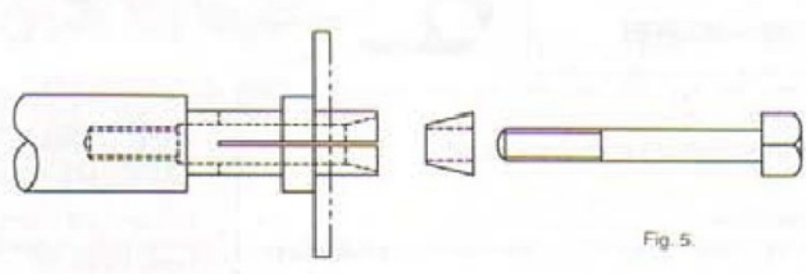


Fig. 5.

SPLIT MANDREL WITH FLANGE FOR MACHINING NARROW PARTS

©

A long component being machined. It is supported and driven by a tapered stub mandrel and stop collar. In the case additional support is given by use of the tailstock centre.

The tapered stube mandrel and stop collar from the set-up above, together with the long component which was seen being machined.

with patience and the cut kept to a minimum, almost anything should be possible.

Should a number of parts be required to be machined, then it is essential that the bore diameters are similar, to within a tenth of a thou or two, or else some parts will be too loose.

Solid type – parallel

This type intended for the part to be fitted using a grub screw or similar, is very tolerant of errors in the bore. As clearance will be taken up one way, by the action of the screw or screws, then concentricity may suffer.

Split type

This type can cope very well with varying bore conditions, and achieve relatively good concentricity. This will depend on the care taken in its manufacture. Its main limitation is the amount of work involved in its manufacture, particularly for a one off application.

Long components

Sometimes it will be required to machine a part which is too long to be mounted on a stub mandrel, of any type. This will occur when it is necessary to machine the complete length of a part, which will prevent it being fitted either in a chuck, or between centres, in this case due to a driving dog having to be fitted.

It will in some cases be possible when machining between centres, to first turn one end, and then for the part to be reversed to machine the other. This approach is less likely to be practical if mounting the part in the chuck, due to lost concentricity.

Stub mandrels are not satisfactory to hold parts where the length is say more than three times its diameter. This may be even less for small diameters, perhaps a little more for larger diameters.

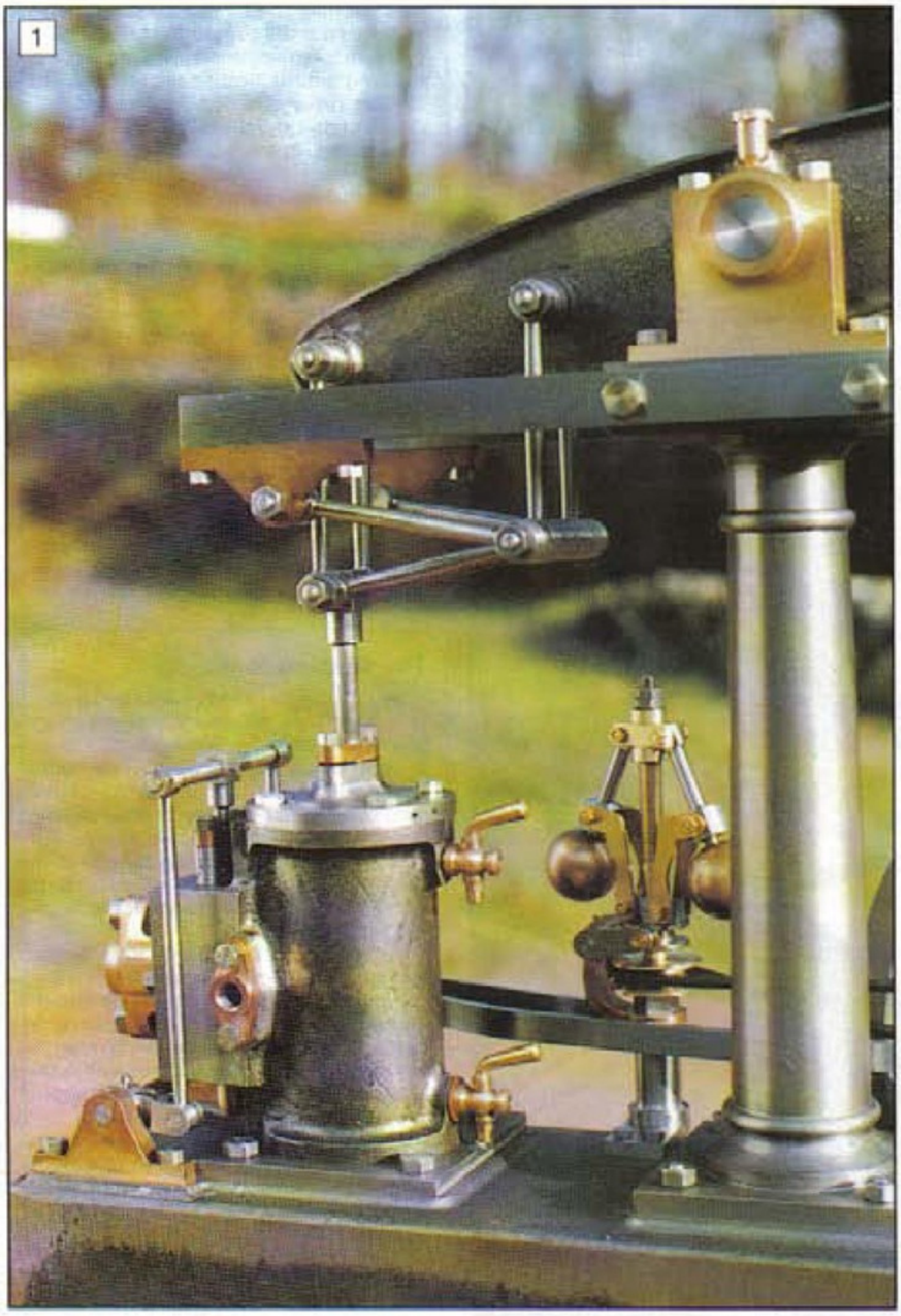
In the case of long components therefore the following approach should be considered. Make a normal tapered stub mandrel to support one end of the part and arrange for the other to be supported with the tailstock centre.

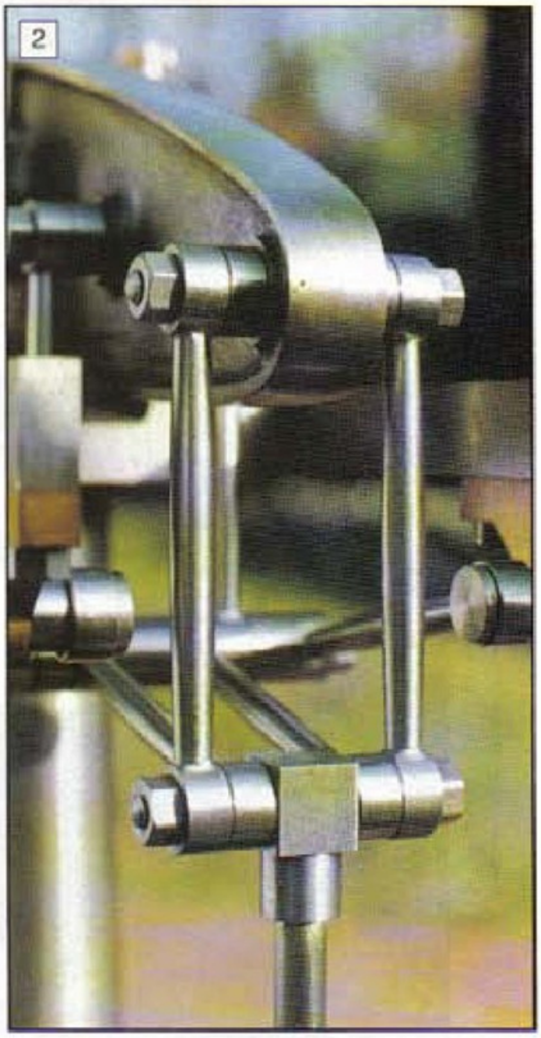
One potential problem with this method, is that if the part is forced further onto the mandrel due to the machining action, then the part will become loose at the tailstock end, and damage to the part may result.

To overcome this, make a collar which can be brought up to the end of the component, and fixed using a grub screw. This would be fixed after the part has been pushed onto the mandrel, sufficient to provide the required drive, and the tailstock centre moved into place. This can be seen in the photographs.

One instance where this procedure could be of help, is when it is required to drill, deep through holes, on the lathe. This operation can often result in failure, due to the drill wandering, especially where a small size drill is used. This can be the case, even where the degree of concentricity required is not very demanding.

In this situation, the part is made from material larger than the required finished diameter. A true hole can be then achieved, by bringing the part down to the required size, whilst mounting the part by the methods outlined above.





1: *A view of the author's part built Stuart Beam Engine, the Watts parallel motion pivots were the subject of the method used in this article.*
2: *A close-up of the links at the cylinder end of the beam, the success of the method of shaping the link ends is highlighted in this detail shot.*

A VERTICAL SHAPING FACILITY

In this article Howard Moor describes an interesting approach to vertical shaping. It can be seen from the photographs of the Stuart Beam Engine he is making that the method is capable of producing immaculate results.

During the recent construction of the Stuart Beam Engine, I was faced with the task of producing over sixty radii on various components. Many of these were in the form of steel links, forming the Watt's parallel motion. Others, such as plummer blocks and glands, were of gunmetal, but all had one significant feature in common, a hole, concentric to which the various radii were to be formed. **(Photos No. 1 and No. 2)**

The two most commonly used methods of dealing with small radii, end-milling in the lathe or filing to shape using a filing button, did not appeal to me for the following reason. Hand-holding the component on a spigot is an awkward business and fingers are best kept well away from milling cutters. Using toolmakers clamps reduces the risk somewhat, but following the cutting action, especially if using an eyeglass, brings one's head uncomfortably close to the lathe chuck. The idea of filing was considered (half-heartedly I must

4: *The complete set-up on the author's drilling machine. There is no workpiece in position, so that the undercut on the spigot is visible. The method of operation is self evident from the photograph and drawings.*

was possible and for this purpose I had acquired a small compound table. The titanium job mentioned involved machining longitudinal 'fins' on the inside wall of a circular vessel and with a (borrowed) circular table and the twin-cutter tool (**photo No. 3**) the drilling machine proved to be entirely adequate to cope with such tough material. Locking the spindle and quill from turning, when adapting the machine for vertical shaping, was accomplished by making the clamp plate (**photo No. 4**) guided by the 2in. dia. column. This plate is not included in the drawings as the method of locking the spindle will be determined by the type of machined owned. If there is no appreciable rotational play in the quill, then it may be a fairly simple job to connect both spindle and quill with some form of clamp. This might prove to be the only solution if the machine has no parallel column but the use of a wedge under the cone pulley, if your mill/drill or miller is belt-driven, may not be such an easy way out as the play in the splines may still allow some twisting of the cutter holder.

The shaping tool

At first glance, it may seem odd that twin cutters are necessary, if all we intend to use the device for is machining a radius of up to 180 degrees of arc a single cutter would suffice. Components such as links require a circular traverse of around 320 degrees, however, and as we approach the point where the radius meets the shaft the body of the tool will foul the component. Another point to be considered concerns tool rake angles.

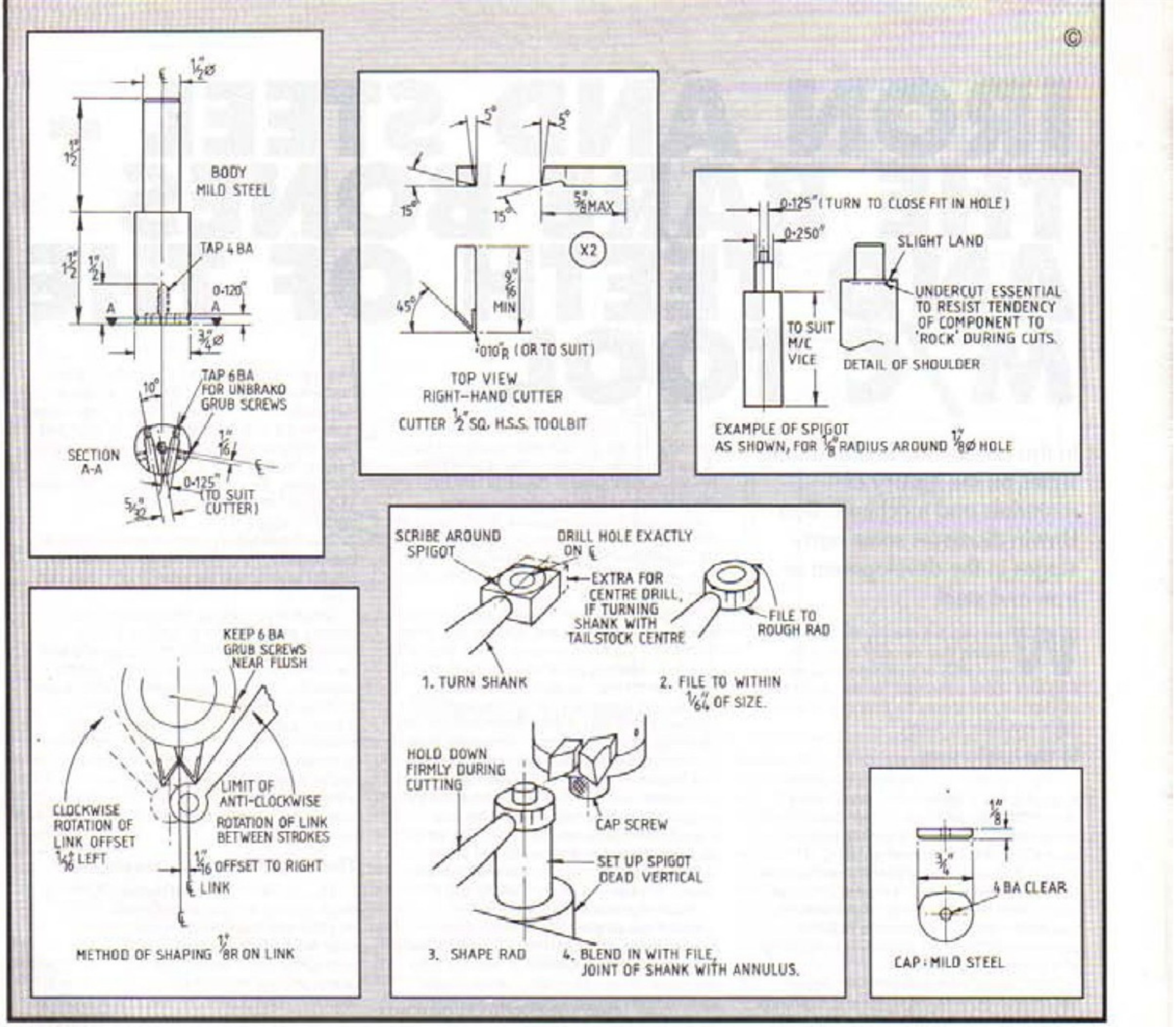
As we are going to "feed" the material against the cutter by pivoting the component on its spigot, it will be found necessary to make part of the arc of cut in a clockwise direction and the remainder anticlockwise. The provision of twin cutters allows the top and side rakes to be opposite-handed, which gives the correct shearing action, so necessary if we are to avoid chipping bits out from the underside edge of the radius at each stroke of the tool. The drawing shows cutters made

admit) as I prefer to machine things whenever possible, even if this means spending time adapting a machine to do unconventional things.

For the beam engine job, I dug out, from amongst some old cutters, a special-purpose tool I had used twenty years ago to cut some difficult shapes in titanium. During my wartime years in tool rooms, mainly as a jig-borer, I spent a few months on a vertical shaper and experienced its versatility, particularly in machining radii, using the circular table with its power feed. Such machines are not to be found in garden workshops; at least not in mine, but I was fortunate to have a very accurate ½in. capacity bench drilling machine, made from a kit of castings etc. by E.W. Cowell of Watford (usual disclaimer). The spindle and quill were of such rigidity that light milling

3: *The holder, with the twin shaping tools in position.*

from a ⅛in. square HSS toolbit and the rake angles given have been found to give good results on mild steel and gunmetal. The grub screw behind each cutter provides adjustment of the amount by which it projects and also prevents it moving away from the job, during cuts. 6 BA Unbrako grub screws for side clamping alone would not be sufficient.



Maximum rigidity, important with all cutting tools, is essential when shaping as there must be no tendency for the cutter to "dig in". Neither should it be allowed to deflect from the ideal straight-line motion and for this reason it is unwise to grip the shank in a drill chuck. If your machine has a Morse taper spindle or can take collets either facility is suitable.

Mounting the workpiece

Turn the spigot shown in the drawing, ensuring the two smaller diameters are concentric and that the pivot is a really close fit in the hole drilled in the component. The diameter of the shoulder should be the same as the finished diameter required on the component and to provide a firm support the shoulder should be undercut slightly as indicated. It is assumed that the job has been filed roughly to size, say to within twenty or, at most, thirty thou. of the final diameter. The shoulder diameter of the spigot is useful for scribing around when marking out the component, by the way. Set up the spigot vertically in a machine vice or drilling vice. The type with a vertical Vee groove in one jaw is very convenient. Leave enough of the shoulder diameter of the spigot above the vice jaws to allow the cutting tools to just clear the underside of the job without hitting the vice. The depth stop of the machine should be locked at this point and the quill should be fully retracted when the cutters are above the top surface of the component by about ⅛in. or so. This is to assist with keeping play to a minimum and also to limit the stroke length so that the hand movement of the lever can be simply a wrist action.

Using the shaping tool

It is assumed that the set-up is arranged with the tool to the rear of the spigot. Start with toolholder and spigot on the centre-line of the cross feed of the machine. If you are not simply radiusing the end of a parallel bar, in which case the choice of cutter to use depends whether you swivel the job clockwise or anti-clockwise, you need to proceed as shown in the diagram. This takes as an example the production of a ⅛in. radius on the end of a link, or a component such as a locomotive coupling rod. In both cases the radius exceeds an arc angle of more than 180 deg. and the reason for off-setting the spigot alternately to left and right, to avoid fouling the toolholder, will be apparent. As there will be some friction between the cutter and job during the upward stroke, the use of a neat cutting oil will help prevent the component lifting off the spigot. Keep cuts light, hold the job down firmly, swivel it only when at the top of a stroke and all that remains is to acquire the knack! If finishing cuts are kept to a thou. or two, and amount of swivel to 5 deg. increments, with a ⅛in. radius there should be only a small job of cleaning up with the file.

Postscript

Unfortunately E.W. Cowell of Watford (0923 229664) no longer supply the ½in. capacity drilling machine castings mentioned by Mr Moore in his article. They do though supply castings for a lighter ⅜in. capacity drilling machine, also for a bench mounted power hack saw and a rack feed tailstock attachment for a Myford ML7. All these have been supplied for many years. Their ⅜in. capacity drilling machine was my first home workshop project in about 1952 when I was 18, Ed.

IRON AND STEEL – THE BARE BONES AND TEETH OF THE M/C TOOL

In this article, the first of a long series on the history of materials and machines, Don Unwin discusses some early stages in the development or iron and steel.

When you are merrily turning or milling that piece of steel with your HSS or tungsten carbide cutting tool spare a thought for the craftsmen of antiquity who only had copper or bronze tools available to them.

In the beginning

The first cutting tools were of course knapped flints, but the first metal ones about 3500 BC were of copper, hammered to harden it. These were slowly replaced about 2000 BC by bronze, an alloy of copper and tin with other trace metals due to imperfect ores. With a melting point of about 1100 deg.C, it was just possible to smelt the ores in their simple hearths, sometimes blown by a bellows consisting of a sewn up animal skin.

Iron began to be generally available about 1200 BC with the scattering of smiths following the destruction of the Hittite Empire. This early iron was the fibrous wrought iron. In some areas the bog-ore was plentiful on the surface but in others it had to be mined, for example the Scoles near Bream in the Forest of Dean (SO 605045) are the remains of Roman iron ore mines.

Iron is in three forms, the chief chemical difference being the carbon content. Wrought iron, the earliest form is almost free of carbon, then steel 0.5 to 1.25% and cast iron 3 to 4.5%.

Wrought iron was virtually the only iron produced for 2000 years, up until the introduction of the blast furnace about 1500 AD. The high melting point of iron, 1535 deg.C was beyond the capability of the early furnace or 'bloomery' which consisted of a hollow with a clay dome. Ore covered with charcoal was put into this, never liquifying but becoming a pasty lump which when the 'bloomer' judged right was taken out of the hearth and hammered to drive out the slag, reheating as necessary. This produced a fibrous wrought iron which could be forged and fire welded by the smith. Unfortunately although very malleable it would not retain a sharp cutting edge.

As always the need for weapons fostered development and the sword maker needed a material better able to take a sharp edge than bronze or iron for their products. About 1500 BC a rather haphazard cementation process was developed by the Chalybes, an Asia Minor tribe of the Hittite Empire. The wrought iron bars were repeatedly heated in contact with charcoal and hammered causing the carbon to diffuse into the surface of the iron giving a steeled surface. Some 200 years later it was discovered that by heating to red heat and quenching in water it could be made much harder. All this was of course discovered practically, why it occurred had to wait until 1780 and Lavoisier's chemical analysis system.

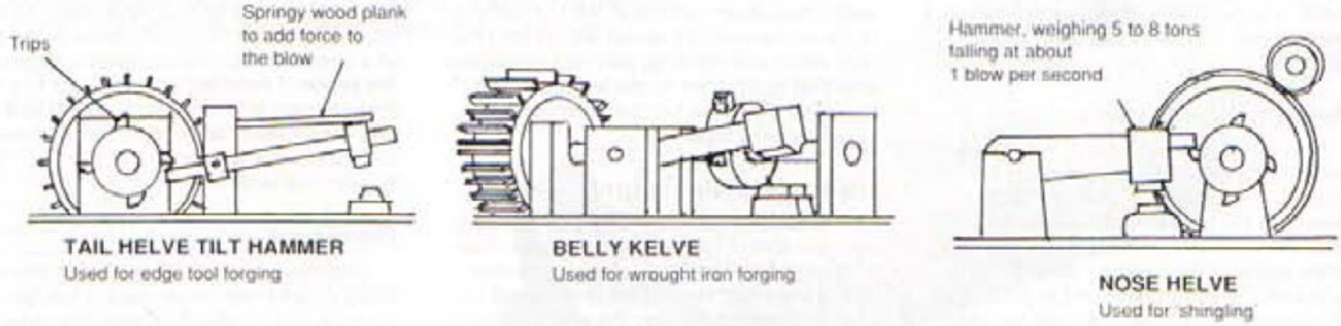
This hardenable material did not become available for making cutting tools until after 500 BC so enabling the turning of metals possible.

Somewhere about 1100 AD the iron making process was divided with the bloom being reduced in the bloomery and the reheating in a second 'string' hearth whilst by 1400AD water wheels were in use to drive the blowing bellows and ore crushing stamps. These improvements allowed an increase in quantity and weight of blooms from 30 lb. in the 14th century to 100 or even 200 lb. in the 15th century, by which time the water driven tilt hammer was being used for the hammering operations, **Fig. 1.**

The blast furnace is developed

The arrival of the blast furnace with it's much higher temperatures about 1490 deg.C made possible the production of what was effectively a new material, cast iron. Once again armaments were the first users, initially for casting shot for artillery then for casting cannon, the first non-military use being cast fire backs. Unlike the bloomery producing cast iron by a blast furnace was a continuous process, the ore

Fig.1 FORGE HAMMERS



TAIL HELVE TILT HAMMER
Used for edge tool forging

BELLY KELVE
Used for wrought iron forging

NOSE HELVE
Used for 'shingling'

Examples can be seen at:-
Abbeydale Hamlet, Sheffield. SK325820. Wortley Top Forge, nr. Sheffield. SK294998.
Sticklepath Forge, nor. Okehampton, Devon. SX639940.
(Note: the 'S' prefix figures given are Ordnance Survey map references

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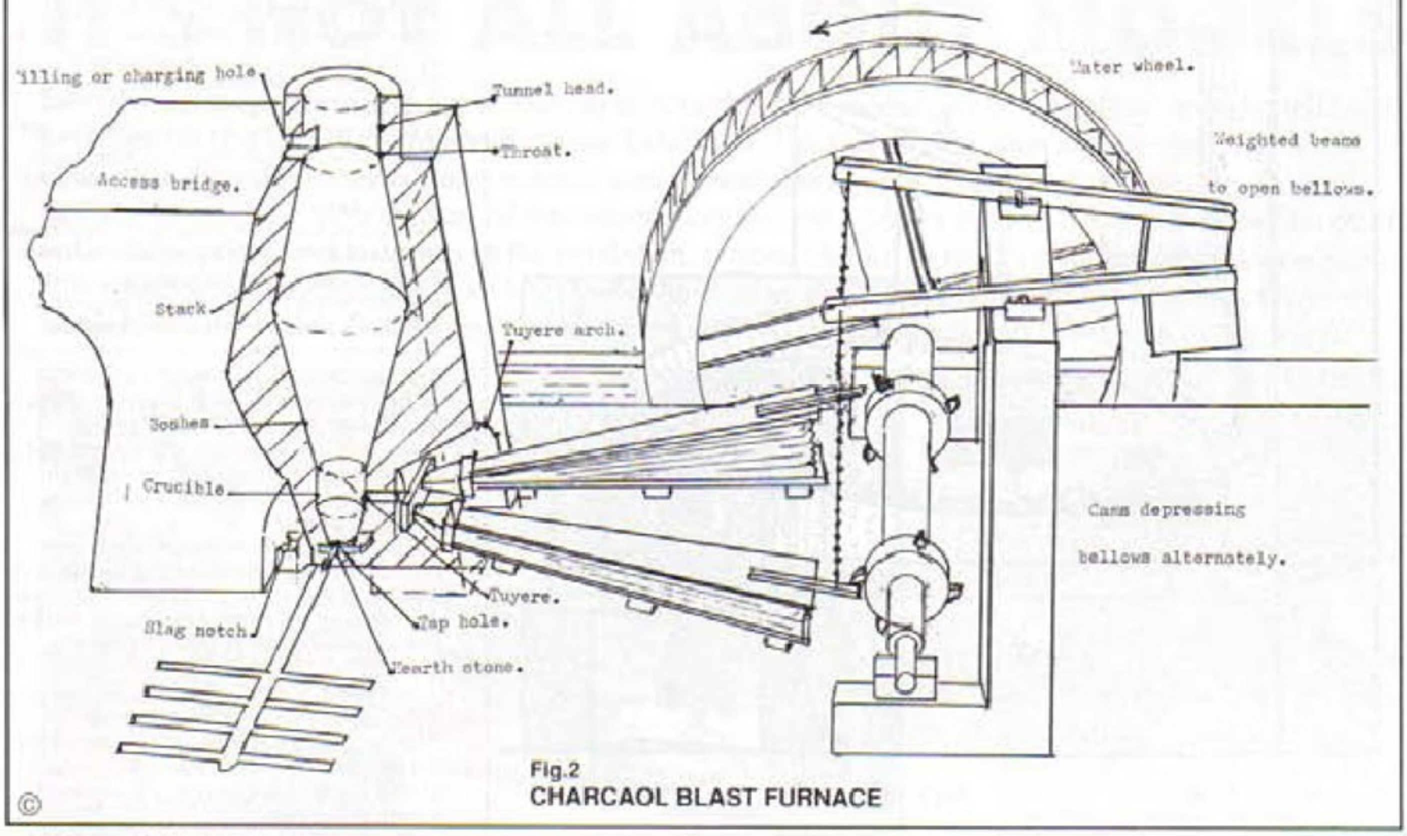


Fig.2
CHARCAOL BLAST FURNACE

and charcoal fuel being fed in at the top and the molten iron periodically tapped off at the bottom. This was fed into channels in a sand bed called 'sows' with side channels appropriately called 'pigs'. An example of an early charcoal fire blast furnace can be sen at Bonawe Ironworks 1762-1888, near Oban beside Loch Etive in Scotland (NNO10317). **Fig. 2**.

The sows and pigs were broken up and remelted in a 'finery' where it was stirred in the presence of an airblast. The oxygen in the air combined with the carbon in the iron which as the carbon was reduced became a pasty lump of wrought iron. This was taken to the forge where the impurities were hammered out on a nose helve hammer, Fig. 1, to make a bloom of wrought iron weighing about half hundredweight (20 kg.). Next it was reheated in a 'chafery' and further hammered into bar form to be sold.

One of the disadvantages of the charcoal fired blast furnace was the weak nature of the fuel which limited the weight of the charge.

This limitation was removed by the discovery in 1709 by Abraham Darby of a means of production using the much stronger coke as the fuel. Darby's original furnace can be seen at Coalbrookdale (SJ667047) and near by the Bedlam furnaces, the first to be built specifically for coke smelting in 1757 (SJ677034). Other examples can be seen at Moira, Leics. 1804 (SK314152) and Morley Park, Heage, Derbys. 1780 and 1818, (SK308492). Up to 1750 other ironmasters producing wrought iron were slow to adopt the coke pig iron as any sulphur in the fuel produced 'hot short' wrought iron. They did not have the low sulphur content Shropshire coking coal available to Darby who was only concerned with producing castings. Also the output of early coke furnaces was low and more costly. After 1760 a rapid expansion took place, firstly stimulated by a rise in price of charcoal and with the increase in demand a fall in coke prices. The coke furnace requires a much stronger air blast than the charcoal furnace and in 1856 Isaac Wilkinson introduced a box bellows followed in 1860 by John Smeatons invention of the cast iron blowing cylinder, both being water powered at first but gradually steam powered after the introduction in 1775 of the Watt steam blowing engine, first used by 'Iron mad' John Wilkinson at Brosley, Shropshire.

The iron is rolled into bars

From the 1730s raw coal was gradually replacing charcoal in the conversion of pig to wrought iron, firstly in the 'chafery' stage which was only reheating involving no chemical change so the use of a less pure fuel had no undesirable effects. Then came the two 1783 patents of Henry Cort. One was to convert the iron into bars by passing it at welding heat through pair of water driven grooved rolls. This both consolidated the grain and squeezed out the slag. His other patent was to use a coal fired reverbatory furnace in which the pig iron was heated and whilst in a molten state stirred or 'puddled' by an iron bar or 'rabble'. This increased the speed at which the carbon was removed until bubbling and 'puddlers candles' were given off. With continued stirring the iron became a large spongy ball of iron which was then removed and hammered called 'shingling' to drive out the slag, finally being passed through the rolls at welding heat as in his other patent. Cort's process when perfected increased the speed of throughput of wrought iron production as much as 15 times. However, the process was wasteful, needing 2 tons of pig to produce 1 ton of wrought iron and in the 1820s Joseph Hall invented an improvement in which he added 'bosh cinder', the cinder from the water tank in which the rabble was cooled, to the charge. This caused the pig to 'boil' and produced a good iron using only 21 cwt of pig to make 1 ton of iron. The process was known as 'pig boiling' or 'wet puddling' whilst Cort's process was called 'dry puddling'. Hall's process with minor improvements continued until the end of wrought iron production. The iron produced from the first rolling was known as 'puddled' or 'muck' iron. It was then cut into short lengths, stacked, reheated to welding heat and rolled again giving 'crown' or 'merchant' iron, repeating the operation again gave 'Best', once again 'BB', yet again 'BBB'. Merchant or Best being adequate for most uses. Wrought iron is still made at the Blists Hill Museum near Ironbridge, the only place in the world now doing so, (SJ695935). **Fig. 3.**

Steel was still being produced using essentially the same cementation process evolved by the Calybes. Bars of wrought iron made from pure Swedish ores were packed in charcoal and sealed in fire resistant boxes. These were heated in a furnace to about 1100 deg.C for several days, which with heating and cooling extended the process to 20 or 30 days. The result was an unhomogenious steel of about 1.5% carbon with a blistered surface hence known as 'blister steel'. It was sorted by appearance into 'spring heat' or 'cutlery heat' then reheated and hammered to improve homogenity. About 1720 a method of improving quality was to bind 2ft. lengths into a 'faggot', heat to welding heat and forge weld then reduce to bar called 'shear steel'. Further faggoting, welding and forging made better and more expensive, 'double shear steel'.

A need for better spring steel

In 1745 Benjimin Huntsman, a Quaker clockmaker who was dissatisfied with the

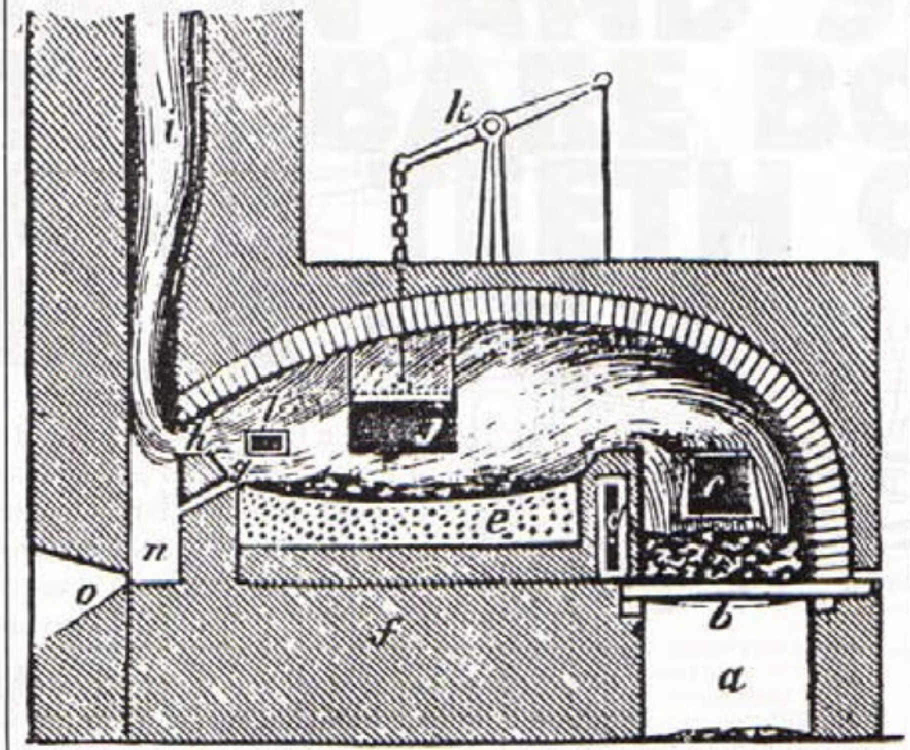


Fig.3

PUDDLING FURNACE. The Reverbatory Furnace is similar

e. Sand bed

j. Charging door

g. Cinder tap hole

The puddler's rabble is passed through the small hole at the bottom of the charging door

©

quality of clock springs discovered that he could make a far better steel by remelting blister steel with a flux in a crucible then teeming it into cast iron moulds. These ingots were then reheated, hammered and rolled into the required sections. The very high temperatures around 1550 deg.C required crucibles of a special clay and a coke furnace with a very tall chimney to give a powerful draught. The equipment can be seen at the Abbeydale Industrial Hamlet, Sheffield, (SK325820).

All these developments were the result of experiment and observation without any awareness of the scientific principles involved, the chemical composition of steel not being known until some 40 years after Huntsman's invention.

Yet again in the 19th century the requirements of war influenced materials. The outbreak of the Crimean war caused Henry Bessemer to look at a stronger material for guns and projectiles which ended with his steel making converter in 1856. He had noticed that blowing air through molten cast iron produced very high temperatures at the same time reducing the carbon content to make a low carbon steel called 'mild steel'.

At first only iron made from low phosphorus ores could be used but this limitation was removed by Sidney Gilchrist Thomas who used a converter with a 'basic' lining instead of Bessemer's 'acid' lining.

R.F. Mushet also improved the process by adding 'spiegelesen', an iron containing manganese and carbon, to the charge.

Until the introduction of mild steel by Bessemer, 'steel' was understood to refer to the hardenable crucible cast product.

Soon after the Bessemer process, in the 1860s, C.W. Siemens introduced the regenerative open hearth furnace. This was similar to the puddling furnace but larger and fired with producer gas using hot air. Although slower than the converter it had several advantages, it did not need a molten charge which could include scrap, was able to make a much larger melt and was much more flexible. These two developments made available a material stronger and cheaper than wrought iron which by 1900 had been largely superseded by the new mild steel.

Into the 20th century

In the 20th century production techniques for mild steel have continued to advance with, in 1953, development of a special converter, called the LD or BOS (basic oxygen steel) process made possible by the availability of 'tonnage oxygen'. Then in the 1960s 'continuous casting' of liquid steel became practical.

To go back to the second half of the 19th century the only material for cutting tools was carbon steel with cutting speeds of 40 feet per minute. This was dramatically changed in 1865 by the discovery by Robert Forester Mushet working at Coleford in the Forest of Dean of an improved tool steel made from pig smelted from manganese rich ore to which wolfram ore (tungsten) was mixed and melted in a crucible furnace the result being a steel much harder than carbon steel and also self hardening. This was further improved in America by Fredrick W. Taylor about 1900 who added chromium and vanadium to make 'high speed steel' with yet another increase in cutting speeds.

Tool steels and other alloy steels were still made using refinements of Huntsman's crucible process. The 20th century has seen this replaced by the electric furnace and for some special alloys the vacuum remelt furnace.

In the mid 1910s Taylor's successors in America came up with another material, 'Stellite', a cobalt chromium tungsten alloy, not as hard or having the tensile strength of HSS but retaining it's cutting performance at red heat.

The great cutting material advance of the 20th century was originally developed to make drawing dies for tungsten lamp filament wire. This was tungsten carbide, a matrix of pulverised tungsten carbide in cobalt hydraulically moulded then sintered. It's value for cutting tools was realised in 1926 but it was not until 1934 that the Norton Company developed a diamond impregnated grindstone to cut it! Tools of other carbides, molybdenum, titanium or tantalum followed and like Stellite had low tensile strength so small cutting tips were brazed or more recently clamped on to steel shanks. Another recent development of the 1950s has been the ceramic tool tip. All these materials have allowed cutting speeds to increase to over 400 feet per minute. However it is worth remembering with all these developments in the 'teeth' of the machine tool, none of these materials will take such a keen sharp cutting edge as the simple hardened carbon steel tool, excepting of course the exotic diamond tool, first used in 1790 by Jesse Ramsden.

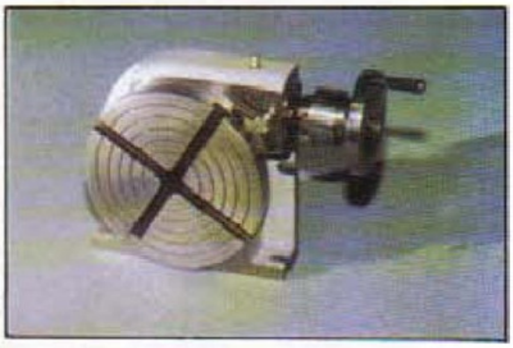
Early machine tools

The 'bones' of the early machine tools were of wood with some iron or brass components. With the advent in 1750 of good quality iron castings these were rapidly adopted by the tool builders. This continued until the development arc welding allowed the production of large mild steel fabrications, a technique which was tried by some manufacturers, not however always successfully. Cutter and gear induced vibrations proved to be a problem, being slow to decay due to the relatively low internal damping capacity of mild steel. Cast iron however has a specific damping capacity some 10 times that of mild steel so that any vibrations rapidly decay, which leaves various grades of cast iron remaining the principle material for the 'bones' of the machine tool.

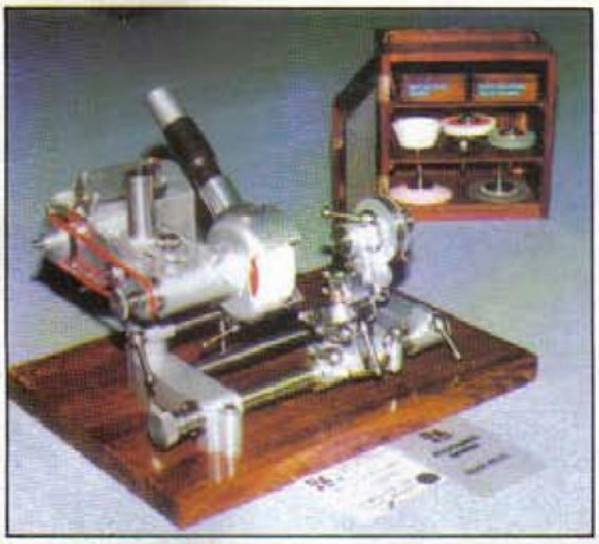
To be continued

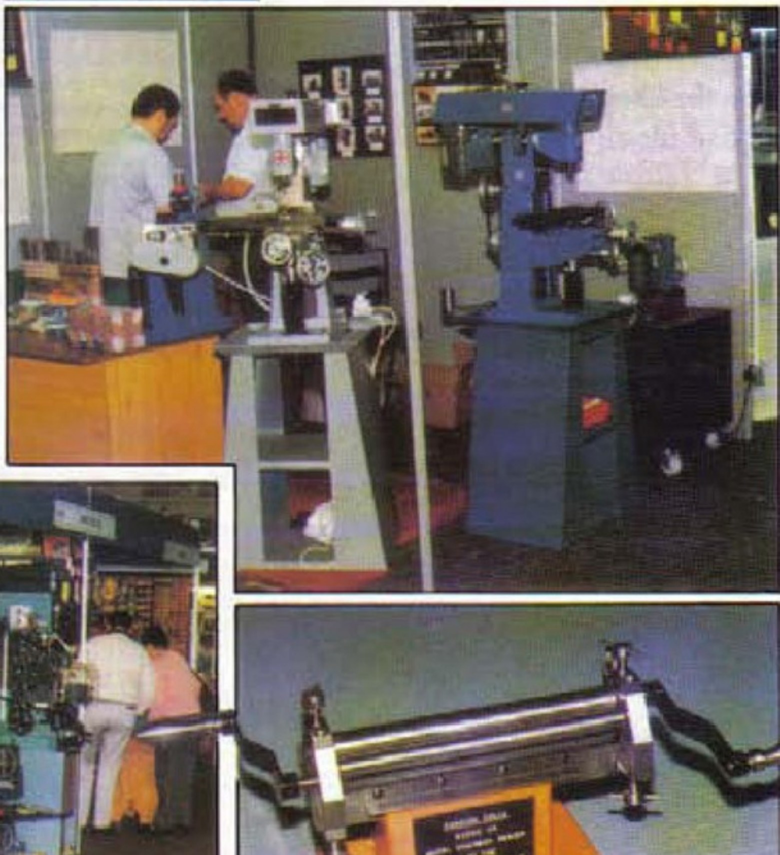
IT'S NOT ALL ABOUT MODELS!

Even if your major interest is not in looking at superbly built models, of all disciplines, there is still much to recommend a visit to the Model Engineer Exhibition. The tool section often shows examples of innovative thought, many of these exhibits repay careful study. The trade stands, especially those devoted to machine tools display all the recent changes and updates in this field. Many trade stands offer unbeatable prices and bargains at the exhibition, a good chance to stock up for the forthcoming season. This selection of photographs from last year's show serve to illustrate a little of the breadth of interest available to the visitor. Details, as regards opening times etc. are displayed elsewhere in this issue.

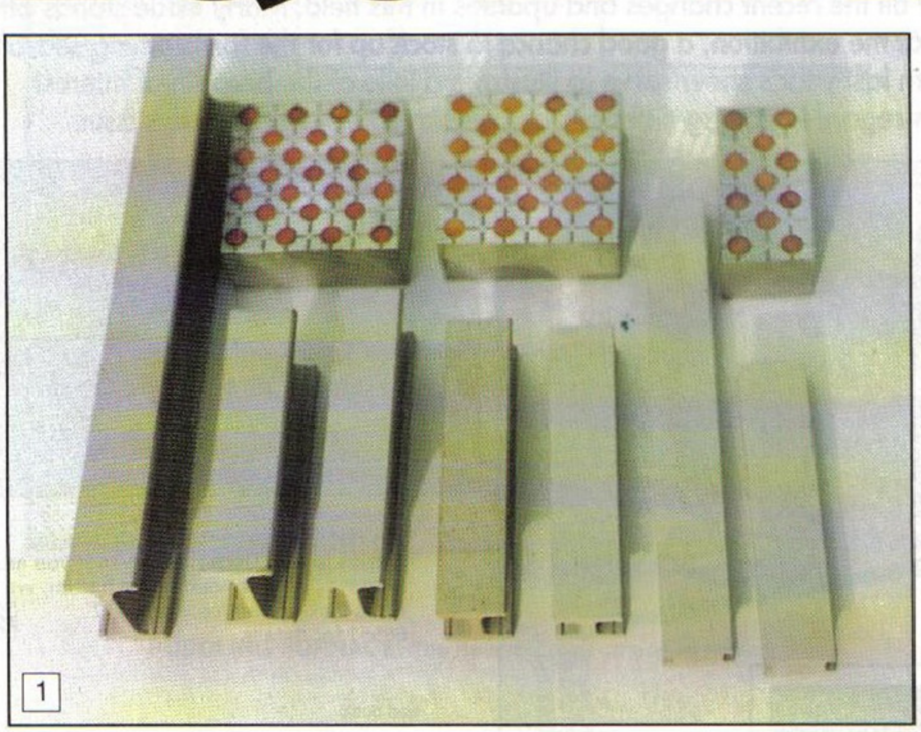


It is not too late to enter. Last date for entries is 18th December, even if you are a long way off this need be no barrier, we run a Pick-up service, ring 0442 66551 for details



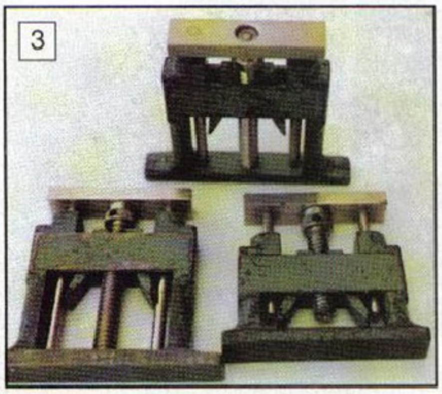


WORKSHOP EQUIPMENT



1

Mr A.T. Davies suggests a source of workshop equipment on the cheap. Sounds like a good idea.



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There must be many owners of home machine shops who have either come into the hobby upon retirement, like me, or who are young, with the problems of a mortgage and a growing family. In either case cash is usually short, therefore any savings that can be made, whilst at the same time building up workshop accessories must be of interest to these categories of modellers.

As in most businesses, the printing industry over the past few years has undergone a dramatic change, especially in the composition or typesetting side. The printed word used to be set in cold type or cast in hot metal, but these days more and more firms are using computers for setting up camera ready copy. This makes lots of equipment obsolete, which, with a little imagination can be adapted to our needs.

In my case, the college where I lectured before retirement turned over exclusively to computer typesetting and I was asked to look at all the equipment before it was disposed of in case there was anything that I would like. The descriptions that follow plus the photographs will show some of the articles I "saved" and how I expect them to be used in the workshop.

Photo 1. Shows 'H' girder material in various heights and lengths which used to be used as packing in Letterpress formes. These are made in a hard alloy and have been milled to exact sizes – it is easy to imagine how useful this can be as parallels in marking out etc. On the same photograph, the aluminium pieces at the top of the picture have hardwood dowels inserted in a honeycomb pattern, again accurate on all faces – uses to date include packing – especially behind jobs on the face-plate, on the drilling table tec. Self tapping screws can be inserted into the hardwood dowels with ease

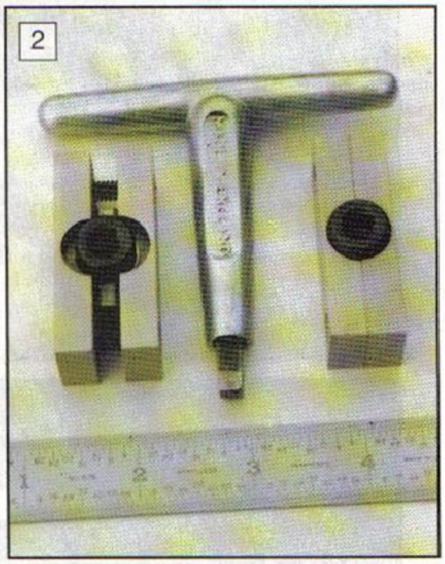

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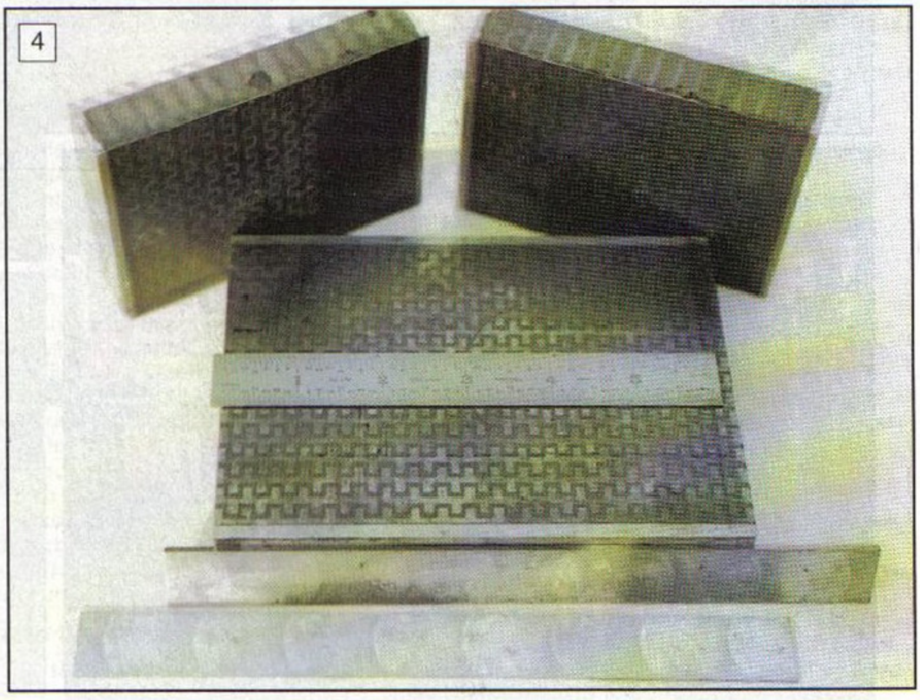
Photo 2. This shows two 'quoins' (pronounced coins), one in the fully open position and one fully closed – complete with key, the key is inserted in the centre of the quoin and turned to open and close it.



4

ON A BUDGET

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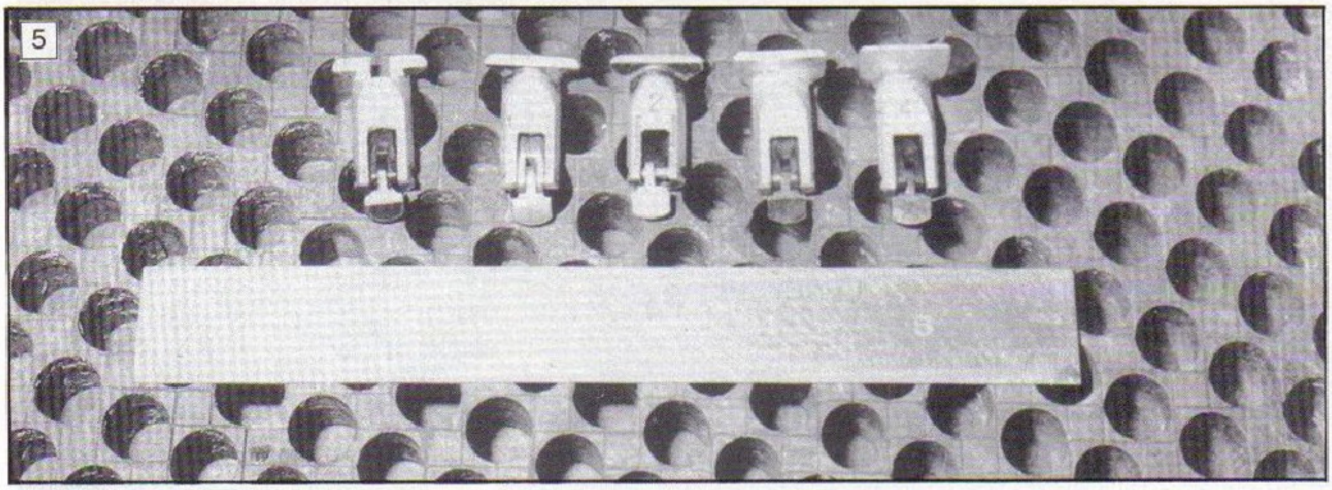

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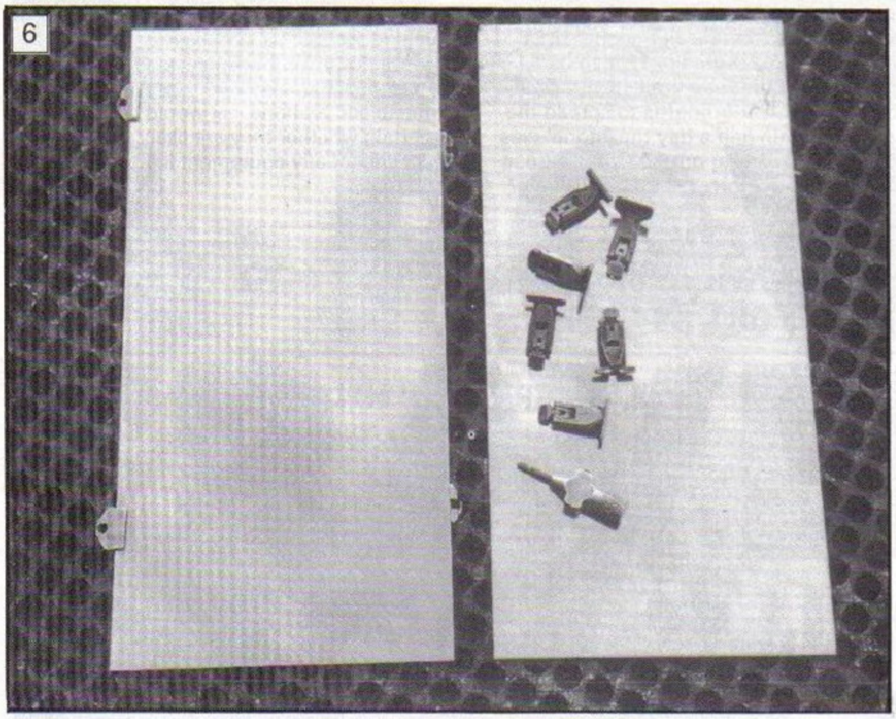

the magnetic properties being effective. Once again these are accurately milled with perfectly square edges. The two thin pieces of metal in front of the blocks are 'leads', again in a variety of thicknesses and lengths – very useful for packing lathe tools. Being made of Printers' metal, and so very soft they can be used to pack work which otherwise could be marked by harder packing.

Photo 5. Is of a 'Honeycomb Chase' complete with a variety of fasteners. They go from '0' on the left to '4' on the right. The higher the number the greater the lip or overhang. The number '0' has no lip at all. In use the fastener is dropped into an appropriate hole in the honeycomb and tightened up with a small key.

Photo 6. Shows the key and fasteners laid out on a brass sheet whilst the other sheet of brass is clamped down ready for marking out.

Photo 7. Shows two pieces of brass being held down for marking out.

Photo 8. Finally, an accurately ground 'Compositors Stone' (which is actually made of cast iron) on a sturdy oak base. The size is 42 × 28 inches. Although I envisaged loads of problems, for

These have been used in a confined space to exert pressure outwards, in conjunction with the 'H' packing mentioned earlier, e.g. inside loco frames to open them up slightly to allow, say, a stretcher to be removed or inserted.

Photo 3. These items can be used upright or horizontally. A quick release/adjustment is made by squeezing the two clips seen inside the vertical pillars which releases the female threads from the centre screw. A fine adjustment can be made by using a small bar inserted into one of the holes of the knurled top section of the centre screw. Possible use – instead of the quoins already mentioned, if there is sufficient space.

Photo 4. Shows a variety of magnetic blocks. They have an aluminium base and two sides so that they can be used without

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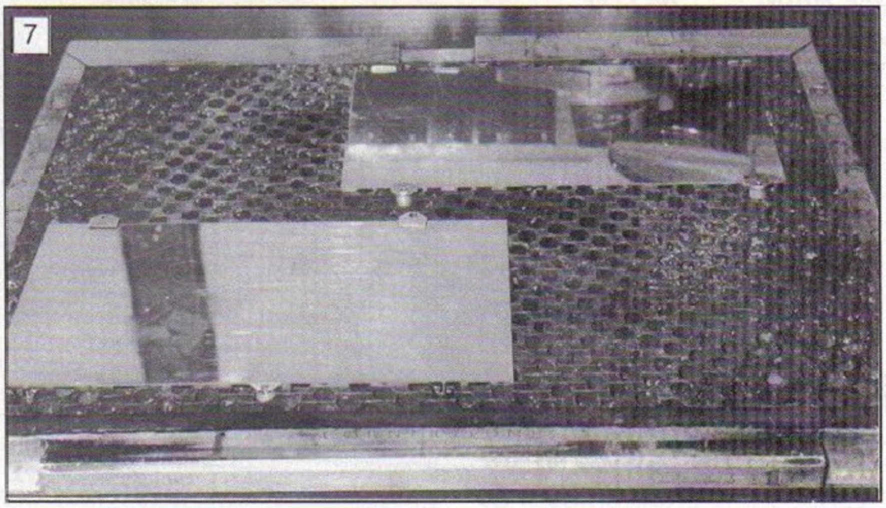
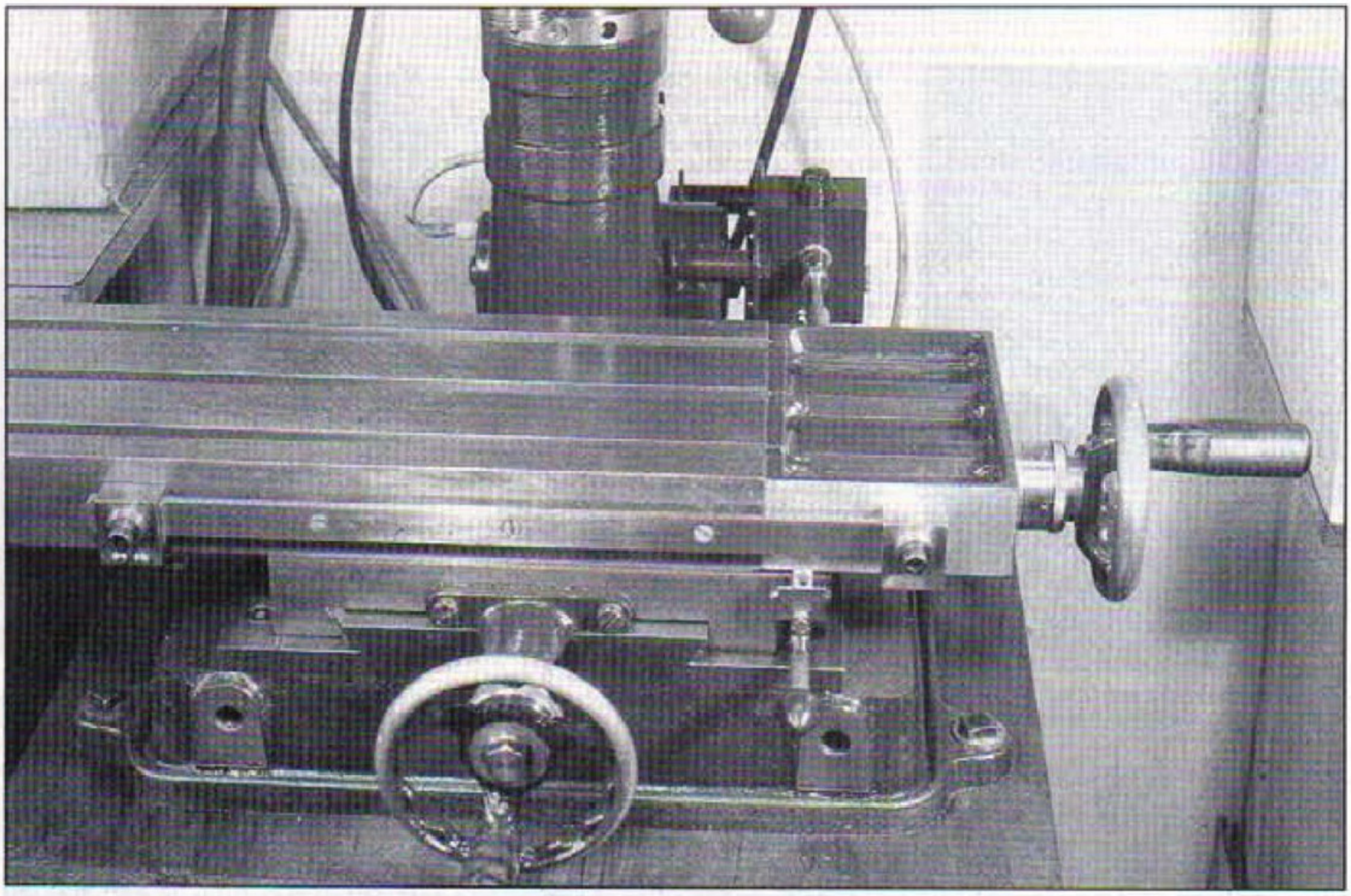


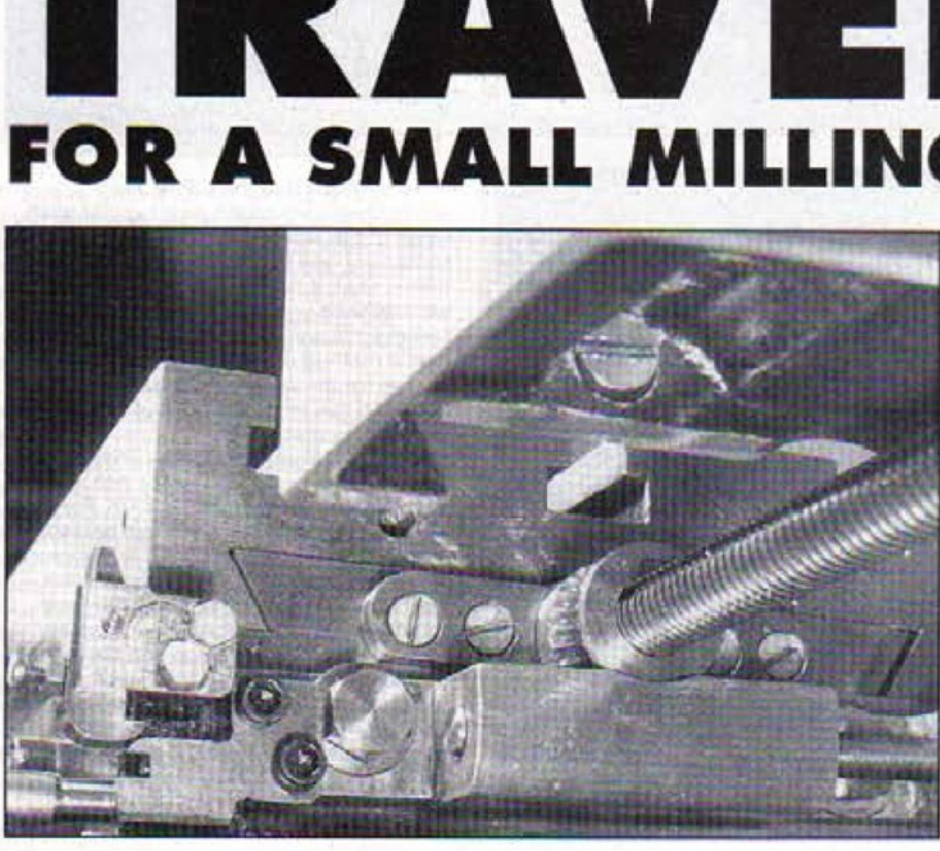
example, transportation and the limited space in my workshop, I immediately said that I would have it. A friend used his van to collect it and two more neighbours were 'volunteered' to help. Using 4 × ⅜in. steel bars in appropriate holes in the cast iron top it was soon on a set of wheels and in the van, the base was loaded and off we went to the workshop (shed!). It was found that the end of the shed had to be taken off to get the base in! This wasn't much of a problem as having built the shed myself it just entailed taking out six coach bolts, the insulation and the inner skin. Two lengths of 12 inch by 1 inch by 4 foot timber were laid side by side across the floorboards to spread the load and within half a day the 'stone' was in situ. As a marking out table it has been well worth the effort. The cost of all this? Nothing, just the cost of collecting it.

I hope that the foregoing will prove helpful to anyone looking for a cheap way of building up their workshop equipment.

A glance in Yellow Pages should provide names and addresses of Letterpress Printers and a phone call would soon ascertain whether they are likely to be disposing of any equipment in the near future.



A POWER TRAVERSE
FOR A SMALL MILLING MACHINE

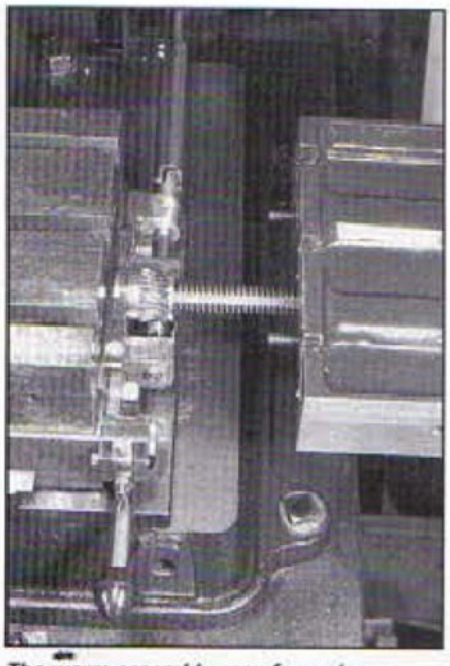


Above: *The finished assembly. Note the operating handle at right hand end of the table. This is complete with the auto-stop mechanism.*

Left: *The worm assembly from below, clearly showing the latch at the left hand side, this is also used for the auto-stop.*

PART 1

David Machin provides this excellent design of a power feed for a Westbury Milling Machine. It is easily adaptable for other machines, and this will be covered in the concluding parts of the series



The worm assembly seen from above, prior to fitting the bearing bracket.

I built my Westbury milling machine twenty years ago, and have often felt the need for a power traverse. I have finally found the time to design and make such an attachment. Its success, I believe, merits sharing the idea with others, hence this article.

In designing the power traverse for the machine, I had in mind the possibility of lengthening the table traverse. This has been achieved using a longer feedscrew bearing bracket. It has also necessitated the making of a longer feedscrew.

The design

The basis of the design is a wormwheel keyed to a keyway milled along the feedscrew. It is arranged so that a worm can be engaged and disengaged with the wormwheel by mounting the worm on a pivoted arm, capable of being latched in mesh. Disengagement can be made manually or automatically, the latter using a linear cam arrangement. The power source is a 12 volt D.C. motor coupled to a reduction gearbox (another worm and wormwheel). The drive is taken from the motor gearbox to the feedscrew worm by a universally jointed shaft with a telescoping arrangement to allow full movement of the cross-slide. A simple thyristor speed control is incorporated, together with a reversing switch.

This has proved to be a worthwhile project taking all the tedium out of milling large areas, etc.

One advantage of the design is that all the "works" are protected by the feedscrew bearing bracket, so no trouble is experienced due to ingress of swarf to the moving parts.

Although the design as drawn is intended for the Westbury, it can easily be adapted to other machines. The Dore Westbury springs to mind as well as the machines from the Far East. The latter, having a larger diameter feedscrew, will need a larger wormwheel. This and other points will be dealt with later on.

It should be noted that drawings, castings and materials for the Power Feed project can be obtained from N.S. & A. Hemmingway, 30 Links View, Rochdale, Lancs. 0111 4DD. Tel. (0706) 45404.

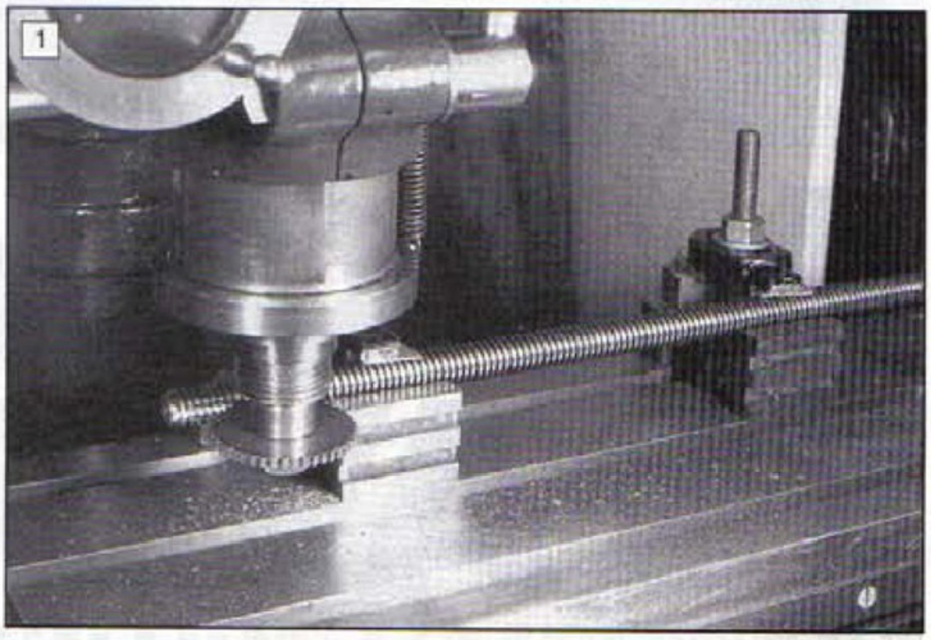
Manufacture

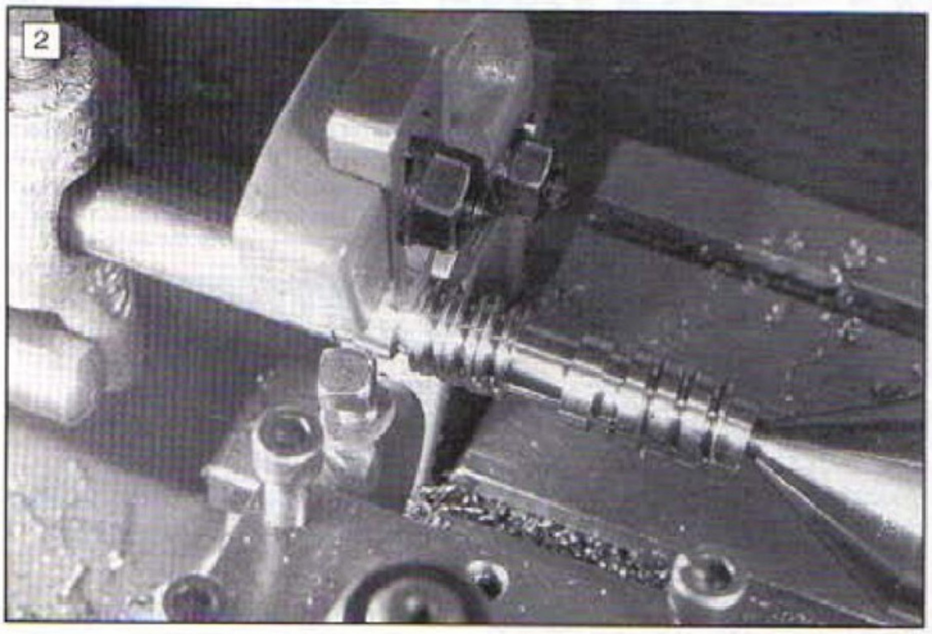
The feedscrew

The first task is to make a longer feedscrew, (part 7) and then mill a groove down it. Screw cutting is easily accomplished using a Myford (or similar) lathe, though a travelling steady is essential, of course. To mill the groove, the traverse on the Westbury is insufficient, so I had to mill as much length as possible and then very carefully reposition to complete the cut. **Fig. 1** shows the set up for this. To reposition, keep the cutter at the same height and move the screw to a new position on the table, carefully "fitting" the cutter to the part of the cut where you previously reached the end of the traverse. Re-clamp and complete the groove. This should ensure that the key will slide up and down the groove freely.

The worms

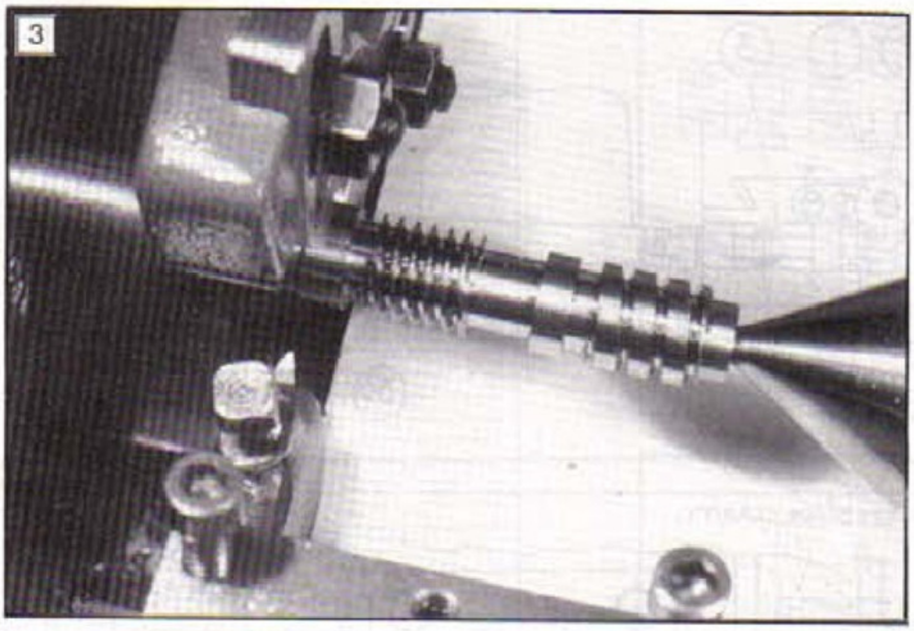
The worms, (parts 2a and 2b) can be made next. I originally made single start worms, but the traverse was rather slow, so two start worms are now suggested. To make them easy to cut, I used standard pitches.





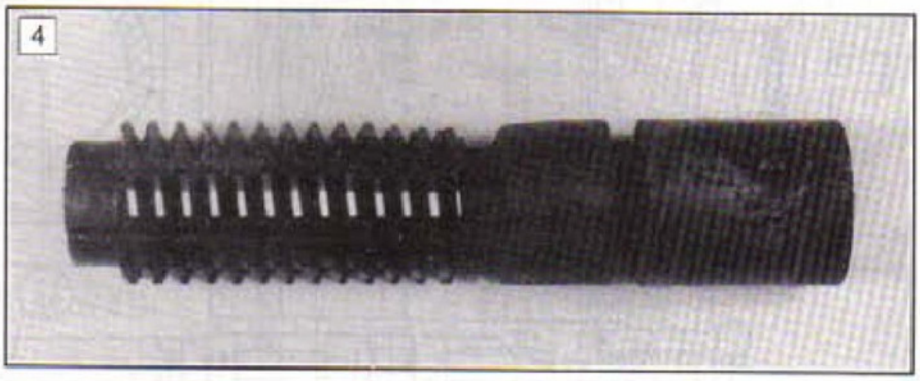
This means that the D.P. of the wormwheels are based on a circular pitch equal to the worm pitch, of course, giving some very odd D.P.'s indeed. This doesn't matter at all if you're making the wormwheels yourself. If you'd rather buy commercial wormwheels of standard D.P., then a method of cutting non-standard pitches for the worms will be needed. I'll deal with this later when discussing the Far East milling machines.

Back to making the worms. They have a pitch of 0.1in. and a lead of 0.2 inch. Thus the lathe will need setting to 5 TPI. For a leadscrew of 8 TPI the gears will be: top stud: 40T, intermediate: any T. leadscrew: 25T. This also means that the leadscrew will be turning faster than the headstock spindle. Ideally, therefore, the leadscrew should drive the headstock, and the thread should be milled using a toolpost milling spindle. I must confess that I didn't do either of these, but screwcut the worms conventionally. However, to avoid straining the gears, I took very small cuts at a low



3

speed. I would suggest cuts of 0.004in. initially, gradually reducing to 0.001in. for the final cuts. A travelling steady is again essential. Allow enough length of workpiece to make a hob, as well as the worms. Having cut the first thread to depth, the tool is moved longitudinally by the length of the pitch (0.1in.) using the top slide for this, beware of backlash. The second thread will then be cut down, the centre of the first, giving the two start thread. **Figs. 2 and 3** show this, and the Acme form tool. The profile dimensions for this tool are the same as those shown in **Fig. 6** with allowance for the helix angle, of course.

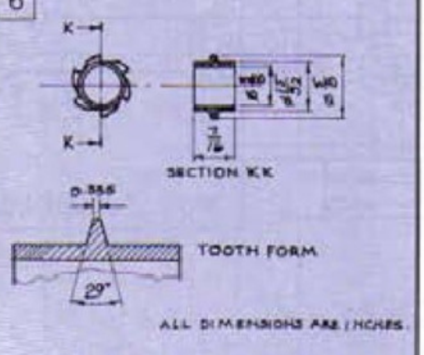


4

5

Before parting off the worms, it is a good plan to machine – whilst still set up between centres – the diameter at each end of each worm and a spigot on the end of what will be the hob. This will assist checking concentricity when boring the worms to receive their shafts. More about this later.

Once the worms have been parted off (not between centres please!), a new centre drilled hole will be needed in the end of the embryo hob, if this is mounted in the three jaw, its concentricity can be checked using a D.T.I. Up to 0.002in. can be accepted. Beyond this, use the four jaw chuck, adjust to run true and centre drill. Milling grooves (rather like those on a tap) can now be completed. I used the dividing head for this, and with a dovetail cutter, managed to cut 6 grooves as shown in **Fig. 4**. Four grooves, however, would be quite adequate. The hob can now be case hardened. I attempted to get a reasonable depth of hardening by repeatedly plunging the workpiece in the case hardening compound and heating for a total of about 10 minutes, before plunging into cold water. It would be possible, of course, to make worms and hobs in silver steel, but this would have put even more stress on lathe gears, and was thus rejected on these grounds. As was later found the case hardened mild steel hob proved quite adequate – since it did the job – admittedly cutting phosphor bronze. Further tool making is now needed in preparation for machining the wormwheel and is shown in **Fig. 5**. This is a "gearcutter" designed to gash the wormwheel prior to the use of the hob. It is best made in silver steel. The form is Acme and the dimensions are shown in **Fig. 6**. Once the roughing cut is completed, the Acme form can be produced by the same tool used for cutting the worm, feeding in sideways, (at low speed), or by taper turning using a top slide set to 14½ degrees. The tip of the cutter can be measured with a micrometer.

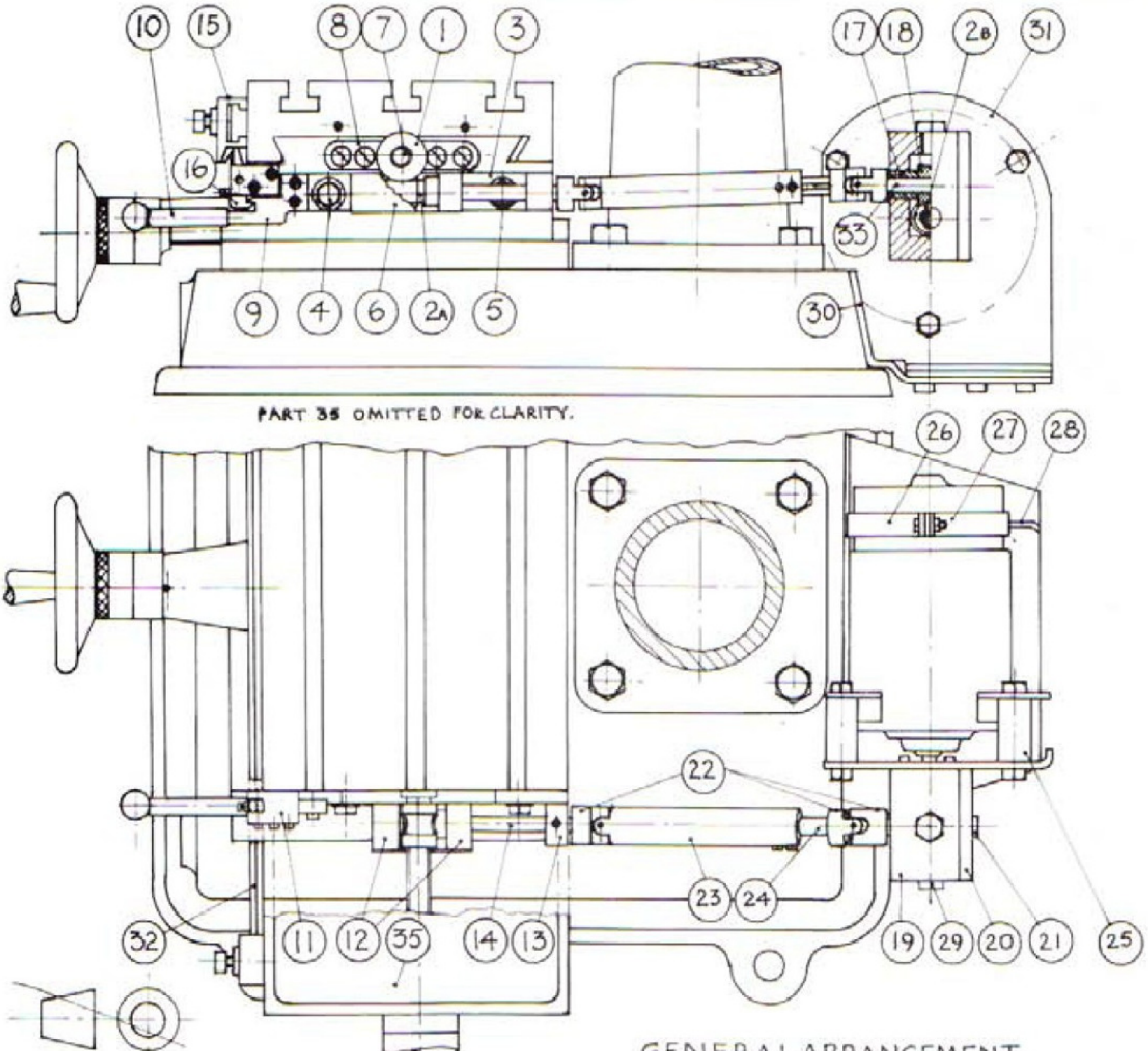


6

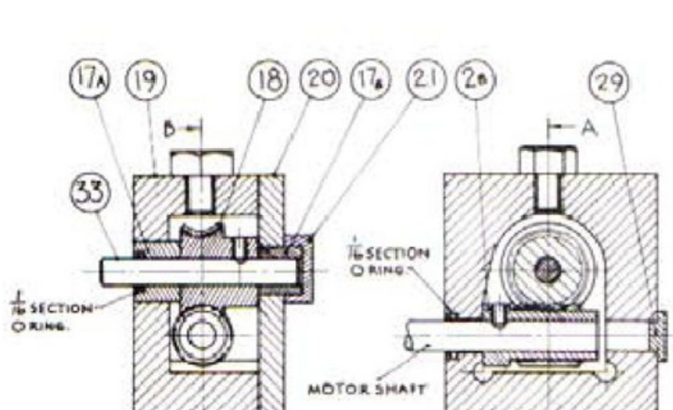
FIG. 6 WORMWHEEL CUTTER.

The cutter can then have teeth cut as for the hob, and a ⅜in. dia. hole bored. Clearance behind the teeth can also be filed now. Parting off, hardening and tempering to straw colour will complete this item. An arbor for it will also be needed. **Fig. 7**.

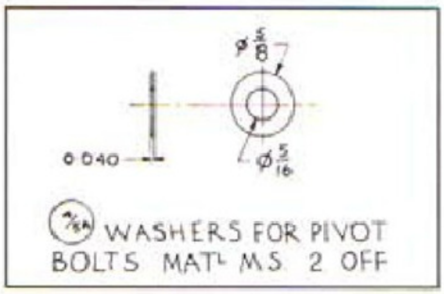
7

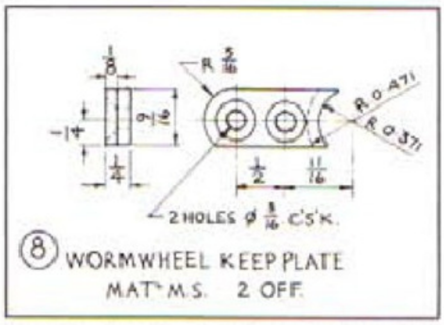


GENERAL ARRANGEMENT.



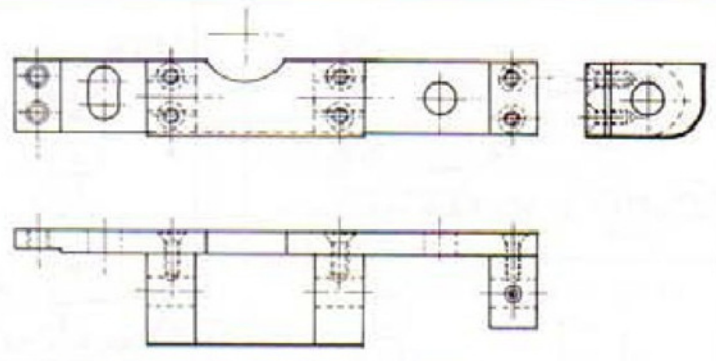
ASSEMBLY OF PARTS 2B, 17, 18, 19, 20, 21, & 29.



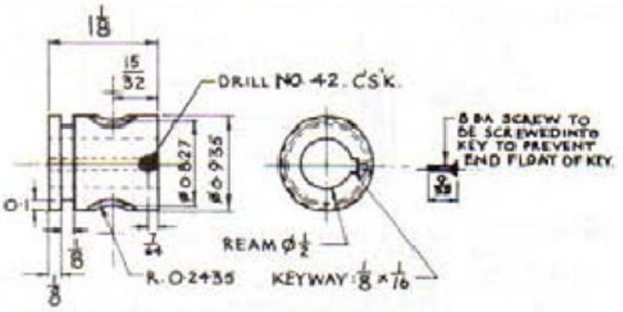


We are grateful to N.S. & A. Hemingway, 30 Links View, Half Acre, Rochdale, Lancs, tel. 0706 45404, for permission to include extracts from their drawings to illustrate this short series. Drawings, materials etc. to make this assembly are available only from this source.

Part	Description
1	Wormwheel
2	Worm
3	Worm backplate
4	Pivot bolt
5	Pivot bolt
6	Worm oil sump
7	Feedscrew
8	Wormwheel keep plate
9	Latch block
10	Latch block arm
11	Pawl block
12	Worm shaft bearing
13	Worm shaft bearing
14	Worm shaft
15	Auto stop
16	Pawl
17a	Bearing
17b	Bearing
18	Wormwheel
19	Gearcase
20	Gearcase cover
21	Sealing cap
22	Universal joints
23	Drive tube
24	Drive shaft
25	Spacer
26	Motor strap
27	Motor strap
28	Motor cradle
29	Sealing cap
30	Motor bracket
31	Motor / Gearbox location plate
32	Auto stop rail
33	Wormwheel shaft
34	Mechanical time delay switch box
35	Bearing bracket
36	Key $\frac{3}{16} \times \frac{1}{8} \times \frac{1}{8}$ MAT^L EN6. Not drawn

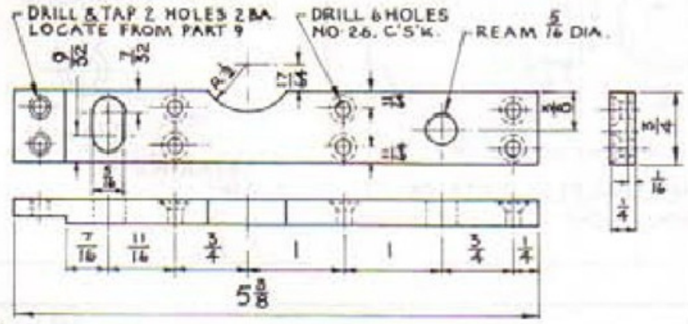


SUB-ASSEMBLY : PARTS 3,6,12 & 13

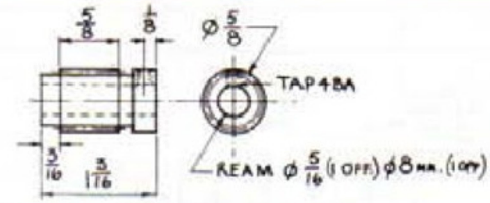


WORMWHEEL 24T D.P. 51·416 C.P. 0·1

① WORMWHEEL MAT^L P.B OR G.M. 1 OFF

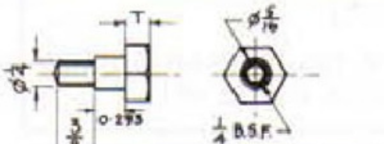


③ WORM BACKPLATE MAT^L BRASS OR M.S. 1 OFF.



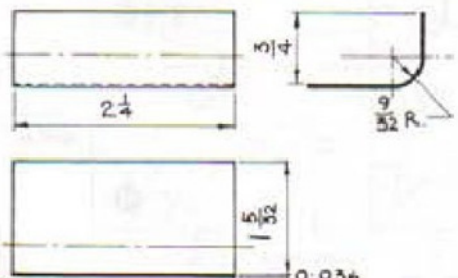
WORM: ACME FORM, 2 START. LEAD: 0·2 PITCH: 0·1 DEPTH OF TOOTH: 0·069

(2 & 18) WORM. MAT^L M.S. 2 OFF

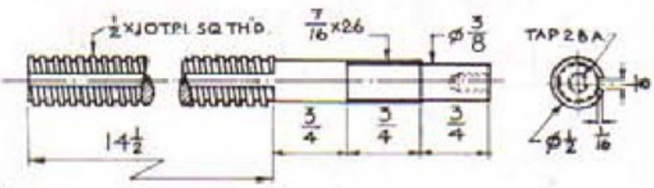


DIMENSION T	PART NO.
¼	4
⅜	5

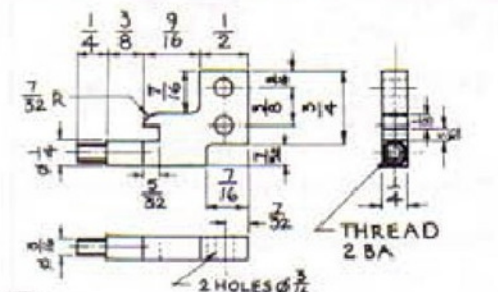
④⑤ PIVOT BOLTS MAT^L M.S. 1 OFF EACH



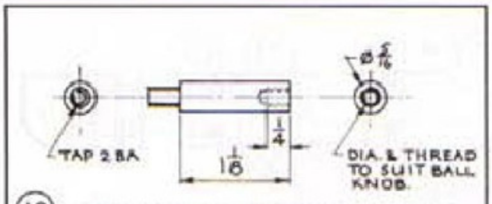
⑥ WORM OIL SUMP. MAT^L BRASS 1 OFF.



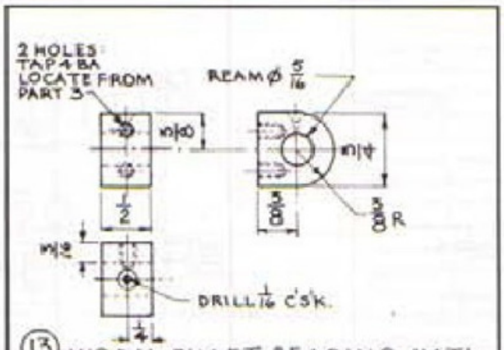
⑦ FEEDSCREW. MAT^L M.S. 1 OFF.



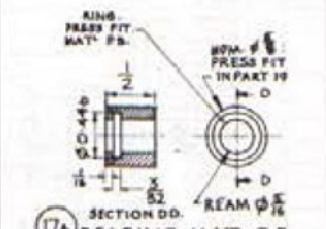
⑨ LATCH BLOCK. MAT^L EN9. 1 OFF.



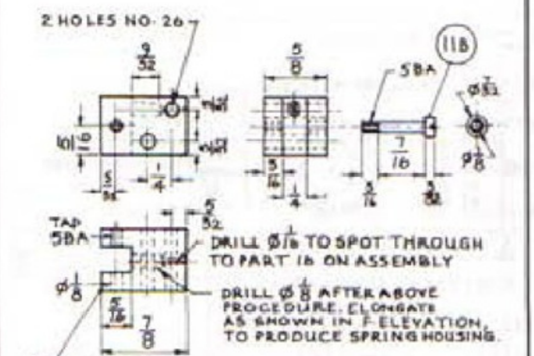
(10) LATCH BLOCK ARM. MAT^L M.S. 1 OFF



(13) WORM SHAFT BEARING MAT^L BRASS OR G.M. 1 OFF.

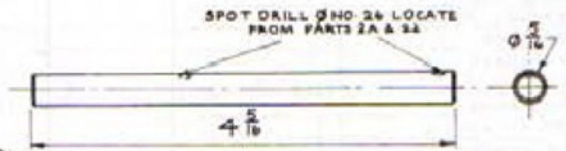


(17A) BEARING. MAT^L P.B. 1 OFF.

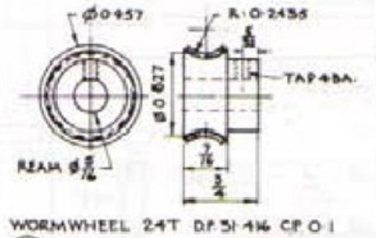


(11A) PAWL BLOCK MAT^L M.S. 1 OFF.

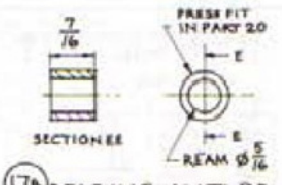
(11B) PIVOT PIN MAT^L SIL. ST. 1 OFF.



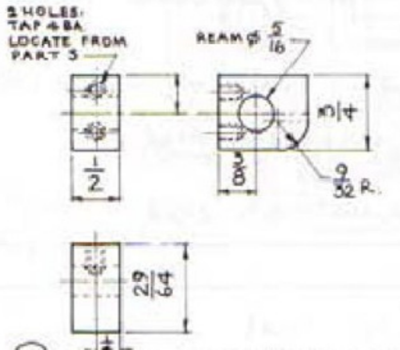
(14) WORM SHAFT. MAT^L SIL. ST. 1 OFF



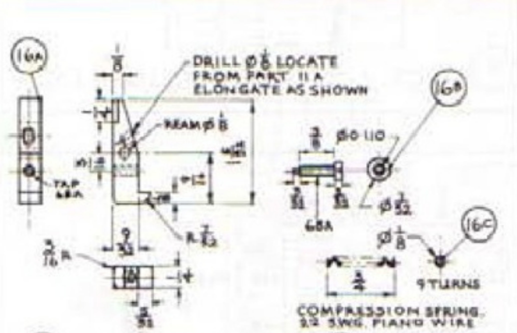
(18) WORMWHEEL MAT^L P.B. OR G.M. 1 OFF.



(17B) BEARING. MAT^L P.B. 1 OFF.

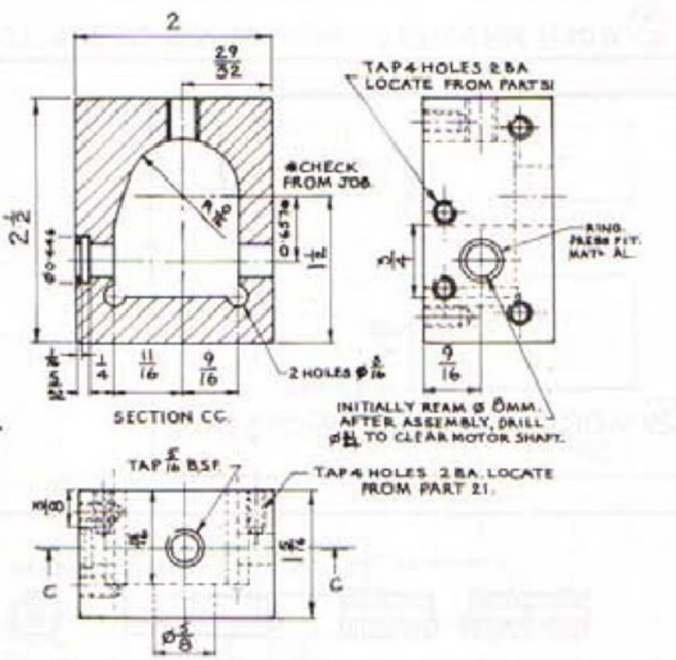


(12) WORM SHAFT BEARING. MAT^L BRASS OR G.M. 2 OFF.

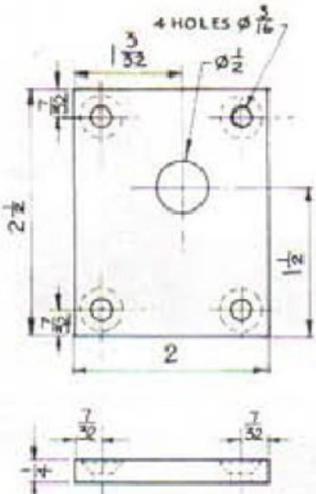


(16A) PAWL. MAT^L EN9 1 OFF (16C) SPRING 1 OFF

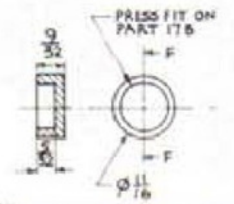
(16B) ADJUSTMENT SCREW MAT^L MS. 1 OFF.



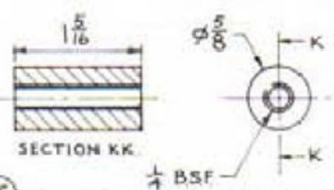
(19) GEARCASE MAT^L AL. 1 OFF



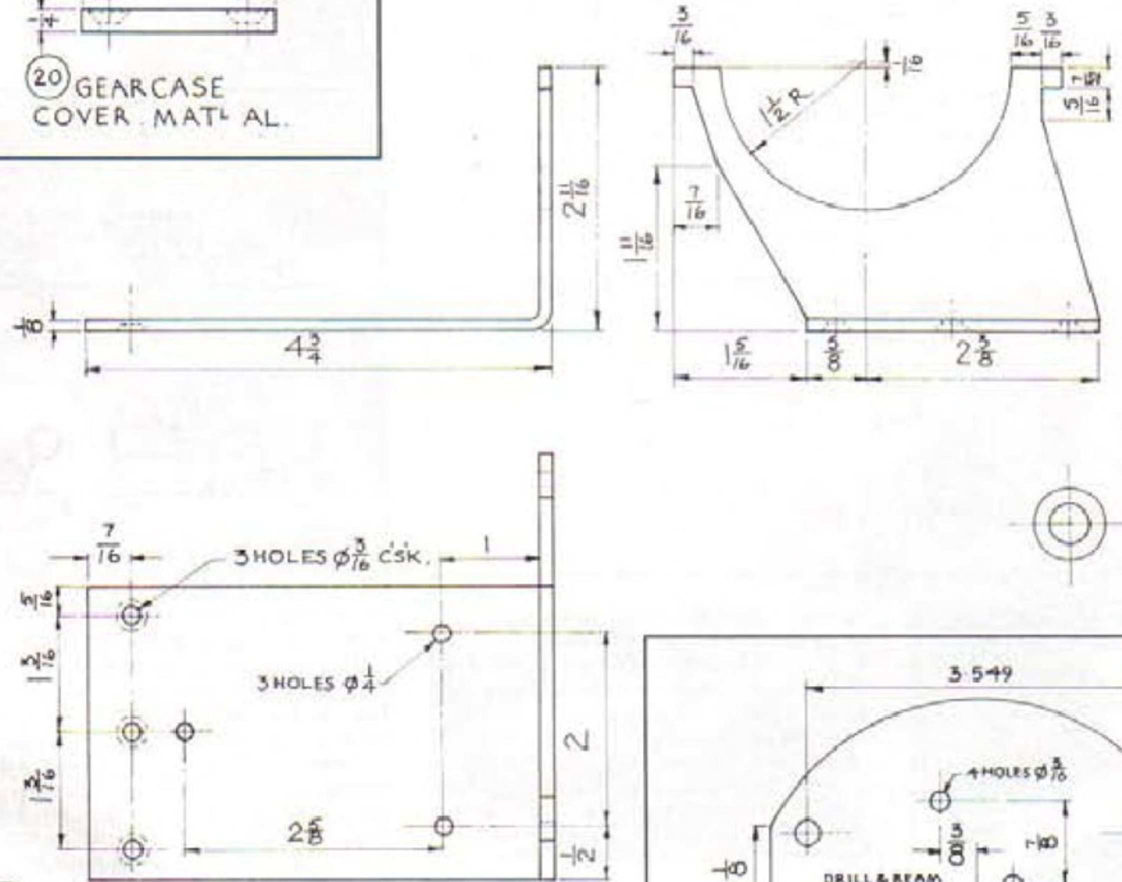
(20) GEARCASE COVER. MATL AL.



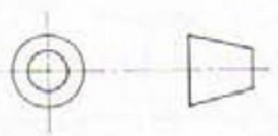
(21) SEALING CAP. MATL AL. 1 OFF.

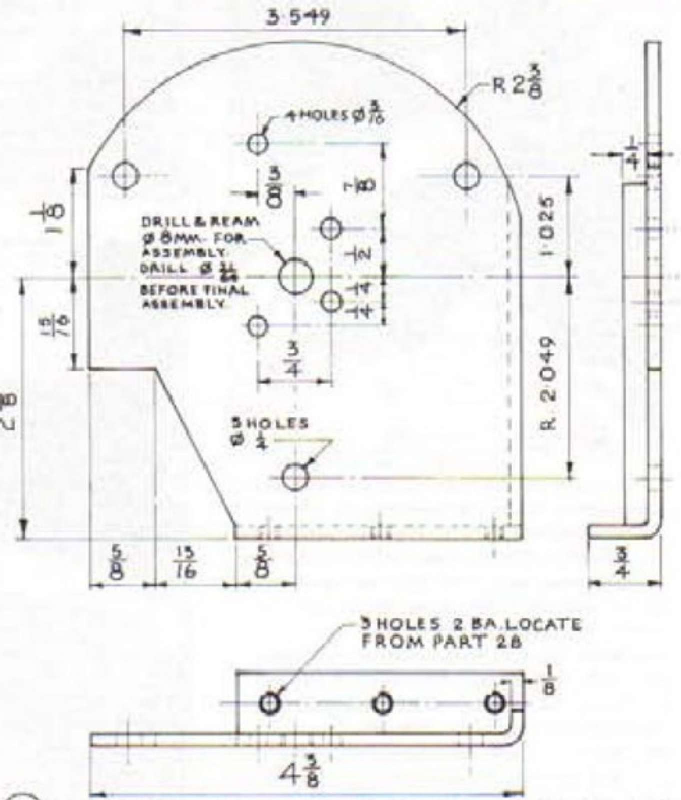


(25) SPACER. MATL M.S. 3 OFF.

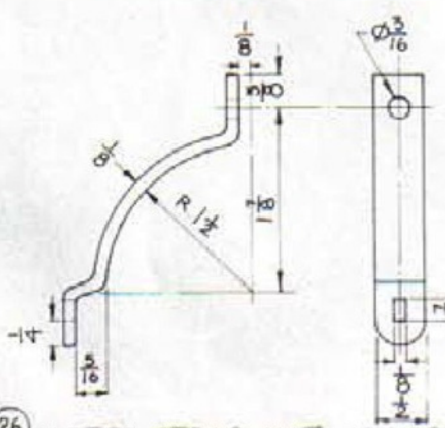


(28) MOTOR CRADLE. MATL AL. 1 OFF.

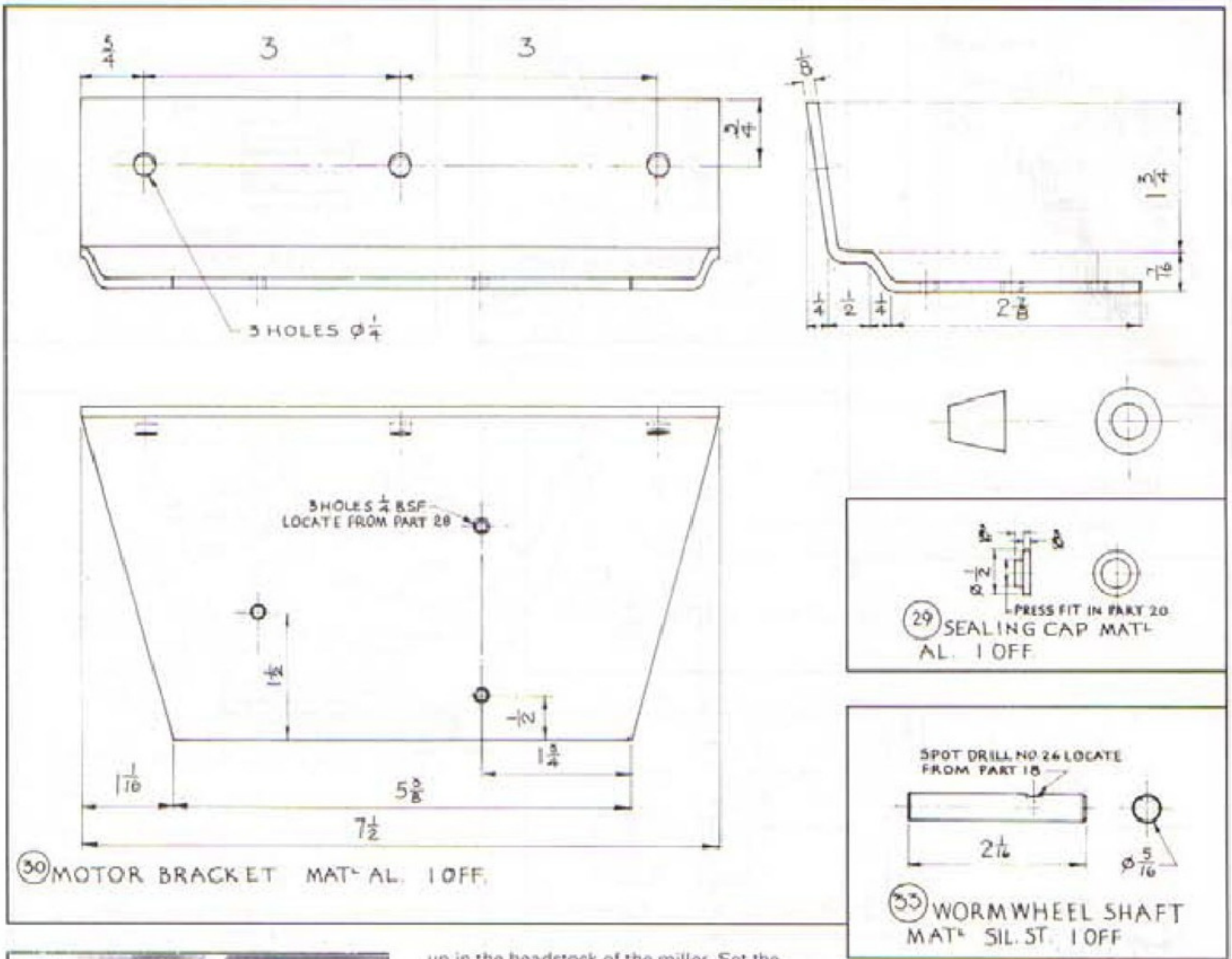




(31) MOTOR / GEARBOX LOCATION PLATE. MATL AL. 1 OFF.

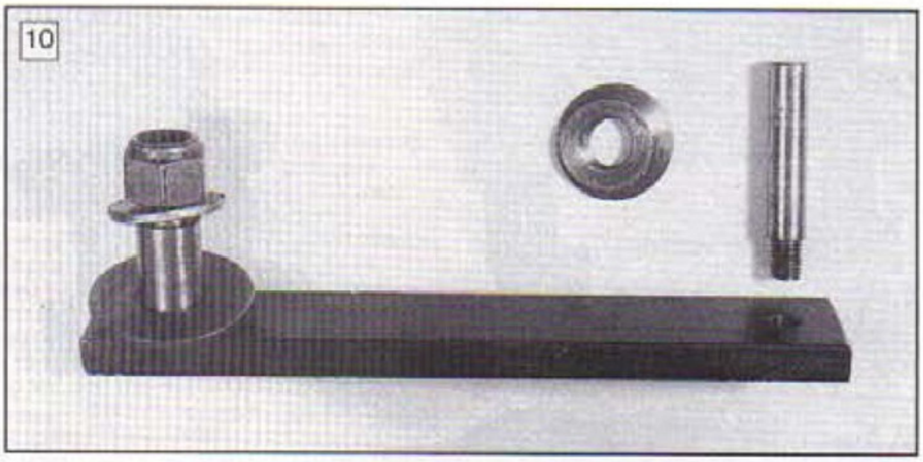


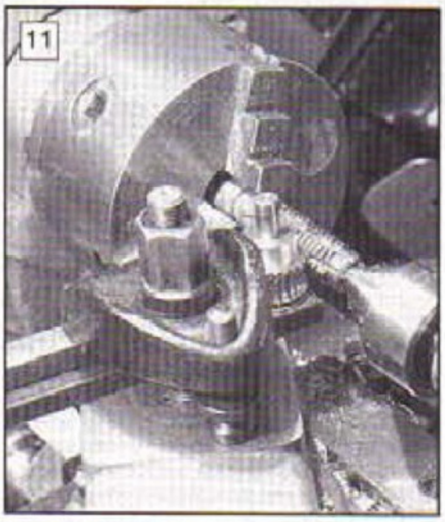
(26) MOTOR STRAP MATL AL. 1 OFF.



Having made the special tools, let's now use them to make the wormwheels. First the wormwheel to go in the gearbox (part No. 18). Phosphor bronze, or gunmetal can be used here, preferably the former. Grip a suitable length in the three jaw chuck, centre drill, drill and ream to $\frac{5}{16}$in. diameter. Rough turn the outer diameters and part off to length. Mount on an arbor, finish turn the diameters and machine the radius with a form tool (**Fig. 8**). Remove the chuck with the arbor and workpiece still in it, and fit it onto your dividing head on the milling machine. Now set the dividing head to divide 24 divisions. Fit the "gearcutter" to its arbor and then set this up in the headstock of the miller. Set the angle of the cutter to 7 deg. (the helix angle), by tilting the whole headstock, (**Fig. 9**). Set the centre of the cutter to the centre height of the dividing head, then carefully bring the workpiece to just touch and be central with, the revolving cutter. Set the index to the depth to be cut, 0.069in. Feed in the workpiece to zero on the cross slide index and the first tooth space will be cut. Withdraw, index round and cut the second toothspace. Repeat for the rest of the teeth.

To finally hob the wormwheel, a hobbing arbor is needed. This is shown in **Fig. 10**. The arbor is clamped on the toolpost, and the wormwheel set at a suitable centre height, using washers if necessary. The hob should have relief ground behind the cutting face, and the latter should also be sharpened by stoning. It can then be gripped in the three jaw





chuck and supported on a centre. At the lowest speed, the wormwheel blank is gently fed into the revolving cutter. As soon as the blank starts to rotate, it will follow the previously gashed teeth, and further in feeding can be carried out until the full depth of tooth is reached, (**Fig. 11**).

The other wormwheel (part 1) can now be tackled. Again grip a suitable length in the three jaw chuck, centre drill, drill and bore to 0.498 inch. Machine the outer diameters to drawing. A parting tool will deal with the keep-plate groove. Transfer the three jaw chuck (with its workpiece still in it), to the dividing head. The tooth spaces can now be cut, as for part 18.

Return the chuck and its workpiece back to the lathe and part off, allowing extra length for final facing.

Regrip the workpiece in the three jaw chuck in preparation for slotting the

keyway. Use a boring tool holder with a ⅛in. wide square ended cutter, (**Fig. 12**), set to centre height (i.e. 1/16in. above centre height and 1/16in. below). If you have a slotting attachment, this should be used. If not, lock the carriage, and (having checked that the top slide is parallel with the bed) use the top slide to traverse the cutter backwards and forwards to produce the keyway. If the tool is gradually fed in with the cross slide, then the key way can easily be cut to depth. Note that the headstock spindle should be locked for this operation. Regarding the depth of cut, it is beneficial to go deeper than the nominal 1/16in., say 0.070 inch. The bore can finally be reamed ½in. diameter.

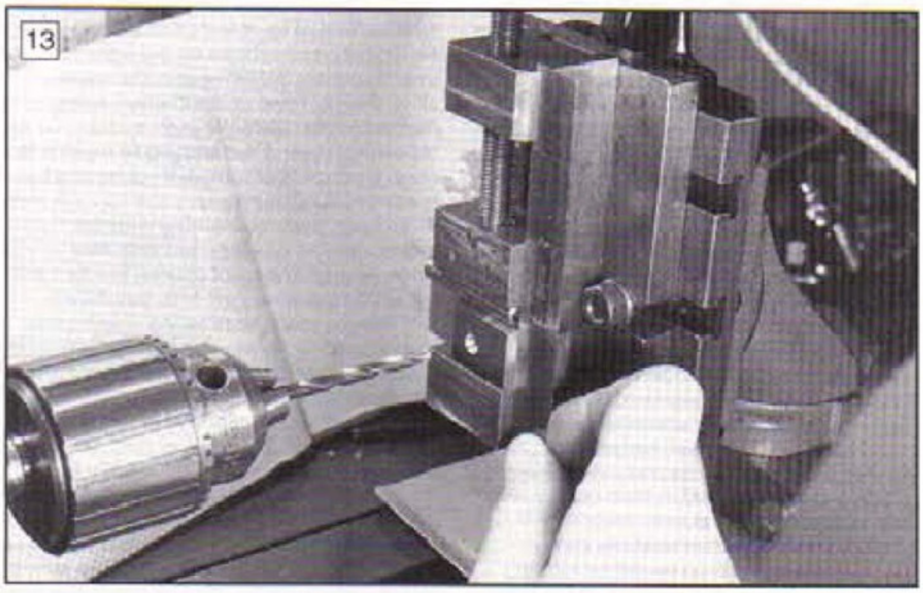
An 8BA clearance hole (No. 42), is cross drilled into the bore and countersunk. The position is shown on the drawing. This is to allow an 8BA countersunk screw to be fitted into a tapped hole in the key. This will prevent end float of the key.

Final hobbing is as previously described, except that the arbor spindle will need to be ½in. diameter. It should be found that these wormwheels will mesh sweetly with the worms.

To finish off the worms, these can be mounted in the four jaw chuck, with a layer of paper to protect the crest of the thread, and set to run true, using a D.T.I. on those plain ends, previously machined. The worm can then be centre drilled, and drilled in stages up to letter N, but only half way through, since a drill can wander off centre. The worm can then be turned round end-for-end set to run true again, drilling as before, and finally reamed 5/16in. diameter. This procedure should lead to a concentric bore. If there is the slightest hint that the bore is not concentric during the preliminary drilling operations, use a tiny boring tool to restore concentricity before reaming to size. The holes can be drilled and tapped for the grubscrews. Part 36, the key for the feedscrew wormwheel is 1⅛ x ⅛ x ⅛in. EN6, (not drawn). It is a simple part but it is worth taking care over. The fit against the *sides* is particularly important. I have specified key steel (EN6) but a piece of silver steel or gauge plate will do just as well. (So long as it's harder than mild steel, to reduce wear.) When fitting, into the wormwheel, spot through No. 42, drill and tap 8BA to receive the 8BA screw. When fitted to the feedscrew it should be possible to easily slide the wormwheel up and down, but without axial shake.

The worm assembly

The worm backplate (part 3) carrying the worm bearings (parts 12 and 13) can be made next. This is a fabricated component, and its base is a piece of ¾ x ¼in. section



brass or steel strip. To make subsequent alignment easy, this should be flat. If it isn't, it will need to be made so, probably most effectively, by gripping it in a machine vice on parallels, and taking light skim on the milling machine. Mark out, and drill (tapping size, No. 32) the six holes for the fixing screws.

The material from which the bearings can be made could be either gunmetal or brass, the former for preference. All faces should be squared up by facing in the four jaw chuck. The bolting faces should then be marked, because these will act as reference faces when boring the holes. It is essential to take some care over this, to ensure alignment.

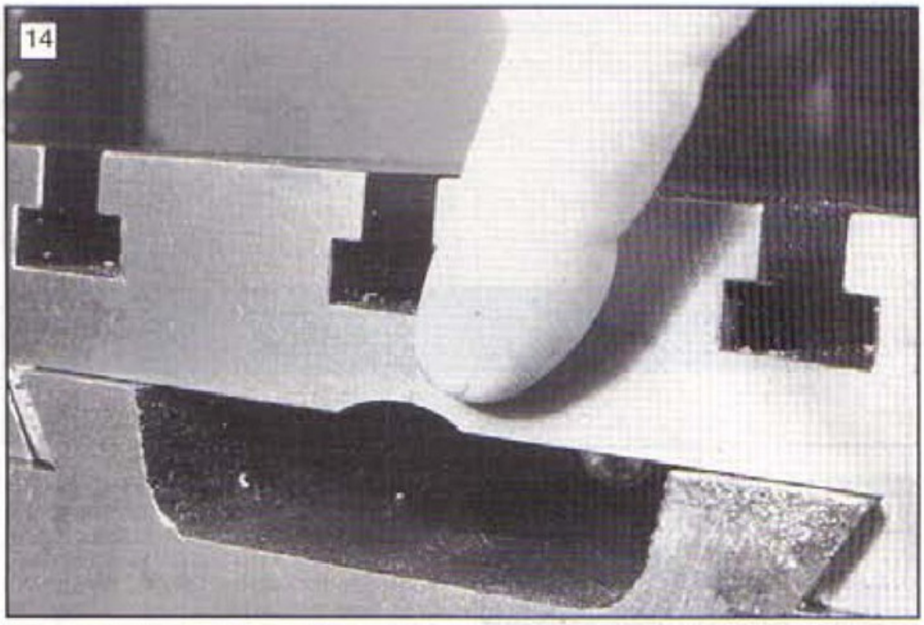
Set up the vertical slide so that its face is square to the bed. (Use the face plate mounted on the lathe spindle with a parallel between it and the slide face to ensure this.) Mount a small vice on the vertical slide and grip each bearing block with its reference face against the fixed jaw. A ruler against the sides of the vice and block will ensure alignment, (**Fig. 13**).

Adjust the position of the vertical and cross slides to achieve correct position of the hole. Centre drill, drill and ream 5/16in. diameter. Repeat for the other two blocks, taking care not to move the slides. Next, thread a piece of 5/16in. dia. silver steel through the holes in the blocks. Clamp the assembly to the arm, checking for correct positioning. (The silver steel rod should be free to rotate.) Drill tapping size through the holes in the arm into the blocks. Disassemble and tap the holes in the blocks 4BA. Drill clearance for 4BA in the arm and countersink. Reassemble with 4BA countersunk screws, and try the 5/16in. dia. silver steel rod again. If tight, some slackening and re-tightening with the rod in position may assist. If it doesn't, line ream through the 5/16in. holes. Finally soft solder the joints for additional security. The pivot and slotted holes can now be drilled – but at this stage, drill them No. 3 (tapping size for ¼in. BSF) on the arm, file the radius to clear the wormwheel. The oil hole in the right hand bearing block can be drilled now, together with filing the radii. There is no need for such holes on the other two, since the worm and adjoining bearings are to run in an oil bath. The "bath" (part 6), is provided by soft soldering on a piece of suitably bent brass sheet. If this is made slightly oversize, the protruding edges can be filed flush with the surrounding surfaces.

To enable some fitting to be carried out, disassemble the bearing bracket, etc., from the milling machine and fit the wormwheel on the new feedscrew. Assemble the worm and its shaft into the arm, but don't tighten the grubscrews so that the shaft can slide along, as required. Offer up the assembly, centre the worm and mesh it with the wormwheel. This will give the engaged position. If a carpenters sash cramp is available, this can be used to clamp the arm to spot through with a tapping size drill, using a hand held pistol drill. If a sash cramp is not available, open up the right hand (pivot) hole in the arm to ¼in. diameter. Make a special centre punch from ¼in. dia. silver steel, harden and temper. Offer up the assembly as before; position and centre punch through the ¼in. hole with the special punch. (You may need help with this method), the centre punched mark can then be drilled tapping size for ¼in. BSF – either with the pistol drill with help to ensure squareness), or by removing the cross slide, and drilling on a drilling machine. A ¼in. BSF screw can then be temporarily fitted on reassembly to spot through the left hand hole, ensuring correct mesh, of course. The left hand hole can then be drilled and tapped as before. The pivot bolts (parts 4 and 5), can then be made and the right hand hole in the bracket opened up to 5/16in. diameter. The left hand hole can also be opened up to the same size and slotted to allow disengagement of worm.

Part 9. Latch block can be made next. This needs little comment except to suggest that the 3/32in. wide slot is best cut with a slitting saw. Because of the rubbing action when engaging the pawl EN9 (a medium carbon steel) is specified. This is harder than mild steel, to resist wear. I used Allen screws to fit the latch block to the arm, after first milling the bolting face. To machine the spigoted portion, a four jaw chuck is used to grip the workpiece.

Part 10. Latch block arm, is a simple turning exercise. The knob can be from



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metal or plastic, according to what you have "in stock".

It occurs to me that you will want your milling machine back in action, and you will find that the underside of the table needs a small radius removing to clear the wormwheel, (**Fig. 14**). I used a boring bar set up between centres on the lathe for this, clamping the table onto the cross-slide. Three "bites of the cherry" were needed to complete the radius, repositioning and reclamping to be able to cover the whole length. A stout boring bar is essential, of course.

You can then reassemble with the wormwheel in position, but with less traverse than before of course, but this will be overcome later. Part 11A, pawlblock, can now be made to drawing. It is a good plan to drill for tapping before slotting, because if drilling across a slot, then drill has no centre to guide it and could wander off centre and ruin alignment. The spring recess hole should be left at 3/16in. dia. initially, to enable this to be used to spot the hole in the pawl (part 16A) when this is made and fitted.

Part 16A, Pawl, can be next and again needs little comment except that the spring recess hole is spotted through 3/16in. dia. on assembly with the pawlblock. The angled face should be pressed against the pawlblock face for this. Disassemble to open up both spring recess holes, the pawl hole being square to the angled face. Elongate, vertically, both holes, with a round needle file.

Part 11b, (pivot pin) is a simple turning exercise, and note that the material is silver steel to reduce wear. Part 16c, spring. This is quite a strong spring, and is necessary to keep the worm in mesh, particularly when the worm is turning anti-clockwise. I was fortunate in having such a spring in stock. However, this *can* be wound from piano wire. The method is shown in **Fig. 15**. If a piece of 20 swg piano wire is gently gripped in the vice, its end can be bent at right angles and fitted between a jaw in the hand drill. The arbor in the chuck is a piece of 3/16in. dia. silver steel (for stiffness). Winding the handle will produce the spring. Some unwinding will occur when you let go of the handle, and it may well be that a smaller dia. arbor is needed. If the right angled end comes out of the chuck, slacken the vice slightly and try again. When the spring is formed, (and you don't need much), pull it out to make a compression spring.

Part 16B, Adjustment Screw. The making is simple, but its use needs explaining. If

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not fitted, lifting the arm into mesh becomes difficult, if not impossible, since the spring pushes the pawl too far towards the pawlblock. A standard 6BA nut is needed to lock the assembly once the correct working position is found. Locating the pawlblock into position needs care since there is no provision for adjustment. (However, this could be provided by slotting the fixing holes in the pawl block.) If a sash cramp is available, this can be used whilst spotting through one of the holes. (With the worm in mesh – just a tiny clearance between worm and wormwheel is needed.) This can then be drilled and tapped, and one screw fitted. Spotting through, drilling and tapping the other hole completes this assembly.

I fitted hex. head screws here, but Allen caphead screws would give more room and are recommended. Don't forget that when testing the assembly, the worm teeth and wormwheel spaces need to be aligned to allow their meshing!

Part 14, (Shaft). This is simply a piece of 5/16in. dia. silver steel, and needs little comment except that once all grubscrew positions are established, small "dimples" should be drilled to positively locate them. Hardening is not necessary or desirable, since if it distorts, it cannot then rotate freely.

Part 8, wormwheel keep plate. A piece of 5/16in. x 1/8in. mild steel strip will be needed for this, and is made initially from one piece. The position of the central hole is marked, and the workpiece is clamped to the faceplate. The central hole can then be drilled and bored to size together with the recess. It is important of course, to aim for a close fit in the groove already machined in the wormwheel, and some careful measuring will be needed. Use of the top slide index can be made for this. If the saddle is locked, the boring tool can be advanced by the top slide traverse until it just touches the face of the work, and the reading noted (or adjusted to zero). Simple calculations can then be made to indicate depth of cut needed. Some clearance will be necessary however, so allow an extra 0.003in. for this. The diameter is not so critical since it merely needs to clear the O/D of the wormwheel.

When this machining is completed, you will have two pieces. These can be drilled and shaped to drawing to complete. Finally, when fitting it is essential, of course, to locate each half from the wormwheel. A sash cramp is again most useful to clamp the components for spotting through the holes, to drill and tap. If not available, recourse to a specially made centre punch, as already mentioned, will be needed. Fitting countersunk screws will complete the modifications to the miller feedscrew assembly.

The motor and gearbox

It may be as well at this stage to deal with the motor and its gearbox, as this then determines the length of the drive shaft assembly. For the motor I eventually chose a motor car cooling fan. My reasons for this, and details of the controller for same, are detailed in my separate article on the subject *(in this issue. Ed.)*.

The method of mounting to the gearbox can be seen on the drawing, together with the method of mounting the motor on the milling machine.

First to make the gearbox (part 19). The design is simple, but to get all aligned and correctly meshing is anything but simple, so rather crafty means have to be employed. A block of aluminium or a casting is needed here, and if necessary its faces can be machined to size, flat and square to each other in the four jaw chuck. Mark out the centres for the main shafts, and set up in the four jaw chuck to bore the 8mm dia. hole. (8mm because the motor shaft is this size.) Machine the recess for an 'O' ring by boring to a dia. of 0.446in. and to a depth of 3/32 inch. A very small boring tool is needed (or a D bit could be made). A ring is then made by drilling and reaming to 8mm, a stub of aluminium (or bronze) and machining the O/D to a light press fit in the 0.446in. bore. Part off to 3/16in. long, and press into the 0.466in. bore.

A piece of 8mm silver steel should be obtained to (a) make an 8mm reamer and (b) act as a temporary shaft.

The reamer is made by filing a "flat" at an angle of about 15 deg., and hardening and tempering. (**See Fig. 16**). Sharpen the reamer by rubbing the flat on an oilstone. This can then be used to bring the hole to 8mm dia. (All this assumes that you haven't got an 8mm reamer, of course!) The block is then repositioned in the four jaw chuck to bore (*a*) a recess for the wormwheel and (*b*) a through bore of 5/8in. dia. to later receive a bronze bush. The recess is simply made large enough to clear the wormwheel, say 1 3/16in. diameter (**Fig. 17**).


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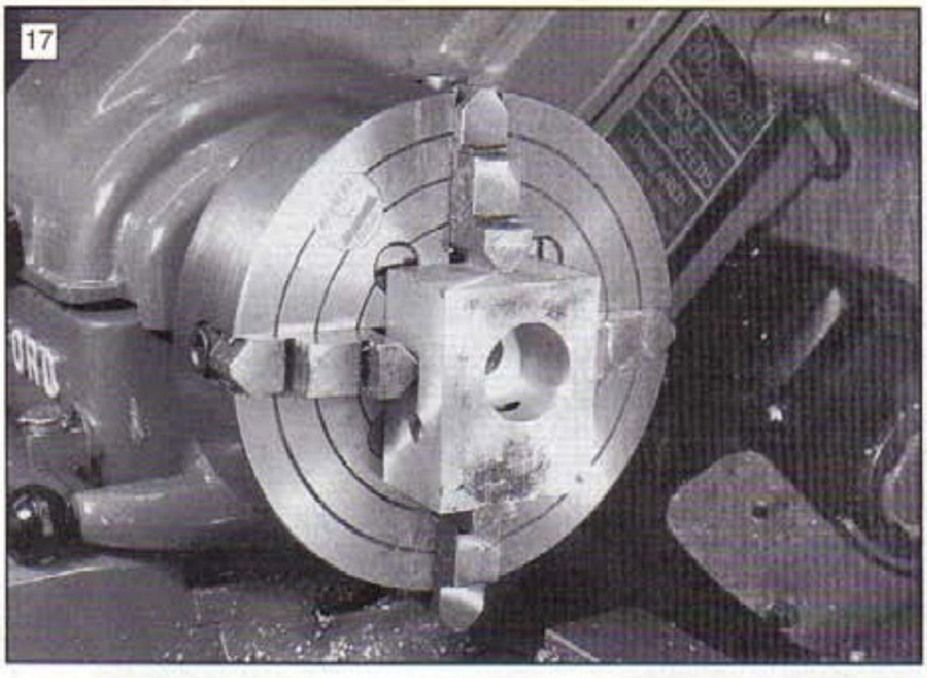
The block can now be removed from the lathe and set up on the milling machine to machine a recess for the worm. Again this is not critical, and should be made large enough to clear the worm, all round. (**Fig. 18**). A stub of bronze (part 17A) can now be machined to a press fit in the 5/8in. dia. hole. Note: don't bore the 5/16in. dia. hole yet, but simply press the stub in. A smear of Loctite would be helpful, of course, if you have it.

The cover (part 20) can be conveniently made and fitted now.

This is a piece of 1/4in. thick aluminium plate which is cut slightly oversize, drilled, countersunk and screwed into position. The four jaw chuck can then be used to machine the oversize portions level with the block. When this has been carried out, remove the cover, and put to one side.

Now we can prepare for boring the central hole for the wormwheel shaft, and ensuring that the correct mesh between worm and wormwheel is achieved. To do this, remount the block in the four jaw chuck, so that the bronze stub is central, and recess is outward facing.

Fit a piece of 5/16in. dia. silver steel rod into the tailstock, and on this mount the wormwheel. If the tailstock is now moved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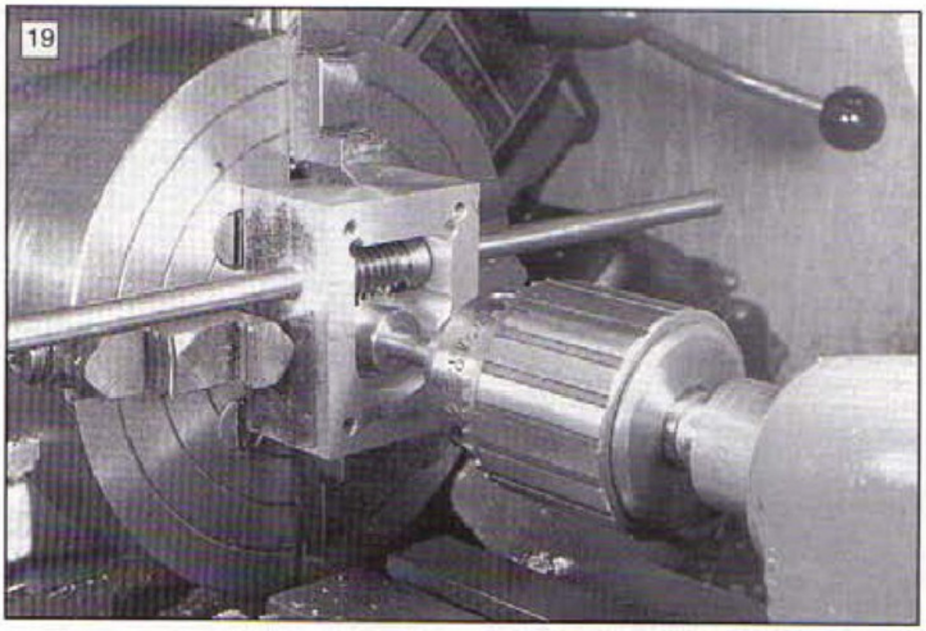
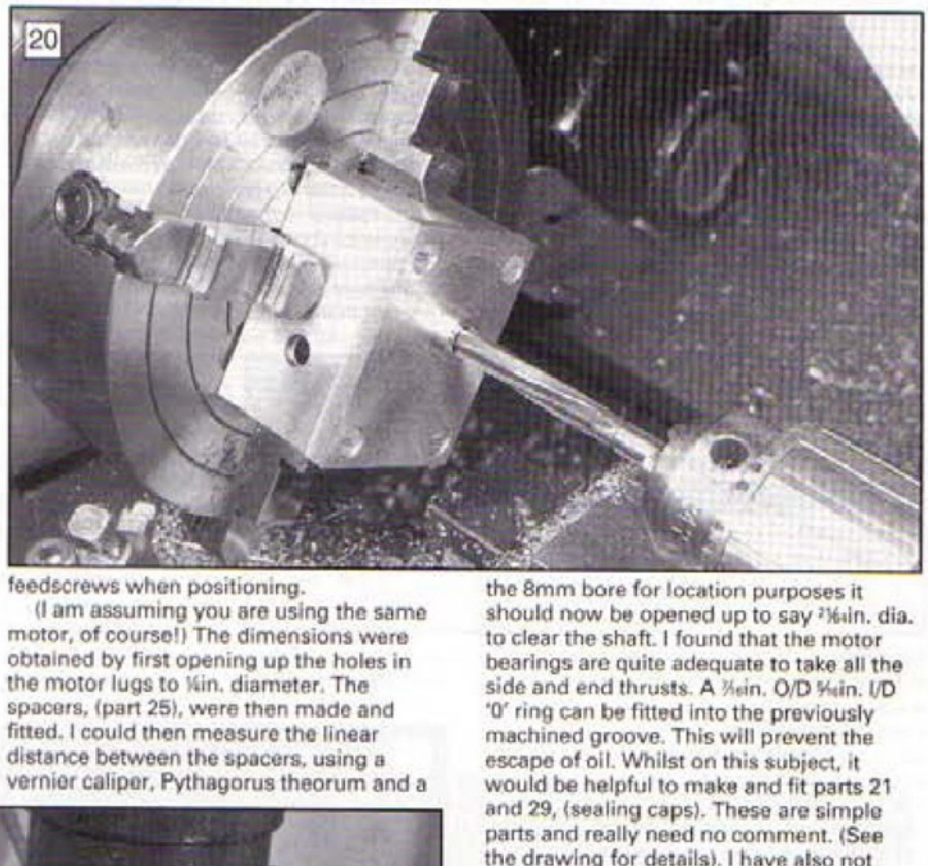


so that the wormwheel is in the recess, the worm and its shaft can be trial fitted, and if necessary the chuck jaws adjusted for correct mesh, (**Fig. 19**). Turning the worm should easily turn the wormwheel without binding or too much looseness. When this has been achieved, the pressed in bronze stub can be drilled and reamed, 5/16in. diameter. Whilst the block is still in the four jaw chuck, the cover can be fitted and bored ½in. dia. for a bronze stub (part 17B) to be pressed in. To make the stub, the four jaw chuck can be removed (still with the gearcase in place) to allow fitting the three jaw chuck. When made the stub can be pressed into the cover (preferably using Loctite). With the four jaw chuck refitted on the lathe, and the cover replaced the bronze stub can be drilled and reamed 5/16in. dia. (**Fig. 20**). The reamer can also be taken right through into the other bore. This will ensure true alignment. It only remains to drill and tap a hole for an oil filler plug, and the gearbox is almost complete.

The motor/gearbox location plate (part 31) is next. This is cut from ¼in. aluminium plate, 5¾ x 4⅝ inch. It is essential to keep this flat. After preliminary marking out is completed, to accurately locate the 8mm and ¼in. holes, it is essential to use the miller indices, as shown in **Fig. 21**. It is also essential to allow for backlash in the



feedscrews when positioning.

(I am assuming you are using the same motor, of course!) The dimensions were obtained by first opening up the holes in the motor lugs to ¼in. diameter. The spacers, (part 25), were then made and fitted. I could then measure the linear distance between the spacers, using a vernier caliper. Pythagorus theorum and a bit of trigonometry then gave the other dimensions. The gearbox holes are marked out and drilled normally. Returning to the spacers, it is essential that these are all exactly the same length. To ensure this, measure, (with a micrometer), all spacers after initial machining. Pick out the shortest, and machine the others to match. By locking the saddle and moving the tool with the top slide, the top slide index can give precise depth of cut, but do check again after machining! The motor can now be bolted to the adaptor plate, and the gearbox worm bore slipped over the motor shaft. This will locate all parts in correct alignment. The gearbox can now be clamped to the location plate and the motor removed. This will allow the 3/16in. dia. holes to be spotted through onto the gearbox. These can then be drilled and tapped 2 BA.

It is tempting to think that the 8mm reamed bore in the gearbox will line up exactly with the motor shaft. When I tried it, there was some binding; so having used the 8mm bore for location purposes it should now be opened up to say 21/64in. dia. to clear the shaft. I found that the motor bearings are quite adequate to take all the side and end thrusts. A 3/8in. O/D 5/16in. I/D '0' ring can be fitted into the previously machined groove. This will prevent the escape of oil. Whilst on this subject, it would be helpful to make and fit parts 21 and 29, (sealing caps). These are simple parts and really need no comment. (See the drawing for details). I have also not mentioned the '0' ring groove for the wormwheel. This is made in exactly the same way as the one for the worm shaft. However, the gearbox will need to be remounted in the four jaw chuck, so that the original bore runs true. If a piece of 5/16in. dia. silver steel is fitted into the bore, the protruding end can be used to check concentricity, using a D.T.I.

The motor mounts and brackets can be made next. I have specified 1/16in. aluminium sheet here because it is easy to cut out and bend to shape. The developed sizes are: part 26: 3¾ x ½in., part 27: 4½ x ½in., part 28: 6⅛ x 4 11/16in., part 30 7½ x 5⅜ inch. Between parts 28 and 30 on my version, I put in two thicknesses of 1/16in. rubber – taken from an old car inner tube. The idea was to avoid any vibration. It seems to work! (*Continued in part two, next issue.*)