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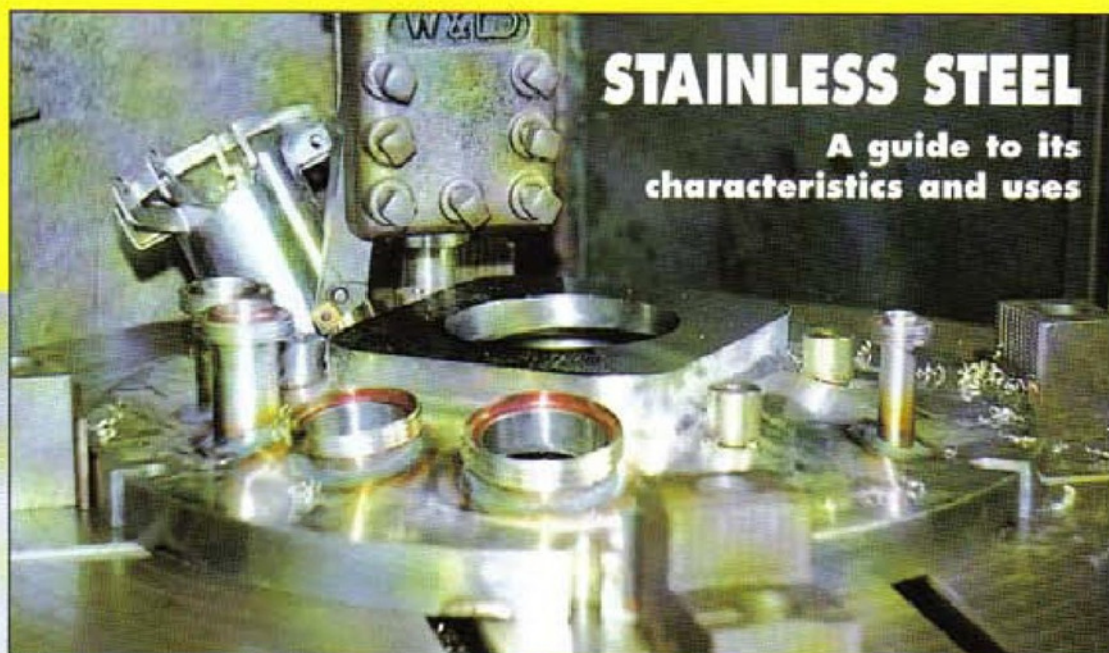
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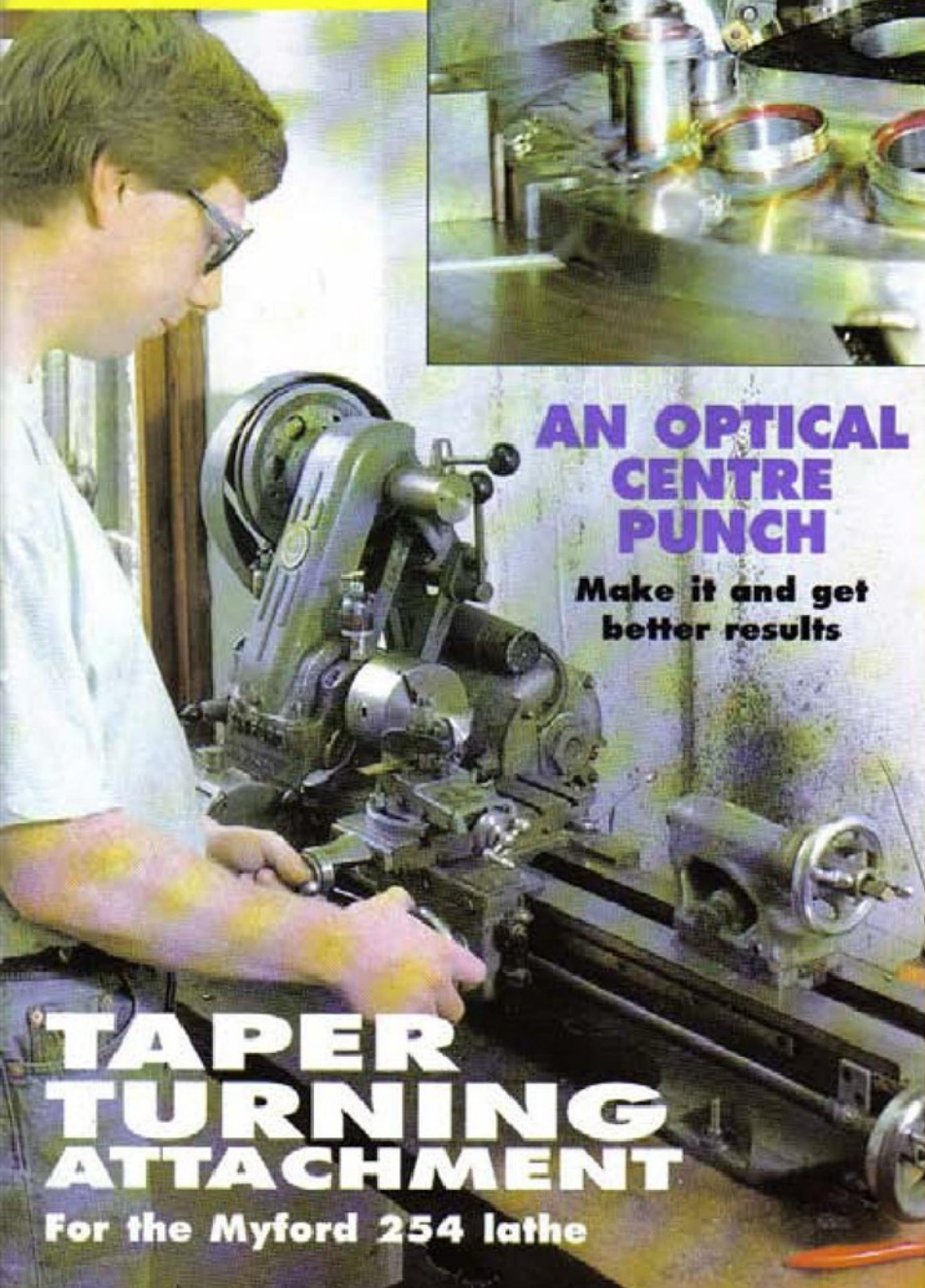
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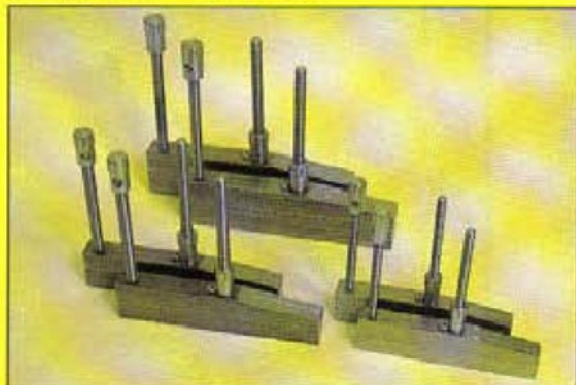
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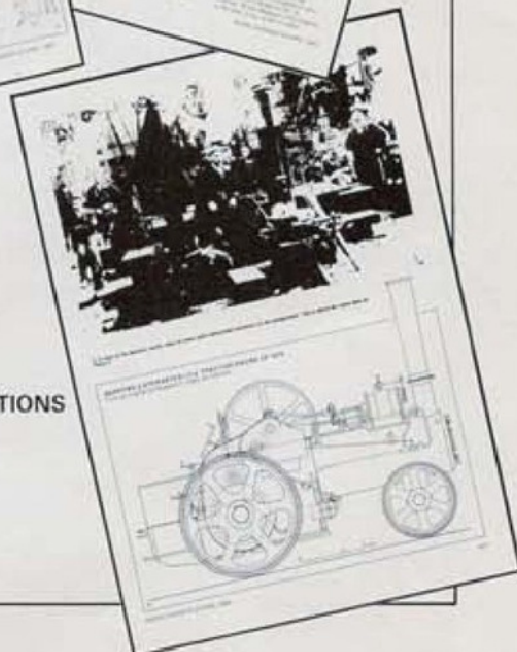
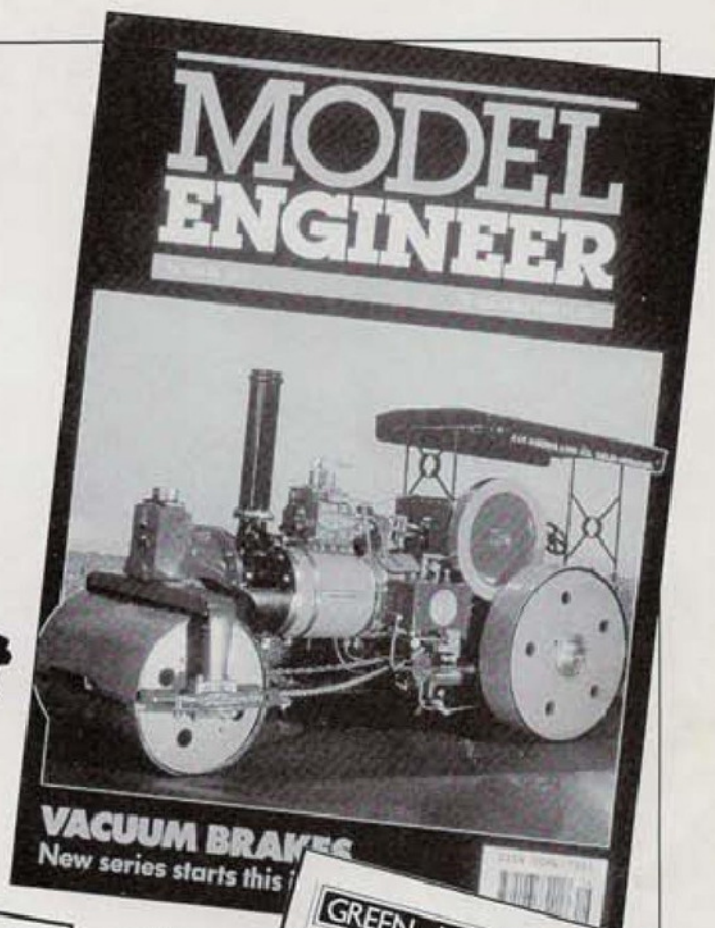


TAPER TURNING ATTACHMENT

For the Myford 254 lathe



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

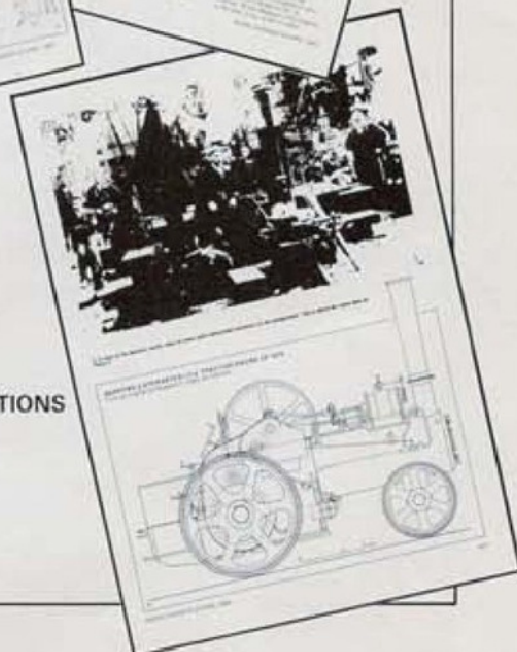
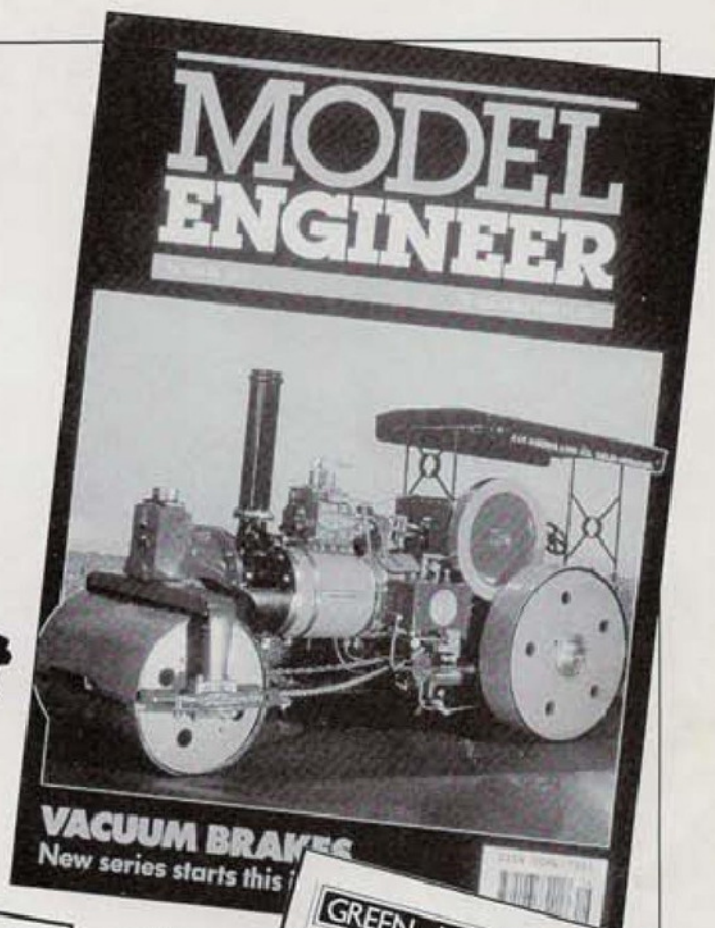


There's something to anticipate twice every month in fascinating Model Engineer magazine! Whether your interests lie in live steam locomotive models, traction engines, internal combustion motors or stationary engines, world famous M.E. will inspire, instruct, advise and encourage. Model Engineer is published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

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Harold Hall

ON THE EDITOR'S BENCH

Early machine data

I would like to repeat my request for help in establishing a library of useful data relating to older machines. It is possible that some readers with manuals, or other useful data, may have, at the time of my earlier request, intended to offer copies but did not get round to it. The library, whilst having some useful information, still has some gaps to fill, so any offers will still be gratefully received. However, if you are offering copies of manuals with many sheets, write first, in case I already have the information.

Machine manuals and sales brochures are the main items being sought, but details of sources of spares, accessories etc. are equally beneficial. Costs of obtaining photocopies and postage can be met.

Frequently requests for help are received for which data is required which is not always quoted in the manual, even if I do have a copy. Typically, readers ask for sources of gears to replace missing change wheels. If I do not know the details of the gears, DP, width, bore etc. then it is difficult to help fully. In an endeavour to establish such data a questionnaire has been established. This asks for such details as, centre height, centre distance, number of speeds etc., etc. If you feel you would like to help, please send in an addressed envelope, not stamped, but marked in the corner Mc data. No need to include a letter. Do not be put off by the fact that, you may not know all the details requested, partial details are better than no details at all, or by considering that many others will offer. Replies from many readers will also be helpful in giving an indication of the extent of ownership of any particular model. In any case, it may also be possible to develop it in to a simple owners correspondence circle for the exchange of ideas, spares etc. I have an idea for a very simple to operate system for this and will enclose details in with the questionnaire rather than take up space in this editorial to explain it in detail.

Model Engineer and Modelling Exhibition

A reminder that it is now time to start making plans for exhibiting at the Model Engineer and Modelling Exhibition to be held at the start of 1995. Do remember that in addition to the competition exhibits, there is a Loan Section for those who wish to exhibit but not competitively. With the emphasis of this magazine on workshop equipment, may I urge you to exhibit some such items you have made which fall into

this category. From correspondence received, I know a number of readers did respond to my request last year, let's see if we, myself included, can do better this time.

Arrangements for collection will be largely as last time. However, of benefit to the exhibitor is the abolition of the entry fee which has been charged in the past.

Inflation plus

In these days of belt tightening it is nice to report that the fee paid for the majority of construction articles, other than the simple, or those that require additional editorial involvement, has been increased appreciably above the level of inflation. Constructional items are those with an end product. As I am always saying, when you start a new project do it with a view to an article being created from it when complete. This means taking photographs as the work proceeds. Preferably also, produce your drawing at the start so that these can be used and proven. The need for medium to large size constructional articles is the biggest problem in filling the magazine, so please help if you can.

Toolmakers clamps

A letter published in Model Engineer recently expressed concern on the number of times milling operations were being illustrated using toolmakers clamps to secure the work, both in M.E. and M.E.W. While the correspondent had some very valid points regarding the dangers of such usage, I feel that with the proper care they are totally acceptable. In view of this I felt that a brief article on their use in this way was a very worthwhile item to publish. This can be found elsewhere in this issue.

Data Book

With one exception, the data book has been well received by readers of M.E.W. However, I have to say I am disappointed that from a presentation point of view it has got off to a less than perfect start. This is now being addressed and every effort is being made to improve the situation. To eliminate one area where the published sheet is at fault, page H3/H4 is being reprinted in this issue. Please destroy the existing page, I would stress that the errors in question are of page layout and not one of errors in the data.

Can I remind readers that a ring binder is available for the data book and as the book will grow into a sizeable reference, the price of £4.00 is well worth spending. Now is the time to send in your order, rather

than when the sheets start to get tatty by being stored in some temporary manner.

Tailstock turret

A number of readers have been misled by the article on the three way tailstock turret published in issue 22 and sent to A. J. Reeves and Co. for castings to make the item. Reference to the drawings will show that it is made from stock bright mild steel.

However, for additional information, reference was made to two six way turrets for which designs are available and Reeves's were mentioned at the end of the article as the supplier of castings for one of these, this appears to have caused the confusion. There was an error in the article, in that the numbers quoted on the two extracts from the plans have been interposed, that is the number on page 33 should be WE6 and that on page 34 should be MM127.

T.I.R. error

An attempt to convert dimensions in an article from Imperial to metric has led to an error being made. The T.I.R. (total indicator reading) at the end of the article on page 30 should read 0.01mm and not 0.01in. Similarly on page 65, T.I.R. should be 0.015mm and not 0.015in. My apologies to the author and you, the readers, for the error.

End of term

If you have left the reading of this part of the magazine till last, and why not, you will have seen the advertisement for a new editor of M.E.W. With so much encouragement having been given to me, both face to face and by letter, I feel that some explanation is called for. First perhaps it is appropriate to say what has not caused me to give up this position. It is not because of arriving at retiring age, or having found an alternative position. I do not, to my knowledge, have any health problem and have no serious differences with the publishers. Neither have my family asked for me back, however I do feel they would like the dining room back. I am finding the job unacceptably arduous, to a small extent the responsibility, but much more so, a question of the time taken by the task.

In the case of the time taken, I am without doubt my own worst enemy, attempting activities which perhaps should have been left alone, typically the digital readout, the CAD articles, (no quick job attempting to learn a number of programs), and more recently writing a computer program for an M.E.W. index. Such is in my nature and it is probably rather late to change my ways. I did consider the possibility of benefiting by the help of an assistant but have not pursued this for a number of reasons. However, it has been a super job and one I would not have missed, and can thoroughly recommend it to anyone who likes the idea of a challenge. I will say a little more in my final editorial.

I have given more notice than is required of me as I feel the new editor will benefit by more time in hand prior to taking over fully. I am therefore continuing until the end of the year, which means issue 28 will be my last.



TAPER TURNING ATTACHMENT FOR THE MYFORD 254 LATHE

Mr B.J. Curson provides owners of the Myford 254 lathe with a design for a taper turning attachment, no doubt it can be adapted for other machines.

Introduction

Separate articles in previous issues of *M.E.W.* have described taper turning attachments for mini lathes and the popular 3 1/2 in. centre height sizes.

Here is a version for the next step up in size, in my case a Myford long-bed 254S. The various methods for obtaining a taper on the lathe and their relative merits were outlined in one of the articles mentioned so I will not repeat them again here. Suffice it to say that the attraction of an attachment for me is the facility to use power feed without the drawbacks of the off-set tailstock method - improperly seating centres and the need to reset the tailstock central after offsetting it for taper turning.

My attachment is the result of a very lengthy gestation and draws together a number of loosely connected strands. The initial outline was conceived when I too had a 3 1/2 in. lathe - a Super 7 - and even then it was actually for copy turning, not tapers. A rudimentary set-up was made for that lathe, the job in hand completed, then the project shelved pending time to develop it. The lathe was changed in the meantime, however, and though the bits were reshaped to carry out another copying job on the 254, it really meant starting again.

The spur to finalise the design and complete the attachment came when I had the task of machining some brake drums for a vintage motor cycle. These were dish to follow the wheel spoke contour. I did the first by offsetting the top slide and though it worked, it did involve an inordinate amount of tool overhang due to the diameter of the drum preventing the saddle passing underneath. I therefore began to think of how an attachment could alleviate this by leaving the top slide in its normal position thus affording the tool more support. A flash of inspiration revealed I already had the bulk of the answer in existence, not from the previous copying work but in the form of a device I had made to produce curved valve gear links on the Senior milling machine (Photo 1). Just a clamp plate to enable it to be mounted across the lathe bed, a bar to couple up to the cross slide and I was in business (Photo 2).

Now this attachment can be used in not

one but four ways as follows:-

On the lathe

1) Normal taper turning.

2) For tapers at large angles to the lathe axis.

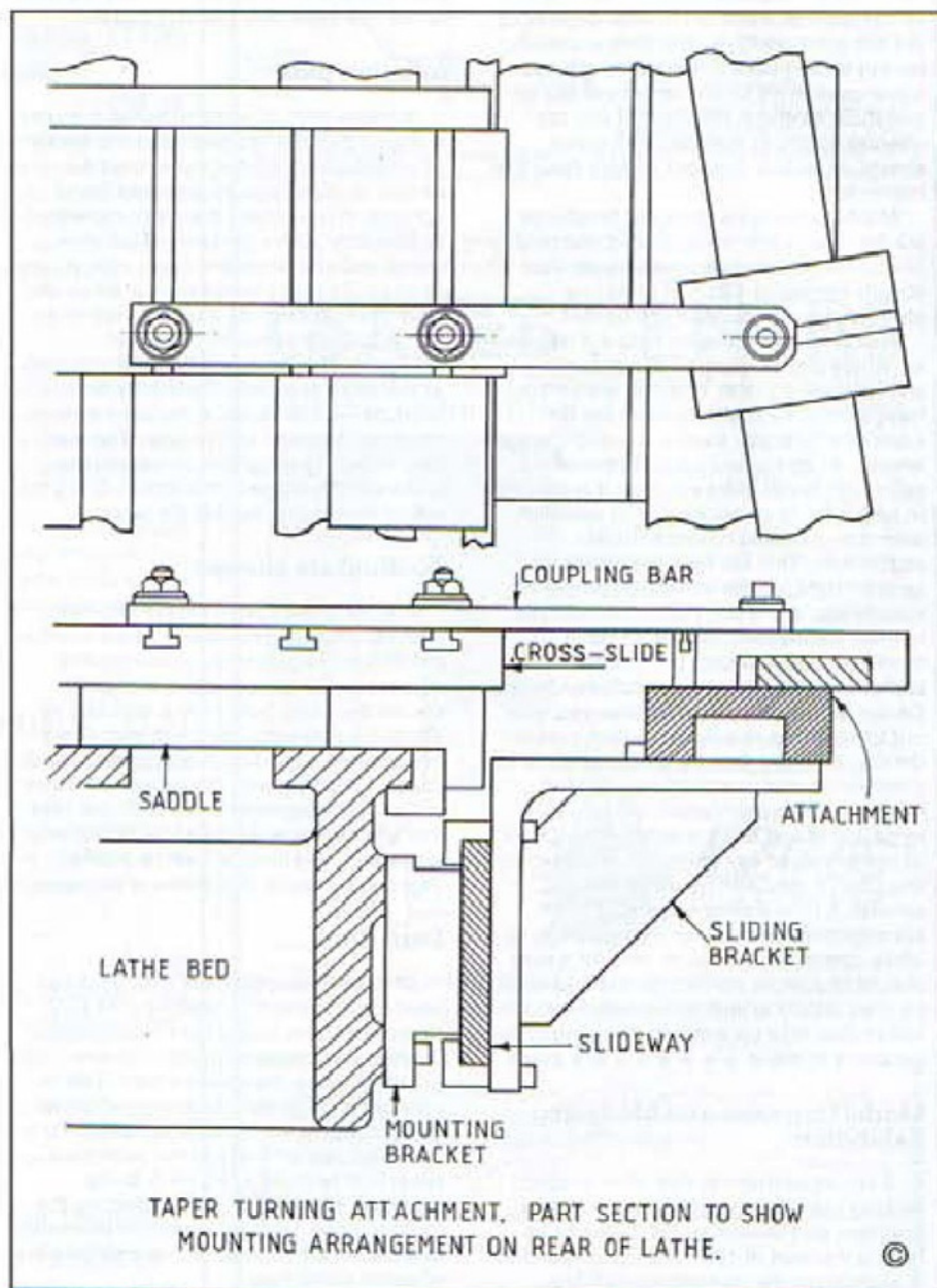
3) For copy turning.

On the milling machine

4) Milling curved links and other parts.

of any of them or the need to construct a separate attachment each time.

Using the milling attachment means the length of taper which can be turned is limited to about 8 inches. This should not be a disadvantage however, for if one thinks about tapers - Morse, arbors,



This brings out a precept worth bearing in mind, that of maximum versatility in the workshop. Often a little thought will enable one accessory to fulfil the role of a number, without undue compromise to the function

flywheel seats, etc. - they are seldom very long, though it may be necessary to produce them anywhere along what may be quite a long component, e.g. a crankshaft. This design therefore enables

the attachment to be positioned anywhere along the lathe bed and clamped there. Some features of the design were dictated by the space behind my lathe being limited, due to squeezing a large machine into a fairly small workshop. This is why the graduated collar is inside the bearing block and the ball handle seen in photo 2 has been changed to a disc wheel in the final design. A removable handle is provided for use on the milling machine.

Construction - basic attachment

Construction of the basic attachment allows the choice as to which of the functions are used. The drawings outline dimensions, which were largely determined by the materials to hand and are open to some variation. This explains why there are detail differences between the photos and the drawings. The rounded slot in the end of mine, for instance, has no function. It was already there in the hefty chunk which forms the body (1) and which had been laying under the bench for many years. Every so often it would be dragged out whenever a use might possibly be found for it, till the milling attachment suggested itself. It is unlikely many others will have a similarly sized piece available and if something suitable cannot be obtained, I suggest it can be built up from a piece of $3 \times \frac{1}{2}$ in. and two lengths of $\frac{1}{4} \times \frac{1}{2}$ in. screwed, riveted or even welded together, though the latter may cause unacceptable amounts of distortion.

Note the mounting holes are spaced to suit Senior milling table slots and 254 bedways. Different machines may need adjustment to these. Similarly the two slots in the underside of the body are to locate the fitment across the lathe bed for use as in use 2 in the introduction, so again these must be made to suit individual machines. For flat bed lathes only one need be a good fit on a bed shear but it should be cut square if the calibration is to be relied upon.

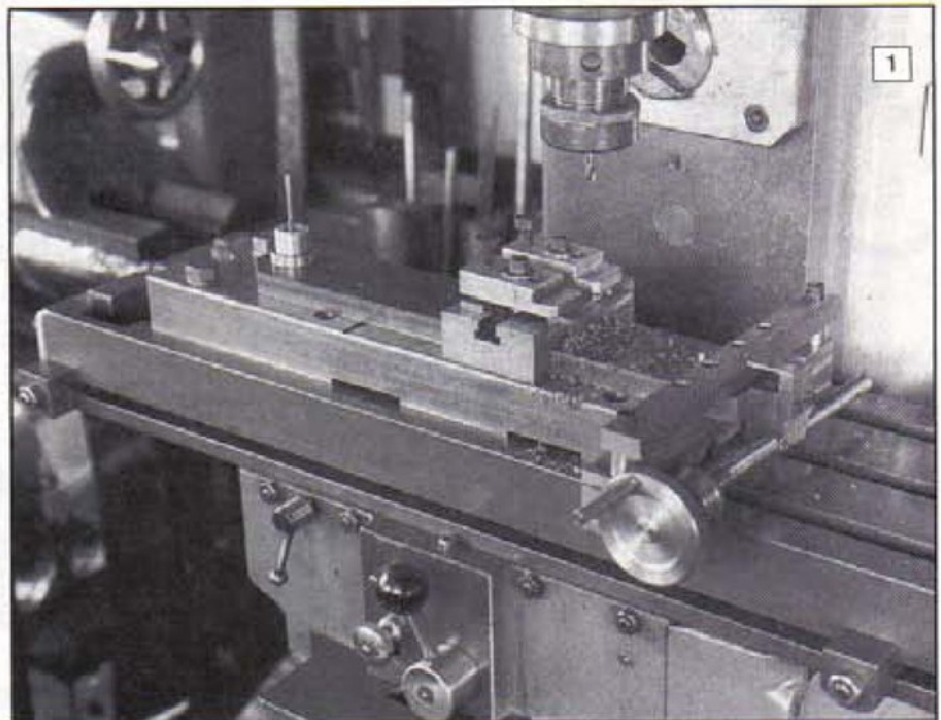
If used on beds with inverted 'V's' both sides will need to fit, of course, but rather than attempt to machine two accurately spaced grooves, it may be simpler to make some separate Vee-blocks to screw on when required. The piece of bar I selected for the swinging arm (2), again from the scrapbox was, I discovered machined cast iron. Purists might well say this is as it should be, but there should be no problem using BMS here, as with the relatively little use the attachment is likely to have, wear due to similar metals in contact is going to be minimal, especially if kept lubricated.

Whatever is used, the edges must be straight and parallel and the pivot hole needs to be bored to a reasonable finish. The pivot bush (3) should then be turned to a good fit in this hole. The length to the shoulder should be such that the arm is only just free to pivot when the nut is tightened onto pivot bolt (4). A shade of stiffness is preferable to even slight slackness here, especially if it is intended to use the milling function. Similarly the lengths of spacer bushes (17) should allow arm (2) to slide without shake between the cross piece (5) and retainer bar (6). When fitting the cross piece to body (1) ensure the top surfaces are flush. For fastenings to the slide block (8) a single 'T' slot was milled in to standard Myford dimensions, as shown. This was so that existing 'T'

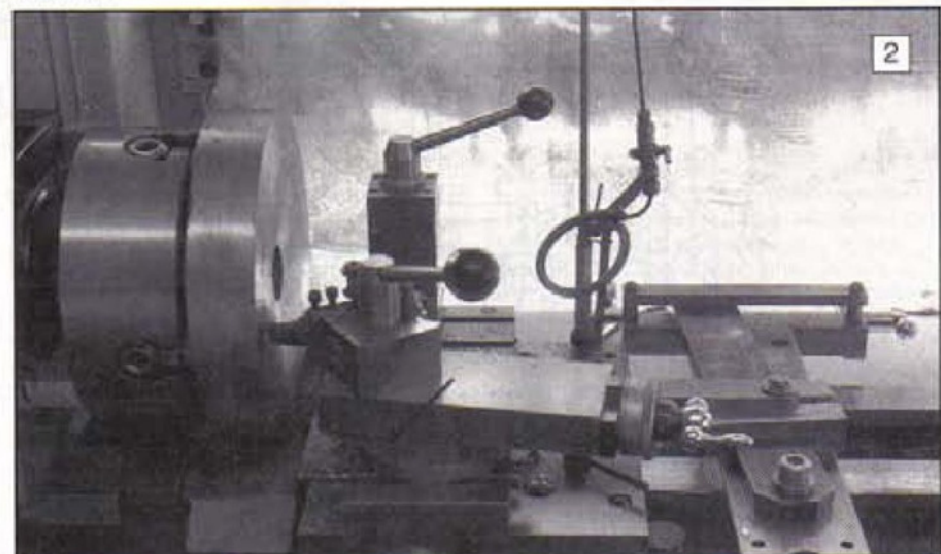
nuts, etc., could be used but this again is open to individual interpretation. Some may prefer a matrix of tapped holes for instance. It may perhaps be wondered why the block (8) is not dovetailed to arm (2). Indeed, if anyone wishes, there is no reason why this should not be done, though it is debatable if the extra effort is worthwhile. In the milling mode everything is tightly clamped together anyway and when taper turning the parallel edges allow some vertical float to the block. This eliminates any need for cross slide and block top surfaces to be exactly in line, only that the coupler bar lifts the block very slightly.

The gib strip locating screw (10) should be a nice fit in reamed holes in both block and strip. The two clamping screws should preferably be on the stiff side to turn. This will ensure they will stay put when backed off just enough to allow the block to slide in the tapering modes. A small amount of pliable material, such as PTFE tape,

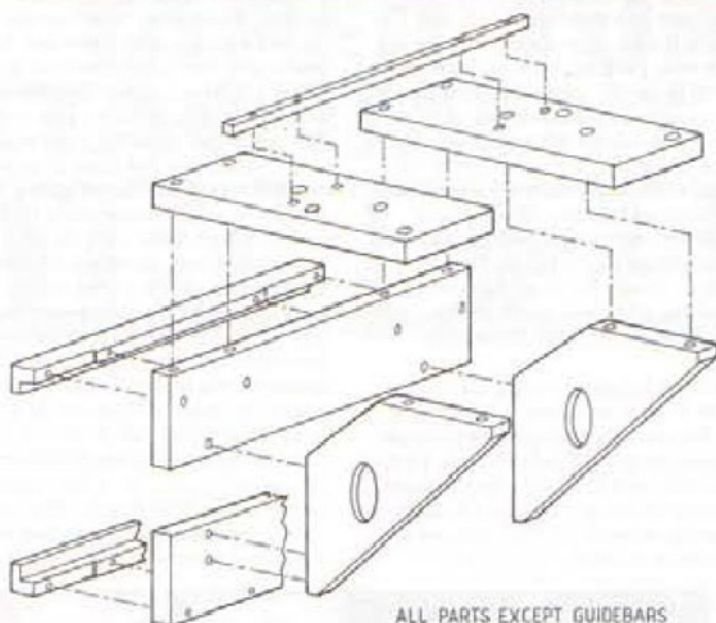
trapped in the threads to take up any slack is what is required. Alternatively the screws could be longer and fitted with lock nuts if preferred. The feedscrew (14) and nut (15), 20TPI left hand, came from the remnants of a small lathe. Like much else in the design, this specification is not hard and fast and any relatively fine thread, of either hand, would be perfectly satisfactory. The thing to bear in mind, however, is that the pitch of the thread other than 20 TPI may not give convenient numbers of divisions of the graduated collar per degree of angular movement. As it is, the geometry has been worked out to give four turns per degree and with the collar marked with fifty divisions the mental arithmetic for setting angles to decimal fractions of a degree is easy. This is the reason for the $11\frac{1}{4}$ in. dimension of the pivot hole from the end of the swinging arm (2). (The prototype was made with a different dimension here, before its importance was realised, with the consequence that one degree



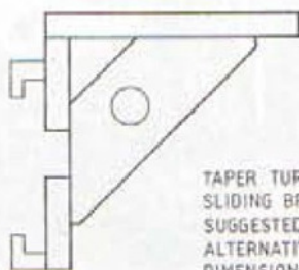
1: The attachment being used for its original purpose, making a curved link on the milling machine.



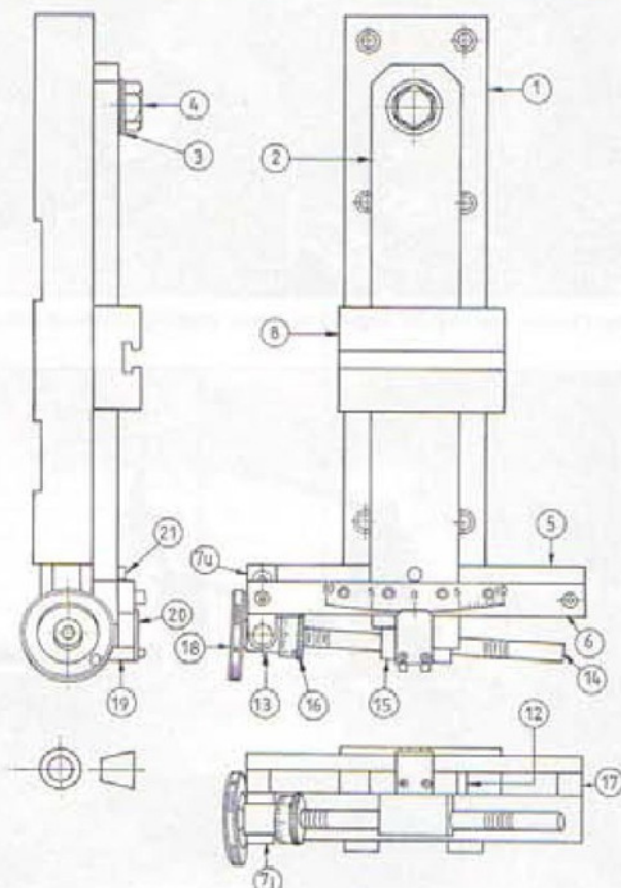
2: The original milling attachment adapted to taper turning. A cast iron brake drum being dished.



ALL PARTS EXCEPT GUIDE BARS
AND LOCATING BAR CAN BE
FROM THE SAME SECTION
STOCK.
(E.G. $2 \times \frac{1}{2}$ OR 50MM x 12MM)



TAPER TURNING ATTACHMENT MYFORD 254S
SLIDING BRACKET.
SUGGESTED FABRICATED CONSTRUCTION AS
ALTERNATIVE TO USE OF HEAVY SECTION
ANGLE. DIMENSIONS AS SHOWN ON ANGLE IRON VERSION.



TAPER TURNING ATTACHMENT FOR MYFORD 254S.
ITEM NUMBERS SHOWN.

movement is 196 divisions!) The original collar was made with a friction setting facility but this has been found unnecessary so a simpler version locked with a grub screw is shown on the drawing. It was graduated in the lathe with the aid of an adaptor which enables the Myford dividing head to be coupled to the headstock mandrel. The fairly standard method is then used, a side mounted screw-cutting tool, with point set at centre height, being racked along by the top slide. The topside collar calibrations give the lengths of line, say 0.050in. for units, 0.075in. for fives and 0.100in. for tens; note that it is important not to lose count with this method. A longer line in the wrong place looks awful. So too do poorly marked numbers. It is surprising the number of otherwise well made workshop appliances which are to be seen with appearances spoiled by collars with figures stamped every where but in the right places. Free-hand will not do. My own design of tapping and staking tool comes into play for operations such as this. Failing the availability of such an item, it should require little ingenuity to devise a simple jig to hold the stamps positively. Once the numbers are stamped, the collar is returned to the lathe for a light skim with a fine file to restore a nice smooth surface.

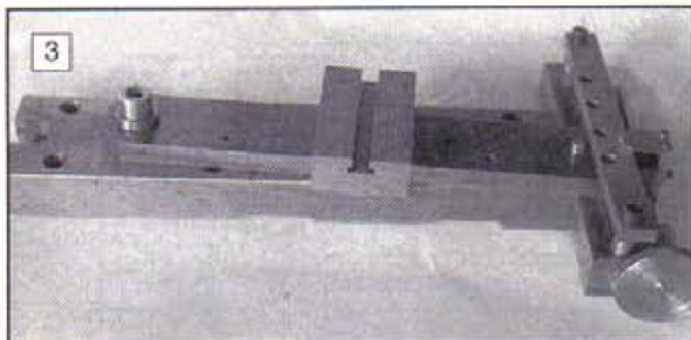
No fiducial line against which to read the collar is provided, the sharp corner of the feedscrew pivot block serves very well for this purpose. The block (13) requires careful marking out and manufacture to ensure both spigots are in line and the feedscrew bearing hole is on their axis. The most obvious way, if the piece of stock is long enough, is to centre in the four-jaw and turn both spigots at one setting, using a parting type tool for the one "behind" the central square section. Otherwise, each end will have to be machined in turn, reversing and re-centring for the second one. By the same token, the pivot holes in the trunnions (7u & 7l) must be in line.

Best here after bringing both to size and shape is to mark out the holes in the top one only. Drill the fixing holes only in this first then use it to transfer the holes to the cross-piece (5) and the lower trunnion (7l), noting the first two are clearance but tapping size in 7l. Tap 7l then screw all together. Clamp the assembly to a machine with the pivot hole centred then proceed with centre drill, drill and reamer. While the drilling machine might seem the obvious choice here, it should be born in mind that it may not have sufficient quill travel to enable all three operations to be carried out without shifting the table. This would almost certainly lose vertical alignment.

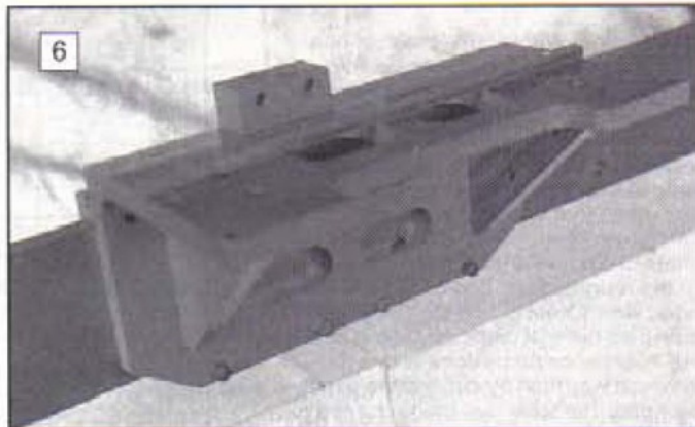
Mounting

For normal taper turning the attachment must be mounted to the rear of the lathe bed and for this a substantial bracket is carried on an additional slideway. As mentioned earlier, this enables the attachment to be placed anywhere along the bed as required. The slideway was made to go the whole length of the bed; for although there will be little call for use at the extreme tailstock end, it is a useful place to "park" the bracket out of the way when not required.

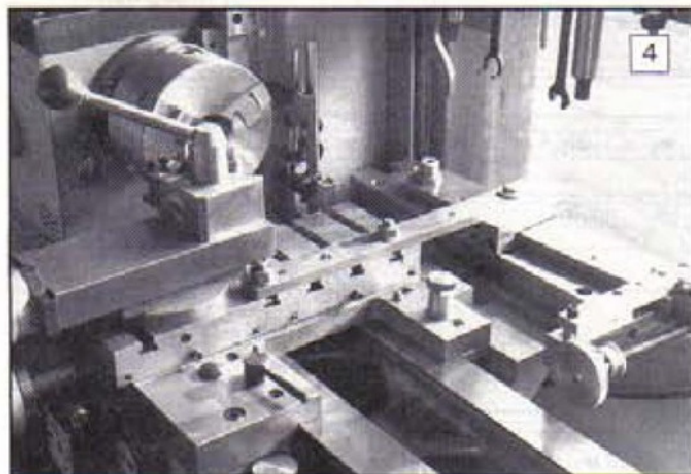
A fair quantity of steel is called for this part of the project, especially if it is to be made for a long bed machine. One thing



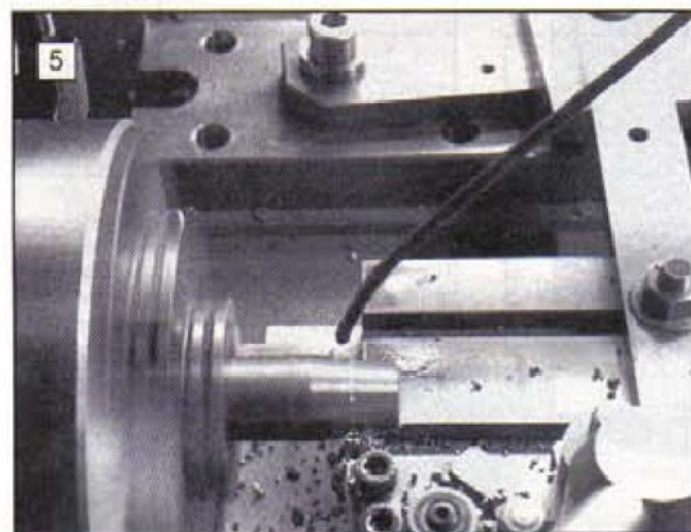
3: The basic attachment.



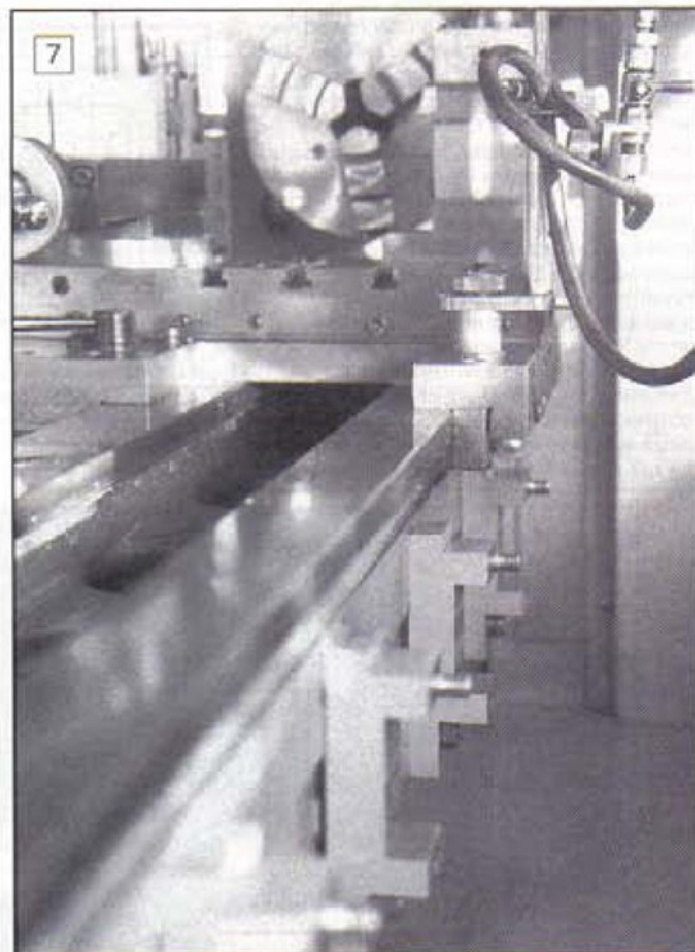
6: The sliding bracket mounted on the additional slideway.



4: The set-up finally evolved for normal taper turning. The cross slide feed nut is removed and the tool is fed by the top slide. Note the DTI holder "parked" close to the headstock.



5: A taper being turned with the aid of the attachment.



7: The mounting brackets in position on the rear of the lathe.

learnt from experience is that flimsy machine attachments are a useless waste of time. A saving could be made by making the slideway shorter so as to cover only the area the attachment is most likely to be used. Constructors can decide this for themselves. A shorter slideway will be necessary anyway if the lathe is fitted with the maker's vertical milling attachment as the bracket for this occupies space on the rear of the bed, where the slideway would otherwise fit. In order not to waste time by producing an inadequate article, some may consider it was wasted in another way during the production of the original. The late George Thomas was the author of much excellent material on workshop matters and somewhere amongst his prolific writings

he stated that time spent using a hacksaw could really be better used.

How then, he would have frowned on the next stage. Not having a suitable piece of stock bar from which to make the slideway, the original was sawn by hand from a slab of $\frac{1}{2}$ in. steel plate which had propped up the garage wall since being struggled home from the scrap man some years ago. It was intended for another project which never materialised. In extracting a piece for the slideway, plus another to make a reinforcing rib (later found unnecessary) then attacking a large lump of angle to bring it to size for the sliding bracket, it is estimated a total of about 13ft. of $\frac{1}{2}$ in. steel had been cut! In all seriousness, if sawing by hand is the only

way to reduce a very large piece of metal, one should not be put off as the task is not really that daunting. The secret is to pace oneself. The cuts were roughly divided up into pencilled 1in. intervals and a technique adopted of "saw an inch, rest a few moments, saw an inch, rest ..." and so on. In addition every few inches were marked as "targets" to be reached by certain times, which gave a psychological boost as each was passed. With a new 18 TPI blade in a sheet-metal saw and with regular smears of Treflex on it, the task was completed in much less time than anticipated.

Sawing completed, the 42 x $3\frac{1}{4}$ in. bar so produced then required some machining, for as well as the cut edges it had a rather rough surface due to heavy but uneven

Technical drawing of ITEM 1. BODY, showing top and side views with dimensions and specifications.

Top View Dimensions:

- Overall length: $9\frac{3}{4}$
- Overall width: $3\frac{1}{2}$
- Distance between centerlines of holes: $3\frac{1}{2}$
- Distance from end to centerline of first hole: $3\frac{1}{2}$
- Distance from centerline of last hole to end: $1"$
- Total distance between first and last hole centerlines: $12"$

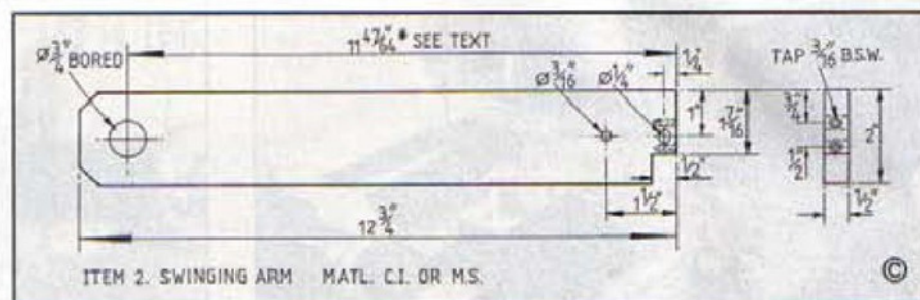
Side View Dimensions:

- Overall height: $3"$
- Distance from top to centerline of holes: $2\frac{1}{2}$
- Distance from bottom to centerline of holes: $1"$
- Overall width: $3\frac{1}{2}$
- Distance between centerlines of holes: $3\frac{1}{2}$
- Distance from end to centerline of first hole: $3\frac{1}{2}$
- Distance from centerline of last hole to end: $1\frac{1}{2}$

Specifications and Notes:

- $\phi \frac{1}{2}$ REAM
- $\#1$ TO SUIT SENIOR T' SLOTS.
- $\#2$ TO SUIT MYFORD 254 BEDWAYS.
- MATL. M.S.
- 8 HOLES $\frac{5}{16} \phi$ C'BORE $\frac{1}{2} \times \frac{3}{8}$ DEEP.
- 2 HOLES $\frac{5}{16}$ BS W $\frac{3}{4} \times \frac{5}{8}$ DEEP.

ITEM 1. BODY

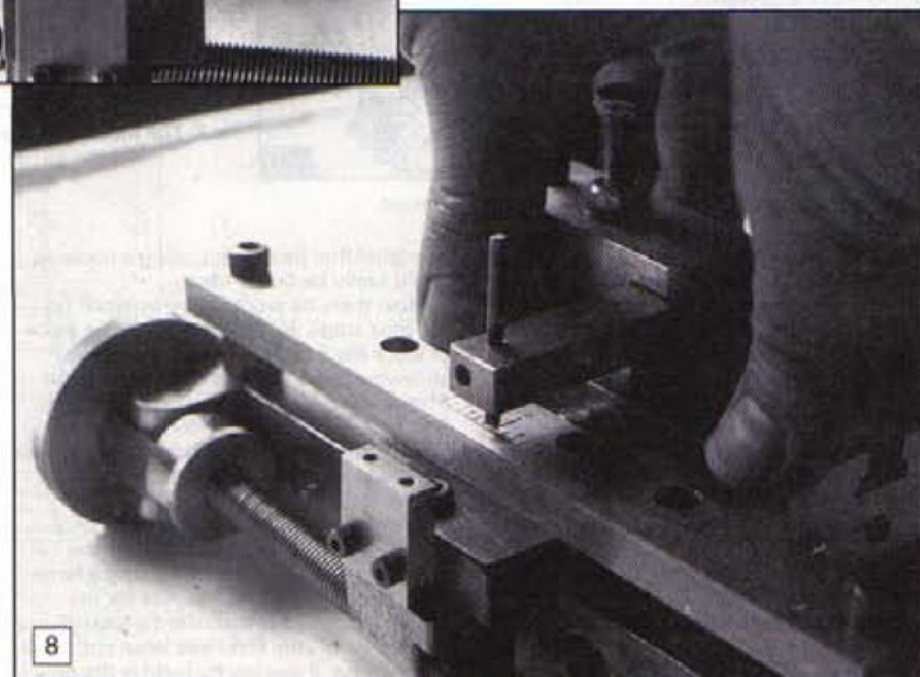


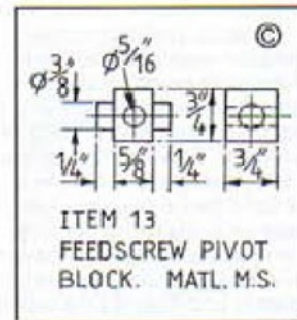
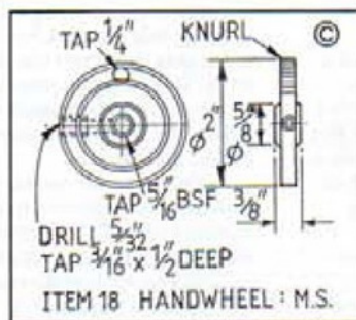
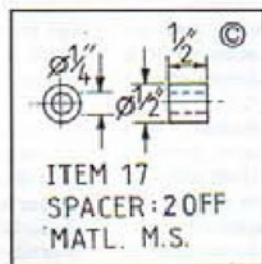
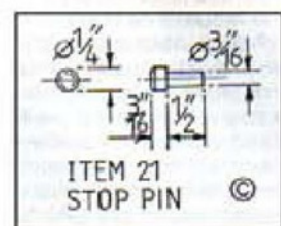
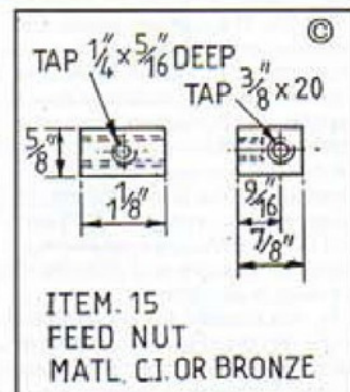
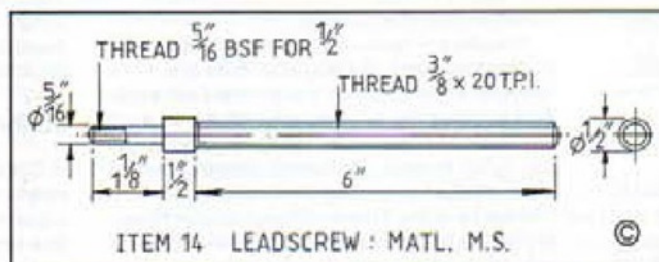
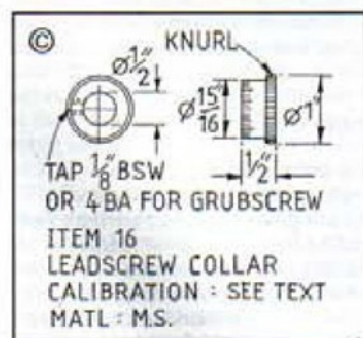
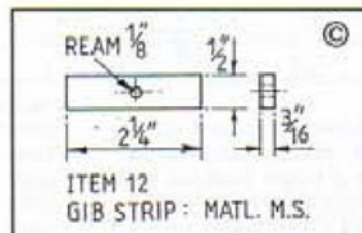
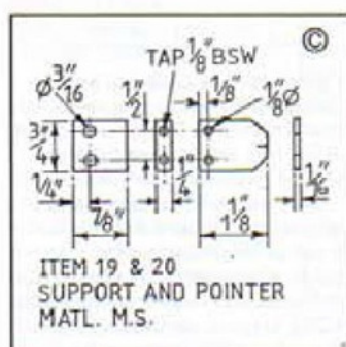
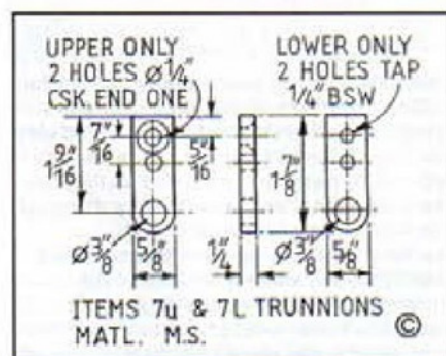
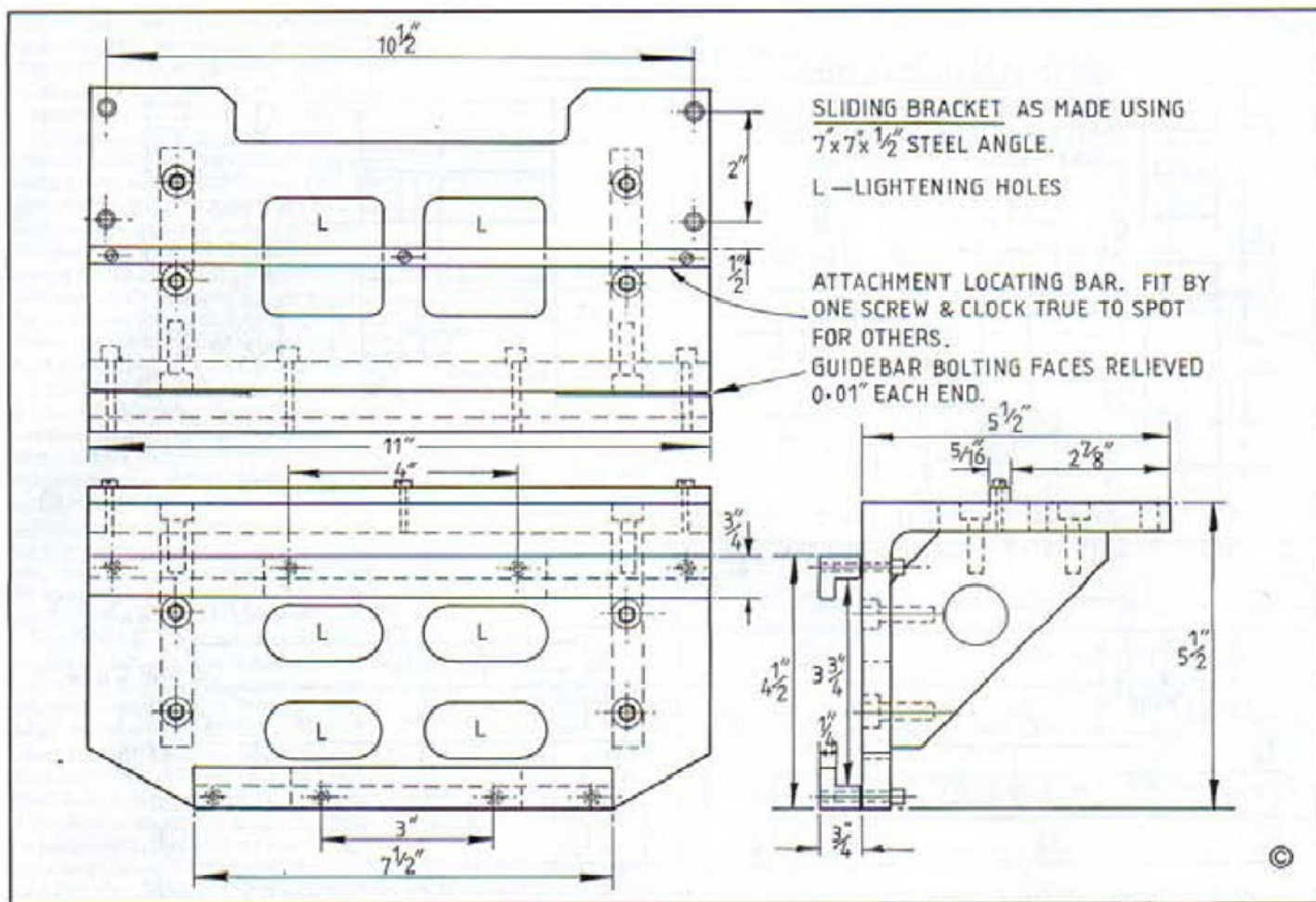
ITEM 3
PIVOT BUSH
MATL: M.S.

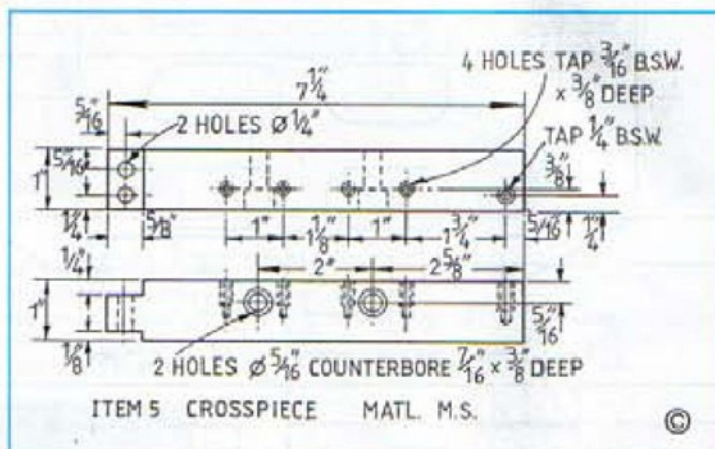
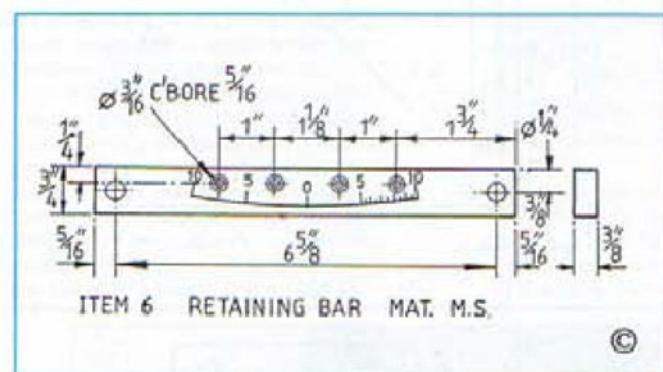


9

9: Angular scale and graduated collar. Note the swinging arm clamping screw installed in the right hand screw in the retainer bar.
10: Another use for the additional slideway - a permanent mounting for a DTI holder.





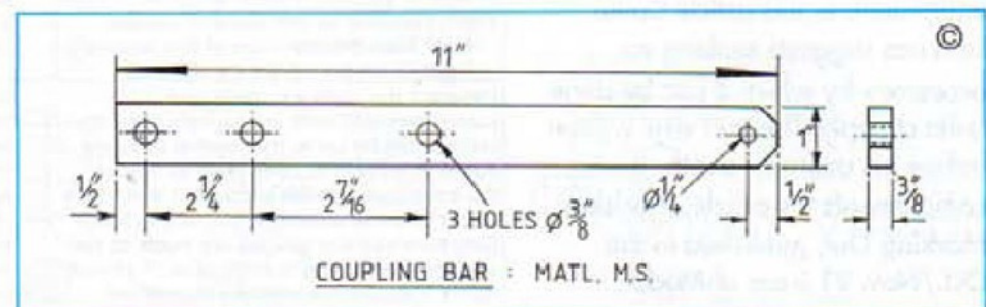
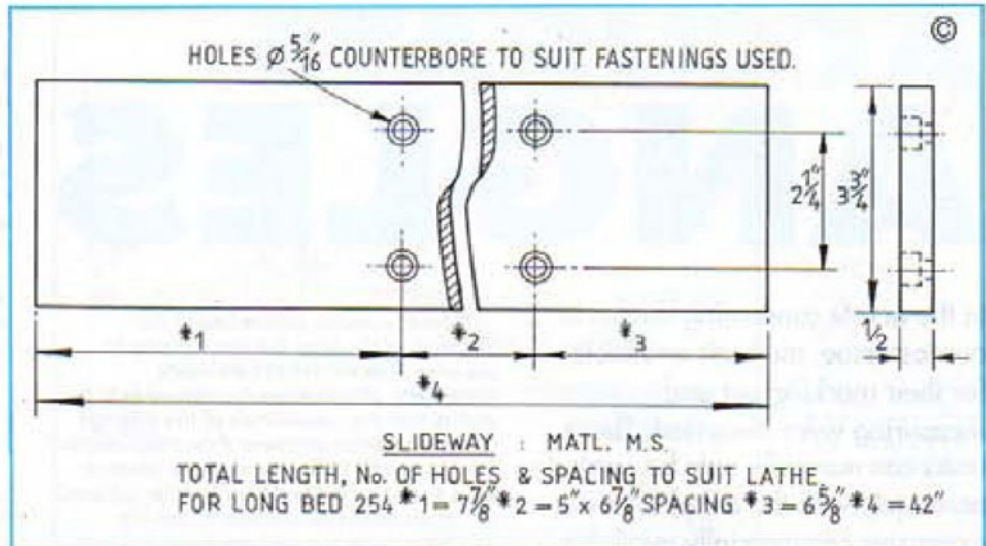


pointer index line. Temporarily remove the pointer. Put some packing about 0.005in. thick under the block, then drop the engraver into the hole in the arm so its point rests on the top of the retainer bar. Lock the engraver with a grub-screw then remove the packing. Care is needed now or the retainer bar may be marked where not required. Lift the block to bring the engraver point clear then slide the block till its edge is against the scribe mark. Press the block down and slide towards the stop pin. The engraver should scribe a line on the retainer bar at the scale zero position. Lift the engraver point clear. Set the first half degree angle on the swinging arm by adjusting the screw the required number of turns, as counted on the collar. Scribe another line, this time with the block edge starting from the $\frac{1}{16}$ in. mark. Lift clear, add another half degree and this time scribe a $\frac{1}{16}$ in. line. Another half degree and back to a $\frac{1}{16}$ in. line. Then $\frac{1}{16}$ in. again and so on till the five degree point is reached, when the $\frac{1}{16}$ in. mark should again be used.

Then back to alternate $\frac{1}{16}$ and $\frac{1}{8}$ in. lengths till ten degrees is reached with a final $\frac{1}{16}$ in. Return the arm to just past zero then come back to it to zero the collar. Note the amount of backlash present when the screw is turned the other way then proceed to mark the other half of the scale with that amount of correction applied to collar readings. If a base line is required to the scale, turn the engraver through 90 deg. and hold the block against the stop pin while the swinging arm is wound from end to end of its travel. The procedure may seem a little cumbersome but a rhythm is quickly developed and the scale can be completed quite quickly. The figures were stamped using the arm from the staking tool temporarily mounted on the sliding block.

Operation

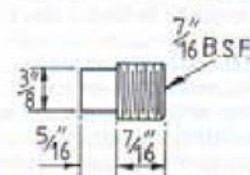
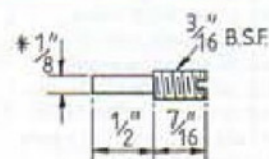
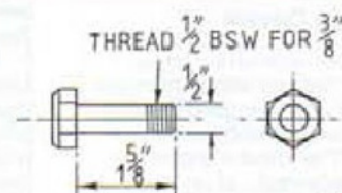
In use the methods are pretty well self explanatory. For conventional taper turning the cross slide feedscrew must be disconnected, and the top slide swung round to provide tool feed. For most applications the scale and/or the collar should suffice to set the desired angle. Once the angle has been set, the swinging arm is clamped by inserting a screw and tightening in the nearest convenient holes in the retainer bar and cross-piece. For more exacting work it would probably be as well to at least check the zero by use of a DTI after mounting. This was done during tests on the original, after which the angle for No.2 Morse taper was set using the collar. The taper then turned fitted first time, requiring no further adjustment. This would seem to illustrate the methods are adequate but anyone wanting to be absolutely sure of the angle could use a DTI to employ the Sine method for setting. For large angle tapers, with the attachment clamped across the lathe bed, saddle and cross slide roles are reversed. The cross slide screw remains connected and feeding by the cross slide moves the sliding block along the swinging arm, so moving the saddle along the bed in sympathy. Tool feed is again by the top slide but this time



left in its normal position parallel to the turning axis. The photo. showing the attachment in use as a milling accessory should need no comment.

Footnotes

For copy turning the slide block is removed and a template of the required form bolted to the swinging arm. As for taper turning, the cross slide feedscrew is disengaged but the coupling bar is replaced by a spring loaded template follower. The small block seen mounted on the top of the sliding bracket in some of the photos, has no significance to the present applications. It enables the bracket to be coupled to the saddle so it slides with it when used as the basis for a projected relieving attachment. The additional slideway suggests itself as the mounting for other attachments as well. A photo shows a clamp block made to accept the column, etc., of a commercially produced DTI holder. No doubt other uses will emerge as time goes by.



ACCURATE ANGLES

In the article concerning angles in our last issue, methods available for their marking out and measuring were discussed. These tasks can normally only be carried accurately with the aid of relatively expensive commercially available equipment. In this article David Lamm suggests making an accessory by which it can be done quite cheaply. The text was written before his untimely death. It complements his article, *Precision Marking Out*, published in the Oct./Nov. 91 issue of *Model Engineers' Workshop*.

A Precise Angle Device

For the purpose of accurate linear marking out readers may remember my previous article entitled *Precision Marking Out* on page 66 of issue No. 7 (Oct./Nov. 1991). The present article describes the construction of an instrument that is used in conjunction with the modified Vernier calliper to enable the accurate measurement and marking-out of angles.

Many amateurs possess only a common protractor, often of the school variety, as their means of measuring, marking or setting angles. It will be appreciated that the accuracy achieved depends upon the diameter of the protractor, larger ones having a more open scale, thus being easier to read. However, even with good eyesight it is difficult to obtain a reading much better than the nearest half a degree or so. The engineers protractor fitted with an adjustable steel rule is somewhat more convenient to use but is no better in practice. If you have the cash to afford a Vernier protractor you may well believe that this article has no interest for you ... but, hang on a minute, ... what sort of accuracy do you get from the £100 or more spent on that instrument? It might surprise you to learn that it can only be set to the nearest 5 min. of angle or $\frac{1}{2}$ deg.; I don't call that a bargain!

When an engineer requires greater accuracy of angular measurement he resorts to a Sine Bar which consists of two hardened steel cylinders fixed an exact distance apart, usually 5in. for a small one or 10in. for the larger version. Again this would set you back upwards of £100 but that's the cheap bit. To use a Sine Bar one also needs a set of Slip Gauges which cost you considerably more of your hard earned cash.

Now my device makes use of the principle of the Sine Bar but without its expense. It does need to be made accurately, although such a task should be well within the capabilities of the average home workshop engineer if the instructions are followed. I understand many readers have already modified their Vernier calliper, which we shall use in place of the slip gauges so they are halfway there anyway. A table of settings is given at the end of this article therefore no calculation is needed.

How does the provision of this system compare with the others mentioned? Provided the parts are made and assembled with care and knowing that the calliper can be set to the nearest thou we ought to be able to do at least as well as the expensive Vernier protractor and much better than the common protractor. Since Sine Bars and slip gauges are made to an accuracy measured in millionths of an inch rather than thousandths we should not expect to match their performance though if we compare them on a cost basis what we get for our 'pence' will look pretty favourable.

Figure 2 shows the principle of the device. It was known to the ancient Greeks that the angle of a right-angled triangle changes in proportion to the length of the side opposite the angle. By making the side opposite the right-angle exactly 5.000in. (or any other exact length, though 5in. is a convenient size) long and making sure that we always measure at 90 deg. to the base we can use a fixed table of settings for the length of the side in question. You will see from Fig. 2 that an angle of 60 deg. corresponds to a length (or 'height' of the triangle) of 4.330 inches. Figure 1 shows that an angle of 30 deg. corresponds to a height of 2.500 in. and the table gives all whole degree settings up to 65 degrees.

Why don't we go up to 90 degrees? If you try to draw a triangle with two angles of 90 deg., it will quickly become apparent that it is impossible. With one angle of 89 and the other of 90 deg. in. it is extremely difficult and so on, as we go above about 65 deg. it becomes more and more difficult to set the angle accurately. The Sine Bar suffers from the same problem but it is still extensively used.

The 3 corners of the triangle on our instrument are represented by the centre of the pivot, a point on the upper arm exactly 5.00 in. from the pivot centre and a point on the base directly below the latter. (The length of the 'base' of the triangle also changes as the angle alters but we do not need to know its length.) For convenience in use, the upper reference point is made detachable and the lower reference is a scribed line parallel to the edge of the base because it is easier to measure to a line than to an edge with out calliper points. Note that the distance of the line from the edge must be added to the 'height' of the

triangle, therefore it is wise to make it a round figure such as 0.100 inch for easy addition. The calliper setting for the angle of 30 deg. would then be 2.600 inches.

If, like many people, you don't care for mathematics do not let that put you off making this item. When you use your TV I'm sure you do not often think about the electronics that determine how it works (it's an interesting exercise to do it once to understand how it does function but there is no need to consider it every time you watch a programme is there?) You will soon get used to setting out angles in this fashion and never give it a second thought.

Description

The device consists of two arms pivoted together near one end, the inner edges of the strips being coincident when closed. These two edges must be as straight and true as it is possible to make them and it is also a great advantage to make the outer edges true as well as parallel to the inner ones.

With careful use parts made of mild steel will suffice, though gauge-plate even in its soft state would be better, for a deluxe article it could be hardened and tempered. To resist wear a large diameter pivot is specified which must be a close fit in the bore of the base, a clamp is fitted adjacent to the pivot in order to hold the arm firmly once an angle is set. The pivot is riveted into the upper arm and fastened in frictional contact to the base by means of a brass spring washer and retaining nut.

It will be seen that the base is milled to half its thickness at the pivot end allowing the arm to lie on the same level at the right hand side.

A recess is also milled to half the depth on the upper edge of the base whereon a reference line is scribed parallel to the edge.

There are several ways in which it might be arranged for the upper reference point to lie in-line with the pivot centre, for instance a solid projection could be left instead of the detachable piece shown but that would make it more of a problem to ensure the straightness of the edge. It would too, get in the way when measuring angles and a notch would have to be cut in the base to accommodate it when the arms were closed. It must be clearly understood that the detachable block must be very accurately fitted by taper-pins so that it will go back in the same place precisely or the precision of the instrument will be nullified. A method of doing this is given. If you do not yet possess a taper-pin reamer, now is the time to get one plus some taper pins to suit.

Taper pins are available in a number of different sizes for $\frac{1}{8}$ to $\frac{1}{2}$ inch and up to 1 $\frac{1}{2}$ in. long. We need the $\frac{3}{32}$ size for preference though $\frac{1}{16}$ would do as well, these are the 'nominal' sizes that one asks for when buying pins and reamers. $\frac{1}{8}$ nominal size is 0.044 at the small end and 0.065 at the large end, $\frac{3}{32}$ nominal is 0.070 small end and 0.096 large end. They have many uses so your purchase will be well worthwhile in the long run. Don't throw away the cut off pieces of pin as they can be used on other jobs.

When using the instrument the calliper is set to give the desired dimension then one point is inserted in the punch mark and the arm raised until the other point just touches the scribed line. The shortest distance from punch mark to line is when it

is a 90 deg.in. to the base therefore it is quite easy to decide by merely moving the calliper in a small arc. Because we take care to make both edges of each arm true and parallel we can use any of them in angle setting, for example the lower edge of the base can rest on the surface plate whilst we scribe along either the upper or lower edge of the arm. Again by inserting a pointed pin through the hole in the pivot it can be located in a centre pop on the work while scribing along both inner edges, etc., etc.

Construction

Start by selecting two pieces of nice flat mild steel for arm and base. The former requires $\frac{1}{8}$ in. thick material 1in. wide by 6 $\frac{1}{2}$ in. long, the base is from $\frac{1}{8}$ in. thick steel 1in. by 7 $\frac{1}{2}$ in. long. Bright drawn mild steel when extensively cut away on one side tends to distort due to internal stresses induced during the drawing operation, to prevent this happening we must first of all stress relieve the metal. This simple heat treatment, known as 'Normalising' the steel, consists merely of heating the piece to a uniform red heat for a minute to so then hanging it up to cool naturally in the air without being exposed to any draught.

Before normalising sketch out the shape roughly in pencil on the metal to decide where the waste will be then drill a small hole in the waste part close to one end. This will allow you to hang it on a length of steel wire during heating and cooling.

After normalising, when the metal is cold carefully true one edge of each piece and check the accuracy by rubbing the edge on the surface plate which has been covered with a very thin, even smear of the greasy 'mechanics blue'. When the strip shows a blue colour all along the edge you know it is true. If any portions are not blue you will know they are below the level of the blued areas, to correct, remember it is the blue parts that must be gently filed or scraped until another test reveals all-over contact.

From the edge thus trued the modified calliper can be set to mark 'from edge to line' in order to scribe a longitudinal centreline along each piece. Complete the marking out and centre pop where holes are to be drilled.

On the base piece drill the two holes $\frac{1}{2}$ in. dia. giving clearance at the sides of the boss but do not drill the pivot hole; this will be done at a later stage in conjunction with the arm in order to make quite certain that the inner edges align precisely when closed up. After drilling the two holes saw away the waste metal as near to the lines as you dare but without actually touching them. The tricky bit comes next in filing or milling exactly to the line to the nearest thou.

Milling or filing will give the result we want on arm and base, provided we proceed with care and keep checking with the micrometer from the edge first prepared. Check at a number of points along the length to keep things parallel. As a final check rub the edge on the blued surface plate. Remember to check the original edge again before taking off the last thou or so in case any slight distortion has occurred.

I have given sequence drawings for this

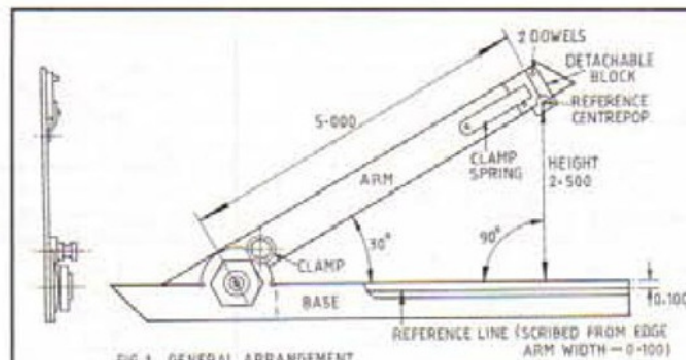


FIG. 1 GENERAL ARRANGEMENT

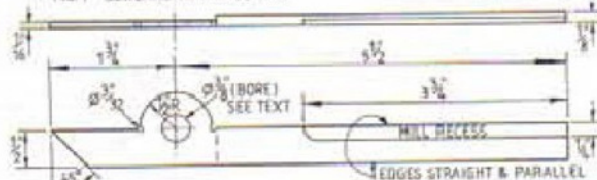


FIG. 3 MATL. M.S. BASE
A PRECISE ANGLE DEVICE

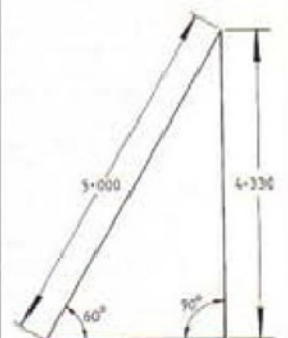


FIG. 2 PRINCIPLE OF INSTRUMENT

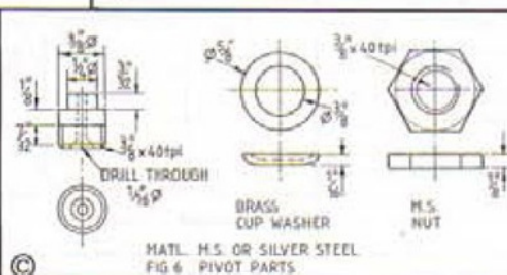


FIG. 6 PIVOT PARTS

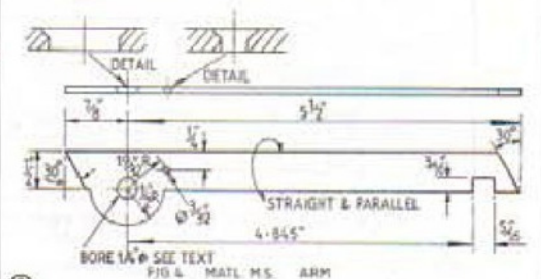


FIG. 4 MATL. M.S. ARM

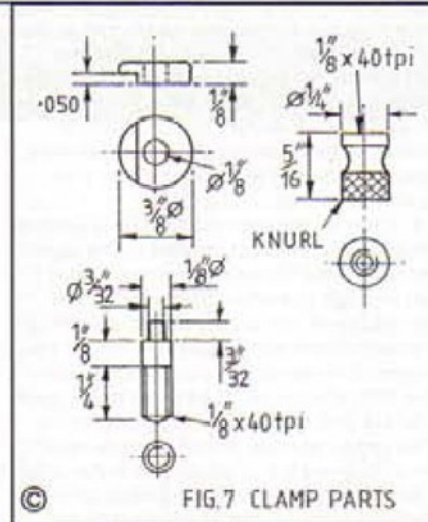


FIG. 7 CLAMP PARTS

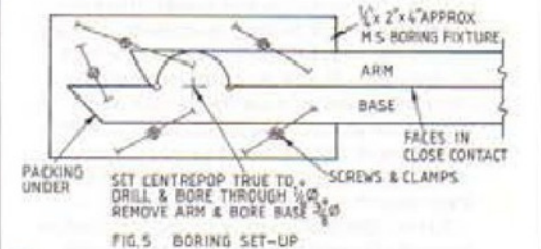


FIG. 5 BORING SET-UP

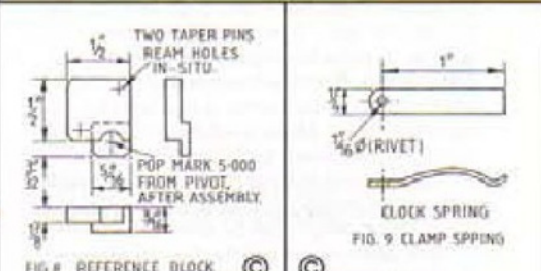


FIG. 8 REFERENCE BLOCK

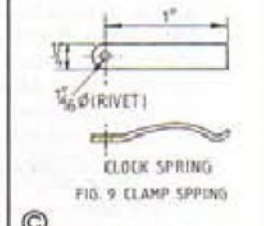


FIG. 9 CLAMP SPRING

job as an aid to progress.

When arm and base are fully shaped, but before drilling the pivot holes we need to make the pivot itself and the block for the end of the arm. The pivot will be used as a gauge when boring the holes, but if you do not have a boring head for this job they will have to be drilled and reamed in which case the pivot can be made afterwards to a close fit in the holes.

Don't be tempted to just hold a length $\frac{1}{8}$ in. dia. steel in the self-centring chuck, they are very rarely accurate enough to obtain true concentricity. Start by holding a length of $\frac{1}{8}$ in. dia. steel with about 1 to 1 $\frac{1}{2}$ in. sticking out from the jaws. Face the end, centre drill fairly deeply and drill $\frac{1}{8}$ in. dia. to a depth of just over $\frac{1}{2}$ in., there should be a reasonable size countersink left around the hole but not too big. Turn down to 0.375in. dia. for $\frac{1}{4}$ in. length, aiming for a

good smooth finish. Either screwcut 40 TPI or use a $\frac{1}{8}$ x 40TPI die in the tailstock die holder to cut the thread. If you elect to screwcut, take any burrs off the crests of the thread with a fine-cut file. Polish the $\frac{1}{8}$ in. dia. with fine abrasive paper.

Next set the parting tool or a recessing tool to cut with its edge parallel to the work and turn the 0.250in. dia. spigot going towards the jaws as far as the $\frac{1}{8}$ in. dia. goes. Take the sharp edge off the shoulder with the fine file before parting off to length. I hope you remembered to chamfer the threaded end first!

The 'block' is a simple milling job in which the projection on the underside should be made a free fit in the arm notch.

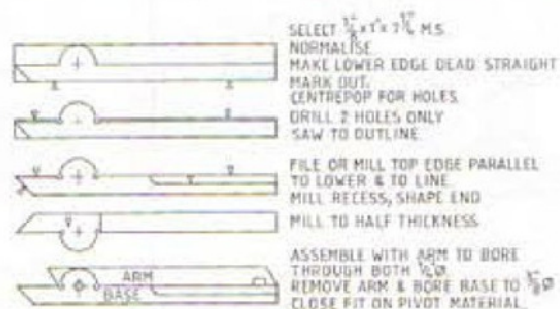


FIG. 3A MACHINING SEQUENCE FOR BASE



FIG. 4A SEQUENCE FOR MACHINING ARM

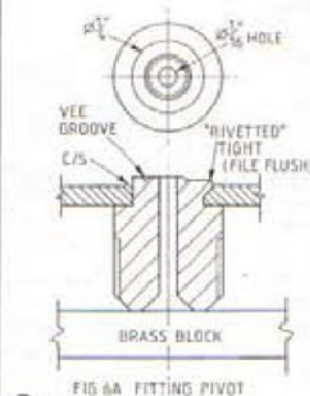


FIG. 6A FITTING PIVOT

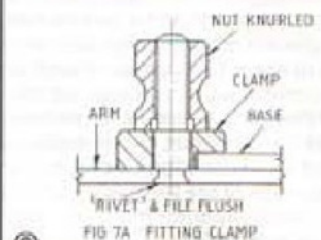


FIG. 7A FITTING CLAMP

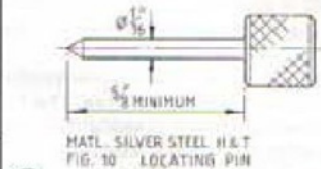


FIG. 10 LOCATING PIN

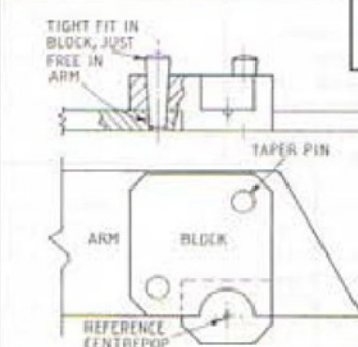


FIG. 8A FITTING BLOCK

The block will be located on the arm by the two taper pins not by the notch. The semi-circular recess at the top is made by feeding a $\frac{1}{8}$ in. dia. end mill or slot drill in for half its diameter. At this stage do not drill the taper pin holes or mark the centre pop position. It is much easier to hold the metal for milling if it is left attached to the parent metal until all the shaping has been completed, then saw off and clean up the edge.

Clamp the block firmly to the arm with a toolmakers clamp before drilling the two holes straight through both. For a $\frac{1}{8}$ in. dia. pin select a drill $\frac{1}{8}$ in. dia. (1.20 mm) or for a $\frac{1}{16}$ in. pin use 1.9 mm drill. Keep the reamer upright in use and turn steadily by hand without forcing the pressure, give it time to cut, withdrawing at intervals to clear the flutes. Make sure it cuts the taper all the way through both pieces of metal. Try a pin in the hole to check it fits properly with a short length projecting at the small end, this surplus length can be trimmed off later.

With both pins a satisfactory fit remove the clamp to very lightly countersink the holes at both sides, this should be no more than a scrape to remove the sharp edge plus any burrs. Also use a flat needle file to remove a few scrapes from the three sides of the notch in the arm and lightly chamfer the edges to provide clearance.

Fit the pins into the block with a tiny smear of Loctite to make sure they stay put but push the pins firmly into the holes to squeeze out surplus Loctite or the fit in the arm may not be correct. When the Loctite has set wipe off remaining liquid then saw away the large end of the pins a short distance above the block; round the end with a file to improve the appearance.

Fit the block back on the arm when it should seat properly with absolutely no movement. If by any chance it is slack then one or other of the pins must be tapped

down very slightly until firm. If the block sits with a gap between it and the arm, the holes in the arm must be given another scrape with the taper-pin reamer. A minute gap between arm and block is preferable to any slackness however small. This is a good exercise in fitting skills that will well repay the effort when other fiddly jobs have to be tackled in the future.

It might be thought that ordinary parallel dowels could be used instead of the taper pins but a little thought will show that if tight enough to be free of movement in both pieces of metal they would be difficult to remove from either. Dowels should only be used for permanently assembled parts, ones that only rarely need to be taken apart or where precise location is not essential. In the latter case the dowel is made tight in one component but relatively free in the other.

At this point, scribe the position of the reference point on the block. Fit it to the arm then use the modified calliper set to the micrometer dimension of the arm width to scribe from the rear edge of the arm. Make sure the calliper leg rests against the arm itself and not on the block, which should be slightly clear of the rear edge for this reason, file the block back if necessary.

Now for the longitudinal dimension. Set the calliper points to 5.000in. apart to scribe an arc on the block centred from the pivot position centre pop. Do not centre pop the block yet as we must check the longitudinal position again after the pivot has been fitted just in case there is a small error in drilling.

The pivot holes

This is an important operation that must be accurately performed. The way in which it is done will depend upon your facilities. I

shall describe two of the possible methods that will cater for the majority of readers but if you have a better method by all means use it.

Those without a boring

head can set the job up on

the fixture shown in Fig.5

for drilling a reaming in the

drilling machine if it is in

good condition, otherwise

with lathe or vertical milling

machine. On the lathe the

fixture should be clamped to the vertical

slide facing towards the headstock. The

work should be clamped to the fixture as

shown in order that the arm may be

removed after the first $\frac{1}{8}$ in. dia. hole is

formed without disturbing the position of

the base before drilling the $\frac{1}{8}$ in. dia. hole.

Setting the pivot centre pop exactly in

line with the drill axis is the next task. One

way is to use a 'sticky pin', that is merely

an ordinary pin with its head buried, in a

small lump of Plasticine, Blue-tack or other

sticky but not too soft substance. This is

attached to the chuck with the point of the

pin facing the work. Start the drill running

then lightly hold the end of the pin with

finger and thumb until it runs truly without

the slightest wobble at the point. It doesn't

matter what the other end of the pin is

doing but the tip of the point itself must

run dead true, have several goes at it if

necessary. Traverse the saddle until the pin

point is very close to the work without

actually touching it and adjust the vertical

slide and cross-slide until the middle of the

centre pop is aligned with the pin point.

Lock both slides.

The traditional 'wobbler' held in the

lathe toolpost with its short point located in

the centre pop is of course only useful

where the work rotates, in cases like the

present other methods of centring must be

used. There is an optical system wherein a

short telescope plugs into the spindle

allowing the pop to be centred at the

intersection of the cross-wires but few

amateurs will own one of those I suspect.

Having got it set properly, centre drill,

drill right through work and fixture with a

Letter B drill (6.00 mm) and ream $\frac{1}{8}$ in.

diameter. Slacken only the clamps holding

the arm which can then be removed

without disturbing the position of the base.

Place a small piece of $\frac{1}{8}$ in. thick packing

under the boss where the arm previously supported it and reposition one of the clamps to hold it. Again centre drill and drill through the packing 6 mm dia. then open out the hole to $\frac{7}{16}$ in. dia. (9.10 mm) and ream $\frac{7}{16}$ in. diameter.

Very lightly deburr the holes and additionally countersink the underside of the arm to just halfway through the thickness of the metal.

The second method involves boring the holes after the preliminary drilling by means of an adjustable boring-head mounted in the machine spindle. Whereas a hole produced by drilling and reaming might wander slightly off course, this depends upon a number of factors including the mechanical condition of the machine, straightness and truth of sharpening of the drill, etc., a bored hole should be exactly concentric with the point it was centred on. It is more difficult to obtain a hole to the exactly desired diameter when boring but that little problem is overcome quite easily by making the pivot to fit the holes afterwards. When boring use a drill shank or short length of nominal sized metal as a gauge to make certain the size is not wildly out then concentrate on getting a good finish rather than an absolutely exact dimension.

When the pivot has been riveted into the arm and filed flush on the back the precise length to the reference mark can be checked, either by measuring from the far

side of the pivot and deducting half its diameter, or by going from the near side of the pivot and adding half the diameter. Use the modified calliper with appropriate legs in both cases. If it should be different from the original mark just scribe again to make a new one, making sure that the correct intersection is lightly and accurately centred-popped, use a magnifier to set the finely pointed punch before tapping it whilst holding it perfectly upright.

The retaining spring is made from a short length of clock spring or similar material. This is usually not too hard for drilling through especially if a good sharp centre punch is first employed to make a reasonable sized pop. Another method is to punch the hole with a hardened flat-ended punch and matching die. Bend the spring to shape, taking care that it will exert some pressure at the tip when riveted in place. The rivet is closed by hammering it into a small countersink on the back of the arm whilst supporting the head in a suitable 'dolly' fixed in the vice. File flush after riveting. Do not rivet so tight that the spring cannot be rotated on the rivet, it should be capable of being swung aside before the block is removed.

The clamp screw is also riveted into the arm but this time make sure it is tight. The clamp itself must have the step milled slightly less than the thickness of the boss left on the base so that it will grip when the screw is tightened. A knurled head to the screw will provide sufficient grip.

The pivot is fitted with a brass cup-washer that acts like a spring washer providing a frictional force, this means the arm is able to move on the pivot without being so slack that it is difficult to control. When sufficient tension has been given, a drip of Loctite 241 Nutlock applied to the outer end of the thread will seep in enough to prevent it turning inadvertently.

To make the washer drill a hole of the required size in a length of somewhat springy brass strip about $\frac{1}{16}$ in. thick or thereabouts. Cut roughly to the OD size with tin snips then mount on a threaded mandrel, using a nut to secure it and turn to size. Place the washer so formed on a block of lead (or soft wood if you have no lead), put a large ball bearing in the centre of the washer and hit it firmly with a fairly heavy hammer. If you have no large ball bearing either than place the ball-peen of a hammer within the washer and hit the other end of the hammer with a heavy mallet to do the trick. Note that you should not hit one hammer with another hammer; the violent contact between two hard surfaces might result in fracture with the possibility of a steel chip flying off at high velocity to cause injury. One way to overcome that would be to rest a thin sheet of mild steel on the hammerhead before hitting it; a mallet is safer.

The washer is given only a slight curve, we do not need to make it hemispherical therefore some restraint in hammering is necessary.

With all the parts made the instrument can be assembled. Before fitting the block carry out a check to ascertain that there is no gap anywhere along the length between arm and base when the pivot is in place. If there is a small gap at the pivot end there is not a lot that can be done about it. A small gap at the far end can be corrected by carefully filing the inner edge of the arm towards the pivot until they fit properly, but take it very steadily. The outer edge of the arm must then be corrected to be parallel to it as measured by micrometer.

The table of settings of the calliper for each degree is opposite:-



Height of triangle and calliper setting for each degree of scale

Angle (degrees)	Ht. of triangle (in.)	Calliper setting (in.)	Angle (degrees)	Ht. of triangle (in.)	Calliper setting (in.)
1	0.087	0.187	41	3.280	3.380
2	0.174	0.274	42	3.346	3.446
3	0.262	0.362	43	3.410	3.510
4	0.349	0.449	44	3.473	3.573
5	0.436	0.536	45	3.536	3.636
6	0.523	0.623	46	3.597	3.697
7	0.609	0.709	47	3.657	3.757
8	0.696	0.796	48	3.716	3.816
9	0.782	0.882	49	3.774	3.874
10	0.868	0.968	50	3.830	3.930
11	0.954	1.054	51	3.886	3.986
12	1.040	1.140	52	3.940	4.040
13	1.125	1.225	53	3.993	4.093
14	1.210	1.310	54	4.045	4.145
15	1.294	1.394	55	4.096	4.196
16	1.378	1.478	56	4.145	4.245
17	1.462	1.562	57	4.193	4.293
18	1.545	1.645	58	4.240	4.340
19	1.628	1.728	59	4.286	4.386
20	1.710	1.810	60	4.330	4.430
21	1.792	1.892	61	4.373	4.473
22	1.873	1.973	62	4.415	4.515
23	1.954	2.054	63	4.455	4.555
24	2.034	2.134	64	4.494	4.594
25	2.113	2.213	65	4.532	4.632
26	2.192	2.292	66	4.568	4.668
27	2.270	2.370	67	4.603	4.703
28	2.347	2.447	68	4.636	4.736
29	2.424	2.524	69	4.668	4.768
30	2.500	2.600	70	4.698	4.798
31	2.575	2.675	71	4.728	4.828
32	2.650	2.750	72	4.755	4.855
33	2.723	2.823	73	4.782	4.882
34	2.796	2.896	74	4.806	4.906
35	2.868	2.968	75	4.830	4.930
36	2.939	3.039	76	4.851	4.951
37	3.009	3.109	77	4.872	4.972
38	3.078	3.178	78	4.891	4.991
39	3.147	3.247	79	4.908	5.008
40	3.214	3.314	80	4.924	5.024

Read the note below in conjunction with this table:

To calculate any intermediate or other angle is quite easy especially if you own a pocket calculator having a 'Sin' key the procedure being merely to multiply the Sine of the angle by 5 to find the Height of Triangle.

e.g. To find the height of triangle corresponding to 20.5 deg. (20 deg. 30 min.)

Sin 20.5 deg.in. = 0.3502074 (by calculator) or it could be looked up in the Table of Natural Sines in your Zeus or other reference book.

We now multiply the Sin by 5
 $0.3502074 \times 5 = 1.7510369$ or rounded up to three decimal places this becomes 1.751 in. as the height of the triangle. To find the calliper setting just add 0.100 to it to get 1.851 in..

THE CONSTRUCTION OF A SIMPLE OPTICAL CENTRE PUNCH

Ted Hartwell provides us with a simple design for an optical centre punch. Even if you have no intention of making the tool, do read on for the short course on optics.

The requirement to position a number of hole patterns within an overall tolerance of plus or minus 0.005in. resulted in the design and manufacture of the device described below.

While other, and more complex optical centre punches, are available commercially, that made by the writer is simple in the extreme and can easily be made from readily obtainable materials without the need for precision machining, other than the fit of the elements in the base and the forming of the lens surfaces.

The magnification considered desirable was thought to be in the region of $\times 5$ or $\times 6$ i.e. similar to that of a typical watchmaker's eyeglass, the only constraint being the total length of the magnifying elements. The need for an adequate base depth together with sufficient projection for illumination and holding purposes suggested a measurement of between $1\frac{3}{4}$ and 2 inches.

In the absence of readily available information on the refractive index of the acrylic rod (Perspex?) purchased, experimentation was resorted to, which, together with some basic calculations, gave a theoretical power (when viewed by the human eye), of a little over $\times 5$ and a lens radius of $\frac{1}{2}$ inch. The method of forming the profiles described later will, however, allow for any variations in the optical properties of the material actually used, together with any difference from 'normal' eyesight of the user.

Actual manufacture

The base shown in the sketch was made from aluminium alloy, although brass may be preferred, which, being heavier, can facilitate the 'holding down' of the unit. Those not wishing to submit their lathes to the heavy radial pressure necessary for a satisfactory 'full' knurl, may also decide to adopt a 'curved waist' for this purpose. The three holes in the base must be reamed accurately to a similar size and have a good surface finish. The spacing is not critical, and while reasonable squareness is desirable, drilling and reaming under the bench drill is perfectly acceptable. (Many such drills have tables that are not precisely square to the drill spindle axis).

The two magnifying elements were made

from $\frac{1}{2}$ in. nominal diameter clear polished acrylic rod which, was in fact, 0.525 in. or 13 mm in actual diameter, the method of machining suggested being as follows:-

a) Hold the length of rod in an accurate three jaw chuck and reduce the diameter until a smooth sliding fit, without perceptible slackness, in the holes in the base is achieved.

b) Face the end of the rod 0.005 - 0.010in. shorter than the base depth and finish with 400 grade 'Wet and Dry' abrasive paper followed by metal polish to give a flat transparent end surface.

c) With a 60deg. tool having excessive flank clearance, cut two concentric grooves in the polished end face, one $\frac{1}{32}$ in. dia. and the other $\frac{1}{16}$ in. dia., to a depth of about 0.005in. to provide a 'target'.

d) Part off to 1 7/8 in. overall length. The second element is machined in a similar manner except that a 'noughts and crosses' box is cut in the end face as follows:

e) With the 60deg. tool used in (c) above on its side and $\frac{1}{8}$ in.

above centre height, level number one jaw of the chuck and cut a 0.005in. deep groove across the face. Level number one jaw at 180 deg. and cut a further groove parallel with the first (and $\frac{1}{32}$ in. from it).

f) Using the head of a combination square, set number one jaw vertical and cut another groove at 90deg. to the first pair, followed by a final groove with number one jaw at 180deg.. Part off as in (d).

The precise circle diameters, box dimensions and groove depths are not highly critical but must be cut with the pre-turned shank perfectly true, i.e. at the same setting.

If not satisfied with one's first attempt, the end can be faced off, polished and recut whilst maintaining the shank length by facing back the shoulder; so that when fitted to the

body, the end is 0.005 to 0.010 in. clear of the workpiece, thus protecting the 'target' from accidental damage.

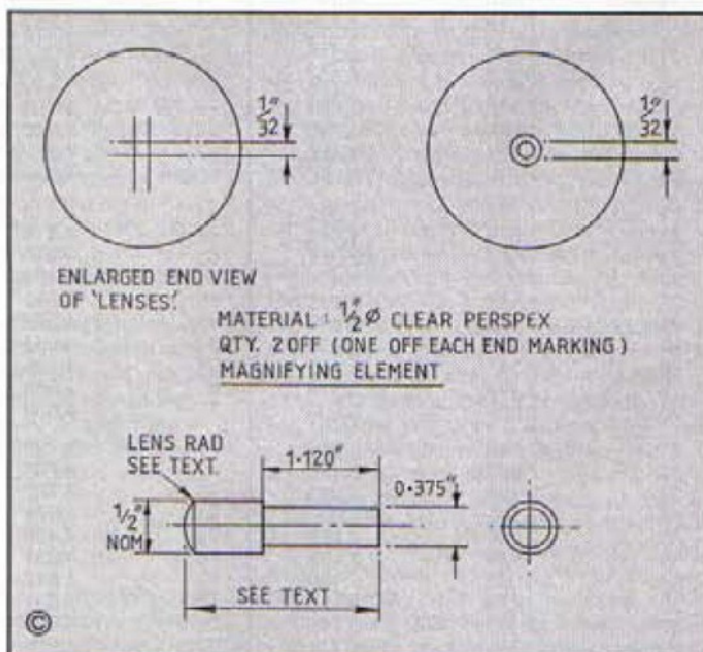
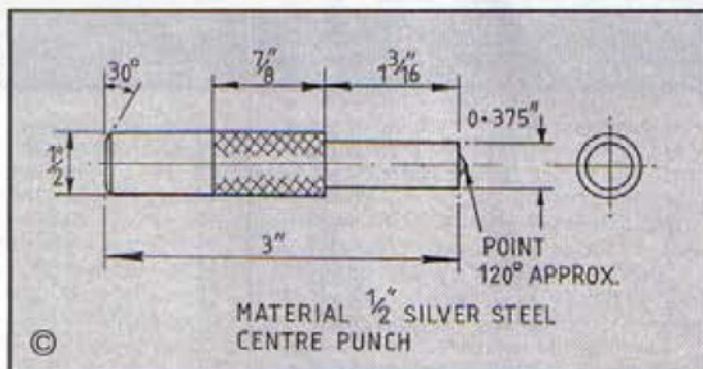
Holding the element with the 'noughts and crosses target' in the three jaw chuck, or preferably a collet, form and polish the lens surface as follows:

g) With a grinding point mounted in the bench drill, which is set on top speed, dress the diameter to 1 1/4 in. and grind a piece of square HSS tool bit to create a form tool having about 8 deg. top rake and side clearance.

Safety Note

The grinding point should be properly guarded as a precaution against bursting, with safety glasses being worn during the total operation.

h) Clean up the end face to produce the lens profile and using the form tool removed from the tool post as a gauge, check that the surface forms part of a



sphere. Polish the surface with metal polish, preceded if necessary, by the use of 400 grade 'Wet and Dry' paper, and remove from the lathe.

i) Holding the element to the eye, with a sharp 6in. rule beyond, check the focus. Should the 'target' be indistinct, but a clear image of the rule be possible, (by slightly moving the rule away) the focal length is too long, i.e. the form tool will need to be reground after reducing the grinding point by say, $\frac{1}{32}$ in. on diameter.

Alternatively, should it not be possible to obtain a clear image of either the 'target' or the rule, the focal length is too short, which, to avoid regrounding the form tool on a slightly larger diameter point, can be corrected by reducing the length of the magnifying element with the form tool,

again followed by polishing.

Either of these operations may need repeating until a crisp image of the 'target' is obtained.

Should the 'noughts and crosses' 'target' exhibit 'pin cushion' distortion, i.e. the pairs of lines diverging at their outer extremities, advance the cross slide by say 0.010in. and remove a small amount of lens surface adjacent to the outer edge. Repolish.

It should now be possible to form the other magnifying element lens using the previously established length and form tool radius.

The Centre Punch

This is reduced from a previously knurled (but not essential) piece of $\frac{1}{2}$ in. dia.

silver steel to give an initial push fit in the base holes. The 120 deg. centre point must, of course, be turned at the same setting to ensure concentricity.

Harden by heating to red heat and carefully quench (vertically); then temper to a light straw colour at the extreme point, followed by stoning and/or polishing the shank to provide a slide fit in the base block holes - again without perceptible shake.

Those fortunate to have access to a small cylindrical or universal grinder will, no doubt, prefer to grind the shank and centre point after hardening, having left a suitable grinding allowance - say 0.008 - 0.010in. on diameter.

Using the centre punch

Place the base on the carefully marked out workpiece and, using whichever magnifying element is preferred, align the intersection of the scribed lines in the 'target'. Holding the body firmly down on the workpiece, interchange the magnifying element with the centre punch and give a light blow with a 4 oz. hammer.

Replace the magnifying element and recheck.

The actual drilling should be preceded by the use of a small pilot drill or centre drill, with correct alignment ensured using a 'wiggler' or as an alternative, a sewing needle secured to the end of the drill chuck by a blob of Plasticine.

The writer has had no difficulty in holding the base of the device whilst changing the elements, but the following aids may be worth consideration:-

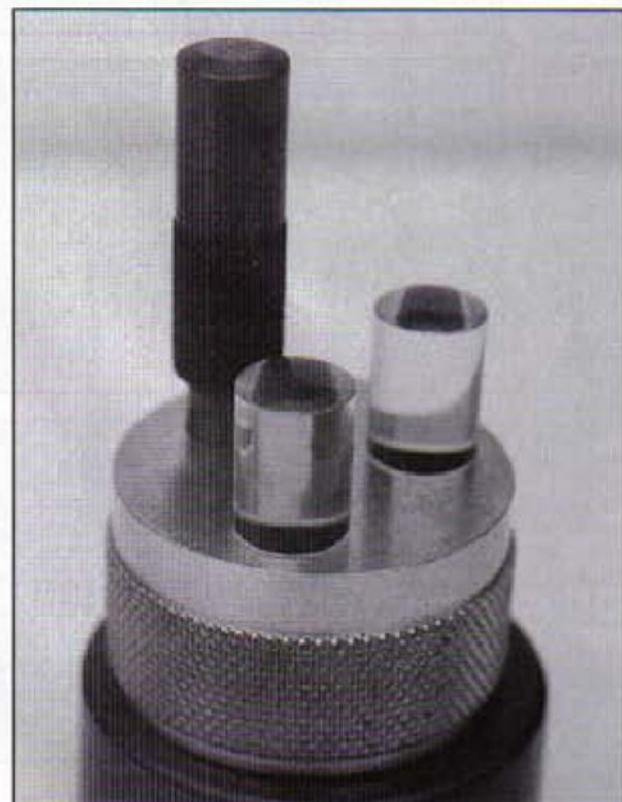
a) A small 'pot' magnet inset in the centre of the base.

b) A disc of fine emery cloth (with the appropriate holes) fixed to the base with an epoxy adhesive.

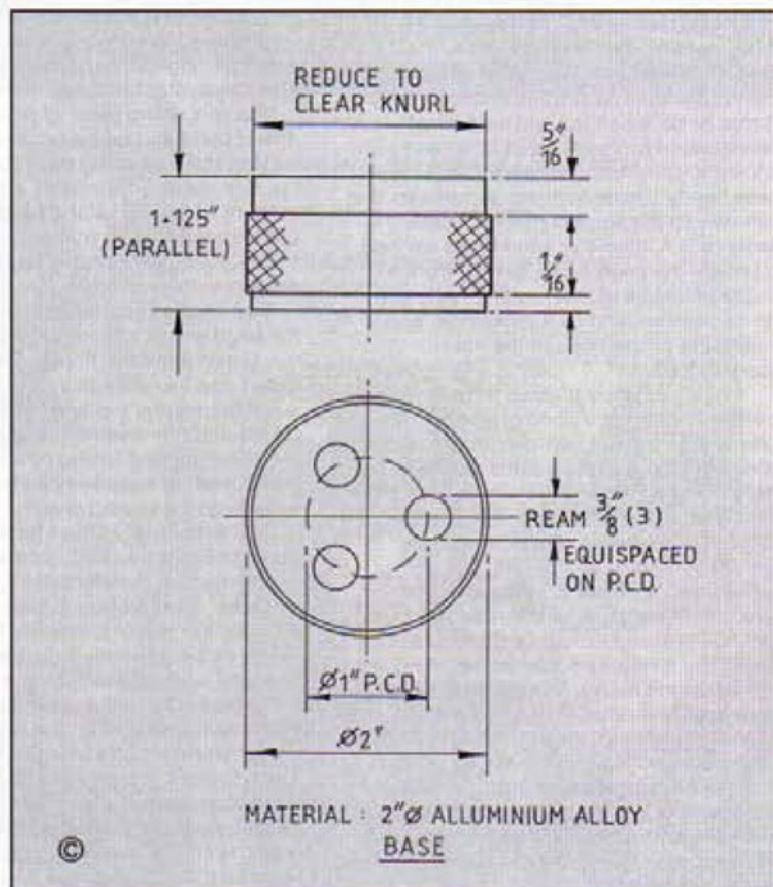
c) A thin piece of cork secured in a similar manner.

With the last two options it would, of course, be necessary to remove sufficient metal from the top of the base in order to bring the two magnifying elements within 0.005 - 0.010in. of the workpiece surface.

In the search for a suitable protective container, the writer was fortunate in finding that the lid of an aerosol paint can fitted a tomato puree tin (opened with a Miracle can opener). A spray of matt black paint on the outside of the tin, together with a disc of felt in the base, was then all that was required to give a professional appearance.



Two views of the completed punch, note the circle and 'targets' incised in the ends of the magnifying elements





The completed dribbler.

A similar tool, charged with heavier oil and kept by the lathe could be useful when turning work between centres, to keep the fixed centre cool and well lubricated without flooding the lathe with unwanted oil.



Construction of the tool is self evident from this photograph.

A BRASS OIL DRIBBLER

I made this oil dribbler as a means of lubricating small parts on firearms without 'flooding' the object with oil. Other methods of doing this could be employed but I also required this oil bottle to appear attractive and fit in with my other gunsmithing equipment, much of which is very old and well made. The oiler is all made on the lathe and is a very simple project although some care is needed.

with the needle.

The material for the reservoir body, **item 1**, was an offcut of 1 1/2 in. diameter solid brass bar, a size which is often obtainable as surplus material. Only 43 mm or so is needed and such small pieces would probably be of little use to an industrial user. As a fortunate consequence these handy pieces of metal sometimes find their way to the surplus market. I have plenty of 1/2 in. diameter solid brass bar and so I made the needle cap, **item 3**, from a couple of inches of this material. Any size can be used so long as it looks right and is in pleasing proportions to the main reservoir body.

It is handy to have the cap knurled in order to provide a good grip when screwing it in or out with the thumb and index finger and I knurled this one very easily using a knurling tool which resembles a pair of pliers and is simply clamped onto the job and held against rotation by hand.

The fixed lid, **item 2**, was parted off from the parent stock of the reservoir body. A small fibre washer can be fitted to the needle cap if required, to seal the filling hole when not in use. Mine is fitted with a small leather washer.

Once completed, the whole bottle can if required, be polished. This can be done in the lathe or using a polishing spindle. A high polish is attained and no further treatment is necessary throughout its life if it is handled properly. As it tarnishes it takes on a 'look of quality'.

How to make it

The piece of bar which has been selected for use is put up in the lathe chuck. First part to be made is **item 2**, so the 35mm diameter outer diameter is turned, followed by the 32 mm diameter spigot. There will be a slight clearance between the lid and the body (if tolerances have been observed) when assembled; this is to aid soldering. While the material is in the lathe a 5 mm hole is drilled in the centre of the lid about 10 mm deep and then tapped M6. This hole will also assist when parting off the component which is now done after breaking all sharp edges.

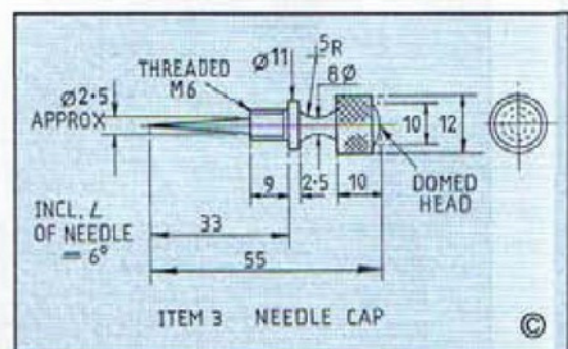
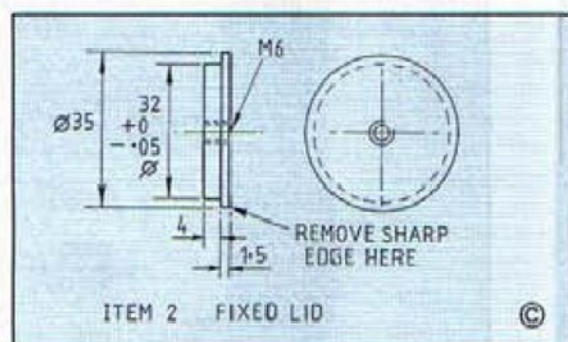
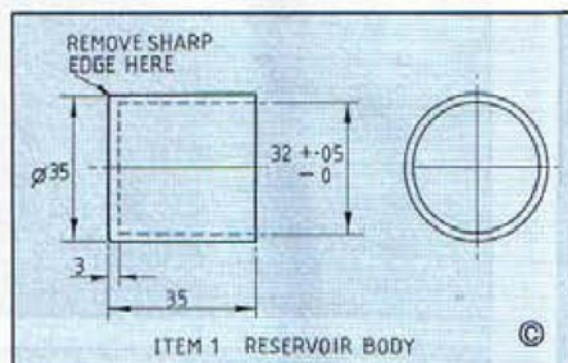
The remaining piece of brass is then drilled blind and bored out to 32mm, leaving the wall at the base thicker than the side walls. This creates a small amount of 'ballast' at the base making the bottle more difficult to overturn on the bench. Both faces should be reasonably parallel with each other.

The needle cap material is chucked and the head end is turned up to and including the 11mm diameter flange. The 5mm radius can be easily plunge cut using a suitable tool and the knurl generated. This completed, the work is reversed in the jaws and gripped (using protective pads interposed between jaws and knurled surface) on the knurled portion.

The remainder of the metal is brought down to 6mm diameter, and then the needle section is reduced to 2.5 mm diameter. The compound slide is set at 3 deg. and the needle is carefully turned. An M6 thread is generated on the 6mm diameter and the machining is complete.

To fix the lid to the reservoir body all that is required is to tin the first 5mm of the bore of the body using any soft solder. The lid spigot is cleaned and coated with flux before being located into the body. The whole job is heated with a blow torch until the solder is seen at the joint, having reached there by capillary action. Once cooled the whole object can be polished

Applying small quantities of oil is frequently a requirement for such activities as clock making, small engineering models and, as importantly for the author of this article, those of a gunsmith. What at first sight appears a simple operation is in practise more difficult than one might anticipate. Alan Jeeves provides this elegant and attractive solution to the problem.



and the needle cap screwed into the lid. The reservoir can be filled with a suitable grade of light oil from an oil can and the brass dribbler is ready for use.

FINAL STROKES WITH A SHAPER

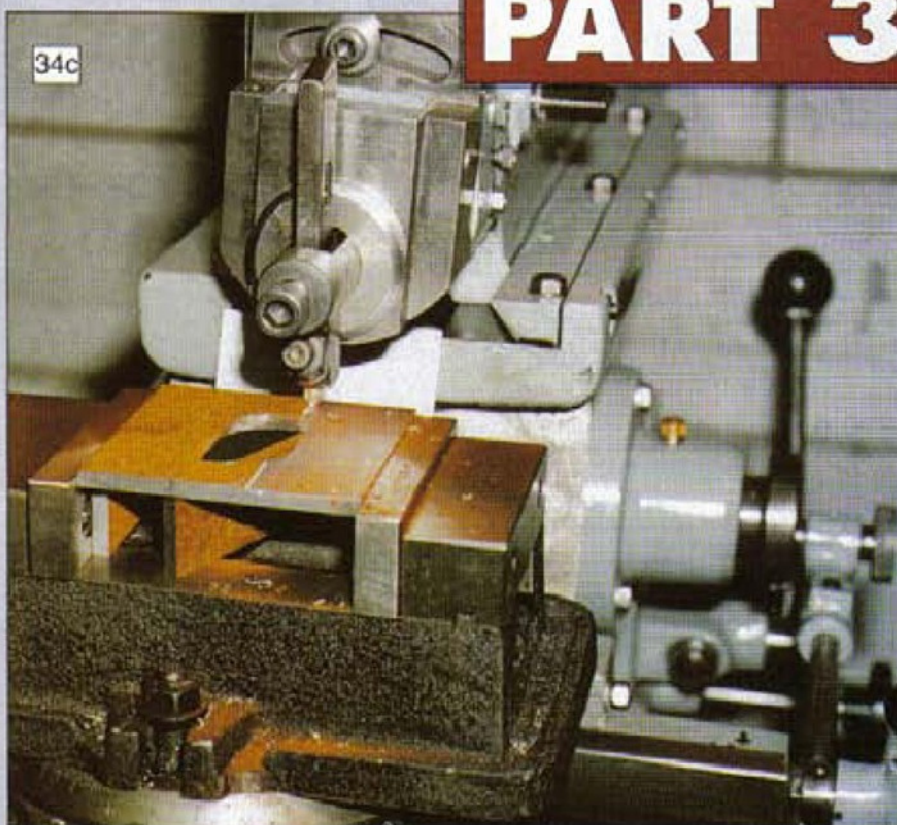
PART 3

Bill Morris concludes his series on the shaping machine, with a brief series of photographs illustrating its potential for a variety of operations

It is often said that a picture is worth a thousand words. In this final part of the series on using a shaper I illustrate a few more shaping operations using photographs and captions to illustrate the processes.

Having read the first two parts of this series the shaping machine should now hold no terrors for you; you will tend to use it whenever you need a plane surface when previously you would have used a milling machine. Odd bits of rusty plate can be pressed into service to profile and slot locomotive motion plates (**Figs.34 a to f**), and the slide bar seats on cylinder covers are easily made square to the part face (**Fig.35**). The battered top surface of your bench anvil will easily succumb to the shaper (**Fig.36**) and you can at last true up that vee block left so badly scarred by its former owner (**Fig.37**).

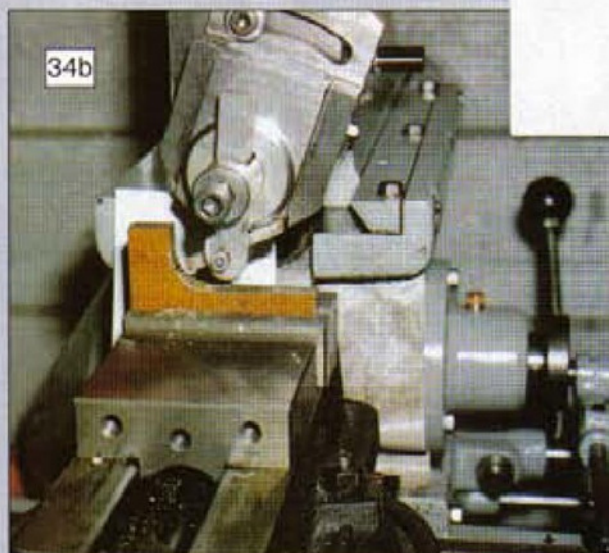
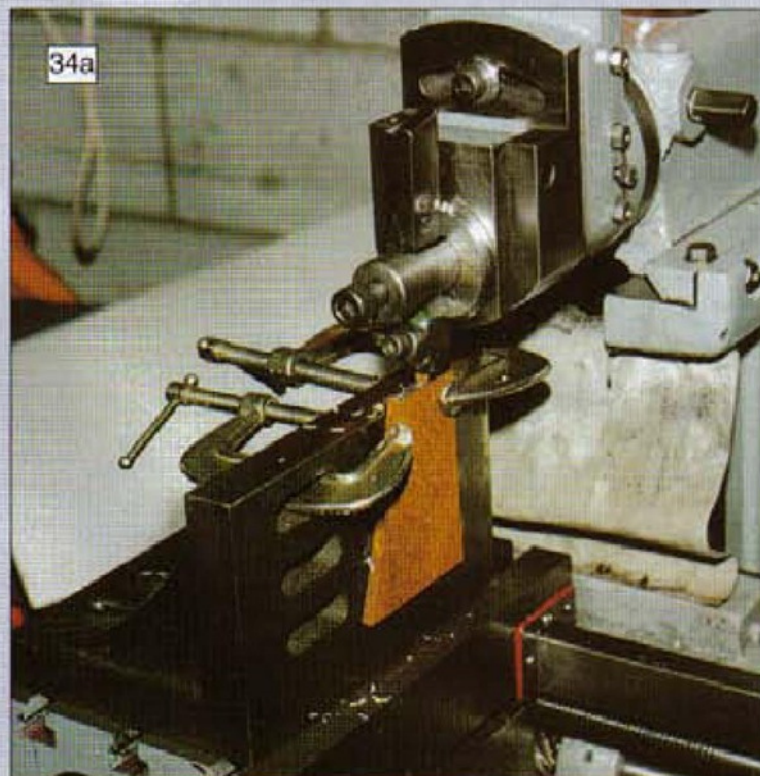
To paraphrase Dr Johnson:
When a man is tired of the shaper,
he is tired of life.

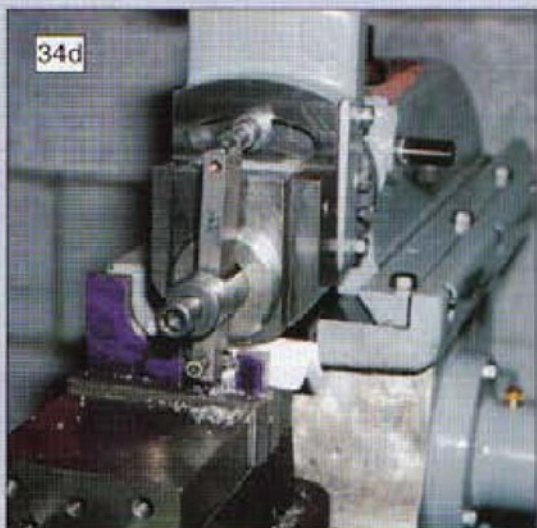


34a: Cleaning the edge of a rusty plate.

34b: Profiling a large radius

34c: Finishing the surface of embryo locomotive motion plates.





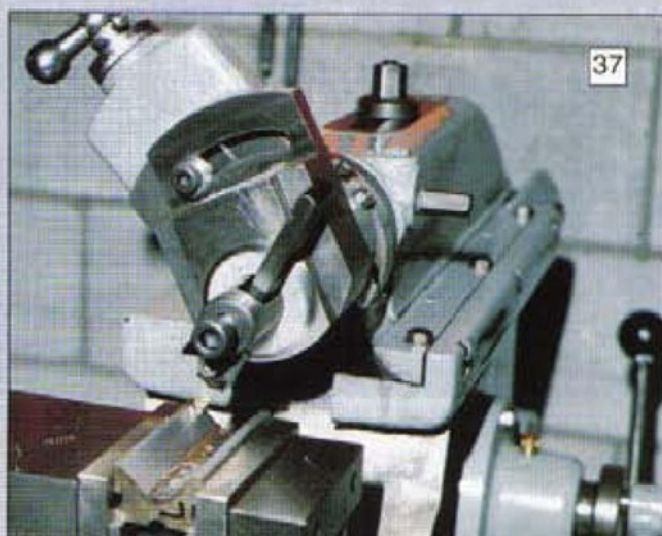
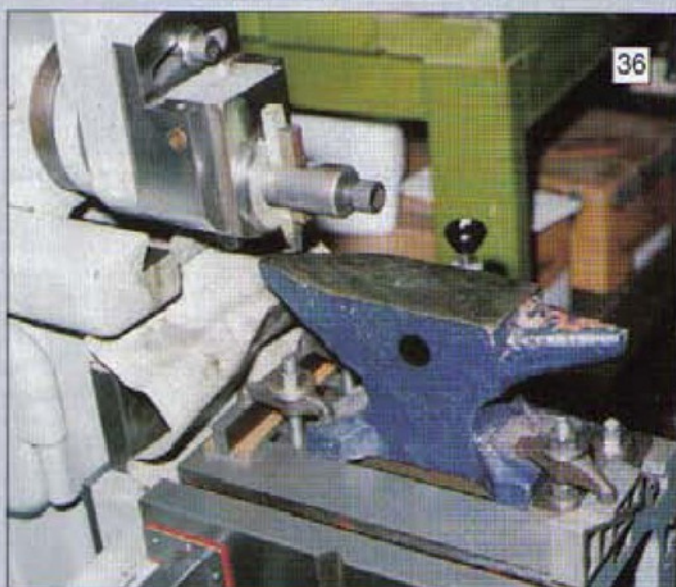
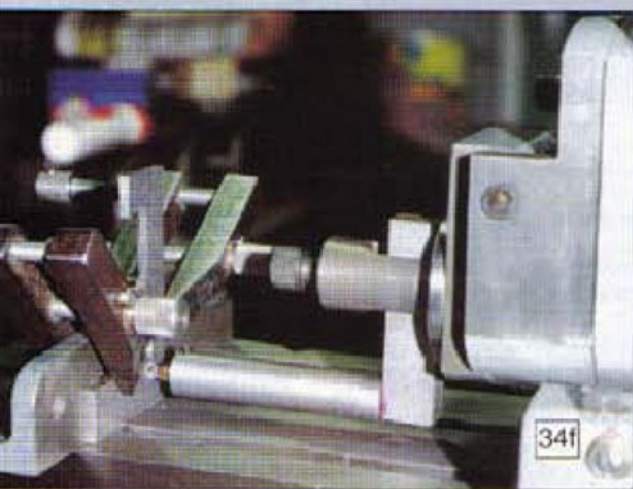
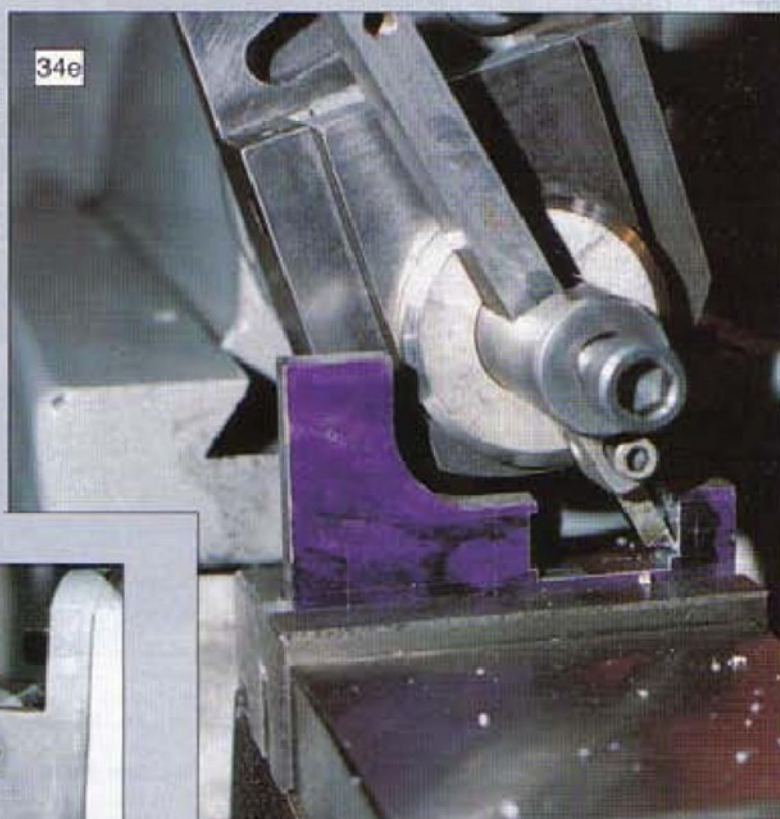
34d & e: More locomotive work, the operation here is preparing seats for guide bars.

34f: Slotting motion plate, note that the clapper box is fixed and a fixed tool carried in a special holder is used for this operation.

35: Preparing the seats for the guide bar on a locomotive cylinder end cover.

36: Cleaning up the working face of the bench anvil.

37: Cleaning up the working faces of a badly battered vee block, this was bought in very cheaply secondhand.



FILE STORAGE

Storing items on the rear of cupboard doors is an excellent way of making maximum use of the space available. John Steele describes his method of storing files and a hack saw in such a position.

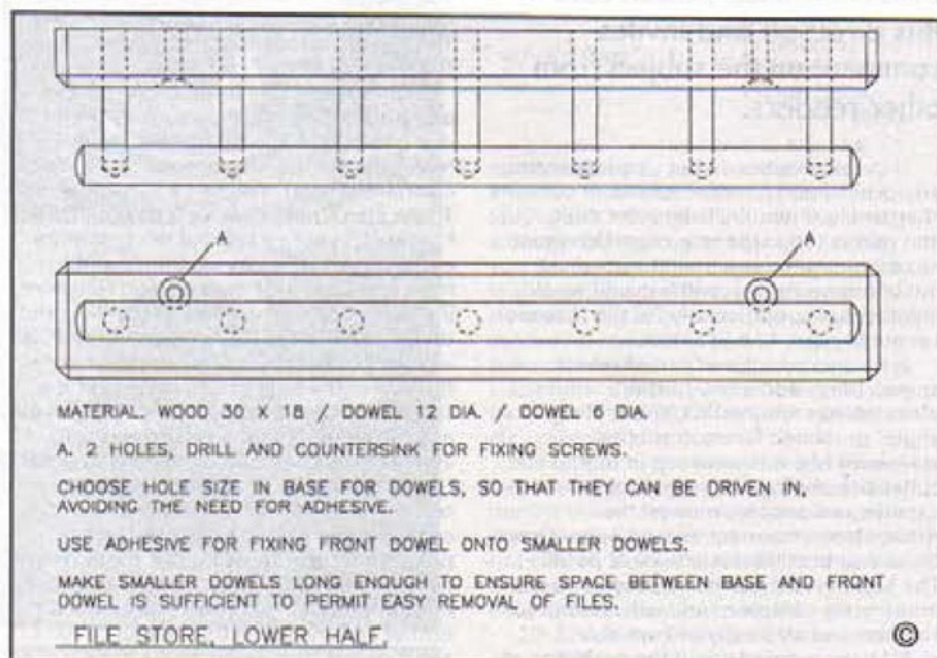
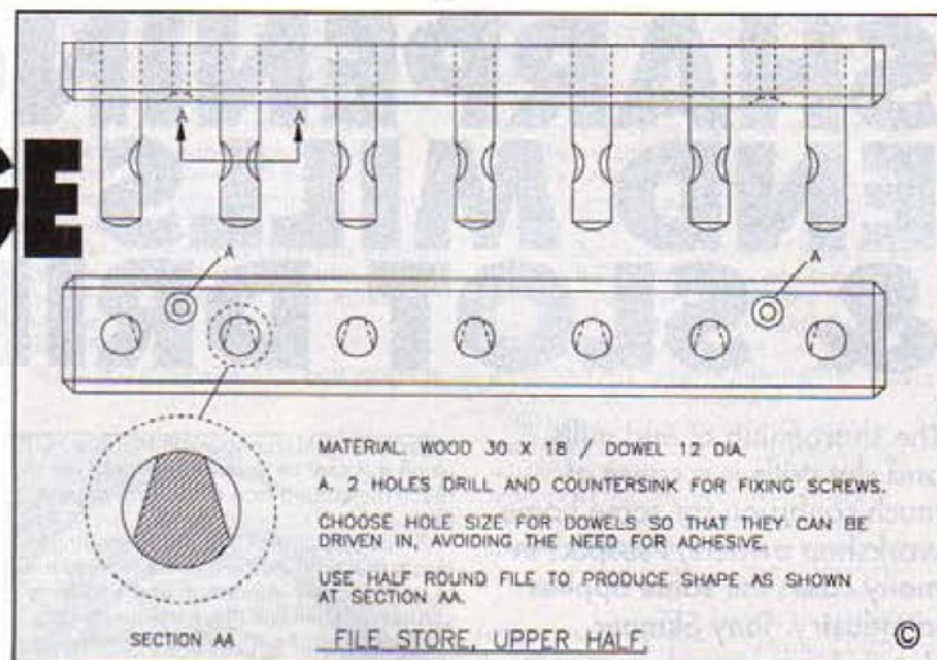
The file store, seen in photo 3 and published in the article describing my new workshop, (M.E.W. issue 24, page 49) has proved so successful that I feel, with the editor's indulgence, that its construction is worth expanding on, in case other readers wish to make something similar.

The drawings really tell the whole story, and little needs to be added by way of explanation. The need was to securely house the files on the back of a door without them vibrating out when the door was opened and closed, and without the need for them to be lifted clear of a clumsy arrangement, such as a bar with holes in for removal.

With the arrangement shown, the files need lifting only some 20mm to enable them to be removed. The secret of this is the small indents made with a half round file on each side of supporting dowels, these enable the door to be slammed shut and yet the files still remain in position. It is preferable that all handles are the same size, and if you are particular about appearance, an extra stroke or two of the file will enable the height of each file to be adjusted so that they all rest at the same level. If handles are of differing diameters then the spacing of the dowels can be varied to suit.

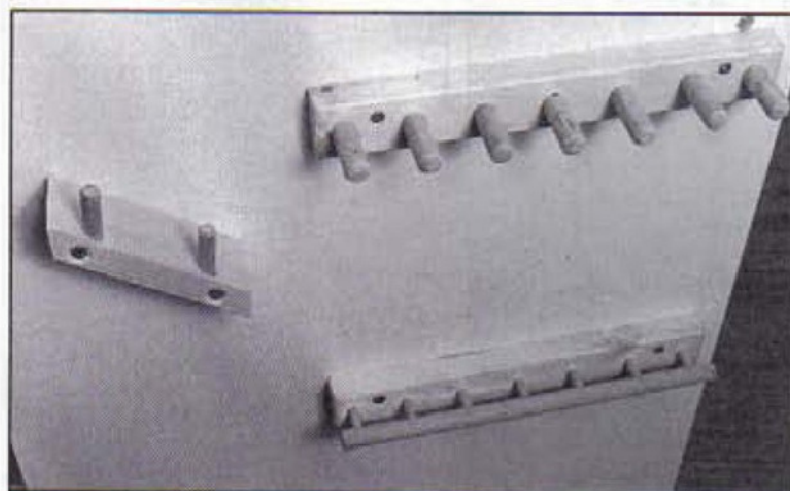
The system would equally suit mounting onto the workshop wall, in which case the dowel on the front of the lower half could be omitted. In fact the whole lower assembly may be considered superfluous in this case.

Whilst not intended to be part of this

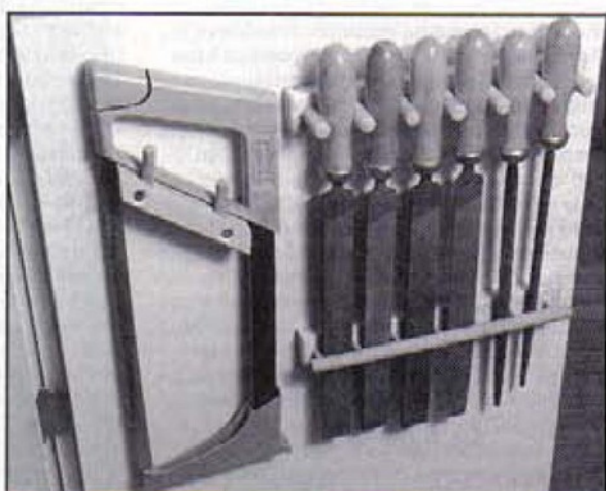


article, the hack saw, seen in the photograph, is worth a mention. This is an Eclipse high strength frame which permits a much higher blade tension than can be achieved with many other frames. As a

result, the saw is much more pleasing and easy to use, and well worth considering. It is of course more expensive being around £13.00 (mine was purchased from Electromail)



The rack seen on the rear of a door, complete with files and hack saw.



The rack without files and saw.

SHARPENING END MILLS & SLOT DRILLS

The sharpening of end mills and slot drills is a cause of much confusion for some home workshop owners; I suspect in many cases the same applies in industry. Tony Skinner details his own endeavours in this direction and invites comment on the subject from other readers.

1) Derek Brookes, in his very interesting article in Issue 17, discusses the sharpening of end mills and slot drills, and makes the extremely important point not to grind off more than the absolute minimum necessary, with which I would heartily agree, particularly for the reasons set out in para. 12 b iii below.

2) He also mentions "a third relief angle". May I add a few further observations around this "third relief angle" or related facets, from the viewpoint of a total newcomer to tool and cutter sharpening, in the hope that experienced people amongst the readership can correct, extend or confirm these points to the assistance of us all. The aspects and geometry's involved are moderately complex, but I will attempt to set them out as clearly as I am able.

3) I have worried about the problems of sharpening milling cutters for very many years, and have had a kit of castings for the Quorn for over 20 years, but never managed to get around to its construction. Recently, having got other details of milling in my small lathe to work pretty reliably, I set out to see if I could knock up, for a smaller time investment than I suspect the Quorn to involve, a stop gap system for end mill sharpening, to keep these milling facilities going until the Quorn is completed (assuming I am spared that long!). At present, this stop gap is looking promising.

4) However, within this recent work I have spent appreciable time looking at the sharpening facets of a range of end mills and slot drills, some new but many secondhand. These latter have been very useful, since (I guess) many of them have been resharpened within the commercial usage field. The primary clearance angle (approx. 6 deg.) and secondary clearance angle (approx. 12 deg.) are easily seen. These two facets would be fairly easy for the home engineer to resharpen with a suitable tool such as that described by Derek Brookes (or possibly by the jig

described by Mr. Longworth in issue 14. If using this tool be extremely careful not to touch the cutting face of the following tooth.

5) However, there are other grinding facets present, of which one seems to me to be extremely important, and also fairly complex. I shall call this particular facet the "end tooth gash", to use the name used by the Presto company in their Counsellor booklet on Engineers Cutting Tools (Publication PC 3, p. 51, [see footnote for details - Ed.]).

6) To explain this further, refer to **Fig. 1** and **photo 1** which shows a 2-flute slot drill which I have resharpened. In **Fig. 1** I have labelled the first, second and third clearance angles, and this end tooth gash. These also show in photo 1, although the lighting has not picked out the rear edge of the narrow primary clearance and I have had to mark it on the print. However, if you look carefully at any end mill or slot drill, you will see that the helix of the flute will only give a front cutting angle over a fraction of the total radius present at the radial tooth position (around a third, as far as I can see). What the end tooth gash, vitally importantly seems to have to do, is to pick up from where the helix flute is beginning not to form an efficient front cutting angle, and to create the best possible cutting angle for this tooth from here inward until this tooth runs out near the centre of the cutter (see 12 below for further comments on this runout). The angle of this front-cutting rake in new cutters seems to be about 2-3 degrees.

7) In many new cutters, the effects of this end tooth gash of extending the tooth front cutting angle toward the centre, may be achieved by a very precisely controlled edge shape to the grinding wheel that produced the third clearance angle. (This can be seen in **photos 3 & 4** which I have provided - Ed.).

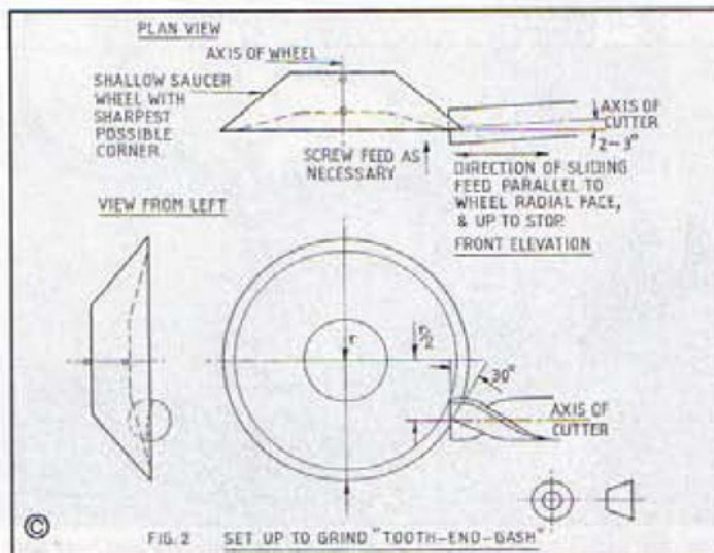
8) However, the set-up mode to which I have just come to generate this end-tooth-gash, is illustrated in **Fig. 2** and **photo 2**. My prototype grinding jig has a sideways sliding action up to an adjustable stop, and a micrometer

in-feed, while the motor and wheel are on a round vertical pillar. Thus although it is much simpler in construction than Derek Brooks' machine, it is capable of very similar actions. The wheel I used is a very shallow saucer wheel of about 75mm OD, with a narrow radial face and as sharp an external corner as possible. The jig was set with its slide horizontal and virtually parallel to the radial face of the wheel. The cutter was set with its axis horizontal, but inclined backwards from the radial face of the wheel by about 2-3 degrees, (see the plan view in **Fig. 2**), and at about 19 mm (i.e. half the wheel radius) below wheel centre height (see **Fig. 2** elevation).

9) The prime reasons for my adopting this mode for the "end-tooth-gash" were as follows:-

a) The critical face to be formed by this operation was the front cutting angle face to the following tooth. It therefore seemed best to generate this from an accurately trued face to the wheel, which is mainly the radial face.

b) It seemed to me as if the narrow



saucer wheel used in this sort of mode could cope with a number of end mill and slot drill sizes (and possibly some rather different uses as well).

c) Having the cutter axis at half the wheel radius below the wheel centre, causes the arc of the wheel perimeter to be at 30 deg. to the vertical at the cutter centre (see the front elevation view in Fig.2). This is then very similar to the usual tertiary clearance angle, if such is present or necessary.

d) I couldn't see any other way of creating this tooth front cutting angle which would be applicable to a fairly wide range of cutters.

10) The setting of the cutter in its holder in the rotational sense is very critical, as is the use of the longitudinal slide feed and the screw feed. I try to illustrate these in Fig.2 and photo 2.

11) The aims of these settings are as follows:-

a) To leave untouched the front cutting angle of the outer portion of the tooth generated by the flute helix shape.

Secondary clearance land
Primary clearance land

b) To pick up from this front rake (really, I suppose, where the curve of the helix flute would start to carry it fairly markedly forward), and to generate a new front axial angle (of about the 2-3deg.), which new front angle runs slightly behind the radial line until it meets a convenient or desired termination point (see 12 below).

12) The optimum form of these settings may vary slightly to suit the particular cutter - end mill, slot drill, its number of flutes, etc.

Specifically:-

a) For end mills where the end recess is

still big enough, the "end-tooth-gash" merely has to run into this recess as convenient.

b) For two or three flute slot drills where one tooth is required to reach to or just beyond the cutter centre,

i) the "end-tooth-gash" for other than this long tooth have to be shorter than that for the long tooth

ii) all the "end-tooth-gash" have to just run into each other, by an amount that avoids any central pip but doesn't weaken the teeth more than is unavoidable. This is the reason that the tooth front so generated has to be slightly behind radial, as mentioned in 11b) above.

iii) because these end-tooth-gashes have necessarily only just to run into each other, this means that only a limited amount of regrinding of the primary or secondary clearances is likely to be possible before the end tooth gashes have

to be reground. This is a key reason to regrind early and keep the amount that has to be removed to the absolute minimum, as noted in 1 above. It is also the

crucial reason to have available an effective means to regenerate this end tooth gash, otherwise you are likely to get a couple of regrinds at best after which you throw the cutter away while it still has lots of good spiral flute length available. However, my inspection of second hand cutters mentioned in para. 4 suggests that even commercial shops can have substantial difficulty in restoring this end tooth gash. Hence, in part, the questions etc., raised in this note.

c) For end mills where the end recess has been largely ground away, I would think it should be feasible to resharpen these by again making the end tooth gash run slightly behind the radial line so that the various gashes intersect, although I haven't had occasion to try this yet.

13) Specific points about these settings are as follows:-

a) To have the gash run in at slightly behind the radial line, requires the upper tooth point to be slightly further away from the wheel than the vertical through the cutter centre.

b) The micrometer screw in-feed has to be very carefully limited to meet 11a), and yet to allow the gashes just to intersect.

c) The longitudinal slide feed has again to be very carefully limited so that the gashes intersect by the required amount at the desired position.

Quite tricky, but photo 1 shows what can be done after very little practise.

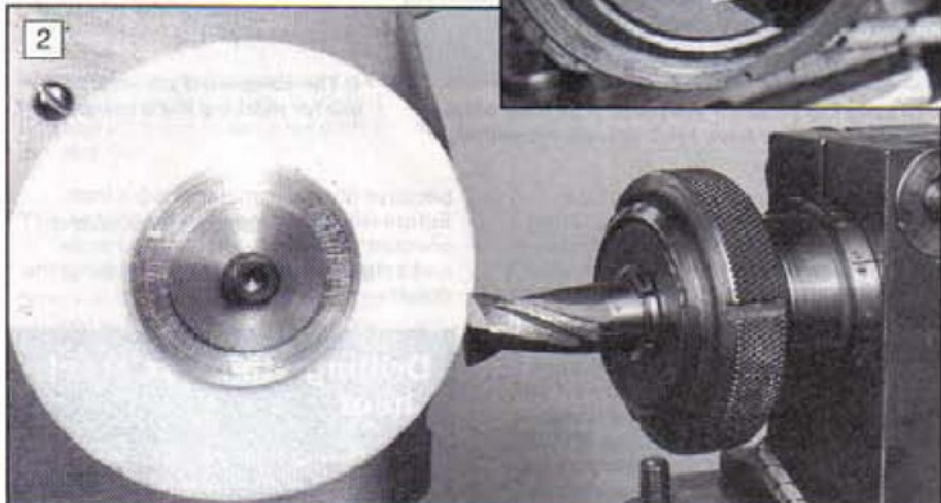
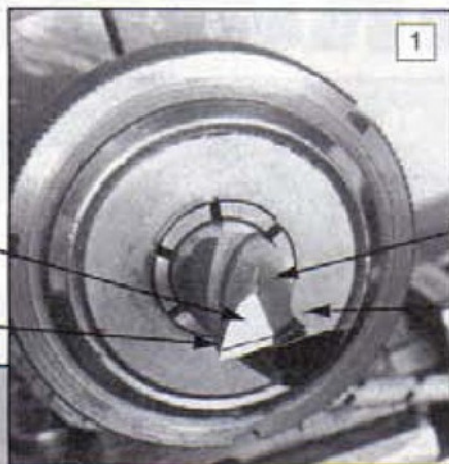
14) I don't know whether having the cutter axis at $(r/2)$ below the wheel centre height, as per 9 c). above, is a conventional way of achieving a 30deg. angle at the cutter centre, but it seems to work quite well.

15) Can anyone with much more experience than I further clarify, extend or correct these ideas.



Supplier address

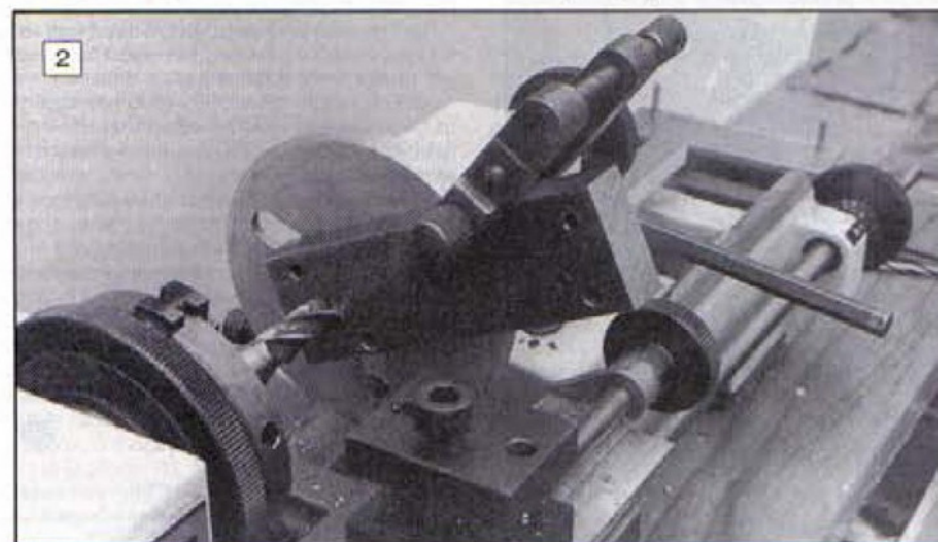
Presto - Easterbrook Allcard and Co. Ltd,
Penistone Road, Sheffield, S6 2FN,
tel. 0742 349361.



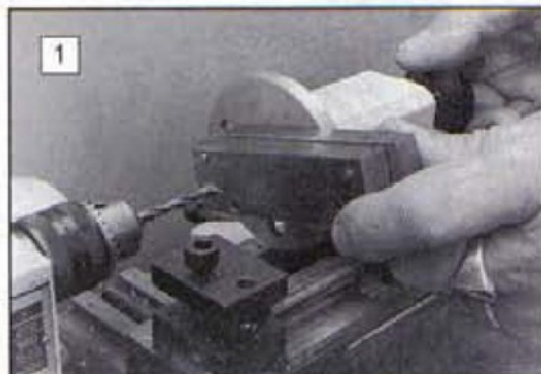
A VERNIER CONVERSION

Not a new idea by any means, but this Vernier calliper to height gauge conversion by R.J. Loader benefits by its simplicity. It is shown being made on a Unimat 3 lathe so it should be within the scope of most home workshops.

There are times when I need to mark out very accurately. Not often, but often enough to think how useful a Vernier height gauge is and wish I had one. I think someone once said that the wish was father to the deed, or words to that effect. In my case it was, because after thinking about the differences between a Vernier calliper and a Vernier height gauge, I concluded that if a Vernier calliper was stood on its head with a scribing nib of some sort fitted to the moving jaw, it was very similar to a height gauge. The other part of the conclusion was, why fork out about £80 for an instrument which would be used infrequently? Especially when I had a perfectly good calliper which could be adapted by making one or two bits and pieces, all well within the scope of my Unimat 3.



2: The set-up for counterboring. This must be done in stages.



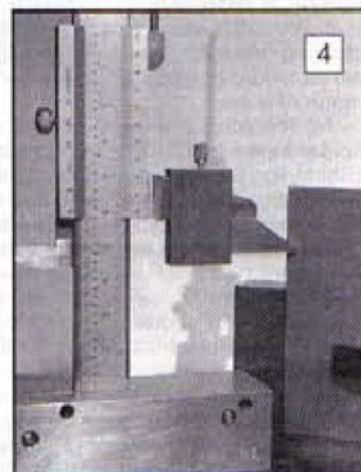
1: Drilling the holes for the bolts. The base blocks and packing piece have been doweled together.

I started with the base and found a couple of pieces of mild steel 25 x 12mm just over 50mm long which would make a good solid base. The idea was to sandwich a packing piece, the thickness of the calliper fixed jaw, between the two other ones, with the shape of the jaw cut into the packer.

The calliper jaw was nominally 3mm and it varied between 0.116in. and 0.117in. I had some 3mm strip mild steel which could be rubbed down, ideally to 0.1155in. as near as possible, so that when the base assembly clamped, it would just nip the calliper without doing any damage. The assembly was to be held together with cap head screws for clamping and located by dowels for accuracy. I worked in a combination of metric sized materials mostly and Imperial where I had to,



3: Finishing the profile in one of the packing pieces.



4: The completed conversion in use for marking out a component.

because my micrometer is a 0-1 inch. Before doing any work on the pieces, I checked that I had suitable cap heads and some 1/4in. silver steel for making the dowels.

Drilling stainless steel sheet

When drilling stainless steel, sheet in particular, it is an advantage to re-grind the drill point to an included angle of 135 degrees. This reduces the length of the cutting edge and the material is less likely to work harden around the hole. Maintain a steady firm pressure on the drill so as to avoid it rubbing and stop and sharpen the drill if it shows any sign of distress.

Alan Jeeves

The base

I began the base by drilling pilot holes where I wanted the dowels to go in one of the base blocks. Fig. 1 shows the positions. The size of the drill can be No. 39 or 40. Not having a drilling machine yet, I used my Unimat as a horizontal drilling machine by screwing the face plate to the tailstock for a table and the drill chuck to the spindle. The photograph shows the set-up. It isn't the first time I have mentally thanked the designer for identical threads on spindle and tailstock.

Having drilled pilot holes in the one block I clamped the two together with the 3mm strip between them. I had cut the

strip roughly to size with one edge as flat as possible. The clamping must be done accurately; a small variation lengthways will just need some work with a file at the end of the job. If the three surfaces which form the base aren't flat, trouble will crop up later. The best way is to level them off on a surface table, if not, a piece of plate glass, failing that, a machine table or other true machined surface. Check when the clamp has been tightened in case it has moved anything.

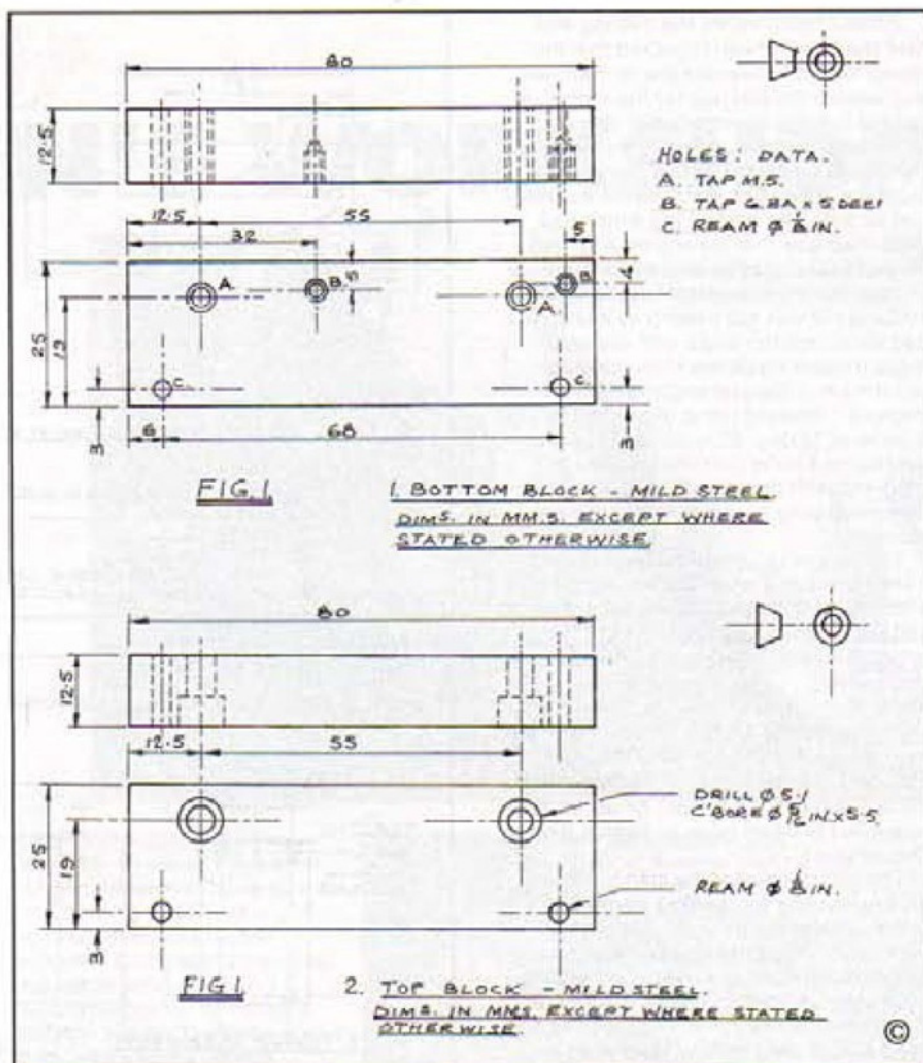
With everything clamped the dowel holes were drilled for reaming, a No.31 drill (0.120in.) will leave near enough the 10% the reamer likes to take out. I reamed the block by hand, still clamped together as one piece, leaving off when the reamer poked through about $\frac{1}{16}$ in. so that the dowels would be a press fit in the one block and a sliding fit in the other and the strip. The dowels were tapped in at this stage and the assembly checked to see that it came apart as it should. It didn't, so I fiddled about a bit with the reamer until it did.

When one block would part reasonably easily from the other, the now solid sandwich of blocks and strip was clamped again and I drilled and tapped for the screws. I used M5 cap heads but 2BA would do just as well. The screws don't have to be let in flush but it does look neater. If it is a problem, countersunk screws could be used. It is not an easy job to counterbore by the method I was using and needs taking out little by little. I finished off my counterbores with a $\frac{1}{16}$ in. dia. slot drill.

The packing piece

The next major job was to make a profile in the packing piece to fit the fixed calliper jaw. It must be accurate, especially where the beam of the calliper fits and although it is possible to cut out the complete shape, it isn't easy. An alternative is to fasten the strip to the lower block with 6BA countersunk screws and then cut it into two pieces, the pieces will still locate accurately and it will make life easier when filing out the shape. The cut is made so that the two parts nip the beam in position and as long as enough of the jaw shape is left to locate in the packing, there can be quite a gap at the bottom too.

The beam of my calliper, which is a

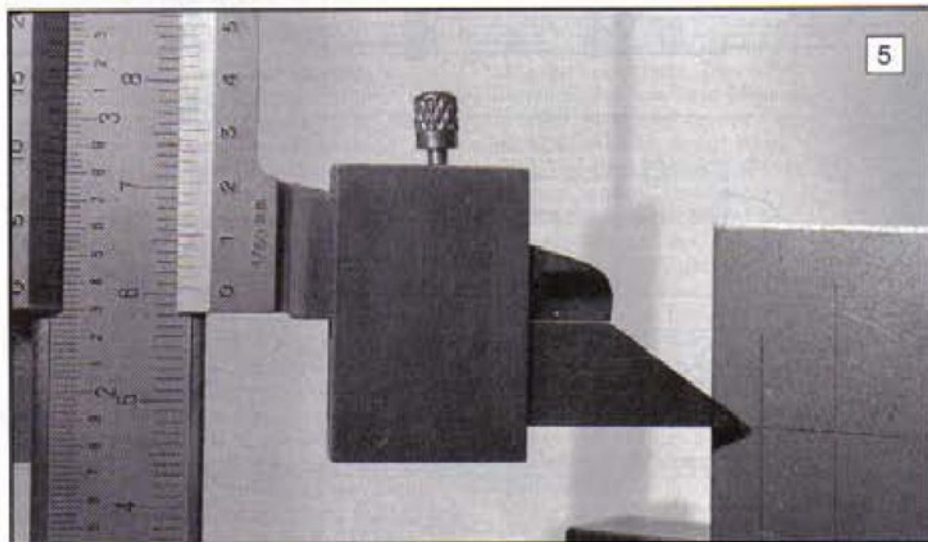


Mitutoyo, measures 0.625in. I expect the nominal size is 16mm I have checked another calliper of the same make and a Kanon; they are both the same within a couple of thou - the fixed jaws are also the same shape. I took care to mark out the gap for the beam so that the rest of the jaw would lie where I wanted it to. The rest was just careful cutting and filing till the beam fitted without any shake. With the calliper laid on the packers and lined up with the filed slot, the jaw profile was scribed round. I cut as much as I could with a junior saw and filed the rest. I used an

Abrafite to cut relief holes where the jaws came to a point. The photograph shows one of the pieces being finished off. Fig. 2. shows the main dimensions.

The scriber and clamp

Figure 3 shows the clamp and scriber. The clamp was a sandwich; 3mm mild steel used for the inner strips, and $\frac{1}{16}$ in. for the sides, fastened together with rivets made from $\frac{1}{16}$ in. dia. mild steel welding rod. The inner strips were made too long by about $\frac{1}{16}$ in. each side so that they could be filed off flush after the riveting was finished. I marked out one side only, clamped everything together with the smallest parallel clamp I had and drilled the $\frac{1}{16}$ in. holes. With the pieces still clamped I countersunk the drilled holes lightly, no larger than 0.080in. is the ideal size. There are two main reasons for poor countersunk riveting; one is making the countersinks too large so that they are difficult to fill up; the other is to have too much rivet sticking out so that a lot of hammering has to be done to close them down. For what I was doing I made the rivets long enough to stick out each side $\frac{1}{16}$ inch. To be quite safe it isn't a bad idea to soften the rivets before starting so that they will be as malleable as possible. I knocked them down carefully, working first from one side then the other, using the flat face of the hammer as much as I could and only using the ball pein to finish off.



5: A closer view of the clamp and scriber.

When I had finished the riveting and filed the bumps flush I checked that the clamp would fit over the jaw as it should and leave a parallel gap for the scriber. It did neither, the hammering to close the rivets had distorted it. The damage was put right by filing the clamp out using a 4in. pillar file, a 4 or 6 in. warding file will do just as well. The other thing which had happened was that the angled strip had magically changed its angle and the piece of scrap which was pretending to be the scribing nib was not seating as it should. I had measured the angle with the only angle measuring device I have, a plastic pro-tractor, it gave an angle of $13\frac{1}{2}$ degrees. I checked using trigonometry and it came to 13 deg. 40 minutes. Whatever the reason for the error it was soon put right and with the substitute scribing nib fitting correctly it was time to make the real one.

The scriber or scribing nib was made from a piece of a worn out 6in. hand file which I had softened. A slice was cut off and filed to the size shown in Fig.3. The important dimensions are the thickness, so that it doesn't wobble about and the edge which fits against the jaw. Once finished it can be hardened. Only the tip needs to be hard, about the first $\frac{1}{8}$ or $\frac{1}{4}$ in. This will allow it to be quenched in cold water and not tempered, so that it will be as hard as possible. I finished mine by honing it on a fine oil stone.

The trickiest part of the clamp was drilling the hole for the 8BA clamping screw. It must be in the middle because there is very little room to spare at each side. I drilled it using a redundant sewing machine motor which I have adapted to take a small chuck. It functions well as a hand-held drilling device; I had used it earlier when drilling the $\frac{1}{8}$ in. rivet holes.

The last item was the clamp screw. I made it from brass because I had some ready knurled. The reason why the head is small is so that it will give enough pressure to clamp but not too much. Brass is ideal because it is softer than the calliper jaw and won't damage it. The screw has a spigot turned on the end so that it won't spread the thread under the clamping pressure.

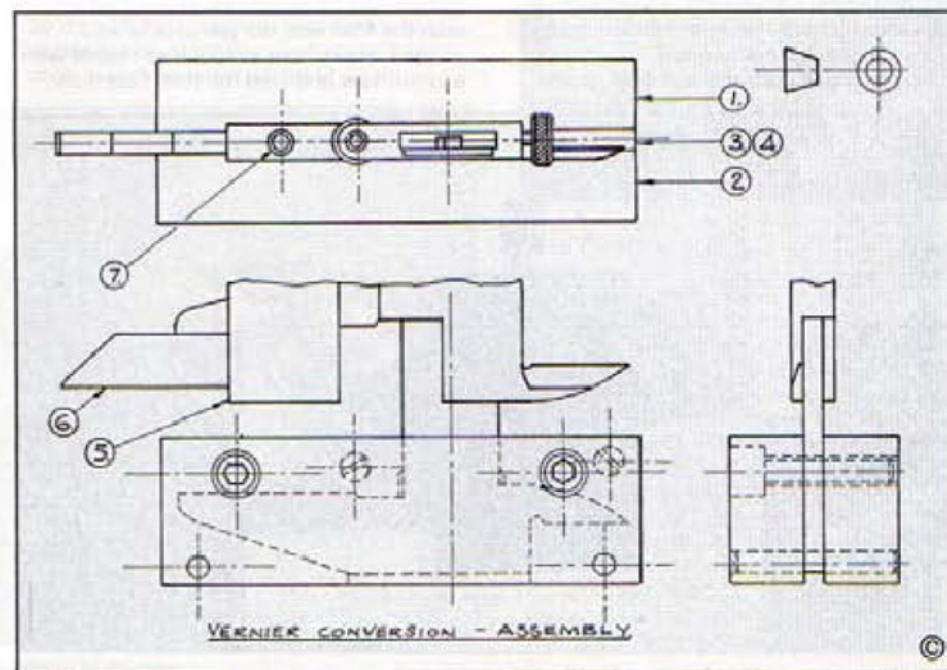
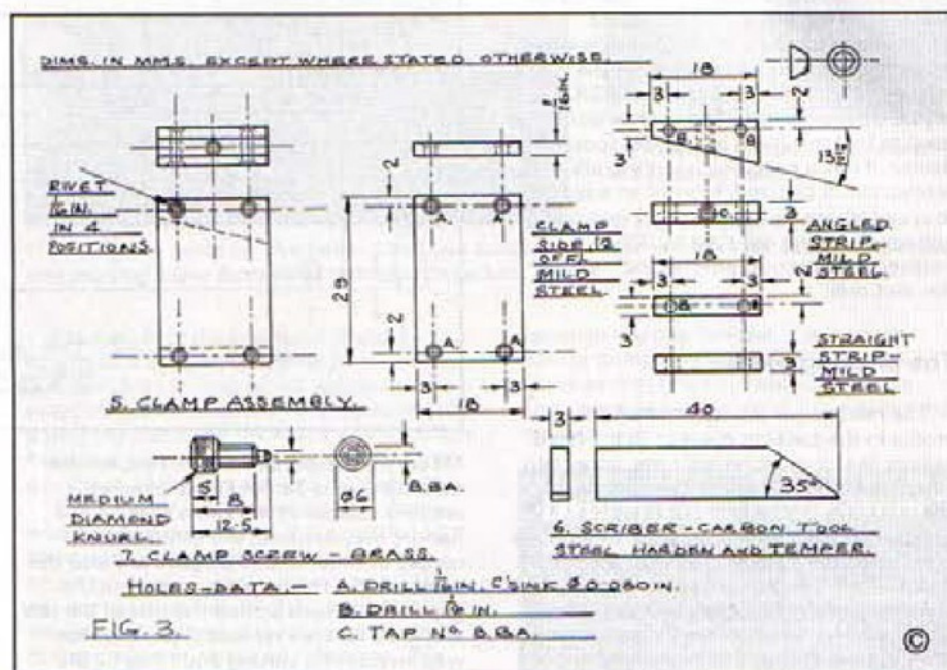
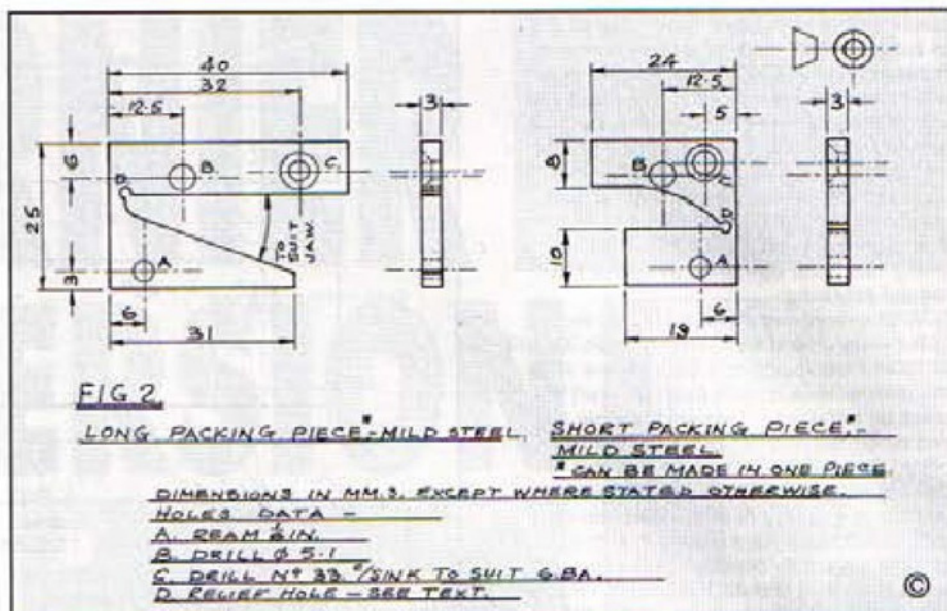
All that was left to do was clean up and thoroughly de-burr all over. The base could be oil-blackened and lapped flat on the bottom if the equipment is available.

It works well with a minimum height of $1\frac{1}{4}$ inch. For work which is smaller, the workpiece can be stood on parallel blocks. When scribing lines, keep the nib as flat as possible against the work, it will last longer between sharpenings. Sharpen with a stone rather than grinding. A cork fitted over the depth probe will avoid accidents. Verniers are one of the most versatile instruments in the workshop, by making these few simple components that versatility is increased no end.

Did you know?

The Chrysler Building tower in Manhattan, New York, U.S.A. was capped with stainless steel in 1930, it has remained in position, and gleaming ever since.

Alan Jeeves



We visit GUY KEEN'S WORKSHOP

We visit Guy Keen this issue. He is one of our younger readers and has both professional and non professional interests in mechanical engineering.

Early correspondence in Model Engineers' Workshop magazine included a number of letters from readers expressing concern as to where new participants in the home workshop hobby would come from. This was considered especially a problem in view of the decline in the engineering industry and the number of young people entering the metal working trades. A number of readers expressed a wish that M.E.W. may be instrumental in encouraging young engineers. Readers surveys and correspondence show, that, while the majority of readers are in an older age bracket, not an insignificant number are still on the lower rungs of the ladder. One such reader is the subject of this reader visit.

Tank locomotive Tich first model

Guy Keen, now 28 years old, first gained an interest in engineering at the age of 13, when his father purchased a Unimat 3 lathe. With this lathe, and some ingenuity, the two of them made their first project, the 3 $\frac{1}{2}$ in. gauge, 0-4-0 tank locomotive, *Tich*. The Unimat was soon replaced by a Myford ML4, the increased size of which made the next two modelling projects much easier. These consisted of the 3 $\frac{1}{2}$ in. gauge, 2-6-0 locomotive, *Princess Marina* by LBSC and the six column beam engine, *Lady Stephanie* by Tubal Cain.

During this time, a need was found for accessories to supplement the equipment available, many of these being made, rather than purchased. In any case, when eventually studying for a degree, making workshop equipment became a logical alternative to model making, due to the limited time available for workshop activities. Guy has recently moved to a home of his own and, like the vast majority of young people in such cases, finds that money has to be carefully apportioned. As a result, making, rather than buying, is the order of the day. He has now constructed his own 10 x 8ft. workshop, which has been up and running for two years. This has a concrete floor and is of a wooden construction, insulated with loft insulation and lined with plaster board. His machines to date are an ML7 and a large pillar drill of unknown origin. Guy spends most of his workshop time making items of workshop equipment, which, at least for the time being, he prefers to model making. He points out that in many cases these are items that he first made in his father's workshop and is now a case of second time round.

Look at **photo 1**, of his ML7 it shows the countershaft clutch that he made from



1: ML7 complete with countershaft clutch made to the M.E.W. design.

the design published in the June/July 91 issue of M.E.W. It can also be seen in close up on the Contents page. Like a number of readers he had problems with getting the clutch to engage securely, and overcame this by the use of a stronger spring. The lathe is also fitted with a screw cutting gearbox which is not considered to be of Myford's manufacture. This is illustrated in **photo 2**, can any reader shed light on its origins?

Degree in Mechanical Engineering

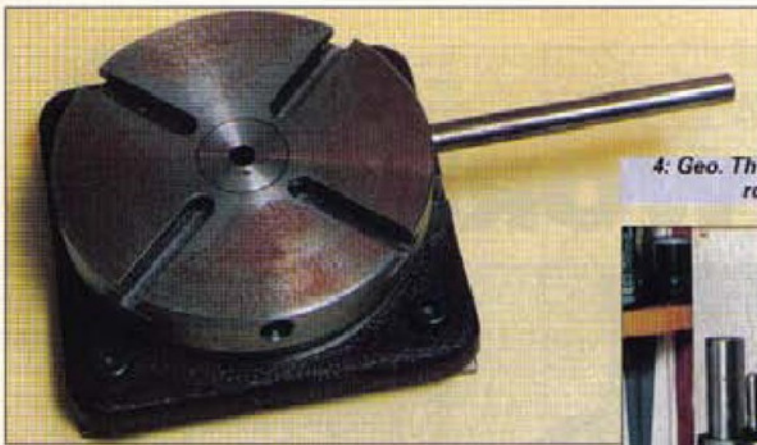
Guy has a degree in mechanical engineering which he gained at Hatfield Polytechnic, now called the University of Hertfordshire. During the early part of this four year course, machine shop practices were studied, part of which was to make a bench vice on a production line, as would be used in industry. This rather unusual vice is seen in **photo 3**. Around the workshop are a number of items designed by Geo. Thomas. **Photo 4** shows his non geared 3 $\frac{1}{2}$ in. rotary table, while **photo 5** is of a Universal Pillar Tool, Guy is a fan of Geo. Thomas's designs. Another can be seen in **Photo 6** which shows his boring tool holder. **Photo 6** also shows, in addition to the wiggler and centre finder, a device for cross drilling round bars in the lathe. This simple device is first made by setting a suitable block of mild steel under the tool clamp on the top slide of the lathe and, while in this position, drilling a hole using a drill in a chuck in



2: A screw cutting gearbox of uncertain origin.



3: An unusual bench vice made as part of an engineering degree course.



4: Geo. Thomas's non-geared rotary table.



5: Universal Pillar tool, also designed by Geo. Thomas.



7: Fabricated vertical slide and vice.



8: Fixed steady for the ML7.

the lathe spindle. This hole is now at centre height and with the block turned through 90 deg. the item to be cross drilled is inserted and drilled, first with a centre drill and then by a drill of the size required. A screw is added to the jig to hold the workpiece securely whilst being drilled.

A major project is the vertical slide and machine vice in **photo 7**. These have been fabricated from stock materials, a method that was particularly beneficial in avoiding the necessity to machine the tee slots.

Photo 8 shows a fixed steady made from a College Engineering Supply casting and **photo 9** a set of toolmakers clamps. The

blackened set were apparently used for holding an item being silver soldered and finished up with a pleasing black appearance as a result. Guy feels that they had a coating of WD40 prior to being used in this way.

A very ambitious project being undertaken at the moment, and well under way, is a Vernier height gauge. Guy has made his own scales for this using the lathe lead screw and a single point engraving tool.

Time spent in the workshop amounts to around 15 hours a week during the winter and 6 hours during the summer. I should point out that he is a single man so there is also does his own housework. Even so, he still finds time for many other activities and is definitely not a one track man. These include, DIY, very much in evidence with a new kitchen being fitted, Wargaming, reading, golf, car mechanics, also lighting and sound for a local amateur dramatic society.

We thank Guy for letting us into his workshop and showing us the work he is undertaking. We are, as a result, very encouraged.

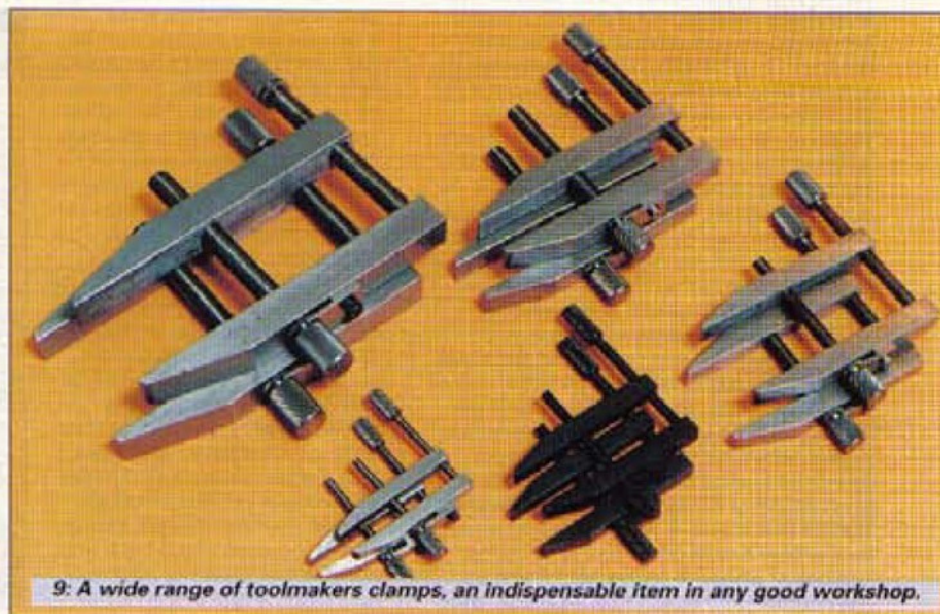
Suppliers

Fixed steady; College Engineering Supply, 2 Sandy Lane, Codsall, Wolverhampton, WV8 1EJ. Tel/Fax 0902 842284.

Rotary Table, Universal Pillar Tool; A.J. Reeves and Co (Birmingham) Ltd. Holly Lane, Marston Green, Birmingham, B37 7AW. Tel 021 779 6831.



6: Some smaller items including Guy's own cross drilling jigs.



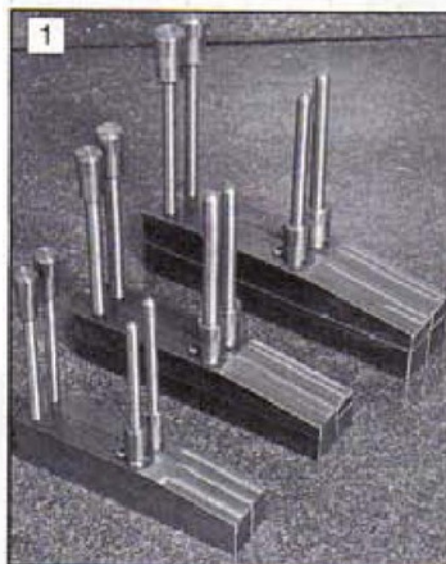
9: A wide range of toolmakers clamps, an indispensable item in any good workshop.

TOOLMAKERS CLAMPS

John Steele starts to put his new workshop to use by making some toolmakers clamps. However, they are of particular interest as they are made to a non traditional design.

With my new workshop in a reasonable state of completion it was time to start putting it to use. The first task was to make those items of workshop equipment, necessary for the easy use of the workshop, which it had been decided should be made rather than purchased. The short list was, toolmakers clamps, angle plate and toolmakers vice. I was soon to learn however that, before I could complete some of these, another item of equipment would be necessary, from reading this magazine, not an uncommon situation I would believe. When I attempted to make the vice I found a hole was needed larger than I could drill, and the casting was obviously too large for it to be bored on the lathe.

A boring head for the mill was the answer, but more about that in a later



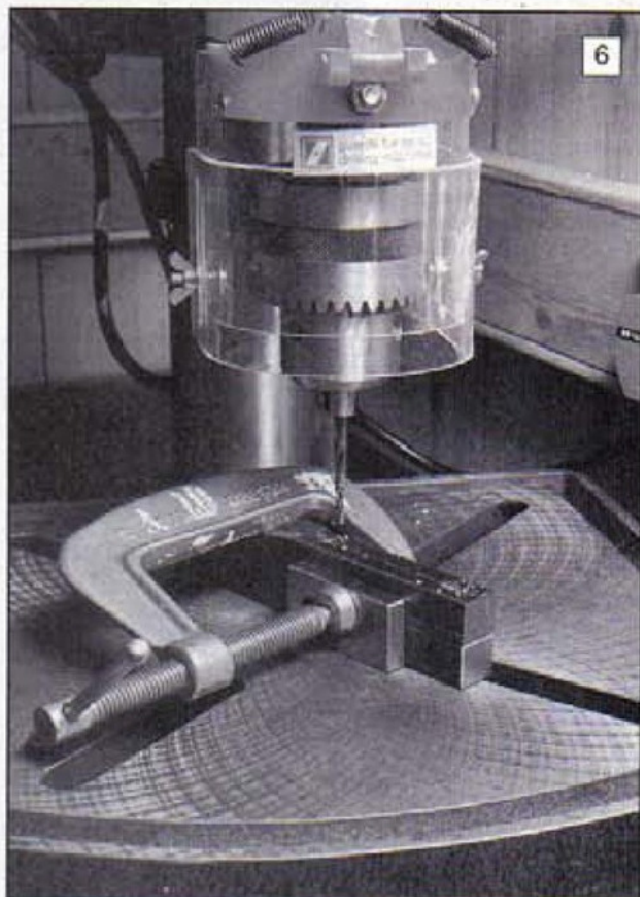
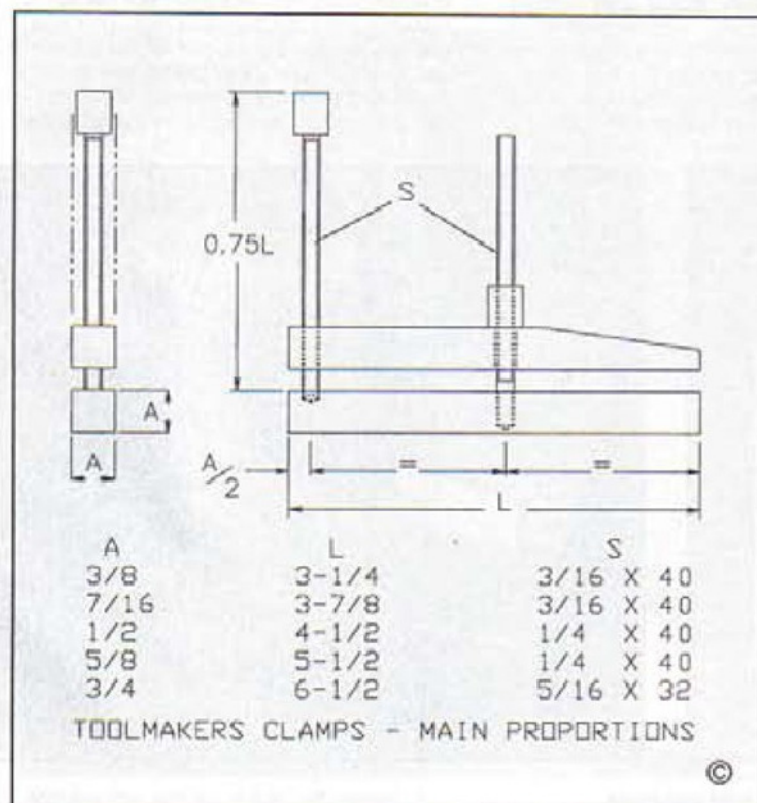
The three sets of finished clamps. One benefit of the alternative design is obvious.

article. Of course I had to make some tee nuts and clamps for the milling machine, but this is commonplace and not worthy of more than this one mention.

An idea from Scribe a Line

Toolmakers clamps were detailed in an early issue of MEW (Oct/Nov 1991) and I see no point in publishing another full set of dimensions. With a few minor exceptions, for one reason or another, the ones I have made followed generally the dimensions quoted. Realising that some readers will not have that copy I am providing a schedule which should provide guidance for all the major dimensions. I did however take up the idea put forward by two readers (*Scribe a Line*, Dec/Jan 1991/92 issue) for the clamps to be made to a design somewhat different to the norm. The final result can be seen in **photo 1**. Why clamps are not available commercially to this design I do not know, the advantages seem to outweigh the disadvantages, more about that later.

I soon found that even with these simple items I was to find some difficulties due to



Drilling a pair of arms in the same operation, so as to ensure the holes line up.

lack of equipment. It was as a result, necessary to bring into service some G clamps from the woodworking kit. This can be seen in **photo 2**, where four lengths of steel are being held as a group for machining the ends of a pair of identical clamps.

The next stage was to machine the taper on the ends and this was carried out as seen in **photo 3**. The end not being

either side for added security. Movement of the workpiece during machining is at best an inconvenience, and at worst a spoilt workpiece, maybe even a broken cutter and a safety hazard, so it pays to be sure.

With all six pairs of arms machined it was time to mark out and drill. One from each pair was marked out using the small surface gauge and surface plate. To establish the centre line of each arm, the height gauge was deliberately set to a height very slightly less than half the arm width. With this done the arm was marked twice, once from each side of the arm, the two lines enable the centre to be established very accurately. This can be seen in **photo 4**. Two vee blocks were then used, as in **photo 5**, to position the bars accurately upright, when the position of the holes along the length were marked out.

It is obviously preferable

Polishing stainless steels

Scoring of the surface is common when polishing stainless steel using a polishing wheel or mop. To prevent this, put a little tallow or lard onto the mop, the result will be a much better quality finish.

Alan Jeeves

together. This operation can be seen in **photo 6**, the G clamp again being pressed into service. Whilst each size was accurately marked out, some wander of the drill may take place, it was therefore, considered preferable that they were retained in their pairs. Simple marking of the inner faces in the none clamping area with centre punch marks made this easily possible.

It was now time to make the turned parts and the Hobbymat lathe was very much at home with these. **Photo 7** shows the commencement of turning the nuts with the slot for the lift off screw. The slot being made using a small parting off tool. However, the absence of a two wheel knurling tool presented a problem, and I was loath to make a temporary single wheel tool due to the strain I considered this would place on the machine. I therefore opted for the arrangement seen in **photo 8**.

Avoiding knurling

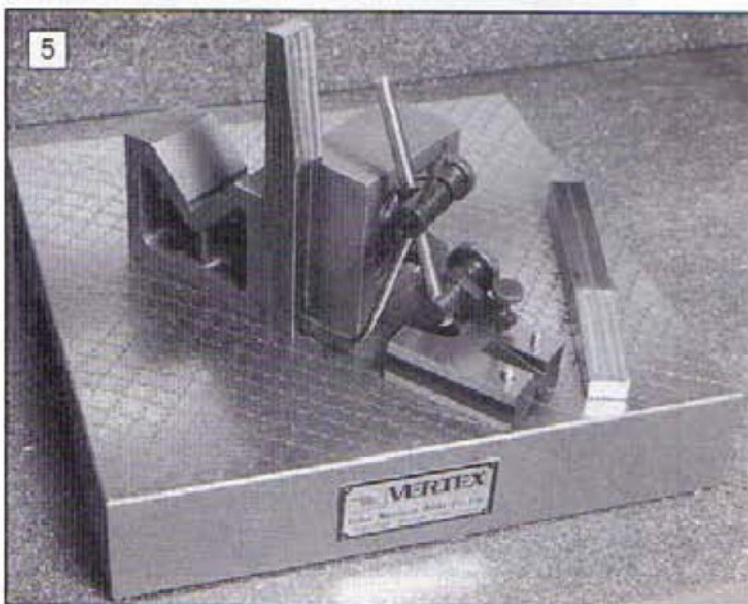
The small grooves around each nut and screw head were made using a small round file, and this was done whilst the part was being held in the bench vice. The first one I moved around the circumference endeavouring to make each slot the same distance from the previous one. This was not totally satisfactory, as I ended up with a space which was wider than those already made and yet too close for an additional slot. I therefore decided to be a little more

Machining the ends of four pieces to make a pair of clamps.

machined was rested against the inside edge of the front tee slot and the other end raised by a piece of round steel resting in the rear tee slot. The diameter was chosen to achieve a suitable angle, which of course is not that critical. It was considered that the grip provided by the two clamps spanning the bars would be insufficient, and because of this, additional blocks of metal were provided

The method adopted for machining the tapered ends.

that the holes in each half of a pair of arms line up so as to ensure that the two arms come together accurately. The best method of achieving this was to drill each pair



Marking out the hole positions.

precise. Making a simple dividing device seemed a little extreme as, in any case, I would probably replace them with knurled heads when knurling facilities were available. The compromise method adopted was to make the first slot and then make one immediately opposite as accurately as could be achieved by eye. The pair of slots were then halved on each side to make four slots and then each gap halved again to make eight, this gave a reasonably consistent result, and is quite acceptable for the purpose. To save on turning the other head was also made a separate item and fitted very tightly onto a stud, also using some adhesive, to make the complete screw. The small lift off screws were screwed into a tapped rod in the lathe and the step on the rear also made using a small parting off tool, as shown in **photo 9**.

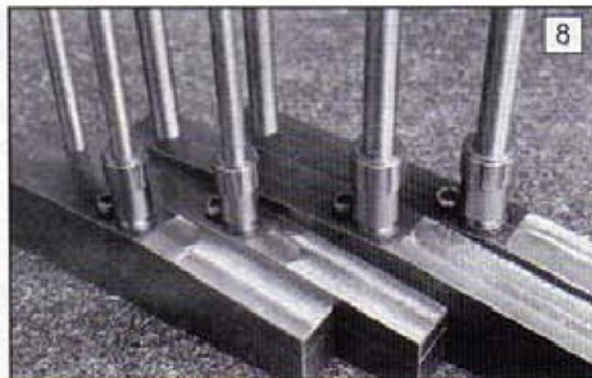
The pros and cons

Finally holes for tommy bars were drilled in the screw heads, but here lies the only disadvantage, as it is not possible to provide a tommy bar hole in the nut. This makes it impossible to make any adjustments with this once the clamp is reasonably tight, should the clamp not be bedding down properly; essential when

being used in a machining operation. (There is a short article on this very subject elsewhere in this issue - Ed.). To make an adjustment, it is necessary to loosen the screw, make a slight turn to the nut, and re-tighten the screw. An alternative would be to make these with hexagonal material so that a spanner could be used. If this method is adopted, do ensure that the across corners of the hexagon chosen is less than the width of the jaw, as some times it is useful to be able to use the clamps resting on their side. I did say one disadvantage, but one other minor point is that they are slower to open and close than the conventional type. Their main advantage becomes obvious when **photo 10** is viewed. This has benefits in many applications, drilling, milling, use on the bench in assembly activities, also surface plate work. They are also much easier to store on the shelf, **photo 1** is an indication of this.

Next project

The next project was to produce an angle plate, and whilst this was accomplished without the use of a second



In the absence of knurling facilities the heads were made as seen in this photograph. The grooves were made using a small round file and positioned by eye.

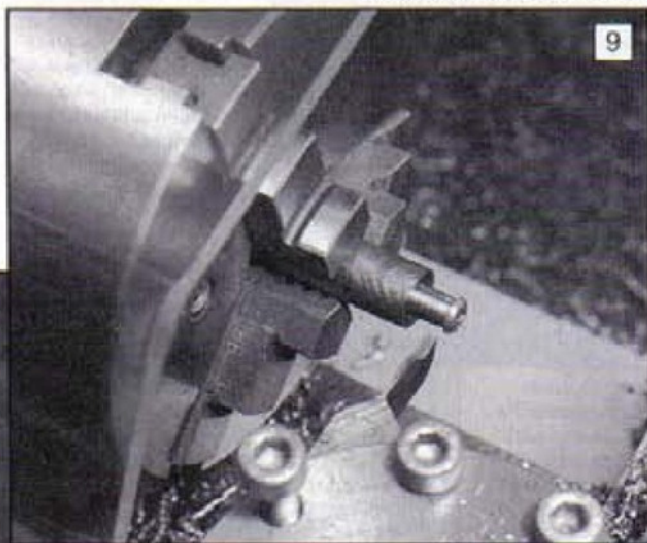


Showing one of the potential uses for this form of toolmakers clamp, that would not be possible with the traditional design of clamp.

Tapping stainless steels

It is easier to tap holes in stainless steel if the second cut, rather than taper hand tap is used to start the thread. If a taper tap is used there is a far greater area of cutting edge in contact with the stainless which can cause it to work harden and perhaps break the tap.

Alan Jeeves



angle plate, the obvious method; a very accurate result was achieved. This was much better than my best expectations. During making the angle plate the toolmakers clamps were made use of, I did find however that the largest size, 5 1/2 in. long, was still not big enough for some operations. I am already considering that some made from 1/4 in. square, and probably 6 1/2 in. long, as suggested in the schedule, would be a good idea. I will provide another short article illustrating the method used for producing the angle plate.

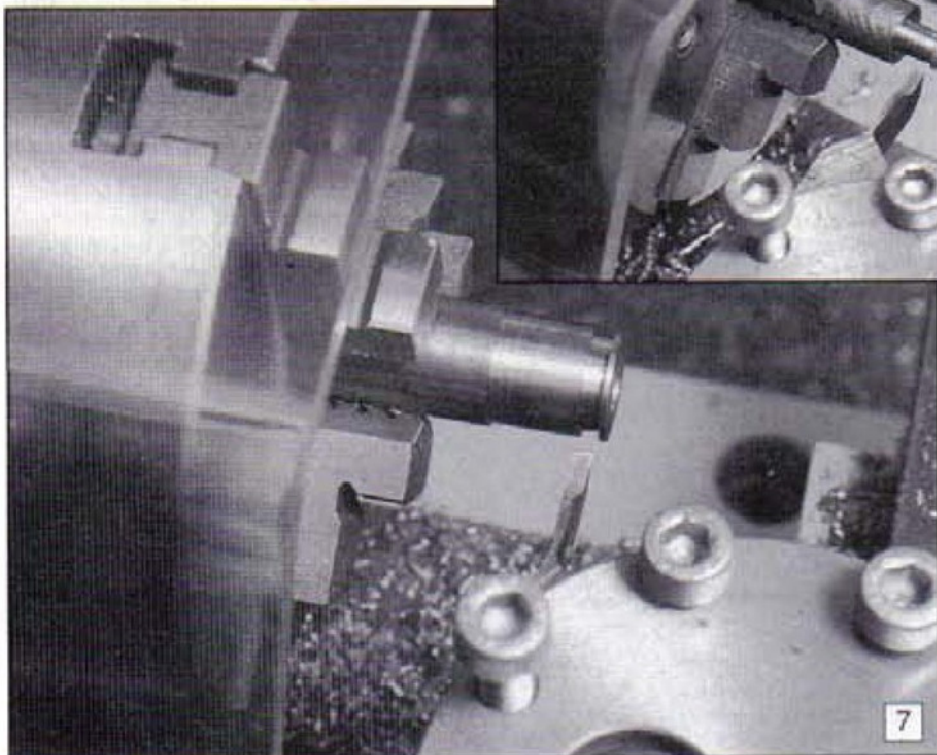
Making the step on the rear of the lift off screw.

Slot drills preferred

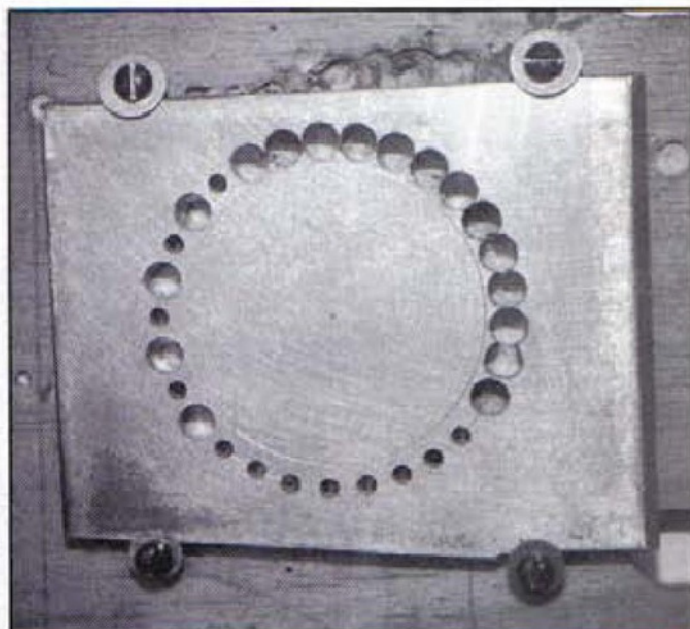
For producing accurate slots in the milling machine, such as keyways, slot drills should be selected in preference to end mills slot drills are manufactured to much closer tolerances. Typically

0.076mm (0.003in.) for end mills.
0.02mm (0.0008in.) for slot drills.

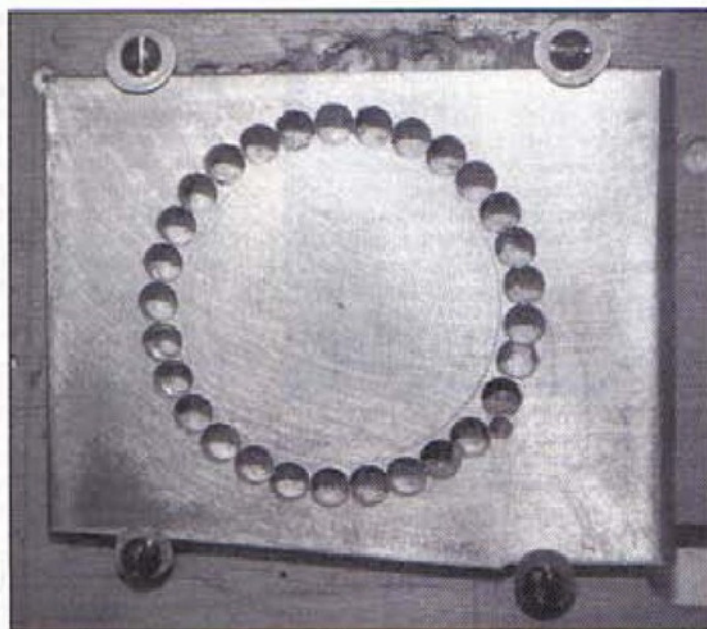
Alan Jeeves



Making the slot for the lift off screw.



Drilling underway.



Drilling complete.

CHAIN DRILLING

I am sure we all have attempted this operation at some time with varying degrees of success. Pat Twist suggests a methodical approach which should prove foolproof.

station, it will be well worth while taking care to do this accurately.

With a $\frac{1}{8}$ in. drill, drill through the plate at each centre pop and follow up at every other hole with the $\frac{1}{4}$ in. drill, finally go round again, which will link up all the holes. If you omit the $\frac{1}{8}$ in. drilling, the $\frac{1}{4}$ in. drill will wander and break into a neighbouring hole, (probably break the drill too).

Select a suitable size drill for removing the last piece of metal between the first and last holes, (use a smaller drill first). One good clout in the middle of the piece with a heavy hammer will break out the required shape.

Why do I use a $\frac{1}{4}$ in. drill? Out of all the drills in fractional, letter, and Number drills, only $\frac{1}{4}$ in. and Letter 'E' are duplicates.



The parts separated.

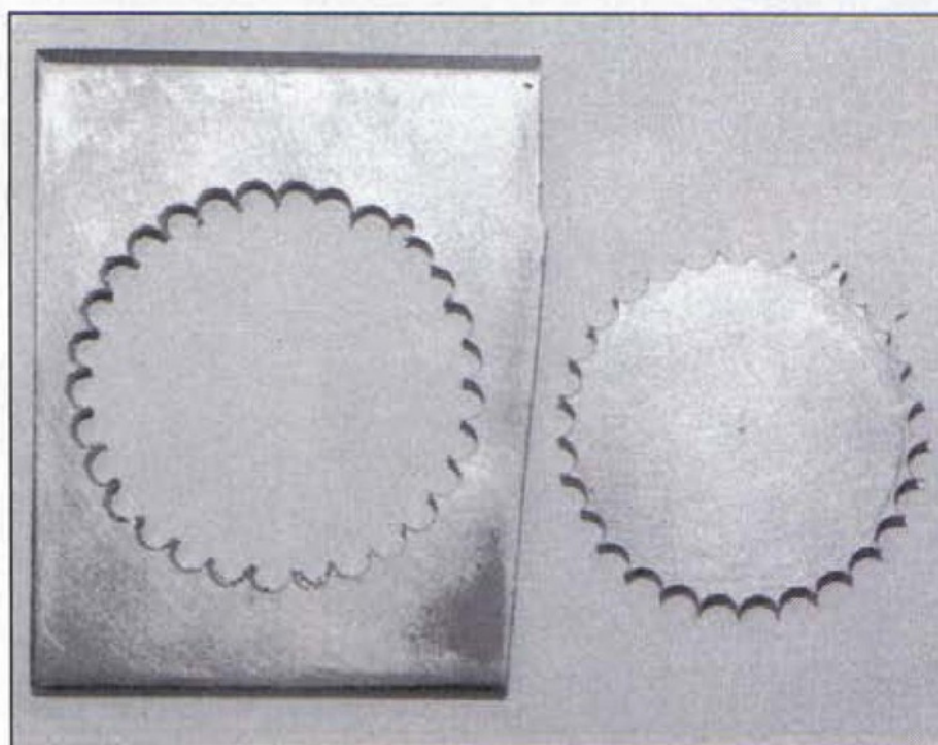
When chain drilling to obtain a blank from fairly thick material, unless the drilled holes break into each other, it is very difficult to break out the wanted piece. This can be more than difficult, even impossible if the wanted blank is a smallish circular disc from a thick sheet. To try and free the blank using a hacksaw will be frustrating and will probably result in a broken blade.

In order to arrive at a chain drilled blank, just needing one blow from a hammer to release it from the parent sheet, proceed as follows.

Mark out on the sheet the shape you need, then if you decide to use a $\frac{1}{4}$ in. drill, mark out another line $\frac{3}{8}$ in., outside the first line, to give you $\frac{1}{8}$ in. to clean up to the desired shape.

Set the dividers accurately to $\frac{1}{4}$ in. and check the setting by walking the dividers along, four steps in a straight line, which should be exactly 1in. long, adjust the dividers if necessary.

Walk the dividers along the line to be drilled, just making a little arc crossing the line each time. When you arrive at the point where you started, halve the distance between the first and last arcs, and with a magnifying glass carefully centre-pop each

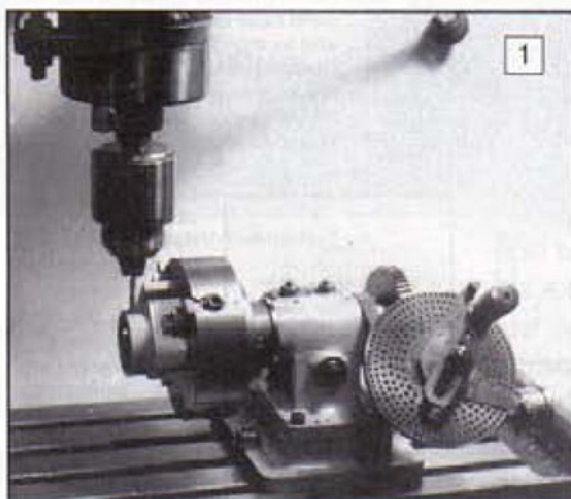


A FOUR WAY CARRIAGE STOP

It is probable that all readers will at some time, have a need to turn a number of identical parts on their lathe. In such an instance it is also probable that the operation will benefit by some aids to repeatability in their production. Bill Morris of New Zealand suggests one such aid; a four way carriage stop. Use of this accessory will improve production rates and maintain accuracy in the batch

Palmerston North in New Zealand is in the process of setting up a science centre in which visitors can interact with the exhibits in a way that is much more interesting for them than just looking at things as in a conventional museum. From time to time I help them out by doing odds and ends of machining that would be prohibitively expensive if sent out to a jobbing machinist. Recently, I was faced with some repetitive work which involved modifying four obsolete computer hard disc drives to do things that their designer had never intended. I resolved to start by doing something that I had never got around to doing for years and construct a multi-position carriage stop so that components for the four units would be interchangeable.

It seems to me that if there is room, the place for the stop is on the saddle as far away as possible from the chuck, rather than on the bed, handy to the left hand but dangerous to the knuckles if struck by a chuck jaw. Not all lathes can accommodate it on the saddle, but there is room on my Taiwanese lathe (equivalent to the Warco 13279H); and lathes such as the Boxford, Southbend, Atlas and Emco should also have room, though you will have to modify



1: Cross drilling holes for ball ratchet.

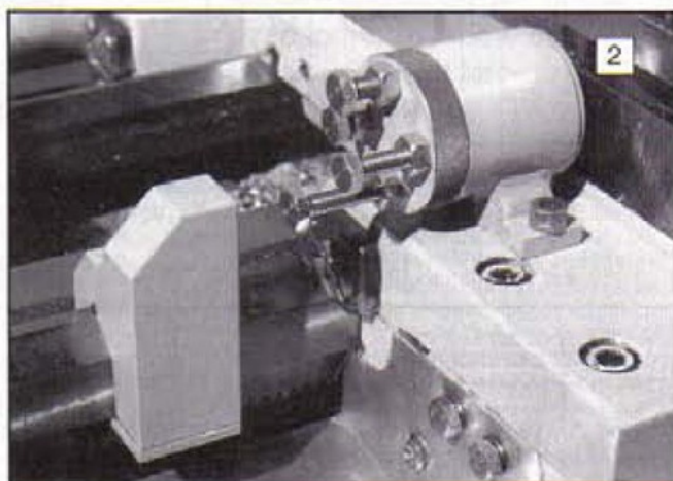
2: Carriage stop and plain bed stop.

some of the dimensions to suit your machine.

I started by turning off the galvanised outside coat from an odd piece of water pipe about 42mm outside diameter that I had in the scrap box and parting off to 35mm length. As well as finishing the outside diameter, this also got rid of a source of irritating white fumes when it came to welding on the base, a piece of 6 x 22mm rectangular bar. I do welding so infrequently and so inexpertly that I often have recourse to Polyfilla prior to painting but I am getting a little better each time. The base could be silver soldered to the barrel, in which case a flat would have to be filed on the barrel to increase the area of contact. It would scarcely be worth milling or turning a flat which a few strokes of a file would produce. The body can then be put in the four jaw chuck, centred with a dial test indicator (DTI) on the outside diameter and the bore cleaned up to a nice finish. A facing skim across both ends and removal of sharp edges completes the turning of the body. While it is still

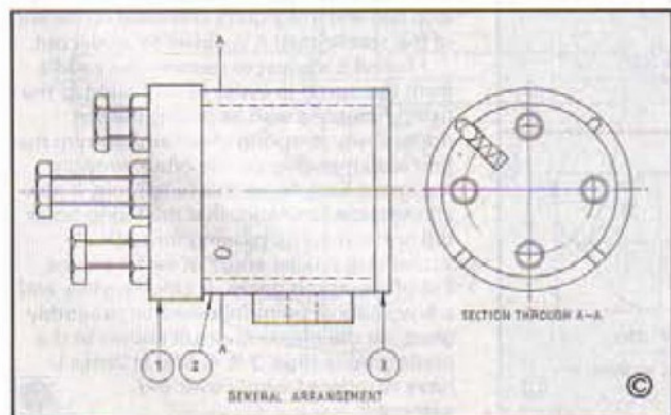
in the chuck, the 45deg. part of a combination square can be used on the chuck jaws to set the base at 45deg. to the horizontal. A sharp tool is then used to lightly scribe the position for the two through holes in the underside of the front end of the barrel.

The cylinder is straightforward turning for the most part. Mine started life as a piece of 1½in. (44.5mm) mild steel bar which I knurled first and then turned down to an easy running fit in the barrel. It was then faced off to the same length as the barrel plus about 0.02mm., although a little more would not matter as the thrust is



all taken on the shoulder. Undercut the shoulder a little to ensure that the thrust is taken squarely on the face of the shoulder. At this stage I marked out the end for the holes, again using a combination square on the chuck jaws rather than resorting to more complex dividing techniques. I parted the cylinder from its parent bar and then took a finishing facing cut from the front, but for those with weak nerves or light lathes, the cylinder could start as a piece of bar sawn to length and could be held by the rather short larger diameter while machining the smaller diameter, in which case it would definitely be wise to give some support from the tailstock. However, gripping short lengths is not good for the chuck jaws, but neither I suppose is a jamming parting tool good for the lathe generally.

Whichever way you proceed, the rest of the cylinder is simple drilling and tapping. It is perhaps easiest to drill right through at 5mm and open out to 6.5mm for a depth of 30mm from the back, then turning it around to tap M6 through to the clearance hole. Do not be tempted to hold the part in



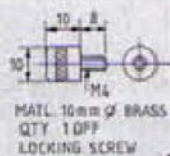
your hand while drilling it; if the drill takes charge, a hefty piece of out-of-balance metal will be whizzing around, possibly taking your hand with it for part of the way. The very least you can get away with if this happens is a bent drill. Use a drilling vice attached to the drilling machine table by at least one nut and bolt. The tapped holes are best spotted through from the retaining washer. This latter can be a slice parted off from the parent bar or even a square piece of 3mm material screwed into place on the

cylinder and carefully turned it to size.

I built up the bed stop "blank" by welding a 30mm length of 25mm square bar onto a 70 x 30mm piece cut from a piece of 10mm hot rolled slab. I ground substantial bevels at the joins to make sure of good penetration of the welds and built up a substantial fillet above the vee. When grinding my rather lumpy welds to a more pleasing contour, I learned something about slag inclusions by inspecting the ground surface with a hand lens. This led me to grind one very defective weld back to the parent metal and to start again. I don't think silver soldering would do here unless it were given reinforcement by some screws. Those who enjoy using a



3: Exploded view of carriage stop.



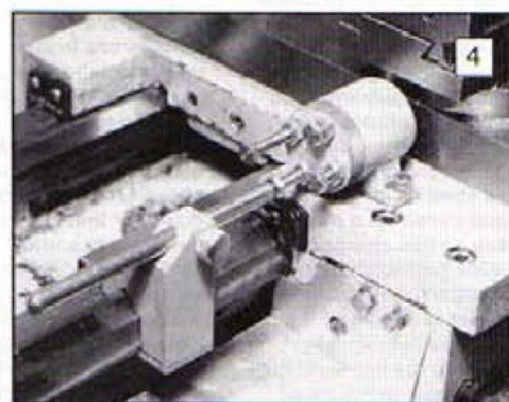
MATL 10mm Ø BRASS
QTY 1 OFF
LOCKING SCREW

hacksaw could cut the whole blank out of 30mm slab. Having made your blank by whatever means at your disposal, the next step is to clean it up on the two end faces (those that face the head and tail stocks), either by milling or by facing in the four jaw chuck. It can then be gripped by these faces to clean up face "A" before settling on a pair of parallels in the milling vice

on face "A" to clean up surfaces "B" and "C". Still gripping by the end faces then rotate it through 45deg. and end mill the vee in easy stages. It is quite important to get the angle as close as possible to 45deg. so that the stop fits snugly to the vee and the front face of the front shear. Any errors here can be corrected by filing and scraping later. I did not get things quite right and had to get the marking blue out. Having got the bed stop to a snug fit on the front shear, spot through and drill a tapping hole into the under surface from the retaining plate, mill a little step and then tap the hole M4.

Assemble the bed stop on to the front shear and tighten the retaining plate. Put the cylinder into the barrel, decide with reference to the bed stop where it is to sit on the saddle and mark around the base on to the saddle. Then rotate the cylinder so that an M6 bolt in one of the holes can encounter the bed stop without interference from bolts in any of the other three holes and, maintaining this position, spot through one of the two holes in the underside of the barrel into the cylinder. Remove the cylinder and drill a hole for the ball and spring. Then drill the blind holes in the barrel diametrically opposite the through holes, as shown in the general arrangement diagram, (fig.1). It would be easier to drill four through holes from the outside of the barrel, but then two of them would be on the top and dirt of course falls downhill into any hole not intended to receive it, a special case of Murphy's Law.

In order to do my job for the Science Centre, I left the bed stop as it was at this stage (fig.2) as I did not need the sliding



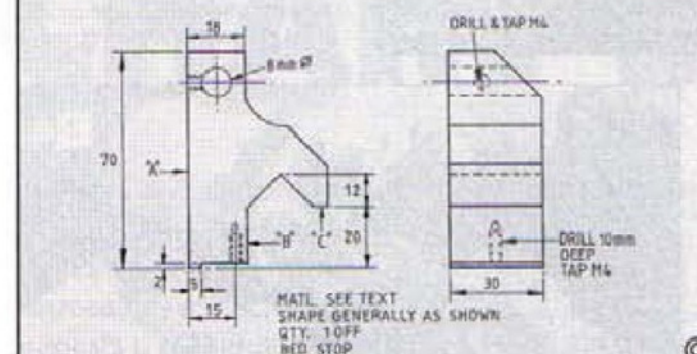
4: Carriage bed and bar stops mounted for action.

stop bar. Unwisely, I cut one of the shoulders off to give a more pleasing contour, so before doing this, drill and ream the 8mm hole in the bed stop or you will have a nerve wracking time as the drill breaks through into an angled face. Then drill and tap a

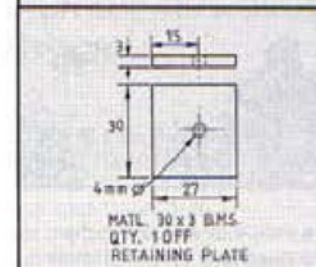
cross hole for the M4 locking screw.

The locking screw is best made out of brass to avoid raising burrs on the sliding stop bar; and if any burrs are raised on the end of the screw itself it is easier to screw out.

I found it easiest to remove the saddle from the apron in order to drill and tap the fixing holes. As well as giving me the opportunity to spring clean and admire the fine workmanship on the often wrongly maligned East Asian machine tools, it also allowed me to ensure that the fixing holes did not end up by passing through something crucial and that swarf stayed out of the apron gears. A little Polyfilla and a few coats of paint followed by assembly gave me the pleasing result shown in the photographs (figs. 3 & 4) and at times I have wondered what I ever did without it.



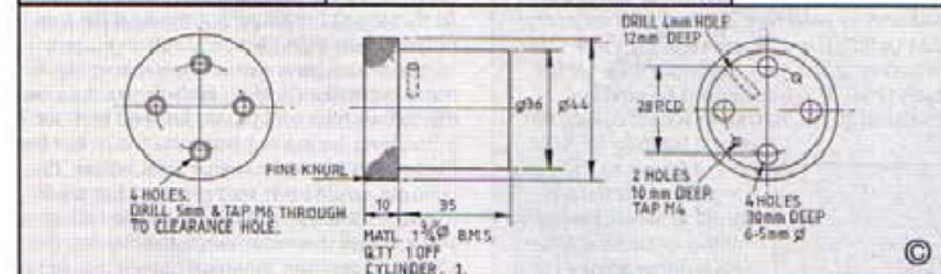
MATL SEE TEXT
SHAPE GENERALLY AS SHOWN
QTY 1 OFF
BED STOP



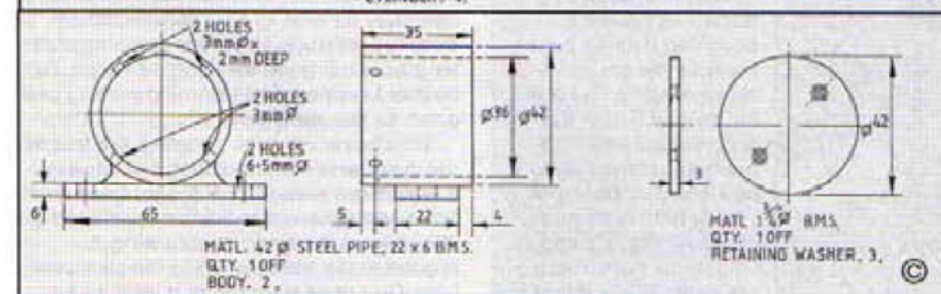
MATL 30x3 BMS
QTY 1 OFF
RETAINING PLATE



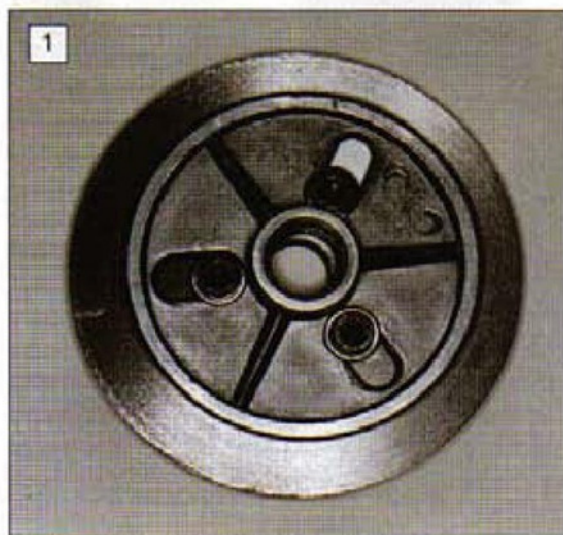
MATL 10mm Ø BMS
QTY 1 OFF
STOP BAR



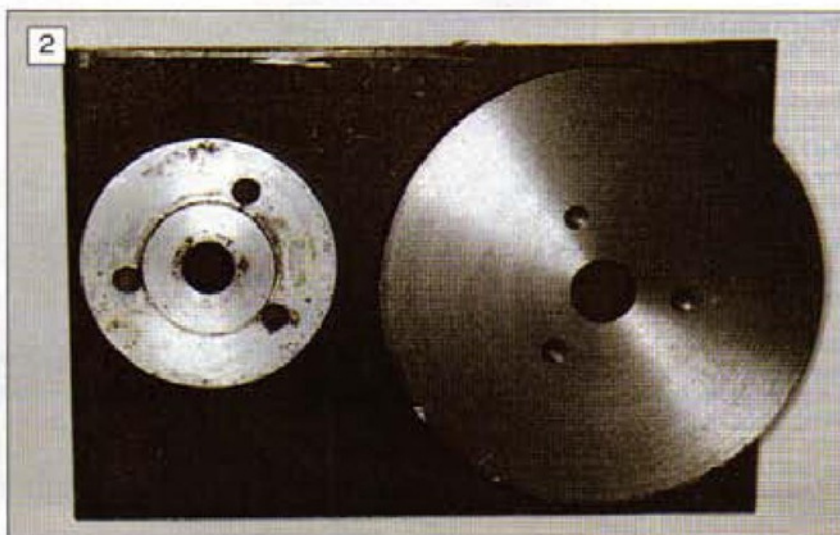
MATL 1 1/2" BMS
QTY 1 OFF
CYLINDER, 1.



MATL 42 Ø STEEL PIPE, 22 x 6 BMS.
QTY 1 OFF
BODY, 2.



1: The cast iron blank for the quadrants screwed to the face plate.



2: The raw materials.

FABRICATED FACEPLATE FOR THE UNIMAT

As regular readers will know, my sole machine apart from the usual Black and Decker drilling tackle, is a Unimat 3, a lovely machine, but I wish the face plate was a bit better designed. It is excellent as a catch plate for turning between centres, but it has limitations for my requirements. My fault perhaps, for using it as a drilling table when I use the lathe as a drilling machine.

I have three main grouses; firstly, it isn't big enough; the swing over the bed is 92mm, and I'm sure that a diameter of

90mm, would be better than the 70mm one supplied. Secondly, there is a pronounced rim round the periphery and ribs in the casting, which make clamping difficult; thirdly, it has three clamping slots which rarely coincide with where I want to put the bolts. Four slots would be, much better.

Photograph 1 shows the rim and ribs.

Every time I have used it I have vowed that I would do something about it. I decided to do just that and make a better one, with four tee slots to make the clamping easier.

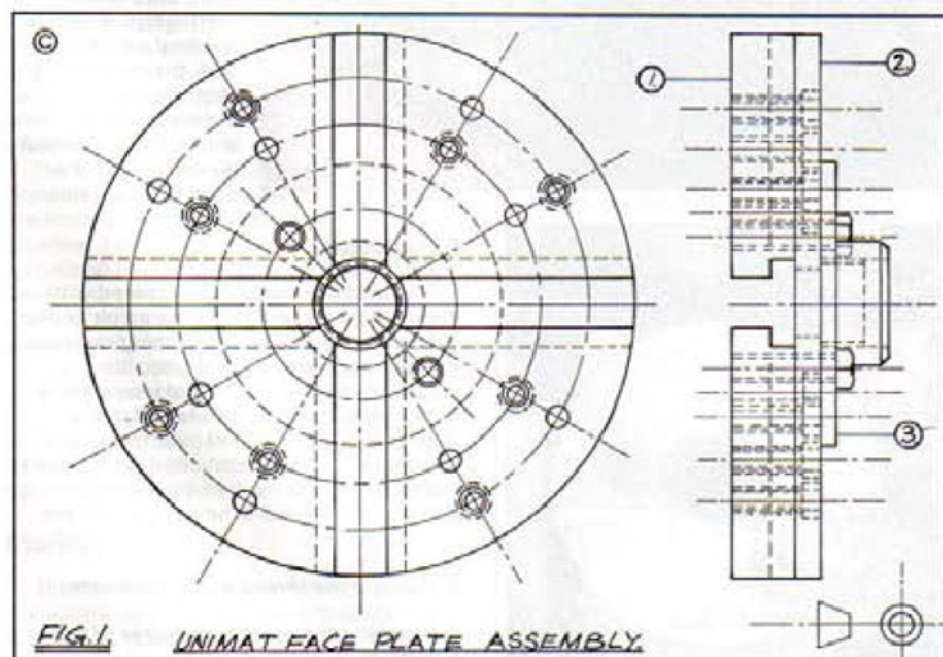
Bob Loader provides another of his excellent articles showing just what can be done with limited equipment. This time, he describes a fabricated face plate which he has made for his Unimat. However, it is equally applicable for similar sized lathes, or could even be scaled up to suit larger machines.

Having one machine to do everything, I normally opt for fabricating where I can, to save the Unimat from the milling jobs, which it isn't keen on; it groans and makes noises. So I intended to use similar methods to those I used to make a 4 jaw chuck, in fact I thought I could use some of the rejected bits from the chuck job and wasted quite a bit of time trying. Common sense prevailed, and I began with the materials shown in photo 2, a cast iron blank, just over 90mm diameter and about 12mm thick. The photograph was taken after a face had been trued and 3 holes drilled. In the raw, the faces were sawn, one concave, one convex; I have a hacksaw which does that, not often, but enough to be a nuisance. The other pieces were a 50mm diameter blank of duralumin which was the wheel bearing of a luggage trolley and a piece of mild steel plate 5mm, thick and, 130 x 100mm. I used these materials because I had them, I have specified them on the drawings, the parts can be made from other materials, providing they are good enough to do the job.

Apart from the screws and dowels, the parts to be made are, the back plate, base plate and disc. to make the four quadrants from, Fig. 1, shows the assembly. I have left out the cap head screws and some of the hidden detail to avoid clutter.

The base

This is the backbone of the job, because the back plate is fastened to one side and the quadrant to the other. It also locates the other two parts accurately, the back plate by a fitting recess and the quadrants by dowels. If fitted bolts are available, the



dowels can be left out and the bolts will do both the locating and the clamping.

To cut the circle for the base plate, I tried my usual method, the coping saw. It took the teeth off very quickly; the steel must have been a bit harder than I thought and needed something better than the coping saw. I cut it with a hacksaw using a high speed steel blade, bit by bit - so that the cut line followed the curve as closely as possible. It still had to be filed a little to bring it as near round as it could be, so that the Unimat wouldn't protest too much; a large diameter exerts a large force against the tool and a small irregularity can make the belt slip. When the belt slips badly, or there is a graunch up, sparks flash in the motor switch, so I am cautious.

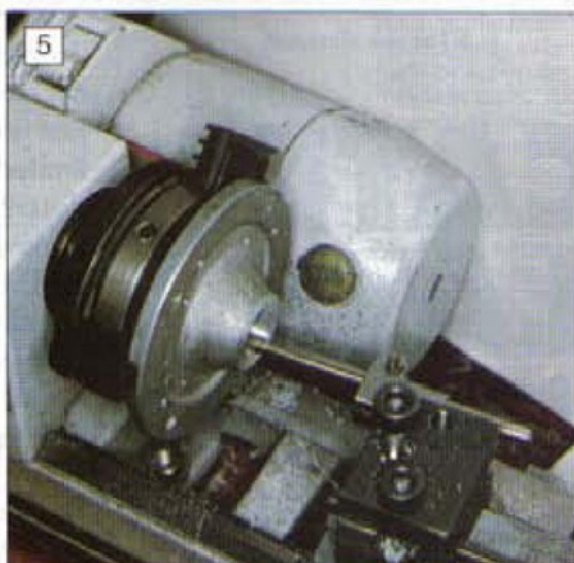
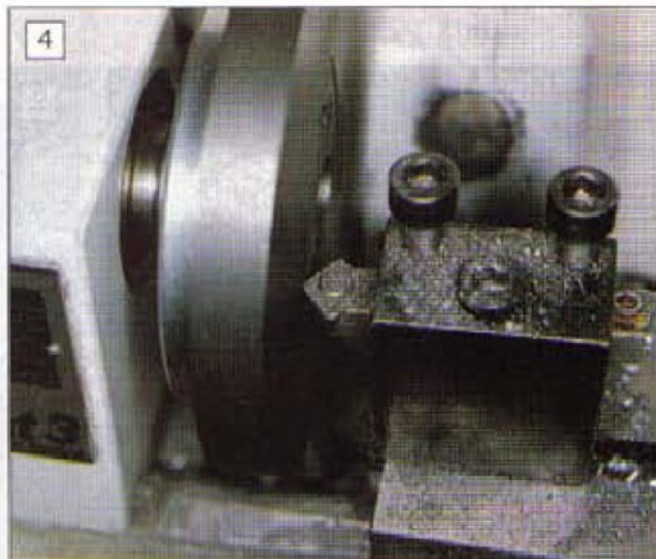
To skim the disc to just over the 90mm dia., I drilled a $\frac{1}{8}$ in. hole in the centre and mounted it on a $\frac{1}{8}$ in. BSF bolt with a large thick washer under the head. The washer was $\frac{1}{8}$ in. diameter and $\frac{1}{2}$ in. thick; it gripped tight and accurately in the chuck, much better than holding on the hexagon. It ran quite true, so the skimming went smoothly with only a couple of small belt slips.

I used HSS tooling, which I found cut best, and turned the recess for the back plate as far as the bolt head with a right-handed tool, the rest of the recess with a left-handed one and the facing to the outside with the left-handed one to save changing round again. As the other side of the plate was clean and flat, I left it alone, **photograph 3** shows the diameter being turned to size, the last operation to be done.

Fig.2, gives the dimensions for the base plate. Do not drill at this stage, wait till all the parts can be drilled together,

Quadrants (1)

The cast iron blank for the quadrants was one from which I had already cut some slices when making the front plates for the 4 jaw chuck I made a long time ago. Because of the way the hacksaw cut, or perhaps the way I made it cut, one side was concave, the other one convex. Now it isn't easy to hold a 90mm, plus diameter in the Unimat, even when it is flat on both sides. The best way I could think of was to bolt it to the faceplate, so I drilled and tapped two equally spaced 2 BA holes in three equally spaced positions, to pick up the slots in the face plate. 2BA screws allowed enough movement to line



3: The last cut off the diameter of the base plate.

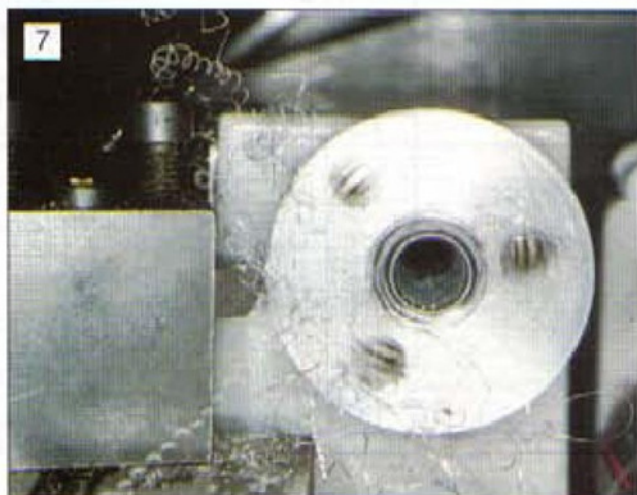
4: The finishing cut being taken from the cast iron blank.

5: Boring the discarded backplate ready for threading.

it up accurately enough so that I could face both sides. **Photograph 1**, shows the blank screwed to the faceplate. The holes can be opened up and used to fasten the backplate if they are accurate enough. Unhappily, mine weren't, so I plugged them and drilled fresh ones when the time came. During the machining of the cast iron, I was glad that I had carbide tipped tools. I kept the speed down to 130 rpm because there was bit of wobble on each side, as well as the concave/convex business already described. I locked the

saddle for each cut, took it steadily and eventually had a disc, 90mm diameter, 10mm thick. I bored the centre out to 14mm. It was deburred and put aside for finishing off and cutting into individual quadrants later.

Photograph 4 shows the final cut off the face, the tool cutting from the centre outwards. **Fig.3**, shows the shape and dimensions of the finished quadrants.

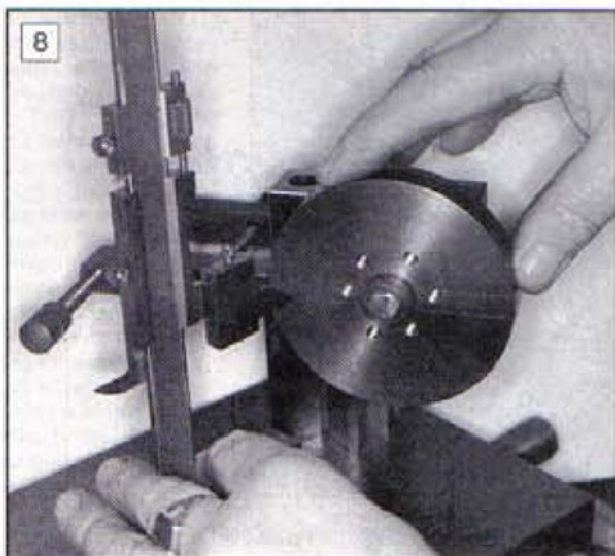


Backplate

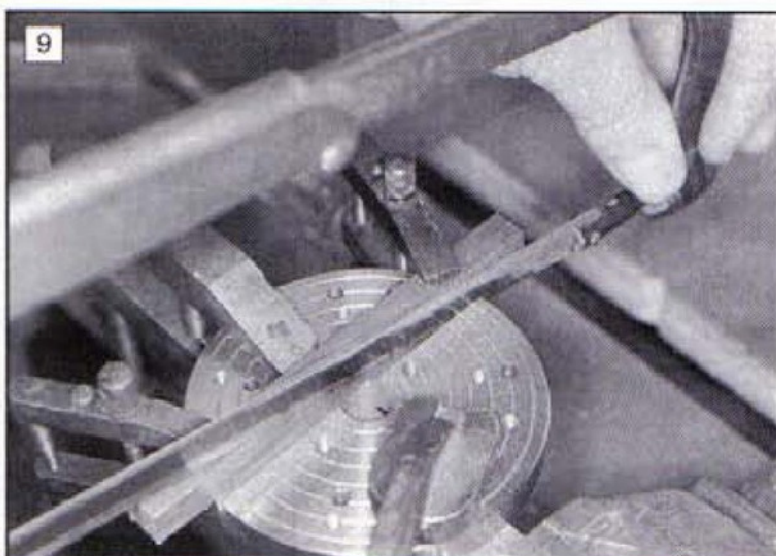
This was a simple job, compared with the other two. I wanted to use an old pump flange from a redundant washing machine, it was made from die-cast zinc alloy, judging by the way it cut and would have done nicely. It would also have fitted a selection of bits I had left over from the 4 jaw chuck, the job I mentioned earlier, but I made a complete hash of it and hence it was discarded. I have, however, used the

6: Tapping the thread in the backplate.

7: Finishing the outside diameter of the backplate.



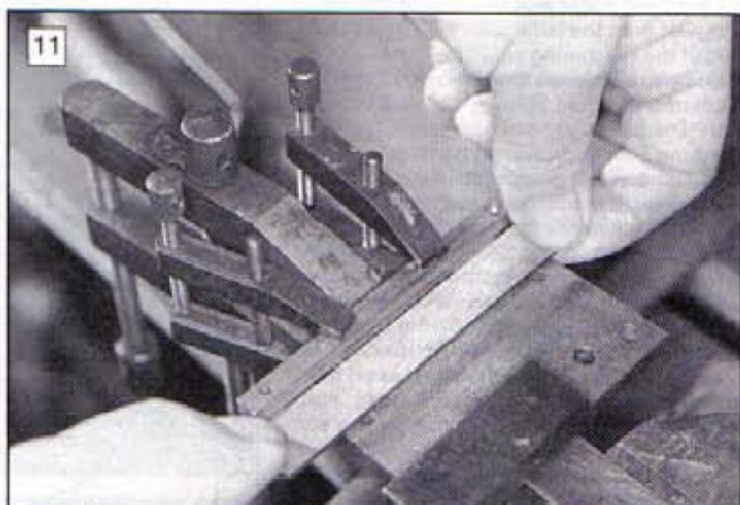
8: Marking out the quadrants, note how two of the unwanted tapped holes will be removed when the quadrants are cut.



9: Cutting the quadrants accurately by sawing against a fence.



10: Sawing one of the quadrant steps using a fence again, note the bar clamped in the vice for clamping the work. The stamped numerals are where the number stamps were tested. This is the size used to identify positions for the quadrants.



11: Filing the step in one of the quadrants.

across them, they are accurately ground parallels, 1in. x 2in. x 3in. with holes, some tapped, some not, in useful positions. I used one of my pair, bolted the assembly to it and clamped it to a combination vee block; **photograph 8**, shows the method. I used my home made vernier height gauge attachment to mark out. It was easy to set the job at 90 deg. for the second lot of lines because although it isn't easy to see on the photograph, the 1-2-3 block is sitting on a ledge on the combination vee block.

I marked the lines to give a gap of 8mm when the quadrants were cut. Before unclamping from the 1-2-3 block, horizontal and vertical centre lines should be marked as these will be used for datums for marking the screw and dowel positions.

The last bit of marking to do is to punch numbers 1 to 4 on the underside of the cast iron disc and on the hidden side of the base plate. Use small punches and put the numbers where they won't be cut away. They will identify the quadrants when they are separated and match them up. If you haven't any number punches, use the appropriate number of centre punch dots in each position.

To mark the screw and dowel positions, put a centre punch mark in the centre of the plug used to line up the parts. The easiest way is to use the bolt which clamped them

to the angle plate or whatever was used to mark the centre lines. It only needs a small centre pop, big enough to take the point of a pair of dividers.

Mark the two pitch circles by setting the dividers first to 28.5mm for the 57mm PCD, then to 35mm for the 70mm PCD. For the hole positions, leave the dividers set at the radius for the circle and with the point on the intersection of the pitch circle with one of the horizontal or vertical centre lines, make an arc to cut the pitch circle on each side. This will mark the first pair of hole positions. It must be repeated four times in total, from each intersection. Do the same for the other pitch circle and centre all the positions with a centre punch mark. All the holes can now be drilled, reamed or tapped, whatever is specified.

The drilling, reaming and tapping are straightforward. Should some sharp eyed reader look at some of the photographs and think that the dowel holes look a bit big for 3mm., they are quite right. When I looked for the dowel material; I normally use $\frac{1}{16}$ in. or 3mm silver steel, I had run out, so I had to improvise. The only possibility was some pins of a non-standard size, so I had to make a quick D bit to ream the holes. Whatever size the dowels are, make sure that they are a tight fit in the base plate and a sliding one in the quadrants, in

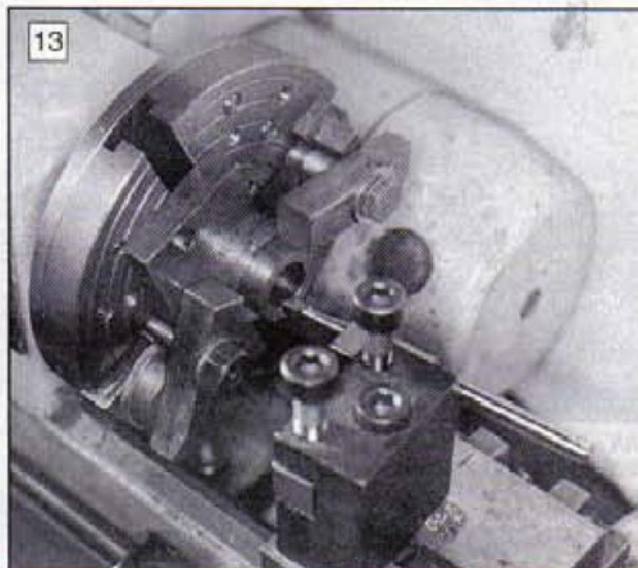
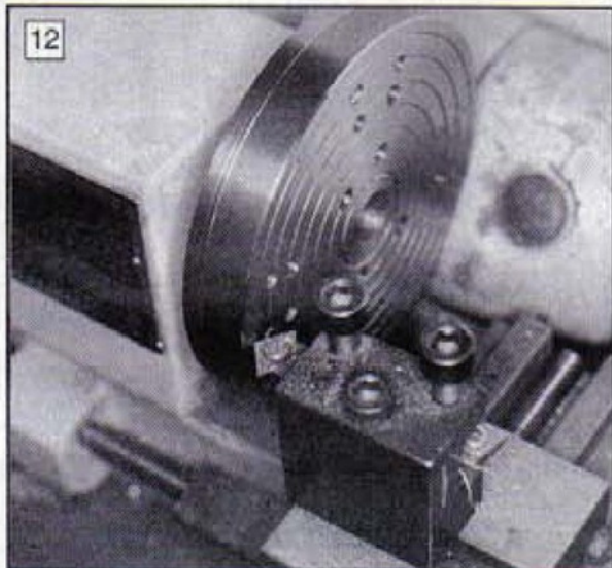
case they have to be lifted off. I used M4 cap head screws and a $\frac{1}{16}$ in. dia. slot drill for the counterboring.

With all the holes done, everything was de-burred, and checks made that all fitted and the numbers lined up. It was disassembled. The real business comes next.

The quadrants

These are sawn to rough size and finished by filing. I could have made a fixture and milled them, but the Unimat would have made noises, the belt would have slipped and the miniature dragon which lives in the switch housing would have spat fire at me, so I filed them.

There were one or two problems. My vice will only open to 70mm or so and the diameter to be worked on was 90mm, I did what I've done before and clamped a bar of mild steel 1 x $\frac{1}{4}$ in., in the vice and clamped the work to that. **Photograph 9** shows the method in use for hack sawing the disc along the marked lines. The main problem, in common with a lot of handwork, is keeping it accurate; the photograph shows one way of doing the sawing with reasonable accuracy. The disc is clamped to the bar with a large toolmakers clamp and a piece of 10mm, square mild steel is clamped to the disc, in line with, or allowing a bit from, the marked line, it acts



12:
*Machining
setting rings
in the face of
the faceplate.*

13: *Using the
finished
faceplate to
bore out an
awkwardly
shaped job. It
would
normally
have to be
saddle-bored,*

as a fence to cut against and if the saw blade is kept firmly against the fence, it can't help but cut down the right line. The reason for allowing a bit extra is so that the face can be cleaned up afterwards; even the best directed hacksaw won't leave a brilliant finish. I was glad of the exertion of filing and sawing because in the Spring, when I made the faceplate, the small spare room which I'm lucky to work in, is used as a cold greenhouse. The radiator is turned off and tomato, sweet corn, marrow and cucumber plants have priority. So I have to co-exist with them and the exercise was welcome in what has been, up till now, an awfully cold Spring.

Once the quadrants had been sawn out, I used variations of the same method for sawing and filing the steps. Reference to Fig. 3, gives the step dimensions, 3mm deep and 4mm in from the edge. It can all be filed, if you are a masochist, but is easier to saw most of the metal away.

Photograph 10 is of the sawing, the blade is against a 6mm square bar, clamped with the two small clamps. The depth is left a bit shallow to avoid sawing too deep.

To finish the steps, a piece of 6mm steel plate was clamped to the bar and the finished edge of the quadrant butted up to it. This made the vertical datum. The horizontal one was the piece of 6mm square again. Photograph 11 shows a 4in. hand file cutting away at the edge. When it

is almost there, the file is used vertically with the safe edge to the 6mm plate. Watch two things; firstly, that the safe edge of the file is really safe, if not give it a touch with a stone to take the burrs off; secondly, do not be tempted to use hardened steel for the fences; not if you have any respect for the files or saw blades. Remember to put the fence material in a separate place when it has done the job; it will no longer be accurate enough to used as stock size. The finished quadrants should have nice clean square edges, because filing against a fence will produce good results even if the filer's skills are moderate.

Assembly and final machining

When all the quadrants were checked and de-burred, the face plate was assembled, screwed to the lathe spindle and the lathe turned on to make sure that everything was running freely. The last two jobs were to chamfer the outside diameter and machine the setting or guide rings in the face at 5mm intervals. If the lathe doesn't jump about and the belt slip, fine; if there are any problems, take the belt off and rotate the chuck by hand, feeding the tool in little by little. Photograph 12 shows it being done, I did mine at an earlier stage but it is better to do it last in case there is any final skimming or adjustments for added accuracy.

Special tee nuts.

The tee nut shown in Fig. 4, can be used in the Unimat cross slide as well as the face plate. I prefer tee nuts to tee bolts because they are easier to make and more adaptable, you can use a bolt of any length in them and it avoids the hunting for the right length of bolt, which takes up so much time. If, however you must use bolts, I have designed it so that the slots will take an 8mm or $\frac{5}{16}$ in. bolt, the dimension across the flats will fit and all the bolts would need would be the head faced to 3.5mm thick.

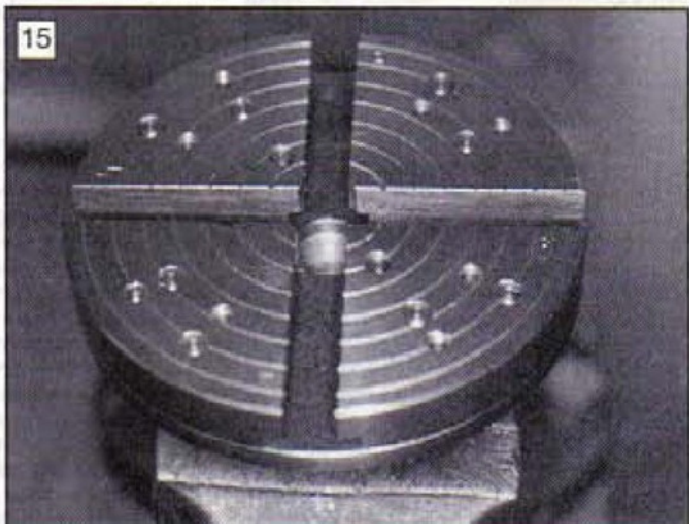
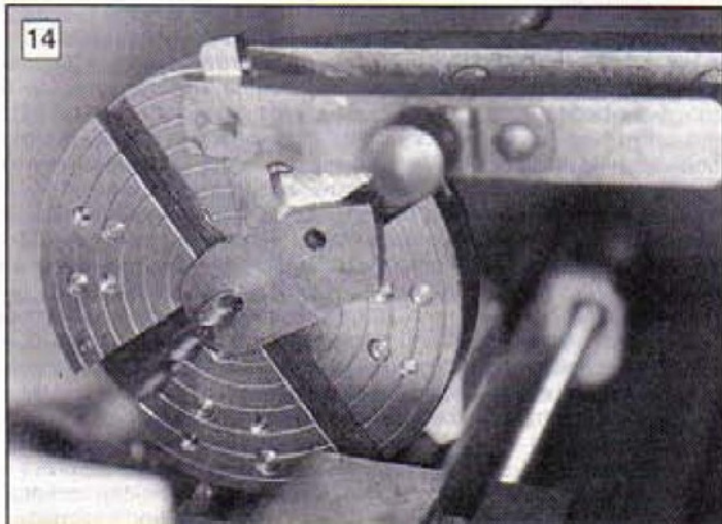
Photograph 13 is the sort of job it is useful for, but photograph 14 is the nitty gritty, this is the sort of work it will get most use, as a drilling table. It gives me a large surface and lots of room to get a clamp on, or the option of using bolts and strap clamps. The only awkward bits to make were the quadrants, but even those are not too difficult with a bit of help from suitable fences. Photograph 15 shows the complete faceplate.

The making didn't take too long and the materials were mostly odds and ends. Both the materials and the dimensions are flexible and don't have to be strictly followed. I'm glad I made it and I recommend it as a useful piece of equipment for the Unimat or similar small lathe.

14: *The type of job for which the faceplate will found very useful.*

Note that there is lots of room to secure the workpiece using clamps.

15: *The completed faceplate..*



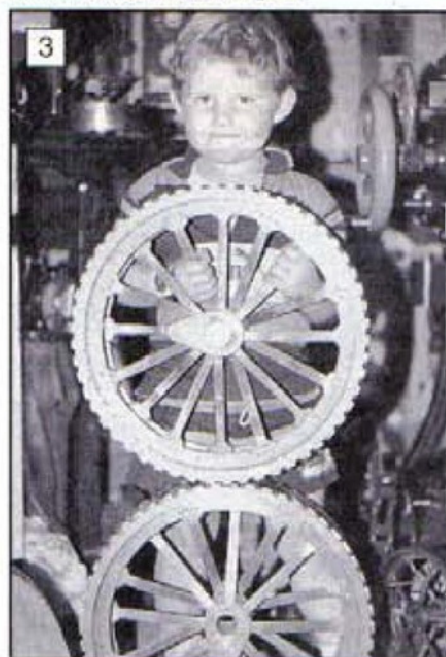


1: The author with a 350 mm dia. marine propeller made from grade 347 stainless steel.

In 1916 a metallurgist named Brearly took out a patent covering a new cutlery steel which contained (no more than) 0.7% Carbon and between 9% and 16% chromium. The name of this material was stainless steel. Nowadays the term stainless steel is applied loosely to any of the corrosion free steels (and valve steels) which contain above 10.5% chromium. Gradually stainless steel was used for other applications in the engineering industry and, by about 1930, was in general use throughout the UK, Europe, and the USA.

The early stainless steels were named by the percentage of the major alloying elements (other than iron), for example, one of the most frequently used of these early alloys was designated 18/8 (still a familiar term today), which told potential users that it contained approximately 18% chromium and 8% nickel. As different grades of stainless steel were introduced over the years, different systems of identifying these grades were also introduced, and make no mistake about it, there are many grades available to the industrial user. Things have come a long

3: 'Child's Play' - although considered inauthentic, 5 year old James Holroyd is pleased with the stainless steel strakes for his 3in. scale traction engine.



LOOKING AT STAINLESS STEELS

Alan Jeeves shares his knowledge on the subject of stainless steels and the problems associated with machining and working with them in the home workshop environment



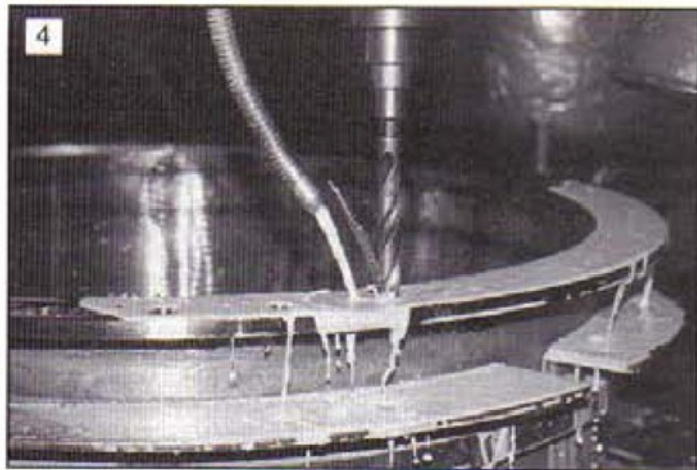
2: A selection of stainless materials on offer at a steam rally.

way since the early days when this material was very expensive, not only in terms of cost to buy it in the first place, but also because of the fact that it was extremely difficult to machine or work with. At least one of these drawbacks has been overcome in that many of the stainless grades today are, due to the addition of certain elements, easy to machine and although by the standards of the home workshop owner, they may seem very expensive, they are relatively cheap compared with pre-world war II costs. I will stick my neck out and say that at model engineers' supply outlets, the popular sizes of round bar stock in good free machining grades are priced roughly the same as the same sizes in silver steel. Rectangles, hexagon, and special sectional stock can be a little more expensive, however, stainless steel is becoming more and more readily available on the surplus market and bargains can now be had by those who keep their eyes open. Also, many small machine shops are now using it and people who work in such shops may be able to purchase offcuts on your behalf, which will most likely come with identification numbers to give a clue as to what grade it is. Another useful source for rectangles and flats are local fabrication shops who may be able to supply strips which have been cropped off large sheets or plates. Thicknesses up to 20mm are not uncommon, which are large pieces in terms of model engineering. A further practical source of bar material is in the form of stainless steel bolts, which are usually free cutting. These are now becoming very

common in scrap yards. No opportunity should be passed up to acquire stocks of this most useful of metals, if it is offered cheaply.

What are stainless steels?

In order to make the most of obtaining and using stainless steel, it is always an advantage to know more about it. All stainless steels are alloys of iron and chromium. Some are alloys of iron, chromium and also nickel, while some other grades are alloys of iron, chromium, nickel and manganese. In addition to the above metallic elements, small amounts of other elements (not necessarily metallic) are introduced to produce specific mechanical properties. As has already been stated, chromium is present in all stainless steels but the amounts vary considerably, the minimum amount being 10.5% while some types have been known to contain as much as 30%. The modern design engineer has therefore, a great choice of materials at his disposal. The significance of chromium is that it has a high affinity for oxygen. It forms a stable oxide film, called the 'passive film', and this film will resist any further physical or chemical change (to a greater or lesser degree depending on the grade of material). In other words it resists corrosion. But what is so exceptional about this passive film is that, in ordinary atmospheric conditions, it is able to form almost instantaneously. In addition to that, if the film is broken or scratched it rebuilds



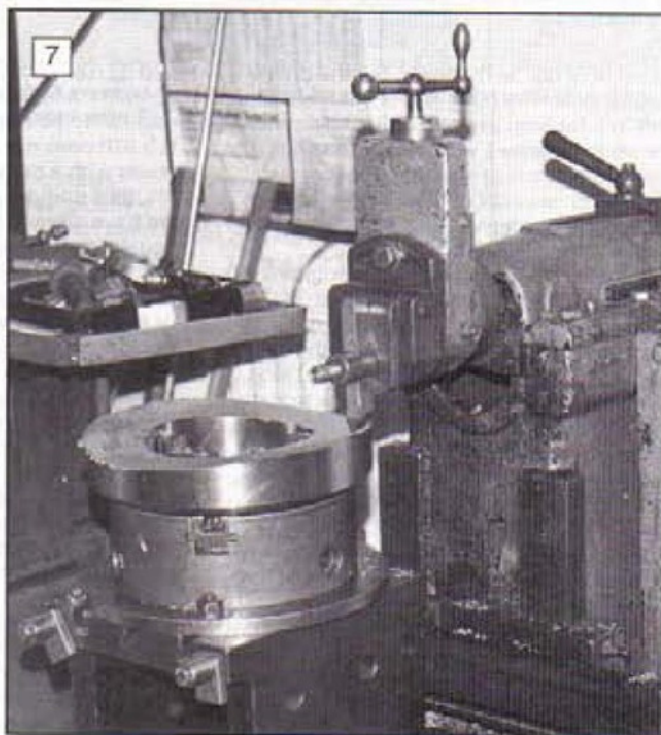
4: Drilling a stainless flange.



5: Slotting swing bolt holes in a flange.



6: A complex stainless steel fabrication - a split bearing for the shaft of a mixer. This is lined with Teflon.



7: An unusual operation - profile shaping a vessel outlet pad to fit a 1180 mm dia. tank. (590mm R as stated on the guard).

itself straight away. The ability to do this is generally termed 'self healing' often likening it to human skin. When a cut is taken, say on the lathe, the new surface produced by the removal of the old one will remain virtually the same indefinitely without further corroding or tarnishing because it is protected by the passive film. Chromium, then, is the most important single factor in the production of stainless steel.

Austenitic steels

Stainless steels are divided into two classes, 'austenitic' and 'ferritic', and the ferritic group is further sub-divided into two more groups which are known as 'martensitic' and 'ferritic'. About 70% of all stainless steels produced are austenitic. They are exceptionally corrosion resistant and easy to work. They contain between 16% and 28% of chromium according to the grade and also contain between about 3.5% and 23% nickel, (some special grades have been known to contain as much as 37% nickel). Nickel is responsible for forming austenite as we shall see when we look at nickel in more detail. When the chromium content is, or exceeds, 25% austenitic grades are able to resist temperatures of up to 1039 deg. C. (2000 deg. F.) without the disadvantage of becoming brittle. The property of the ability to become brittle at

elevated temperatures is known as 'hot shortness'. They do work harden but cannot be hardened by heat treatment. They are widely used in the manufacture of process plant - especially in the food and pharmaceutical industries, surgical instruments, cutlery, and architectural and ornamental items (sinks and sanitary ware). They are by far the best group to choose if welding is to be encountered as the low carbon content in the material enhances their 'weldability'. As we shall see later, some of the grades are suffixed by the letter 'L' which indicates to the user that they have an even lower carbon content than is normally present in that grade. Most austenitic grades are also classed as non-magnetic. The majority of stainless steels encountered by the home workshop owner will be of the austenitic variety.

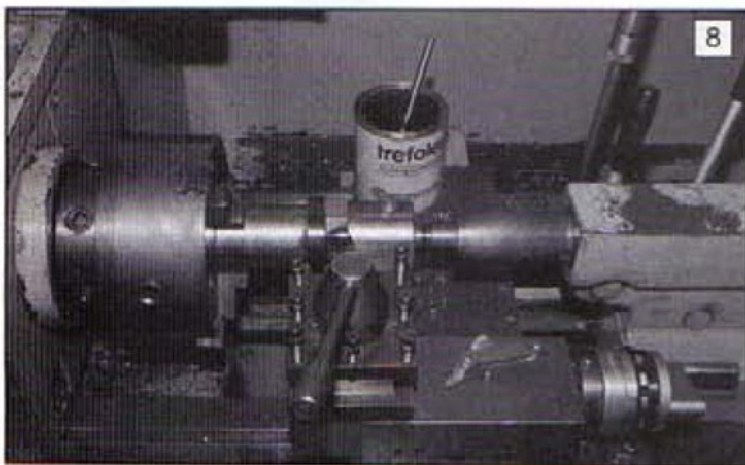
Ferritic and Martensitic steels

The second group of stainless steels are known as ferritic. This group is then further divided into two secondary groups, one called 'ferritic' and the other called 'martensitic'. This sounds like a contradiction in terms as martensitic steel is also ferritic, but read on regardless. Once you have sub-divided them, the austenitic group being disregarded altogether, the major difference between the two sub-groups is that ferritic steels cannot be

hardened by heat treatment while martensitic steels can. This is because of the high carbon content (between 0.08% and 2%) present in martensitic steels. A good example of the application of martensitic stainless steel is where a bearing needs to be used in conditions which are vulnerable to corrosion, say on an oil rig in the North Sea. It is quite possible to produce a bearing journal which is hardened and also 'stainless'. The martensitic steels, though, are not as corrosion resistant as other classes because of the lower chromium content (usually between 12% and 15%), ferritic grades being higher at between 17% and 27%. Both martensitic and ferritic grades are classed as magnetic. Ferritic grades do not contain nickel.

Identification of grades

As you now may already have gathered the term stainless steel covers a wide range of materials which differ considerably within the corrosion resistant classification. Most of the grades will not be appropriate in the average home workshop, but it is useful to know something about them and how they are named. For example, it is often said that a metal cannot be stainless steel if it is magnetic. This is not so - as we have already seen. Try a magnet test on a modern stainless steel kitchen sink top. The



8: Screwcutting in the lathe, using a suitable threading compound.

bowl may not be magnetic but the drainer probably is. The bowl is likely to have water left in it for long periods while the drainer is never submerged, water just runs off it. The bowl, therefore, is made from a more corrosion resistant (and accordingly more expensive) material, the joint between the two is simply welded.

Most of us are familiar with 'engineering numbers' - steels which are termed 'EN' followed by a number. This system of designation originated in 1941 in the form of BS. 970. It was further revised in 1955 but in 1972 was replaced by a new system of numbers which makes identification simpler. B.S. 970/1972 by no means covers every type of steel produced in bar form (silver steel, for instance, is found in B.S. 1407) but it will probably cover all the stainless steels used in the home workshop. Briefly B.S. 970/1972 works like this:

Six characters are used to describe the steel. The first three are from 000 to 999 and give a broad description of the steel. Numbers 000 to 199 are all plain carbon steels which contain some manganese. The final two digits of this first three denote the manganese content as a percentage after a decimal point. (e.g., B.S. 080M30 contains 0.80% manganese). Numbers 200 to 240 are simply free cutting types of plain carbon steels which contain some manganese and some sulphur. The final two digits of the first three denote the sulphur content. (e.g. 220M 07 contains 0.20% sulphur). The above materials do not concern us here. However, numbers 300 to 499 are all classed as stainless steels or valve steels, and it is these types which we will be looking at.

Some people include many of the steels found between numbers 500 and 999 as stainless but, because their chromium content is below 10.5%, they are more properly classed as alloy steels other than stainless. i.e. B.S. 501 has a chromium content of between 4 and 6%, much lower than our border-line of 10.5%.

After the first three numbers, a letter is usually found. This letter indicates the type of specification of the steel. Four different letters may be found to identify the type of specification, 'M' will indicate steels supplied to specific 'mechanical properties', 'H' will indicate steel which will adhere to a specific 'hardenability', while 'A' is used for steel with a specific 'chemical analysis'. The letter 'S' may also be encountered and indicates the steel is stainless steel or valve steel, valve steel being a term used for the high percentage

chromium alloys used for engine valves which will resist high temperatures. These are usually included within the broad term stainless steels.

The final two numbers in the six character code identify the carbon content of the steel. If a decimal point is written on a piece of paper and these two numbers written after it, the carbon content will be revealed, e.g. The popular plain carbon steel BS. 080M40 contains 0.40% carbon,

and its free cutting equivalent BS. 212M44 contains 0.44% carbon. The highest number to be found here will be 99 as B.S. 970 does not cover high carbon tool steels with a carbon content in excess of 1%, 99 signifying 0.99% carbon content. (as we have already seen with silver steel - usually containing 1.1% or 1.2% carbon). Getting back to stainless steels, these last two numbers have only relative application or significance here and are not absolute. For industrial purposes a separate test certificate will be issued by the supplier giving full metallurgical details of the material. It is normal for stainless steels to be generally described in the home workshop by the first three characters. We usually ask a supplier for a piece of 316 or 303 or 321 etc. Some suppliers still even use the old 'EN' designations and catalogue their stock as, say EN 58M, free cutting, or EN 58J molybdenum bound. This can cause a little confusion so some comparisons between 'BS' numbers and 'EN' grades are included in Table 1. These are not direct equivalents, as none exist, but are the nearest alternative grades between the two systems. From here on all references to stainless steel grades will be by using the easier and more correct system of B.S. 970/1972 (stainless & heat resisting steels in the form of blooms, billets, bars and forgings) and by using the first three characters of the six character code (between 300 and 499), and its variants. (Plate and sheet may be found in B.S. 1449 & B.S. 1501).

Table 1
Some examples of comparisons between B.S. designations and Engineering Numbers

B.S.	303	S	41	EN 58A or EN 58M
B.S.	304	S	15	EN 58E
B.S.	316	S	16	EN 58J
B.S.	321	S	12	EN 58B
B.S.	410	S	21	EN 56A
B.S.	416	S	41	EN 56

It should be noted that there are no direct equivalents.

Alloying elements

Apart from iron, chromium, nickel, and manganese, the different grades of stainless steel contain other different alloying elements, selected for inclusion after consideration of the use to which the material is to be put. A useful table of chemical symbols is included (Table 2). The base metal in all steels, stainless or not, is iron. Iron is a silvery white metallic element

(found in many ores but particularly 'haematite') with a melting point of 1535 deg. C., and is easily the most abundant of all the elements extracted from the earth. In the manufacture of stainless steel the iron is introduced into the furnace in the form of plain carbon steel or mild steel scrap. It is what is added to the iron which gives it its individual characteristic.

Carbon is a non-metallic element which is always present in stainless steel, it is just the amount which varies, between 0.03% and 2%. We know that **Chromium** is always added to stainless steel. It is a metallic element but has a much higher melting point than iron, 1830 deg. C. It is obtained from a double oxide ore of chromium and iron called 'chromite' or 'chrome iron ore'. It is added to increase the resistance to oxidation. It follows that the more chromium is added to the steel, the more the resistance to corrosion increases.

The next most important metallic element which is added is **Nickel**. It is obtained mainly from the ores 'pentlandite' and 'niccolite'. It is greyish-white in colour and has a melting point of 1450 deg. C., which is lower than both iron and chromium. The addition of nickel to the steel has a tendency to form 'austenite' (a solid solution of iron and carbon, named after Sir William C. Roberts-Austen, 1843-1902, the metallurgist who first identified it). Austenite is responsible for the high strength and toughness (at both low and high temperatures) of these much used austenitic stainless steels.

Manganese is another important metallic element which is included. It is a brilliant white with a red hue about it and is very hard and brittle. Manganese is usually found in ores such as 'pyrolusite' and 'rhodonite' and has a very complicated crystal structure. It melts at a relatively low temperature, 1245 deg. C. and stainless steels contain between 0.6% and 10%, 2% being quite common in austenitic types and 1% common in martensitic and ferritic types. The reason manganese is added is to improve the hot working properties and also it increases the strength and toughness. As well as nickel, manganese is an austenite forming element and, in certain grades, has been used as a substitute for nickel. However, by and large, both elements are present in most stainless steels.

Molybdenum, is not usually present in

Table 2
Chemical symbols for alloying elements

Symbol	Element	Metallic?
C	Carbon	no
Mn	Manganese	yes
Cr	Chromium	yes
Ni	Nickel	yes
Mo	Molybdenum	yes
Ti	Titanium	yes
P	Phosphorus	no
S	Sulphur	no
Se	Selenium	no
Nb	Niobium	yes
N	Nitrogen	no
Si	Silicon	no
Co	Cobalt	yes
Ta	Tantalum	yes
Cu	Copper	yes
Fe	Iron	yes
Zr	Zirconium	yes
Al	Aluminium	yes

N.B. Niobium is sometimes known as Columbium (Cb)

any quantity in ferritic and martensitic steels, is found in the ore 'molybdenite'. It is added to improve the austenitic grades' resistance to the 'pitting' type of corrosion which is caused, in particular, by chlorides and sulphur chemicals. Amounts vary between 0.4% and 4%, the latter being present in the very high quality grades of stainless steel used in the manufacture of all types of process plant.

Titanium is a metallic element with a melting point of 1675 deg. C, and found in the ores 'rutile' and 'ilmenite'. It is used in the production of some grades of austenitic stainless steel in the proportions of 0.8% or 0.9%. Sometimes it is added in the proportion of five times the carbon content. The main reason for the inclusion of titanium is for 'carbide stabilisation'. In chromium-nickel steels a chemical reaction sometimes takes place, especially during welding, where the chromium near the perimeters of the grains actually flow to the perimeter, and there it combines with carbon forming 'chromium carbides' (see Fig. 1.). This reduces the amounts of chromium in the alloy around the edges of the grains and renders that area vulnerable to 'intergranular corrosion' when exposed to some chemicals or gasses. (The chemicals or gases attack the metal between the chromium grains where chromium carbides have formed). This chemical reaction is called 'carbide precipitation', and materials where it has taken place are referred to as 'sensitised'. The introduction of titanium in direct proportion to the carbon content has the effect of causing the same chemical reaction except it forms 'titanium carbides' instead because of the fact that the carbon prefers to combine with titanium instead of chromium. This then, reduces the effect of intergranular corrosion and makes titanium alloyed grades exceptionally good when a large amount of welding is anticipated. These grades are often referred to as 'stabilised stainless steels'.

The metallic element **Niobium** (or **Columbium**) is used in much the same way as titanium but it also strengthens the alloy for use in high temperatures.

Another metallic element, **Tantalum**, is used in the same way as niobium.

Other minor alloying metallic elements are **Aluminium**, **Zirconium** and also **Copper**, which is used in a few grades of stainless steels to encourage 'precipitation hardening' properties (to be dealt with later). **Cobalt** is present in the nickel alloys because it is a residual product of the nickel which is used (this can cause problems when the material is to be used in connection with any nuclear service as cobalt becomes radioactive when exposed to radiation). In addition to carbon, a few other non-metallic elements are added to some stainless steels. **Phosphorus**, **sulphur**, and **selenium** are used to enhance

the free cutting machinability of a certain grade (these grades are sometimes suffixed 'F' or 'Se'), however, the inclusion of phosphorus can promote cracking during welding. **Silicon** is used as a de-oxidising agent in the melting process when making steel and because of this, most steels contain a small amount of it.

The introduction of **Nitrogen** gas as an alloying agent is also undertaken on a few austenitic steels. About 0.25% added to the alloy greatly improves the yield strength of that grade. Nitrogen also forms austenite in the same way as we have seen for nickel and manganese. When designing pressure vessels for use under certain conditions, for instance if the weight of the vessel has to be kept to a minimum, it is permissible to construct it using thinner plate if it is a nitrogen bearing grade. The reason for this is that, in addition to the yield strength, the tensile strength is also increased, and the calculations for the plate thickness are influenced accordingly. These grades are rarely seen and are suffixed by the letter 'N'. (e.g., 316N).

Precipitation hardening steels

Some nickel-chromium stainless steels can be annealed at high temperatures, a process which in effect suspends alloying elements which cause the material to be hard and strong. The material is then supplied to the user and can be easily worked as it remains quite soft at atmospheric temperatures. When the product has been manufactured out of the material (either machined or fabricated), it is a relatively simple process to re-harden the material at surprisingly low temperatures (up to 600 deg. C.). This releases the suspended alloying elements and restores the hardness and strength to the steel. These steels may be described as 'semi-austenitic' or 'martensitic'. They are also described as 'precipitation hardening' or 'PH' steels as the term 'precipitate' describes the process in which the alloying elements are suspended (small amounts of copper added to the alloy promote precipitation). These steels are not covered by B.S. 970, but are worth mentioning as



9: A stainless product should always be protected after polishing. This one is covered with PVC tape.

we are destined to see a lot more of them.

Some of the grades in common use and their applications

In B.S.970/1972, the austenitic grades of stainless steel fall between 300 and 399. These are the most likely to find their way into the home workshop. A good selection of these grades will be found to be extremely useful. In the making of models, stainless screws, dome nuts, thumbscrews, and countless other components. They will look superb when highly polished. Shop tools, too, can be enhanced by this marvellous material. Imagine, no more rust.

The most abundant grades to be had in the form of offcuts and small quantities on offer by model engineers suppliers will all be suitable for ornamental purposes. Unless you are doing a special purpose job for someone, maybe a screw which has to be exposed to acids (in which case a molybdenum bound grade would be used), your choice is very wide.

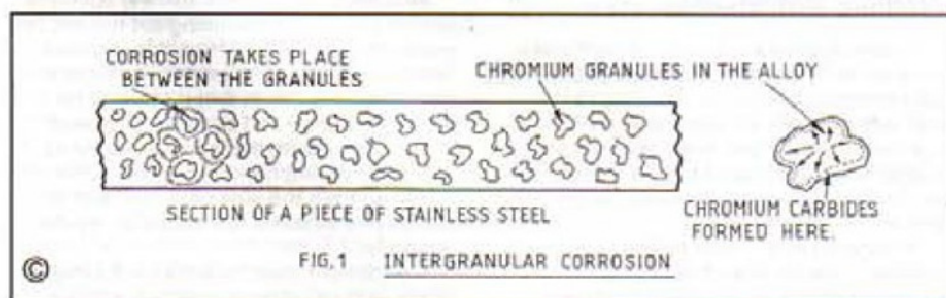
Reference may be made to **Table 2** (chemical symbols of elements) in conjunction with the following notes on grades which may be taken to be in their annealed state. There are many others but these are the most common.

Austenitic grades

All austenitic steels are annealed in the 1000-1100 deg. C. range. After heating they are cooled very quickly (plunge in water) to anneal.

302 contains up to: 0.15% C, 19% Cr, 10% Ni, 0.03% S, 2% Mn, 0.045% P, and 1% Si. This is one of the basic grades of stainless steels (one of the old 18/8). Most other grades have been developed from this one. It can be brazed, soft and hard soldered, has good forging properties, average machinability, and excellent weldability. It also takes a good polish.

303 contains up to: 0.15% C, 19% Cr, 10% Ni, 0.35% Se, 0.06% S, 2% Mn, 0.06% P, 1% Si, and can also contain up to 0.6% Zr. Molybdenum is optional in this grade, but when included the maximum is 1%. 303 is similar to 302 but does not cold forge very well. It machines very well but is not suitable for spinning and is quite poor to weld because of the high carbon





10: 'Throw away tip' lathe tools and 50 mm dia. milling cutter. Go for grade 235 for stainless (all the tips seen here would cost the best part of £100 today)

content. It is somewhat easier to saw.

304 contains up to: 0.08% C, 20% Cr, 12% Ni, 0.03% S, 2% Mn, 0.045% P, and 1% Si. 304 is similar to 302 but the lower carbon content means it welds better (less inter-granular corrosion).

305 contains up to: 0.12% C, 19% Cr, 13% Ni, 0.03% S, 2% Mn, 0.45% P, and 1% Si. 305 is similar to 302. It is an excellent spinning grade as it does not work harden as readily as other grades.

316 contains up to: 0.08% C, 18.5% Cr, 14.5% Ni, 3% Mo, 0.045% P, 0.03% S, 2% Mn, and 1% Si. 316 is similar to 302 but, because of its molybdenum content resists most acids to a large extent.

317 contains up to: 0.08% C, 20% Cr, 15% Ni, 4% Mo, 0.045% P, 0.03% S, 2% Mn, and 1% Si. 317 is similar to 316 but contains a higher proportion of molybdenum.

321 contains up to: 0.08% C, 19% Cr, 12% Ni, 0.8% Ti (usually 5 x C), 0.03% S, 2% Mn, 0.045% P, and 1% Si. 321 is similar to 302 but does not polish to a bright or mirror finish as well as other grades. It is a first class material for welding as the titanium content drastically reduces intergranular corrosion.

347 contains up to: 0.08% C, 19% Cr, 13% Ni, 1% Nb or Ta (usually 10 x C), 0.03% S, 2% Mn, 0.045% P and 1% Si. 347 is similar to 302 but is highly suitable for high temperature work, due to the niobium (or columbium) and tantalum content.

Ferritic grades

Ferritic steels are annealed within the 700-820 deg.C range.

405 contains up to: 0.08% C, 14.5% Cr, 1% Mn, 1% Si, 0.04% P, 0.03% S and 0.3% Al. This grade is magnetic.

430 contains up to: 0.12% C, 18% Cr, 1% Mn, 1% Si, 0.04% P and 0.03% S. This grade is mainly used in its sheet form. It is magnetic and reasonably good for spinning.

446 contains up to: 0.2% C, 27% Cr, 1.5% Mn, 1% Si, 0.04% P, 0.03% Cr and 0.25% N.

This is a magnetic grade and is nitrogen bound to increase the yield and tensile strengths.

Martensitic grades (all hardenable and magnetic)

403 Contains up to: 0.15% C, 13% Cr, 1% Mn, 0.5% Si, 0.04% P and 0.03% S Heat treat in the 700-780 deg.C range, cool in air.

410 contains up to: 0.15% C, 13.5% Cr, 1% Mn, 1% Si, 0.04% P and 0.035% S Heat treat in the 950-1020 deg.C range, cool in air.

416 contains up to: 0.15% C, 14% Cr, 1.25% Mn, 1% Si, 0.06% P, 0.15% S and sometimes up to 0.6% zirconium or molybdenum. Heat treat in the 950-1020 deg.C range, plunge in oil or cool in air.

431 contains up to: 0.2% C, 17% Cr, 2.5% Ni, 1% Mn, 1% Si, 0.04% P and 0.03% S. Heat treat in the 950-1020 deg.C range, plunge in oil or cool in air.

440a contains up to: 0.75% C, 18% Cr, 1% Mn, 1% Si, 0.04% P 0.03% S, and 0.75% Mo.

440B contains up to: 0.95% C, 18% Cr, 1% Mn, 1% Si, 0.04% P, 0.03% S and 0.75% Mo.

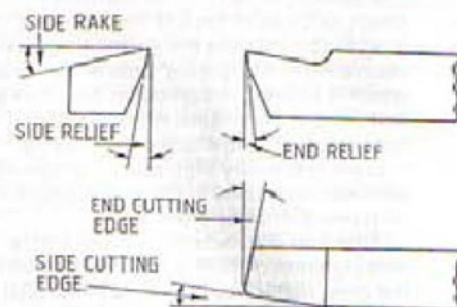
440C contains 1.2% C, 18% Cr, 1.25% Mn, 1% Si, 0.06% P, at least 0.15% S, and up to 0.75% Zr or Mo.

The 440 grades can be hardened to a very high degree - the higher the carbon content the higher the hardness. 440C is completely suitable for bearing type application (60 Rockwell C).

Working with stainless steel

I have often heard it said how difficult it is to machine stainless steel, especially in the home workshop; it is accurate to say that some grades are extremely difficult to cope with. But by and large, the austenitic grades readily available to home users can be machined on modellers machinery without too much trouble.

In order to machine stainless steel, however, certain rules have to be observed. The main problems with this



© FIG 2 LATHE TOOL GEOMETRY

material are work hardening during machining and the immense amount of heat which is generated by friction due to the hard chromium-nickel content. Speeds and feeds have to be reduced. Both these problems are inter-related as when the material work hardens, more heat is generated and as more heat is generated the more the material work hardens. Work hardening has to be reduced in order to be successful. Lathe work is probably the easiest way of machining stainless, but high carbon or silver steel turning tools are really out of the question. The heat produced will easily draw the temper of the cutting edge and render the tool useless unless it is re-heat treated.

Tungsten carbide tools are now widely available to small users, both in the form of the brazed on tip and the throw away tip types. These will perform quite satisfactorily on stainless steel but there is no reason why high speed steel should not be used. Most of the smaller lathes found in the home workshop will not cope with heavy cuts in any case, so depth of cuts will not have to be reduced much. Speeds and feeds can be dropped back to around two thirds of those used for comparable size mild steel as a rough guide. If a full flood of soluble oil as coolant is available, then cutting should not be a problem. Even if coolant is not available as a full flood, it can be brushed on from time to time to ease the situation. Good results can even be obtained with no coolant at all if you don't intend to remove a lot of stock. Tools will have to be regularly sharpened as they must be cutting all the time and not be allowed to rub. This is when work hardening will occur. It is very disappointing to have to take out of the chuck and anneal a piece of work half way through its production. Getting the tool geometry correct also reduces rubbing of the cutting edge and the following relief and rake angles used in conjunction with fig. 2, may be useful if difficulties are encountered grinding high speed steel tools:-

Side relief 5 - 8deg., Side rake 4 - 10deg., Side cutting edge 5 - 15deg., End relief 7 - 10deg., End cutting edge 4 - 10deg.

Another problem with turning stainless occurs after the metal being cut has left the parent stock. Depths of cut, speeds, and feed will not be sufficiently high to get a 'chip breaking effect'. Swarf tends to be long and stringy and comes off hot and sharp so that extreme caution should be exercised during handling. It should be removed from the area of the lathe and transferred to somewhere safe at regular intervals.

One danger spot for work hardening is when using a tailstock centre. If a solid

centre is used to support a piece of bar, it is likely to work harden because of the friction between centre and work. The best solution here is to use a revolving centre. As is becoming apparent, whenever friction is present it promotes work hardening. If screwcutting is to be carried out in the lathe, the method should be adopted where the tool only cuts on the leading edge. For every cut taken with the cross slide feed, the tool is advanced a couple of thou with the compound slide as well. This at least takes some of the burden of friction off the tool.

Milling stainless steels

Milling can present a different proposition. In the lathe we use a single point cutting tool, when it loses its edge we re-sharpen it. Milling cutters, on the other hand, have to be re-sharpened on a cutter grinder of some description or, if no such machine is available, replaced. Replacement is very expensive as the cutters will soon lose their edge when put up against stainless, and if they start to rub instead of cut, work hardening can occur. When ever possible a single point milling cutter should be used for economic if no other reasons. This may take the form of a small fly cutter with a HSS bit which can be easily re-sharpened by hand whenever the edge starts to show signs of dulling. Carbon tool steel is not really suitable for this type of work. Another option for machining a flat plane surface is to use a shaping machine instead of a milling machine. The cutting tool then becomes exactly the same as in the lathe. Anyone who has a shaper in their workshop should seriously consider using it for harder materials, anyone who hasn't a shaper but has room for one might consider obtaining one as they can be had quite cheaply these days.

Drilling

The drilling of stainless steel is a reasonably common occurrence in the home workshop. A good formula which I use for basing my high speed steel drill speeds on is:

$$\frac{8890 \text{ (mm)}}{\pi d} \quad \text{or} \quad \frac{350 \text{ (imp)}}{\pi d}$$

where d = diameter of drill.

A plentiful supply of cutting compound brushed onto the cutting edge of the drill, and holes can be produced with ease. Normally the drilling process does not last as long as turning or milling and it follows that not as much heat is generated. However, a couple of quick calculations using the above formula and it soon becomes clear that with the cheap 5-speed bench drilling machines in abundance on the market these days, the largest hole that may be drilled is going to be about 6.5 mm (the slow speed on these drills is usually around 400/500 rpm). In addition to this, the output of the motor is usually in the region of 190 watts (1/4hp) and 6.5 mm will be about its limit in stainless anyway, otherwise the motor may stall. It is possible to get over this problem when drilling mild steel by first drilling a pilot hole and then opening it out with a drill of the required size, but when drilling stainless it is not a good idea to drill pilot holes. If they must be used, the diameter should never exceed that of the web thickness of the drill. Twist

drills are designed to cut on the full width of the lip length and any attempt to reduce the amount of work the cutting edge has to do (by drilling pilot holes) can very easily encourage the possibility of work hardening. If a larger diameter hole is called for, it is better to drill it in the vertical miller if one is at hand, or set up in the lathe, where slower speeds can be obtained. When drilling the hole, it is very important that the drill is being fed into the work at all times. If you relax the pressure on the feed handle, even for a moment, the drill may start to rub and work harden around the locality of the hole. This is most likely to happen as the drill is breaking through the work piece. As the drill point exits the back of the work there is a tendency to ease off the feed pressure. This is why the work should be firmly clamped to the work table, in order to maintain a constant feed during the complete drilling of the hole. After all, if the drilling machine was equipped with automatic feed it would not ease off as the drill broke through. A rigid set-up is vital in all machining operations relating to the working of stainless steel.

Should work hardening occur during the drilling of a hole, and cutting be unsound or the drill overheats, drilling should cease immediately. The drill and work should be allowed to cool; the drill can then be re-sharpened at a slightly steeper angle so that when drilling is resumed, the hardened material is gradually eased away without too much heat being produced (Fig. 3.). I know this is contrary to what has already been said about cutting on the full lip length, but the circumstances are exceptional here and the drill soon returns to par for the coarse cutting. This method does work. Fig. 3. should make this very successful trick of the trade clear. Another of the work hardening predicaments (especially when using the smaller sizes of drills) occurs when the punch dot, to start the drill off, is indented. It compresses the material and hardens the area locally around the indentation. When the drill is fed into the work it, at once, loses its edge and starts to rub. Punch dots should be kept as light as possible and for the larger drill sizes a light punch dot can be opened out with a small drill to the depth of the point forming a 'dimple'. Another way of keeping work hardening to a minimum around the punch dot is by the use of a centre punch which has been ground in the form of a three sided pyramid instead of conical. A light indentation with this type of punch very rarely hardens the area.

Grinding

The use of cylindrical and surface grinding, as likely as not, won't concern the model engineer at all but a few words are included for those who wish to employ these methods when machining stainless steel. Heat dissipates very slowly with stainless, much more slowly than mild steel or high carbon steel, and overheating can very easily occur during grinding. The surface of the metal turns a light brown when overheating happens (at circa 300 deg.C).

A secondary cause of excessive heat is that the grinding wheel easily becomes 'loaded' with stainless steel particles and then does not cut at its optimum

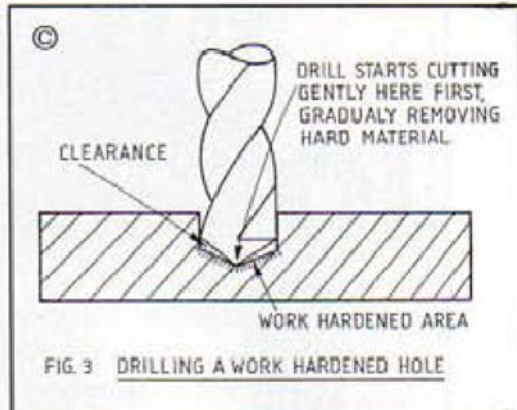


FIG. 3 DRILLING A WORK HARDENED HOLE

capability. To forestall overheating of the work, coolant should be used during grinding and the wheel should be frequently re-dressed to avoid 'glazing'. If a job involves grinding it is most likely that accuracy is being sought. A point to watch is that, by machining, internal stresses are fairly easily set up in this type of material and the 'breaking' of the surface can release these stresses and cause the metal to move. This is especially so when producing long slender lengths between centres. A cut can be taken the full length of the job and it is perfectly true. The job can be examined later and it may be bent slightly due to the release of internal stresses. This happens persistently. In order to try to prevent this, the austenitic and ferritic materials should be 'normalised' by heating to over 1000 deg.C and being allowed to cool slowly in the atmosphere. This, of course, will harden martensitic grades so grinding will have to be resorted to in order to finish to size anyway. Because many grades of stainless steel are non-magnetic, it is not possible to hold them on magnetic chucks. Alternative methods have to be used to grip them which adds to the awkwardness of grinding this material.

Forming threads

When it is necessary to tap stainless steel, the taps must be kept sharp and lubricated with sulphurised oil at all times. When a tap starts to dull on the cutting edges, it starts to 'squeak' which implies that it is rubbing. Work hardening is then to be expected. Taper taps should never be used to start the thread. On this type of tap well nigh the first ten threads are all cutting at once, and at different depths, by the time the first full thread is cutting. This brings about far too much friction for stainless steel. It is much easier to start the tapped hole off with a second cut tap having only about five threads tapered. Also if a lot of tapping is forecast, the rake angle of the tap should be increased to 12deg. from the customary 7deg. which is the tap makers' normal standard angle. This assumes that you have a Tool and Cutter Grinder, or have access to one. For general applications it is permissible to decrease the percentage of thread down to 65% or 70% on stainless steel, which makes tapping easier. External threads should be cut in one pass without having to close up a split die and if possible it is better to use a solid screwing die (not a die nut), than the more normal split button type die.



11: A dish which has been spun from 6mm stainless steel plate and is 80cm diameter. The 25mm hole in the centre is used for the spinning centre. It is eventually closed by means of a welded in plug.

Storage

Stainless steel is an easy material to hoard. It can be kept anywhere, indoors or out, without the dread of it being ruined by rust or corrosion. It is best stored away from the danger of being contaminated by sparks if any work is being embarked upon with an angle grinder. Each spark is a tiny particle of metal and can easily infuse itself into the surface of stainless steel and cause it to appear rusty when exposed to moisture. If you have different grades of material in stock it is worth stamping the ends with the grade number or at least colour coding them. Someone in future may need just such a piece of material and may be prepared to swap it for something you need. No harm is done by marking up materials. It is also worth keeping any extracts from the relevant British Standards. These can be useful for reference. A list of related standards is included for those who are interested (Table 3); libraries and technical institutes are good sources of information on standards. Also manufacturers' and suppliers' catalogues contain much enlightenment and are usually free or available at very small cost.

All in all I hope that by providing a greater understanding of stainless steels, much more use can be made of this material in future in the home workshop and that its use will amplify and augment the scope and versatility of the home craftsman.

Additional notes for mariners

Grades 304, 316, 321 and 347 are all especially suited to sea water applications. All are deemed fully resistant to sea water, having a theoretical corrosion rate (submerged) of less than 0.009 mm (0.00035in.) penetration per month.

All four grades are non-magnetic and have good hot and cold forging properties. 304 and 316 are very good for cold rolling operations (threads etc.). 321 and 347

machine marginally better than 304 and 316. They can all be used for spinning cowls etc. but another grade, 305, is the best stainless grade for spinning. If rivets are to be made out of these materials they will not be ideal to work with. Care has to be taken not to split the metal when peening. Corrosion resistance requirements must outweigh workability when considering rivets.

These grades can all be hard and soft soldered, and sawing them can be hard going. Where welding is to be used, they are excellent for this method of jointing though 321 and 347 are the best. Risk of inter-granular corrosion can occur at 1038 deg.C (1900 deg. F) on 304 and 316. 316 expands slightly less per degree rise in temperature than does 321 and 347. 304 expands slightly more than the other three. 316 and 347 have a higher yield strength

and are, to a small extent, harder in their annealed state than are 304 and 321.

It has become fashionable these days to abrasive blast stainless steel as a method of enhancing its appearance. I must admit that the 'satin lustre' so produced is highly attractive and creates a 'professional finish'. This work will probably be 'contracted out' and care must be taken with marine components when they are treated in this manner. Blasters use either quartz or steel sand and, especially with the latter, corrosion can occur because of particles of steel impregnated into the surface (maybe even from a previous job as the abrasive is recycled within the blasting unit). Pickling is, therefore, necessary to avoid this. If an acid bath is not on hand some good pickling pastes are available. This class of finish also presents another problem in marine work. The 'flat' finish allows a film of dirt to form more readily on the surface of the stainless steel than does a highly polished finish. The layer of dirt then constricts the oxygen which is required to form the passive film. If the passive film breaks down, corrosion occurs. 316 therefore, is a better grade for abrasive blasting because of its molybdenum content. Also copper bearing and nitrogen bearing alloys resist corrosion under these conditions but are harder to obtain.

The popularity of home welding equipment has encouraged the fabrication of many items which were at one time bought off the shelf. One such item is the marine propeller. Instead of buying a cast bronze or aluminium screw it is very satisfying to produce your own from a machined hub and welded plate blades. 347 may be found to be the most suitable material for this purpose. The welding can be carried out using an ordinary 'stick' set, one of the many MIG welders currently available, or even the TIG units which have now become within the reach of home workers.

Table 3

British Standards associated with stainless steel
(British Standards Institution, Linford Wood, Milton Keynes, MK14 6LE.)

- B.S. 21 Pipe threads for tubes and fittings where pressure tight joints are made on threads.
- B.S. 970 Pt. 1 Stainless heat resisting steels in the form of blooms, billets, bars and forgings.
- B.S. 1449 Pt. 2 Stainless and heat resisting steel plate and strip.
- B.S. 1501 Parts 1 (1980) & 2 (1988).^{*} Flat products made of steels for pressure purposes.
- B.S. 1501 Pt. 3 Corrosion and heat resisting steel plates.
- B.S. 1502 Steels for fired and unfired pressure vessels. Sections and bars.
- B.S. 1503 Steel forgings for pressure purposes.
- B.S. 3014 Welded and cold drawn welded austenitic stainless steel tubes for mechanical, structural and general purposes.
- B.S. 3059 Steel boiler and super heater tubes.
- B.S. 3600 Dimensions and masses for unit length or welded and seamless steel pipes and tubes for pressure purposes.
- B.S. 3605 Seamless and welded austenitic stainless steel pipes for pressure purposes.
- B.S. 3606 Tubes for heat exchangers.
- B.S. 4127 Light gauge stainless steel tube.
- B.S. 6323 Pt. 8 Longitudinally welded stainless steel tubes for automobile, mechanical and general engineering purposes.
- B.S. 6362 Stainless steel tubes suitable for screwing in ACCORDANCE WITH B.S. 21

Note to Table 3.

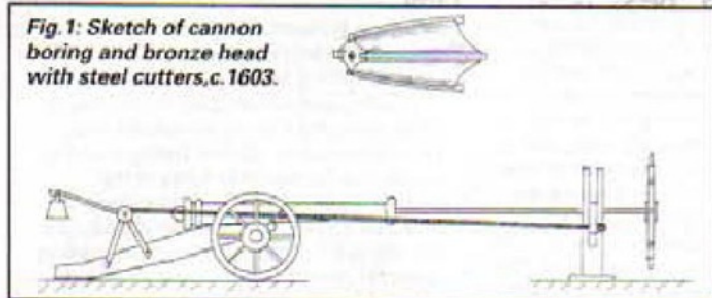
^{*}B.S. 1501 Parts 1 (1980) & 2 (1988). Flat products made of steels for pressure purposes. When this table was originally compiled this section was undergoing review a revision now applies, as below:-

B.S. EN 10028. Specification of flat products made of steels for pressure purposes.
B.S. EN 10028: parts 1, 2, & 3 (1993) supersede B.S. 1501: part 1 (1980) and partially supersede B.S. 1501: part 2 (1988) which has now been amended.

THE BIRTH OF THE LARGE MACHINE TOOL

Don Unwin continues his occasional series on the history of machine tools with this brief exposition on the birth and development of boring machines; they were so linked with the munitions field that progress in this direction seemed inevitable

Fig. 1: Sketch of cannon boring and bronze head with steel cutters, c. 1603.



engine later provided further encouragement. With the arrival of gunpowder from China and India to Europe about 1300 it wasn't long before the cannon was invented, the first

accuracy resulted in the development of a crude form of machining. A tool head with cutter was fixed to the end of a long horizontal rod which could be rotated by a capstan or water wheel whilst the cannon was pulled on to the cutter by weights, Fig. 1. Vannoccio Biringuccio illustrated in his *Pirotecnica*, published 1540 a water wheel driven cannon boring machine in which the barrel was mounted on a carriage or sledge pulled along by ropes and a windlass, Fig. 2. It has been suggested that the 'hammer ponds' in Sussex were used as much for driving cannon boring machines similar to Biringuccio's as for driving forge hammers. These methods were used for many years, Diderot illustrates a similar machine in his *Encyclopedie* of 1772. However the method did no more than clean up the bore, following any cast misalignments, in fact sometimes making them worse. As can be seen from the early 17th century drawing, Fig. 3, the cannon boring machines were little more than adaptations the methods used to bore wood pipes and pump barrels.

The first machine tool was the lathe; until the beginning of the 19th century these were mainly used by woodworkers, clock and instrument makers and for ornamental turning, hence they remained relatively small.

As always armaments provided the first stimulus for the development of the large machine tool although James Watt's steam

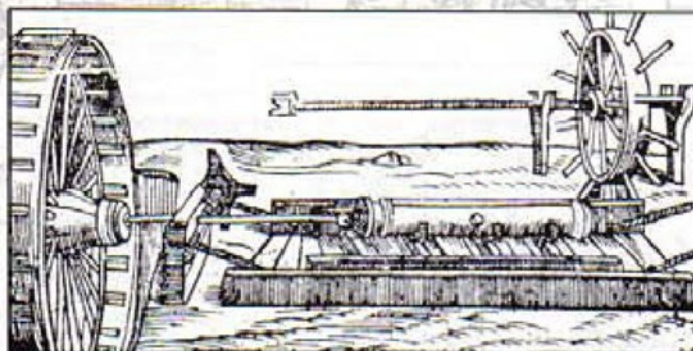


Fig. 2: Cannon boring mill 1540. Biringuccio's *Pirotecnica*.

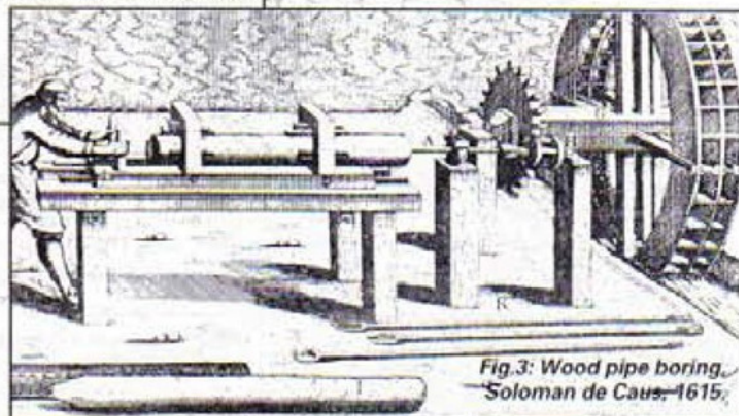
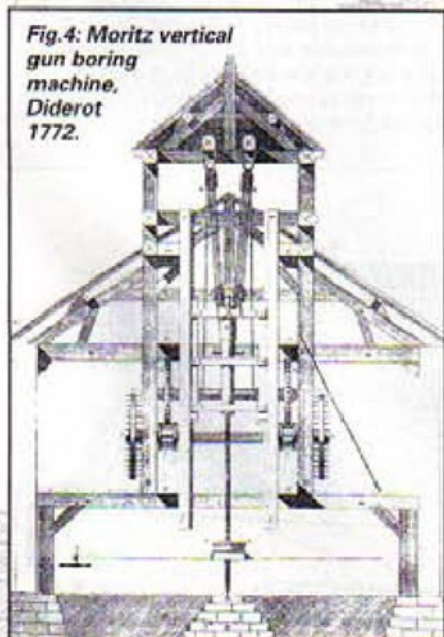


Fig. 3: Wood pipe boring. Soloman de Caus, 1615.

Fig. 4: Moritz vertical gun boring machine, Diderot 1772.



recorded use being at the battle of Crecy in 1346. At first they were cast in bronze with cored bores and were quite small, only weighing between 20 and 30 pounds. Next, around 1400, came forged iron barrels, made of longitudinal bars fire-welded together, bound with iron hoops and weighing as much as 600 pounds. Cast iron appeared in Germany in the second half of the 14th century where the first cannon was cast in that material. The use of cast iron was slow at first, bronze being preferred as it suffered less from corrosion and the cracking to which the poor quality irons of the period were very prone. At first the bores were used as cast but the need to improve fire power and

Vertical Boring Mills

In an attempt to improve this situation, a Swiss engineer named Moritz devised a vertical boring mill in 1713 which was able to bore barrels from a solid casting. Perfection was not achieved for several years but eventually the Netherlands State Gun Foundry at the Hague adopted the system in 1747, issuing a decree that all guns were to be bored from the solid. It was kept secret for many years but it had become known by 1772 as Diderot illustrated such a mill in his

Encyclopedie. Fig. 4.

Jan Verbruggan, gun founder to the Netherlands Admiralty, moved to the Hague Foundry in 1755 and being dissatisfied with the Moritz machine devised his own horizontal version in 1758. In it he used a horizontal bar and for the first time rotated the cannon on bearings. This produced a much more accurate bore than was possible with rotating the bar used by all other methods then in vogue.

In 1770 Verbruggan misbehaved himself

In 1774 Verbruggan prepared comparative costs of making machined cored cannon barrels, and machining them from solid castings arising from which the Board of Ordnance decided that in future all would be bored from solid. Verbruggan's machines remained in use until 1842, 56 years after his death. These were probably the first large machine tools capable of reasonably accurate work.

A need for large bore cylinders

In the meantime, in 1712, Newcomen had invented his atmospheric steam engine which called for large bore cylinders although with much thinner walls than cannon. These were cast in brass or bronze initially and being about 8ft. long with a bore diameter of 28in. were far beyond the capability of the contemporary cannon boring machines. The bores were finished by rubbing with abrasive stones but

circularity, parallelism and straightness depended entirely on the skill of the founder.

As the Newcomen engine moved slowly and at a low working pressure, an adequate seal could be made with water on the top of the piston in the open topped cylinder.

The Quaker, Abraham Darby's, Coalbrookdale Iron Works, with their exceptional iron founding skills soon entered the field making cast iron cylinders for Newcomen engines in 1722. At first bores were hand finished but by 1725 a cylinder boring machine was mentioned, able to bore cylinders up to 46in.

diameter, although not without problems involving breaking boring bars. A new mill was made in 1734 with a heavier bar 12ft. long and 3in. diameter. We do not know the exact details of the machine but there are indications that it was a development of the horizontal water driven cannon boring mill.

Coalbrookdale lost their monopoly in 1759 when the Carron Ironworks near Falkirk started up. Unlike Darby's works, where the Quaker principles of the management would not allow them to make weapons, Carron soon introduced the famous Carronade as well as making steam engine cylinders. John Smeaton who was responsible for the plant at Carron installed his cylinder boring mill in 1770, Fig. 6. As Dr. Roebuck, founder of Carron Ironworks had poached some men from Coalbrookdale it is very likely that the mill was very similar to the Coalbrookdale machine. The cutter head on the end of a long bar was supported by rubbing shoes and hence followed the cored bore. Smeaton had tried to reduce errors by supporting the cutter head with a carriage running in the bore and passing the cutter through the cylinder four times rotating it 90deg. between each pass. The results were quite adequate for the Newcomen engine but James Watt found them useless for his engine with external condenser. His first engine was built in great secrecy at Dr. Roebuck's house at Kinneil near Falkirk from parts made by Carron Ironworks and was a failure due to the inability to maintain an adequately steam tight piston in the inaccurate cylinder.

Probably the leading ironmaster of the period was John Wilkinson whose ironworking skills rivalled that of Coalbrookdale and like Carron made guns on a large scale. Strangely, in 1774 Wilkinson applied for and was granted a patent for a cannon boring machine which

Fig.5: Diagram of Verbruggan's cannon boring machine, Woolwich Arsenal, 1770

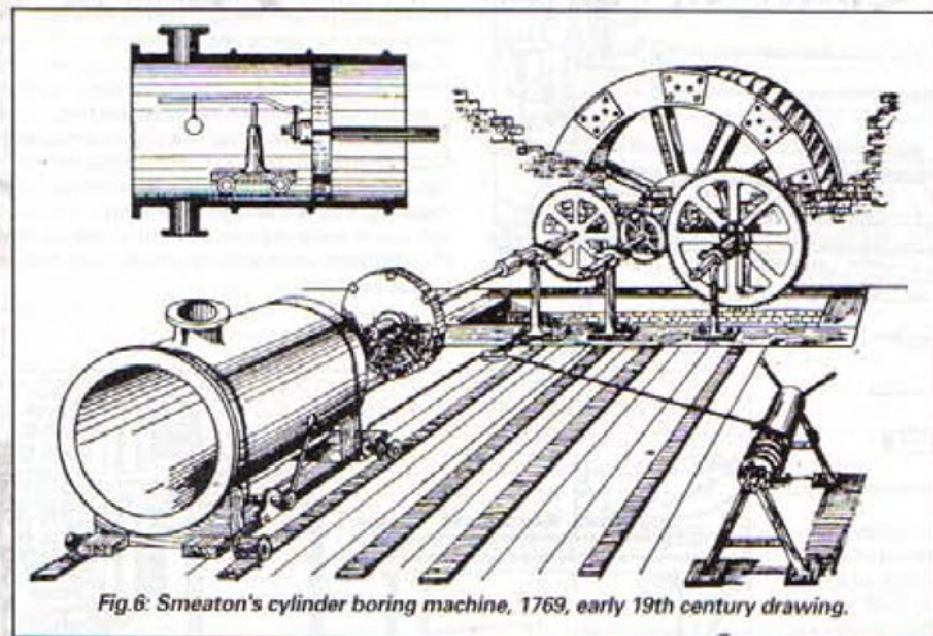
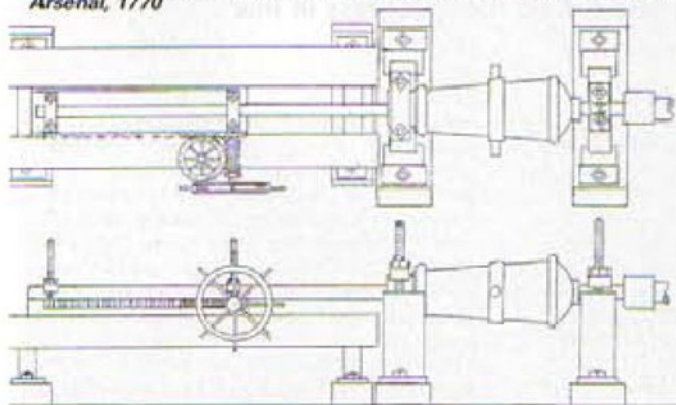
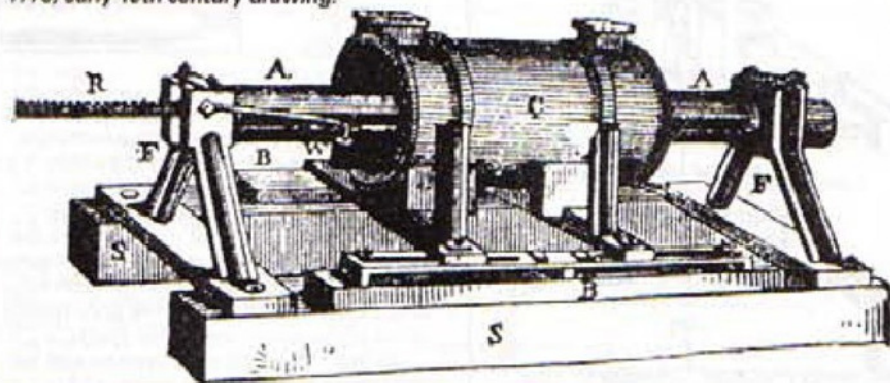


Fig.6: Smeaton's cylinder boring machine, 1769, early 19th century drawing.

in some way and was discharged from the Hague, only to be immediately appointed Master Founder at the Royal Arsenal, Woolwich; he appears to have brought one of his mills with him. By the end of 1770 two large heavy mills and a small one of the same type to bore mortars were working at Woolwich.

Verbruggan's predecessor Andrew Schalch had a machine for which he was issued with ".....material for the female of the great screw for the engine at the Royal Foundry....."; which suggests that it had some form of lead screw feed and if so it is the earliest known application. However Verbruggan did not appear to perpetuate the method as contemporary drawings indicate a rack and worm driven pinion shown in Fig. 5.

Fig.7: Wilkinson's cylinder boring mill, 1775, early 19th century drawing.



was virtually the same as that which Verbruggan had introduced at Woolwich Arsenal 4 years previously, illustrated in the sketch, Fig. 5. The Board of Ordnance challenged the patent which was withdrawn in 1779.

Boulton, after Watt had joined him, suggested that Wilkinson be approached about the cylinder boring problem. As the Kinneil cylinder was only 18in. dia. it seems likely that Wilkinson bored it on his cannon mill and when the re-machined cylinder was delivered to Soho Manufactory in 1775 it was found to have solved the problem. Wilkinson realised the potential of the Watt engine - he was one of the first users - and knowing the limitations of the cannon boring mill which was designed to bore blind ended holes, designed and built a machine specially for dealing with steam engine cylinders of much larger diameter and open both ends. In his machine the

cylinder casting was stationary and the hollow boring bar running in bearings one at either end of the cylinder. The cutting head slid along the boring bar, being pulled along by a rod in the hollow bar and connected to the head through a longitudinal slot. A rack on the outer end of the rod driven by a pinion and crank handle advanced the cutter head through the bore as it rotated, Fig. 7.

Using this machine Wilkinson was able to bore cylinders circular and parallel, some as large as 72in. dia. with an error, to quote Watt, "... not further from absolute truth than the thickness of a thin sixpence at the worst part...". The mill was not copied by others until after 1779, although Wilkinson continued to make the cylinders for all Boulton and Watt engines.

One of the copies, that by Matthew Murray in 1795 is believed to be the first cylinder boring machine with self acting

feed to the cutter head although it had already been fitted to cannon boring machines.

Boulton and Watt had a serious rival steam engine builder in Matthew Murray. Murray started in 1795 at Holbeck, Leeds, his works later being known as the Round Foundry. Unfortunately a fire destroyed all the Murray records in 187, making it difficult to establish exactly his contribution to machine tool building. However it is certain that he was one of the first manufacturers to make machines for sale, most others making them for their own use. Murray had introduced the D slide valve and made the machine to produce the flat surfaces. Later, about 1822 he also made two cylinder boring machines sketches of which still exist, while there is evidence that he made a third. Several of the second design were exported to France where they were highly regarded, Fig. 8.

Most of these 18th century machines were driven by water wheels or occasionally by horse but the Watt rotative engine which the boring mill had made possible soon began to take over and remove the need to locate mills near running water.

William Murdoch, Boulton and Watt's foreman in Cornwall was recalled to Soho Works to take charge in 1798; he soon introduced manufacturing improvements and new machines. One was a large horizontal cylinder boring mill installed in 1799 and still in use when the Foundry was closed down in 1895 on which occasion *The Engineer* published a series of articles describing the plant, Fig. 9.

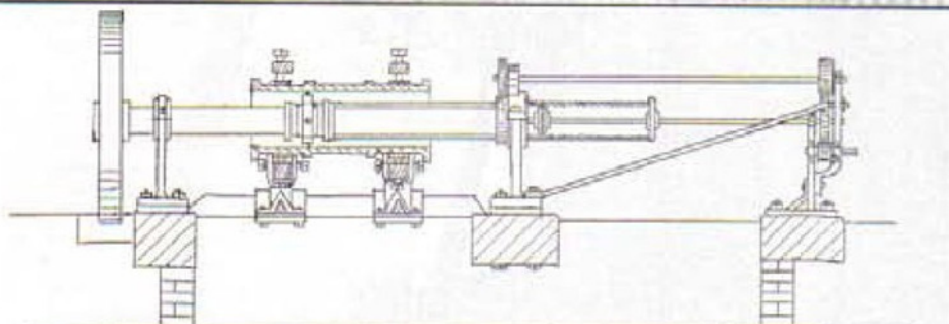


Fig.8: Diagram of Matthew's Murray's cylinder boring machine, 1822 version.

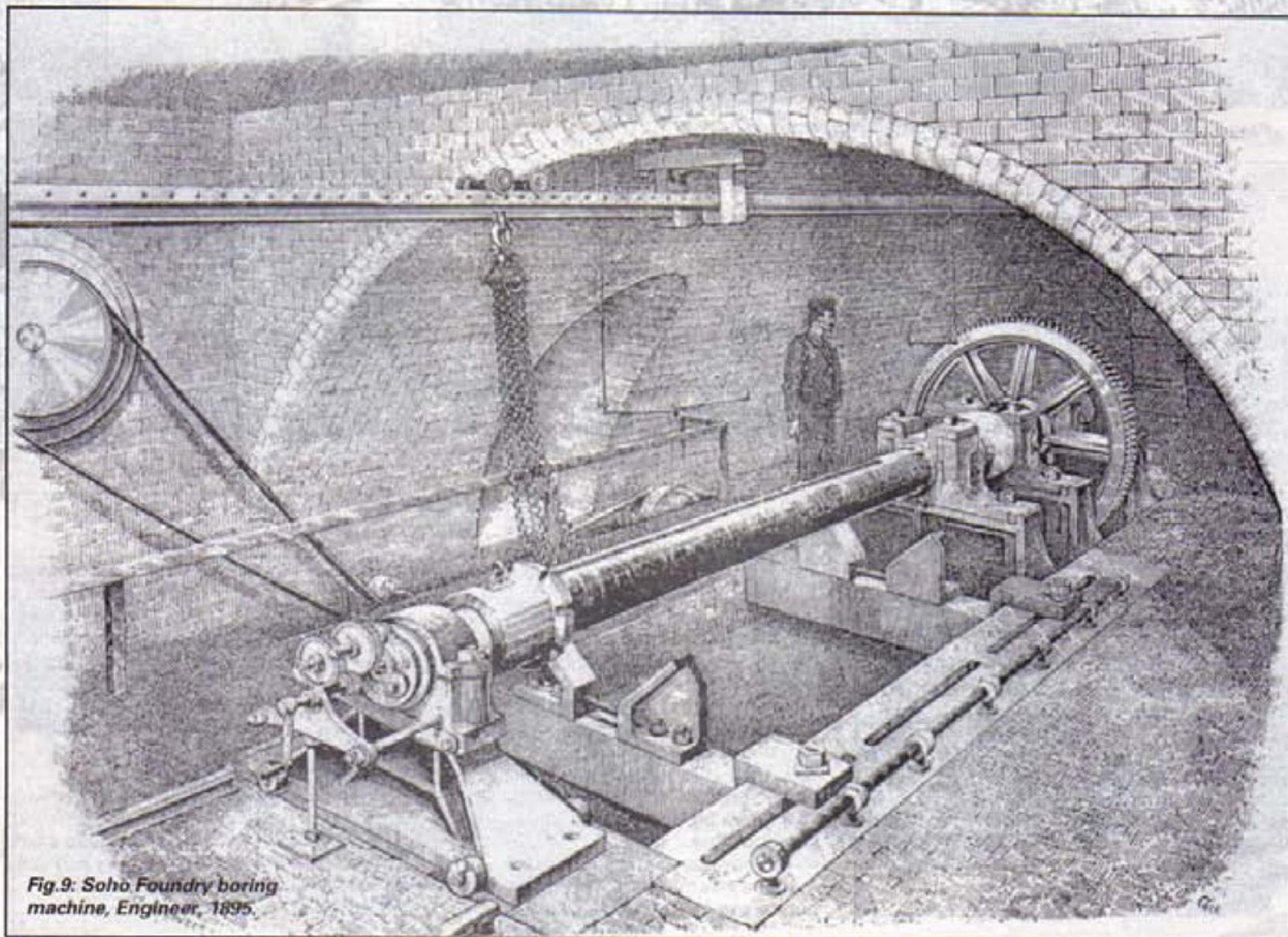


Fig.9: Soho Foundry boring machine, *Engineer*, 1895.

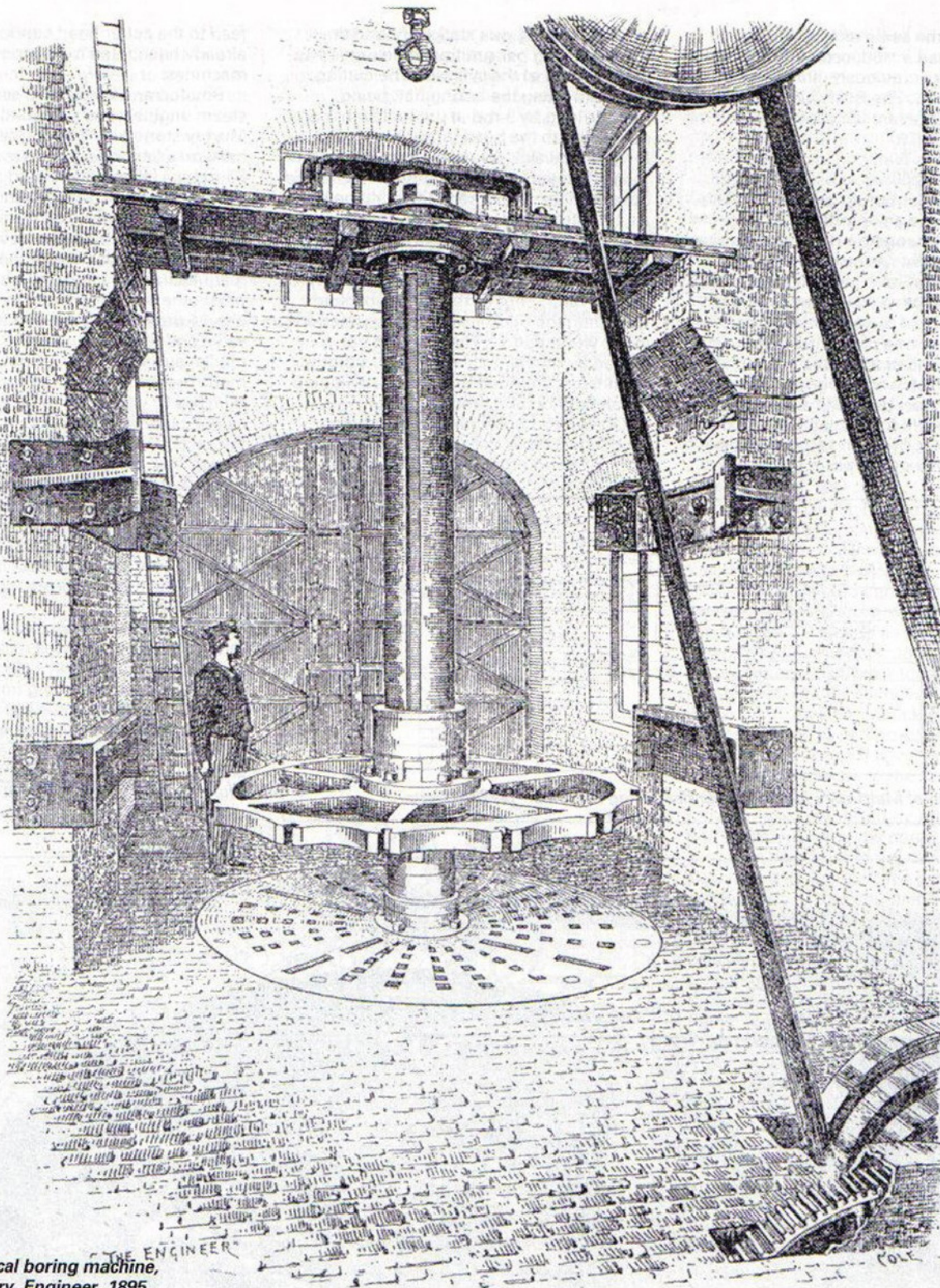


Fig.10: Vertical boring machine, Soho Foundry, Engineer, 1895

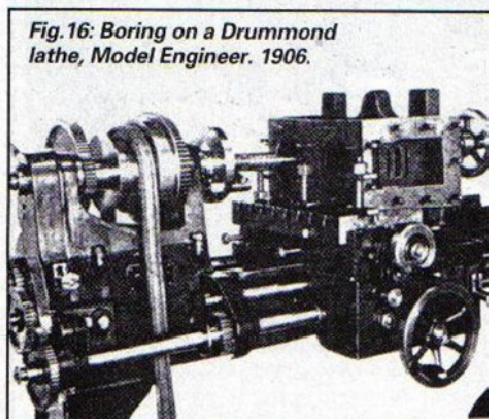


Fig.16: Boring on a Drummond lathe, Model Engineer, 1906.

A slow process

The job time for boring a 65in. dia. cylinder is interesting. "Getting on, $\frac{3}{4}$ day; Centring and fixing, $1\frac{1}{2}$ days, Facing, $\frac{1}{2}$ day; Setting cutter, $\frac{1}{2}$ day; Boring, $11\frac{1}{2}$ days; Preparing to go through a second time, 1 day; Boring, $8\frac{1}{2}$ days; Facing, $1\frac{1}{4}$ days; Bell-mouthing, $1\frac{1}{2}$ days; -Getting off, $\frac{1}{2}$ day; Total $27\frac{1}{2}$ working days". These would have been at least 12 hour days so it was a pretty lengthy and laborious task.

The advantage of the horizontal machine was the ability to face both ends but the sag of the long boring bar and

the build-up of swarf could cause problems. To obviate these Peter Ewart had designed a vertical machine for Soho in 1795 but it was not built. However the design was copied and patented in 1802 by Micheal Billingsley of Bradford. We know that one was installed at Soho later as it is recorded that a vertical boring mill was used in 1854 to machine the four 84in. dia. cylinders for the screw engines of Brunel's steam ship Great Eastern and the machine was illustrated in the Engineer articles of 1895, Fig. 10.

Both types from very large to quite small enjoyed favour in the 19th century and still do, each being particularly adapted to certain types of work.

The horizontal machine is well adapted to bore large components which cannot readily be rotated such as steam engine cylinder blocks for example, Fig.11 and the large turbine casing in Fig. 12. Some of the vertical machines in addition to boring with a rotating boring bar on stationary work can also be used as a vertical lathe in which the work is rotated, the tool remaining stationary.

In 1803 E.P.Bullard in the USA designed and built the first of a long range of boring and turning mills, really vertical lathes but often called boring machines. These developed into quite complicated production machines with several tool heads on a cross bar over the table and other heads on the side standards. Fig. 13 shows a very large machine of this type and another was illustrated in Fig.18 of Part 2 of my previous article The Evolution of the Lathe (M.E.W.issue 16). Duplex machines with two tables and tool turrets were also developed, an example from the late 1920s is shown in Fig.14.

A smaller horizontal machine, the Union borer-miller, also of the late 1920s is shown in Fig.15, which was invaluable for dealing with the varied boring and milling operations involved in the manufacture of scientific instrument components. Notice the clutter of belts which was so typical of machine shops of the period!

It is nice to remember that when boring with the work mounted on the saddle we are enacting in a small way the principles of the 18th century machine builders

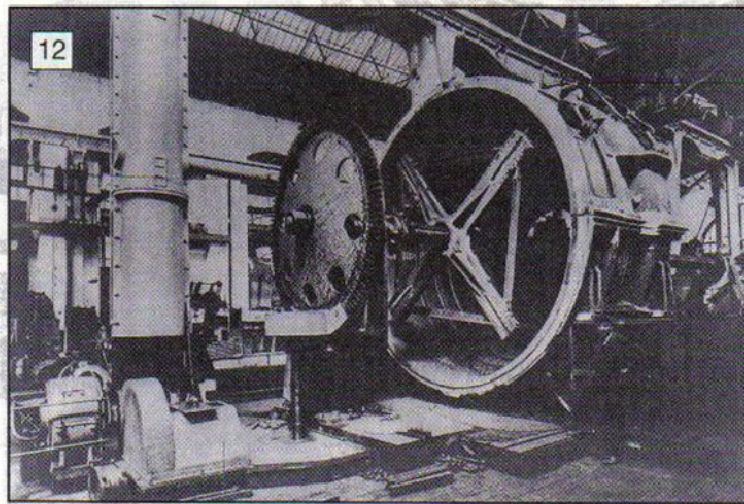


Fig.12:
Horizontal
boring
machine
working on
low-pressure
turbine
casing,
c1930.

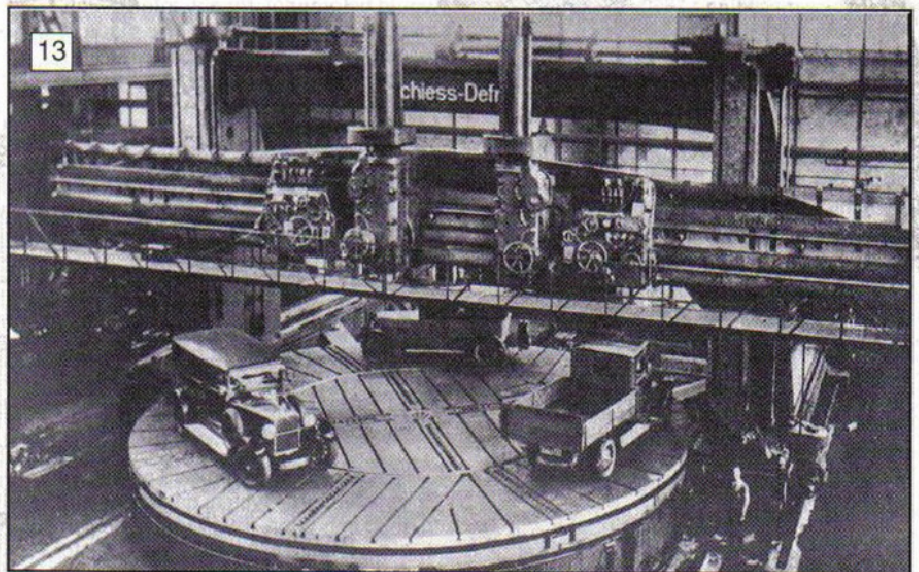


Fig.13: Large boring and turning mill, c.1930, Alfred Herbert.

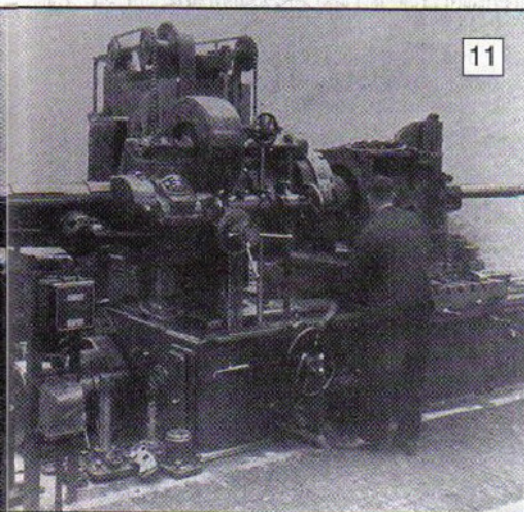


Fig.11:
Locomotive
cylinder boring
machine, Crewe
Works, 1929.

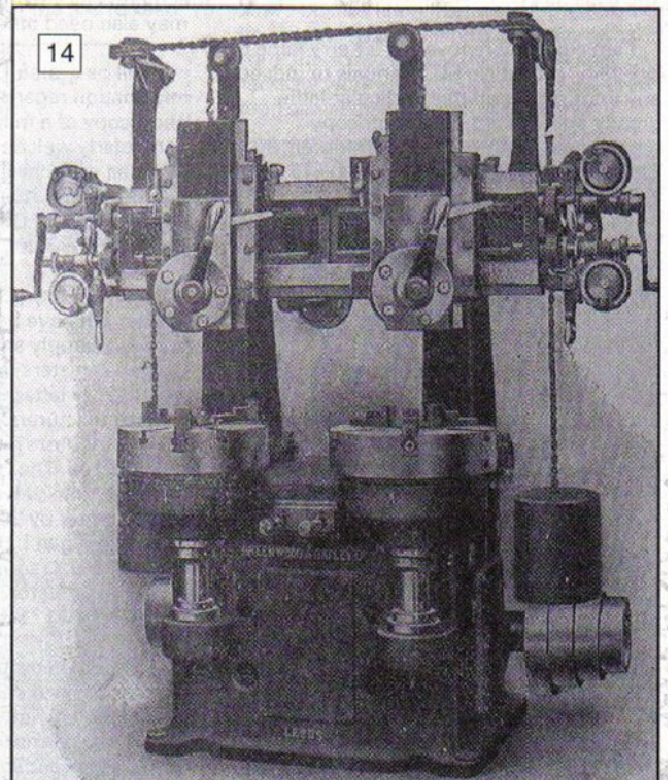


Fig.14: Duplex vertical borer, 1930s.

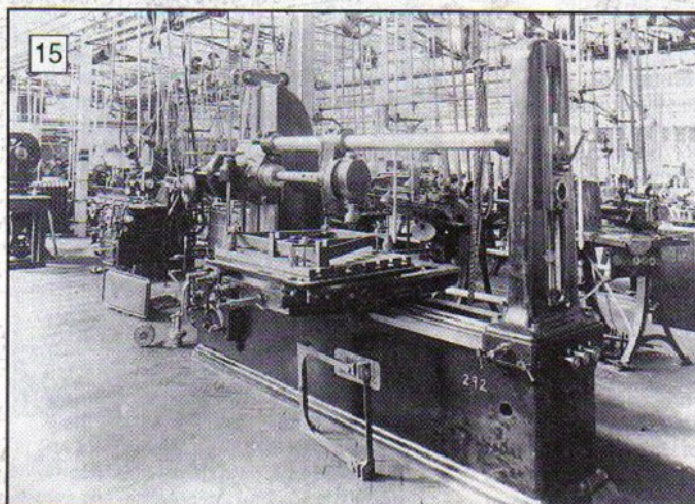


Fig.15: Union borer-miller, 1929. Cambridge Instrument Co. Ltd.

LINK UP

WANTED

Can anyone please lead me to knowledge of the manufacturer's "special quadrant and gears" supplied as an option to allow metric threading on the 10in. La Blond Regal lathe? I will happily reimburse for, post, photos, copying etc. Maurice Sawyer, Beaconsfield, 0494 673947.

Wanted old issues of *Practical Mechanics* magazine - 1950s or earlier. Also copies of *Popular Mechanics* (American) 1950s-1960s. K Balzan 53 St Catherine Street, M QABBA, ZRQ 08, Malta, GC.

Wanted, Instruction manual (photocopy would do) for Sigma Jones MT 368 milling machine. Also, does anyone know if it will take collets bigger than 1/2 in. and can anyone offer such? Tel. Oakham (0572) 756069.

I have recently purchased a small Edgar Lathe, patent No. 194047, makers date 1922. Some parts are broken and need repairing or replacing. I would be grateful for any literature, information or manufacturers drawings about this lathe to assist in my getting it back to its original state.

If anyone could help in this matter, please send details to Mr. M. Lambert at "Woolersend", Garrard Place, Ixworth, Bury St Edmunds, Suffolk IP31 2EP. Tel. 0359 30137.

I am currently renovating a Kerry lathe 5 1/2 x 23in., model No 6G. Manuals or indeed any information on this particular lathe greatly appreciated. Can photocopy anything and return. Peter Symington, 30 St Lawrence Road, Scunthorpe, DN16 1RB. Tel. (anytime) 0724 271576.

Wanted. 1-2 HP 3 phase electric motor foot mounting. Telephone: 0322 330556 (NW Kent).

Wanted:

a). *Machinery's Handbook* edited by P.S.Schubert and others preferably a copy printed 1970 - 80 but any edition will suit.

b). *Metalwork Made Simple* by Tom Pettit a paperback published in the "Made Simple Series"; and

c). *Workshop Technology*, (Part 3 only) by W.A.J.Chapman.

Please state condition and price. Write or phone Eddie Martin, 15 Park Rd., Broxbourne, Herts, EH52 5RF. Tel. 0506 852457.

Elliott horizontal/vertical milling machine type MO (Model 07) table approx. 32 x 7inches. Does anyone have any information on this machine please. Some of the adjustments (table nut/backlash) seem to be similar to those of the later and larger V1/U1 Elliott machines but I would

appreciate information on the correct way to adjust the belt tension (second stage in the 3 stage drive) and also on how other owners fitted a cross feed lock. Malcolm Leafe, 49 North Park Street, Dewsbury, West Yorks. Tel. 0924 460884

I wonder if any reader can help. I recently obtained a 3 1/2in. Mikron lathe and would be grateful, for any information, manuals etc. about this Swiss made machine. The tailstock taper is non-standard, as far as I am able to measure, it is a Jarno 4.5. Someone must have come across this problem before, can anyone help either by selling me some tooling for the lathe or with the name and address of a company to grind up an adaptor sleeve with No. 1 Morse taper. Tel. 0751 472392.

I have a Clarkson Autolock N.S. (Non-Stick) 1 1/2in., taper (very nearly 30 INT) milling chuck for sale or exchange. I require a 30 INT Clarkson Autolock Small S type chuck. I also have some surplus collets to suit same. Telephone Hall, 0926 624456 (Warwickshire).

I have recently purchased an old Colchester Lathe which, despite its age, is in good condition. The name plate states that it is a Colt 7 x 20inch. The headstock mandrel has a screw thread (1 1/2in. OD and 12TPI, 1/2in. long) for which I need to acquire a face plate and a four jaw chuck. I may also need other change wheels.

I will be grateful if anyone has any information regarding this machine, a photocopy of a manual would be particularly welcome. I will be happy to cover all expenses.

L B D'Alton, Avonia, 45 Greenfield Road, Mount Merrion, Co Dublin. Tel 288 0778 (Eire).

I have an oxy-propane torch outfit Clean Welder but have been unsuccessful in finding a supply source for the propane or oxygen canisters (approx. 14 oz. gas weight). My letters to Cleanweld Turner, the manufacturers, asking for details of U.K. distributors have remained unanswered. The metal canisters are both threaded (into valve assemblies) approx. 1in. diameter by 20 TPI.; the propane RH, and the oxygen LH, threads. Does anyone know of a U.K. source of supply please? Keal, 14 Middleton Way Knottingley, West Yorkshire WF11 8HA, (tel. 0977 674434).

Wanted: A compound slide or vertical slide or both for a 3in. Drummond flat bed lathe. Also any information on this lathe; especially the change wheel gear train set-up for screw cutting, or a chance to look at an original manual. Please telephone 0481 726168 or write to Mike Day, 39 Valnord Lane, St Peter Port, Guernsey GY1 1YQ.

I have acquired a Denham Lathe, I am interested in what year it would be and a suitable manual on how it works, adjustments, etc. The lathe has a 7in. centre height and is about 30in. between centres, it has a gap bed, it is belt driven by a flat belt. Stamped machine No.2251, also has a plate: Charles Churchill & Co. Ltd, Engineers & Co.; London, Birmingham, Manchester, Glasgow, Newcastle on Tyne. Please help, write or telephone: Burnie, Strype Croft, Garmouth Morayshire, IV32 7LG, 0343 87303.

FOR SALE

For Sale. Variable speed drive 1/2 HP. Spec. available £35 plus carriage. Tel: 0322 330556 (NW Kent).

For Sale. Old unusual 7in. chuck with unusual jaws external/internal. No key £40. Small chuck backplate £10. Tel: Blackpool 0253 354478.

For Sale. Clare 3MT milling chuck, new, unused, 1/4, 3/8, 1/2, 3/4 collets, 1 MT collet. £45.00. Tel: 081 363 2825 (Enfield).

For Sale. Old type 3 jaw self centre chuck. Approx 5in. diameter. One set self centre jaws fitted. No back plate but various possible back plates available to callers £40. Small 4 way tool post £10. Tel: Blackpool 0253 354478. 5 Gresley Place, Blackpool.

Free offer (you pay postage) I have a set of change wheels with a bore of 9/16in. with key way. 16, 24, 28, 32, 36, 40, 44, 48 and 52. Also large lathe dog marked with a 40. If these are of any use to anybody please telephone Hythe (Kent) 0303 267115 after 6pm.

Have table power feed for Centec 2A Milling machine. Presently fitted with 1/2hp 3 phase motor, but could be converted. Will sell (offers) or swap for w.h.y.? Also 12BA LH tap seeks similar die for lasting relationship. Call 0602 734 587 (Nottingham) to haggle.

Model Engineer magazines as follows:-

1971 - 80 Bound copies: 1970 - 75 Loose copies, all complete, 1980/81/82/83/84/85, unbound and incomplete,

1962 - 9 loose copies. I also have a bound set of *Model Maker* magazine for 1980. Offers for all or part of the above to (Oxford) 0865 375942.



VERTICAL BELT GRINDER

One of the simplest of workshop machines to make is the belt sander; it is, none the less interesting to make and providing a very useful end product. This design for a vertical belt sander is by Malcolm Leafé

Over the years various writers in *Model Engineer* and other magazines have extolled the virtues of the finisher or belt sander/grinder as a metal remover, chiefly in free-hand operations. The propaganda eventually affected even me and I too decided to join the band of belt grinder owners by the long but cost effective way around self design and construction; preferably from materials on hand.

The approach taken to the project was to "eye up" as many versions of the device as I could find, at exhibitions, in workshops and in drawings; this is, I suspect a popular approach to many amateur design projects. After some procrastination, I opted for a vertical format machine which seemed to me the most useful for freehand metal removing - most of the uses envisaged by myself appeared to involve the edges of workpieces rather than large flat surfaces for which a horizontal machine would appear to

offer pseudo surface grinder facilities. A final design factor was that the construction had to be within the capabilities of my 1917 Drummond "twin bed" lathe.

Before establishing the design parameters i.e. looking in the scrapbox, I considered it worthwhile to check on the local availability of consumable - abrasive belts. It appears that abrasive belts come in all manner of widths and lengths. I thought it useful to avoid unpopular lengths and widths which may have required a lot of horse power and settled on using 42 in. long belts which seemed to be easily available in 1 in. and 2 in. widths and in a variety of grits.

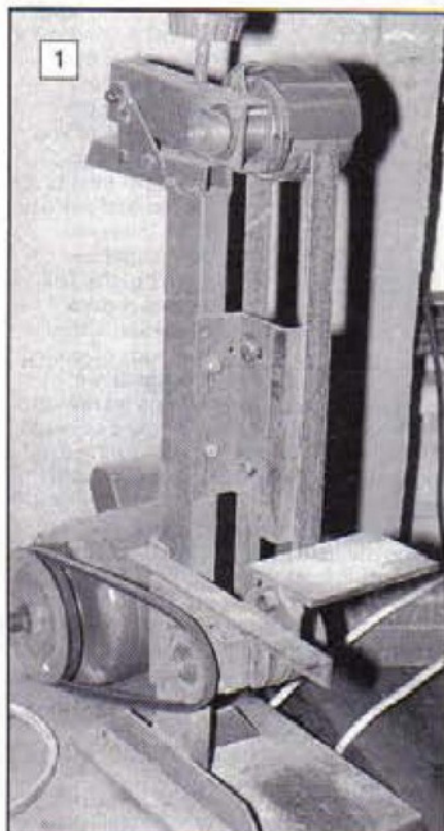
Having chosen the abrasive belt size the metal strangling could begin. The main requirements for a belt grinder (I understand that Linisher is a registered trade name) are for some kind of rolls for the abrasive belt to run on and a suitable piece of metal to keep the rolls sufficiently far apart to keep the chosen belt tight. A search through my material stores (i.e. scrap box) revealed a supply of 2 x 1in. and 1 x 1in. steel tube which looked promising for the bits to keep

the rolls apart, some 3in. dia. galvanised tube - very roll looking and a box of sealed surplus ball races already fitted in pairs in steel housings, obviously just what I needed. Construction started with, what in my opinion were the easier parts to visualise - the rolls.

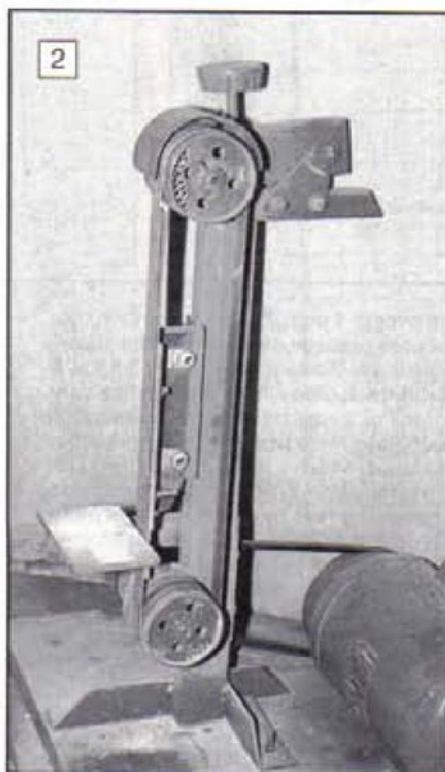
Roller assembly

The drawing (Figure 1) shows the relevant details. Although construction in this way is more time consuming than turning from solid would be, I feel, that a hollow, relatively lightweight, construction has benefits in reducing the inertia of the belt/roll system.

The initial work was the end plates (item 12b). I cut four 3in. square pieces of $\frac{1}{8}$ in. sheet and using the 4-jaw drilled/bored the centre $\frac{7}{8}$ in. hole in each square individually. After clamping the 4 squares together (aligning them with a stub of $\frac{7}{8}$ in. dia. rod in the centre hole) the 4 x $\frac{3}{8}$ in. dia. "just for effect" holes were drilled. The steel centre bushes (item 12c) were turned from 1in. dia. steel bar. The next operation was to braze them into the centre holes. A spell of hacksaw work and a little sweat of my brow soon saw (pun intended) the squares



1: The picture that tells the whole story, the machine with all guards removed shows the simple yet rigid construction.



2: A view of the other side of the unguarded machine.



3: A close-up of the drive arrangements.

reduced to rough octagons - very rough octagons. A $\frac{1}{2}$ in. mandrel was produced in the 3-jaw (never remove such a mandrel from the chuck until you are sure that it is finished with) and the embryo end plates were fastened on the mandrel in back to back pairs with a retaining nut. A spell of clonk, clank cutting soon saw the corners knocked off in the lathe and the plates were turned circular to $2\frac{13}{16}$ in. diameter. This size should be adjusted to suit; i.e. if you take off a little too much or if your tube is of a greater wall thickness than mine was then take appropriate action.

Two pieces of the 3in. dia., or thereabouts, tube were cut off at $2\frac{1}{8}$ in long - more sweat of the brow - chucked snugly in the 3-jaw, (either set of jaws will do) faced cleanly and bored to $2\frac{13}{16}$ in. (or to suit your previously prepared end plates) to a depth of $\frac{3}{16}$ in. from each end, to form seats for the end plates, aiming for a finished length of $2\frac{1}{8}$ in. If a 2in. wide belt is envisaged, I didn't worry too much over concentricity at this stage beyond setting the tube sections firmly and evenly in the chuck before turning each end recess as there was a further brazing operation to come after that a final skim between centres would solve the concentricity problem.

The end plates were placed into their appropriate recesses and brazed in with Sifbronze (leave a largish gap for the spelter to flow into), they could have been silver soldered (aim for a snug fit) or welded (if there is a gap then fill it). Should you have a choice of fixing method available then you could turn the parts to leave a suitable clearance according to the fixing method chosen or of course vice-versa choose the fixing method to suit the gap/fit which you have finished up with.

No prizes for guessing which way round I worked. The hole through the previously fitted bushes makes clamping before brazing a simple task, requiring only a through bolt and a couple of washers.

This operation completed, the rolls must now be crowned; this is essential to ensure that the abrasive belt will run true. In 8 years of use I have never had a belt run off centre - having said that I bet that Murphy's Law will be at its worst next week.

To mount the rolls for crowning and skimming for concentricity a mandrel is needed. The mandrel is obviously required to fit the centre holes in the endplate bushes. I made the holes in my bushes $\frac{1}{2}$ in. dia. (reamed finish) a little thought would have shown me that 12mm would have been a more sensible choice, never one to let sense stand in the way I stuck to Imperial size. It later occurred to me that the

bearings were 12mm bore.....nuff sed.

At a later stage a pair of shafts are needed for the rolls (items 9 & 10) to rotate on, I next made the shafts and used one of them as the mandrel for roll turning. It should now be clear why it would be as well to choose the endplate bush bore to be the same as the ball race bore, it saves a lot of turning down from $\frac{1}{2}$ in. to 12 mm for one thing. I allowed a full 6in. (little point in cramping yourself when working between centres) and turned the shafts to $\frac{1}{2}$ in (and 12mm!) diameter between centres.

The rolls were clamped, using the grub screw in the centre bush, for skimming the cylindrical surface, the two rolls do not need to be exactly the same size - but keep a sense of proportion about it, don't finish up with a penny farthing pair. The top slide was

Main Frame (Item 1)

Although the main dimensions are shown, to ensure satisfaction in use I would suggest that you check with your chosen belt size. In my case I used 42in. long belts in various widths; mainly 1 and 2in. wide. Any length is possible of course but 42 in. gives a fair sized machine with a useful capacity. Incidentally wider belts are cheaper than narrow ones in terms of £/inch width and can easily be split into narrower multiple widths. I chose a two-roll set-up; one less roll to make and as yet few disadvantages in use.

The best starting point seemed to me to be to buy a few belts of the chosen size lay them on edge on the bench, place a roll in each end of the loop and measure the inter-roll distance. Belts

seem to vary in length, so choose the shortest and lop a bit off the roll distance for safety - to allow for adjustment in case the next one is even shorter - there is no need for great exactness as there is some adjustment in the machine for belt length but do check that the bearing spacing on the rolls suits your particular belts.

Armed with a trusty hacksaw and some more sweat-of-the-brow I proceeded to cut the two main frame members to length from 2 x 1in. and 1 x 1in. tubing, they were welded together at the upper end. (If you clamp the two pieces of tube to a substantial piece of $\frac{1}{2}$ in. plate or similar before welding, this will help to reduce distortion. Other methods of joining the frame are

possible of course, there seems no reason why silver solder may not be used or even fish-plates and bolts/screws, ensuring that neither the belt or your fingers can catch on any protrusions.

The steel angle foot, although detailed, can be made to suit available material, all it has to do is hold the main frame upright and provide somewhere to put the mounting holes for the bolts which will eventually hold the whole device to the bench.

I now turned my attentions to the bearing assemblies and their mountings.

Bearing housings and mountings (Item 8)

I was indeed fortunate in obtaining ready made bearings/housings but for those less fortunate or those whose scrap box is at the embryo stage and not yet a

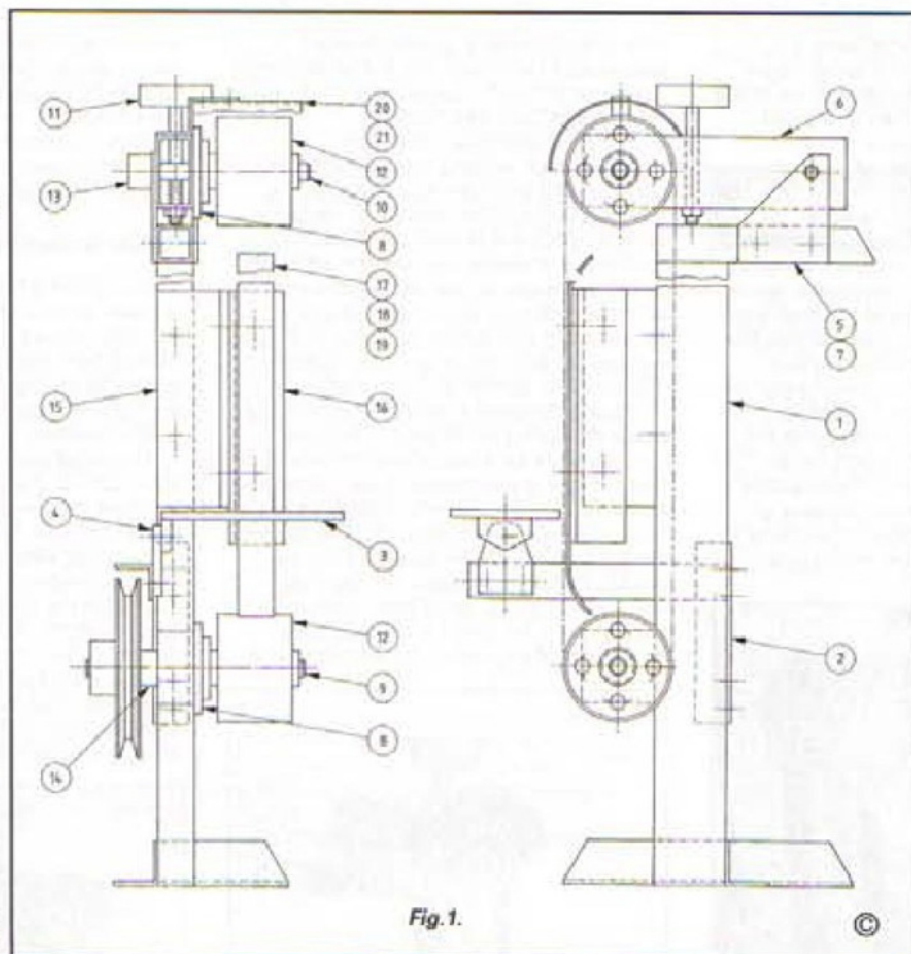
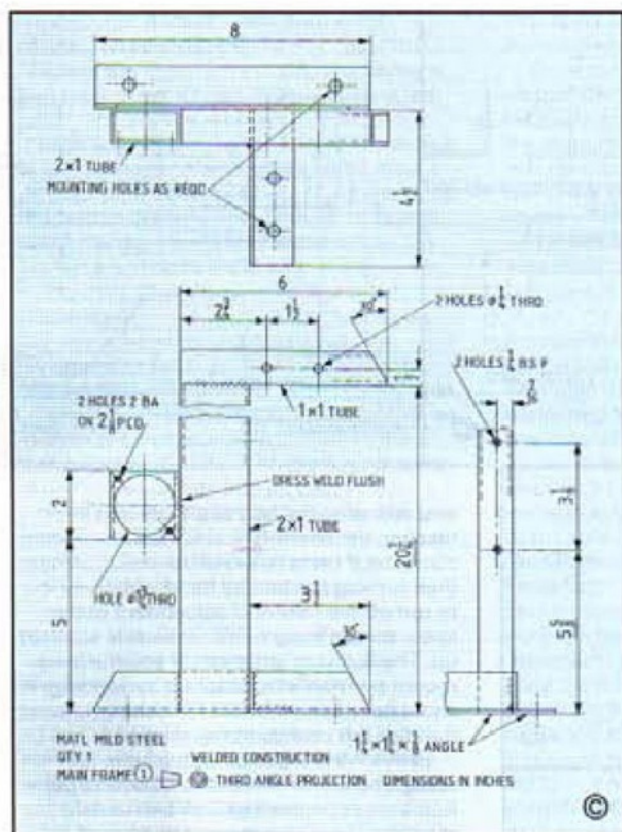


Fig. 1.

set over to 1 deg., first one way then the other to produce a gentle two way taper meeting at the centre of the roll length. A few nifty strokes with a large file (be very careful of the catchplate/chuck when filing) soon gave me a fine pair (well not bad) of crowned rolls.

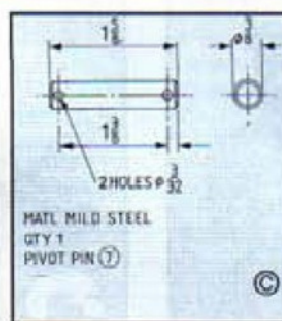
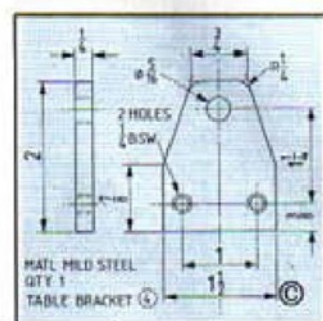
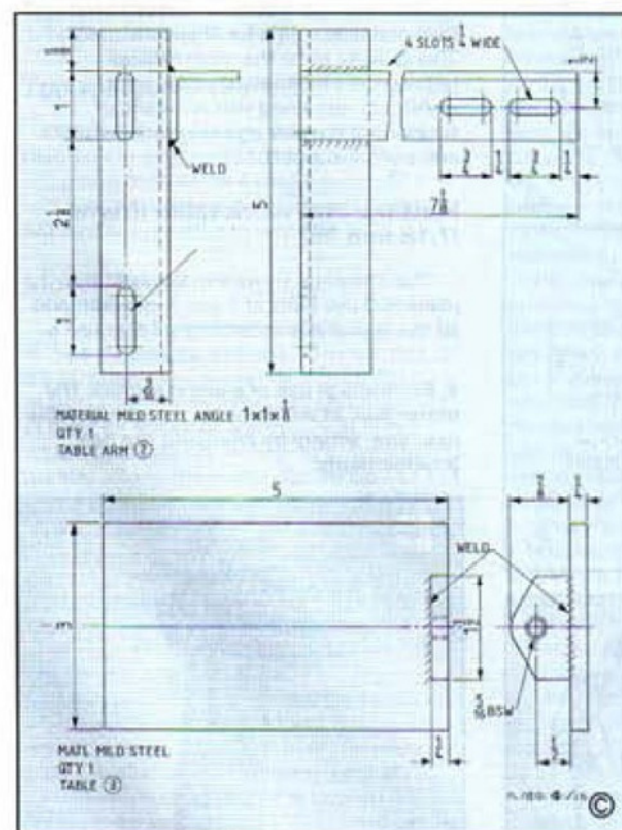
As the photos show I later attempted to balance my rolls by drilling the end plates; they rotate at a fair speed. However, there is no vibration in use and I doubt whether it is worth the effort, after all given reasonable material and machining the only out-of-balance forces will be due to blobs of bronze or what have you and should be minimal. The end faces of the rolls can now be painted and put aside and left until they are needed.

The next item which I tackled was the main frame, the bits which keep the rolls apart, and at the correct height above the bench.



mature creature of some years standing, I suggest that you obtain 4 ball races approximately the same size as mine and go from there. Mine were 1.25in. x 0.375in. x 12mm bore. I was pleased that I made the rolls 0.5in. bore aren't mixed units a mixed blessing? The duty of the machine suggests that shielded bearings are a useful idea to prevent the ingress of grit, belt residues and other assorted debris (single shielded would do, with the unshielded sides facing inwards in the housings). My bearings show no signs of wear or ingestion of grit after 8 years of use.

The housings are plain turning jobs from ends of bar. I would suggest that each housing is turned, faced, bored and recessed to a push fit for the bearing outer race taking one end at a time and then to turn up a stub mandrel in the 3-jaw to fit the already machined bearing recess, wring the part-finished housings on to the mandrel in turn and turn to finish. The size of the housings can be varied to suit the chosen (available ?) bearings, but it is an advantage if the outer diameter of the housing (except for the flange) can be kept to 1.75 dia.- the mounts can then be made from offcuts of the 2 in. x 1 in. tube.



Bearing Mounts

The lower bearing mount, included in item 1, main frame, is simply a 2in. piece of the main frame tube bored squarely using the 4-jaw to accept a bearing housing.

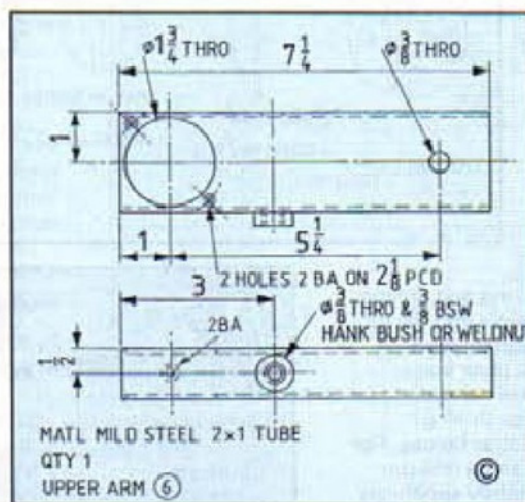
The upper arm (item 6) provides the adjustable mounting for the other bearing housing. A piece of the 2 x 1 in. frame tube was used and again using the 4-jaw, bore the hole for the bearing housing to a "nice" fit - this is hardly a Newall classification of fit, but I'm sure that all amateur/model engineers will recognise the fit almost instinctively. Should your lathe not permit you to swing the tube without chipping paint off the bed (of the lathe that is!), then the upper arm is a simple rectangular shape to clamp to the cross slide for boring from the chuck.

The holes for the pivot and the belt length/tension adjusting screw, having been marked out before the centre of the bearing housing hole was bored away and lost forever, were then drilled, a nut was attached for the adjusting screw, weld/braze or use a hank bush, the tube at 1/8 in. wall thickness is not really adequate to hold a coarse thread.

A bearing assembly (housing and two bearings) was fitted to each of the just completed mountings, and after spotting through, the flanges were drilled and tapped for a couple of 2BA retaining screws, the holes in the tube mounts were opened up to clearance size.

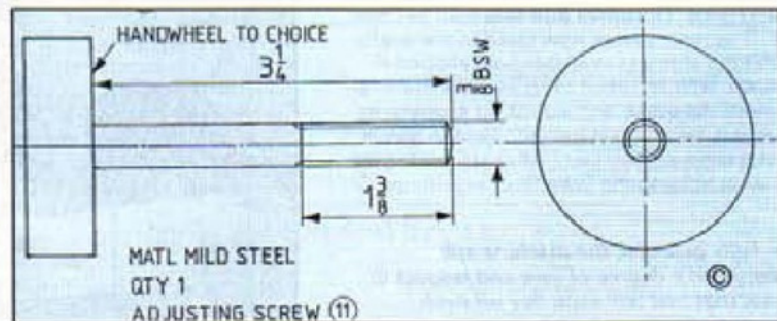
Before proceeding with any assembly just a few more bits were needed. The upper arm pivot (item 7), which is a short piece of rod with provision for retention either by cotters or a nut, and a pair of arm pivots (item 5); these are simply cut from scraps of flat 1/8in. sheet.

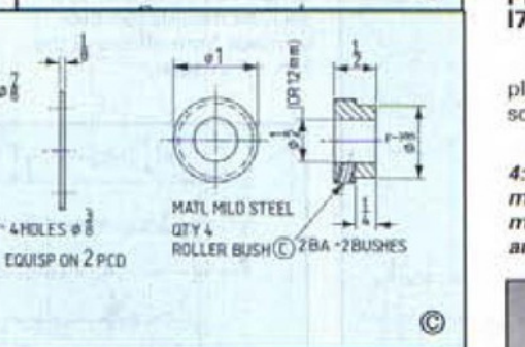
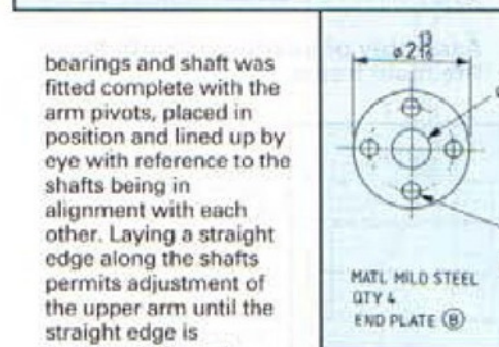
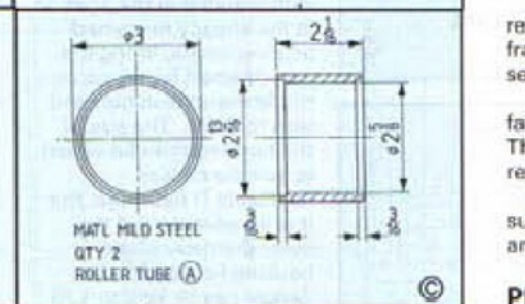
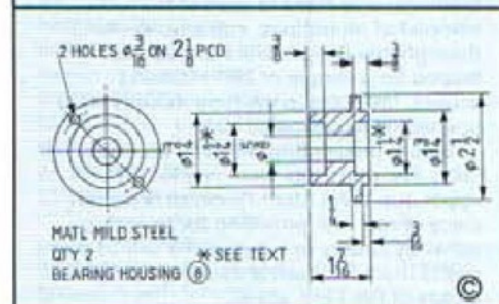
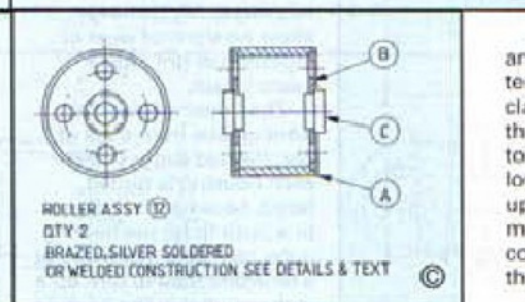
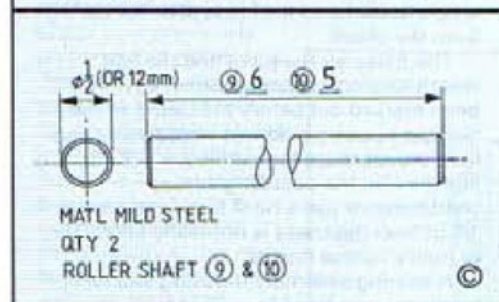
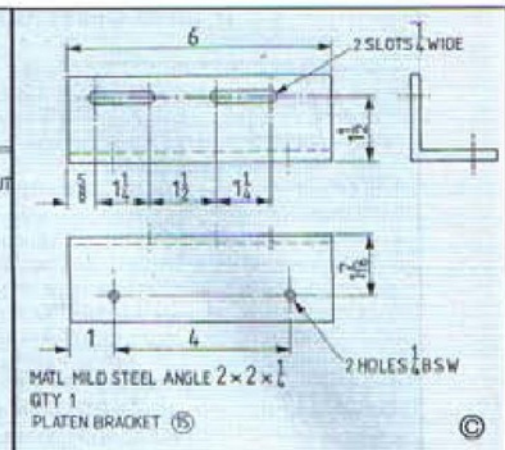
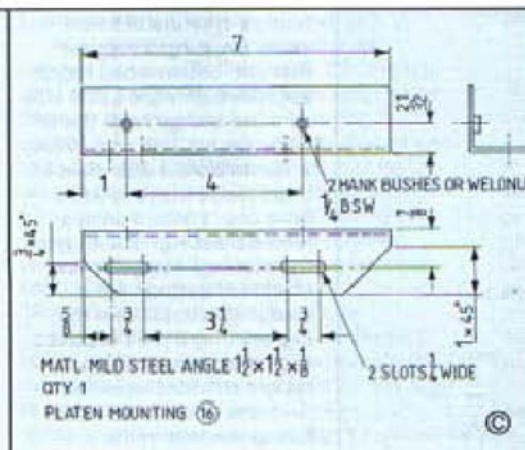
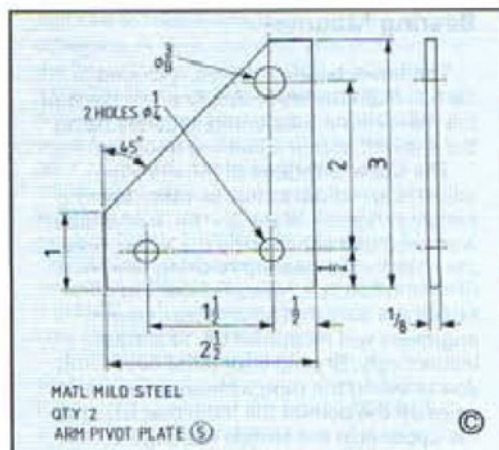
Assembly of bearing mounts to the main frame



Examination of the G.A. together with the photographs will show the general idea. The lower bearing mount complete with bearings and shaft was clamped to the frame in the measured position, checking with a square that it was, square that is! The shaft should be at right angles to the vertical frame member in both directions.

The upper arm complete with its

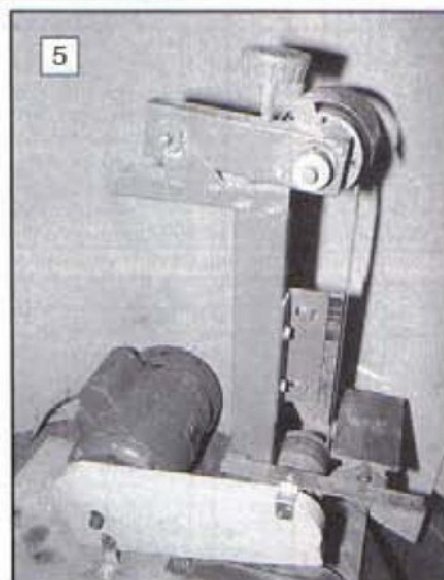




bearings and shaft was fitted complete with the arm pivots, placed in position and lined up by eye with reference to the shafts being in alignment with each other. Laying a straight edge along the shafts permits adjustment of the upper arm until the straight edge is equidistant from the main frame member at both ends. Following marking and drilling through one of the arm pivots into the top frame member (the 1 in. square tube component) the other arm pivot was moved to and fro until there was good alignment of the two shafts. Drilling through the other arm pivot as before. The upper arm was removed, and a drill run through both sets of previously separately drilled holes and the pivots were bolted to the frame. The upper arm was then re-fitted.

The rollers were now fitted to the shafts and the shortest available belt slipped in place, with an offset of 1/4 in. thick material under the upper arm adjusting screw in its lowest, i.e. slackest position (just to give a little extra adjustment). After slackening the clamp holding the lower bearing mount

5: Fully guarded, the machine still demands a degree of care and respect in use, that belt will soon flay off flesh.



and adjusting the belt to a fairly taut tension, the bearing/mount was re-clamped. If there is any gross misalignment then turning the belt by hand will cause it to run off the rolls and adjustment of the lower mount is called for until all is squared up. The belt was stripped off and the lower mount permanently attached by welding; it could have been marked for bolting through the vertical frame member.

In this way, together with a little realignment later if needed, quite a large frame was constructed with two widely separated bearings in good alignment.

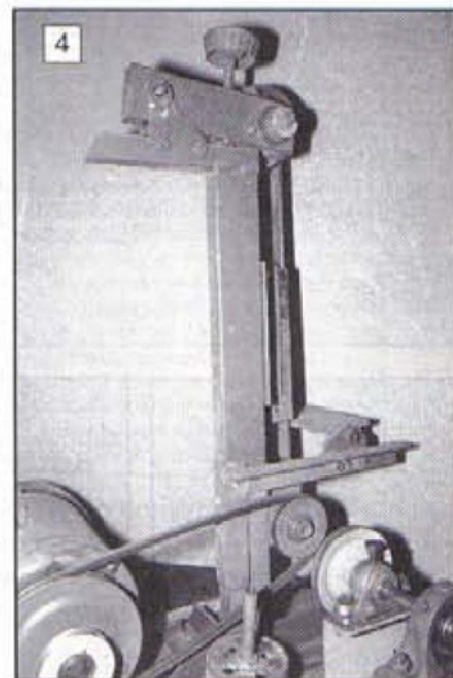
The machine was now reassembled and fastened down on a bit of vacant space. This is likely to be the most difficult requirement in amateur workshops!

All that remained was a means of supporting the belt against work pressure and a work support.

Plattens and work table (Items 17, 18 and 19)

The drawings show the details of the plattens. I use belts of 1 and 2 in. width and so made plattens accordingly. I also use a

4: Economical use of electric motors, the motor can, at will be used to drive another machine, simply by changing the belt arrangements.



"half-round" platten made from what blacksmiths called hoop iron (at least the blacksmiths in my family did). The plattens and table assembly are mostly assembled with $\frac{1}{4}$ or $\frac{5}{16}$ BSF or BSW screws into anchor nuts riveted to the frame. The design is not intended to be limiting; by all means do your own thing, but I would suggest that the platten is made long enough to almost reach the top roll and to extend below the work table, it does assist with safety in use.

Following the drawings will result in plattens which are centred across the roll, this is useful when using narrow belts. Reference to the G.A. drawing shows the attachment of the plattens and the work table.

The work table must, for safe working, be substantial and soundly attached to the frame of the machine. The pivoting feature is useful and comes into its own when pattern making. Again the table, as the platten, is adjustable and should always be adjusted close to the belt, mine usually works with a $\frac{1}{16}$ in. belt/table gap.

When making the bits and pieces of plattens and work table a good search through "what is available" could pay dividends but the structures must be strongly attached to the frame and adjusted so as not to be finger trapping - the belt is moving at a fair rate of knots and the ease with which a 60 grit belt removes mild steel will give a none too subtle indication of what it could do to a carelessly placed finger; on the other hand, if the belt were fully guarded then it would be useless.

Top roll guard (Item 20)

Although no one ever intends to tangle their hair in any machine I feel that the top roll guard does serve a useful purpose. It was simply constructed as shown and does not hinder operation in any way at all.

Motor/Drive

The lower roll on my machine has a $2\frac{1}{2}$ in. Vee pulley coupled at 9-10 in. centres to a 5 in. pulley and driven by a $\frac{1}{2}$ hp TEFC motor. This seems to be just about correct at this belt speed of approx. 2200 ft/min. when "pressing on" or urging a worn belt to greater efforts the motor can be slowed but it doesn't often happen. The use of a TEFC motor is possibly a worthwhile precaution although the majority of the debris from the belt does finish up around the foot of the frame under the bottom roll (a box beneath the roll does collect an awful lot of debris) as there is always a possibility of grit getting in somewhere.

It is worth delaying the awaited switch on for a little longer, to allow time to make and fit a protective guard over the drive belt. It is after all transmitting $\frac{1}{2}$ hp at considerable speed and it is located not too far from the work station. The guard can be made from any suitable material, timber, sheet metal, rigid plastic etc. My guard, shown in the various photographs was made from 18swg sheet steel with the mounting lugs from 14swg steel sheet. The layout is straightforward, two circles of pulley diameter plus $\frac{1}{2}$ in. spaced apart by the machine/motor centre distance. Allow $1 - 1\frac{1}{2}$ in. along the top edge for the flange, think before putting snips to metal. Snip away, knock the flange up over any old bit of bar, add a few tacks of braze or weld and, just to be traditional, add the

mounting lugs by riveting, just like a locomotive tender.

Once the guard is fitted, you can power-up the machine then final adjustments can be made to the belt tracking. On switch-on the alignment shouldn't be so bad that the belt disappears past your left ear on its way out of the workshop, but it may tend to run to one side or the other. However, should a belt make an early bid to escape there is little need to run for cover, as soon as the belt leaves the rolls it loses all its drive and, due to the relatively low weight (or even mass) a belt possesses only a low level of kinetic energy; this is not to say that it is a desirable happening. This event has never happened to my

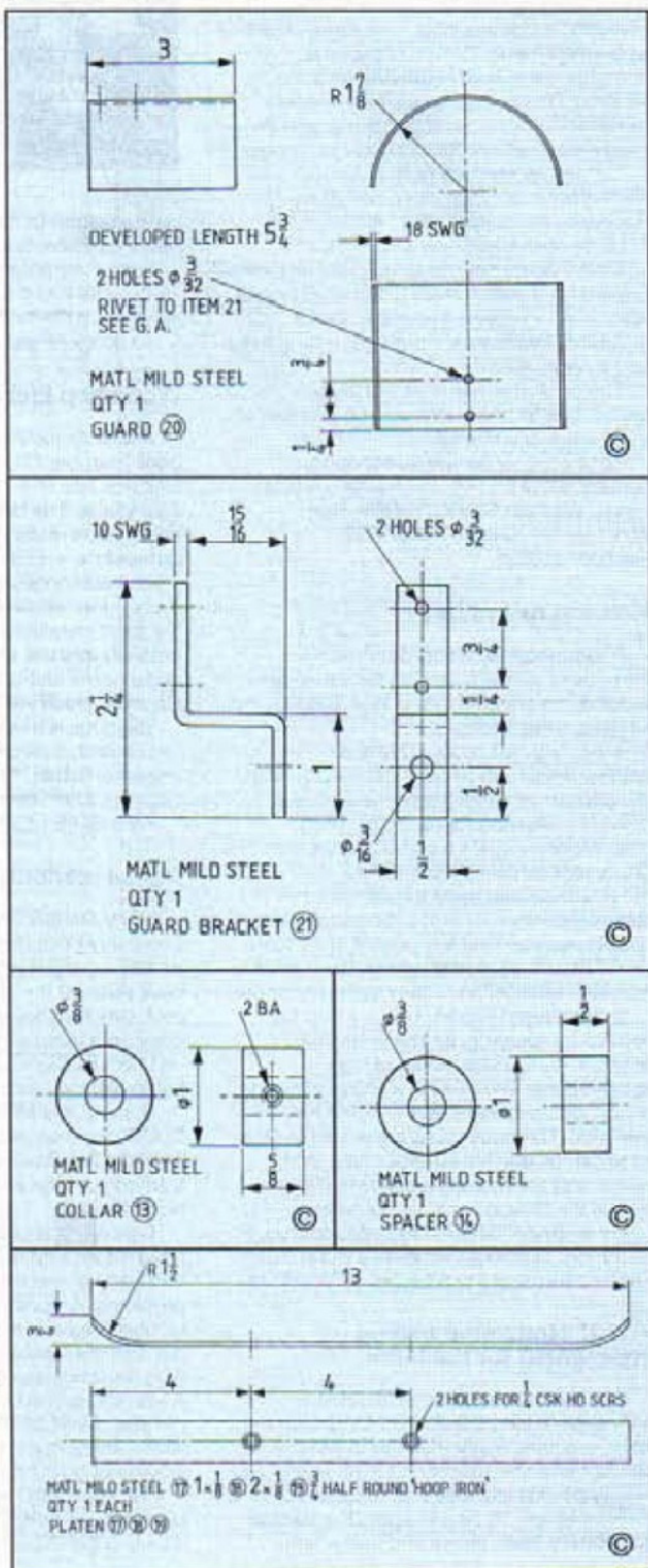
machine in use but the earlier reference to Murphy's Law is without doubt applicable. Rectification of tracking faults is straightforward. Remove one of the upper arm pivots and ease the holes with a round file before replacing it, fasten the bolts which clamp it stiffly but not tightly, start the machine and, with a screwdriver or other lever (truly screwdrivers are misnamed!) placed under the pivot of the arm ease the pivot until the belt tracks truly and then tighten it up. It only seems like a bodge - mine has never needed realigning.

Recommended belt speeds are, I believe, somewhat greater than my 2200ft./min., but it does seem to give acceptable metal removal rates. Belt life seems to be economically acceptable and belts almost always wear out rather than break and when they do break it seems always to be due to catching on an edge etc. - operator error. Worn belts can be saved to be used as polishing/finishing belts. You will notice that new belts are marked on the reverse face with a "preferred direction of travel" arrow, this marks the grain orientation of the abrasive particles. I would suggest that it is worthwhile re-marking the direction with a felt tip pen as the marks tend to fade with use. Of course it will be necessary to mark any narrow belts if you

have made them by splitting wider ones.

Workpieces do get hot - after all you are putting about 200-300 watts into them - so wearing of gloves may be useful (don't catch them in the belt) but I prefer to use a hand vice or toolmakers clamp especially on small workpieces.

My machine has now given 8 years sterling service with no faults (after all what is there to go wrong) and is equally as useful as all the aforementioned writers said - apart from profile shaping it is marvellous for rounding off corners (when required) and will give a smart finish to even the most humble tool, fixture or workpiece.



TRADE COUNTER

New Catalogues

N. S. & A. Hemingway have issued a new catalogue, containing most, if not all, items from previous catalogues.

However, there are a number of new items, ranging from the simple to the complex, some available in kit form, others as finished items. Typical of the new complex items is an engraving machine in kit form. This is obviously a very capable machine appearing comparable to smaller machines available for industrial purposes.

For details, contact, N. S. & A. Hemingway, 30 Links View, Half Acre, Rochdale, Lancashire, OL11 4DD. Tel 0706 45404.

Davall Gears new catalogue lists all their Imperial and metric stock gears of all types. Also listed are many associated items, including, gearboxes, couplings, timing belts and pulleys, etc.

The catalogue has over 200 pages including a technical section and is priced at £4.99 inc. p & p and VAT.

For a copy, or further information, contact, Sales and Marketing, Davall Stock Gears, Welham Green, Hatfield, Herts, AL9 7JB. Tel. Sales: 0707 272722, Fax 0707 268536.

Keeping rust at bay

P. Gammon Technical Services have introduced a kit of materials for assisting in keeping the dreaded rust at bay. The kit contains three items.

1. An Anti-rust paper. This is an impregnated Kraft paper which, if placed in the drawers of a toolmakers cabinet, will provide protection for up to two years.

2. Vaporol. This is a combined vapour-phase and contact inhibitor oil for the prevention of corrosion in such areas as steam and internal combustion engines, gear-boxes etc. This is provided in a 250ml can with a small plastic syringe to enable the accurate application of the required amount.

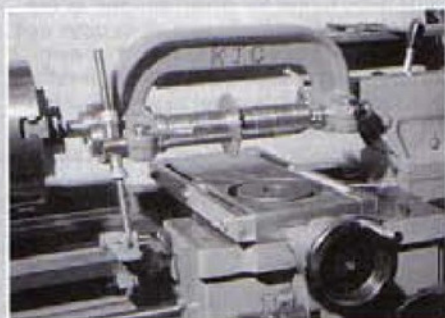
3. Steelguard Export. This is a thin film, applied by spraying, for the protection of bright metal surfaces, even at high temperatures. Supplied in a 500ml plastic container with trigger spray. Refills also available. The three items are available as a kit or can be purchased separately. With winter and the rust season approaching, now is the time to consider such items.

For technical details and prices contact, P. Gammon, Technical Services, 4 Hurst Road, Epsom, Surrey, KT19 8SJ. Tel. 03727 29726.

K. J. C. Horizontal milling attachment for the lathe

Information has been received of a horizontal milling attachment for use on the lathe, available ready made or in kit form. The kit has some machining done and gears are supplied ready made. Brief details are:

Total length 1ft 5in.; Weight 7Kg; Vertical adjustment 1 1/4in. above and below lathe



centre height. Cutter mandrel 1 in. diameter. Bearings Phosphor Bronze.

For full information contact, S P Laurent, 15 Ratcliffe Road, Aldinga Beach, South Australia, 5175 Tel 010 618 85 565 332.

A UK agent is likely to be appointed.

Workshop Electrics

A new Argus Workshop Practice Series book (number 22), entitled Workshop Electrics, has been published, the author is Alex Weiss. The book covers the basic information relating to workshop electrics, it is therefore, eminently suitable for the mechanical engineer who feels the need for more information prior to installing an electrical installation. The books also expands into the area of electrical installation in the home and is written in line with UK electrical practices.

The book is available from Bailey Distribution, Learoyd Road, Mountfield Road Industrial Estate, New Romney, Kent, TN28 8XU. Tel. 0797 366905, Fax 0797 366638.

Price £6.95 + £1 (P&P).

Digital readout

Many readers will have considered the possibility of equipping their workshop machines with digital readouts, but may have rejected the idea because of their high cost. One firm however has attempted to overcome this cost barrier by designing units with a more realistic cost, the firm being BW Electronics.

The unit, the MPS, has been received by M.E.W. for evaluation. It is of a novel design having a thin flexible wire which extends from the unit for purposes of reading the position.

Typically this could be measuring the table movement of a milling machine. The unit is small and fitting it should present few problems. A few simple requirements must be observed and these are clearly detailed in the documentation provided. Typically, the wire must not approach the unit at an angle. A seal is provided to prevent the wire carrying swarf into the readout but I feel some additional protection over the wire would not go amiss.

One advantage is that the unit can easily be transferred from machine to machine, avoiding the expense of multiple readouts.

In keeping with this idea, BW electronics have arranged the readout to be mounted in quick release clips. Clips can remain on the various machines whilst the readout is moved from machine to machine.

The readout is provided with a zero facility, also inch/metric readings. The change from inch to metric and reverse can be made at any time.

Unfortunately, checking accuracy was not possible as the necessary precision equipment was not available. For example, most readers will understand that it is not practical to check one workshop grade micrometer by comparing it with another workshop grade micrometer. Any out of tolerances errors found may be due to the cumulative errors of both instruments, or even an out of tolerances error in the case of the micrometer being used as a reference. It is always necessary to have test items to a higher precision level than that being tested.

In this case all that was available was a 0.4in. travel dial test indicator for testing readings over a short distance and a digital vernier for testing over a distance of up to 5 in. Both items were of very reputable make. Differences of reading were apparent at some dimensions but no more than would be expected from comparing comparable grade instruments. If any reader is particularly concerned regarding accuracy, BW Electronics will be able to give details of the units specification, including accuracy.



A separate mains power supply is available or it can be powered by batteries, in this case the user must provide a location for these. The MPS has a display resolution of 0.01mm, or 0.001in. An enhanced version, EMPS, has resolution of 0.005mm, or 0.0002inch.

Details can be had from BW Electronics 391 Goldington Road, Bedford, MK41 0DS. Tel 0234 219756.

BlackAlloy Cutting tools

A range of cast alloy cutting tools is available from Brunner Machine Tools Ltd. Of particular interest to the home workshop owner, especially those who machine stainless steel, is BlackAlloy 525. This is for general purpose machining on Stainless steels, cast iron, steel, titanium and most other metals. As a single point tool, it is considered unsurpassed by Brunner. (See letter in Scribe a Line. - Ed.)

It is more expensive than normal tool steels, but while tips are not available, it can be cut up and brazed to shanks in the same manner as cemented carbides. When sharpening, it has the advantage over carbide that it can be ground on normal wheels, as used for high speed tool bits.

Details from Brunner Machine Tools Ltd, 6 Colville Road, Acton, London, W3 8DU. Tel. 081 992 6011. Fax. 081 992 7559.

TOOLMAKERS CLAMPS AND MILLING OPERATIONS

A few thoughts on the subject of using toolmakers clamps for securing items to be machined on the milling machine. Also an update on an article from Issue 20 relating to angle plate and faceplate clamps.

In *Model Engineer* magazine, 6 May 94, A. V. Booth writes of his concern in seeing so many illustrations of milling taking place using toolmakers clamps for securing the workpiece. In particular he refers to an article in *M.E.* for 18 Feb 94. I do not agree with A.V.Booth in total; feeling that the use of such clamps for this purpose needs to be done with due concern for the potential problems. I am surprised that the remarks were not equally, if not more so, aimed at the flimsy G clamps also being used in the same set-up. It does lead me to believe that some additional comments are worth publishing on the subject, as I for one frequently publish photos of items being made in my own workshop where toolmakers clamps are employed for this purpose.

The first thing to note in connection with using toolmakers clamps is that, contrary to the normal practice of using packing slightly higher than the work being clamped, so that pressure is applied at the end of the clamp, pressure applied when using a toolmakers clamp should be evenly distributed along the length of the jaw in contact with the workpiece.

The sketch shows the two extremes, these are:

- 1) With the jaws set too far apart
- 2) Set too close together.

neither of which produces a satisfactory result. With the jaws set too far apart, clamping will be at the end of the jaw and will tend to pivot at point "A", if too close the clamping will pivot about point "B".

Pilot drill sizes for stainless steels

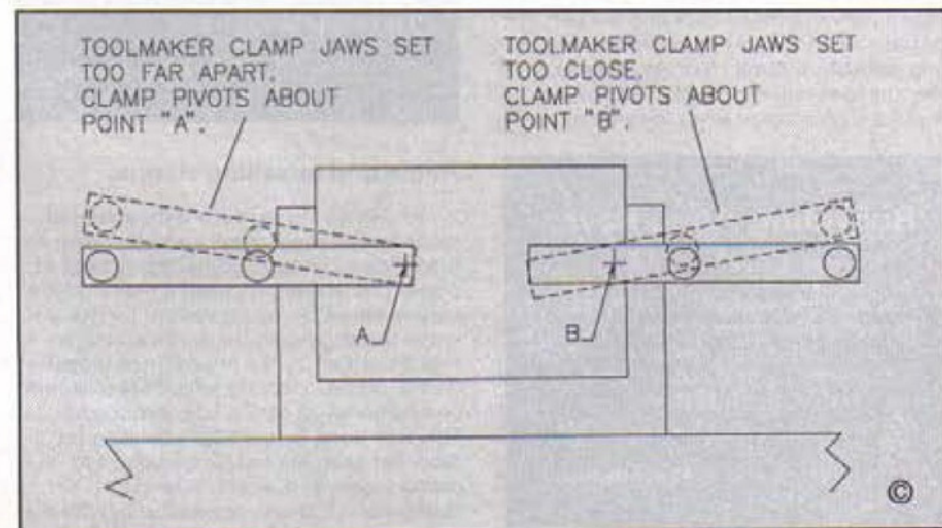
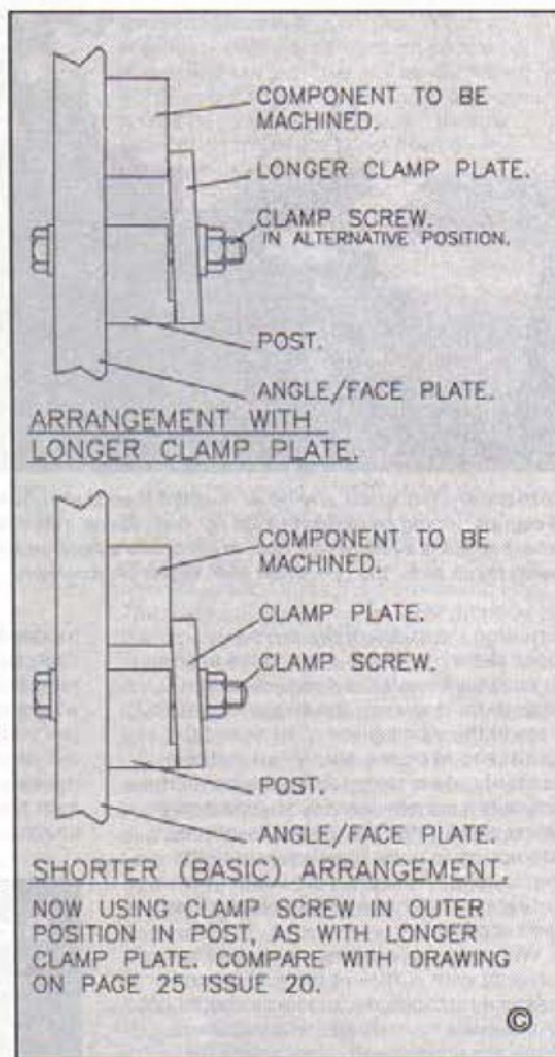
If you pilot drill stainless steel prior to drilling to finished size, the pilot diameter should be no more than the web thickness of the finished size drill. This ensures even pressure on the cutting edges of the latter and reduces work hardening around the hole.

Alan Jeeves

Achieving a satisfactory clamping action is not difficult, but needs to be done with more than a little care. It must be realised that the screw in the centre is used primarily for setting the spacing of the jaws, the one at the end is for applying the clamping force. The result of the clamp being set in either of these two ways, is to allow the clamp to pivot as shown in the sketch. This is obviously not acceptable. Somewhere between these two extremes the jaw will clamp along its length and, with sufficient clamping force applied, will not pivot at all.

The amount of adjustment of the central screw to make the clamp change from pivoting at "A" to pivoting at "B" is small, so adjustment to arrive at the non pivoting position, can only be achieved with care. However, it is essential that no milling takes place until the clamps are set, such that they cannot be moved, certainly, that is, not without extreme force.

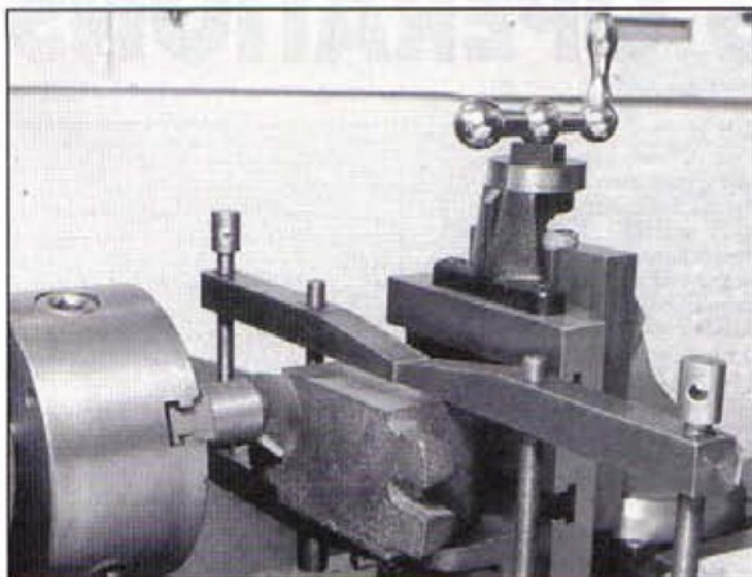
It is also worth realising that this degree of tightness will not be achieved by just the use of the fingers, a suitable tommy bar is essential. It is also essential that the clamps used are sufficiently robust; this may require them to be made, as larger sizes are rarely to be found in suppliers' catalogues. This point was made in my earlier article on making toolmakers clamps, published in the Oct/Nov '91 issue. In this, I thought I had also made a suggestion for



Simple slotting

Hacksaws make good slotting tools. Put two, three or more blades in the frame at once, until the width of the slot is almost correct; use plenty of cutting fluid to wash the swarf away, cut to depth, then all the slot needs is cleaning up with a warding or other suitable file.

R.J. Loader



With the limited space, any other method than that shown, except for using G clamps, would be difficult to set up. Also, never make do with one clamp where space is available for two, in particular where an intermittent cut is being taken as in the operation seen in this photograph.

acquiring the knack of tightening toolmakers clamps. It is not in the article, so perhaps I made the suggestion in a latter item. However, the suggestion is to place in the vice a piece of bar, say 50 x 10mm and to clamp onto this a suitable size toolmakers clamp. With the bar in the vice, it is a simple exercise to repeatedly adjust and tighten the clamp, testing by attempting to pivot the clamp, until the knack; using the word skill would be setting the task on too high a plane, has been acquired.

With a suitably robust clamp and set correctly with sufficient force, I see no reason why toolmakers clamps should not be adequate for very many applications. There are though two other points for caution. If the angle plate is of the type with a non-machined back and the part to be worked on is also not machined. It is just possible, though I feel very unlikely, that the jaws will rest on high points; making it possible to pivot the clamp no

matter how much force is applied. More likely to be a problem will be the temptation to use the clamps in a position where only the first few mm length of the jaw will reach the workpiece. In this case it will be possible to pivot the clamp due to the small amount of jaw in contact with the item being machined. This most certainly is unacceptable.

Did you know?

The German steel manufacturers Krupp set up a special hospital to fit over 3000 German soldiers (who had lost their teeth in battle) with dentures - made from stainless steel. This was for W.W.I troops

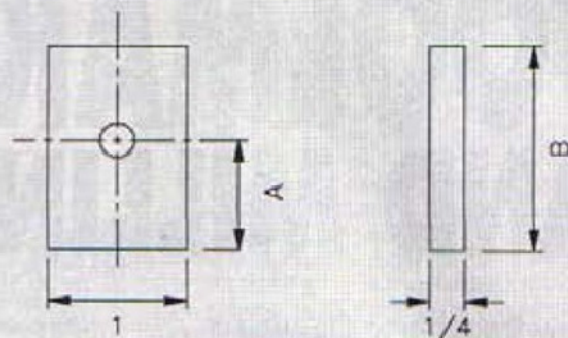
Alan Jeeves

Angle and faceplate clamps

While discussing the secure mounting of items on the angle plate, a small update on the article in issue 20 page 24 is not out of place. This article proposed a method for a very compact clamping system for use on either the angle plate or the faceplate. It was extended by the provision of longer clamp plates, a feature which necessitated an additional off centre hole in the posts. This was done to maintain a satisfactory ratio between the distance, support to clamp screw, and, clamp screw to workpiece. It is now realised, that with the additional hole in the post, it is possible by

using this position for the shorter clamps, these having revised hole positions, to improve the ratio between the two halves of the clamp plate, thus achieving a more secure fixing.

With this arrangement the central hole becomes of little use. However, being easy to provide while turning the parts on the lathe, they are still worthwhile for use as a miniature jack, as seen in photos 5 & 2 as an aid to positioning the outer hole as seen in photo 10. (The note relating to photos 5, 2, 10 refer to the illustrations used in the author's previous article - Ed). The drawings show the revised arrangement and the new dimensions for the clamp plates. Of course, if you have already made the clamp plates, there is no reason why the hole cannot be added as an alternative.



SIZES	A	B
13/16	13/16	1-1/4
13/16	13/16	1-1/2
13/16	13/16	1-3/4
13/16	13/16	2

MATERIAL 1 X 1/4 BRIGHT MILD STEEL.
QUANTITY 2 OFF EACH SIZE MINIMUM.
HOLES. 1/4 dia.

CLAMP PLATES (REVISED).

POSITION OF HOLE "A" IN TWO SHORTER CLAMP PLATES CHANGED. COMPARE WITH DRAWING ON PAGE 27 ISSUE 20.

©

Recycling Allen keys

Small Allen keys seem to wear rapidly; they normally seem to lose their grip just as the shops close. They can, however, easily be rejuvenated by grinding the worn 1/16 in. off the end. (This seems obvious, but nobody ever told me!).

C.Washington

A clean start

When shortening a threaded item such as a screw or stud, sawing, filing or even turning can bend the thin thread end into the screw, and it is then nearly impossible to screw on a nut (particularly in the 8-12BA sizes). To make life easier, screw a nut on before cutting into the thread, then afterwards it can be easily unscrewed, cleaning up the thread end in the process.

C.Washington

SCRIBE A LINE

Shaping tee slots the easy way

Following my prompting, in issue 24 page 63, for an easy way to make tee slots on the shaping machine, a number of readers have come up with the same solution, two follow. D Rothwell of St Albans also pointed out that it had been illustrated in Model Engineer for the 19th Oct. 1961, page 480.

From N. D. Silvester of Totton

With regard to the editor's query relating to shaping tee slots in the excellent article by Bill Morris, I have only in the last few weeks come across a method for easily accomplishing this, despite having served almost 50 years in a toolroom.

The method is very simple and is as described in the book Shaper Ops by J. W.

Barritt and published by Lindsey Pubs. Inc. U.S.A.

The method needs little explanation not covered by the accompanying sketch. Modify a Strap hinge as shown and fit as per the sketch. I have not tried the method myself but am convinced it is foolproof, if properly set up. Of course, Always do a dummy run to prove clearances etc.

And from Kevin W Young of Hull

Re the article in issue no 24 entitled, More strokes with a shaper part 2, I would like to suggest a safer method for cutting tee slots. The method shown is fraught with danger both to the machine and the operator, when a few minutes work can solve the problem. During my apprenticeship I was given a similar task to the one in Bill Morris's article, the problem

of lifting the tool at the end of the cutting stroke was solved by an old hand, who having seen me standing around scratching my head very kindly came to my aid before the shop foreman could pass an opinion as to my mental state or ancestry.

The solution

First acquire an ordinary tee hinge, the type used on garden gates will do, I used a six inch steel hinge to make one for my Elliott ten inch shaper. The accompanying sketch shows where to cut, although the sizes will depend on the size of toolpost on individual machines. Make sure you remove all sharp edges and radius the bottom edge of the tee strap.

The method

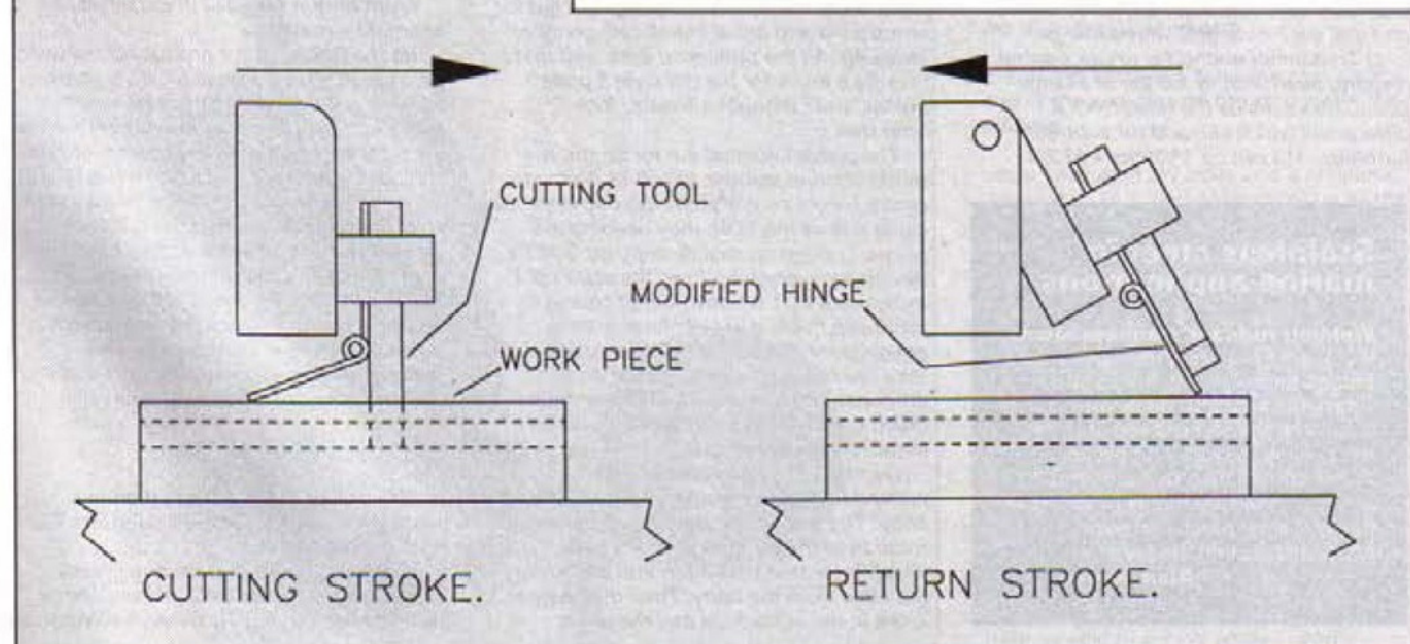
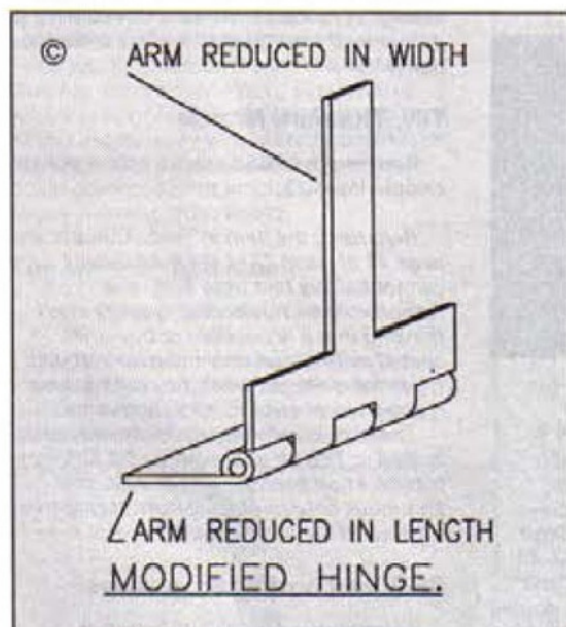
Mount the hinge and tee slot tool in the toolpost, setting the joint of the hinge slightly above the top of the work when the tool is set at the full depth of the slot, the hinge of course goes behind the tool, when all is set move the ram by hand over its full stroke to ensure all is correct. When you are happy with the set-up turn on the power and cut your tee slot as instructed in Bill Morris's article. I hope these few lines will be of some help to shaper owners attempting to get the most from a very under-rated machine tool.

Another automobile gearbox

Brian Cocksedge of Midhurst is another reader who has use an automobile gear box for speed changing a lathe.

Unfortunately, neither Aubray or Brian have indicated the approximate change in ratios between top and bottom speed and therefore an indication of the speed range achieved. Perhaps another brief note from them would perhaps complete the picture.

I was interested to read about Aubray Blake's Car gearbox driven Chipmaster Lathe, (M.E.W. No. 24) I have had a gearbox driving my Pools major lathe for over 30 years, I think it is from an old Ford. The main advantage using a car gearbox is that you don't have to keep stopping and starting the motor or use a clutch. The synchromesh cones on the top 3 gears act like a clutch and the bottom gear speed is low enough to drop it in with a minimum of crunching noises. One soon gets used to easing it into gear with light pressure off the synchromesh cones until up to speed and then more pressure to fully engage the gear. The reverse gear is also useful for the odd times when it is required. A lighter grade of oil can be used in the box to an advantage to reduce drag, this is not detrimental to the box because of the



lower speeds and gear loadings, (around 1500rpm as opposed to between 1000 and 6000-rpm), (approx. 1/2hp as opposed to 8hp). If memory serves correctly I believe 8hp was the Ford Pop's RAC rating). With the gearbox being made of alloy the clutch housing was easily sawn away, but in hindsight this could have been used to advantage as a firm basis for a belt guard.

Dividing high prime numbers

David Dew of King's Lynn provides some further information to that published recently on the subject of dividing funny numbers.

One must congratulate Geoff Gray on the tenacity, he pursued and then resolved his quest to achieve funny numbers (high primes) from the inadequate data given in Machinery's Handbook on an indexing table giving every number up to 250 (M.E.W. No.22 p.47)

Last year I corresponded with the Editor of Machinery's Handbook about this table. As a result the next (25th) edition will have some brief notes regarding the use of this table. These will state that it is intended for use with the 3 original Brown & Sharpe plates.... (16, 17, 18, 19, 20, 21, 23, 27, 29, 31, 33/37, 39, 41, 43, 47, 49) with holes right through. There will be a note about the error but that will be addressed later. I was looking the origin of this extremely clever table, but we failed to get anywhere. Brown & Sharpe in U.K. and U.S.A had no clue at all. If you have a reference to this turn of the century mathematical genius do bring it to light please. This is a fine method for model engineers to use for high prime numbers. Ignore the errors, they are infinitesimal and spread all round the circle as well.

For those not familiar with the difficulties, look at the other methods of obtaining high primes....

a) Industry would now use a CNC machine. Pump in the number and the radius, push a few buttons, the polar coordinates will be converted to rectangular (x and y axis) and the whole thing will be drilled fully automatically!

b) If one has a reasonably accurate mill/drill one can

work the polar to rectangular coordinates on a calculator with that facility and drill each hole on 2 new settings.

c) Traditional method is to use a spiral dividing head with its full set of change gears. Gears inside the head form a differential which can add (or subtract) numbers. 113 can be $13/39 \text{ths} = 37 \frac{2}{3}$

Stainless steel in marine applications

Welding rods for stainless steels

If you are fabricating stainless steel fittings for boats, e.g. hooks and cleats, the welding rod or wire should be the same grade of material as the metal if possible. Welds should then be sanded off and the whole job highly polished as this will deter much corrosion especially around the joint.

Alan Jeeves

turns. The remaining $2 \frac{1}{3}$ turns come from the gear train $56T + 24T$. This type of head is many times the price of a simple worm and wheel.

d) The VDH (Versatile Dividing Head) designed by Geo. Thomas uses two 2 60:1 worms to effectively give a ratio of 3600:1 and 100 graduations to give 360,000 divisions per revolution. Hence $360,000 \div 113 = 3185.84$ divisions. This is a large enough number that an error of 1 or 2 will have little significance. The mechanics and the arithmetic are cleverly blended in the VDH to make the double worm-drive quick and easy to use.

Kearney & Trecker made a dividing head on a similar double worm principle, but it is not as easy to use. (Nor have I seen any directions for it, if anyone has them please.)

e) A finely graduated rotary table. My modified College Engineering Supply table is Vernier calibrated to 1/500th degree (180,000) although it cannot in fairness be that accurate. Geo. Thomas describes a calibrated table on his UPT which is similar to use.

f) He also describes marking out with dividers as a solution. (Dividing & Graduating, TEE Publishing).

Clock lubrication

Clocks, or other mechanisms which are provided with oil sinks to retain oil for the lubrication of moving parts, should not be over oiled; any surplus oil overflowing from the oil sink can draw off the remaining oil by capillary action leaving the moving component dry.

Alan Jeeves

g) The table used by Geoff Gray from Machinery's Handbook

I have just made the 3 original B & S plates on an unwanted dividing head I borrowed (from a CNC machine-shop). This has a more modern single double-sided plate, similar to that used by Geoff Gray 15, 17, 19, 21, (24), 29, 33, 39, 43, 49 (13), 16, 18, 20, 23, 27, 31, 37, 41, 47, and these holes are blind of course. This double plate is OK. for simple indexing, but not for compound and (what I shall call) complex indexing. All the published data, and there is quite a lot, is for the old style 3 plate layout, and I thought it wise to lock onto that.

The plates I wanted are for Spam, my mill/drill/grind spindle, which as it sits at centre height on a Myford it is therefore the same size as the VDH, thus needing 4in. plates. I ended up exactly copying G.H.T's design for everything from the plate up. I must use a 40T wormwheel of course. I produced the first set of plates in $\frac{3}{16}$ in. gauge plate and hardened these. I could then use these as a drill jig (and so can other people) to make BMS plates much, much quicker. These fit the VDH and G.H.T. mandrel dividers too.

Compound and complex indexing is worked by not screwing the plate to the body. The first index is achieved by normal rotation of the plunger over the plate, which is located with a pin into the back of the plate from the body. Then the plunger is left in the index hole and the pin is

Stainless steel in marine applications

Bi-metallic corrosion

Stainless steel marine fittings should be fastened with stainless nuts and bolts, of similar grade to the material used to avoid bi-metallic corrosion, caused by electrolytic action. If the threads are coated with 'anti-seize'. (This is available in aerosols) they will be easier to remove in future years when refurbishing or replacement is being carried out.

Alan Jeeves

removed from the plate. The plate and locked plunger are now rotated over the pin a certain number of holes. Thus $127 = 2t + 23h$ in 39 (on the front) + 12h in 49 at the rear, the work doing 9 whole revs during this. The clever table always uses the pin in the outer circle.

One has to be more than dedicated to tackle large numbers (daft is a shorter word) and to attempt 73, 113, 127, etc. by complex indexing direct onto the work is asking for mistakes. These are best permanently stored onto a spare plate for that purpose.

TiN, Titanium Nitride

Ron Hough of Beckenham points out an error in issue 23.

Regarding the item in Trade Counter on page 40 of issue 23 of the magazine, I cannot believe that Stan Gray was responsible for misleading readers into thinking that it is possible to buy drills coated in Tin. I can only imagine that your typesetters altered what they took to be a typographical error in his submission.

These gold coloured drills are of course coated in TiN, an abbreviation for Titanium Nitride. I had been looking at a Dormer handbook only minutes before seeing this article and the error shouted at me.

Radiused bottomed grooves

From Simon Trendall of Berkshire, an alternative method.

Re the Quick Tip for producing radiused grooves in issue 23 page 64. If you have a vertical mill or milling attachment with a swivelling head an ordinary endmill can be used instead. By tilting the head a 'radius' can be produced of any size from zero with the head vertical to the radius of the cutter with the head horizontal. The groove formed will not be a true radius but a part of an ellipse, the runout at each end (if making the groove blind) will also be different but by indexing the workpiece 180deg.. this can be overcome. This method is adequate for most jobs and a lot cheaper than buying special cutters.

CAD warning

Attempting to learn more than one program is not a good idea, suggests T. Hart of Wrexham.

I have enjoyed the magazine greatly, especially the recent CAD articles. I have recently been trying Turbocad for Windows

which seems fine but my learning curve is rather lengthy as the snaps and other controls are quite different to Autosketch and Draft Choice which I am used to. Perhaps its best to get really proficient at one program and forget the other tempting glossy adverts that arrive in the post every week once the Software Houses find your name and address.

Information sought

From James Hotinger of Richmond, Virginia, U.S.A.

I am asking for M.E.W.'s. readers' assistance in reference to a recently purchased band saw. It is labelled a Continental Band Filer, made by Continental Machines, Inc., Minneapolis, USA. It has English Patent Nos. on it, so I felt that someone in the U.K. may have a similar machine. Mine is marked Model FC, Serial No. 753. I am looking for any information and an operator's manual and exploded diagrams to buy or borrow for copying.

Additionally, while on holiday in England in January I attended, and enjoyed immensely, the Model Engineer Exhibition at Olympia. At a car boot sale I purchased a year's worth (for 1912) of Models, Railways, & Locomotives, edited by Henry Greenly. Does anyone have suggestions where I might obtain copies of other issues of this magazine? I would like to borrow, or buy if needed, other issues from which I could copy pertinent articles. I will respond to any information I receive.

Tee slots in mild steel

From Peter Bowes of Victoria Australia.

I have on several occasions needed to mount a workpiece on the cross slide of my Taiwanese lathe, but having no tee slots I have had no option other than

securing the article to the tool post, a fiddley and sometimes unsteady process.

Just recently I decided I could no longer suffer in this way, and would have to make a tee slot plate which could be bolted to the cross slide, but how to cut the slots without buying an expensive cutter which would be rarely used.

The question was answered on page 36 of Issue 17 M.E.W. (June/July 1993). This simple cutter worked beautiful on a block of mild steel no more dodgy set-ups on the cross slide.

Indexing Device

Gordon Hall of Barford has an indexing device. Can anyone explain its purpose?

I possess an Indexing Cutter Head (I think?) with 6 and 8 hole divisions. The detent plunger is on a collar and this collar

always allows a 35deg. (or thereabouts) angular movement to the plunger, which angular movement cannot be locked. The median angular position of this angular movement can be set against a circumferential scale with divisions (a) 2 - 4BA (b) 1/4in. (c) 1/8 - 7/16in. (d) 1/2 - 3/4in. (e) 1 - 1 1/2in., these divisions embracing 40deg. (or thereabouts). The divisions would appear to relate to threads (BA and Whit?).

Tapholder simplified

From T Taylor of Windhoek Namibia.

I read with interest the article by R.McKenzie in issue 21 of M.E.W. and would like to point out to prospective builders of this useful tool that at least three quarters of this attachment is already in most workshops.

One of the first projects that I made



1: General view of indexing device. The calibrations can just be seen on the end cap at the right hand end.



2: End cap removed. Note the cam on the end of the spindle and the stop pin in the end cap.

when I acquired my lathe was a tail-stock die-holder. This die-holder contains all the parts for the tap-holder except for the buttons to hold the taps. These buttons will have to be turned to suit the die-holder. The dimples for the grub-screws will also have to be made to suit. The only other part that may have to be made is the drill press adapter as that would not normally be required for the die-holder.

Machining stainless, problem solved

From R G Shepard of the Isle of Wight this letter with a recommendation for machining stainless steel.

Regarding your editorial in Issue 15 I think I may be able to supply some useful

information on the machining of stainless steel. I must first inform you that I am not an engineer by profession, but for the last 50 odd years have been interested in model engineering and tool making, and have from time to time been called upon to undertake some rather exacting work on a commercial basis.

I have had not recent experience with stainless steel but 25 years ago I had to make some components in this material on my Myford S7B. I encountered all the usual problems. I do not know the specification of the material, but it was non-magnetic and resistant to corrosion by sea water, in various sizes up to 1½ inch diameter.

To cut a long story very short, I wrote to Myfords explaining my difficulties turning this material using both HSS and carbide tools. Back came a most helpful letter from one of their directors in which he referred me to a tool material known as Blackalloy 525 and TX90, which they had been using in their works on stainless steel. I wrote to the suppliers, Brunner Machine Tools Ltd, (see Trade Counter - Ed.) from whom I obtained a piece of Blackalloy 525. After experimenting with tool angles, speeds, depth of cut, and feed I found my problems were solved, and turning stainless steel became almost as easy as mild steel and tool life was very greatly increased. One important point is that tools can be ground on an ordinary grinding wheel as used for HSS - no green grit or diamond laps, just an oilstone slip.

Novel Dividing

Jack McIntosh of Glasgow suggests a novel approach to achieving a division of 125. No doubt it could be adapted to suit many other numbers by altering the gear ratio.

I recently made an aluminium dial with 125 divisions for the tail stock of my ML7 using 8/1 gearing leadscrew to chuck. Eight divisions on the lead screw dial corresponded to one division on the dial being made in the chuck. The dial was grooved with threading tool on its side using the rack feed as a shaper. It is advisable to have a table of lead screw settings every 8 divisions (0,8,16, ..., 120,3,11,19, ...).

Milling Safety

Chris Ford of Gloucestershire suggests that milling on the drilling machine is not the done thing. Certainly the absence of a draw bar is a major safety hazard.

You have a clash of points. Pages 32-33 on safety are basically common sense but we all need to be reminded of the most basic points from time to time as we are all guilty of bad practice.

However, the letter (Peter Annely) on page 67 contains the old favourite on drilling machines "I use it for light milling".

A drilling machine is for drilling holes with, nothing more. A milling machine is for milling operations.

I know that this has been pointed out many times before in the modelling press,

but if you can please make the point. Everything in the workshop is safe if used correctly, but dangerous if used incorrectly and milling should not be done on a drilling machine.

Safety First

From Mike Holben of Okehampton who is Spares Registrar of the Brough Superior Club.

Mr. P. Smith is very correct when to stress (S.A.L. issue 23 page 67) that it is not advisable to use old half shafts rescued from the scrap yard for making motorcycle fork spindles. The person who suggested this idea cannot have had the experience which I have of changing sheared off halfshafts on a large variety of vehicles from small cars to forklift trucks; no one can tell the strains to which a secondhand shaft may have been subjected; apart from the risk involved the whole thing seems rather pointless, machining large lumps of steel when several advertisers in M.E.W. offer steel of known specification in the sizes and quantities we require for such operations at a very reasonable price.



Easy starting

The corner of a three-square or half-round file is good for marking and cutting a guide for starting a hacksaw cut. It saves wear and tear on thumbs.

R.J. Loader

IN OUR NEXT ISSUE

Coming up in the **NOVEMBER/DECEMBER** issue, No. 26, will be:



Making a precision angle plate without the aid of a second angle plate, and its easy.

Tailstock taper turning attachment. Turning tapers using an offset centre, but without the need to reposition the tailstock.

Removing rust, deburring components, acquiring a surface finish, all can be achieved by using a tumbler. A device much used in industry but rarely seen in the home, except for small versions used for polishing semi precious stones. We consider its possibilities in the home workshop.



AND MUCH MORE

**Issue on sale
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(Contents may be changed)