

No.54

MODEL ENGINEERS'

WORKSHOP

THE PRACTICAL HOBBY MAGAZINE

HOLBROOK LATHE

*A machine tool
in miniature*

ADDITIONS TO THE QUORN

*Cutter grinder
enhancements*

A TALE OF TWO CHUCKS

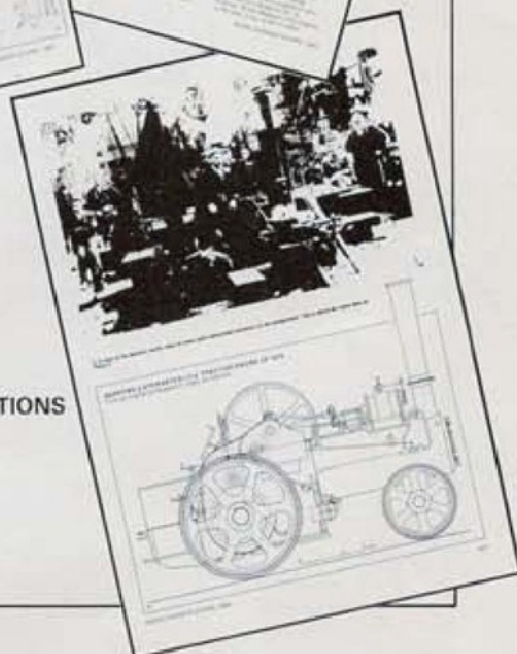
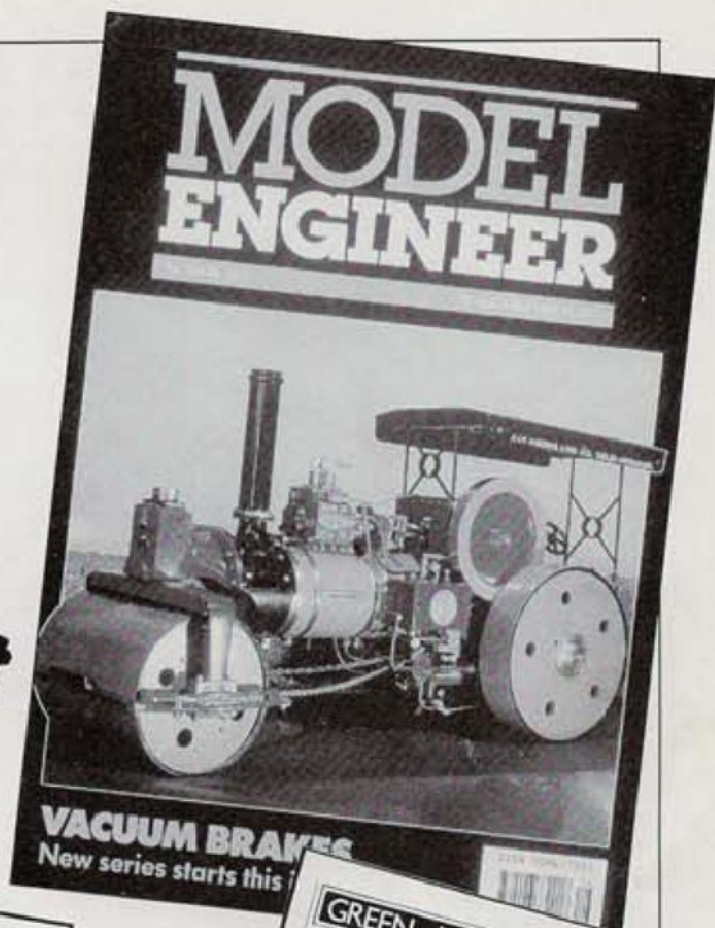
*Equipping a
Southbend lathe*



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...every fortnight



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

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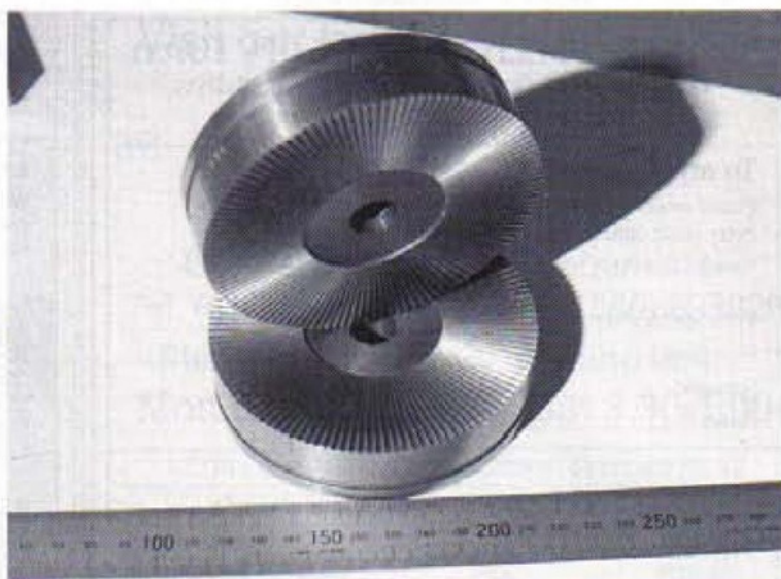
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Reader to reader



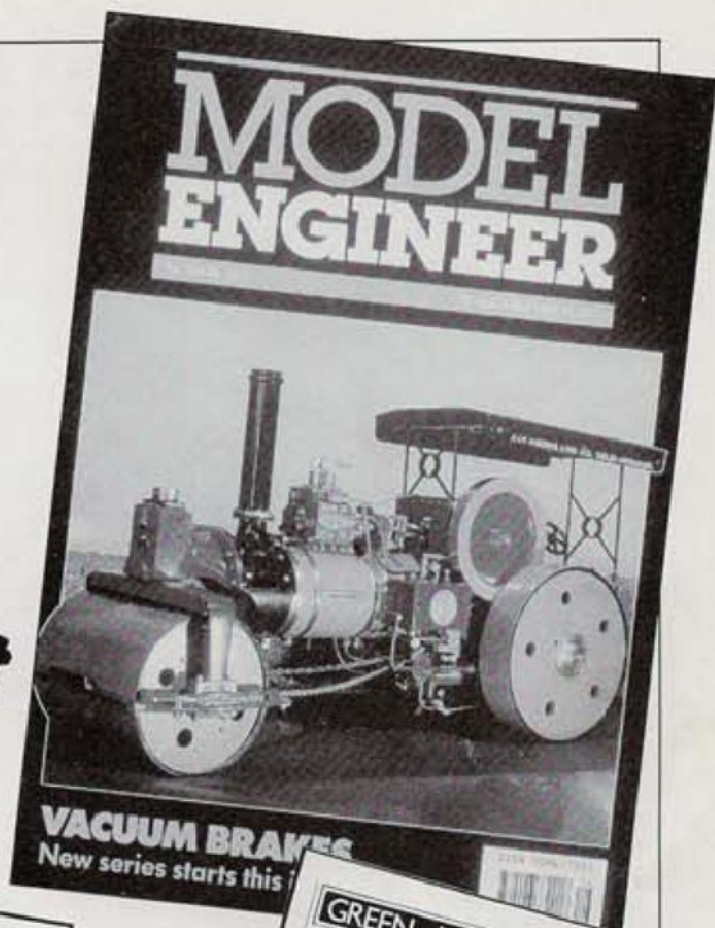
On the cover

Peter Rawlinson's
CNC milling
machine, complete
with dividing head, is
proving to be
capable of producing
complex
components. The
description continues
on page 14.



Machining the teeth on Bill Morris' Face Geared Indexing Table (described in Issue 52) has generated a great deal of comment. Scribe a Line starts on page 63

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ON THE EDITOR'S BENCH

With the main holiday season over, we decided that the time was right to venture in to Cornwall. As it happened, we managed to choose one of the worst possible weekends as far as weather was concerned, but it in no way made the visit any less enjoyable. In fact, we were able to drive without difficulty through some of those delightful fishing villages which are virtually impassable in summer. Wherever we went, people had time to stop and talk about the features which make the county unique and so attractive.

As we drove around the area, I was reminded of how much the science of engineering owes to developments which took place in Cornwall. I never cease to be surprised at the number of engine houses which appear on the sky line, explaining why such enterprises as Harveys of Hayle and Holmans of Camborne flourished so strongly in their heyday. The technical advances encouraged by the need to increase thermal efficiencies and so reduce fuel costs ensured that the Cornish companies were in a position to exploit the emerging markets both at home and abroad. There can hardly be a mining installation anywhere in the world where Cornish engineers failed to make their mark. We had the opportunity of seeing some of this at first hand when we visited a couple of sites on the coast at Pendeen.

Unfortunately, the Levant Engine House was not open on the day of our visit, so we were unable to see the restored beam engine housed there. We were, however able to enjoy the spectacular scenery of its location. Brilliant sunshine and a near gale force south westerly wind meant a blue sea with plenty of white horses, with breakers crashing over the rocks near the base of the nearby lighthouse. In such weather, that must be one of the best places in which to be engaged in a restoration project. Its a pity that it is just a bit too far from home, or I think that I would be very tempted to get involved.

The nearby Geevor tin mine was open for visitors, with attentive guides on hand to explain the details of the installation. The site is now owned by the County Council and managed by the Trevithick Trust, an educational charity which is involved with many of the industrial heritage sites throughout Cornwall.

Geevor is a most impressive exhibit, with good explanatory displays, including a minerals room, which do much to put the mining activity into context. Videos which are repeated at regular intervals also serve to set the scene.

Only after donning hard hats were we allowed to venture on to the site and to follow a trail around the various buildings to see displays depicting the activities which were involved in digging out the tin bearing ores, getting them up from underground and then crushing and preparing them for onward transmission to the smelter. The climax of the visit was a trip 'underground', made possible by the opening up of one of the 'levels' which were driven in to the steeply rising hillside. Our guide here was an experienced mining engineer who had worked at various locations on the African continent, and who must have found the weather of a boisterous Cornish autumn to be exhilarating to say the least.

Of another generation was a young man, about 14 years old, who was visiting Geevor with his parents and other members of his family. Apparently he is well known to the guides as he turns up at least two or three times a year and pays close attention to all that is going on. He has expressed a determination to become a mining engineer and, despite the discomforts often associated with such a profession and the sometimes traumatic times experienced by the various facets of the mining industry, he refuses to be dissuaded. It struck me as yet another case of a born engineer being set upon a path which he is prepared to follow, regardless of the fact that there other professions which promise much greater material rewards. We wished him well.

As I have mentioned before, our understanding and enjoyment of such places are often much enhanced by the existence of models of the installation and its equipment. Geevor is no exception, one of the most impressive being a space model of all the shafts, levels and galleries of the mine and its interconnecting neighbours. This was built by the engineers when the mine was operative in order to provide them with information on the relationship of the workings and the surrounding terrain. It must be remembered that a number of the levels stretched well out under the sea bed. Other models are of the ore crushing and grading equipment and associated pieces of machinery. Many of these were built as working models, but have now fallen into disrepair. The team

at Geevor are seeking help from anyone who would be prepared to take on the task of restoring one or more of these to working condition. Anyone interested should make contact with the Trevithick Trust at Geevor.

The final stop on our tour was to see the Cornish Beam Engines at Pool, between Redruth and Camborne. I must admit that we were a little disappointed at this exhibit. Although both engines (the East Pool Winding Engine and the 90in. pumping engine at Taylors) and their houses have been beautifully restored, their original industrial setting has been somewhat overwhelmed by the trappings of modern civilisation. The Taylors site now has to be approached by way of the car park of a supermarket complex, taking care to avoid the shopping trolleys and the petrol pumps. The former East Pool & Agar Ltd. building also now houses the Cornwall Industrial Discovery Centre which consists of displays depicting the various industries for which Cornwall became famous over the past two centuries. Although each of the exhibits has been superbly compiled, the whole is, as yet, somewhat disjointed, with no coherent pattern or path to follow. I think that my wife summed it up for both of us by saying that she felt that she had come in half way through a tour, and had missed the introduction. To be fair, this is a relatively new display, so is probably not yet in its final form. All the other offerings from the Trevithick Trust that we have seen have been so good that I am sure that this one will soon be developed to the same standard.

One of the items in this exhibition which did catch our eye was a working model of a typical tin mine, with shafts, levels and galleries and the machinery associated with the workings. Triggered by a proximity switch, the scene was illuminated and the various pumping and winding engines began to operate in a most realistic manner. As it happened, the builder, a Mr. Hockings was visiting the Centre while we were there, so we were able to congratulate him on a fine piece of model making. I believe that he had previously worked at the much lamented South Crofty mine and decided to record his experience in a most tangible form. He is currently building a second, more portable model.

Cornwall, with its magnificent scenery and wealth of industrial archaeology is a fascinating place to visit. I feel that our return will not be long delayed.

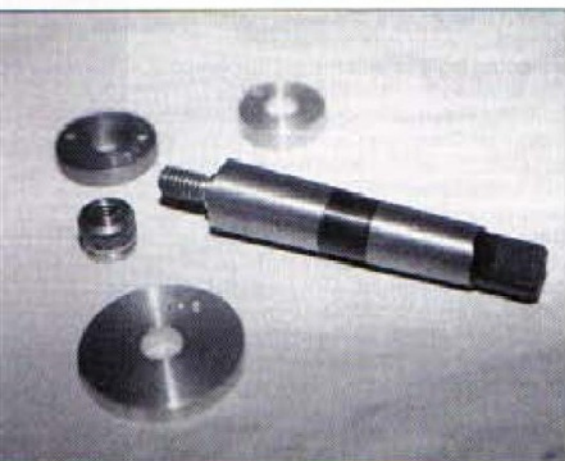


A STEADY SETTING DEVICE (with other uses)

Simple items of tooling often repay the time involved in making them very rapidly. This lathe accessory from Maurice Turnbull of Sheffield is a good example

This is a very easy tool to make. Its simplicity belies its usefulness because, as will be discussed later, it can be used for several other jobs too.

For the basic tool, as shown in **Photo. 1**, first obtain your Morse taper shank. Mine was a drill chuck arbor, threaded $\frac{3}{8}$ UNF, left over from some project which never happened. Don't overlook the



1. The shank, the nut and setting discs

possibility of using old taper shank drills when rummaging through the junk at car boot sales or searching the traders stalls at exhibitions. A scrapped drill could still have a taper in good condition, and be had for a price which hardly makes it worth while switching the lathe on and getting the steel to make your own. You will usually find that the shank past the end of the drill flutes is soft enough to machine, but beware of drill chuck arbors as these are hardened, and no amount of heating on the one that I tried would soften it. If you want to make your own, methods of doing this have been discussed in *Model Engineer* and *M.E.W.* many times. As a very last resort you could BUY a blank from advertisers.

I will describe how I made my setter as an example, but please remember that nothing is fixed and, within limits, make parts to suit yourself. As already stated, the shank had a $\frac{3}{8}$ UNF thread on the end, but for two reasons I decided to change

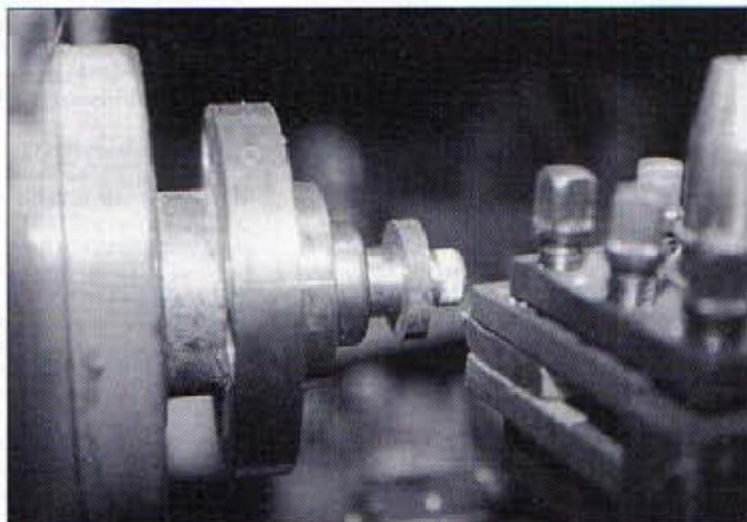
this to $\frac{5}{16}$ BSW. Firstly, I thought that the parallel part at the end of the thread was not accurate enough for the location of the setting discs, and secondly, I hadn't got a suitable tap with which to make the nut.

After fitting the shank into the headstock and machining the locating spigot accurately to the chosen size, I screwcut the thread and undercut the face, like the clockmakers do, so that the setting discs can be tightened up without any rocking. My spigot was $\frac{3}{8}$ in. dia. by $\frac{1}{8}$ in. long.

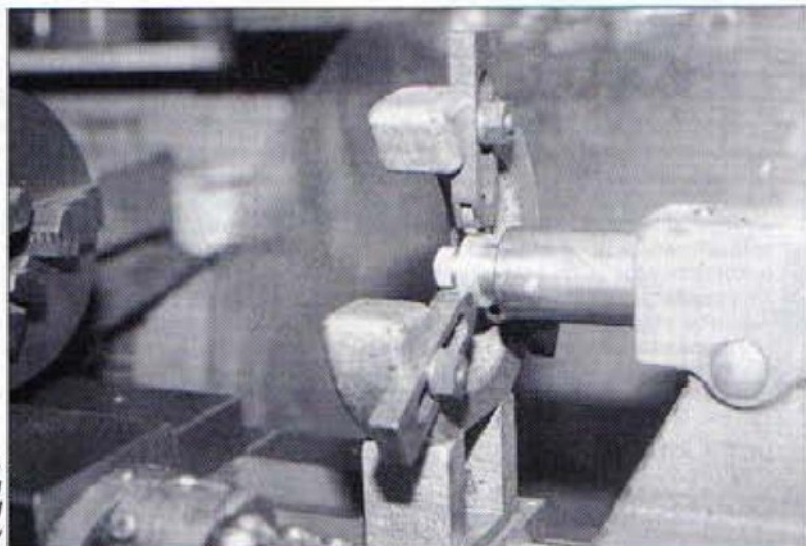
Make it a metric equivalent if you wish, but whatever it is, make sure it is a 'common' size, and that you have a reamer to suit. A nicely knurled brass finger nut completes the main part. The setting discs can be made from a variety of materials, iron, steel, aluminium, brass or even hard plastic as they're not

going to get any wear, apart from fitting on to the shank. Make up a few from different diameters of stock, bring them all to a uniform thickness by machining both sides, say $\frac{1}{4}$ in., then drill and ream the hole in the middle.

With the shank back in the headstock, I fitted each disc in turn and machined it to a standard diameter on the outside, choosing sizes that match the range of stock that I usually carry. I leave at least one disc unmachined, to cover the odd



2. Machining a setting disc



3. Setting the fixed steady

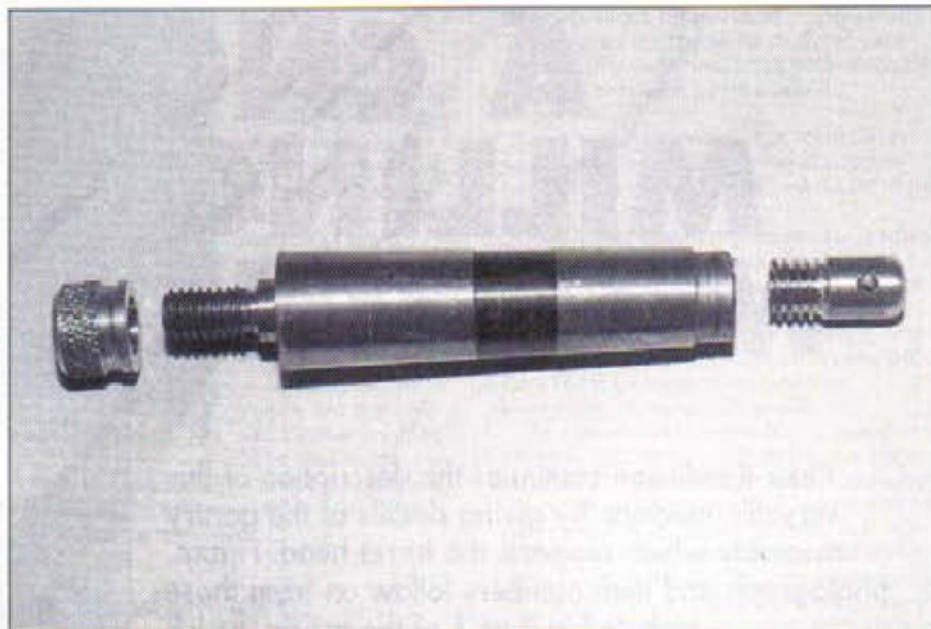
size that crops up now and again. It takes only moments to machine it to size.

Photo. 2 shows this operation on a 1in. dia. disc, and **Photo. 3** is of the same disc, with the shank in the tailstock, being used to set up the fixed steady.

So that is the basic tool finished. However, I decided on the modifications as shown in **Photo. 4**, namely, removing the tang, then drilling and tapping the end to take a draw bar. Now, as well as having a setting tool, I have a stub mandrel for second machining operations in the lathe and an arbor for use in the milling machine. A false tang is now needed, of course, to eject the shank from the tailstock.

Setting a radius

When I was looking at the various components intended for my next model, and deciding how to manufacture them, it became apparent that one part would need a radius machining on one side of a flat bar. This radius had to be accurate, and as it was only about a quarter of a circle I wondered how I could possibly measure it. Measuring with a rule from a centre was not good enough. Thoughts turned to the steady setter, which of course in use is simply a diameter set accurately about the lathe axis. If a disc of the required radius is used to set the lathe tool, and the crossslide dial set to zero, then any work piece machined to the same mark must be correct! I decided to test the theory. A setting disc of 1.125in. dia. was put on the shank in the tailstock, the cutting tool was



4. The modifications

advanced to just touch a 0.010in. feeler resting on the edge of the disc, then after moving the saddle along the bed, the tool was further advanced by the thickness of the feeler and the dial zeroed. A piece of irregular shaped aluminium was put in the chuck and light cuts taken until the dial again read zero. Next, an accurate hole 1.125 was machined in a piece of scrap and then the parts were compared. The

two parts matched perfectly, no gap being visible at any position, even when viewed through a strong magnifying glass. A test with a spot of micrometer blue confirmed this. For short internal radii, on such things as saddle type boiler fittings, the discs can't be used to set the lathe tools but they can be used as plug gauges to check dimensions as machining progresses.



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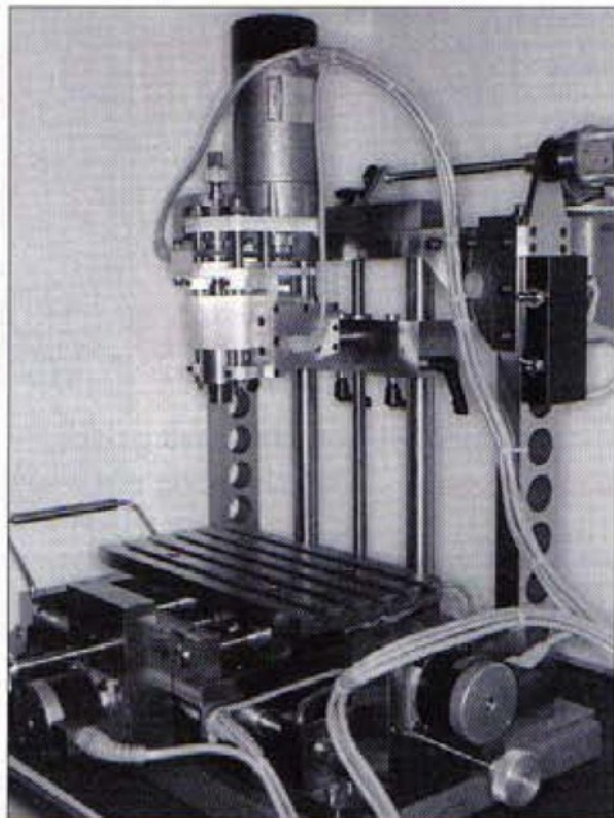
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A CNC MILLING MACHINE

Peter Rawlinson continues the description of this versatile machine by giving details of the gantry assembly which supports the turret head. Figure, photograph and item numbers follow on from those included in Part 1 of the article, which appeared in Issue 53



During the gap between the writing of the last article and this one, things have been hectic, in as much as I have had a virus. Not one of those that attacks human beings, but one of those boy-made varieties that attacks computers. I am usually very careful and can think of no way in which it could have found its way into the system, but it has caused havoc. It has cost time and money to sort out, but it seems that we are now back to normal, thanks to my small local computer shop, so we can again let battle commence.

Gantry Assembly

The first parts to be made are a pair of spacer blocks which fit between the gantry vertical columns and the X axis slide bar supports. If you are making the full 3 axis variant of the machine, these blocks need to be as shown at Item 42, the retaining caphead screws passing through the vertical members and spacers into holes drilled and tapped in situ in the X axis slide bar supports. If, however, you are using the sub-table version, then longer spacers (Item 42A) which incorporate a third hole should be used, the third screw going into a tapped hole in the edge of the sub-table. The gantry vertical columns will, of course, need to be lengthened by 20mm to correspond.

A further variation on the theme would be to make the X axis slide bar supports and the spacers as one item and although this would be a little more rigid, it would be rather wasteful of material and somewhat time consuming.

The vertical columns (Item 43) and the horizontal beam (Item 44) are shown with lightening holes which certainly save weight and give a pleasing appearance, but can be time consuming to produce if drilled. As you may have noticed from my previous articles, I favour the use of a Rota-Broach for

anything over 12mm dia. The positions of these lightening holes are not critical, but those of the drilled & counterbored and tapped holes are, as they all tie up with other holes.

Z axis slide system (Manual)

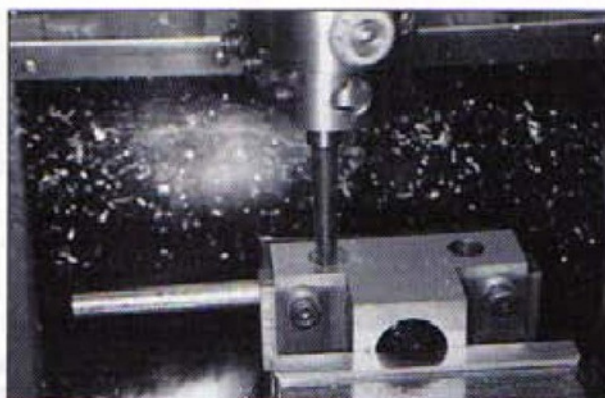
As mentioned previously, there are two independent Z axis movements, one providing for coarse adjustment of the

turret head position, while the other is under CNC control and sets the position of the tool relative to the workpiece. The former is similar in layout to the X and Y axis slide systems, consisting of silver steel slide bars located top and bottom in support bars. Once again, the main holes in these supports and those in the sliding bar which supports the turret must be spaced accurately if smooth operation is to be achieved. The machining system described for the X and Y axis components should therefore be used again. However, before these main holes can be bored in the turret support bar, other holes must be drilled and a few items made to fit them

Clamping systems

To ensure rigidity when operating the machine, the turret support bar is clamped to the Z axis slide bars and the round bars which connect the turret to this support are, in their turn clamped to it. The clamps are made from 12mm dia. brass rod to the dimensions shown, then the halves held together with bolts in place of the M6 studding, before being secured in their locating holes in the turret support bar with Loctite.

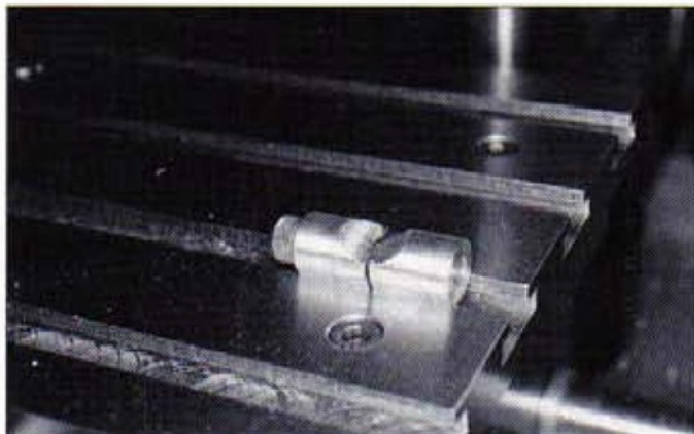
The main holes for the two sets of slide bars and the leadscrew can now be drilled, bored and reamed using the locating procedure described previously (Photo. 12). In the process of machining the slide bar holes, the 'scallops' in the clamps will be produced automatically. Care must be taken to get all the sets of holes at right angles.



12. Boring the turret support bar with clamps in place



13. Heating to remove the clamps



14. Clamp after removal from block

them out.

After the clamp parts have been removed, they should be dismantled, one set at a time, and 1mm removed from the inner faces (Photo. 14). If, when everything is assembled, they are found to 'stick', then either remove a little more, or file away the edge.

As an aside, the clamps are shown with ratchet handles fitted. Ball handles or even a hexagon head could be substituted, but these ratchet types are much better where space is limited.

In order to remove the clamp parts after boring, it will be necessary to break the Loctite bond. This is done by gently heating the assembly (until the steel has blued) (Photo. 13) when it will be found that the Loctite has broken down and, with a little persuasion, the clamps will come out. The two blind clamps should be fitted with a threaded 'pulling piece', so that a slide hammer can be attached to help ease

Leadscrew and drive

To complete this Z axis slide assembly, I will cover the leadscrew and the 'manual' motor drive. The leadscrew assembly (Figure 6) is similar to that used for the X and Y axes, the leadscrew (Item 56) being cut in a similar manner. A loose distance piece (Item 48) again sets the distance between the bearings and two bearing

retainers (Item 49) are used in this set-up. These items are the same as those used on the other axes, and were detailed in the previous article as Items 5 and 6 respectively.

A Nylatron leadscrew nut (Item 53) is again fitted to the sliding turret support bar, but this one does not have to be of the anti-backlash variety.

The upper end of the leadscrew is fitted with the larger of a pair of standard 2:1 bevel gears, being secured with a special washer (Item 58A) and a countersunk screw. Both this gear and the mating one (Item 59) require modification, as shown. Care must be taken to ensure that everything remains concentric.

The motor drive to the Z axis was an afterthought, as it was found that a large amount of time was expended in winding the turret up and down. The motor was to hand and is a standard Parvalux SD1 AS 250 volt 50 Watt which runs at 4000 RPM. (I believe that this type is now superseded by the SD 1 C). It is fitted with a 40:1 ratio gear box which drives a shaft through a 1:1 toothed belt and then, through the 2:1 bevel reduction gears described above, to the 10 TPI leadscrew. In theory this gives a speed of 5in. per minute, which I have confirmed by measuring a travel of 1in. in about 11 seconds. This motor is mounted on a bracket (Item 63) which sits on the top of the gantry and which is slotted to give a small amount of belt adjustment.

As the initial reduction is achieved by using a worm drive in the integral gearbox, special arrangements were needed to provide an alternative manual drive to the leadscrew and, as mentioned in the previous article, I found that a device called a 'Jeclanide' coupling would do the job (see below). There are, however, other motors available which do not incorporate a worm drive in the train and can therefore be 'driven' by a handwheel system. If the use of one of these is preferred, it could be mounted on the end of the gantry remote from the handwheel, with an extended shaft connecting it to the bevel gears. The special coupling would then, of course, no longer be required.

The Jeclanide Coupling

As mentioned above, the belt drive from the motor passes through a modified version of the Jeclanide Coupling (Photo 15). This device was described by Mr. W. B. Taylor in Issue 13 of M.E.W., and if you have access to the original article, you will get a better understanding of its operation. This assembly is shown as Item 65.

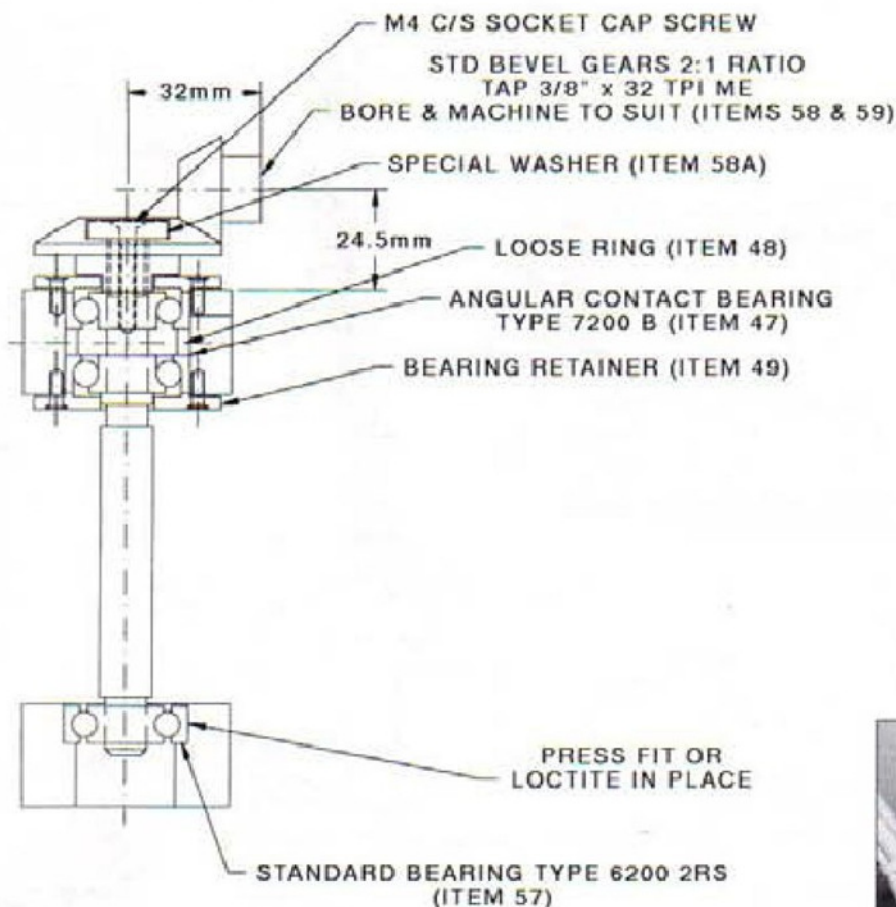
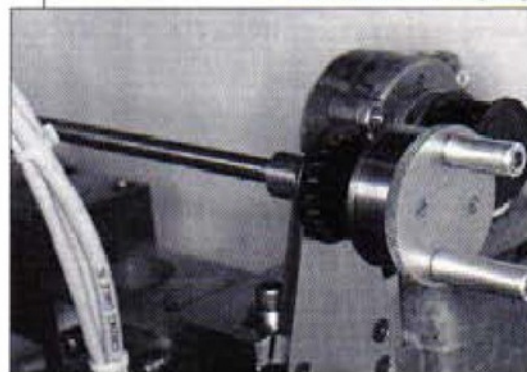
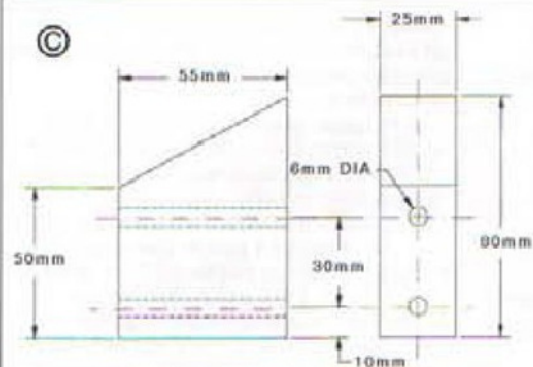


FIG. 6. 'MANUAL' 2 AXIS LEADSCREW BEARING SETUP

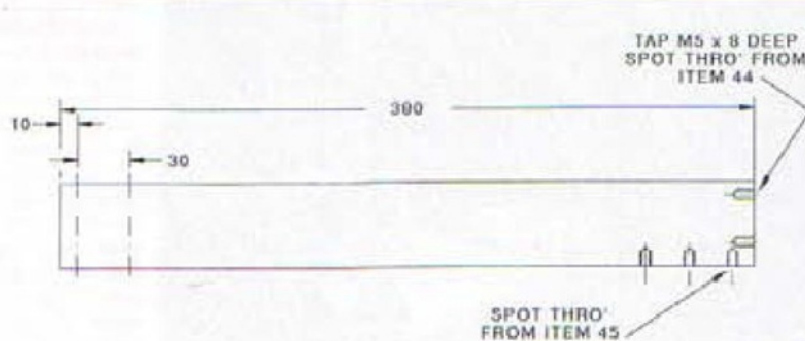
15. Jeclanide coupling



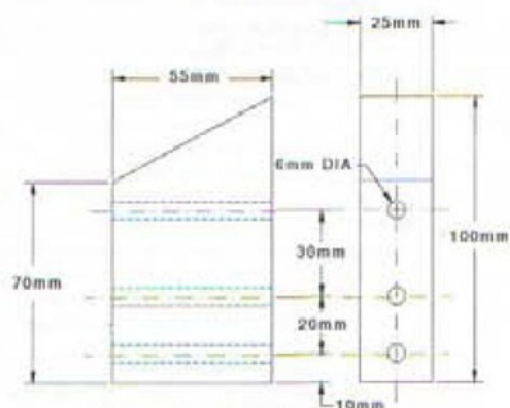


HOLES TO BE SPOTTED THRO' FROM GANTRY VERTICAL COLUMNS (ITEM 43)

ITEM 42 SPACER BLOCKS
(FOR USE WITH BASE PLATE ITEM 2)
2 OFF MILD STEEL



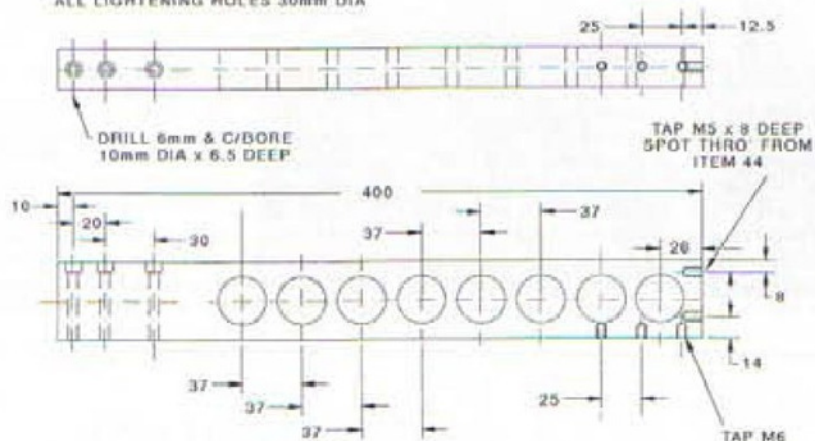
ITEM 43 GANTRY VERTICAL COLUMN
(FOR USE WITH BASE PLATE ITEM 2)
2 OFF MILD STEEL



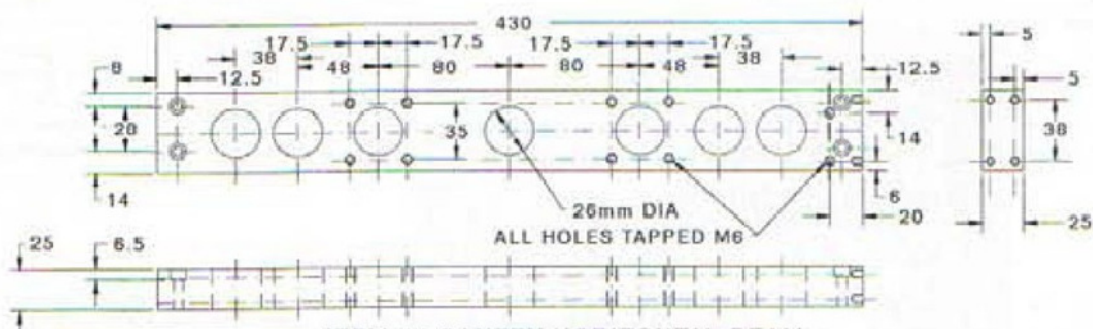
HOLES TO BE SPOTTED THRO' FROM GANTRY VERTICAL COLUMNS (43A)

ITEM 42A SPACER BLOCKS
(FOR USE WITH SUB-BASE ITEM 1)

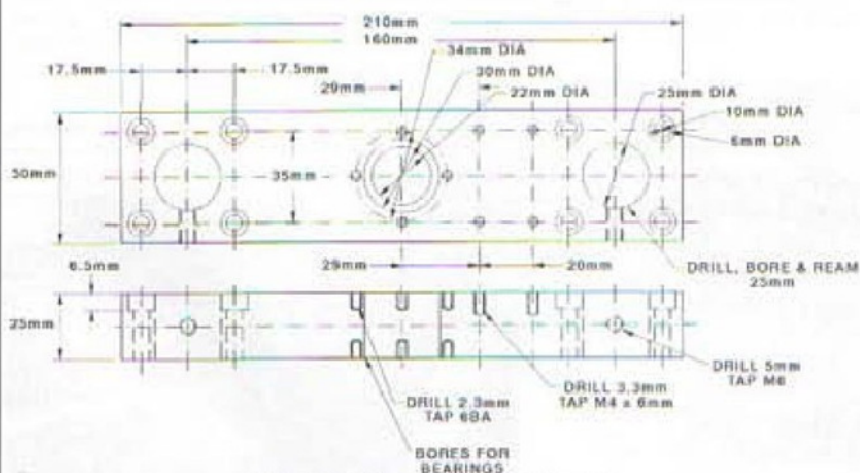
ALL LIGHTENING HOLES 30mm DIA



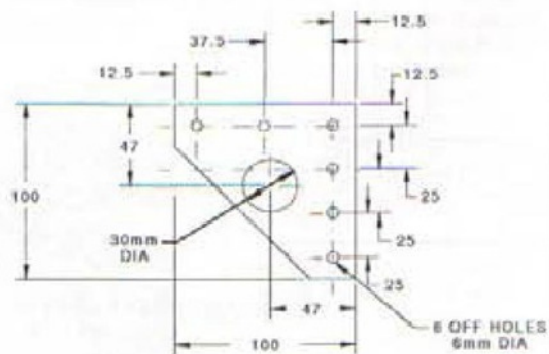
ITEM 43A GANTRY VERTICAL MEMBERS
(FOR USE WITH SUB-BASE ITEM 1)
2 OFF MILD STEEL



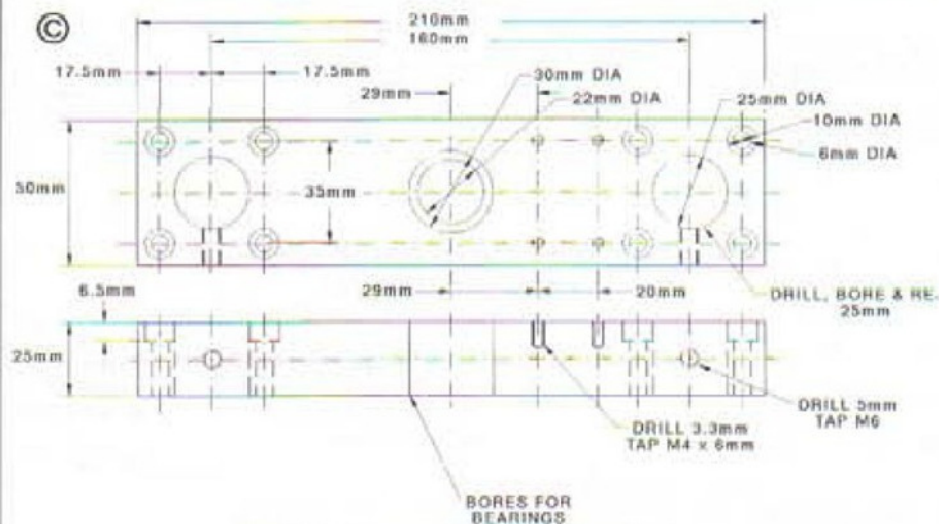
ITEM 44 GANTRY HORIZONTAL BEAM
1 OFF MILD STEEL



ITEM 46 SLIDE BAR SUPPORT (UPPER)



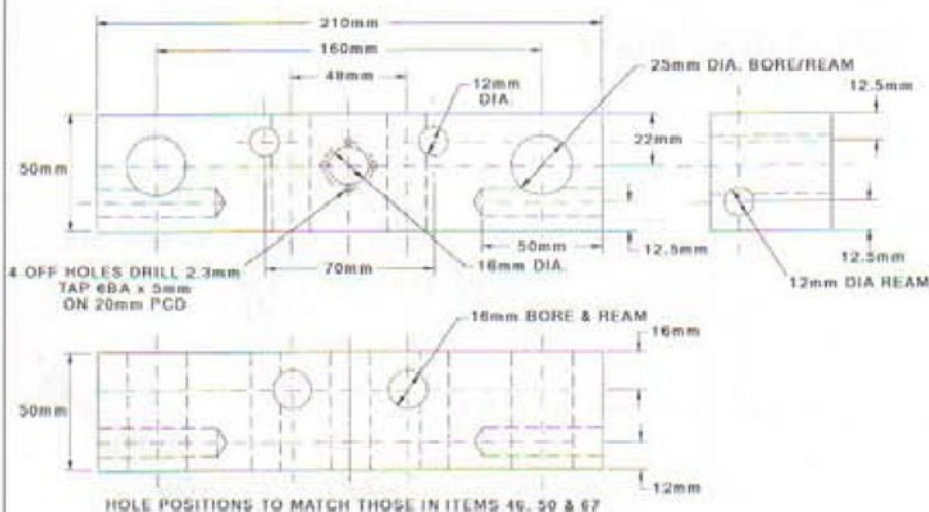
ITEM 45 GUSSETS
2 OFF 6mm STEEL PLATE



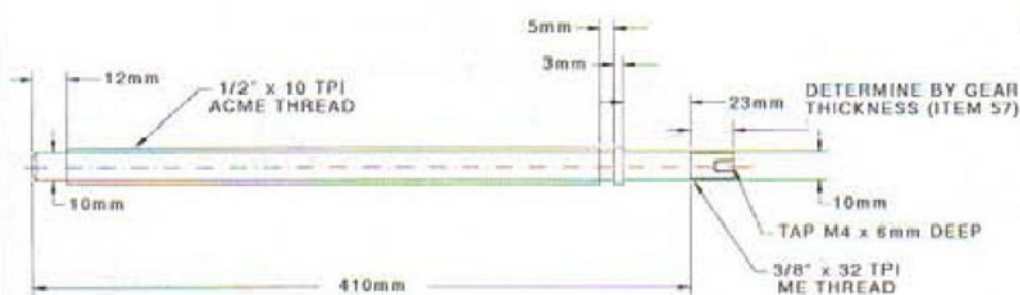
ITEM 50 SLIDE BAR SUPPORT (LOWER)



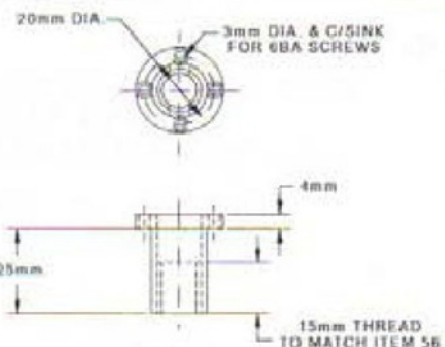
ITEM 51 SLIDE BARS ('MANUAL' Z AXIS)
2 OFF SILVER STEEL



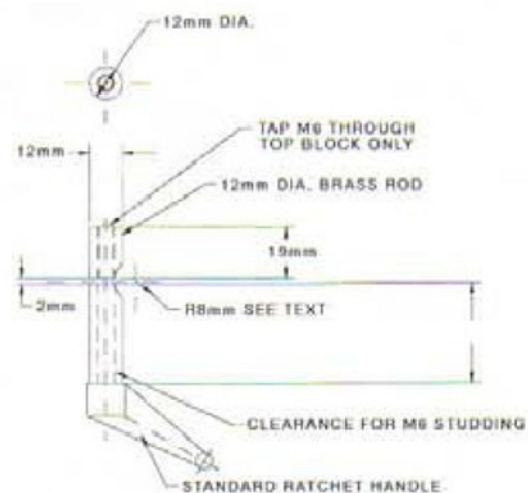
ITEM 52 TURRET SUPPORT BAR
1 OFF MILD STEEL



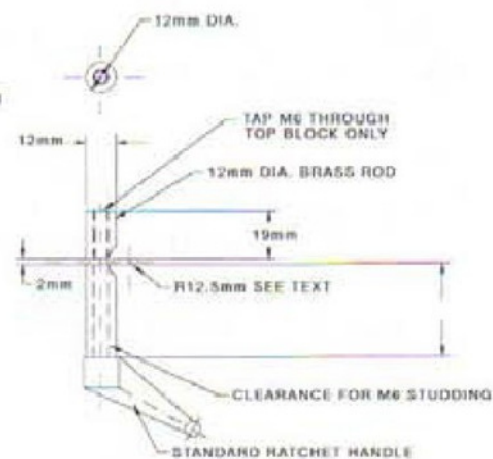
ITEM 56 LEADSCREW ('MANUAL' Z AXIS)
1 OFF STEEL



ITEM 53 LEADSCREW NUT
1 OFF NYLATRON



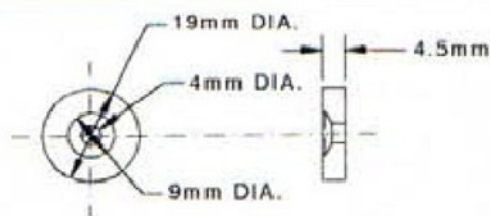
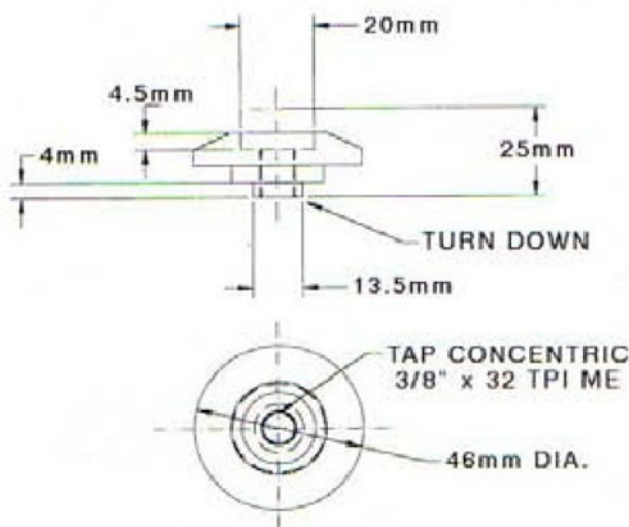
ITEM 55 CLAMP ASSEMBLY
Y (TURRET) AXIS



ITEM 54 CLAMP ASSEMBLY
Z AXIS

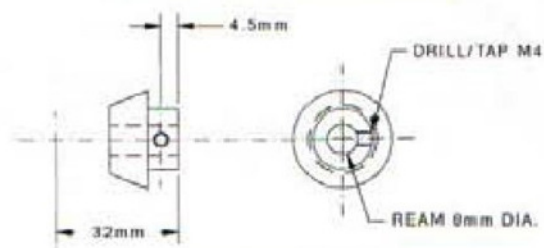
©

ITEM 58 BEVEL GEAR (LEADSCREW) 1 OFF STEEL (STANDARD GEAR MODIFIED)



ITEM 58A COUNTERSUNK WASHER 1 OFF MILD STEEL

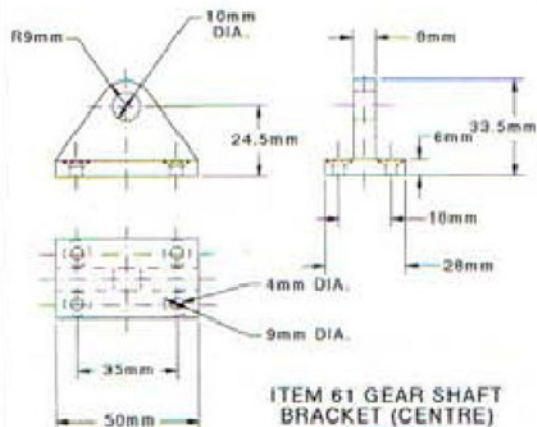
NOTE ITEMS 58 & 59 ARE
A PAIR OF 2:1 RATIO
BEVEL GEARS OF APPROPRIATE SIZE



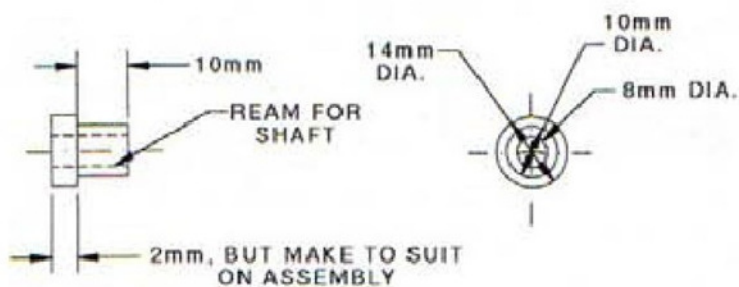
ITEM 59 BEVEL GEAR 1 OFF STEEL (STANDARD GEAR MODIFIED)



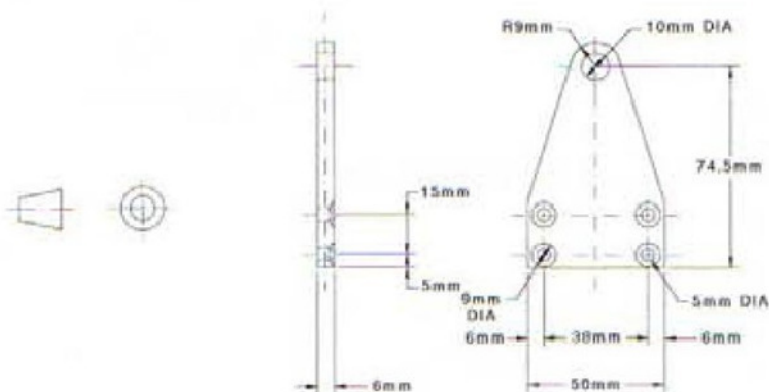
ITEM 60 GEAR SHAFT 1 OFF SILVER STEEL



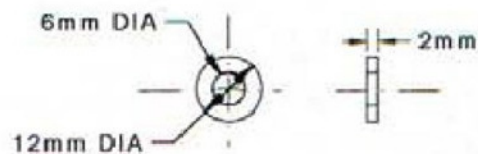
ITEM 61 GEAR SHAFT BRACKET (CENTRE) 1 OFF STEEL



ITEM 61A & 62A GEARSHAFT BEARINGS 2 OFF PHOSPHOR BRONZE



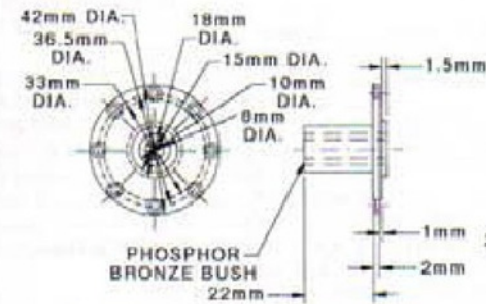
ITEM 62 GEARSHAFT BRACKET (OUTER) 1 OFF STEEL



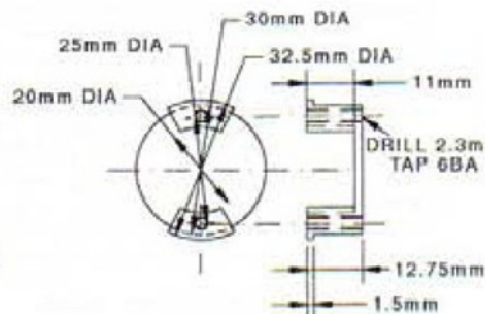
ITEM 63A WASHERS 2 OFF STEEL

ITEM 63 JECLANIDE COUPLING ASSEMBLY

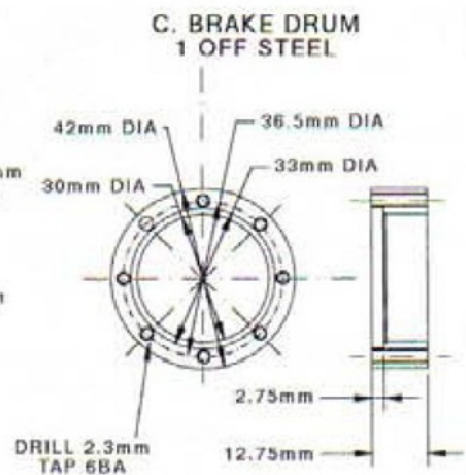
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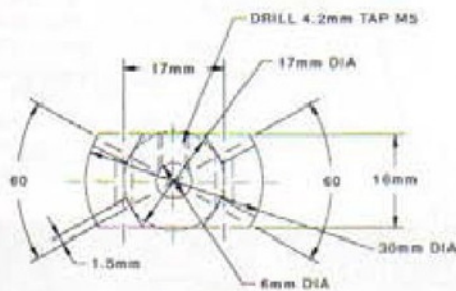
A. COVER PLATE & BEARING
BORE TO 15mm DIA TO FIT 20
TOOTH TIMING PULLEY (ITEM 66)
SECURE WITH TWO M5 GRUBSCREWS



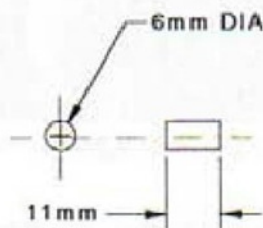
B. DRIVING YOLKE
1 OFF STEEL



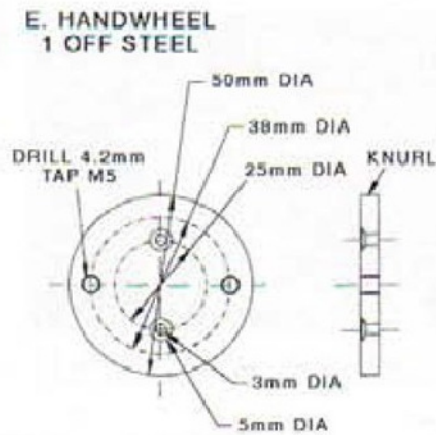
C. BRAKE DRUM
1 OFF STEEL



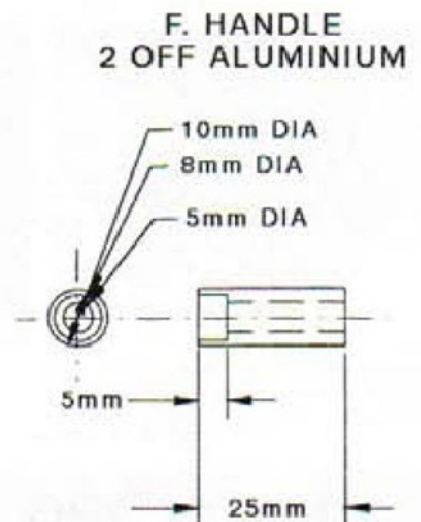
D. RATCHET WHEEL
1 OFF M/S



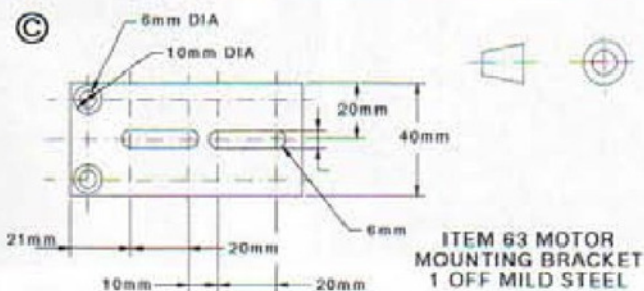
G. ROLLER
4 OFF SILVER STEEL



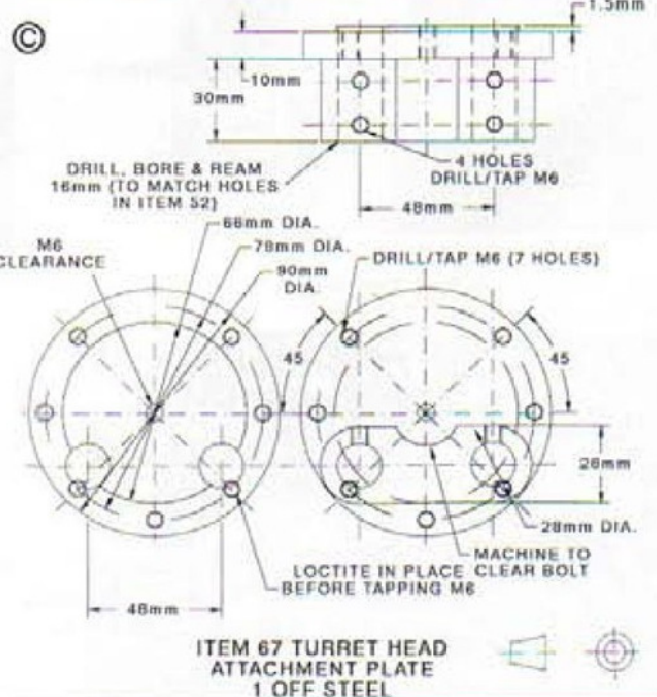
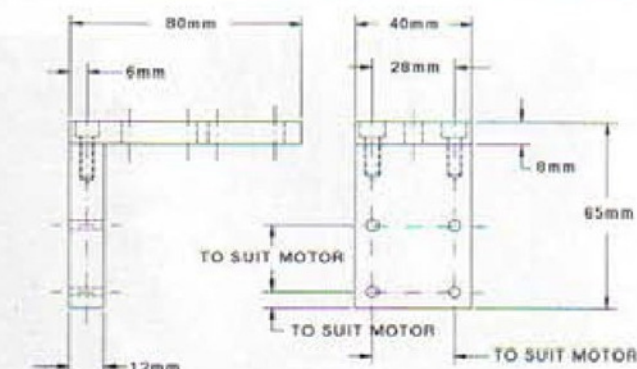
E. HANDWHEEL
1 OFF STEEL



F. HANDLE
2 OFF ALUMINIUM



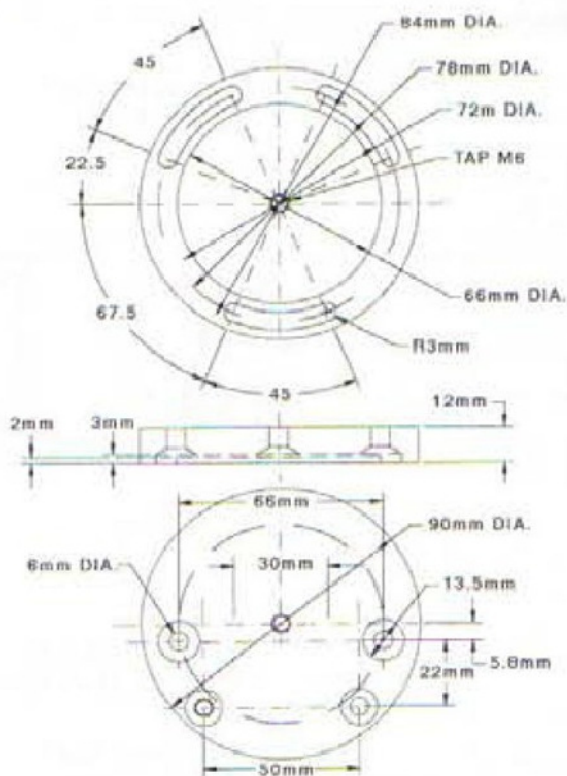
**ITEM 63 MOTOR
MOUNTING BRACKET**
1 OFF MILD STEEL



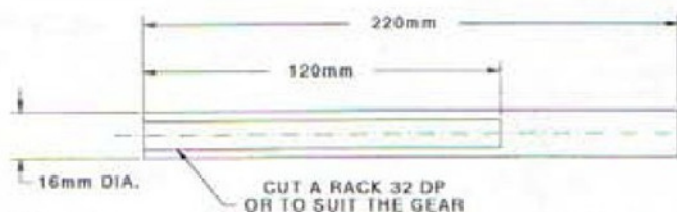
**ITEM 67 TURRET HEAD
ATTACHMENT PLATE**
1 OFF STEEL

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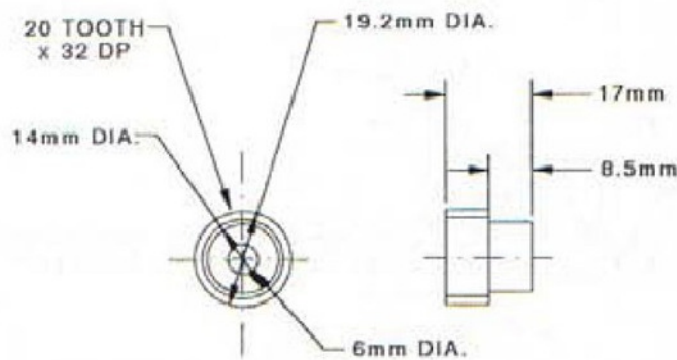
REPEAT ABOUT CENTRELINE



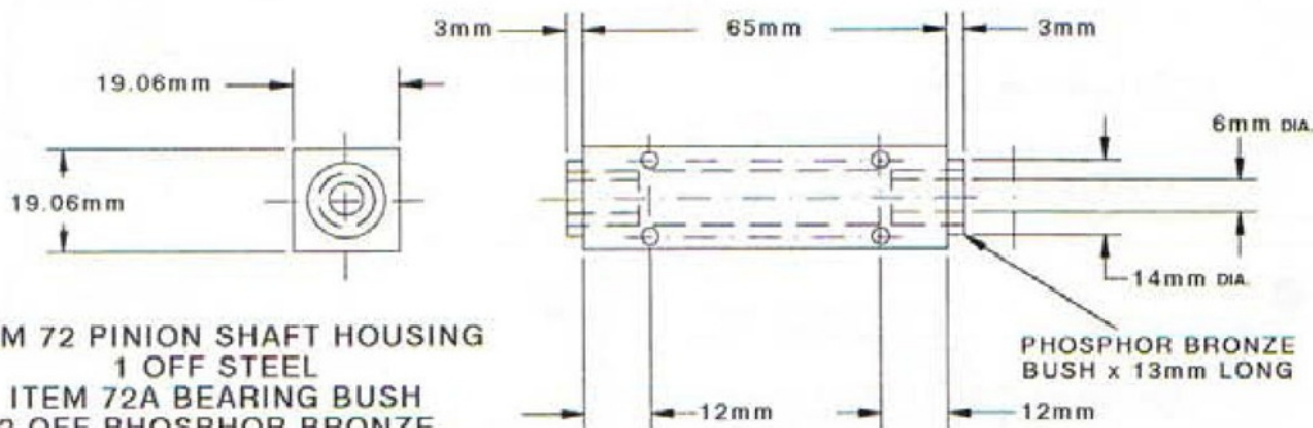
ITEM 68 TURRET HEAD
ROTATING PLATE
1 OFF STEEL



ITEMS 69 & 70 TURRET Y AXIS SLIDE, SILVER STEEL
1 OFF PLAIN (69)
1 OFF WITH RACK AS SHOWN (70)

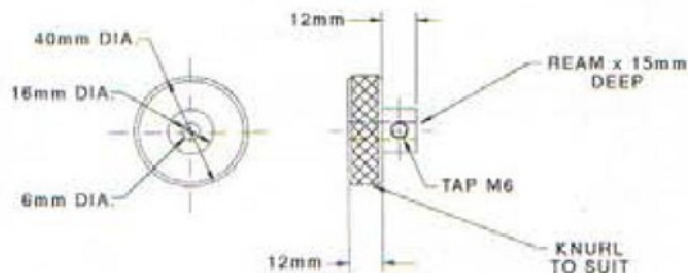
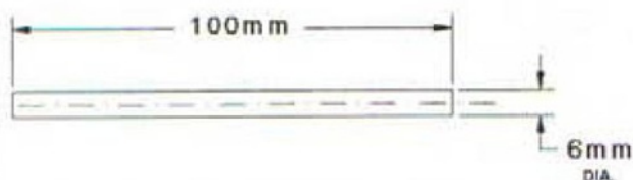


ITEM 71 PINION GEAR
1 OFF STEEL



ITEM 72 PINION SHAFT HOUSING
1 OFF STEEL
ITEM 72A BEARING BUSH
2 OFF PHOSPHOR BRONZE

ITEM 73 PINION SHAFT
1 OFF SILVER STEEL



ITEM 74 HANDWHEEL
1 OFF ALUMINIUM

Motor control

The control system for the motor is contained in a small box mounted on the side of the gantry and consists of an ON/OFF DPST switch, a fuse and a DPCO switch used for reversing the motor. Nothing more complicated is necessary, but do put a small fuse in the plug and make certain that the earthing system is in full working order.

Turret Y axis slide and turret rotation

The components which attach the turret head to the Z axis slide mechanism are shown as Items 67 and 68. The former houses the two smaller slide bars (Items 69 and 70), while the latter is actually part of the turret, but as they need to be mating components, they are both dealt with here.

Photo. 16 shows the slide bar holes being bored and it will also be noted that the holes for the clamp bolts have already been drilled and tapped. The reason for

this and why the unit is mounted on the rotary table becomes apparent when **Photo. 17** is studied, because the circumferential slots in Item 68 can also be machined at this set up.

Photo. 18 shows the pair nearing completion prior to mounting on the slide bars. It is not essential to cut away all the material at the rear of Item 67, but I do feel that it improves the appearance.

Turning now to the small slide bars, Item 69 is a plain silver steel component, but Item 70 incorporates a rack which allows a controlled movement along the 'manual' Y axis. The rack and the mating gear (Item 71) can be of any suitable type for which you have cutters or alternatively could be bought from either Davall or HP Gears.

Photo. 19 shows the gear cutter with the Centring Device previously described in Issue 47, guaranteeing that the cutter is on the centre line of the gear blank, while **Photo. 20** shows the cutting of the gear, with the cutter mounted in the mill spindle on a vertical shaft.

To cut the rack, a flat is machined on the stock material (**Photo. 21**) before the

teeth are cut. I was able to mount the right angled drive (see Issue 51) in place of the milling chuck without disturbing the workpiece (**Photo. 22**). Tooth depth and tooth spacing were controlled by the use of a dial gauge, in the latter case, resetting the gauge each time. As the gear is only to be rotated by hand, the accuracy of the teeth on both components is not too critical.

To complete this assembly requires only the small parts shown as Items 72, 73 and 74, the finished unit being clamped to the rear of the turret support bar (Item 52) in order to adjust the meshing of the rack and pinion teeth. The mounting holes can then be spotted through prior to drilling tapping size and tapping 6 BA.

The next article will cover the turret head, the electrical circuits and the control system. If any builder should have any problems or queries, I would be happy to help, but by telephone only, as typing a reply to a letter is a one fingered job, so is very slow. My telephone number is 01233 712158.



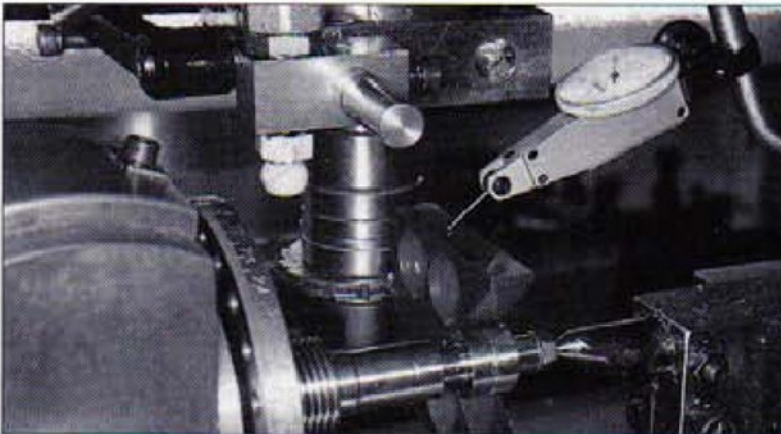
16. Boring the holes which accommodate the turret slide bars



17. The slots which allow the turret to be tilted were machined on a rotary table

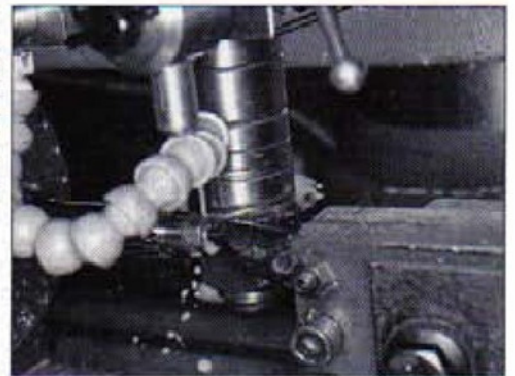


18. Removal of some of the excess material improves the appearance of the turret mounting components

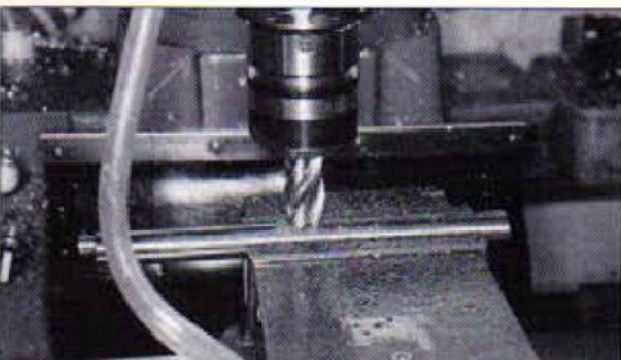


19. Setting the gear cutter to centre height

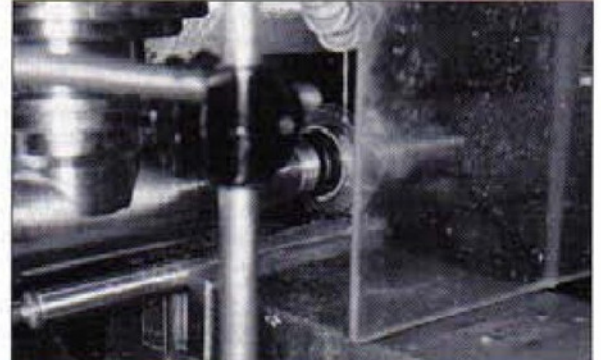
20. A continuous coolant flow was applied while cutting the gear teeth



22. Cutting the rack teeth with the aid of the right angled drive



21. A flat was machined on the slide bar prior to cutting the rack



FIXING MISTAKES

(or Correction, Rescue, Repair, Resuscitation, Rehabilitation, Restoration or Recovery)

Descriptions of the manufacture of some complex project often read as though all went perfectly from start to finish. We all know that this is often not the case, with things not working out as well as we had hoped. Philip Amos faces up to these realities and suggests that there are ways of recovering from the problems which occur from time to time

Background

Most home workshop people aspire to greater accuracy of manufacture and enhancement of their skills with increasing experience of their hobby. Some of these skills are improvements in measurement capability - in particular getting the 'feel' of calipers, micrometers, telescopic and hole gauges, feeler gauges and the like. Too often, such improved capability brings with it some despair that what previously seemed satisfactory workmanship in fact, wasn't. There has been some inaccuracy in the making of a part, or its fit with another. Sometimes a similar problem arises as a result of wear. Perhaps something purchased has not been made quite as accurately as it should have been.

Correction

Any of these events is a cause of disappointment, especially if a lot of time and effort has been put into the job so far; and the question arises "What can be done to rescue it?"

Introduction

What kind of problems are we faced with here?

1. Blocks.

Faces not at correct angles to each other. Dimensions under or over size.

2. Cylindrical

The work may be tapered, waisted or bowed, eccentric or out of round

3. Holes

Too big or too small. Out of position. Not at right angles to the surface. Have broken off drill points in them.

4. Threads

Damaged or stripped. Drunken (i.e. not

at right angles to the surface). Wrong pitch. Wrong thread angle. Too loose or too tight.

Approaches

The works manager at our factory had a background as a toolmaker in a government small arms factory, and consequently was very much inclined towards making things accurately and right first time. In addition to enunciating the carpenter's motto "Measure twice before you cut once", he suggested that "Most workshops are not equipped with a 'Putting-On-Tool'. However this latter statement is not strictly true, as in industry it is common to build up parts by metal spraying, arc welding, brazing etc. and then machining them back to the required dimensions. This is much used in the hydraulics industry, where worn parts are hard chrome plated and then ground to size. So, in some circumstances, the home workshop practitioner can recover his impaired part by building up with weld metal or brazing, and then remachining (See Drawing 1). MIG welding is probably more satisfactory than stick welding, as the latter tends to leave slag inclusions in the job. Nevertheless with (say) farm machinery parts, it can be a useful repair technique.

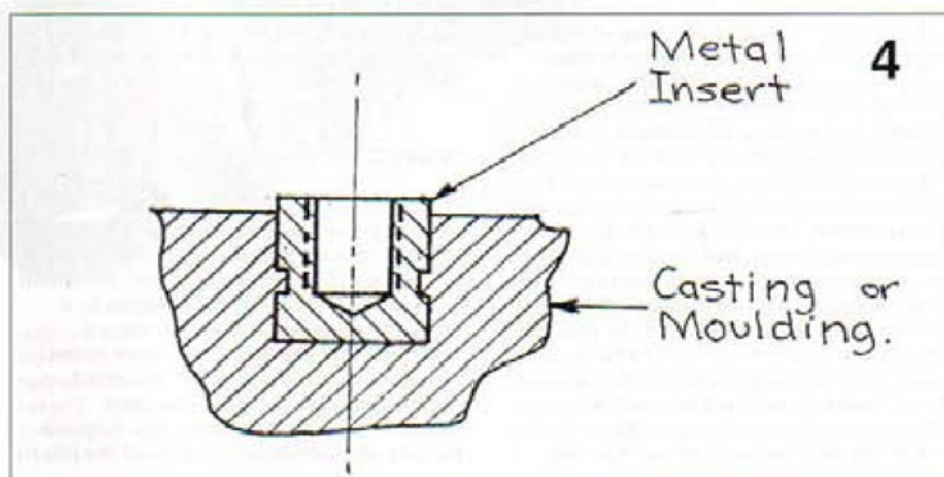
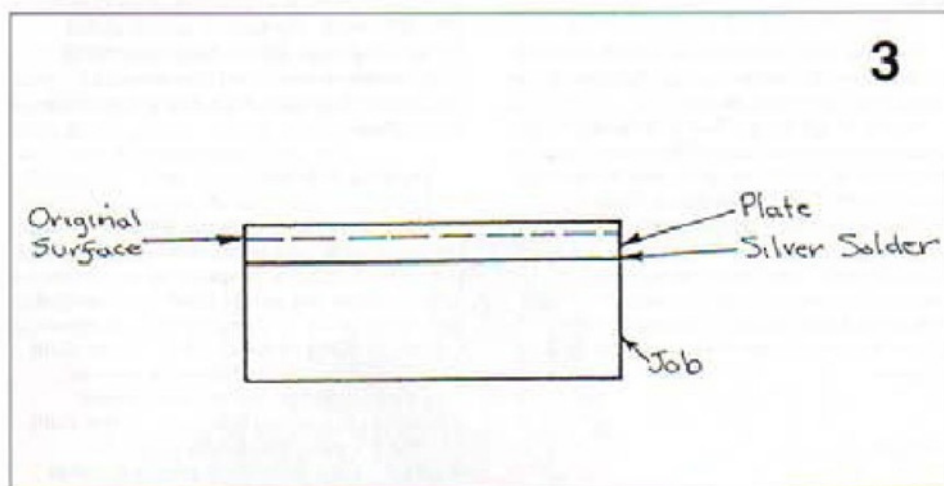
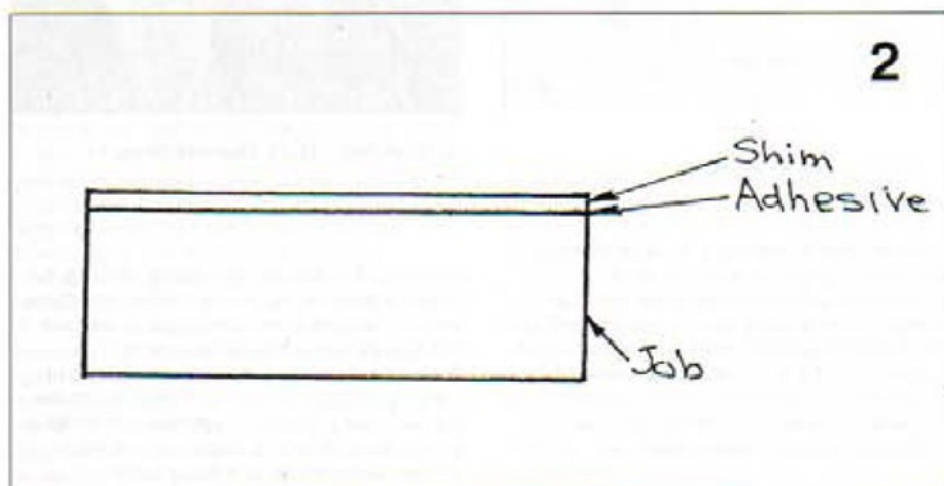
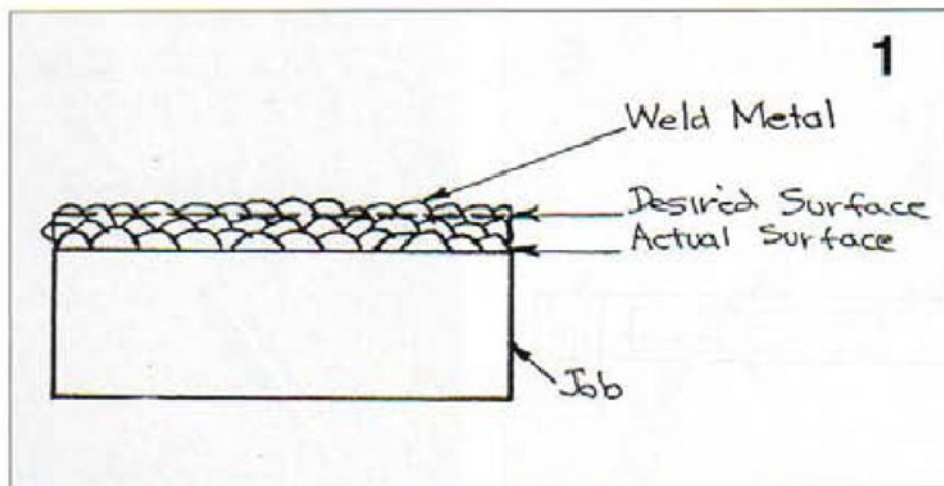
Blocks

For more delicate equipment and smaller corrections, the use of shim brass attached to the surface with an adhesive such as anaerobic (Loctite), epoxy (Araldite) or cyanoacrylate (Superglue) may be a possibility (see Reference 1). The surfaces must be quite clean and the parts rapidly clamped tight together, so that when the adhesive sets it is of negligible thickness. When it has set, the edges of the shim should be trimmed/chamfered with a very smooth file, directed so as to bear downwards on the shim, and not lead

to a peeling action. The whole surface can then be made uniform by rubbing on emery paper on a flat plate (e.g. plate glass) backing (see Drawing 2). Obviously this technique is of no use if the part is to be heated in use or in further processing, as the adhesive will be destroyed. Likewise, if the part is to be drilled, it is better to start through the shim surface so as to avoid pushing it away from the base metal. If the dimension change is more than 'shim' thickness, it is probably better to machine the part down to allow the attachment, by silver solder or brazing, of some 'plate', say 1 to 3mm thick, and then remachining to size. Alternatively, the 'plate' can be attached with adhesive. The silver soldering or brazing approach makes a more robust workpiece for subsequent machining, with little likelihood of peeling off the extra piece (see Drawing 3).

Cylindrical

If the cylindrical part is oversize to start with, it is possible to correct roundness, eccentricity, taper and diameter by the use of a toolpost grinder in a lathe (see Reference 2). If the part is significantly oversize - say more than 0.025mm, a keenly sharpened lathe tool may be used, but it may yield an uneven result and the grinding process is more reliable. Other approaches to the problem are the use of a fine file (smooth or dead smooth grades) or oil and emery cloth. The former is useful to remove burrs or chuck jaw marks, and the latter to polish the surface and to remove local irregularities so that a ring can fit precisely on a shaft (e.g. a ball bearing on a spindle). Now, what happens if the cylindrical part is undersize? Failing access to metal spraying equipment, the only practical approach seems to be to turn the part down by about 3 to 5mm on diameter and to fit a suitably bored sleeve on the part using Loctite, silver solder or brazing, and then to remachine the outer surface.



Holes

Just as sleeves can be fitted on undersize shafts, so too can sleeves be used in holes made deliberately oversize. The sleeve can then be bored to the correct dimension. However, if it is desired to drill the new hole, it is better fill the oversize hole with a solid plug using as before Loctite, silver solder or brazing. If the plug is made slightly thicker than the workpiece, its ends can be machined or filed flush, the new hole drilled and if necessary bored and/or reamed to achieve the desired result. The solid plug approach also works for holes not at right angles to the surface and for those not in the correct location.

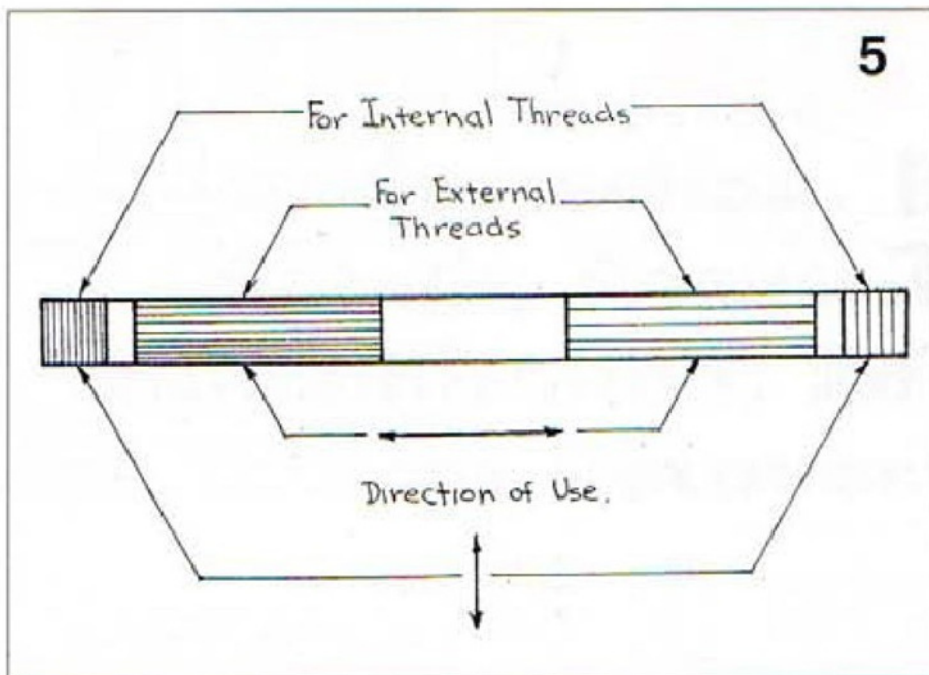
Threads

Stripped threads often occur in soft materials like aluminium or zinc castings or in plastics. For these situations it is probably best at the outset to design for the use of thread inserts e.g. blind threaded holes in steel blocks for light metal castings or brass ones for plastics - see Drawing 4. Where such provision



1. Thread repair file

has not been made and the thread has stripped, then thread inserts such as 'Helicoil' or 'Recoil' or similar can be used. These are available in a wide range of thread standards and sizes. The damaged thread is drilled out, the hole re-tapped with a special thread insert tap, and the helical stainless steel insert wound into the hole with a special tool. The normal bolt, as previously used, can now re-engage the new threaded hole in the previously damaged part. Where damage to a thread is minor, it may be corrected by running a tap or die (as appropriate) down the thread to remove burrs etc. Special hexagon die nuts are sometimes used for this purpose, but normal dies seem to work quite satisfactorily. However, sometimes it is difficult to gain access to the part, whether male or female, and for these situations special files are available (see Photo. 1). These usually have eight different tpi



threads on each and are meant for clearing burrs from threads. Some have teeth cut in each tpi size to deal with both internal and external threads (see Drawing 5). Mine are of French origin (branded Minimax, from Filon, Paris). They come in Metric, BS and US styles. There may also be a special one for pipe threads, but I don't have one of those. I have found these devices useful when nothing else seemed to work. Their rate of working is very slow, and considerable care and concentration is needed to ensure that the correct tpi side (or end) is being applied.

For a drunken thread it is necessary to plug the hole and start again. Likewise for wrong pitch or thread angle. The hole plugging routine is similar to that described for holes, but using a threaded plug, or a plain one in a hole drilled oversize. For threads that are too loose, the only solution seems to be to make another component - either a slightly larger screw or else plugging, redrilling and tapping the hole. Which way to go will have to be assessed in regard to the relative degree of difficulty in a particular case.

Avoidance

Some of the common problems arising in the home workshop can be avoided by particular courses of action - for example:

Blocks

Dimensions of blocks can be more readily controlled when machined on the lathe in a 4 jaw chuck or on a faceplate than when being milled on a drill/mill. A conventional mill - vertical or horizontal is on a par with a lathe for this process. If the job has to be done on a drill/mill then it is best to try for critical dimensions in the X-Y directions rather than in the Z direction, as the backlash in the quill downfeed is difficult to compensate for, whereas the X and Y feed backlash can be overcome by feeding in the one direction.

Cylindrical

Great care in getting the lathe turning parallel is repaid by avoidance of unwanted taper. Bowing or waisting of slender components can be minimised by careful setting of the travelling steady. For concentricity, it is necessary to correctly locate the centres at the outset and to turn between centres - Reference 3 has some useful guidance on this matter.

Holes

The use of a pillar drill or a drill/mill will usually result in holes at right angles to the job surface, to close limits.

Positioning of the hole is facilitated by the use of a centre drill (Slocombe) and the use of a pilot hole drill with increasing sizes of drill, until the desired finished size of hole is reached. Boring with a single point tool, after initial drilling to a smaller diameter than desired finished size, enhances concentricity. Finishing the hole to size and appropriate surface finish can be done either by boring or by use of a reamer.

Threads

Internal Threads.

Getting a tap started precisely at right angles to the job surface can be achieved using a drill press, or in the lathe from the tailstock chuck. Usually such chucks will not turn the tap very far before it slips in the chuck jaws. Furthermore, the job may slip in the lathe chuck jaws, so once the tap is firmly started in the hole, the job can be transferred to a bench vice and a tap wrench used to produce the rest of the thread. Power threading using a tap is likely to lead to tap breakage, although if a tapping head is used between the drill press chuck and the tap, this permits easier control. In this connection, a ground thread tap may also be less likely to break. The internal construction of a tapping head comprises planetary gears and two dog



2. Wobbler - G. H. Thomas design

clutches. It is biased by spring loading, so that it turns the tap in the cutting direction when pressure is exerted downwards on the tap, but reverses when upward pressure is exerted. It is worth setting up when a number of similar holes are to be tapped, but is hardly worth the effort for a single hole. There is usually a limited range, such $\frac{1}{16}$ in. to $\frac{1}{8}$ in. taps for a particular tapping head. However, for accuracy, threads should be lathe cut, which is relatively easy down to about 10mm diameter. Below this the cutting tools become too small and weak, so ground thread taps probably prove more successful.

External Threads

Making external threads accurately can be done on the lathe for virtually all diameters, and the thread shape can be improved by the use of a thread chaser if available, or by running a die over the thread by hand to finish off. If the threads are going to be die cut from the outset, special care is needed to start the die squarely on the job. If the end of the shaft can have a shoulder turned on it, of diameter just less than the thread minor diameter, this will help. The tailstock can be used to ensure that the die is square to the job by the use of a flat faced tapered plug of appropriate diameter to position the die as it is started.

Broken Drills

From time to time, one has the misfortune to have a drill break off in the work, with nothing sticking out to grab hold of to allow removal e.g. the small end of a centre drill. If you have access to a spark disintegrator this will probably overcome the problem - but most home workshops would not be so equipped. Before throwing the job away, two possibilities may be considered. Firstly it may be possible to cut a slice off the job to

get rid of the offending piece of drill altogether. Secondly it may be worthwhile carefully drilling a coaxial hole from the opposite end of the job, right up to the end of the drill piece and then punching it out.

Aids to Accurate Work

There are a number of simple devices which can be used to facilitate accurate working to start with, and in particular:

Wobbler

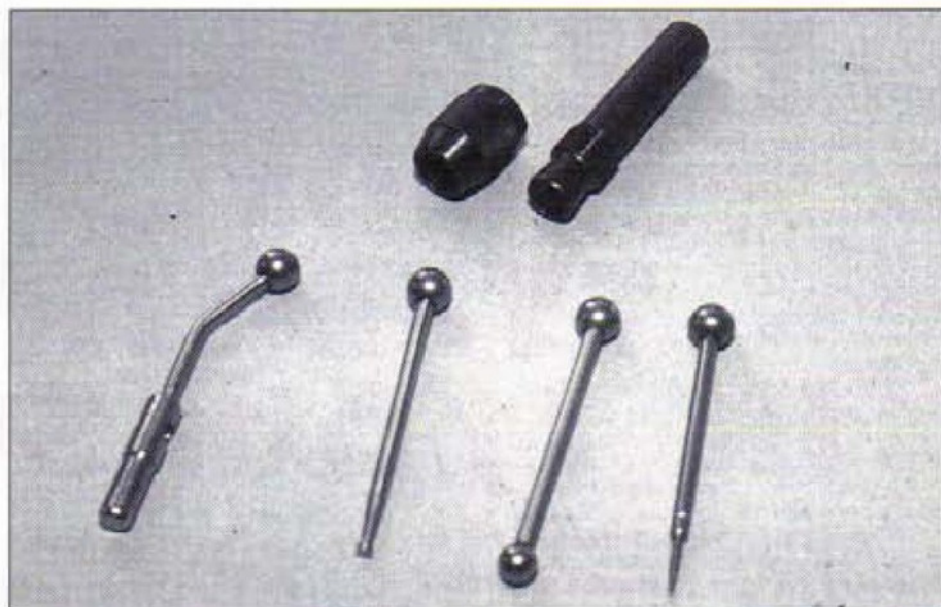
Wiggler

Edge Finder

Toolmakers Buttons

1. The Wobbler is a short parallel cylinder having a 60 deg. point on one end and a spring loaded plunger in the other. The plunger has a normal 60 deg. centre in its outboard end and slides without shake in the main body. In use it is set between a centre pop on the workpiece and the lathe tailstock centre, so that a dial indicator bearing on its periphery near the jaws of a 4 jaw chuck will display whether the workpiece is accurately centred or not. It can also be used to centralise small holes in relation to the machine axes. The accuracy achievable seems to be about 0.01mm - or less the limit of the dial indicator calibration - but even leaning on the lathe will change this of course. Full details of its construction and use are given in Reference 4 (see Photo. 2). It does not seem to be commercially available.

2. The Wiggler comprises a short rod with a ball end held in a device rather like a pin chuck. Several different outboard ends are available - a ball, a disc and a needle point (see Photo. 3). The pin chuck part is held in the lathe or drill chuck, and the motor switched on. When a piece of wood is held against the outboard end, that end accurately adopts an axial position. If the ball or disc is covered with bearing blue and the wiggler brought in



3. Wiggler set

is available commercially from several sources. Mine came from General Hardware, New York, USA and includes one other piece - a bent arm for mounting a dial indicator for centralising large holes or toolmakers buttons in relation to the machine axes. Accuracy for edge finding is about 0.013mm and for centre finding about 0.03 to 0.05mm.

3. Although the Wiggler can be used for edge finding, there is another device specifically for this task. It comprises a ground cylinder of accurately known diameter (usually 0.500in.) with a short bottom piece which can be displaced slightly sideways and held by an internal spring in axial contact with the remainder (see Photo. 4). This device is held in the drill chuck, with the lower piece in a slightly displaced position; it is rotated at high speed and advanced towards the edge in question. The bottom



4. Edge finder

piece gradually becomes coaxial with the top and then suddenly jumps sideways about 1mm. The action is repeatable and it is claimed for commercial devices that the accuracy is about 0.005mm. My own device is again from General Hardware, and my experience of repeatability on my drill/mill is more like 0.05mm probably because of the (lack of) quality in the table feed screws.

4. Toolmakers Buttons are hollow cylinders of accurately known outside diameters and of a convenient length (see Photo. 5). They allow accurate positioning of holes relative to edges or to each other. Firstly, the hole centres are marked out and drilled and tapped to the size of the button securing screws. These screws are used with thick washers to hold the buttons in place. The button is tapped sideways into position and checked with gauge blocks from a job edge, or with a micrometer or vernier caliper across two buttons. When correct, the securing screws are tightened and the job set up in the lathe 4 jaw chuck, so as to have the

button cylinder running coaxial with the lathe spindle. The button is removed and the hole is drilled, bored and reamed to size in its correct location. These devices can be made in the home workshop as described in Reference 7, where also is given a full explanation of their use. They are available commercially - mine came from Starrett, Athol, Mass USA.

Conclusion

In this article there are some ideas presented on how to deal with incorrect parts, and also some devices and techniques which can be used towards making the parts right to start with.

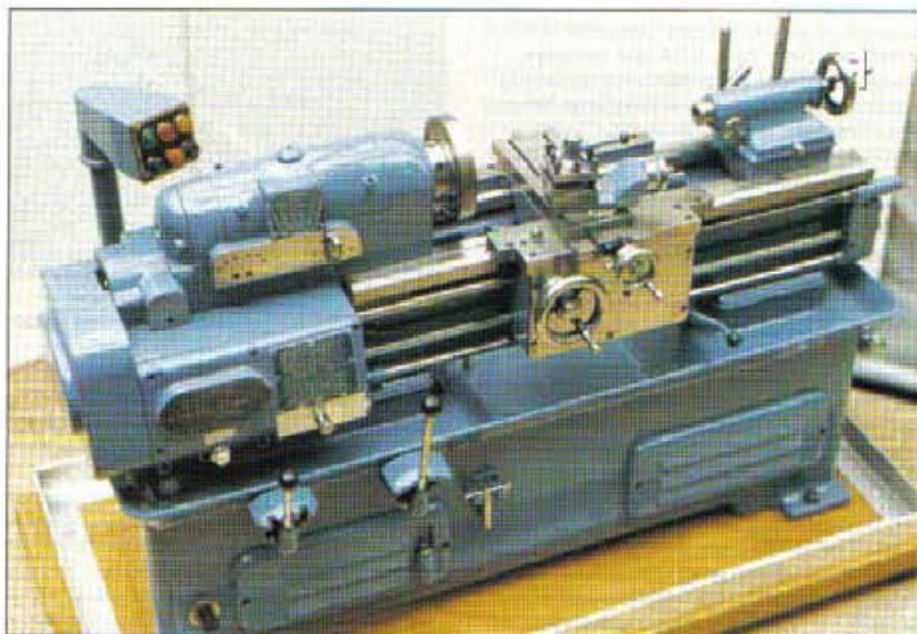
References

1. Adhesives & Sealants - D. Lammas. WPS 21.
2. Cylindrical Grinding in the Lathe - Philip Amos MEW 40.
3. Spindles - H. Sandhu WPS 27.
4. Model Engineers Workshop Manual - G. Thomas
5. Using Edge Finders MEW 7.
6. Making an Edge Finder MEW 8.
7. The Amateurs Workshop - I. Bradley.



THE HOLBROOK MODEL "C" TYPE LATHE IN 1/6th SCALE.

In Issue 45 Dennis Major reported on progress being made by his friend A. R. (Bob) Mellows of Romford, who is constructing a detailed model of this substantial machine tool. We are now brought up to date by Bob himself.



So many times I have been asked "Why did you want to make this model?" and "Where did you get the patterns from?". The idea of making the model arose from seeing the various types of table lighters that were popular some years ago, mounted on models of such things as boats, planes and guns. The thought of using the Holbrook 'C' lathe as the one to copy appealed to me, as I could use the high-low spindle speed clutch lever to operate the lighter. After having made the bed, then the tailstock and headstock, along with the turret with the swivel slide and the feed change box, all shaped from solid Dural pieces, some bright spark remarked "Oh! I thought you were making a working model". That stopped me in my tracks, as a challenge had been made that I could not resist. Realising that I was wasting my time with the lighter, all was boxed and put into storage.

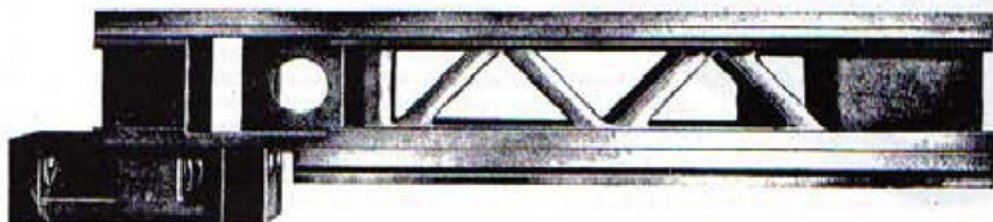
Using the Holbrook catalogue for the early design of the 12 and 15c lathes and also the later version for the 10, 13 and 16c lathes, I began to scale the pictures. The first problem was to decide on the scale, knowing that if I was going to grind the slideways of the bed, I would be limited to 15in. for the bed length, as the only

available surface grinder table travel was about 18in. This would mean a scale of about 1/6th of the No. 13 machine. Instead of trying to copy one particular machine, I intend to make a model which will represent the various changes that were made over the years, as shown by the pictures in the catalogues, without getting too involved with exacting and minor details. As long as it looks like the picture of the later version, I am sure it will be easier to make the model with one cabinet than with two stands. I'm wondering if I do get the model to work whether or not I could do some turning or even facing, but maybe my thoughts are running away with me. I just hope that I do not have to do the same as I did with the table lighter.

The bed

Fortunately, and how lucky can one get? I was able to get a piece of cast iron, 15in. x 3in. square, just what I needed for the bed. There was not enough to make the integral gear box (**Figure 1**), so that would have to be made separately and fitted later on.

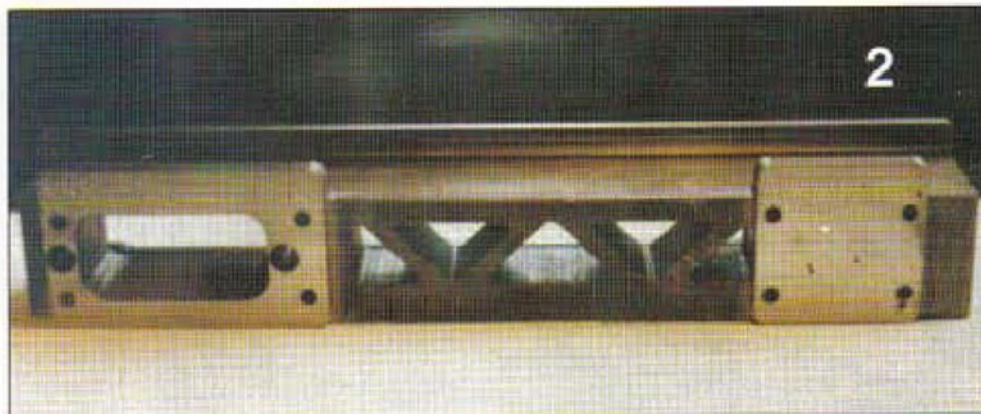
After rough machining all over, it was put out to weather for a few months, to make sure that I had a piece of cast iron that was not going to cause me any trouble after having finished machining and



BED is made from close-grained cast iron to our own analysis and is Precision Ground.
Diagonal ribbing ensures rigidity and the view shows

the ample proportions of the casting. The Quick Change Gearbox is cast integral with the Bed.

Fig. 1



ground the slideways and formed the diagonal ribbing. This would give me time to plan and prepare other bits and pieces, as I now realised that, apart from the standard screws and electrical parts, I would have to make everything from solid, knowing that patterns would not be available. Making use of a shaper, the bed was easily formed, leaving only sufficient for surface grinding. Before grinding I had to slot out the diagonal ribbing and fettle the top edges to shape (Photo. 2). The slot was made with a modified 16mm slot drill, then a tee slot cutter (Photo. 3) used to create the 3mm Tee slot at the back of the bed to locate the taper turning attachment.

The next job was to surface grind the base of the bed, then the slideways and the back of the bed. The grinding wheel was shaped to 45 deg. on either side, to suit the vees, then narrowed to suit the in-between flats. So far so good, now for the cabinet.



Cabinet stand

The cabinet is fabricated from black mild steel. It consists of one piece which forms the side walls, leaving a gap at the rear for the motor casing, four strips which are the side walls of the pan, two pieces for the bed seats, four pieces as the sloping walls of the lower pan and another piece for the bottom, not forgetting the four blocks for the feet.

To seam weld these pieces seemed to be risking distortion and making a complete mess, so I decided to clamp each piece separately and tack weld, then fill in by brazing. Having got so far, I was able to fettle all to shape, and now all that was needed was a little body filler and some paint.

Line boring headstock and tailstock

I next needed a cast iron block for the headstock, a piece for the tailstock and another for the base, as I intended to have the tailstock fully operational, with alignment adjustment and the ability to eject a taper centre. The bases of each needed to be milled to suit the slideways and the tailstock body fitted to its base with squared headed screws.

At this stage I decided to line bore the head and tailstock before making to shape, just in case things

went wrong. I set the bed across the table of a horizontal mill, in line with the spindle, and was able to drill and ream to suit the headstock bearings and tailstock bore. The two clamps for the tailstock are operated separately by the two levers and eccentric shafts; the quill is clamped by means of a split radius cotter and has a short series No. 0 Morse taper bore which will accept a centre which is ejectable in the normal way. The handwheels for the tailstock and the apron were made from bright mild steel and, before being parted off, they were held in a 3 Jaw chuck on a turntable set on a turret mill, and a 3mm slot drill used to form the spokes (Photo. 4) which were then fettled ready for painting. To make the handles for the wheels I made a form tool to create the shape, also making a smaller one for the swivel slide while I was in the mood.

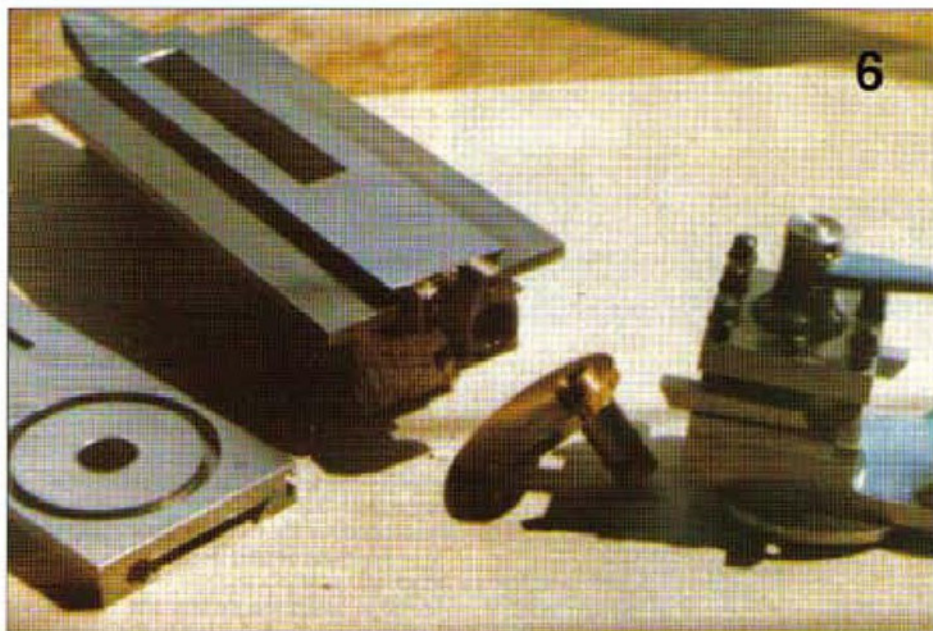
To operate the tailstock quill, I needed a 4mm left hand tap and die. The idea of having to buy these just for one screw and hole directed my thoughts to the need for left hand taps and dies for the cross slide and swivel slide, again each for only one screw and nut. Thus another challenge had arisen, so while I had a lathe set to make the screw blank, I did some screwcutting, using the same setting to make a 4mm left hand tap from silver steel, single fluted of course, which did the job perfectly. I thought that while I was in the mood, I might as well make the 3mm and the 2.5mm taps. Of course, I could have used 4, 6 and 8 BA, but as the available lathe was a metric model, this was the easy way out.

The tailstock body needed to be shaped roughly on a vertical mill, then the contours filed and dressed until it was ready for painting.

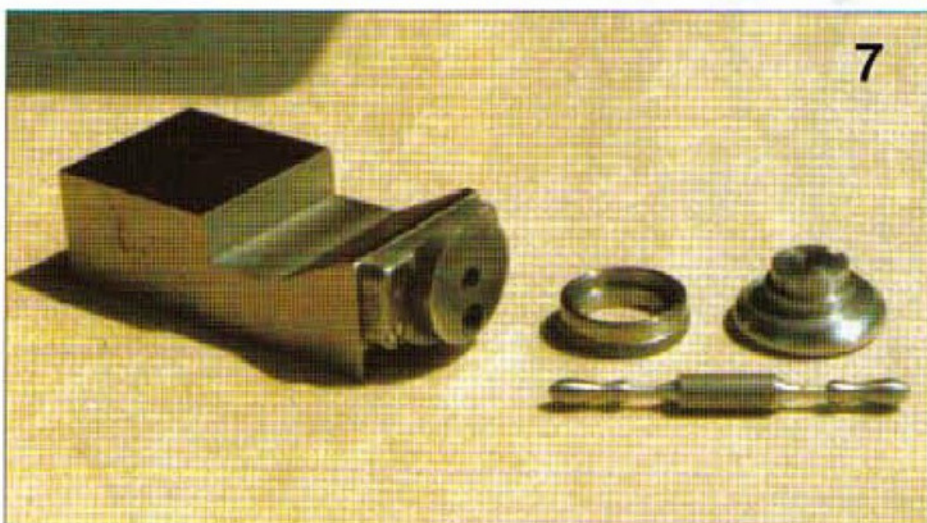
Saddle

To make the saddle I located a piece of close grain cast iron which looks like Meehanite, firstly rough machining to shape then milling the underside to suit the bedways. Bright mild steel was used for the rear keep strip and phosphor bronze for the front keep blocks (Photo. 5). Now to machine the top of the saddle slides on the turret mill while fitted to the bed, so as to keep them level and true to the bed. The internal and cross slides are made from a discarded brake disc (Photo. 6), the internal slide being secured at the rear of the saddle by means of a conical bolt when not in use. A standard dovetail





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cutter was used for the veeways of the slides, not forgetting the two taper gib strips required for the slides which were also made from the brake disc. These are very useful, being of a very fine texture cast iron, just what I needed to be able to machine without fear of breaking while it was being worked on. I had to file the taper to suit the slides, both being 90mm long, tapered from 2.0mm to 1.4mm and adjustable. As the tee slots for the rear twin tool post and side limit stops are scaled for 2mm bolts, another cutter had to be made.

To be able to machine the annular tee slot in the top slide to accommodate the swivel slide, I had to make a fixture to be able to swing the slide in the lathe and to use three tools to create the form. Next to the cross slide screw bearing housing and quick withdraw facility. The housing is of bright mild steel and the withdraw lever of phosphor bronze, the movement of withdraw being provided by a helical groove in the sleeve. The housing was split at the outer end and a square headed screw used to clamp the sleeve secure when not in use. The handwheel for the cross slide has an adjustable dial with 125 graduations and is equipped with a clamp pad with a knurled nut to secure. The top swivel slide has the same facility.

Having got so far, I began to think of

how to make the parts for the top swivel slide and the four way toolpost turret. The handwheel, being above the screw is geared 1:1 (Photo. 7), this being the reason for the LH screw, as the nut is fitted to the swivel base. The latter had to be made from a piece of Meehanite grade cast iron in order to be able to graduate the 360 divisions around the base before milling the vee slide ways, again using the 45 deg. dovetail cutter. Another piece of the brake disc supplied the gib.

The turret is 20mm square and was relatively

easy to make, but I had to make the six square headed 3mm tool post screws using non-shrinking oil hardening (NSOH) steel, heat treating them and leaving them black to look like the real thing, as these screws are not available from standard stock. I can now hold four pieces of $\frac{1}{8}$ in. square tool steel and at a later date I shall be able to fit the twin tool post at the rear of the slide, with the same size tools and screws as used in the turret. Of course a tee spanner will have to be made for the screws.

Spindle

Next to the headstock assembly. The spindle bearings on the full size machines have two taper roller bearings at the front and a parallel roller bearing at the rear. Because of the scale size I did not bother to even to try to purchase the same type, using two sealed cage races instead. I am sure that they will suffice as I do not intend to run the model for any more than a few moments in any of the speeds in the direct range.

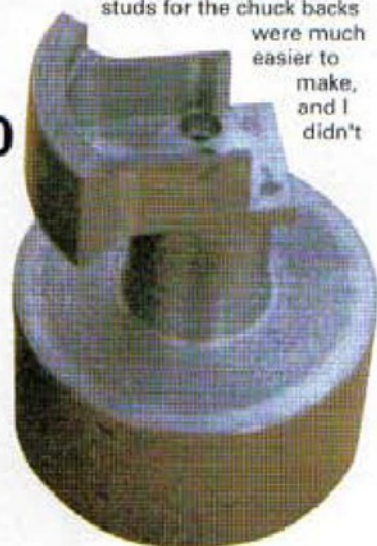
Using a piece of EN 16T for the spindle seemed to be best, rather than using BMS considering that the nose of the spindle will have to withstand chuck and drive plate changing, as well as having a hole through the full length. The races, pulley and take off gear for the feed drive are locked in position by twin ring nuts, so two 'C' type spanners had to be made. The pulley on the original machines were for a flat type 'Gripolastic' belt, later changed for the link type vee belt. This is another part I did not bother to try to purchase, settling for three endless belts of the type used in video recorders. They should give a smooth enough drive. Photos. 8 and 9 show the spindle parts with a flat endless belt which I soon changed for the video belts.

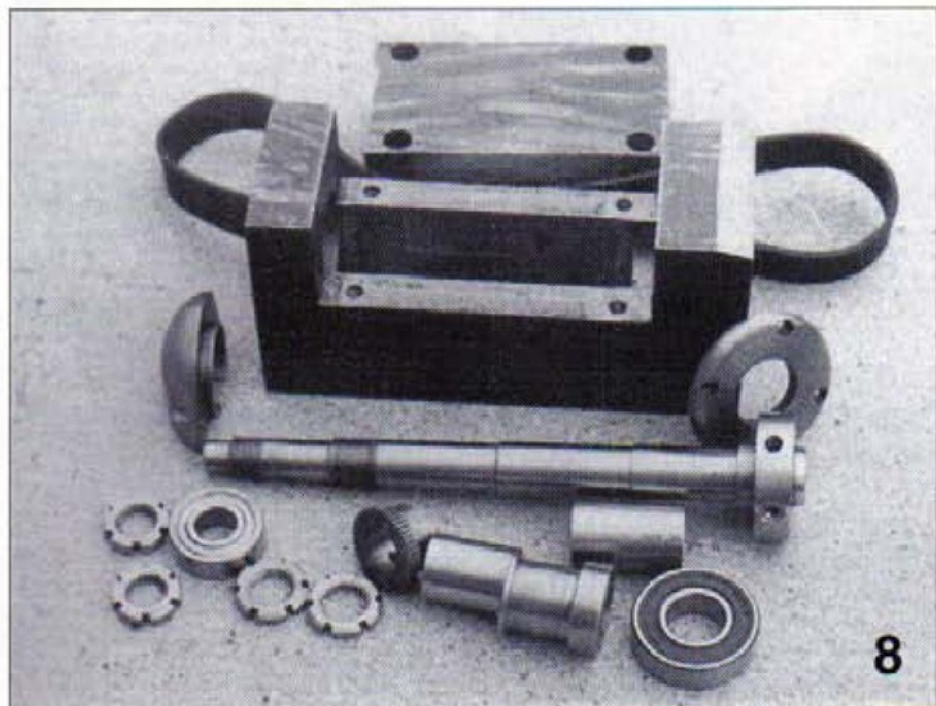
Methods of securing chucks to the spindle nose varied over the years, some of them being for special purpose machines. Stud and nut fixing was employed on the 12 and 15c lathes, and it was not until later that the 10, 13 and 16c lathes were made with the cam lock, with either three or six each. I'll settle for just three. For the cams I again used NSOH steel so that they could be heat treated, using a piece of $\frac{1}{8}$ in. square tool steel to

broach the square hole. The studs for the chuck backs were much easier to make, and I didn't

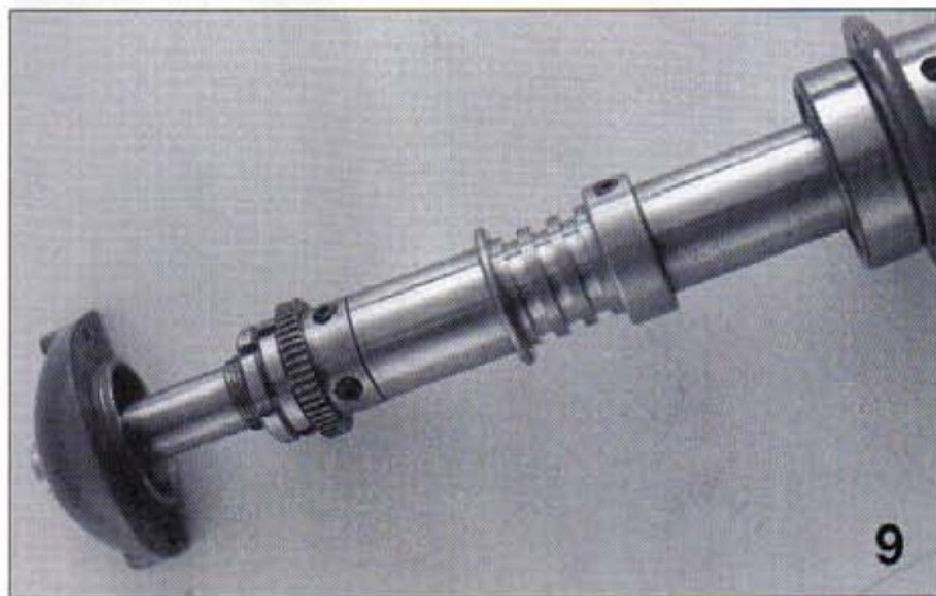


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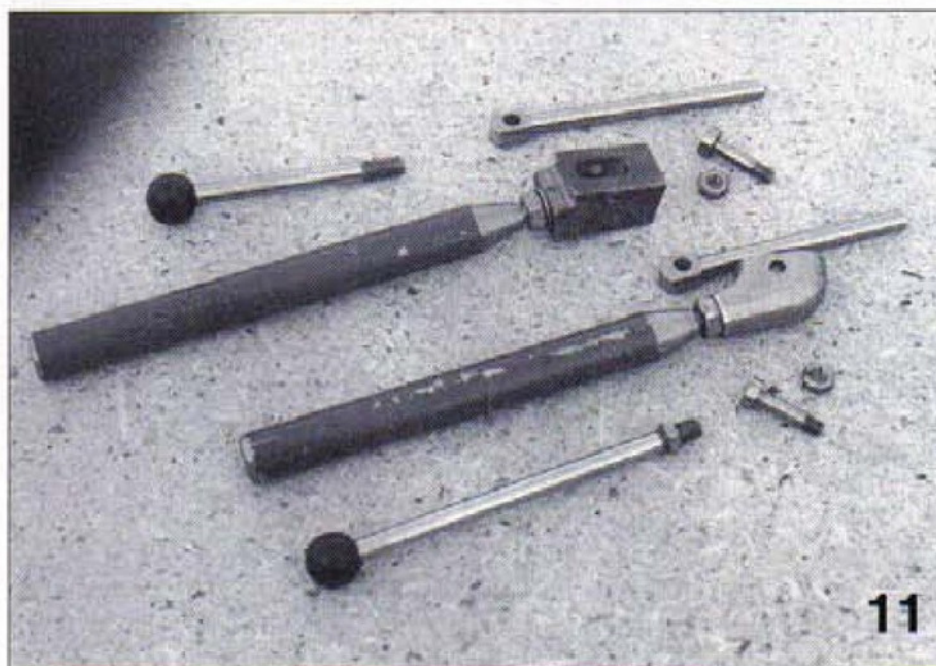




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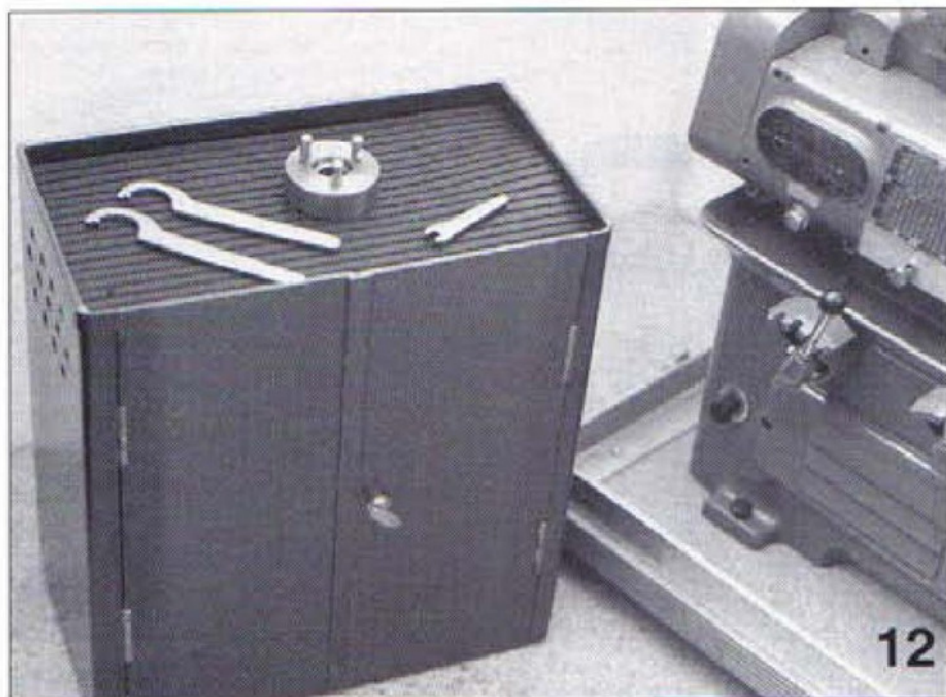
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forget the short series 'O' Morse taper bore for the centre. By now my arrangement of the spindle is far from the Holbrook design, but was easier to make for the purpose of the model. Before being able to assemble the spindle, the top centre section of the headstock had to be milled away and a cover made to suit. The front bearing cover has been made as a simple ball race retainer, similar to the early version, thus avoiding the detail work required for the later version. The other detail I am not getting involved with is that of the drip feed lubricators as on the early type, so I shall put a vent cap on the cover as an easy way around the problem.

To finish the headstock at this stage did not seem to be an advantage, as I wanted to make the switch pillar, with the head fabricated from a piece of copper tube and sheet brass, fitted with mini button switches and lights, all to scale. I had to get on with the speed control levers and switches, as I wanted to see the spindle running to get some pleasure from the progress I had made so far, so my next move was to make the spindle drive operating levers and segmented location blocks. These were made from fine grain cast iron bar, two pieces being needed to save setting machines twice for the same work. One has three notches for the three speed control and the other positions for the high and low speed clutch with a neutral position. These items were drilled and counter-bored for the securing screws, then parted off after being fettled to shape, (Photos 10 and 11). The high-low clutch on the full size machine is the multi-disc type and I'll not be wanting to get involved with that sort of problem at 1/8th scale, so I'll have to consider using cone clutches of some sort to meet the need. Both these levers will operate micro switches linked to relays. Wanting to see some action when the clutch and speed levers are operated, just for the fun of it without using a gearbox, I used four resistors to get six speeds with a 12v motor rigged on the base board. It works, except for the loss of power on the lower speed range. When this was demonstrated at the local model club, there were many suggestions as to how to overcome the problem, one of my colleagues proposing the use of an additional circuit to prevent this loss of power when using second and third speeds. This is the sort of help I really appreciate as my knowledge of electronics is limited, in the same way that some electronics bods are with machine tool work. The additional circuit works perfectly and I'm as pleased as Punch. Now I can continue without that to worry about (good old George). Now we need something to house it all.

Accommodating the electrics

Attempting to house all the electrics with the motor and gearbox inside the cabinet, along with the relay switches and coolant pump and tank would be cramping space, so I have the relays and transformer, along with any other components of the circuit, built as a separated power pack for mains supply or alternatively, the use of a 12v car battery. The cabinet must stand beside and enhance the model, as it would be seen in

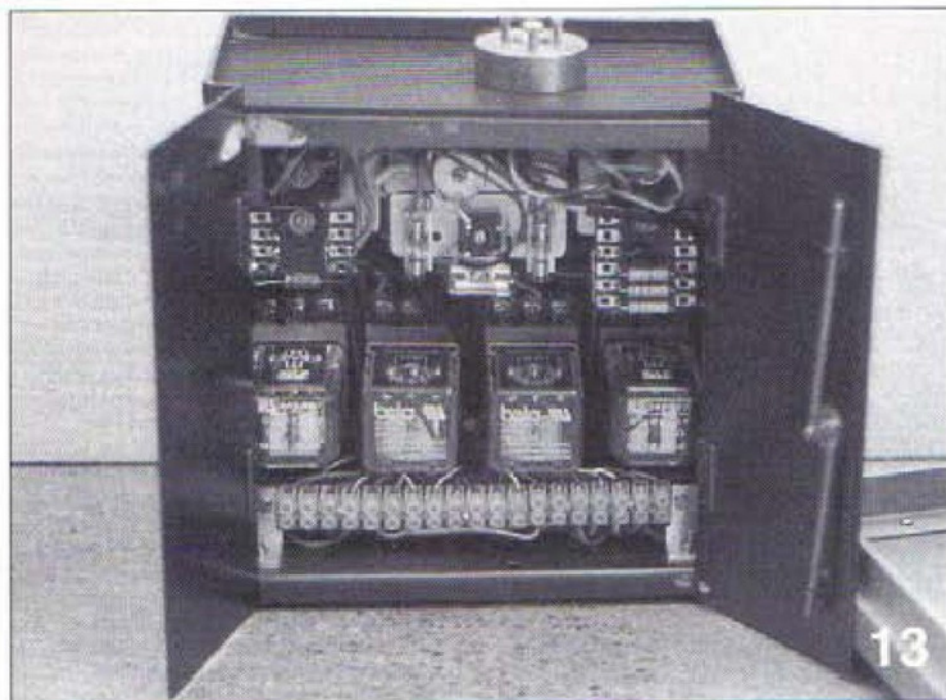


a machine shop. This made me look around, and I decided to make something on the style of the cabinet usually found beside a turret mill. Using some sheet mild steel for the cabinet and some brass for the door handle and some brazing rod for the lock rods, all I needed was some paint and a piece of rubber sheet. I now have in all appearances a tool cabinet, with the power pack hidden inside (**Photos 12 and 13**).

Finishing the headstock

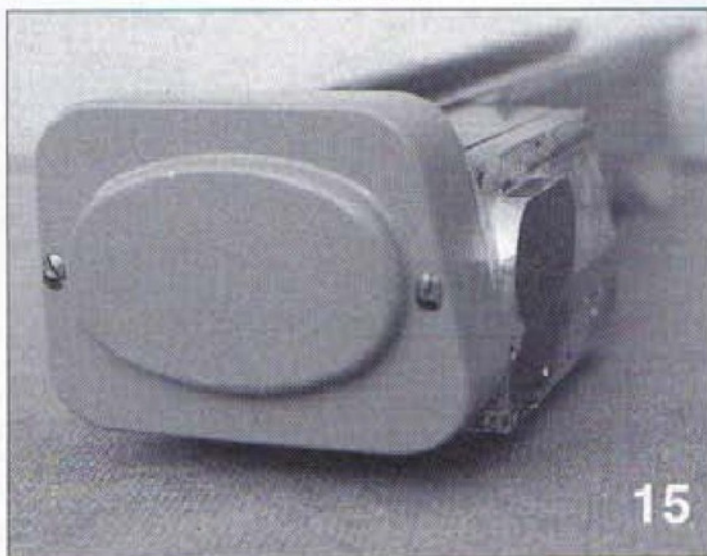
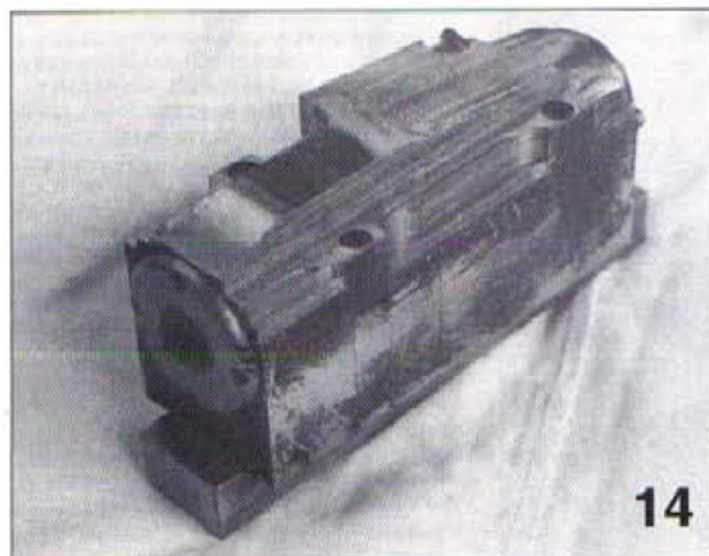
The headstock needed to be finished to shape. First of all, I had to remove as much of the excess material as possible, making use of the turret mill fitted with an end mill, then filing the contours to shape with the cap in place. The pad for the speed chart had to be sized correctly, photographing the picture in the catalogue at various distances to get the correct scale size frame. More filler and paint was used to finish off. **Photo. 14** shows the roughing out, before filing to shape.

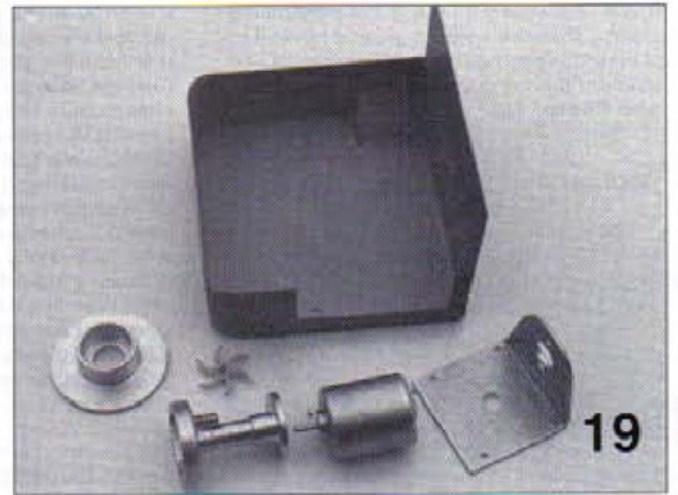
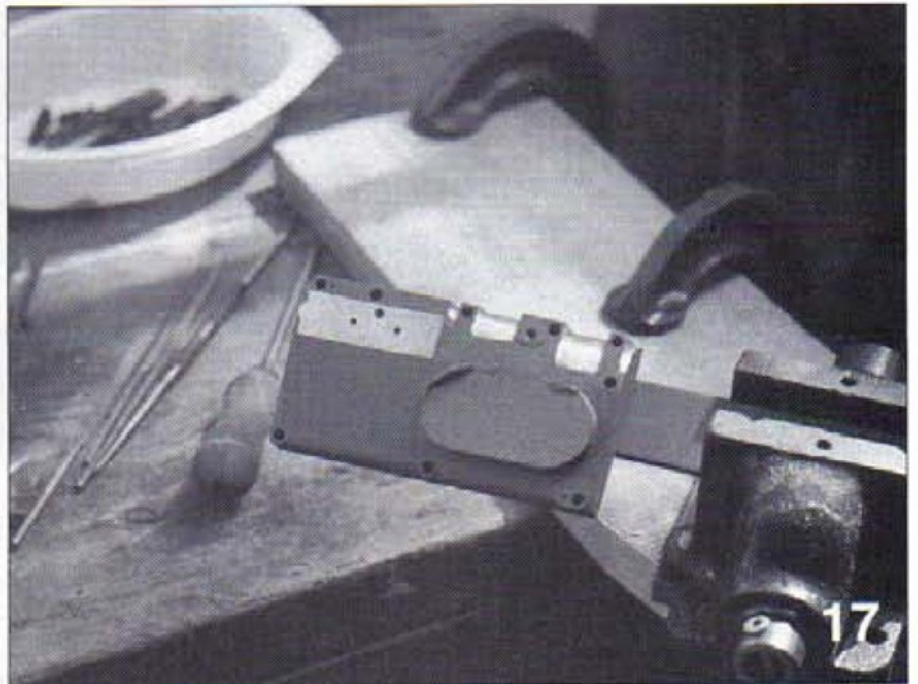
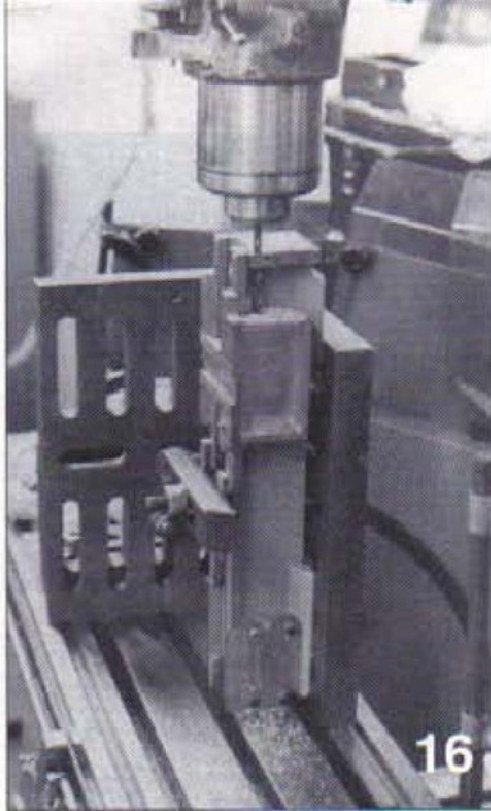
Having provided the apron casing and fitted it to the saddle, I made the 2mm thick front cover from the remains of a brake disc then, just as a temporary measure, I fitted the handwheel that was made in the same way as that for the tailstock, for the coming Exhibition. The quick change feed box is of sheet brass for simplicity, added to the bed. As mentioned, it should have been part of the bed casting. Next was the quadrant change gear box, made from Duralamin, as was the cover, complete with key hole slots for removal (**Photo. 15**). The handles can be made later.



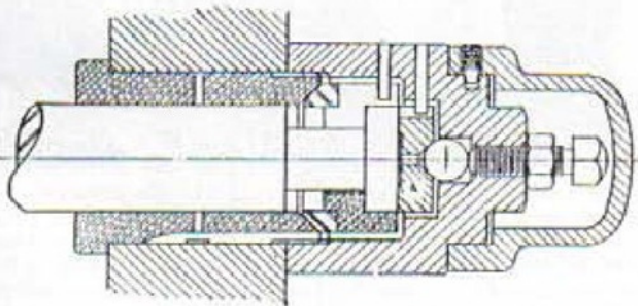
Drilling for leadscrew and shafts

Now for the line drilling. To do this, I again used the turret mill with the bed set against an angle plate in the vertical position. Then, with the saddle clamped close to the end support block for the leadscrew, I was able to drill and ream through to the apron. With the saddle lowered close to the feed and quadrant boxes, I then used an extension drill to reach through (**Photo. 16**). This operation was for the 6mm leadscrew and was repeated for the two 5mm forward-reverse and feed shafts.



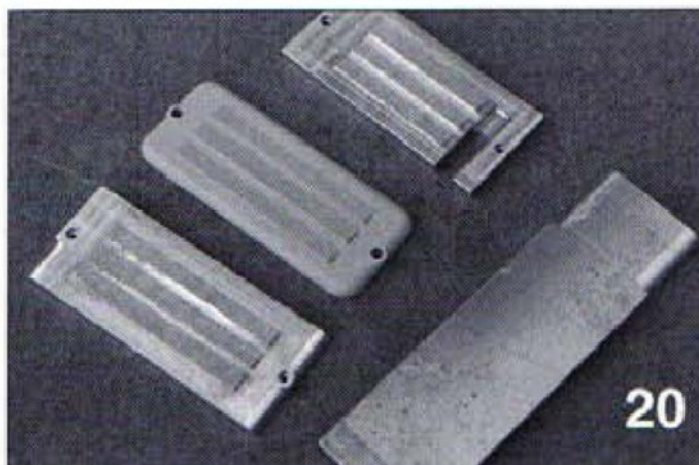


LEAD-SCREW and LEAD-SCREW THRUST



LEAD-SCREW THRUST has been built into our Lathes for some years. The provision of this Unit nullifies the inevitable inaccuracies of the Lead-screw Thrust faces. It is self-compensating, runs in oil and is easily adjusted by the Square Head Screw which moves Cast Iron Collar "A." Lead-screw is finally finished on a special machine shown on page 3.

Fig. 2



The cover for the quick change box is of aluminium. After milling to size and thickness then drilling and counterboring, I attached the piece to a strip of steel to enable me to file and dress to shape (Photo 17). Oil filler and drain plugs are fitted as on the full size machine.

The leadscrew scaled to 6mm x 1mm pitch, Acme form, with a length of 200mm. It was screwcut with the aid of a travelling steady, then the annular groove formed to accommodate the thrust assembly, as used on the full size machines. (Figure 2 and Photo. 18).

Coolant pump

The coolant pump was next, driven by a small 12v motor, 2mm dia x 28mm long. An odd piece of Dural formed the pump casing and the bottom cover for the impeller and filter. The impeller is from a discarded windscreen washer pump, with a little piece of wire mesh from a flour sieve for the filter. I now have now have a centrifugal pump, 65mm tall, which works perfectly, except for the whine of the motor. When I showed the other modellers at the College, they were surprised at the performance, but remarked on the noise. I reduced the voltage to 6v on the transformer which eliminated the whine, so now everybody is happy. In spite of having reduced the speed, the pump has a delivery rate of one pint per minute through the 2.5mm outlet nipple on the 1/8in. delivery hose. The comment was "That is enough for any small component work". This could be the answer to a lot of model makers' problems, as it is so easy to make (Photo 19). The only piece not included in the photograph is the extension to the motor shaft for the impeller (sorry about that).

The vent covers for the cabinet are from Duralamin bar, forming the false vents on a shaper to look like the real thing, then filing and dressing to shape (Photo 20).

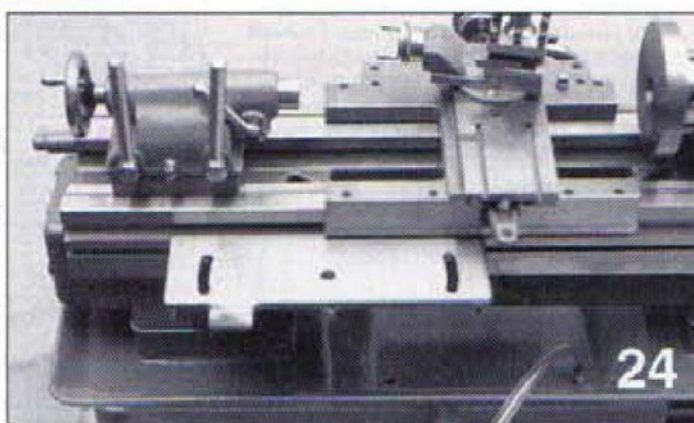
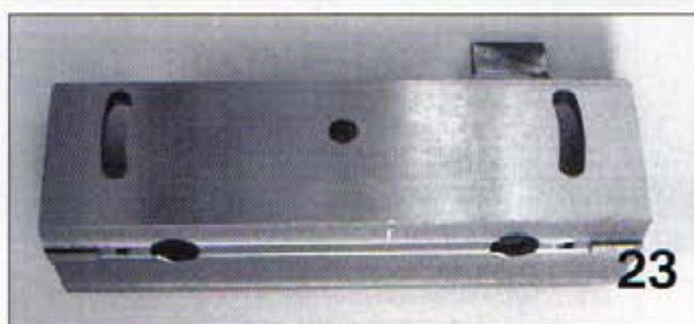
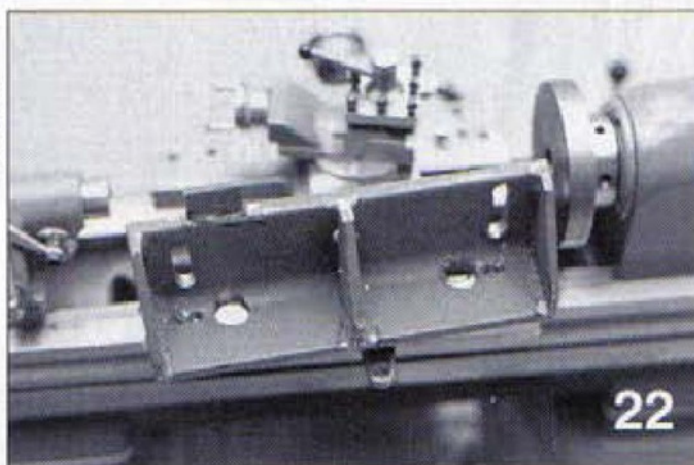
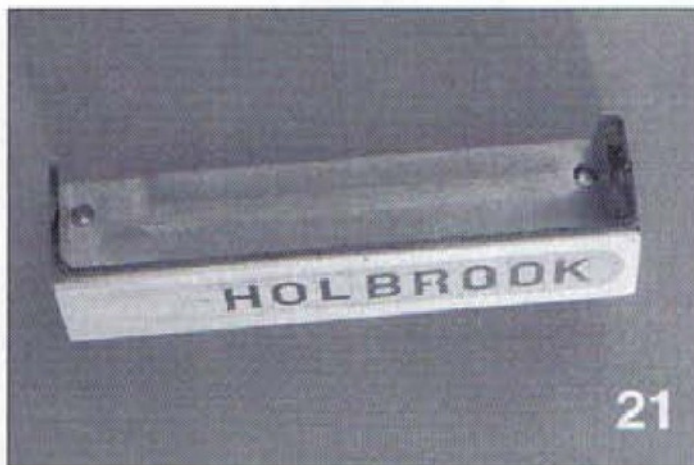
I would like to have made my own 64 DP rack and pinion, but facilities do not permit, so I purchased them ready made. The pinion was easy enough to fit on to the handwheel shaft, but I had to be careful when fitting the rack in position with the aid of a packing piece against the underside of the slideway, then drilling for the socket head screws and dowels. Also fitted to the handwheel shaft is the push-pull facility, which disengages the drive from the pinion.

The tool tray came next, from an odd piece of aluminium. The name HOLBROOK is in raised letters cast in an elongated recess at the front of the tray. After milling the recess, I filled in with a resin filler, then marked the letters so that I can cut around them to produce the style seen in the picture. I hope the idea will work, so I'll put it aside for another time when I can concentrate on what I am doing (Photo. 21). In the meantime I've made a start on the taper turning equipment, just to keep things moving.

Taper turning slide

An odd piece of black mild steel angle 2 x 2 x 2 3/16in. came to hand, together with three pieces of 1/8in. mild steel for the gussets. These have been silver soldered in position (Photo 22) then the walls milled to thickness to provide the taper slide body. Using the turret mill, the central pivot hole and the radial slots for the movement of the swivel slide have been formed (Photos. 23 and 24). I have to leave this for another time, along with all the other unfinished parts to concentrate on the multi speed drive to the spindle.

Other parts yet to be made include such details as the apron and the feed change gear levers and the drive and face plates. Whether or not I shall be able to make the 4 jaw and scroll chucks remains to be seen. The 4 jaw should not be a big problem, but the scroll chuck will be



another matter, as I can see some difficulty in making the scroll and jaws. There are a lot of intricate pieces to make yet, so I'm keeping my fingers crossed, hoping to find a way of overcoming the problems which are bound to arise. I also have visions of getting around to a three point steady and a travelling steady, also a machine light and, how about a few draw-in collets? Dream on, Robert!



MOTOR PROBLEMS? CHECK YOUR BRUSHES

Bob Loader's Unimat is his only machine tool, so it has to do a fair amount of work. When it started to misbehave, he decided that action was necessary

I recently had a bit of trouble with my Unimat 3. This is an unusual thing to happen; luckily it was only a small thing and reasonably easy to put right. It could though, happen to anyone with a well used Unimat, so here is a cautionary tale.

Signs and symptoms

If I remember the limitations of the Unimat and humour it, we get along very well. It has occasional fits of stalling, especially when drilling deep or large holes, or trying to take heavy cuts. When turning it is best to take several small cuts at high speed, rather than vice versa. The trouble started when I was drilling an 8mm hole. My system for this is to drill 3mm first, then 6mm, finishing with the 8mm. I was surprised when there was more stalling than usual, and several times the machine stopped, only starting again when I twiddled the chuck to and fro with the motor turned off of course.

I am normally of the, 'if it isn't broke, don't fix it' school of thought, but there are limits to this philosophy and I thought it best to have a look and see what ailed it, if I could. I had thoughts of repairs beyond my scope, new motors and other dire happenings.

First things

Before beginning I should have put on an overall, and some barrier cream would be a good idea for anyone doing a similar job, especially those with sensitive skins. I've got a hide like a rhino, but the overall would have been a good thing.

Getting the motor off

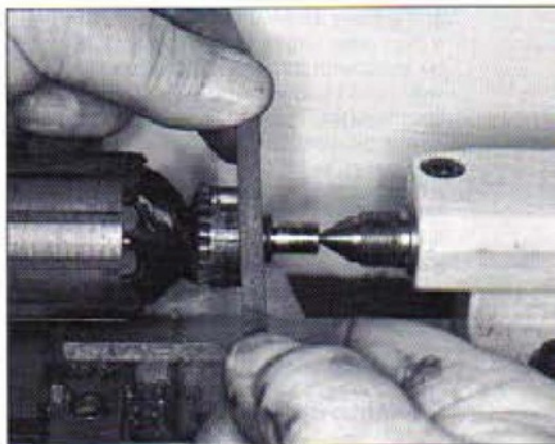
It was easy to get the motor off the machine. Two bolts undid the motor frame from the headstock, two screws released the motor from the frame and a single screw undid the motor pulley. The motor was then free, apart from the electrical connections, which I left alone.

Taking out the armature

I was sure that the problem would have something to do with the supply to the armature via the brushes. The only way to find out would be to take the armature out and have a look. This was not too difficult; I tapped out the pin which fits through the motor shaft and drives the first pulley. Next, I undid the screws fastening the end cap to the motor casing, and as these are quite deeply counterbored, they needed a

screwdriver with a fairly long blade. I had a box handy in which to put the small components, as the driving pin especially, would be very easy to lose. With the end cap free, the only things holding the armature in position were the bearings and the brush gear; a little fiddling freed it.

3. Using a fine file to remove most of the mess.

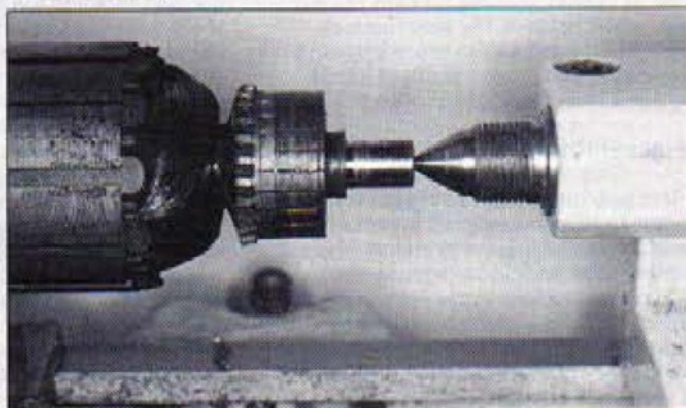


1. The end cap and brush housing of the motor before cleaning.

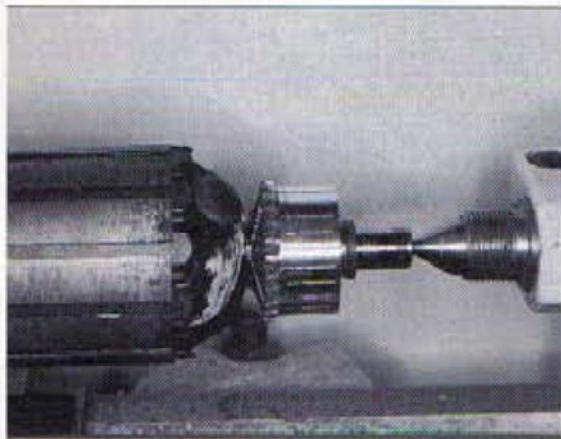
2. The commutator before cleaning.

A bit of a mess

The armature was mucky and the commutator looked as if it would need a skim. Everything was covered with a black coating, not all of it carbon from the brushes. Some may have been from the vacuum cleaner belts I used to use for driving belts. Wherever it was from, it was seriously grubby. **Photo. 1** shows the inside of the end cap with the brush gear and **Photo. 2** the armature before cleaning.



4. The armature and commutator after cleaning.



Skimming the commutator

The skimming didn't look too big a job because there was very little damage. The question was, how to skim it when it was usually done on a lathe between centres, with the lathe going? I had the lathe, the centres and everything ready, but no motor to power it. I thought of several daft things, like driving the lathe with my Black and Decker, or another motor, or fixing up a gear train with a huge ratio and driving it by hand with a handle. Common sense won, and I had another look at the commutator. There was no scoring or lumps gouged out of it, so the solution was easy: put it between centres and use a fine file to get rid of the very small irregularities (Photo. 3), finishing off with fine emery cloth. Photo. 4 shows the cleaned up commutator; it didn't take long and, because of the small amount removed, the mica insulation between the segments didn't need cleaning up or scraping out.

Cleaning up

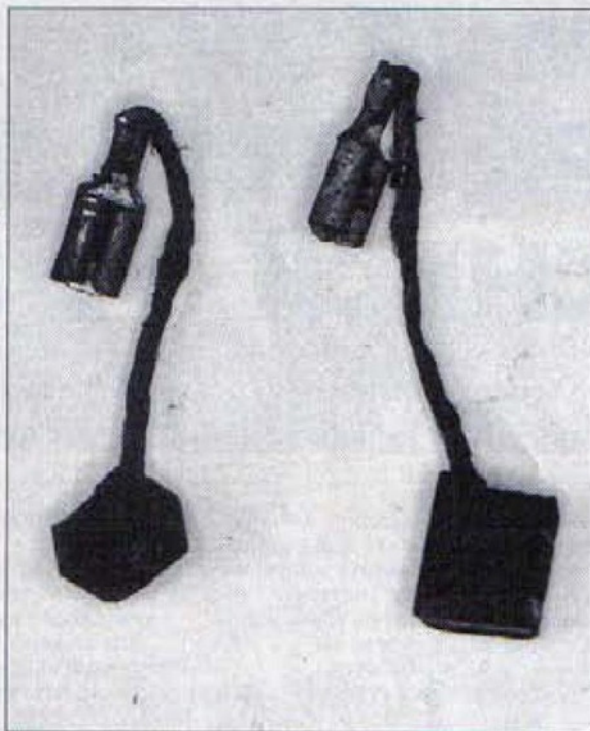
Most of the black gunge round the windings came off with an old tooth brush. I checked everything again and had a go at cleaning the inside of the end cap and the brush gear. I got as far into the field windings as I could with the tooth brush and, once the mess had been loosened as much as I could, I blew hard into the cavities. That's when the gunge hit my face and Pauline asked me if I had started moonlighting as a chimney sweep. It is why an overall is a good idea. I made sure, as far as I could, that the brushes moved freely in the holders. My clean up took longer and I had to wash my shirt, hair, have a bath and a good scrub of hands and arms.

Re-assembling

The only difficulty in putting everything together again was keeping the brushes out of the way when the armature was put back in. Each brush is on a piece of copper braid which I looped through the inspection holes in the motor casing, holding them in position by pushing a short piece of bar through the loop to rest on the motor casing.

More problems - more stalling

With the motor assembled and back in place, I thought I'd won. The lathe went lovely, but not for long and was soon back to the stalling and stopping. There was something wrong still; it would have to be fixed. I had thoughts again of having to replace the motor. I took it apart again and had a closer look at the brushes, and the trouble was obvious. One of them was worn down so far that it wouldn't stay put in the holder. In fact it was so bad a fit that it was able to turn round and jam the armature. Where a new brush is about $\frac{3}{4}$ in. long, the bad one was about $\frac{5}{32}$ in., and the other one wasn't much better (Photo. 6) at $\frac{5}{16}$ in. The shorter one was worn so much that it was down to the braid where the carbon is moulded round it.



6. The old brushes; note the amount of wear.

Three phone calls later

The answer was a new set of brushes, a doddle, I thought, just a matter of a phone call. I tried three places, one of which advertised U 3 motors and spares. I drew three blanks: one did not stock brushes, but would sell me a new motor; another would ring me back, as the man who dealt with such things wasn't there; the last one didn't stock brushes. I know I should have persevered and not given up after three duff attempts, but I was a bit fed up by then.

If in doubt, go Transatlantic

I telephoned my daughter in America, giving her the phone number of Blue Ridge Machinery and Tools Inc. A friend, Cary Stewart of Burbank, had sent me extracts from their catalogue to do with Unimat spares. I dictated all the details to my daughter and the agreement was that she would ring back if the brushes were not available. I was very glad this time to not have a call. They had just what I wanted, on the shelf and it took just over a week. The catalogue was three years out of date too, thanks again, Cary. The new brushes were quite easy to install and the fittings were the crimped quick-disconnect ones. The only problem again, was keeping the brushes out of the way, not that easy this time because they were longer. What I did was to loop the braids out of the inspection holes, the same as with the other ones, but with a longer loop which I Sellotaped to the motor casing while I put it together.



5. The new brushes.

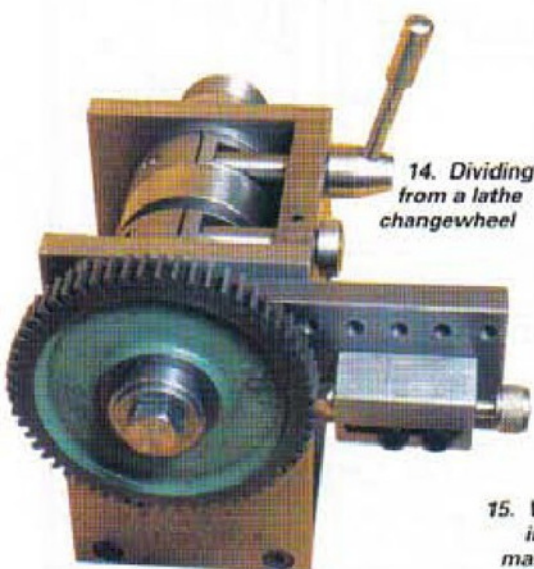
Success!

That time everything worked. It may be my imagination, but the machine seems to go faster and cut better, with no stalling or stopping, unless I get too excited and overdo it. Pauline thought, when I told her the complete tale, that it was a miracle the poor thing hadn't packed up before, considering the treatment it has had. She said that it deserved a good clean and brush up after thirteen years of hard graft. So, if your Unimat, or other lathe, shows the same symptoms, have a look at the brushes.



A FAILED ATTEMPT

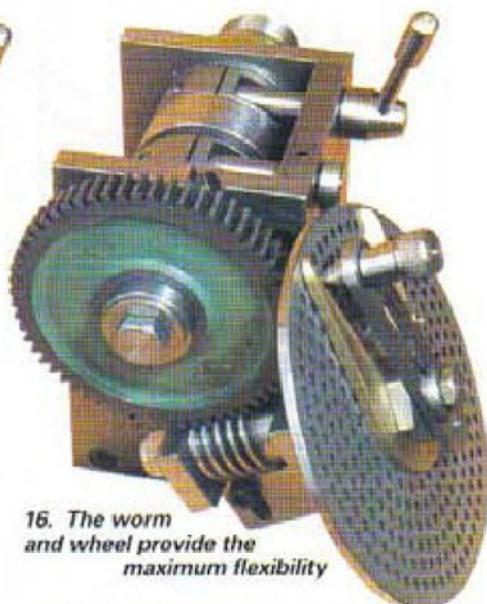
Part 2



14. Dividing from a lathe changewheel



15. With a division plate fitted in place of the changewheel, many more ranges are available



16. The worm and wheel provide the maximum flexibility

Harold Hall continues the saga which started when he tried to improve the appearance of the leadscrew dials on his milling machine. Here, he completes the first item of tooling, the dividing head.

(Figure, drawing, photograph and reference numbers follow those included in Part 1)

Dividing systems

Photo. 14 and the 'Gear and detent attachment' drawing (**Figure 3**) show the unit fitted with a change gear and the detent. Note that the multi tapped plate can be rotated a full 360 deg., thus permitting it to be moved to the best operating position.

Additional ranges of divisions can be provided by using the arrangement shown

in **Photo. 15** and **Figure 4**. The unit is still fitted for direct dividing, but now using a division plate. The long slot at the lower part of the unit permits the detent to be adjusted for the holes being on different diameters.

The system giving the maximum flexibility is that illustrated in **Photo. 16** and **Figure 5**, where the direct dividing arrangements have been replaced by a worm and wormwheel, which was a most

satisfying unit to complete. Not easily seen from the photograph (and, for simplicity, not included in the assembly drawing) is the fact that the axis of the worm is angled, to match the helix to the standard spur gear. Ambitious makers of the unit may like to make a true wormwheel, thus avoiding the need to angle the worm.

However, it was found that the worm/changewheel combination worked well without compensating for the helix and, with limited use such an item is likely to get in the home workshop, some may consider that its inclusion is an unnecessary complication. I had been tempted to go down this road, but chose the more correct approach. If the carrier (Item 26) is made using the two stage method shown on the drawing it does not add much to the complexity.

Worm and gear attachment

This is the assembly, other than the spindle, that creates the greatest challenge. It is also the dividing method that will give the greatest number of divisions. I suspect also, though have not tried it, that with this assembly fitted, the unit could double as a light duty rotary table. The bearings are substantial and adjustable so the occasional use in this way, providing the task is not arduous, would seem possible.

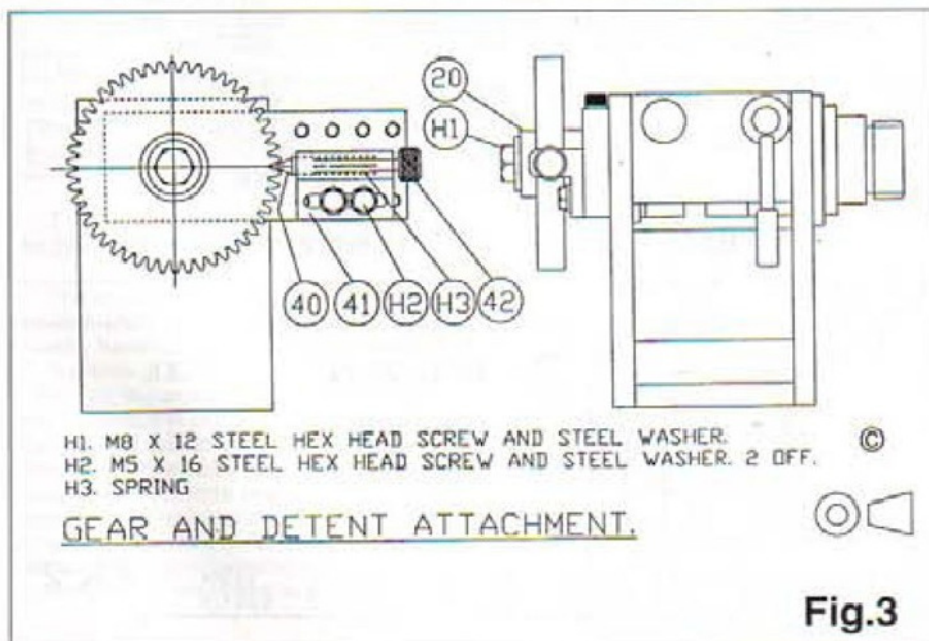
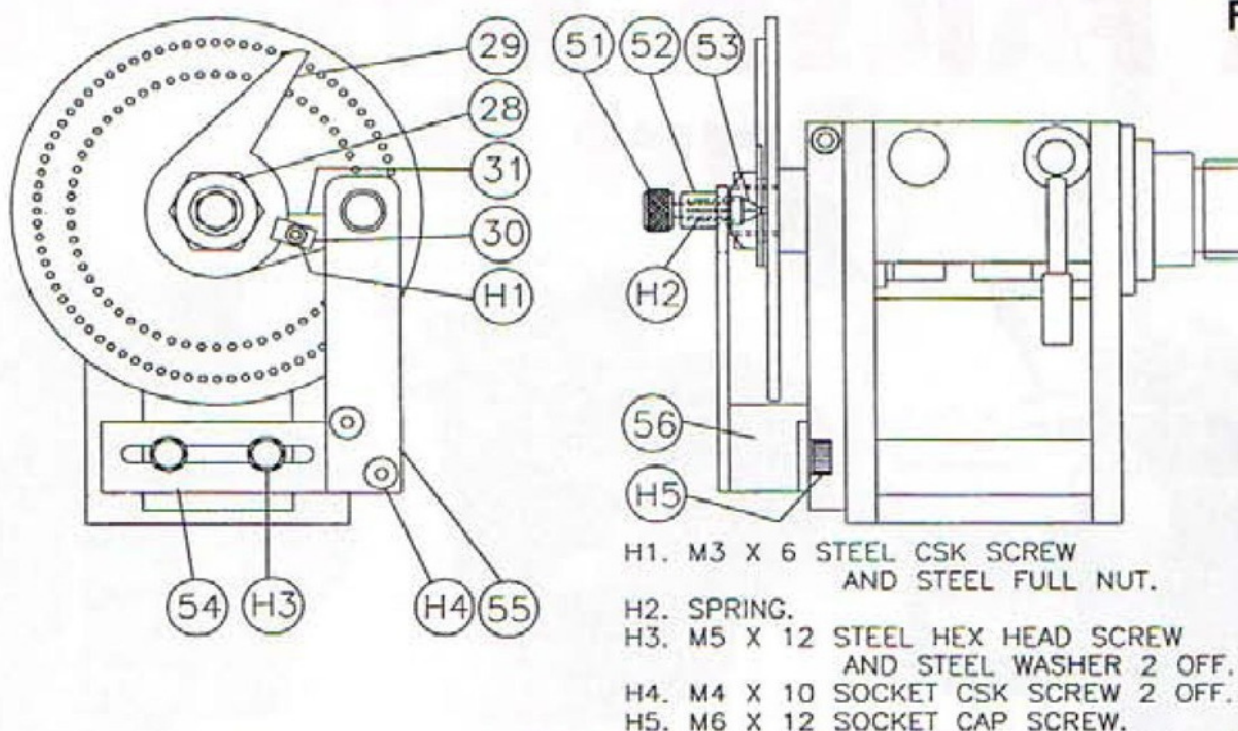


Fig.4



DIVIDING PLATE AND DETENT ATTACHMENT.

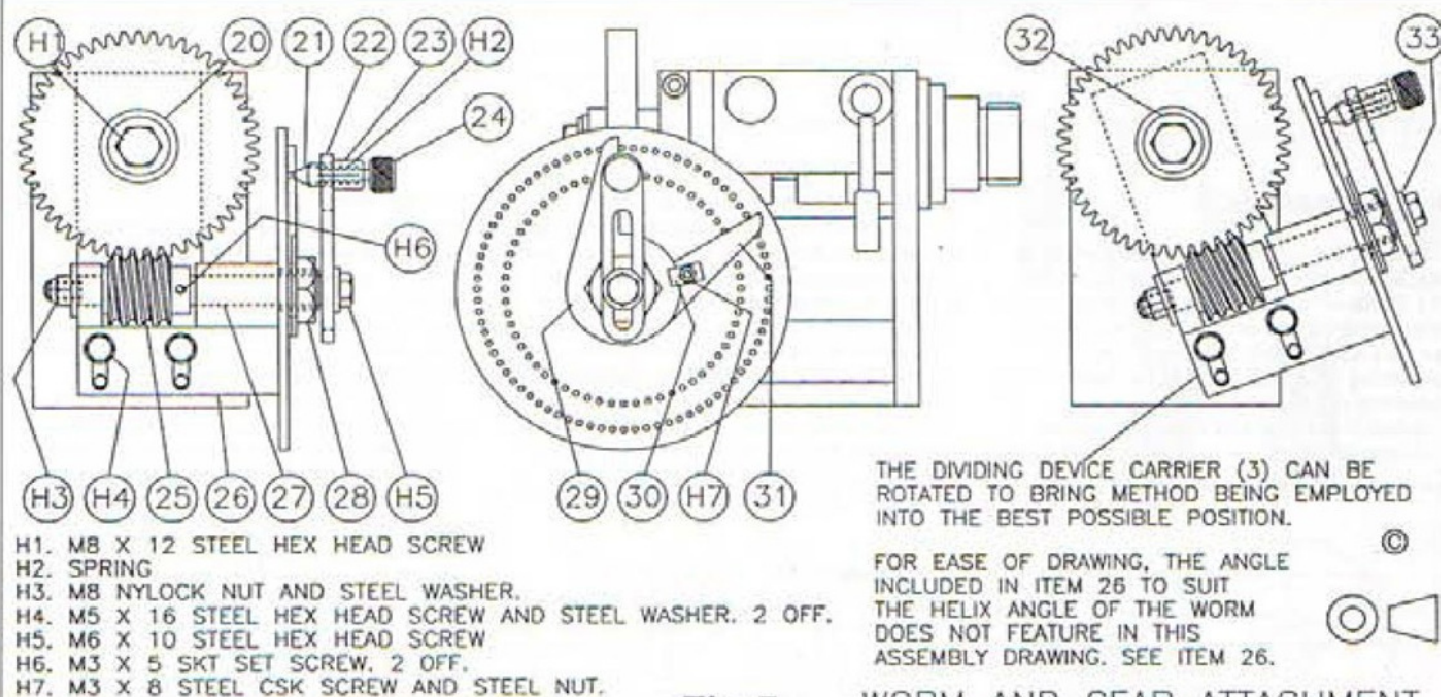


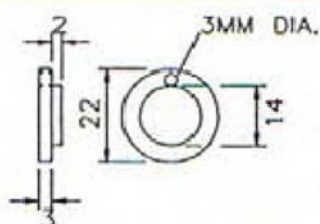
Fig.5

WORM AND GEAR ATTACHMENT

Division plates

The division plates come at around 110mm diameter, but to keep costs down they are punched from sheet steel, resulting in a 'nibbled' edge. The rings of holes are also punched at the same set-up. As the dividing device carrier can be rotated, larger plates can be accommodated, but the detent arm (Item 22) and the index fingers (Items 29 and 31) would require to be made longer.

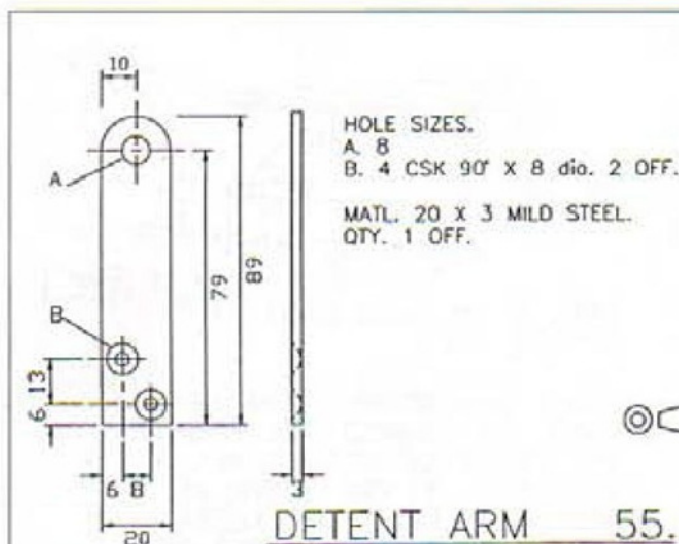
The plates come with a small central



MATL. 22 DIA. MILD STEEL.
 QTY. 1 OFF.

DIVIDING PLATE DRILLING JIG

SK 2



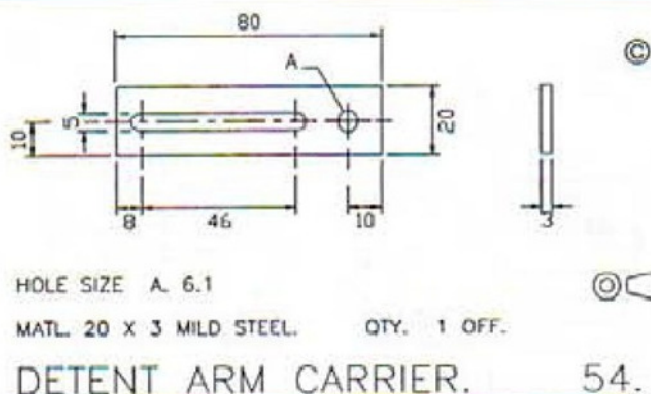
hole which is concentric with the PCD of the dividing holes, but this requires opening up to 14mm diameter to correspond to the mounting on the division plate carrier (Item 26). To maintain concentricity of the mounting with the dividing rings, essential else the divisions will be irregular through the 360 degree rotation, the following approach was taken. With the faceplate mounted on the lathe the first division plate was held in place using the tailstock centre locating in the small central hole. With the plate positioned in this manner, it was clamped to the faceplate and the centre removed. The centre hole was then bored to 14mm, then the remaining plates treated similarly.

A piece of 20mm diameter steel was then turned on the lathe to 14mm diameter by 10mm long and with a central hole tapped M8. The four division plates were all mounted on this at the same time and their outer diameter turned to get rid of the nibbled edge. The 10mm length was then reduced to 2mm and each plate mounted in turn so as to lightly chamfer both edges. Machining the outer diameter of each plate in this way is not of course essential, but it does make for a better appearance. Also, they are more pleasant to use as the rough edge can easily cause minor injury.

No drawing is included for the division plate, but there remained one further task, that is to drill a 3mm diameter hole to locate on the pins fitted in the carrier (Item 26) or the spindle (Item 8). For accuracy, and consistency, a small drilling jig (SK2) was made to carry out this operation.

Index fingers (Items 29 and 31)

These present a situation not often encountered in tool making, the need for mostly hand rather than machine work. Two pieces of 3mm brass were cut a little over size, the position of the 18mm hole marked out, the part set up on the faceplate of the lathe and the hole bored. This was followed by boring to 38mm diameter and 1.5mm deep. Their outlines were marked out and the parts cut roughly to size, then carefully filed to profile, the 38mm diameter counterbore giving the outline of the part in that area.



Division plate nut (Item 28)

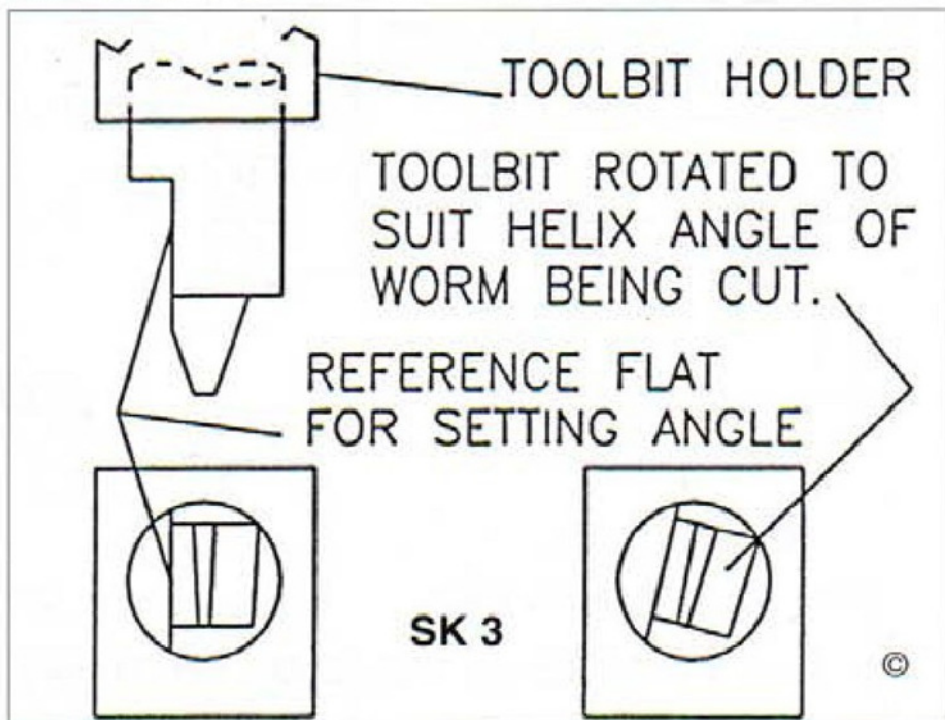
This is a straightforward item to make but, when assembled, must clamp the fingers so that they can be moved, but only with some resistance. If easy to move then they may shift whilst traversing the detent from one hole to another, perhaps resulting in an indexing error. To achieve the required action, the front finger was dish to give the effect of a disc spring. The dish was formed by clamping the finger in the vice, backed by a piece of soft wood and with a piece of 22mm diameter steel placed centrally over the hole in the middle. By tightening the vice a very slight dish was formed, sufficient to provide adequate friction.

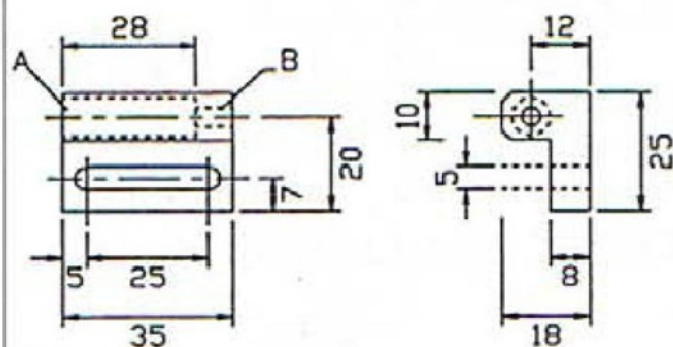
The curve in the index finger clamp (Item 30) was formed in a similar way, but this time the piece of steel was placed with its periphery on the finger to create the

curve. This was done prior to drilling the hole.

The Worm (Item 25)

The drawing details bronze as the material, but when I came to make the part, I found that I did not have the material to hand. Rather than place the project on hold, I decided to use mild steel which I felt would work adequately with the cast iron changewheels. The process for turning a worm is little different to cutting a thread, a subject that has been

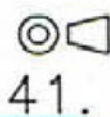




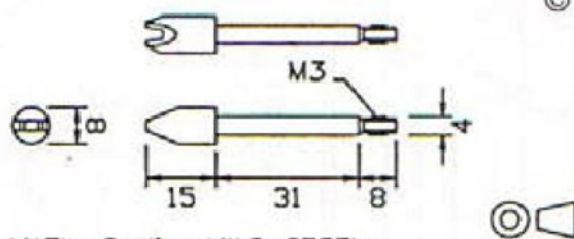
HOLE SIZES. A. 8 B. 4.1

MATL. 35 X 25 MILD STEEL.
QTY. 1 OFF.

DETENT CARRIER



41.

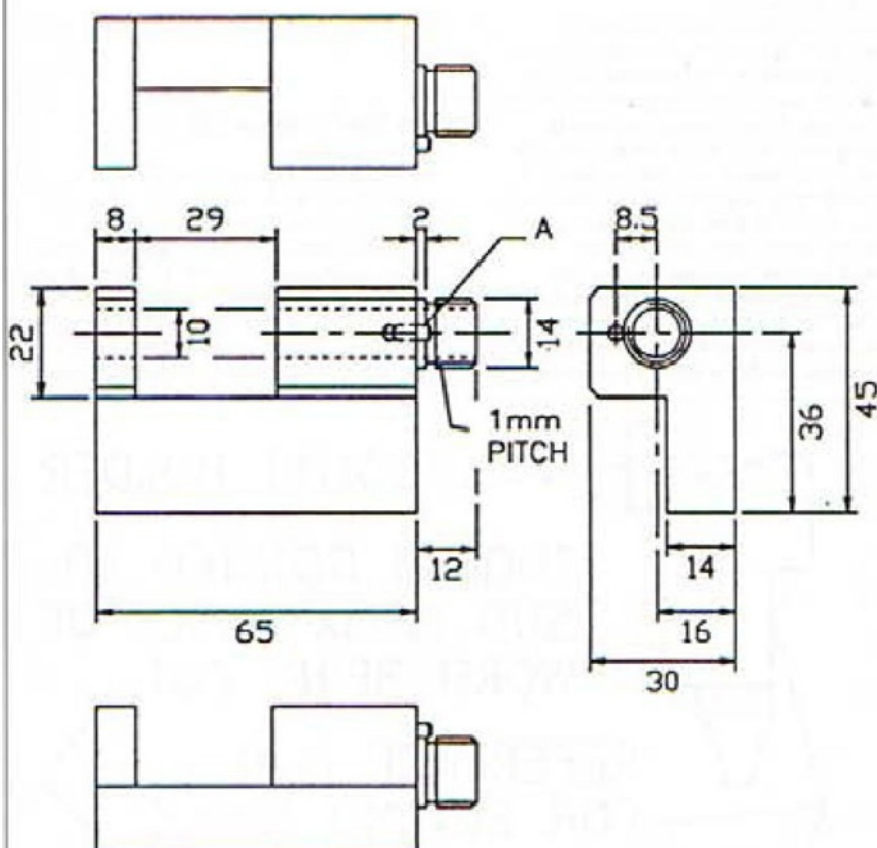


MATL. 8 dia. MILD STEEL.
QTY. 1 OFF.

SHAPE END TO SUIT GEAR BEING USED. THE FORKED END PERMITS THE DETENT, IF ROTATED 90°, TO LOCATE ON ONE TOOTH AS WELL AS BETWEEN TWO TEETH. THIS DOUBLES THE NUMBER OF DIVISIONS OBTAINED WITH A GIVEN GEAR.

DETENT

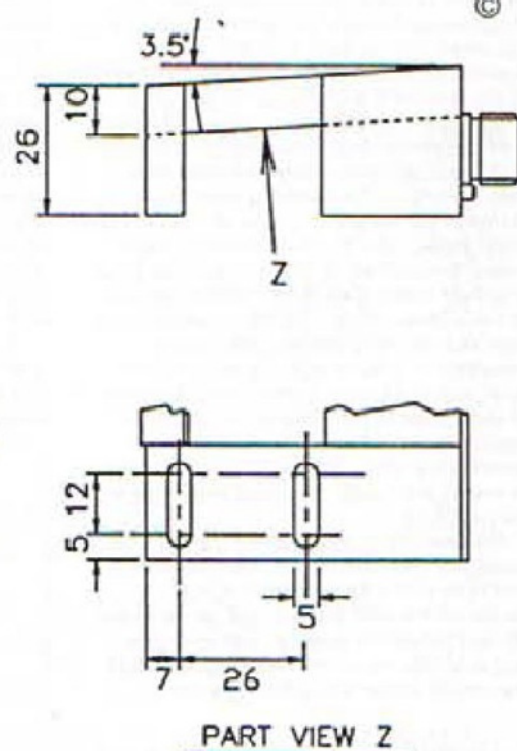
40.



STAGE 1

MATL. 45 X 30 MILD STEEL.

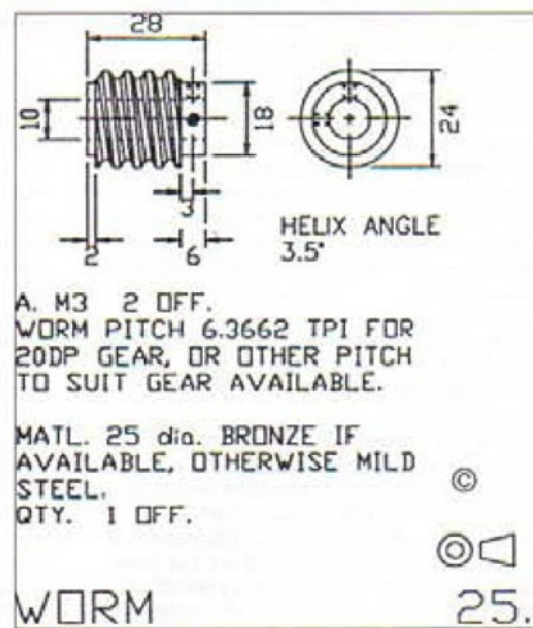
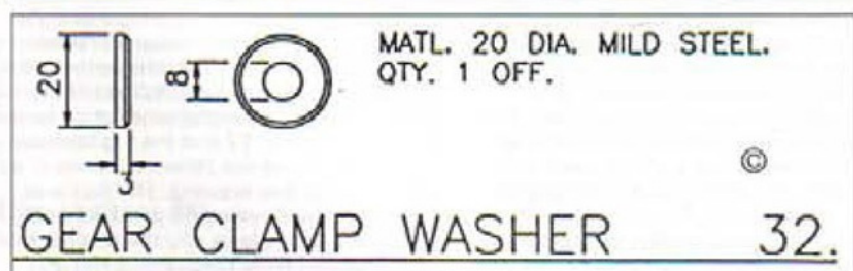
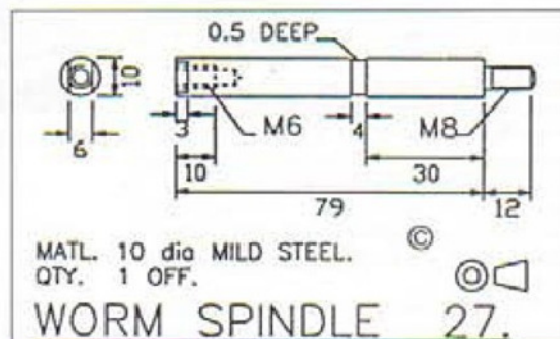
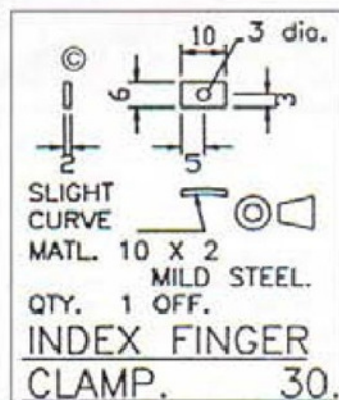
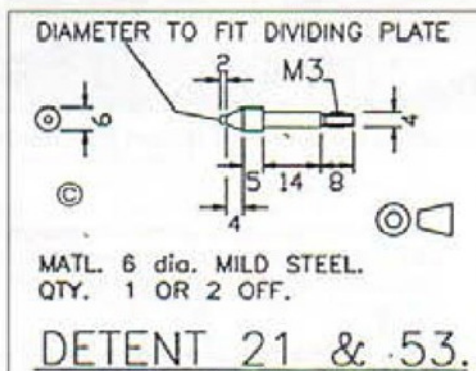
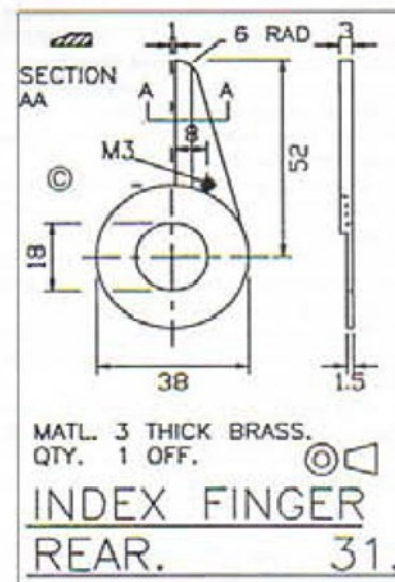
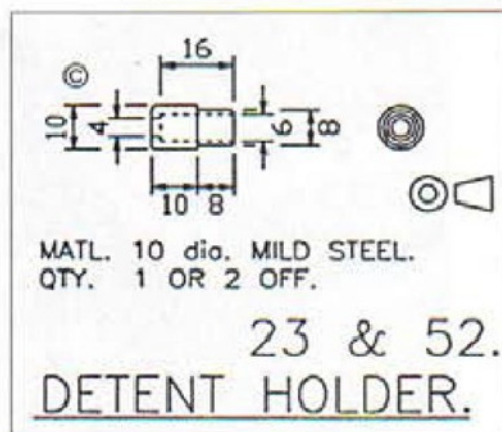
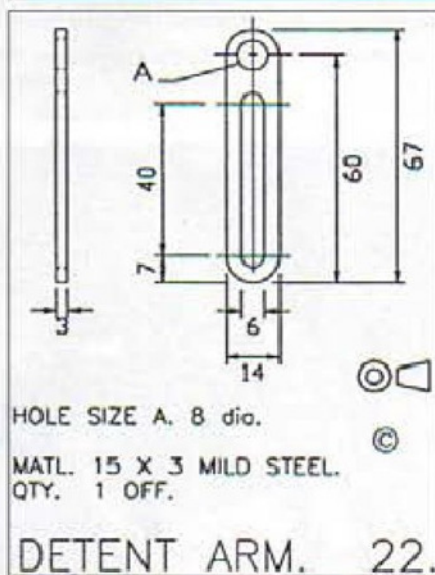
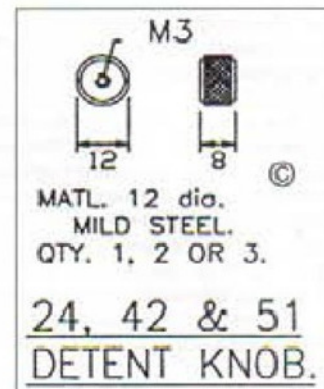
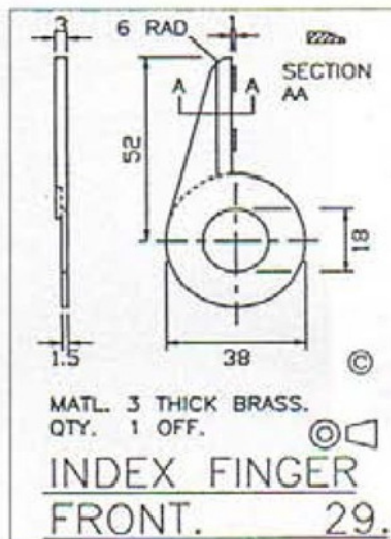
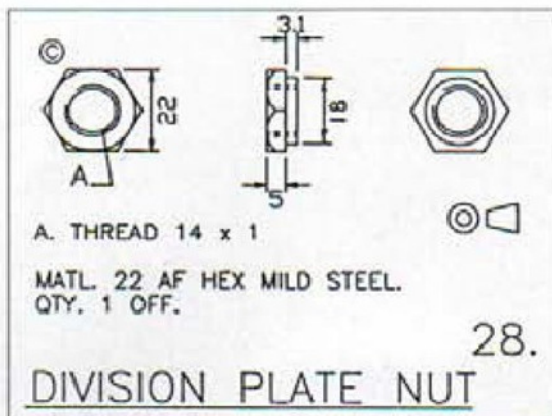
A. 3mm dia. PIN 2.5mm PROJECTION. MAY REQUIRE FLAT SEE SPINDLE PART 8.



PART VIEW Z

STAGE 2

QTY. 1 OFF.



well covered, so I will not go into detail on the method. I will though give tool dimensions, changewheel combinations etc.

The helix angle depends on the worm diameter, and because of this, making the cutting tool out of round high speed steel which can be gripped in a suitable holder will allow it to be rotated to the angle required. This type is easier to make and is adjustable for worms of varying diameters. The principle is illustrated in **Sk3**.

The changewheel set up will depend on whether a gearbox is fitted. If so, the mandrel gear should have 55 teeth and the input to the gearbox 35, with suitable idler or idlers between. The gearbox should be set for 10 TPI. If your lathe has an 8 TPI leadscrew but no gearbox, then the most common combination quoted is as follows:- mandrel gear 55, first stud driven 35, first stud driver 60, second stud idler and leadscrew 75.

The required pitch for a 20 DP worm is 6.36620 TPI. Both the above give a pitch of 6.36364, an error of -0.040%, which is accurate enough for the purpose, though more accurate combinations are possible. The cutting tool tip width should be 0.028in. with an internal angle of 40 deg. It should be set at a helix angle of 3.5 deg.; the depth of cut is 0.12in..

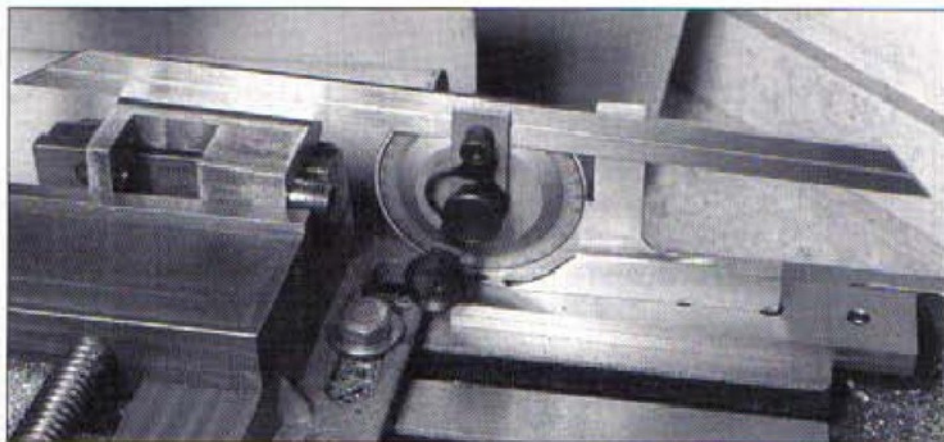
The worm was cut and the through hole bored, not drilled, without removing the part from the chuck so as to ensure concentricity.

Division plate carrier (Item 26)

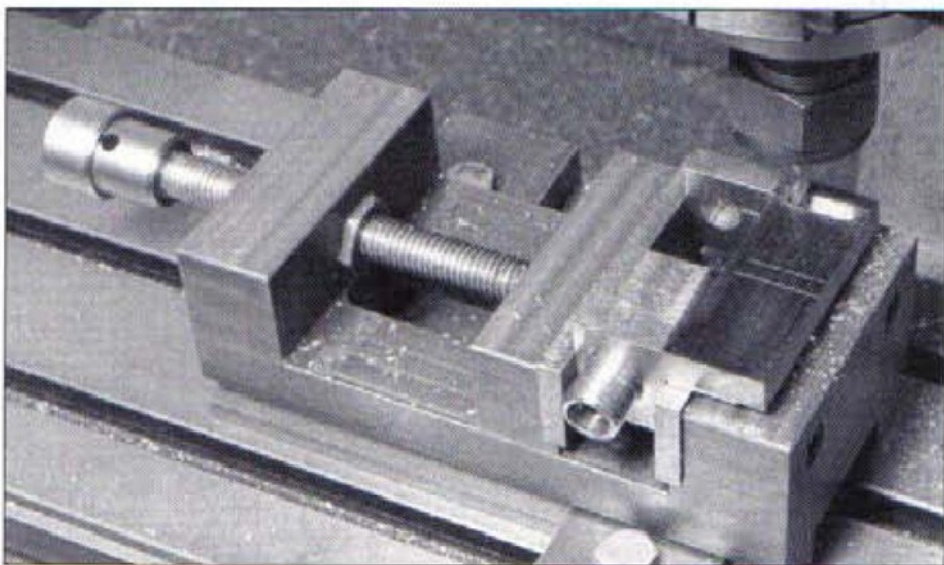
I found that I did not have a piece of steel large enough for this, so decided to fabricate it from two pieces, helping to use up some of the ever growing number of smaller pieces in the odd and ends box. It was fortunate that I did, as it minimised the effect of a disaster due to an error on my part. It would be wrong of me to give the impression that everything goes according to plan in my workshop and in any case, coming clean may help others to avoid the same situation at some point in time.

The material I had was just too short to include the thread, so I decided to turn this on a short piece of steel. A hole, 20mm deep, was bored in the main body and the already threaded steel fixed in place using my favourite two part resin adhesive, a slow setting type for maximum strength. Having already turned a similar threads on the spindle and the division plate nut, it was a case of repeating the exercise. At the time, I had just read 'On the Editor's Bench' in Issue 48, in which Geoff Sheppard advised caution when cutting threads on the lathe, always taking a light witness cut first to ensure that the changewheel combination or gearbox setting corresponds to the pitch required. This I did, even though it was the second time I had cut a thread of this size for the project.

Having started the thread with everything going according to plan, I pressed ahead to complete the exercise. When the thread approached what appeared to be completion, I tried the nut without success. Comparing the diameter with that on the spindle there was still a little to remove, so I continued until the



20. Setting the division plate carrier to an angle of 3.5 deg. for machining to suit the helix angle of the worm



21. Milling the slots in the division plate carrier

two were at the same diameter; still the nut did not fit. I placed the spindle thread against the one I was cutting to check the pitch and both were the same. I reduced the diameter further, still without the nut fitting, or even attempting to fit, I was perplexed, very!

I once more tried the spindle against the one I was cutting, and this time realised that their helix angles were different as the two parts would not lay parallel. It was at this point that I realised that, having made the worm, I had had to move the smaller lever on top of the gearbox and, as its movement is not very great, it is not immediately obvious which of the three positions it is in. In fact the gearbox was set for twice the pitch I required and, as I was using a chaser rather than a single point tool, I had cut a perfect two start thread. I have never had the need to cut a two start thread in the past, and probably will not in the future, so the item has been retained as probably my only two start thread I will ever make, and I did not realise it at the time! Having had the laugh on me, it is worth noting that if using a chaser, this is not too difficult a mistake to make.

Having at the second attempt produced the thread I required, it was also drilled

through, but smaller than the ultimate 10mm diameter bore. The hole would avoid pressure building up when the part was pushed home complete with adhesive.

The block of steel which forms the main body was mounted in the four jaw chuck, adjusted for position, and bored to take the threaded item. Both the bore and the part to be fitted were then roughened to improve the bond strength. The threaded part was fitted into the body whilst still in the chuck and left overnight for the adhesive to set. The 10mm bore was then made using a boring tool, making the bore size a close running fit on the worm spindle (Item 27) which had already been made.

The part was next transferred to the milling machine and machined in accordance with stage 1, being a straight forward operation I will make no further comment. Now came the time to make the part suit the helix angle (3.5 deg.) of the worm. To do this the part was set up as shown in **Photo. 17** and the top surface machined to give the 26mm dimension, as per the stage two drawing. The part was then turned and rested on parallels between the vice jaws and the reverse side machined to give a parallel mounting



22. Machining one of the detents, all diameters being machined at the same setting to ensure concentricity

flange.

Next stage was to machine the slots for the fixing screws. **Photo. 18.** A thin piece of aluminium, just visible in the photo, was placed under the flange to avoid the slot drill damaging the vice as it broke through. After being generously deburred and the locating pin for the dividing plate fitted, the part was finished. In retrospect, it was much easier to make than I had first envisaged.

Minor parts

There remained quite a number of minor parts to be made, only one of which warrants any comment. The detent (Item 21), is required to be concentric, so that no errors occur if it is rotated. With this in mind the part was machined fully, as shown in **Photo. 19**, without removal from the chuck. The drawing details 6mm diameter material but I used $\frac{1}{4}$ in., so that I could also machine the 6mm section. If you have an accurate chuck this precaution could be overlooked.

Division plate and detent attachment

This may be the dividing method which is of least interest to readers as all the increments can be provided by the other arrangements. However, it requires so few additional parts that it is probably worth making as it will also accommodate larger division plates without further modification.

Gear and detent attachment

This is the simplest of the three dividing methods to construct and in many cases may be the only one made. Only four simple items (20, 40, 41 and 42) are required, with only Item 40 worthy of comment.

Detent (Item 40)

This is a simple part but it has

importance with regard to the accuracy of the divisions achieved. Firstly, the 8mm diameter was made a close sliding fit in the Detent carrier (Item 41) as any play would cause errors in the resulting divisions. Of even greater importance was the shaping of the detent end. If either the taper end or the faces between the fork were not symmetrical about the axis, then the resulting division would differ between one position and when rotated 180 degrees to the other.

To assist in achieving symmetry, I drilled a 3mm dia hole in the end, some 3mm deep. I first used this as a guide to filing the outer vee shape, forming first one side and then the other, each time breaking into the drilled hole by about $\frac{1}{2}$ mm. This gave an end which was around 2mm wide. Next, the inside of the fork was filed to shape, again using the hole as a guide to positioning the two faces. The intention is that the fork will locate on its inner faces across a single tooth, so it was necessary therefore to shape the outer faces of the fork to miss the adjacent teeth.

Even with this care, a little adjustment was required on final assembly. With the detent locating between two teeth, the detent was carefully pulled clear, rotated 180 deg. and re engaged, noting any movement this caused to the gear wheel. From this observation, small adjustments were made to the detent until the gear did not move with it engaged in either position. The inner faces of the fork were checked and adjusted in the same manner.

Final comments

I know from my time as editor of MEW that readers frequently commented that they would like, in addition to the details to make an item, instructions into its use. The uses for a dividing head range from the complex to the simple. At the complex end we have gear cutting, and at the simple end drilling a few holes on a pitch circle diameter, such as required for the cylinder end flange of a steam engine. Other uses include the calibrating of machine micrometer dials and the like (see also serrated edge handwheel, Ref. 1, Photo.

13). The list is endless. In terms of the part that the dividing head plays in these operations, the following are points to note when putting it to use:-

No matter how much care is taken in its manufacture, some play will be present which can cause errors in the divisions obtained. In many cases the errors will not cause a problem, but do get into the habit of manually taking up any backlash, always in the same direction, prior to tightening the front bearing. As a simple but effective way of doing this, fix a piece of string to the chuck by inserting the chuck key to give an anchor point, wrap the string around the chuck a couple of times and hang a weight on the end. This will automatically take up the backlash.

Whilst for some light duty applications it may not be necessary to lock the front bearing, it is a good to get into the habit of doing this in all cases. You will be less likely to forget when you perform some more complex task such as cutting a gear.

No matter how careful you have been in making the spindle, it is probable that when transferring a chuck to the dividing head, complete with an already turned part, that the part will not then run perfectly true. For most applications this will not cause a problem but if you are calibrating a dial with, say, a line depth of 0.1mm, then the error may be significant and the line will have a different appearance on opposite sides of the dial. In such cases it is preferable to turn the part in a four jaw chuck, so that minor adjustments can be made when transferred to the dividing head.

One aspect of using a dividing head with a gear and wormwheel that may surprise the beginner, is that errors in the division plate are reduced by a ratio equal to the worm to wormwheel ratio. The end result is therefore much more accurate than the plate itself. Because of this, it can be practical to use home made plates (see Issue 8, Ref. 4) which may not conform to the accuracy of commercially available plates.

Advantage can also be taken of this phenomenon to generate a more accurate plate from a relatively inaccurate version, using the following process. If say one has a rather inaccurate 27 hole plate which has been home made using no more than dividers and a rule, a second plate with the same number of holes can be made by indexing through 2 turns plus 6 holes to position each hole in the new plate. This will be more accurate than the original, with errors reduced to $\frac{1}{60}$ th. If now this plate is used to construct yet a third plate, the errors in this will be a further $\frac{1}{60}$ th of those in the second plate, amounting to a reduction in error to $\frac{1}{3600}$ th of the original error, quite an improvement.

One down

This completes my comments on the dividing head. In the next issue the series continues with the faceplate balancing fixture.

References

4. Dividing by Computer, MEW issue 8, page 26.



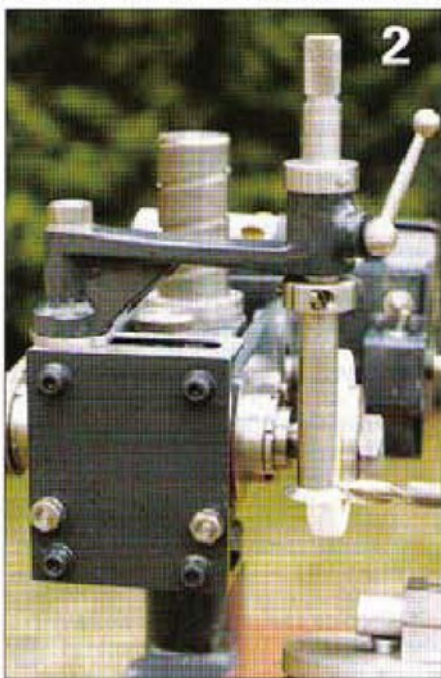
ADDITIONS TO THE QUORN

- A Centre Finder and modifications to assist in the restoration of centre drills

Although the Quorn tool and cutter grinder is a versatile piece of equipment, users often comment that setting is a time consuming and complex process. David Machin has devised two attachments which facilitate use of the machine

The Centre Finder

Owners of the Quorn may have shared my irritation at the rather lengthy process of setting the heights of wheel, tool and tooth rest relative to each other, using the straight edge method. What should be a relatively quick operation is anything but that. What



is required is a device to speed up setting and this is how my centre finder was conceived. It must be admitted that the basic idea is not original and can be seen on commercially available tool and cutter grinders.

The device can be seen in **Photos. 1 and 2**, and the **General Arrangement** drawing. It consists of a shallow conical Disc (Part 4) mounted on a Height Rod (Part 2). For some applications, this disc can be more conveniently mounted the other way up. For securing the disc to the height rod, a screw other than a countersunk one would then be needed. The Height Rod can slide up and down a Bracket (Part 1) and be locked at the required height. A Collar (Part 3) is then used to fix this height. A second collar can be set by feeler gauge to give the precise

distance by which the wheelhead has to be raised to give the necessary clearance when grinding, for example, the flutes on an end mill using a plain grinding wheel.

The Bracket can be adjusted, fore and aft, on a flat surface provided in the form of a small Table (Part 11) mounted on the wheelhead bracket of the Quorn, labelled A on the G.A. Provision is made, on final assembly, to adjust and permanently lock the table so that it is parallel to the axis of the spindle in the wheelhead. A second table is provided for those occasions when the wheel head has to be used inverted.

Now to the making. I don't propose to write a fully detailed account, but rather to comment on the making of parts where it is deemed necessary to explain the design and to emphasise important procedures for a successful outcome.

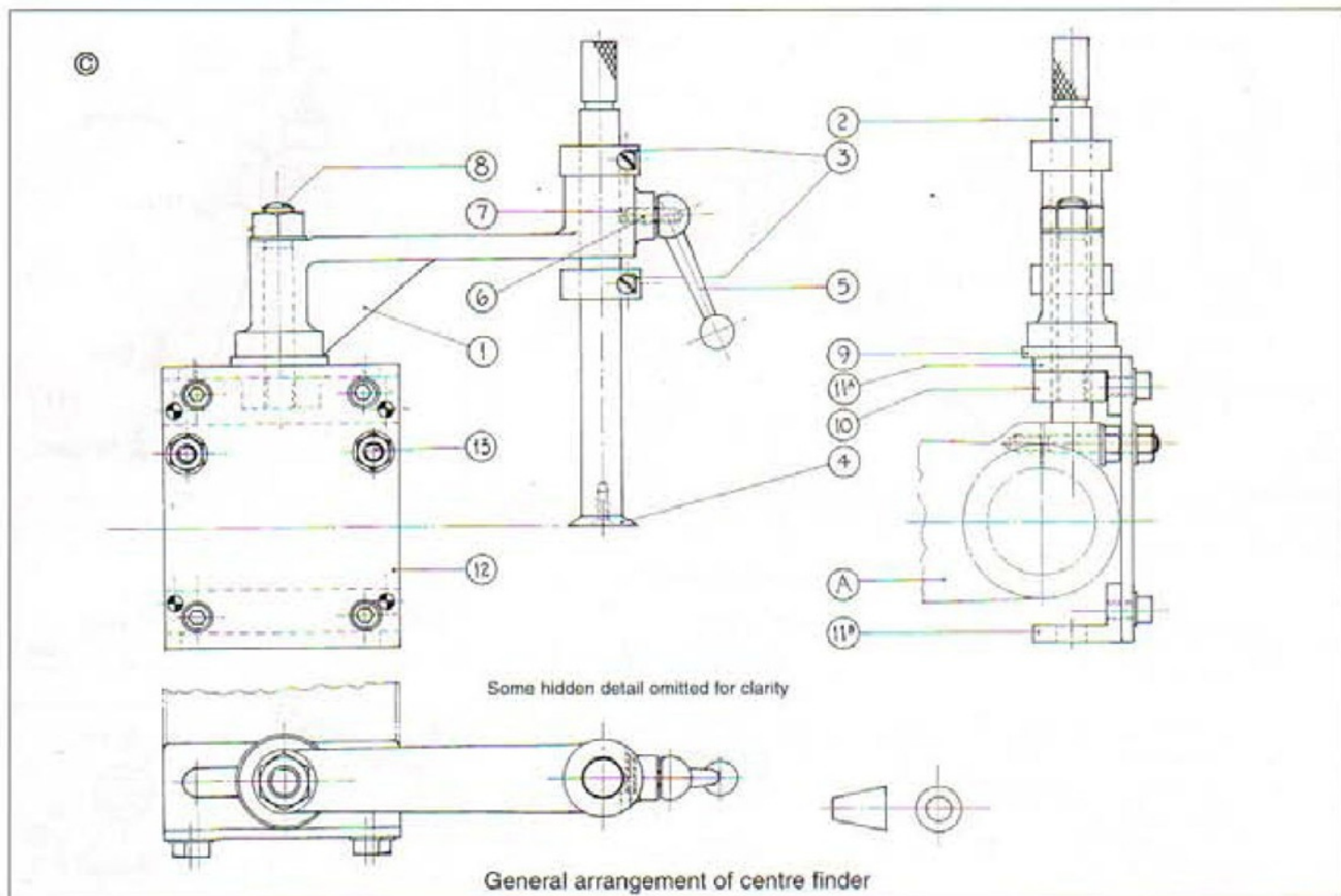


Photo. 3 shows the parts required, and all parts are detailed on the drawings, except commercially available standard fasteners. With the exception of the Front Plate (Part 12), Table (Part 11) and Screws (Part 13), most components can be made in any order.

Part 1. Bracket

The reason for the cranked shape of this item is to clear the grinding wheel and its

guard. The bracket on the prototype is made from an aluminium casting, though cast iron would probably have been better. Since I can produce aluminium castings at home, this was the reason for my choice. I can probably arrange for a supply of castings in iron or aluminium if there is a demand, not that a casting is needed at all. This part can be fabricated from mild steel sections if you prefer. The circular sections could be spigotted to fit into holes drilled in the flat section. These joints could then be Loctited, silver soldered or brazed, according to your facilities. Also, for a steel fabrication, the flat sections could be thinner and the web could probably be omitted. One other point: I used a thick washer (Part 9) between bracket and table because tightening down the (soft) casting to the grooved table could, in time, have put a groove in the casting. If you're using steel or cast iron, make the round section at this end longer and dispense with the washer.

The rest of the machining is the same for both versions, and the only point to emphasise is to make sure that both bores are parallel to each other and square to the bolting face. Similarly, the ends of the round section at the $\frac{1}{2}$ in. bore end should be square to the bore, to ensure accuracy and repeatability in use.

Part 2. Height Rod

This is a straightforward piece of turnery. It does need to be a close fit in Part 1, so a piece of precision ground mild steel could be worthwhile if the drawn steel you have is down on size and likely

to be a sloppy fit.

Part 3. Collars

The collars are straightforward pieces to make.

Part 4. Disc

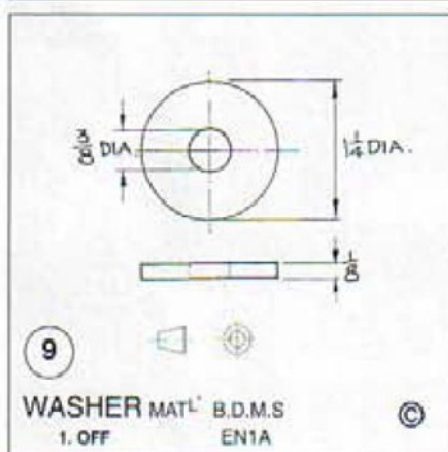
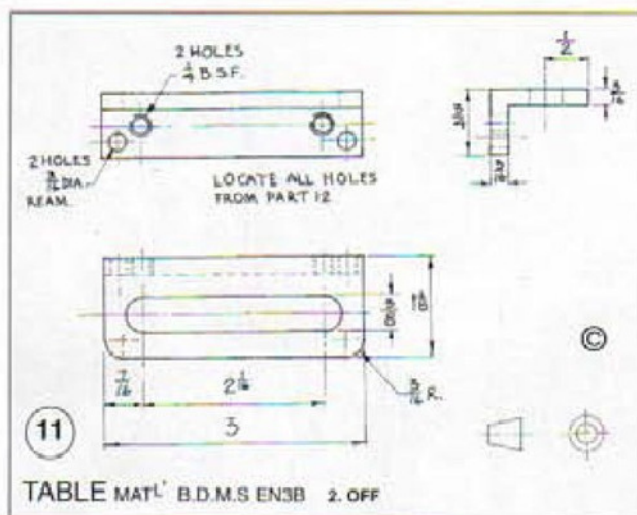
This can be made from a short length of silver steel or, to save buying a piece specially for this part, you could do as I did, and use an old hand file. The old file could be softened by annealing and a piece sawn off to give a square blank. An 8 or 10in. hand file will be thick enough for our purpose. It then can be faced, drilled and countersunk in a four jaw chuck, and could then be screwed to a tapped rod with a smear of Loctite for finish machining and taper turning. Removing the screw and heating will break the Loctite bond. Finally, the piece can be hardened and tempered.

Part 5. Ball Handle

Comments are superfluous! I had one left over from those made for the Quorn. You may want to make something simpler.

Part 6. Small Stud

To fit into the ball handle. Again a simple piece to make. The spigot is to take the thrust pad.



Part 7. Thrust Pad

This is fitted to Part 6 to enable tightening to be done without marking Part 2.

Part 8. Large Stud

Again, an easily made part.

Part 9. Washer

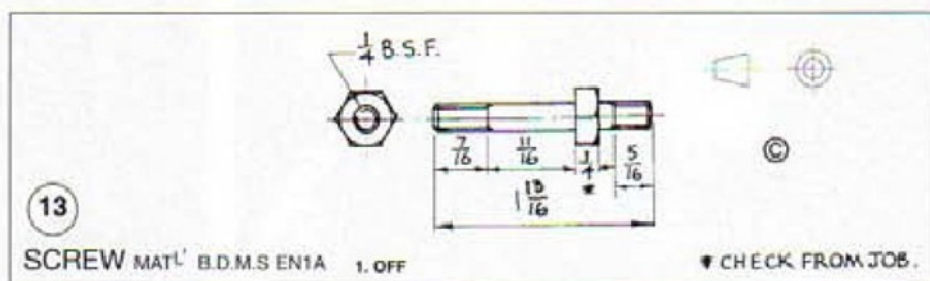
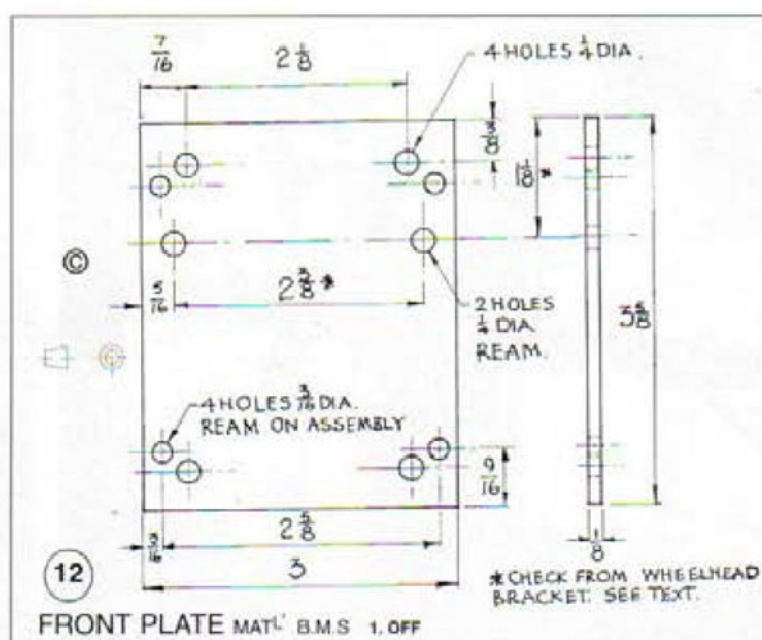
As already explained, this is only needed if you are using aluminium for the bracket. The faces need to be parallel of course.

Part 10. Nut

This item is for the stud (Part 8). The tapped hole needs to be positioned such that the nut cannot turn when the top nut (a plain hexagon, unless you want to make another ball handle!) is tightened.

Part 11. Table

I used black mild steel angle for this. The outer faces were skimmed flat by fly cutting prior to slotting. Because this material is hot rolled it is not stressed, so machining did not produce any distortion. In the case of bright drawn angle, stresses set up during the drawing process could cause it to distort as a result of machining, so anneal beforehand.



Part 12. Front Plate

Before commenting on the making of this part, I should point out that my photographs could cause some confusion regarding the positioning of the 1/4in. dia. holes for fixing the front plate to the wheelhead bracket. On my version of the Quorn - a Mk. 1 - the wheelhead bracket casting is mounted upside down, so my holes are low down compared with the drawing. I only discovered my error when I came to prepare this article. Actually, it doesn't make the slightest difference to the functioning of the machine, and in the Mk 2 version it is this way up. However the

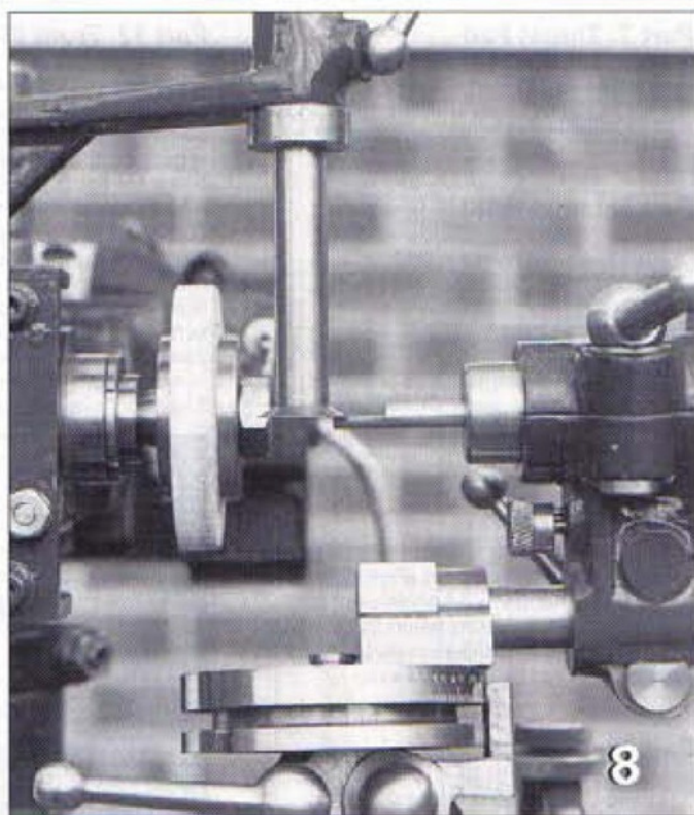
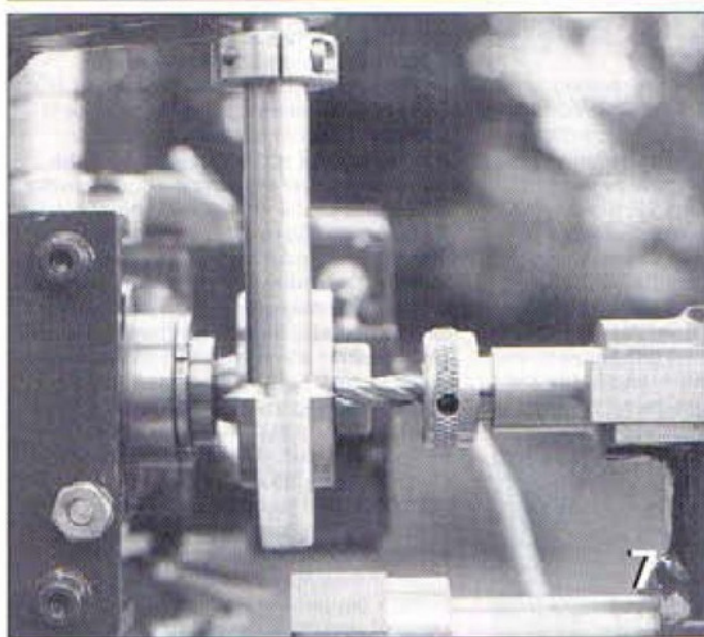
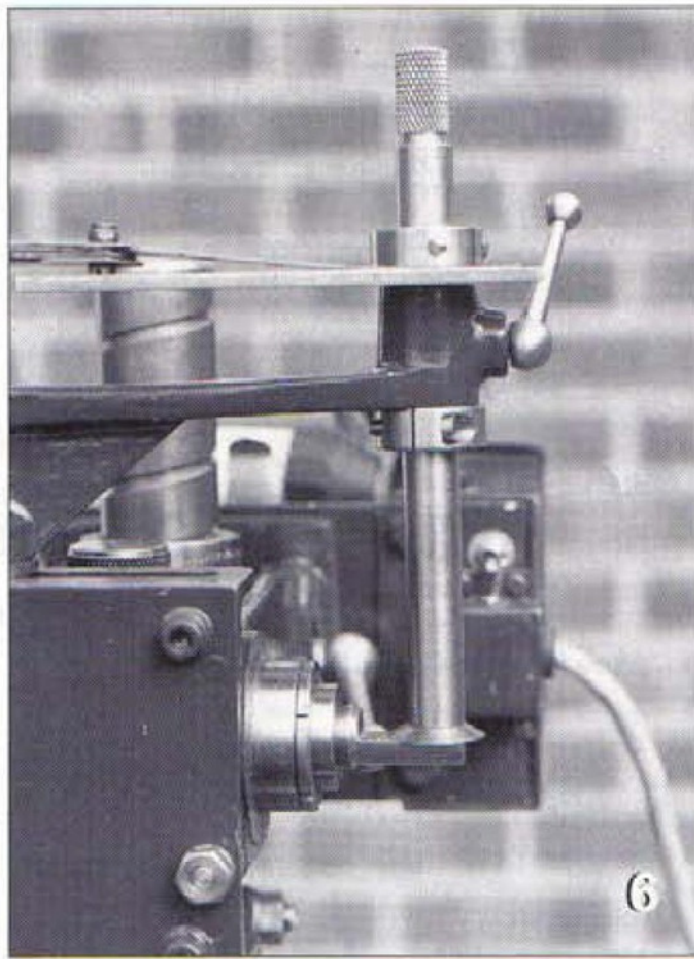
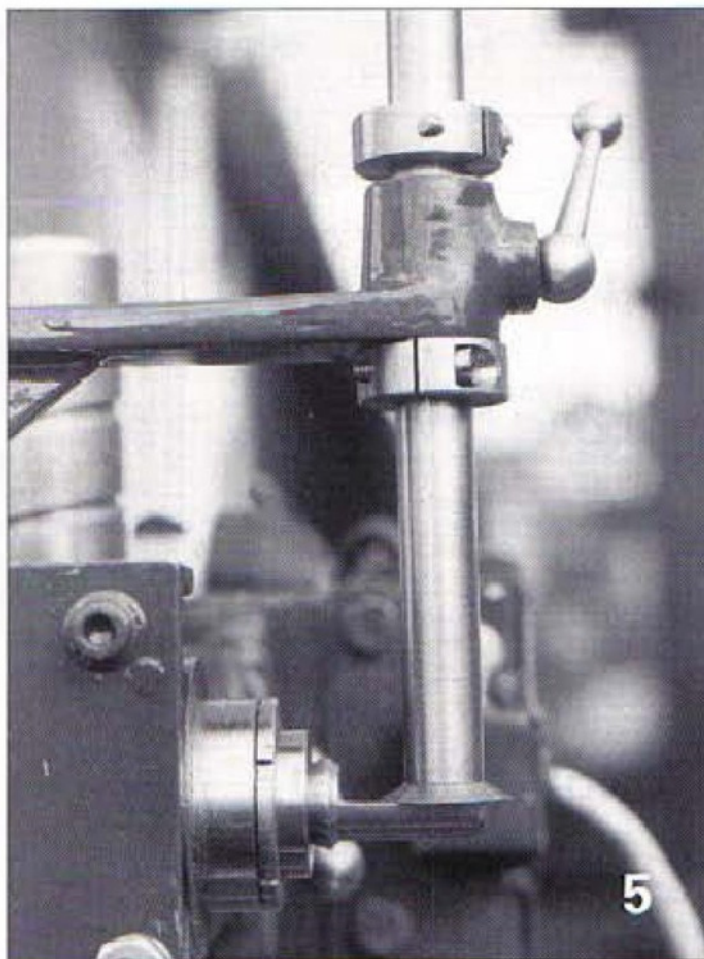
drawing is correct for a Mk. 1. Mark 2 owners please make the necessary correction.

Back to the making: The front plate is the foundation of the accuracy of the device, so care is needed in getting the upper and lower horizontal edges parallel to the axis of the wheelhead spindle. Also, the holes drilled to attach the plate to the wheelhead cannot be 'spotted through'. Instead, the centres have to be measured with a large micrometer or vernier. This can be done by fitting into the wheelhead casting short studs with threads to match those in the casting. Next, measure the distance across the outside. Subtracting one diameter will give the distance between centres. A further point is to check the heights of centres. These may not be parallel with the spindle axis. To check this, a datum can be taken from the bed bars by putting a parallel plate on them and using a d.t.i. mounted on a surface gauge. The parallel plate can be a piece of ground flat stock or plate glass.

Having noted these dimensions, they need transferring to the front plate by use of a vertical miller or vertical slide on the lathe for co-ordinate drilling (measuring distances by use of feedscrew indices). It will be necessary to set up the plate parallel with the table ways or slide. Again, a d.t.i. can be used to check this.

On completion of these fixing holes, further holes can be set out and drilled for fixing the upper and lower tables. The latter can be clamped parallel to the front plate and the holes spotted through, drilled and tapped. Leave the dowel holes until later. The tables can now be bolted to the front plate.





Part 13. Screw

The only point worth mentioning here is that, having completed the long spigot and thread first, it would be a good plan to grip the long spigot in a collet, if you have one, to ensure that the shorter spigot is concentric with the longer one. An alternative would be to machine the component between centres. I have shown the length of hexagon as being $\frac{1}{4}$ in., but check this from the job to ensure clearance between front plate and wheelhead bracket.

Temporary assembly of the tables / front

plate to the wheelhead can now be carried out in preparation for checking the parallelism of the tables and spindle axis. To do this, fit the bracket, and large stud, washers and nuts. Now attach a d.t.i. to the bracket; it may be necessary to make an adapter to fit into the $\frac{1}{2}$ in. bore of the bracket. You next need the test bar you made to test parallelism of the spindle with the bed bars originally. If, like me, you have used it to make a wheel arbor, then

I'm afraid you'll need to make another! To test for parallelism move the bracket to one end of the table and adjust the d.t.i. to contact the test bar. It will be necessary to make sure that the d.t.i. stylus contacts the test bar on the diameter, or a false reading will be recorded. I use a home-made 'elephants foot' for this, as shown in

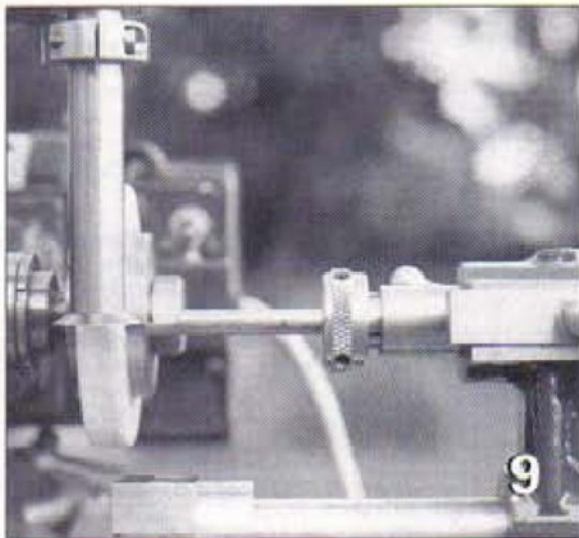


Photo 4. This simply fits over the end of the stylus of the d.t.i. and provides a larger surface, so that it will automatically contact the high point on the diameter. However, the contacting end must be flat and square to the axis of the stylus. Lock the d.t.i. in position and re-check the reading to make sure you haven't changed the position during the tightening. Move the bracket to the other end and take another reading. If it's the same, then the table is parallel with the spindle. Congratulations! But if, like me, you find it isn't, then note the difference and whether it is plus or minus. Remove the table and elongate the appropriate hole in the appropriate direction, using a

round file. Make sure that any adjustment makes the table protrude above the level of the front plate, so that the top edge of the front plate doesn't interfere with the alignment and accuracy of the bracket. Reassemble and re-test. By this means, you should achieve a surface horizontal to the spindle.

Give the screws a final nip, check again, and if all is well remove the front plate / table assembly from the wheelhead casting. Drill, ream, and dowel to lock the position, using Loctite to secure. Repeat this procedure for the other table.

After painting, you can finally assemble and begin to use your Centre Finder.

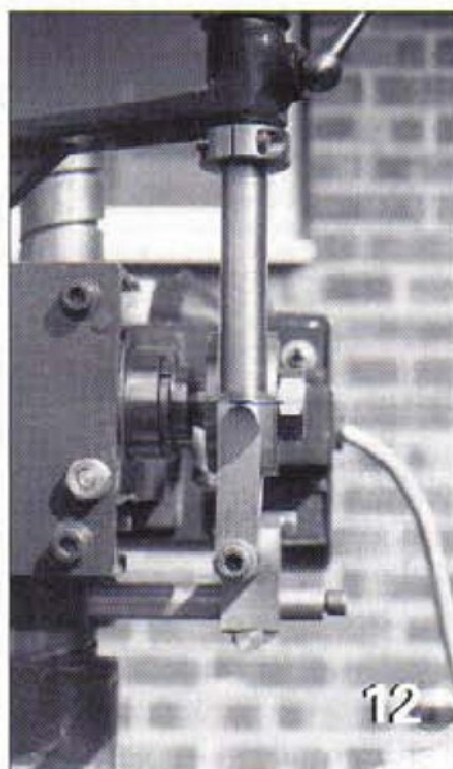
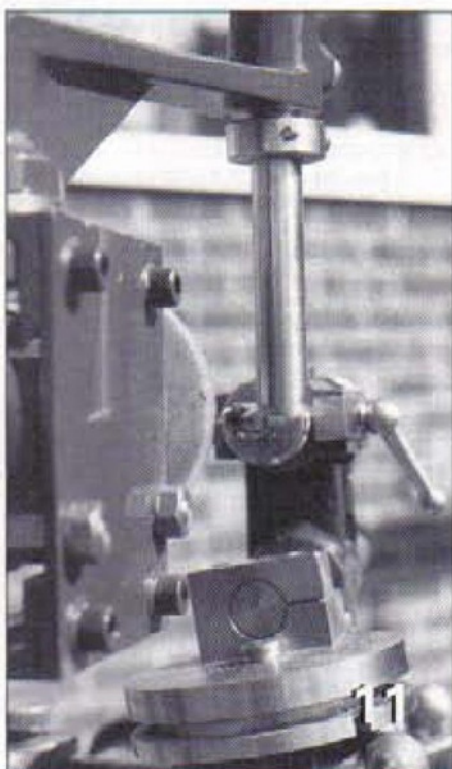
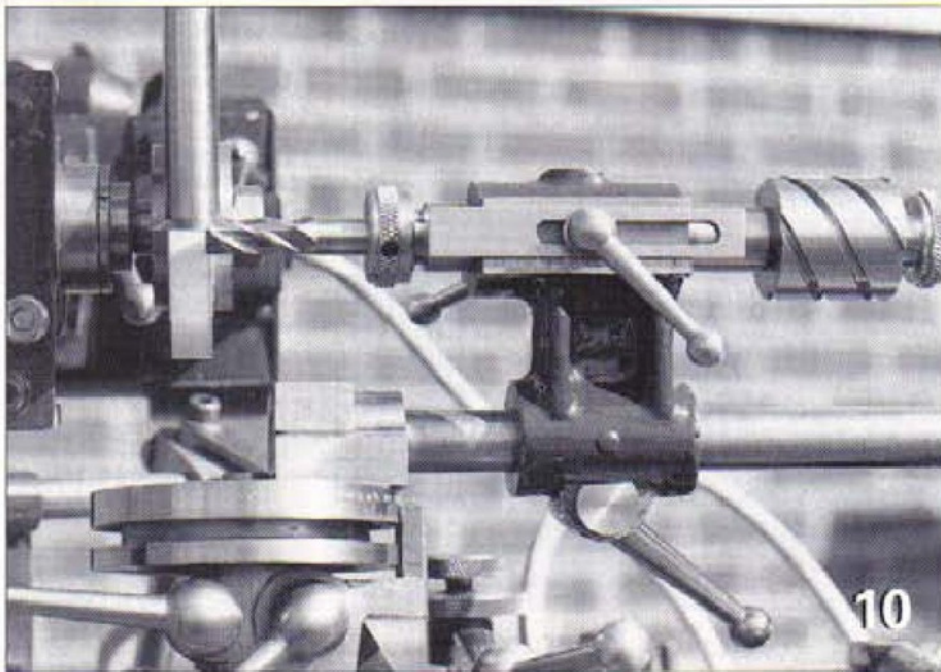
Using the Centre Finder

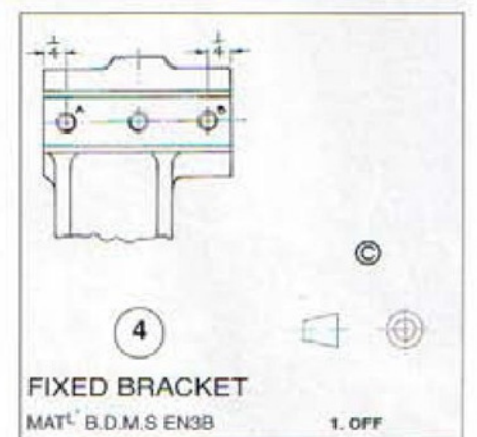
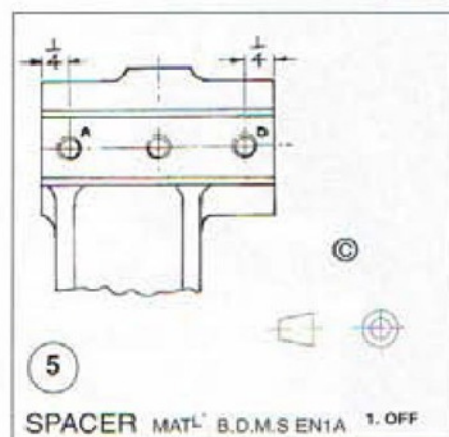
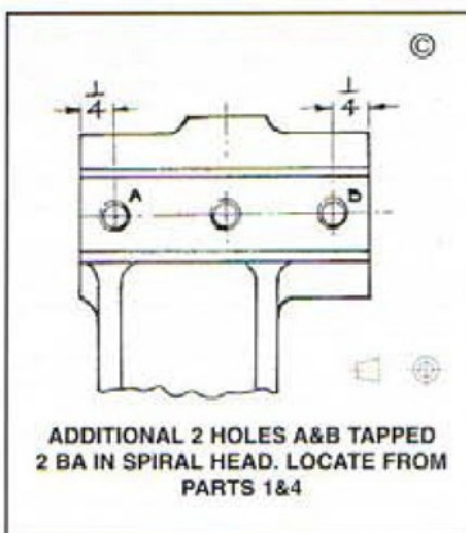
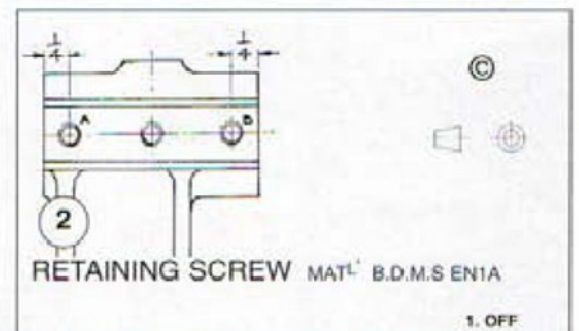
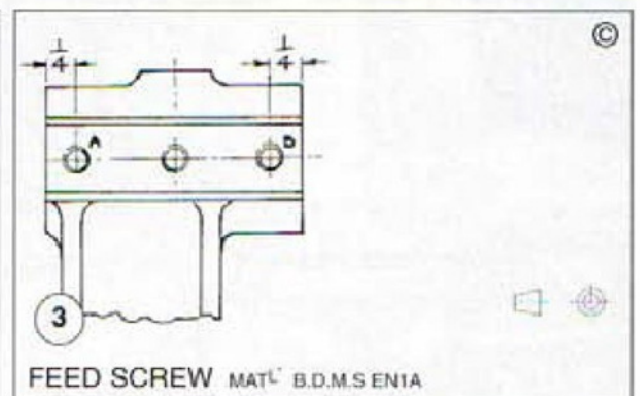
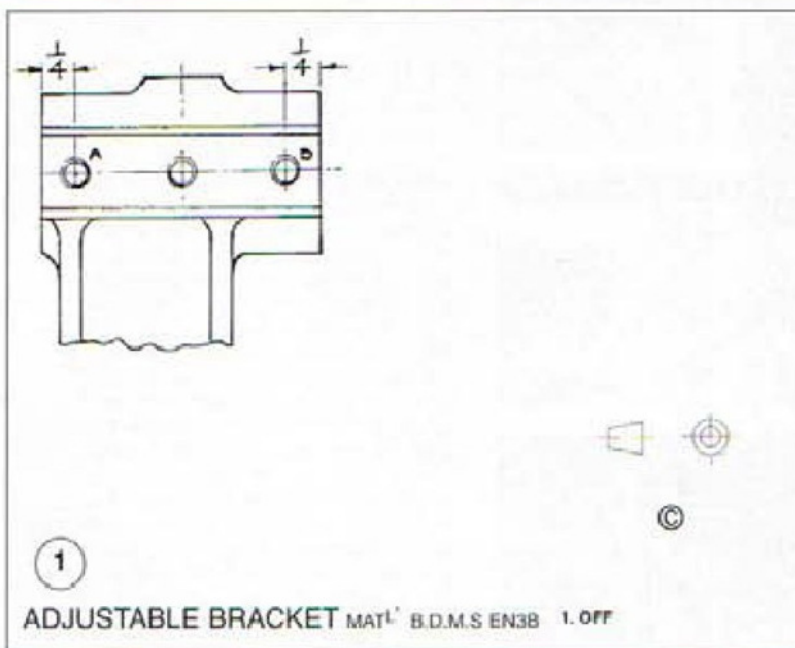
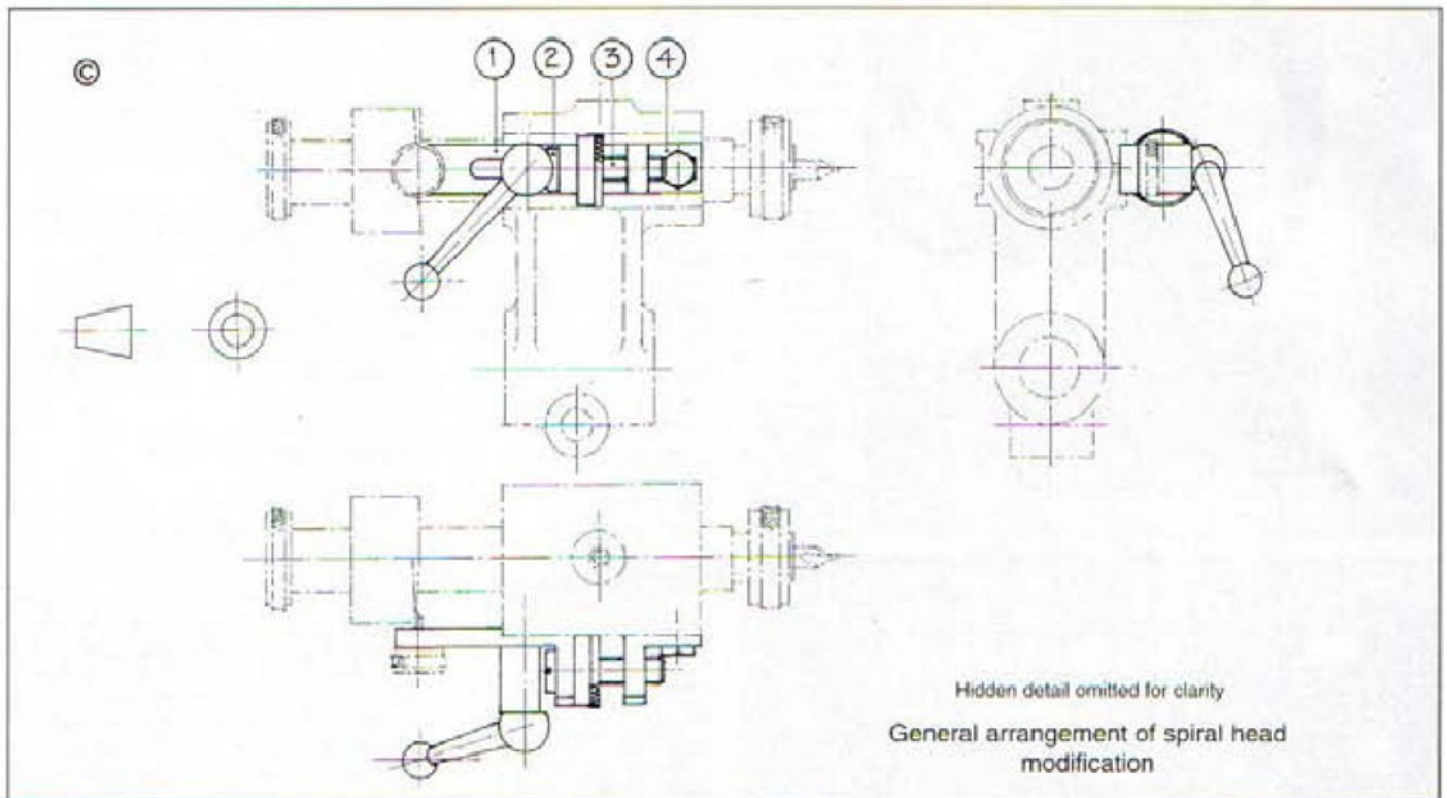
As an example of its use, I have taken the setting-up for grinding the helices of an end mill, the procedure being as follows:-

Find the centre height of the wheelhead by adjusting the height of the disc to touch the flat surface on the wheelhead setting pin (**Photo 5**). Tighten the ball handle. Set the bottom collar to touch the underside of the bracket boss, also seen in **Photo 5**, locking this position using the collar clamp screw. Set the top collar to the clearance distance from the upper surface of the boss on the bracket, using a known thickness of strip plus a feeler gauge to equal the clearance distance (**Photo 6**). Tighten the collar screw. (Clearance distances can be obtained from the table in Prof. Chaddock's book. As an example, for a wheel dia. of 2.75in. and a clearance angle of 6 deg., the distance is 0.145in.). Remove the setting pin from the wheelhead and fit the grinding wheel. Fit the cutter to be ground in the workhead and adjust workhead and cutter relative to the grinding wheel, so that an approximate working position can be established. The wheelhead centre height may need to be adjusted to line up with the workhead centre height, and the centre finder will assist here (**Photo 7**). Remove the cutter and fit the setting pin in the workhead. The centre finder can now be used to accurately set the centre height of the wheelhead and workhead relative to each other (**Photo 8**). (Yes, I know it's the other workhead, but the principle's the same). The wheelhead height can now be set to the clearance angle by first lowering the centre finder to the preset clearance distance and locking it then raising the wheelhead to make the disc just touch the setting pin in the work head (**Photo 9**). The setting pin can now be removed and the cutter replaced. The centre finder, still on the centre height of the cutter, can be used to set the cutter relative to the spiral hob (**Photos 10 and 11**), then the centre finder can be swung out of the way, ready for grinding to start.

Phew! Written down, this sounds little better than that which we had before, but at least the straight edge routine has been eliminated, and it does take longer to explain than to do. Another advantage is that the centre finder can be swung back into action instantly for setting another cutter or for rechecking.

The procedure for larger cutters gripped in the alternative workhead spindle is much the same, the only difference being





that the tooth rest is needed for guiding the cutter past the wheel. Here the centre finder, still at workhead (clearance) centre height, is used to set the tooth rest to the correct height (Photo 12).

The spiral head modification for centre drill restoration

Although we don't like to admit it, we all, sooner or later, break the point on our centre drills, particularly the small ones. In the past, such broken centre drills were used as (expensive) tool bits for boring tools.

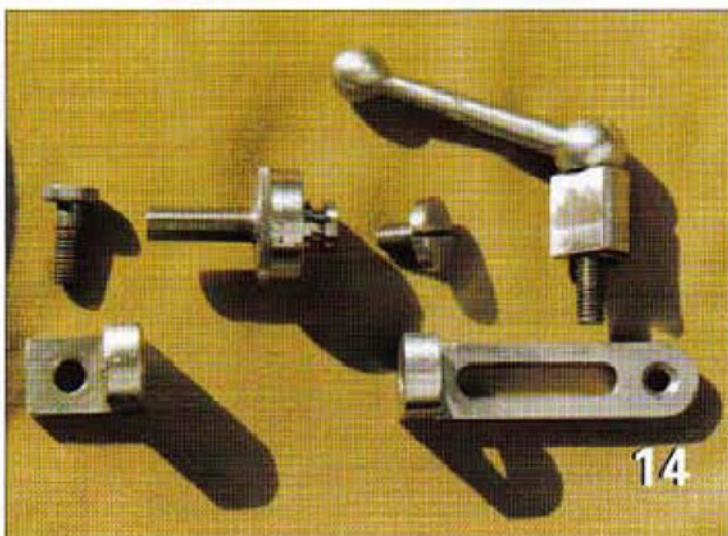
Once you have made the Quorn, broken points can be restored, at least once, before consigning the drill to toolbit duties. In his articles and book on the Quorn, Prof. Chaddock shows how this can be done. Briefly, the body diameter of the centre drill is gradually ground back, to leave the smaller diameter restored. This is carried out on the spiral head attachment, using the specially made face cam to grind the body to a new face which will be at the customary angle of 60 deg. and give the required relief to enable it to cut. The limit to which this can be done is, of course, determined by the amount of spirally cut flute originally ground in manufacture. Photo 13 will hopefully make this clear. Grinding the tip to 118 deg. (or four facet) is of course also necessary before the centre drill can be used.

When I first attempted point restoration on centre drills, I found that gradually and incrementally moving the centre drill forward for each pass was difficult. What is required is more precisely controlled movement, so my attachment aims to fulfil this requirement.

The device is quite simple and builds on the foundation of the spiral workhead. Only two additional holes need to be drilled and tapped in it, and this does not affect the original functions in any way.

Photo. 13 shows the attachment in use and the General Arrangement drawing shows the main features. Photo 14 shows the parts which are numbered from 1 again for this section of the article. All are detailed, except standard fasteners and the ball handle.

The attachment consists of a Fixed Bracket, Part 4, which is firmly screwed to the spiral head. It has a $\frac{1}{4}$ x 40 thread tapped in it to take the Feed Screw, Part 3. The $\frac{5}{16}$ in. dia. boss fits in the Moving Bracket, Part 1, and is secured by the Retaining Screw, Part 2. The moving bracket is drawn along the spiral head slot to give the required movement, controlled by the feed screw. The position of the moving bracket can be locked via the ball handle screw, similar to the original one made for the spiral head, but with a longer



screw. This needs a Spacer, Part 5, to allow the tightening action to take place. A slot is provided in the moving bracket to provide movement fore and aft. (This slot is shorter than that seen in the prototype). The original guide pin is used to work with the face cams.

Please note that the groove machined in the $\frac{5}{16}$ boss of Part 3 (which was intended to take a radially mounted retaining screw), is not necessary and is not shown on the detailed drawing. Also, the feed screw thimble of the prototype was indexed, but this was later found to be unnecessary.

Now to the making. Again, I propose not to give a blow by blow account, but to discuss only those elements which will enable a successful outcome.

Parts 1 and 4. Adjustable Bracket and Fixed Bracket

I have suggested bright drawn mild steel (B.D.M.S.) here, but it may be difficult to obtain these sizes in small quantities. However, if B.D.M.S. is used, please remember to anneal before starting to machine, to avoid the possibility of distortion. For the prototype, I made both brackets from black mild steel angle, machining them all over. The important

points are (a) to make the $\frac{1}{2}$ in. widths a close, sliding fit in the work head groove, (b) to make sure that the $\frac{5}{16}$ in. dia. and $\frac{1}{4}$ in. x 40 holes are aligned and (c) to spot through from the brackets into the workhead at tapping size, so that the holes will align. In the case of Part 1, complete the slot after doing this.

Part 3. Feedscrew

A straightforward piece of turnery, but note that the shoulder dimension length of 0.191 in. is to make sure that the feedscrew has a little clearance to allow it to turn when the retaining screw is fully tightened. The thickness of the bracket will need to be checked here.

Part 2. Retaining Screw

A straightforward part. You may prefer to make this from a piece of hexagonal bar to avoid the slot for a screwdriver.

Part 5. Spacer

Again a straightforward part. The flat along one side is to give clearance for the retaining screw. Also, the tenon machined on the base is to prevent the spacer from turning. Since the milled faces are to take the tightening load, they will need to be milled with care to ensure: (a) the same depth on each side, and (b) a surface square to the axis.

As already mentioned, the ball handle screw is similar to the ones already made, so I have not drawn it again. The ball handle will need a $1\frac{3}{8}$ in. length of 2 BA studding to complete this item. Alternatively, a $1\frac{3}{8}$ in. length of $\frac{3}{16}$ in. dia. rod can be threaded 2 BA at each end.

The 2 BA x $\frac{1}{2}$ in. long hex. head screw used to secure Part 4, Fixed Bracket, is a standard item, although the head depth is perhaps less than standard. As long as it doesn't foul the $\frac{1}{4}$ in. x 40 feed screw, then all will be well. An alternative to thinning down a standard head would be to counterbore the fixed bracket to provide the necessary clearance.

The procedure for grinding centre drills is already covered in Prof. Chaddock's book and in the articles originally published in M.E. in 1974. Since the above device merely assists the process, I think further comments on its use are hardly necessary. However, at the risk of insulting your intelligence, it may be helpful to point out that the feed screw is adjusted with the ball handle slackened, and grinding is carried out with the ball handle locked.

I hope the above description of the modifications will encourage you to have a go at making them. I know the time spent on making them have been worthwhile for me.



TRADE COUNTER

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

Maidstone have moved

There will be mixed reactions to the news that Maidstone Engineering Services have moved from their Hedley Street premises. Customers who were familiar with the old shop will recall the rather cosy and intimate atmosphere engendered by the diminutive size. It was impossible not to become well acquainted with anyone else visiting at the same time. Now, however, the business occupies much larger accommodation at Staplehurst, just a few miles down the A229.

The team will be pleased to welcome visitors between 9.00 a.m. and 5.30 p.m., Monday to Friday and between 8.30 a.m. and 1.00 p.m. on Saturdays. The usual mail order service is in operation, catalogues being available in return for four 1st class stamps (Overseas £1.50)

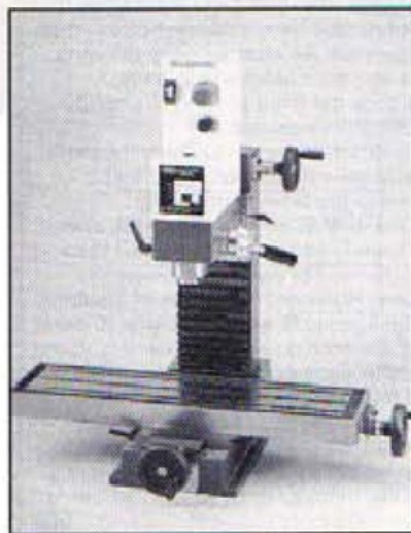
Maidstone Engineering Services
(Sales), 4 Larkstore Park, Lodge Road,
Staplehurst, Kent TN12 0QY Tel.
01580 890066 Fax. 01580 893020

The Levitron

Following correspondence in Scribe a Line regarding the Levitron, a magnetic levitating toy, Hamiltons Magic of Weston super Mare were hoping to obtain some from the USA, but the price quoted proved to be unattractive. The company has now contacted us again to say that they have located a new source, willing to supply at a much lower price (£29.99), subject to a minimum order quantity. Unfortunately, they did not keep a record of all those who enquired, so anyone still interested should give **Noah Kelly** a call on **01934 643475**.

Riveting tool frames

In our recent edition of Tom's Tips we showed a riveting tool made by Tommy Bartlett. He made the frame out of an old blacksmith's bending bar which he had found at a car boot sale. As few readers are likely to be as lucky in finding something suitable, one of Tommy's SMEE colleagues, Ian Cornish, has produced some flame cut U shaped frames of approx. 1 1/4in. square section. Ian is willing to make these available at £9 each, including p & p, a price which is little more than the cost of postage. Anyone interested should contact Ian at the address below.



Mains voltage power tool from Minicraft

Minicraft are well known for their ranges of low voltage variable speed power tools. They have now introduced a new mains voltage unit, the MiniMax, which features a DIN (43mm) body, making it compatible with the existing range of Minicraft attachments including the MB540 drill stand, the MB592 drill holder and the MB850 lathe attachment. It will also fit any other standard drill stand and attachment on the market.

Powered by a 90w output fan cooled motor, the unit has a speed range of 8000 - 21000 rpm and features a ball bearing drive shaft and an internal vibration shock absorber. A keyless steel chuck, which should be used only at lower speeds, will accommodate tooling from 0.3 to 3.2mm dia., while a 3.2mm steel 4 jaw collet is included for maximum grip and high speed precision work.

The Minimax is available in two versions, the MX1 which includes only the basic tool, at a list price of £59.99, and the MX2 which also includes a 100 piece heavy duty accessory set (MB1940) and the tool rest and accessory holder (MB594), all packed in a plastic storage and carrying case at £89.99.

Minicraft, Macford Products Limited, 1 & 2 Enterprise City, Meadowfield Avenue, Spennymoor, Co. Durham DL16 6JF.
Tel. 01388 420535 Fax. 01388 817182



New catalogue from J & L Industrial Supply

J & L Industrial Supply have recently published their 5th Edition 1998/99 Catalogue. A massive volume of 1188 pages, it contains details of over 75,000 products and is free on request. The J & L slogan is "Everything for Metalcutting" and a quick browse through the pages of this publication suggests that this is no idle claim.

The basic catalogue is backed up by a periodic promotional document entitled 'Advantage' in which sale items at significantly reduced prices are listed. This is mailed free to recipients of the main catalogue.

J & L Industrial Supply, 7 Pacific Avenue, Wednesbury, West Midlands WS10 7WP
Free Phone 0800 66 33 55
Free Fax 0800 58 00 58

Wabeco Milling Machine

At the recent Midlands Model Engineering Exhibition we were able to inspect one of the new Wabeco F1210 E milling machines being marketed by PRO Machine Tools Ltd. This substantial machine, manufactured by Walter Blombach GmbH of Remscheid, Germany is somewhat unusual in that the rotatable milling head is carried on a dovetail slide rather than on a round column.

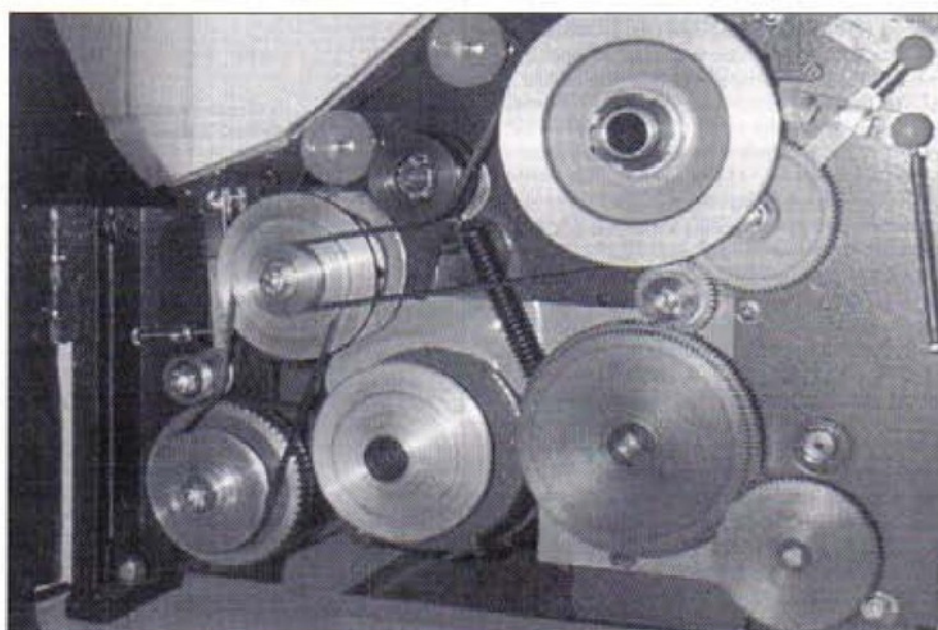
The work table measures 700mm x 180mm and has a longitudinal travel of 500mm and a cross travel of 150mm. Folding covers protect the cross and vertical slides. The 1.4 kW single phase motor features electronic control, giving spindle speeds from 180 to 3000 rpm.

Prices are said to be extremely competitive for a well equipped machine, and digital read-outs and a cabinet stand are available as optional extras.

PRO Machine Tools Ltd., 17 Station Road Business Park, Barnack, Stamford, Lincs. PE9 3DW Tel. 01780 740956 Fax. 01780 740957 email: ProMach@aol.com

A SLOW SPEED DRIVE FOR A WARCO 918 LATHE

A common complaint against the lathes now widely available from Far Eastern manufacturers is that they have restricted ranges of mandrel speeds and that the lowest speeds are often far too high for the needs of the model engineer. David Berrecloth of Crawley, West Sussex has devised a modified arrangement which removes some of the restrictions



The revised drive arrangement and modified door

I was interested to see in *Model Engineer* back in 1997 (Refs 1 and 2), the slow speed fitment for a Warco 918 lathe developed by Mr P A Hickling, using the APTC kit of bits. I am not familiar with the APTC kit and I could not do the same as Mr Hickling because where he drilled and tapped the hub of the 'B' pulley, I have fitted a ball race, so my slow speed arrangement is different.

The features are:-

1. I have nine speeds instead of the original six.
2. The slowest speed is now 42 rpm.
3. The safety clutch operates on four speeds.
4. The standard drive belt is used as normal and the standard belt tensioner operates as normal on all speeds.
5. The standard toothed belt is used, as normal, to take the drive from the motor (but to a different shaft).

In operation, the motor drives an additional pulley block (which I have called the 'X' block), behind and slightly below

the motor pulleys. The 'X' pulleys drive the 'B' pulleys by an additional (small) belt.

New pulley ratios and speeds

My first thought was to have just two pulleys on the 'X' shaft driving the 'B2' or 'B3' pulleys. This would give the original 100 and 500 rpm speeds plus two new low speeds, and one extra belt might suffice. I would relinquish the 250 rpm speed. However, I have broken two drive belts (at about £12 each) when a cutter dug in while milling at speeds other than 100 rpm, which is the only speed on which the safety clutch operates as standard. I therefore decided to have a third pulley on the 'X' shaft and another belt, giving two lowish speeds, driving through the safety clutch.

Once you contemplate an additional pulley block, the range of possible permutations is quite large. The only restrictions are the sizes of the three 'B' pulleys. I chose a ratio for the 'X3' pulley to the 'B3' pulley of one third (the outside diameter of the 'X3' pulley is 1.270in.). The original slowest speed, which was quoted as 100 rpm was in fact nearer to 120 rpm, so slowing it down to about $\frac{1}{3}$ speed

produced a new slowest speed of 42 rpm, rather than 30 to 35 which I initially envisaged. This is driving from the 'B1' pulley to the 'C1' pulley, the 'C' pulleys being those on the headstock mandrel. It would be possible to get the slowest speed lower, down to perhaps 30 rpm, by making the 'X3' pulley smaller, but in my arrangement this pulley is already quite small and I thought if it was made any smaller, the belt would surely slip under heavy or hard cutting conditions. The new speed driving from the 'B2' pulley to 'C2' is 95 rpm. This is without the benefit of the safety clutch. I aimed for a ratio for the 'X1' pulley to the 'B1' pulley of 0.9 (the outside diameter of the 'X1' pulley is 1.410in.). This gives speeds of 240 rpm with the main belt on 'BC2' and 450 rpm on 'BC3', in both cases with the drive through the safety clutch. For the ratio from the 'X2' pulley to the 'B2' pulley I wanted to slightly increase the speeds which were quoted as 100 rpm and 500 rpm. With a ratio of about 1.1 (the outside diameter of the 'X2' pulley is 2.875in.) these two speeds are now 130 rpm on 'BC1', which is through the safety clutch, and 525 rpm on 'BC3'. The speeds of 350, 900 and 1800 rpm on 'AC1', 'AC2' and 'AC3' are unaffected. On my lathe the

lowest of these three is actually 360 rpm. Thus, my new set of speeds is 42, 95, 130, 240, 360, 450, 525, 900 and 1800 rpm, with the 42, 130, 240 and 450 rpm speeds driving through the safety clutch.

Fitting ball races

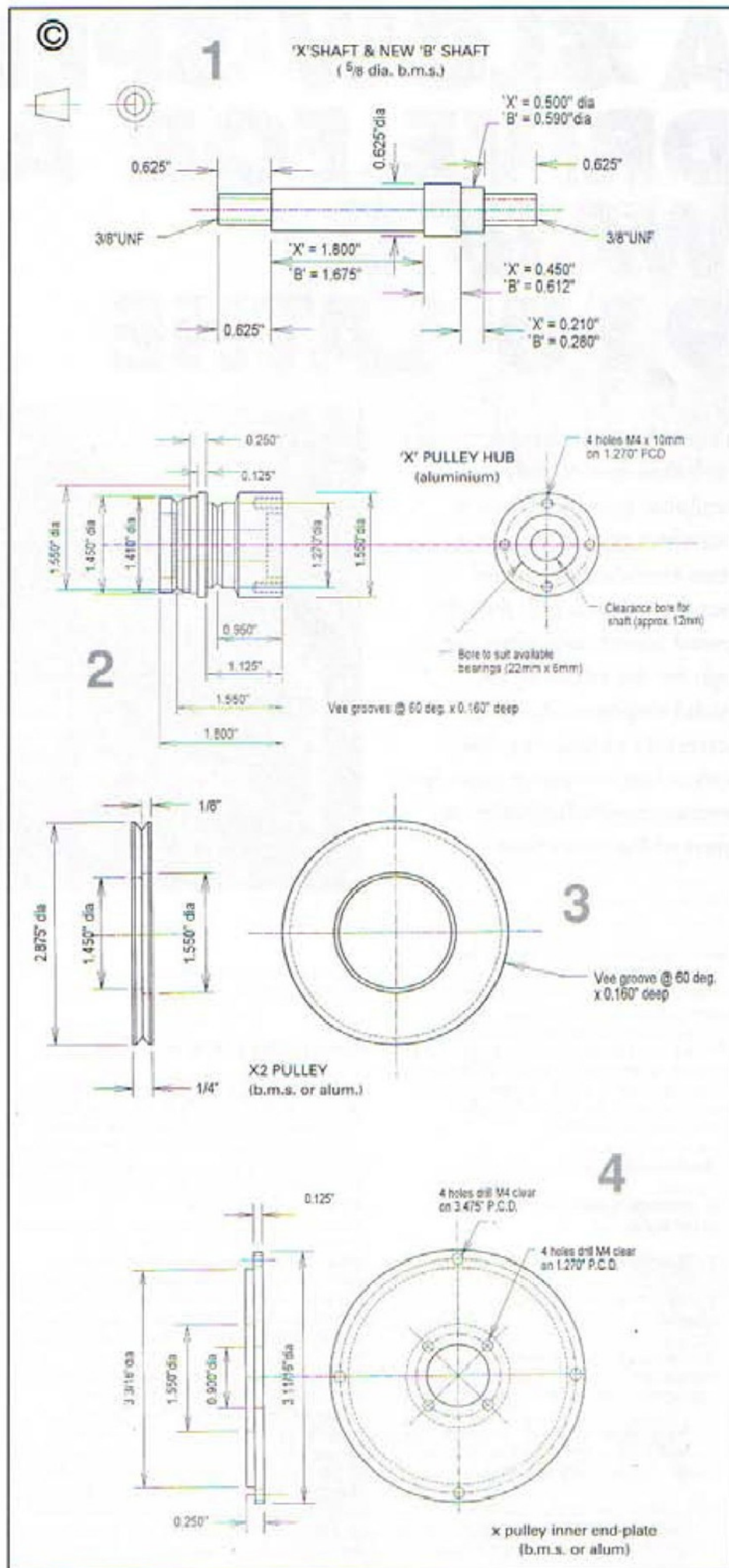
Fitting ball races to the hub of the 'B' pulleys is not an essential part of creating a slow speed, but it became part of my project. When filled with high melting point grease, the bearings should be maintenance free. The 'B' pulleys on my lathe seized up early on, and the brass bush started to break up, so I bored out the ends of the hub and fitted ball races. The largest ball race which will fit in the small end of the hub is about 22mm OD. This means 10mm ID, so a new shaft was needed (**Dwg. 1**). Although this is smaller than the original, which was 12mm, the new one is solid whereas the original was hollow. I bought two more ball races of the same size to use for the hub of the 'X' pulleys. The 'X' shaft is much the same as the 'B' shaft (**Dwg. 1**) but some of the dimensions are different.

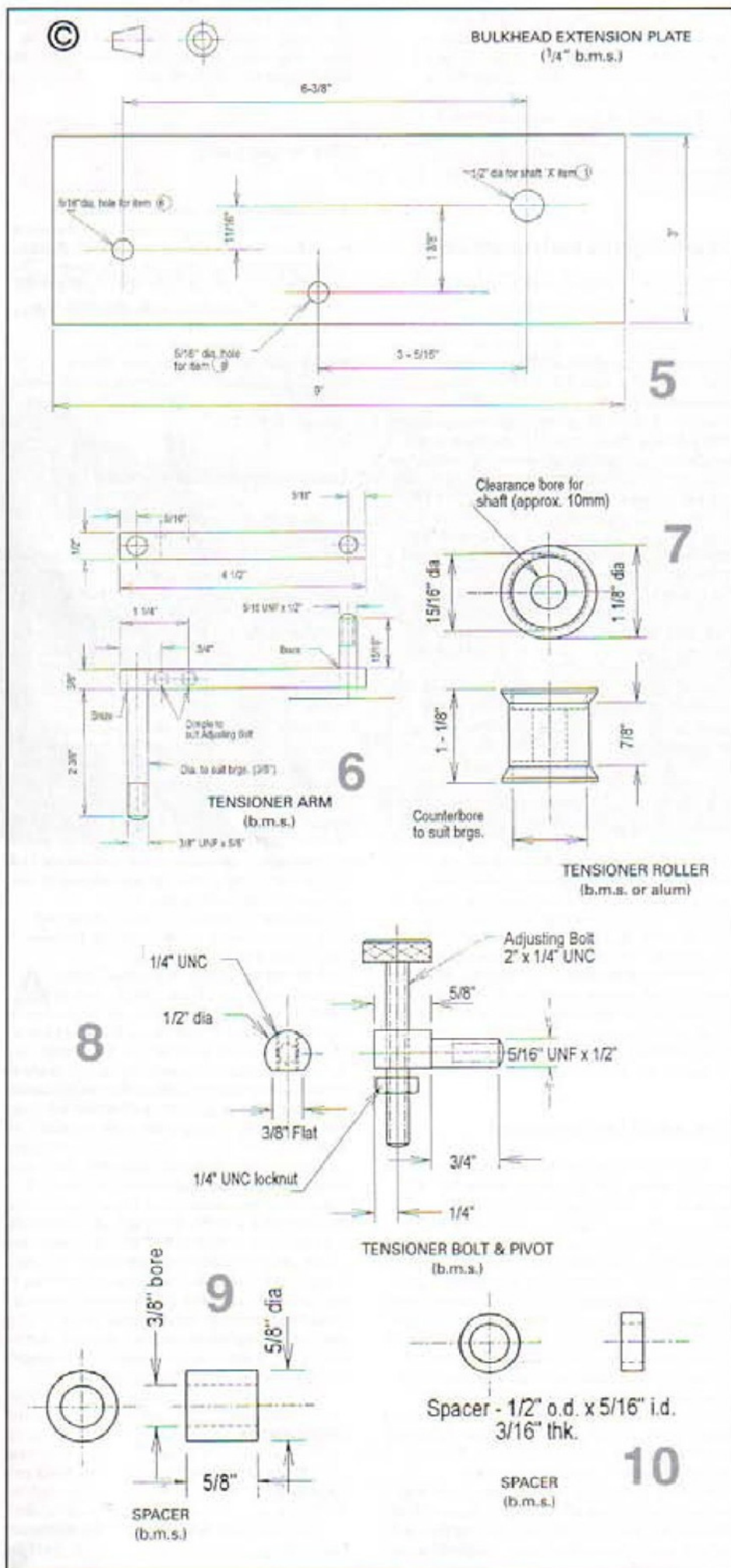
Originally, the 'B' pulleys did not line up very well with the 'C' pulleys. The 'C' pulleys lined up with the 'A' pulleys on the motor shaft, although I had to adjust the motor mountings a little to get the motor shaft parallel with the axis of the lathe, so the 'B' pulleys needed a spacer. Now, with the 'B' and 'C' pulleys lined up, the toothed belt ran right on the edge of the toothed wheel. With the toothed wheel separated from the 'B' pulleys, the dimensions I have given for the new pulleys and pulley shafts ensure that, on my lathe, all the pulleys line up properly and the toothed belt runs in the centre of the toothed wheel. My dimensions allow for a washer outside both bearings on the pulley shafts, to keep the grease in and the dirt out. These washers are a good fit on the shaft and are chamfered at the edge to prevent them touching the outer rings of the bearings.

The bearings for the small belt tensioner were bought at an M.E. exhibition and are to Imperial dimensions. They were so cheap, compared with the bearings from my local stockist, that I wonder what is inside them, but you cannot see because they have side plates.

Modifying the door

I used Nyloc nuts to hold the pulleys/bearings on the shafts because they can be tightened so as to just nip the inner rings of the bearings. However, they do stick out further than the original 'B' shaft, so I modified the door. The door needs to be longer to cover the extra pulleys on the extension to the lathe bulkhead (see later) so I sawed through the top and bottom horizontal panels and folded the end 1 3/4 in. out to create a convex V shape at the point where the door covers the 'X' and 'B' pulleys shafts and the small belt tensioner shaft. I filled in the gaps at the top and bottom of the door by welding in 1mm thick plates. Brazing or riveting would do, of course. I changed the door hinge for one with a removable pin, so the door can be completely removed to give greater access to the pulleys, gears,





etc. Because the larger door has a tendency to droop on the hinge, I fixed a nylon wheel under the front end, and this runs on my worktop when the door is opened or closed.

One of the first things I did to my lathe was to change the socket screw which held the door closed, substituting an arrangement using a threaded plastic wheel. However, I later scrapped that in favour of a simple latch on the front end of the door. This change facilitated another improvement while I was carrying out the alteration: I riveted a piece of $\frac{1}{2}$ in. x $\frac{1}{2}$ in. x $\frac{1}{16}$ in. aluminium angle along the top of the bulkhead to overlap the door when it is closed, thus keeping swarf out of the compartment which houses the pulleys and gears.

Making the additional pulleys

I made the new 'X' pulleys from three pieces of aluminium plus the rim of the toothed wheel separated from the 'B' pulleys. The hub, incorporating the two small pulleys 'X1' and 'X3' was made from a piece of 40mm diameter bar (**Dwg. 2**). The 'X2' pulley, which was made from $\frac{1}{4}$ in. plate (**Dwg. 3**) has a stepped bore in its centre to locate it against a shoulder on the hub, to which it was fixed with shaft grade 'Truloc'. Incidentally, I have mentioned 'Truloc' in this article because that is the adhesive I used, but I think it is similar to Loctite which seems to be used more widely.

I confess that my early efforts to grind a tool to cut the Vee grooves in the pulleys were not a complete success (inexperience!), so I made the Vee grooves the minimum depth which would accommodate the belts. At the inner end of the 'X' hub is a plate, also made from $\frac{1}{4}$ in. material. This has a stepped bore in its centre so that it fits on to the end of the hub, and it has a shoulder on its edge to mate with the rim of the toothed wheel. I clamped the plate to the hub and drilled four 3.5mm holes through the plate and 10mm into the hub, then separated the parts, tapped the holes in the hub M4 thread and enlarged the holes in the plate to 4.0mm.

I separated the rim of the toothed wheel from the 'B' pulleys with a hacksaw and cleaned up the two pieces in the lathe, turning a recess in the rim of the toothed wheel to mate with the end plate on the hub of the 'X' pulleys. With the end plate and the rim clamped together, I drilled four more 3.5mm holes through the plate and 10mm into the rim then tapped M4 threads in the rim and enlarged the holes in the plate to 4.0mm. When I assembled the three parts with M4 set screws, I put a spot of Truloc on the screw threads.

Extension to the lathe bulkhead

The 'X' shaft and the tensioner for the additional (small) belt are mounted on an extension to the lathe bulkhead. For the extension, the main piece of material is mild steel, $\frac{1}{4}$ in. x 3in. x about 9in. (**Dwg. 5**). To get the lower part of the extension piece closer to the headstock, I sawed $\frac{1}{2}$ in. off the back edge of the original bulkhead. I was going to weld the

extension to the bulkhead, but when I realised that the latter is cast iron, I welded a piece of $\frac{1}{4}$ in. x 1in. x $\frac{1}{4}$ in. mild steel over-lapping the extension piece and bolted this to the bulkhead with two M8 bolts. Welded on to the main extension piece were two pieces of mild steel angle to create a fixed back to the compartment which houses the pulleys and gears (this was originally part of the door). This extends the extension by a further $1\frac{3}{4}$ in. I did this - (a) because the original bulkhead flexed when the main belt tensioner was operated and I wanted to add some rigidity by welding a footplate to the extension and bolting this to the bench, and (b) because I wanted the door hinge at the rear left corner instead of the rear right, simply because I would not have room to open the enlarged door if it was hinged at the right. If you fix the door hinge to the bulkhead extension plate, you will need to make a box section $1\frac{3}{4}$ in. deep at the back of the door. This is the minimum space needed to operate the tensioner for the small belt. An alternative is to use an extension plate $4\frac{3}{4}$ in. wide instead of 3 in. With the bulkhead extended by $4\frac{1}{4}$ in., it seems a good idea to bolt the back of the extension to the bench or surface on which the lathe is mounted, to reduce the weight hanging on the headstock.

Having extended the bulkhead, in order to provide a bit more finger space for grasping the main belt tensioning lever, I reduced the travel of the lever. The last part of the travel was not necessary, so I fitted a stop, bolted to the bulkhead. I found the lever could cause a noisy vibration at some speeds, so I fitted a rubber stop or rest. I found a piece of car suspension bush was ideal, the sort with hard rubber moulded on to a central steel ferrule. Also, I thought that the tension of the spring was excessive, so I reduced it by using a file to enlarge the washer on which the spring pulls. Filing a slot for the hooked end of the spring one side of the washer was all that was necessary.

The location for the 'X' shaft

After removing the lathe bulkhead to cut and drill it, I refitted it with the extension to mark the location of the X shaft. My manual shows three bolts fixing the bulkhead to the headstock, but there were only two on my machine and the holes in the bulkhead were so large that there was considerable latitude in the fitting. Where the top bolt went, I fitted a stud and secured it with Truloc. Although I hope I do not have to remove the bulkhead frequently, the stud was useful for hanging the bulkhead on while lining things up. At this stage it is important to ensure that the 'B' shaft is in the right position because this is a datum point. The 'B' shaft must be positioned so that the toothed belt can be fitted and removed and is at the correct tension. It does not have to be very taut. Next, to locate the 'X' shaft, I temporarily replaced the socket headed screw in the motor shaft with a bolt with a centre punch dot in the head. With this as a centre, I used dividers, set to the centre of the 'B' shaft hole, to scribe an arc on the bulkhead extension. I positioned the 'X' shaft on this arc, as far away from the 'B'

shaft as possible, that is, with $5\frac{1}{4}$ in. between the shaft centres. After drilling the bulkhead extension for the 'X' shaft, I checked that the toothed belt could be fitted and was at the correct tension in its new location. If you have not made the 'X' pulleys and fitted the toothed wheel to them at this stage, you can use the 'B' pulleys on the 'X' shaft to check the toothed belt.

Improving the bulkhead fixing

I thought it best to ensure that the bulkhead was located precisely on the headstock, so, with these items held together by the new stud and the other original bolt, I removed the headstock from the lathe bed. I drilled two 7mm holes through the bulkhead into the headstock then separated the parts, tapped M8 threads in the holes in the headstock and enlarged the holes in the bulkhead to 8mm and countersunk them. Countersunk socket screws now provide a precise fitting for the bulkhead, with the stud at the top providing additional rigidity. To facilitate this drilling and tapping, I had to remove the pulleys from the headstock mandrel, so I took out the headstock bearings, cleaned them, and packed them with high melting point grease. The original Chinese grease looked a bit watery and there was not much of it.

While I had the headstock on the drilling machine, I added another beneficial feature. I drilled two $\frac{3}{16}$ in. holes in the business side of the headstock, $1\frac{1}{2}$ in. apart and 1in. above the mandrel. These were to bolt on a piece of $\frac{1}{2}$ in. square mild steel with a vertical 8mm hole in its centre. Through this hole, an 8mm rod (I use the bar of a chuck key or the bar of the toolpost key) can lock the headstock mandrel by engaging one of the three holes in the circumference of the mandrel. This is useful for fitting and removing chucks, the face plate, arbors with drawbars, cutters in a collet chuck, etc.

When I refitted the headstock, I fixed a piece of 24 gauge aluminium sheet below it to cover the end of the bed of the lathe. This is to stop swarf bouncing through the gap into the compartment in which the pulleys and gears reside.

The small belt tensioner

To tension the additional small belt which drives the 'B' pulleys from the 'X' pulleys, I decided on a mechanical tensioner rather than a spring operated one, because I thought it would be smaller and easier to produce and operate (Dwgs 6 to 10). The tensioner arm pivots from the top of the bulkhead extension. The smaller spacer (item 10) holds the arm away from the bulkhead and the larger spacer (item 9) goes behind the tensioner roller. The adjusting bolt bears on the tensioner arm to push the tensioner roller against the rear run of the belt. For the adjusting bolt, I used a 2in. x $\frac{1}{4}$ in. UNC set screw, with the head rounded and knurled. I used Nyloc nuts to hold the arm pivot and the adjusting bolt pivot. Setting the tensioner is the longest part of changing speed. The tensioner needs a different setting for each of the three pairs of pulleys. Regarding the

dimples in the tensioner arm to locate the tensioner adjusting bolt, I found I needed two in order to get the tensioner bolt at the best angle for all three belts.

The small belts

The original belt was made by the American firm of Gates, but there are other makers who use the same reference numbers as Gates for these sizes of belts and whose prices are about the same. The belts I use are 5M387 for 'XB1', 5M487 for 'XB2' and 5M475 for 'XB3'. You can use the 487 belt for 'XB3', but when it has stretched a bit you will run out of adjustment on the tensioner. When changing a belt from one pair of pulleys to another pair, changing to a different belt seems no bother.

Using an additional main belt

Because, when the smaller belt is in position, it is not possible to change the main belt from the inner 'B' pulleys to the outer or to the motor pulleys, I use two main belts - an 'inner' and an 'outer'. When the small belt is on 'XB1' or 'XB2', the 'inner' main belt, when not in use, is stored on fittings on the bulkhead inside the small belt. The left hand of these fittings is an old $3\frac{1}{2}$ in. pulley with the centre cut partly away fixed encircling the 'B' pulley shaft. The belt is looped round this pulley then both runs go round two fittings (plastic bottle tops) to keep the belt out of the way at the top of the bulkhead. The right hand end of the belt is held on another old pulley ($1\frac{3}{8}$ in. dia.) This pulley is on a pin sliding in a slot in a small piece of mild steel screwed to the bulkhead. The pin is pulled by a spring to the right to ensure the belt stays put. This arrangement allows you to make some changes of speed without disturbing the small belt and its tensioner.

The standard belt is a good fit on pulleys 'AC1', 'AC2' and 'AC3', but it is a loose fit on 'BC2' and 'BC3', so my 'inner' main belt is not a standard 5M710 but a 5M690. This (when new) fits 'BC2' and 'BC3' without any slack, so it is not likely to come off the pulleys when the tensioner is released. You could use a 690 belt on 'BC1', but that would mean yet another belt.

It would be easier to fit the 690 belt when new if the tensioner could be released a little more, but I have not thought of a way to do this. I changed to a tighter belt for 'BC2' and 'BC3' because my experience has been that these belts can acquire a twist and if they do, when they are loose, they come off the pulleys every time the tensioner is released. Then, although they are strong in 'stretch', the sideways stress causes them to break up quickly.

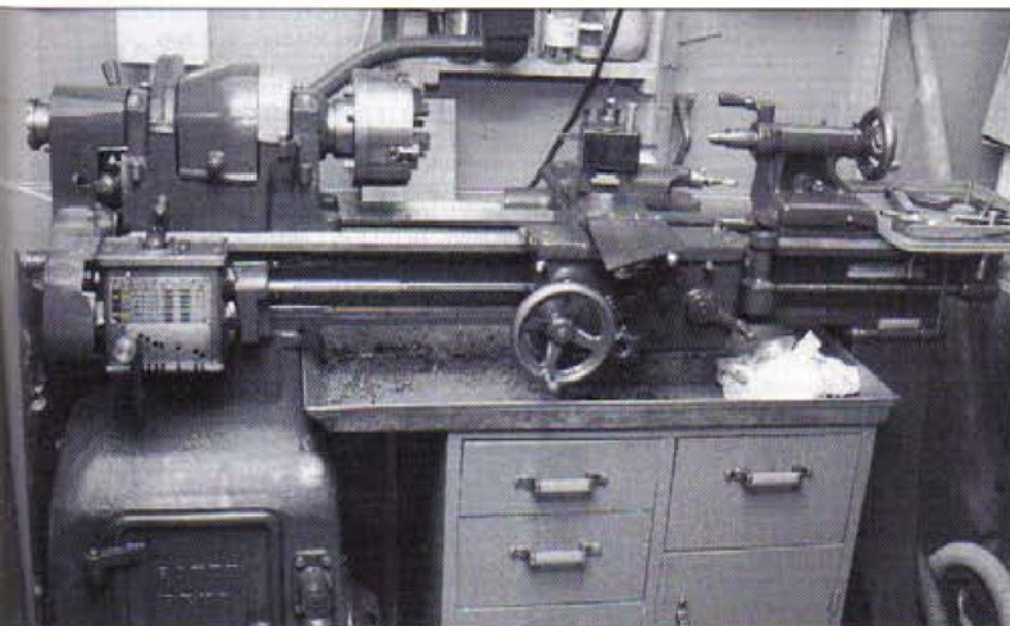
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1. Model Engineer Vol. 178 No. 4043 Page 693
2. Model Engineer Vol. 179 No. 4045 Page 36



A TALE OF TWO CHUCKS

Large lathe chucks are far too valuable to discard without good reason. Ted Wale of Nova Scotia needed chucks for a refurbished Southbend lathe, so set about rehabilitating a couple of well used examples



1. Overhauled and repaired heavy duty 10in. Southbend lathe with the repaired 6in. four jaw chuck mounted

Prelude

A while ago, I was wandering around our local second-hand machinery dealer without any specific need in mind, when I saw a sad looking lathe. It was dirty, it was pushed in half under a shelf and had other things piled on the ways. On enquiry I found out that it was something that I had long desired, a Southbend (it had been 'bought for parts' - the ultimate death of many cars, boats, machine tools and the like).

It was a floor standing model, complete with pedestal for the motor and gears, a quick change gear box with the handle missing and just the stub of a broken casting on the pinion where the handle mount travelled. Several coats of paint had been applied over the years to all the places where it was needed and, in the process, to lots of places where it was not needed.

After a lot of dicker, this old soldier was mine, complete with delivery in the price and the promise of a replacement single phase motor "if one becomes available" (it never did). When it landed on my garage floor and after a telephone call to Southbend Inc., I found that I owned a heavy duty 10in. wartime machine, with a nose spindle 2.25in. x 8 TPI.

Over a year later, it is standing in my

workshop looking BEAUTIFUL. All the essential parts are in very good order, even the ways are not too badly worn - I have seen a lot worse. Throughout all the rehabilitation, the Southbend Company were extremely helpful in supplying the relatively few parts that I needed (for a 57

year old machine!!!) but, far more important, they cheerfully supplied a complete Spare Parts and Service Manual with 60 pages of exploded views of each major subassembly. From this, and the gearbox itself, I was able to make a replacement gear box handle and idler gear (Southbend had all the parts for the lathe except for the gearbox! Hail Mr Murphy) as well as all the other little things needed that I did not buy from the makers.

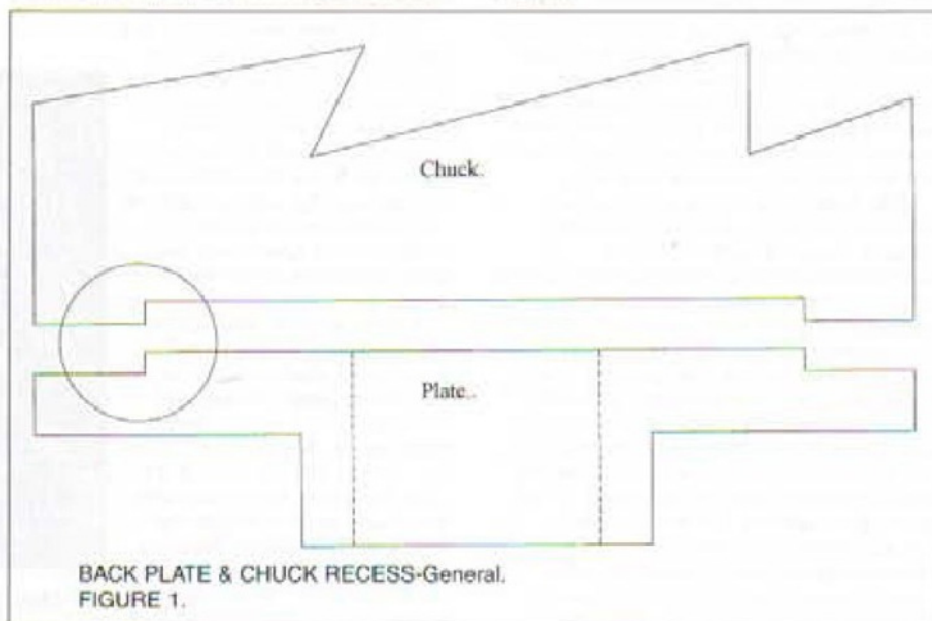
Equally important, this detailed information allowed me to correctly disassemble and re-assemble the various parts during the overhaul.

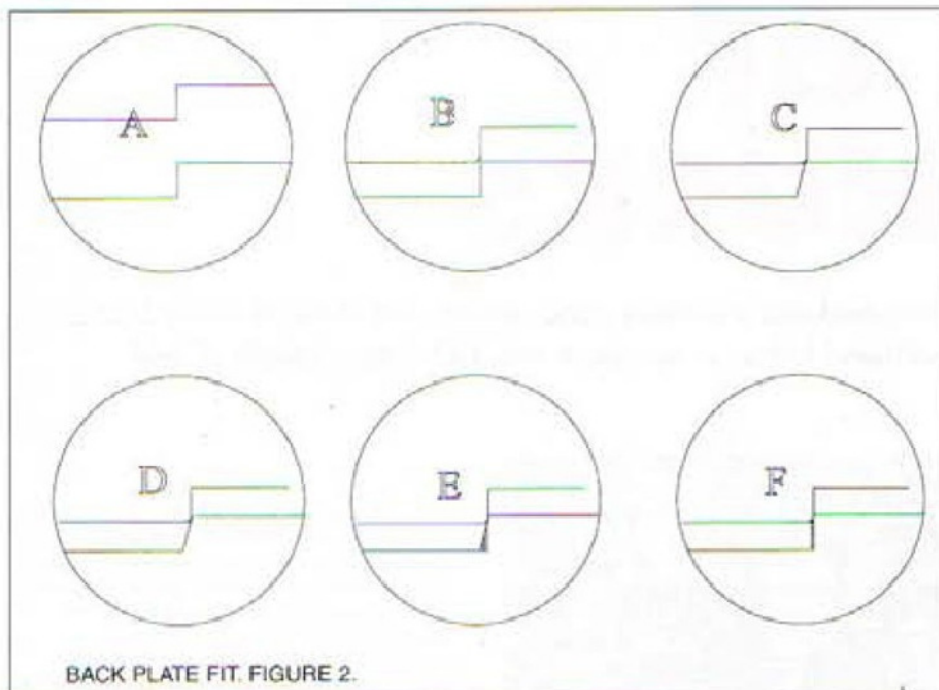
After the stripping of all the gunge, crud, swarf (still there) and finally the layers of paint, I found the original manufacturers brass labels still fixed to the right front of the frame. Polished up they give the restored machine a touch of class.

Photo. 1 shows the end result.

While this was an interesting and rewarding exercise, it did not involve anything out of the ordinary that merits a write up, except the remake of the gearbox change gear and operating handle. (I will try to deal with these in the future). The new handle is seen in the photo. However this all sets the background for the rest of this article.

The most obvious deficiency at the beginning was the lack of good operating chucks.





BACK PLATE FIT. FIGURE 2.

Lathes need chucks

...And chucks need back plates.

Two chucks were involved in setting up the lathe. A threaded back plate casting was bought for each of the chucks in turn and the chuck back bosses turned on them. This was a normal operation and a good 'tap me on' fit was obtained first time. I bought threaded plates because all the problems of obtaining a first class fit on the nose spindle are solved for an addition of only £6.00 by buying them ready made. As they say, "it ain't worth the hammer".

I had been round this back plate fitting course before, when setting up the chucks on my Atlas and, on that occasion, I had not been successful first time; in fact I had to have three tries on one of them, and the memory of this frustration was still with me when I contemplated the 8in. backplate and chuck lying on the bench before I started. They were a lot bigger and heavier than the 100mm Atlas items, and so much easier to get a bad fit.

I thought long and hard about it and finally devised a method so as to make a good fit of the turned boss into the chuck recess. I don't know how many other methods there are (Legion?) but this worked for me and may be of use to other readers. Having conquered the 8in. plate, the 6in. plate was a breeze later on.

Fig. 1 shows an outline of the back plate and the chuck recess. The fitting place is circled. Fig. 2 shows six progressive outlines of the circled area and of the method I used to turn a fit. 'A' shows the step of the recess and, below it, the required boss outline. In 'B' these are brought together and the radius on the edge of the recess is added to make the shape accurate. This radius is the key to this method. In 'C' the waste material of the plate has been cut away to full depth and the point of the resultant boss is just starting to nest into the recess radius. I found it quite easy to offer up the heavy chuck to check, turn a little more, offer again and again until the chuck could be felt just trying to rest on the boss: this in

spite of the weight of the larger chuck being over 15 kgs. It needed a board to protect the ways and some shaped blocks. The important thing to notice here is that the tool is set over at an angle (say 15 deg.). Another few thou (half the radius of the chuck edge) and the chuck has definitely started to accept the boss, as will be seen by the slight reduction of the gap between the chuck and plate.

In my case the recess is 0.20in. and the boss was made 0.190in. At this point the gap was seen to reduce to about 0.170in., so there was a 20 thou entry as illustrated in 'D'.

This is where the 15 deg. angular cut of the boss is so helpful. A slight excess of cut will not suddenly produce a boss that is too small and has some play. It will just go in a little bit further with no serious damage done.

The tool was now rotated to be exactly square to the face and sharpened up (as we all know, cast iron is hell to HST tools); successive small cuts were taken as shown in 'E'. It was very easy to see the square cut creeping up the original inclined cut: this visual aid was an unexpected but very real help when dealing with the few thou involved.

Finally, as in 'F', the next cut allowed the chuck to go on significantly further, showing that the squared off face was now riding well up the chuck edge radius. A little more (with a file, a piece of emery or, in my case, the really sharp tool) and the chuck could be tapped on with a brass or plastic hammer. The chuck was removed, all surfaces cleaned and edges broken, the chuck replaced and

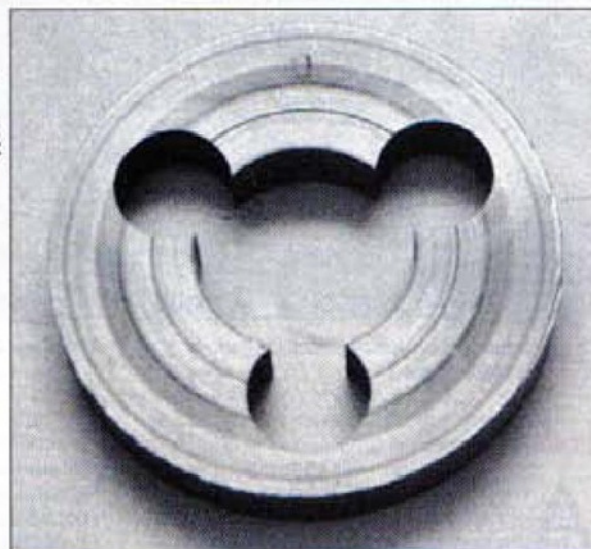
pulled up with its bolts.

In my case, I didn't have to do anything further: under the pull of the bolts the chuck and plate nested together properly with a stiff but snug fit. The second plate, for the 6in. chuck, was made in the same way.

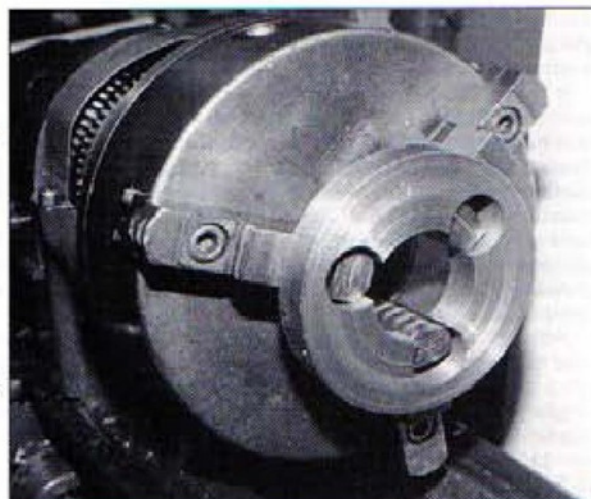
Chuck No 1

The old 8in., 3 jaw chuck with no back plate mentioned above came with the lathe. I had mentally consigned this to be a boat anchor when I bought it, but examination gave hope. It was not so bad underneath the dirt. The jaw faces were damaged, but the jaws moved well in the slides without a significant amount of slop, the scroll appeared to work as it was supposed to do.

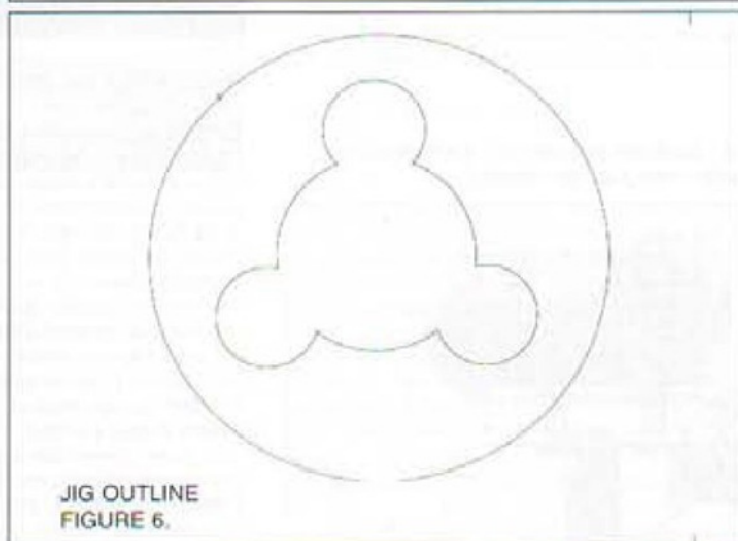
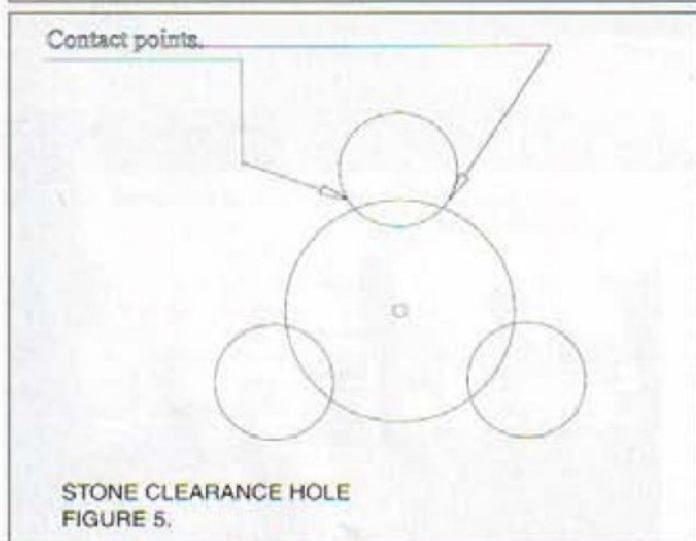
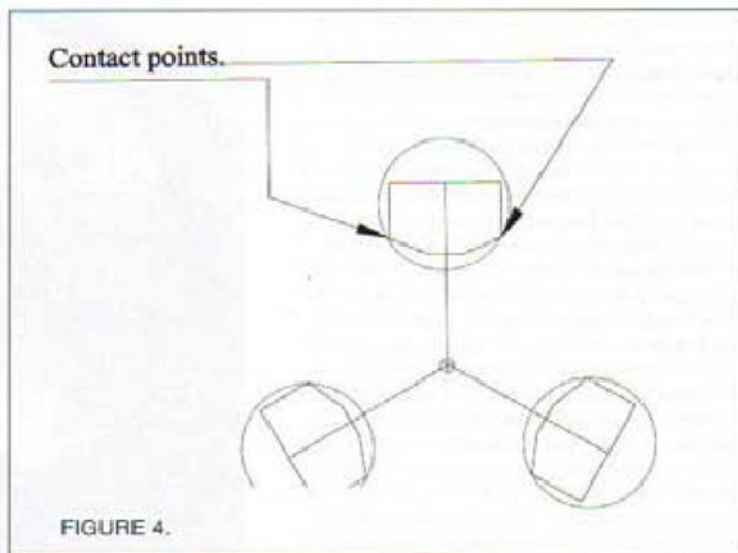
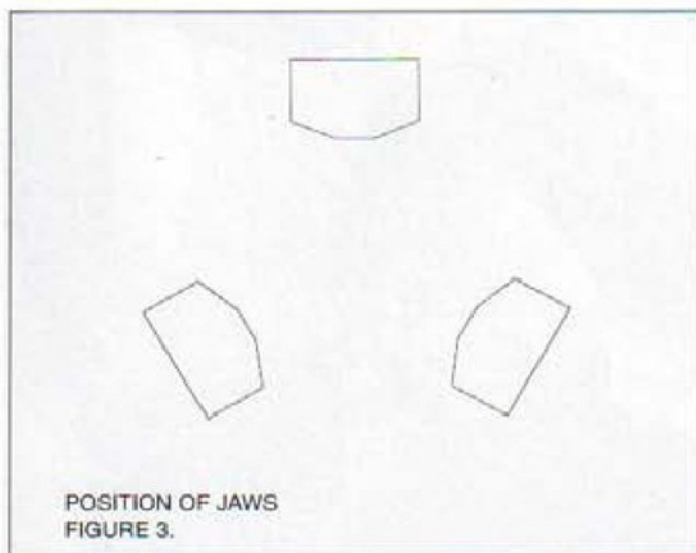
Stripping, cleaning (I had no idea how much crud it is possible for a chuck to hold and still appear to operate) and oiling soon convinced me that this ugly duckling was going to work. The only thing required, after fitting the back plate, was to reface the jaws. To do this I needed to make two items, a jig to hold the jaws while grinding and a toolpost grinder.



2. Grinding jig for 8in. three jaw chuck



3. Chuck jaws held in grinding jig



Jig requirements

Several articles in *Model Engineer* and *Model Engineers' Workshop* over the years, as well as good advice from professional club members, made it clear that the jaws had to be presented to the grinder while being loaded in the same way that they are while in use. To do this, a jig similar to that shown in **Photo. 2** was needed, which would sit over the jaws, as in **Photo. 3**, and so allow the jaws to be tightened while still leaving their faces free to be ground. An alternative jig design, about which I have been told but have not seen, has milled wedge shaped slots to hold the jaws. I don't know whether such a device would be superior.

To design the jig, the first thing was to decide the stone to be used or, at least, its diameter. Then the jaw faces were drawn accurately to scale (on my new CAD program that I was learning to use), sufficiently far apart to allow the stone to enter between them, as shown in **Fig. 3**. Some thought has to be given to the resultant radius that will be placed on the jaw faces - this radius should not be too small else the corners will crush under heavy load, and an 8in. chuck often does carry a heavy load.

Having got these basic dimensions tied down, it was then necessary to draw the clearance holes in the jig. These needed to be of a size and placement similar to that

shown in **Fig. 4**. The corners of the jaws rest on the inside face of the holes, so that the centre hole would clear away the material in front of the jaw faces, as seen in **Fig. 5**. When these four holes had been machined out of the jig material it looked like **Fig. 6** (ref. **Photo. 2**).

Nowhere in this discussion am I giving any dimensions, only general indications of size, because any reader who wishes to do the same job will clearly make the jig to suit their own chuck and grinding stone.

Jig making

A bit of thought and it didn't take long to set out the plan for the production of this simple jig. A piece of steel from the junk box, about 4in. in diameter and $\frac{1}{2}$ in. thick, was found and a $\frac{3}{8}$ in. hole drilled in the middle. A mandrel was screwed onto it and the outside turned roughly circular in the 4in. Atlas (my faithful workhorse of many years). So far, no significant accuracy required. The workpiece was now mounted in a four jaw and dialled up so that the $\frac{3}{8}$ in. hole ran true. This hole was now bored out to be a good fit on one of my $\frac{1}{2}$ in. gear cutting mandrels. After truing up the mandrel in the four jaw and skimming the outside, I now had a true running disc of metal.

This assembly was taken to the milling machine with its dividing head, and a marking tool put in the machine spindle. A

circle of the PCD of the jaw clearance holes was scribed and then three radial marks made at 120 deg., to position the holes. This accurate layout job is easily done with the dividing head and the machine table dials. The circle can be clearly seen in **Photos. 2 & 3**.

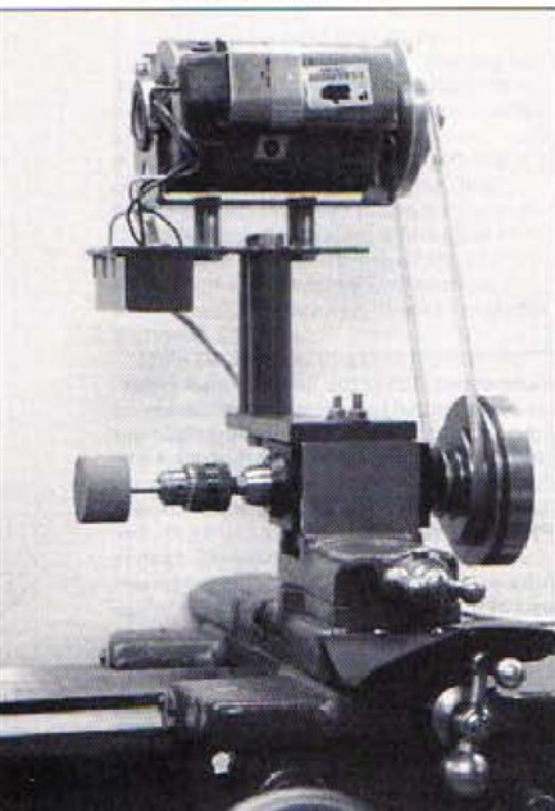
At this stage I borrowed a 6in. four jaw from a kind club member, so that the next part of the job could be done on the Southbend, as it was too large for the Atlas. The mandrel was removed and the workpiece set up to drill and bore the three jaw clearance holes as spotted. The size of these holes is not important as long as they satisfy the basic need mentioned above BUT the position of the centre of each hole AND them being all the same size IS important and that was the reason for machining it this way. The tail stock was accurately aligned to the head stock before starting. Careful adjustment of the jaws allowed the tail stock 'pricker' to find the cross hair marked by the mill. A pilot hole was drilled at this spot after gentle pressure from the Slocumbe drill. Enlargement of the hole to $\frac{1}{2}$ in. drill size and then boring out to final size (in my case $1\frac{1}{8}$ in.) followed.

Rotation of the workpiece and readjustment of the jaws allowed the other two holes to be bored out, care being taken to make them to the same size as the first, using an internal bore gauge and a micrometer. The workpiece was then re-centred in the chuck and the original $\frac{1}{2}$ in.

centre hole adjusted to dial up true. This hole was now bored out until it broke into the three jaw clearance holes. As it approached the breakthrough point, the tool increments were kept small and it was very gratifying to see that the metal assumed a lace like appearance equally at these three points, showing that they were as accurately placed as one could have hoped (this 'lace' effect would not have occurred equally without a nice sharp HST tool and a successful placing of the holes. The trouble taken in getting everything true was shown to be justified here).

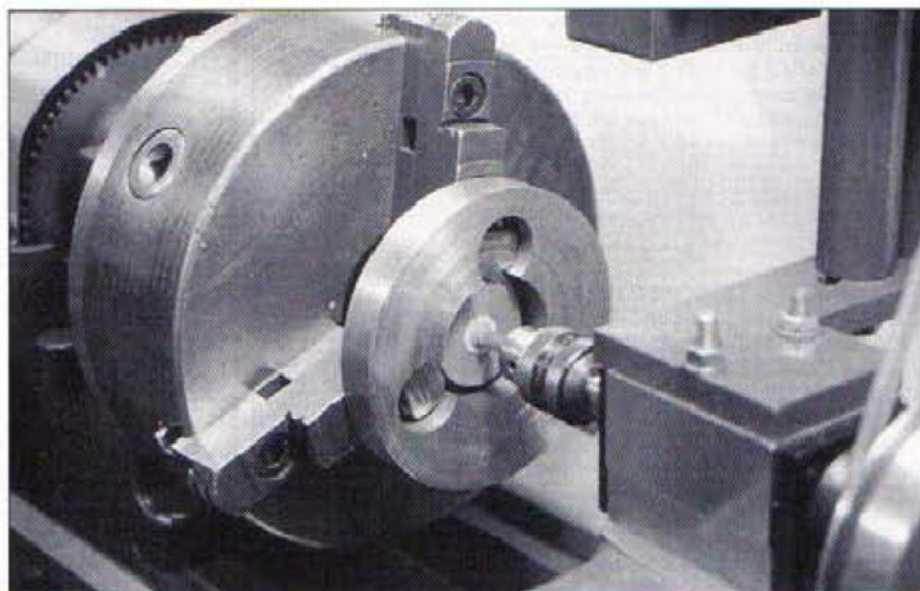
The centre hole was now further enlarged to produce the end result shown in **Fig. 6** and in **Photo. 2**. In this photo it can be seen that I marked the jig with a 'O', so that I could always replace it on the chuck in the same orientation in case this became important (I don't know that it ever did. I can't see why it should, but you never know). I tried it on the jaws, **Photo. 3**, and all seemed fine, with all three jaws apparently held tight when screwed down.

4. Toolpost grinder for chuck jaws (and any other jobs as needed)



Grinder making

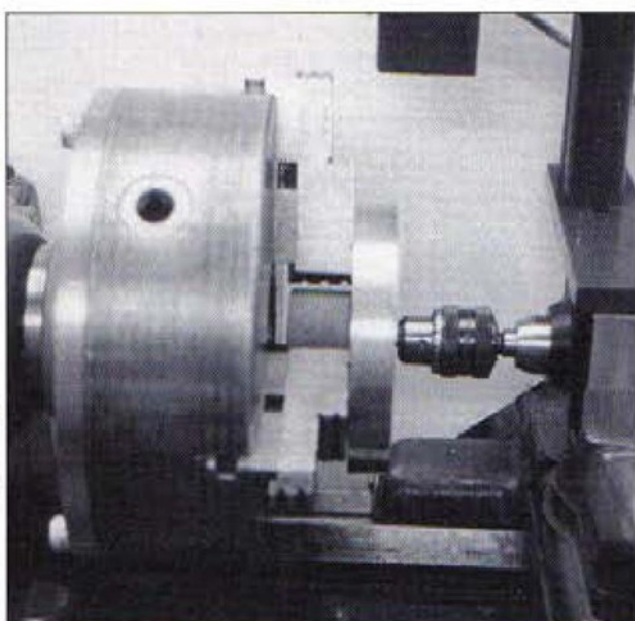
The grinder is a fairly obvious piece of machinery. In **Photo. 4** it is shown mounted on the lathe compound slide. Two holes have been drilled and tapped in the top faces of the slide, into which go two studs to hold the milling spindle and the motor assembly. This assembly consists of (working upwards), a base plate, two spacers made from 1in. pipe, another plate to carry the switch and to support the spacers to the motor mounting plate. All these spacers and plates are held together with suitable studs, and site the motor 'out of the way', and make the switch and belt easily accessible. The



5. Grindstone just entered into the jaws

motor is 1/5th hp, 1850 rpm, capacitor shift, surplus store bargain for £1.50 (\$ 3.90), and carries on its spindle a three step pulley to match that on the J. M. White spindle. I made the pulley from a 4in diameter piece of aluminium, so that there are three speeds of 2.5:1, 1:1 and 1:2.5 on motor speed. The drive is by the common, heat welded, round plastic belting. Again, no dimensions are given as such a device is made from what is at hand and can vary hugely with the same result.

Conveniently, mounting the milling spindle on the compound slide like this brings the centre line of the spindle right onto the centre line of the lathe, otherwise a different mounting method would be needed to get things in line.



6. Stone fully entered between jaws

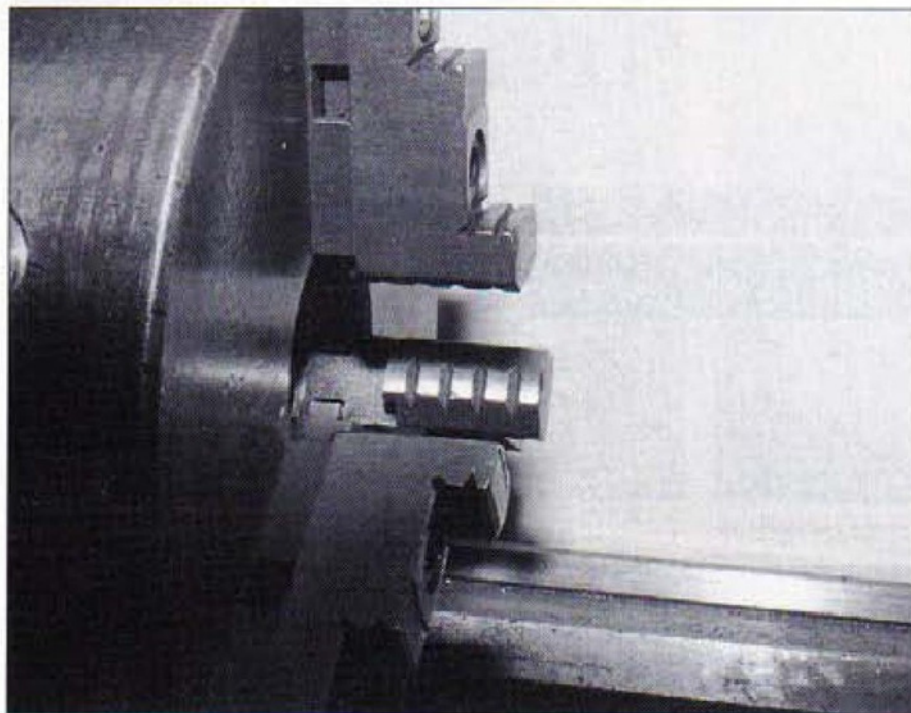
Jaw facing

The first thing to do is to protect the lathe from the grinding powder which is going to be sprayed around. A paper towel inside the front of the lathe spindle and another inside the chuck just clear of where the stone will enter will keep most, if not all, the powder out of those parts of the 'works'. Cloths draped over the ways and cross-slide are an essential precaution.

The jig and grinder are shown in position in **Photos. 5 and 6**, with both spindle and lathe stationary. In use, the stone is carefully entered well clear of the jaws and the grinder started in middle speed: the cross-slide of the lathe is adjusted outwards until the stone just touches a jaw already placed at the front horizontal position. The cross-slide is moved along the ways to bring the stone fully in and out of the jaws. This is to check that the stone only touches at that one point far inside the jaws (where the least wear occurs). It is safest now to note

the cross-slide reading and to move the stone further in away from the test jaw. This is because this particular jaw may not be 'highest' and the stone may cut too deeply on one of the others.

The lathe spindle is now started in lowest backgear speed, the stone entered to the back of the jaws and the cross slide dial carefully returned towards the noted reading, listening for the stone engaging the jaw faces and/or sparks appearing. As soon as grinding is seen or heard to start, the lathe traverse is engaged and the cross-slide driven so that the stone traverses across the jaw faces and emerges. The traverse is reversed and the stone driven back to its starting point, far inside the jaws, as in **Photo. 6**. In normal grinding operations, the piece being ground should rotate in the opposite direction to the grinder. It doesn't matter too much here as the chuck is moving so slowly and the grinder can be made to



7. Jaws cleaned up after grinding.

turn so much faster, so that the speed difference is large.

The cross-slide is moved outwards a thou or less and the process repeated again and again, until all the jaws have been ground all the way across. As an old and wise club member admonished me "Remember that one thou is a very deep cut on a grinder". In my case there were one or two deep gashes that I did not take out completely, as to do so would remove a lot of material, and I felt that they would not inhibit the holding power if left.

As soon as the jaws all appeared to be clean and faced along their full length, the grinding was stopped, the protective cloths and towels carefully removed and shaken off at a distance, and the whole machine vacuumed carefully.

The success of the operation was checked by dialling up several different diameters of round stock. The errors were under 2 thou and varied between jaws 2 and 3, depending on the test and diameter. This was assumed to be scroll error and could not be corrected. Anyway, I was told by the club experts that an error of 2 thou on an 8in. chuck is OK. This chuck would only be used for larger and heavier work, where such an error would normally be acceptable. If any greater accuracy were needed, then the four jaw would be used.

A shot of one of the cleaned up jaws is shown in **Photo. 7**.

Chuck No 2

Just as I was finishing the three jaw chuck, I was told about a four jaw 6in. chuck that another club member had for sale. Checking this out revealed that it was a Pratt and Burnerd of ancient vintage. The obvious damage was that the jaw adjusting screws had been ill-treated. They must have been grossly over-tightened many times, for they were split, one so badly that a piece of the screw was

missing (**Photo. 8**). The splits made the outer half of the jaw travel very stiff - new screws were needed. I was also worried that there might be other damage caused by whatever ill-treatment had split the screws, although I couldn't see any. The club member selling it had bought it many years before at a Government Surplus auction, and said that this is how it was when bought and that it did not appear to have any other defects. So, as the price was right, I bought it.

Trade enquiries led me to a company here in Canada that offered parts for these chucks, but the price of the screws was astronomical and immediately produced the reaction in me that no way was I going

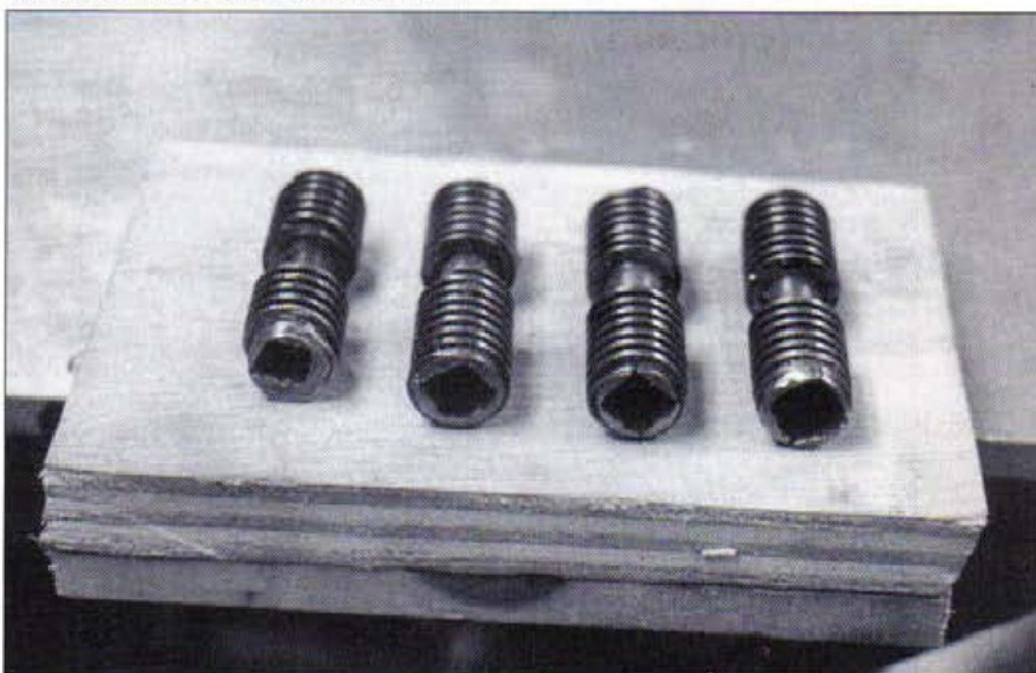
to pay it. A transatlantic call to Pratt and Burnerd elicited the information that the serial number showed that the chuck had been made in 1953! No parts were available, which is not surprising (where were these locally available parts coming from?). Apparently this was a precision chuck specially produced to a tight government requirement and later made available on the commercial market, although few were sold. The only course open was to make the needed screws.

Stripping and cleaning this chuck revealed that, indeed as the member had said, there was nothing else wrong with it. The jaws were individually fitted to their ways with a smooth running fit: ways and jaws were numbered. It was not possible to fit each of them in other than on the intended way. Strangely, the jaws were not damaged (as the 8in. jaws had been), so attention could be turned to the screw production as soon as the back plate was made and fitted (as above).

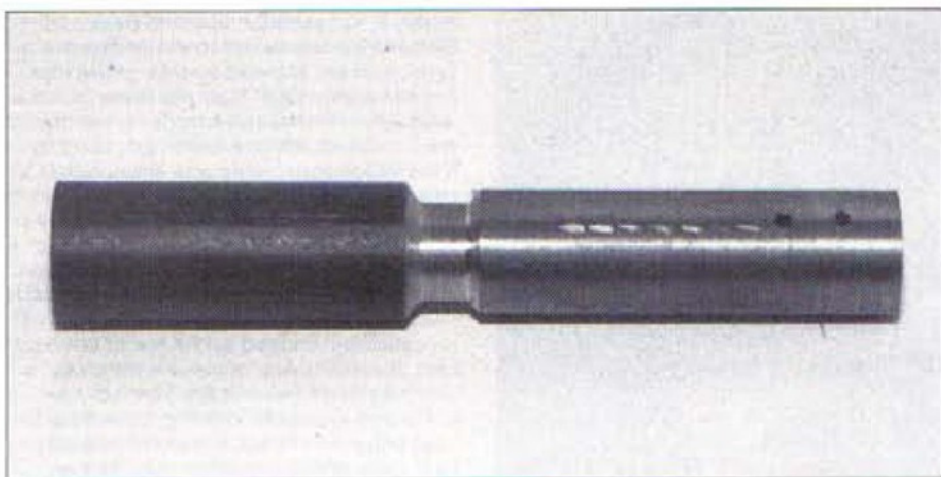
Screw requirements

As everyone knows, the requirements for the screws on a four jaw are not stringent. Each screw only has to move its jaw up and down the one way. Quite a lot of slop and backlash would do no harm. This makes the production of satisfactory screws an easy proposition, but I didn't take advantage of this, and so made the production job a tough but interesting exercise. I felt that the chuck deserved better than a sloppy fit. After all, if the jaws had been individually hand fitted to the ways and still retained that excellent fit, should they not deserve screws that fitted also?

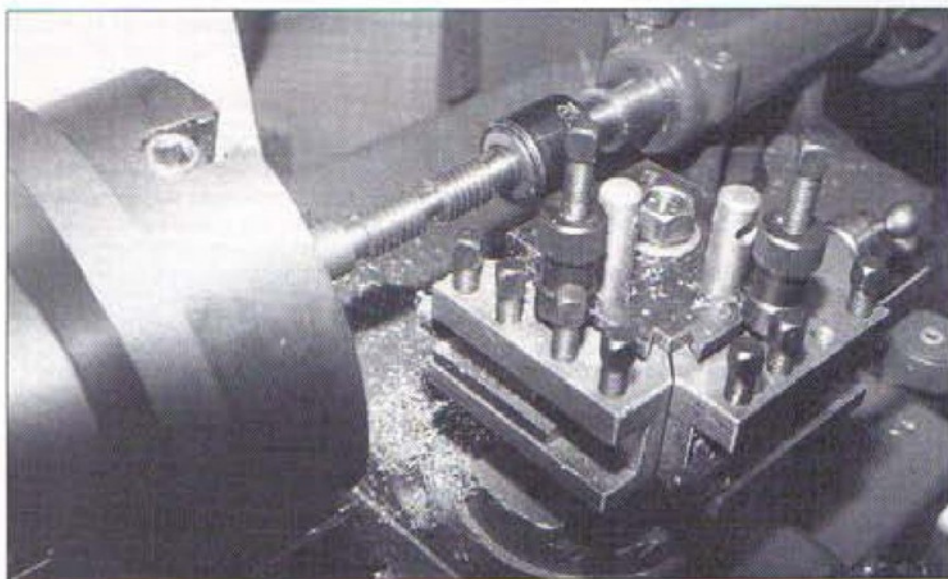
The screws were of normal design: just under three quarters of an inch in diameter, left hand square thread, with a portion removed in the middle to accept the thrust fork. (these thrust forks are a "Tap me in and tap me out" fit in the body).



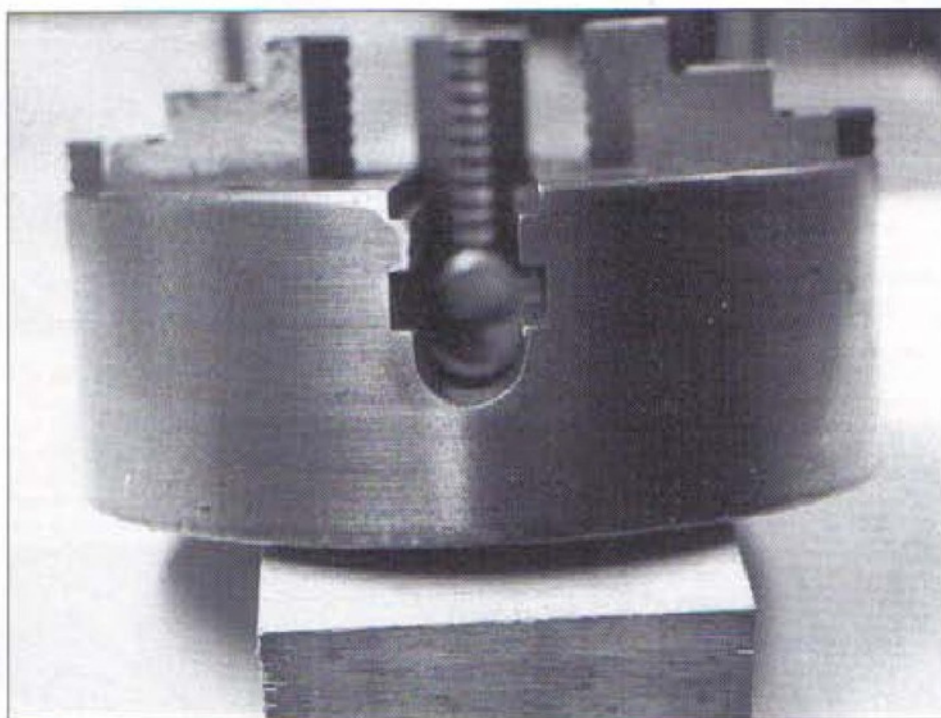
8. Damaged adjusting screws from 6in. four jaw chuck



9. Test piece turned to thread O.D. and thread root waist cut



10. Screw blank thread cut and waisted for thrust fork



11. Screw cavity and jaw way in chuck body

Screw production

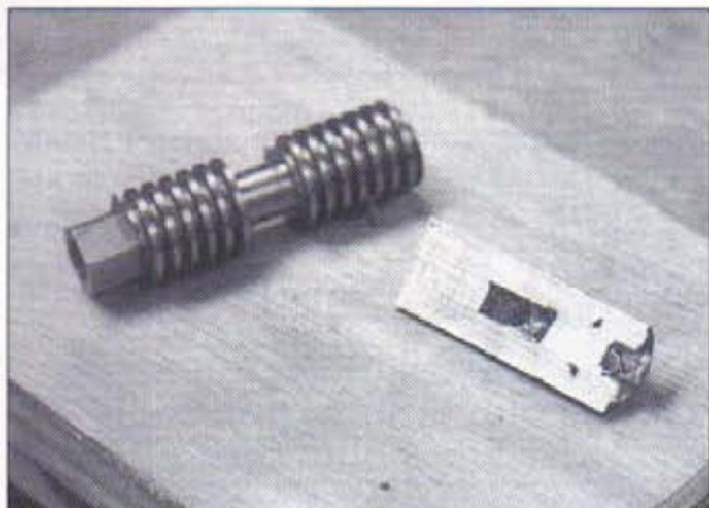
I decided to make a trial screw first (out of a piece of $\frac{3}{4}$ in. drill rod), one that could be operated by a square boss on the end of it instead of the more difficult socket needed in the final screws. I cut the boss on the miller first. The root diameter of the thread was measured from the old damaged screws and they were fairly consistent: a waist was cut on the rod beyond the length needed for the thread and to more than this depth, to be on the safe side when trying for a fit (**Photo. 9**). The damaged screws had variable outside diameters, so the rod was turned to the larger size. I did all this work in the four jaw so that it could always be set true with a dial gauge, no matter how many times it was removed for test fits.

The method used to cut a thread that really fitted the existing jaw thread was given me by a club member and it worked perfectly. The square thread was left hand 8 TPI, and a square tool with the necessary reliefs was ground up so that the end was sharp and narrower by some few thou than that needed to cut the correct width (as measured from the jaw thread). The left hand side was also sharpened so that it would cut well. The thread was cut to full depth, as shown by the runout into the waist already cut. At this stage the jaw thread would not enter the screw thread, of course. The tool was then moved slightly to the left by means of the compound slide and the thread cut run again, so that the left hand side of the tool shaved the thread: this cut had to be very shallow as the tool was cutting to the full thread depth and in its weakest direction - on its side. The jaw thread was tried and this was repeated until the jaw thread just fitted nicely.

Using the same tool, the gap in the centre of the thread was cut for the thrust fork and this was similarly offered up and fitted, as shown in **Photo. 10**, where sharp eyed readers will see that this photo is of the final screw and not the square bossed test screw, but otherwise it is the same. Up to this stage, the test piece had not been removed from the Atlas lathe chuck in which it was being made. Now it was taken out and offered into the 6in. chuck screw channel (**Photo. 11**). There was plenty of freedom for the screw alone, but the jaw would not run on the screw as the screw diameter was too large (as intended). The test screw was returned to the lathe and a skimming cut taken across the O.D. This was repeated until the jaw ran smoothly. The thrust fork was now replaced in the chuck body and tightened. Everything seized solid. Shaving both the thrust fork waist and the O.D. finally resulted in a good running fit, with virtually no backlash, just what I wanted.

Now the test piece had the needed dimensions with which to make the real screws (**Photo. 12**). The root diameter, the peak diameter, the thrust fork slot width and depth, the length of each part of the screw were measured from the test piece and/or the placement of it in the chuck with the whole assembled.

The four final screws were all cut to these dimensions and fitted to each of the four jaws. The end result was very



12. Finished test piece and a sectioned solder sample



13. Finished screw, together with its jaw and thrust fork

satisfactory. **Photo. 13** shows one of the finished screws together with its thrust fork and jaw.

Sockets

Before the screws could finally be made, a method for making the sockets for the chuck key had to be found. Several attempts at drilling and then squaring the blind hole in the end of a piece of rod failed dismally. I even considered, but not for long, making a short sleeve in which I could file a square hole right through and then welding or silver soldering it onto the end of the rod used to make the thread.

A further brainstorming session with a club member produced a great idea. Could a cut down cap screw be fitted inside the end of the rod before thread cutting? It turned out that it could, but a bit of test piece work was needed first.

A $\frac{5}{16}$ in. socket cap screw was just the right size after the O.D. had been turned down a bit and cleaned up to be half the wall thickness at $\frac{15}{32}$ in. The threaded portion was reduced to $\frac{1}{4}$ in. and parted of $\frac{1}{4}$ in. long. The two holes of $\frac{15}{32}$ in. and $\frac{1}{4}$ in. were drilled in a test piece of rod, so that the turned down socket screw piece just fitted. Two small ($\frac{1}{8}$ in.) vent holes were drilled into the two internal diameters to prevent solder lock up (**Photo. 14**) and the whole filled with silver solder and the socket piece pressed home. **Photo. 15** shows two test pieces.

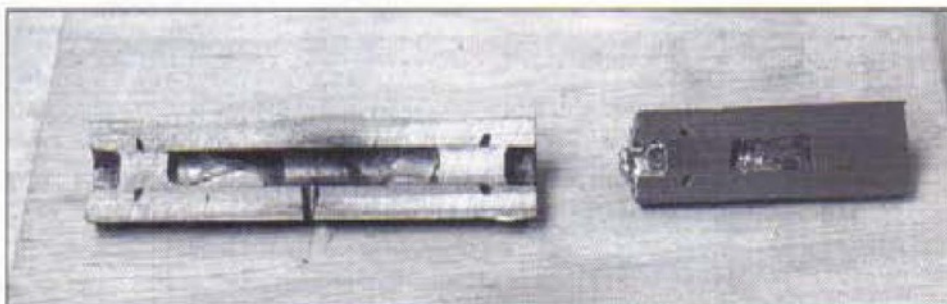
As the whole of the strain of tightening the jaws would be taken on the silver solder bond between the socket piece and the thread rod, I wanted to be sure that this bond was complete, so I sectioned the test piece. It was as well that I did, for the silver solder had not filled the rod/socket gap completely. This can be seen in **Photos. 12 & 16**, where the sectioned piece shows voids where the square back of the screw meets the 118 deg. face of the drilled hole. A counterbore would have produced the square hole needed, but I chose to turn the back of the screw head and the short shaft to match the 118 deg. of the drilled holes; I felt that this might give an easier solder flow. A further sectioned test piece showed a voidless joint between the socket piece and the screw rod where these two faces met.



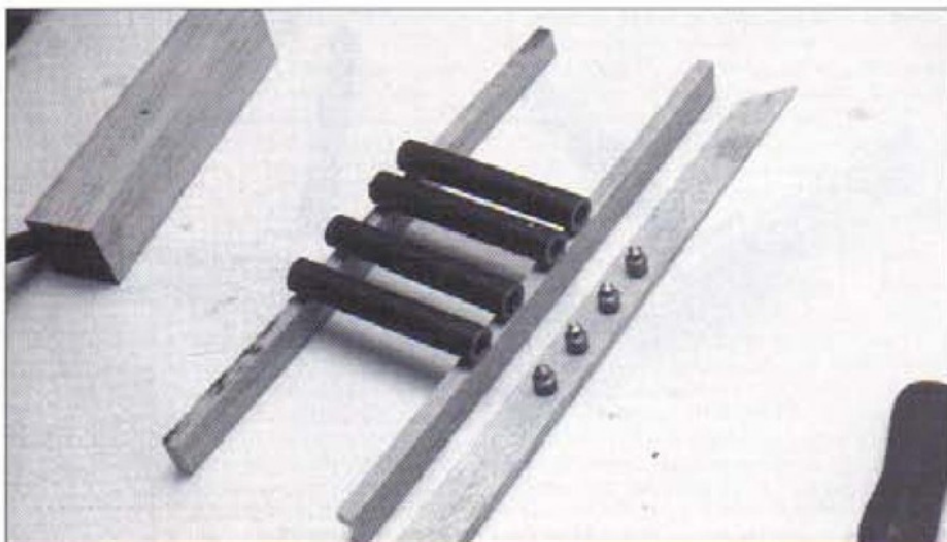
14. Test rod with vent holes and cap screw insert



15. Cap screw pieces soldered into the test rods and into the screw bodies

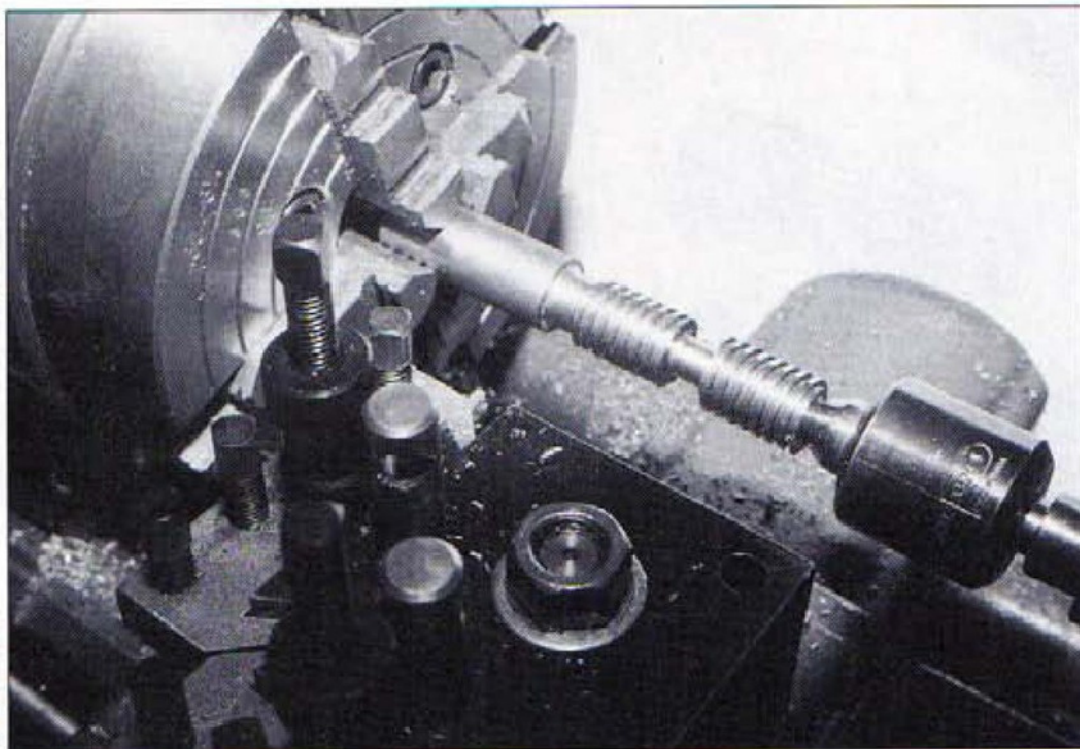


16. Sectioned test pieces showing the cavities that the solder did not fill when faces did not mate

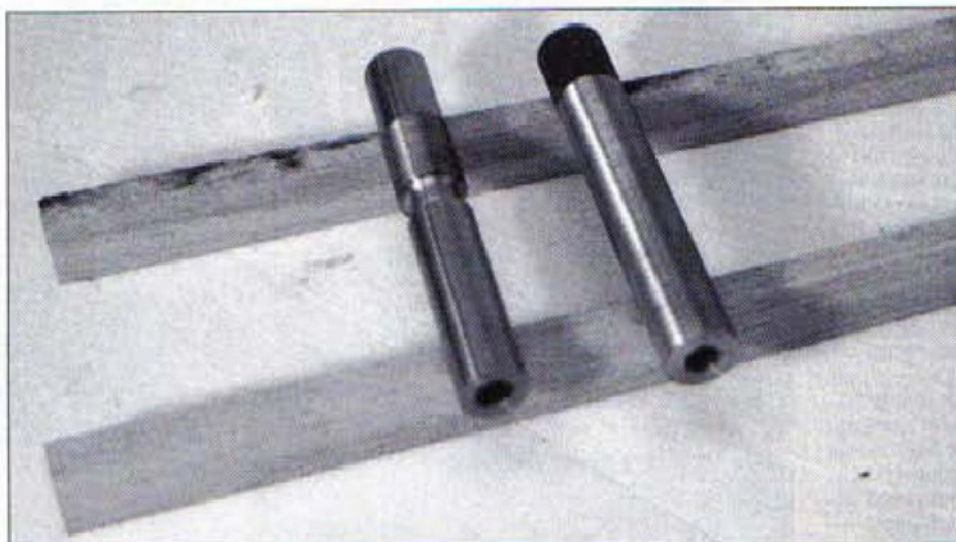


17. The four screw bodies and inserts ready for soldering

This was the method used to produce the sockets in the ends of the rod blanks for the screws. The pieces, before silver soldering, are shown in **Photo. 17**, the soldered pieces look the same as those in **Photo. 15**, and the cleaned up screw blank, before and after waisting in **Photo. 18**. The live centre runs well in the hexagonal hole of the erstwhile cap screw, as seen in the shot of the final screw cutting in **Photo. 19**.



19. Lathe work on a screw body, with the live centre running in the hexagonal socket which had been fitted before machining



18. A cleaned up screw body after soldering, and another shown after waisting

Chuck Keys

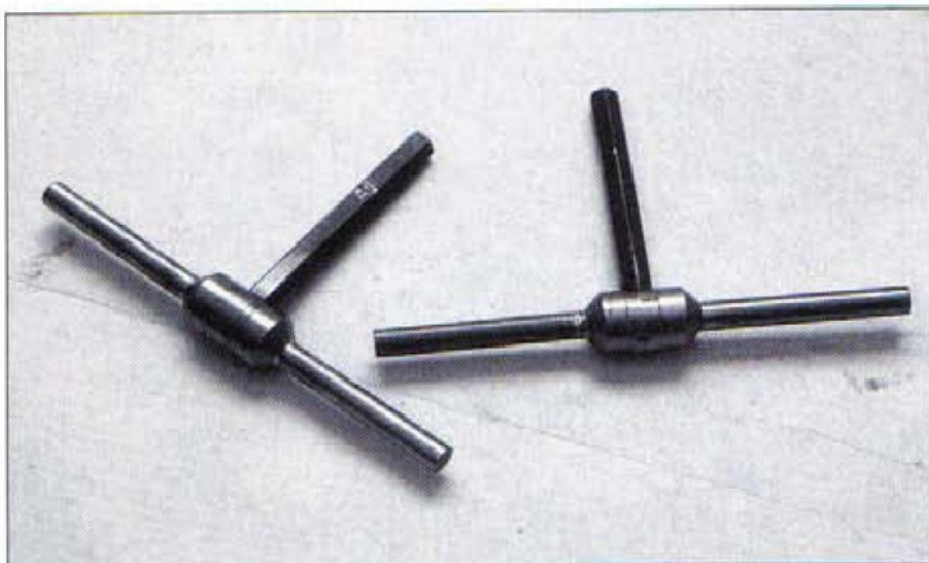
The mating chuck keys, seen in **Photo. 20**, were made by welding part of two 8mm Allen keys into the handles made from two sizes of rod. An 8mm key gives a good snug fit into a $\frac{7}{16}$ in. cap screw as it is 25 thou bigger than $\frac{5}{16}$ in.

While a four sided socket will stand, theoretically, more tightenings than a six sided socket before it wears to the point of stripping, I do not feel that this is any problem here as the key is a much tighter fit than the average lathe chuck key

when it starts its life. The modern material for cap screws and Allen keys is such as to stand a great deal of use.

Conclusion

The finished 6in. chuck, complete with its back plate and four new screws is shown fitted to the lathe in **Photo. 1**, while the 8in. chuck appears, fitted to the lathe, in **Photos. 3, 5 & 6**. The whole exercise was very rewarding and showed the great advantage of belonging to a model engineering club with its wealth of experienced members. One can 'talk out' foreseen problems and reach practical solutions, saving many hours of wasted effort and frustration. In addition 'word gets around' about what one is doing and unexpected helpful things happen, like the sudden availability of the 6in. four jaw chuck, just when I was ready for it. If someone now tells me about a salvageable 6in. three jaw, my cup will run over.



20. Chuck keys made from 8mm Allen keys fitted to steel handles

SCRIBE A LINE

Metric Pitches on the Super 7B

From John Peters, Harrogate

I'm sorry the change gear quadrant adjustment on George Swallow's Super 7B does not allow a 34 tooth gear to be fitted in place of the standard 24 tooth gear (S.A.L. No. 51). It fits easily on mine, and in fact I would expect even a 36 tooth gear to fit, if I had one (but my 38 tooth gear does not fit). It simply did not occur to me at the time I wrote the letter that the slot might vary in size on different lathes by as much as 0.2in or more.

The reason for the variation must be that the slot for the anchor pin is cast into the quadrant and faced off. Normally, no work will be done at the factory to machine out the slot unless the 24 tooth gear cannot be mounted. However, it should be easy for any reader whose quadrant has an insufficient range of adjustment to file (or machine) out the slot to accommodate larger gears.



John Hughes' method of taper turning

From David Dew, King's Lynn

George Swallow's letter (S.A.L. No 51) reminded me that another Magic Number has been uncovered, which extends the range found by John Peters (S.A.L. No 50), based on the

original suggestion by John Walford (No.42). The table below is quite remarkable in that it uses two adjacent gears, and splits the standard metric pitches so evenly. The superb accuracy with the 34T is, as John Peters says, 1 in 2154. With the 33T it is 1 in 467 (this is identical to 22/70, which I considered OK for threads for fastening purposes. The Myford conversion using the special quadrant is 200/63, that is 1 in 8000). Both 33T and 34T gears are available from Myford.

On my machine there is plenty of 'meat' in the casting to elongate the slot. A 7/16in. end mill is reasonable. Precision is not really called for, after all the slot is only cast in. It could well be quickest to mark out and file it. Mr Swallow should not be hesitant to improve his Myford; they are only a tool to be enjoyed, and they are sent from the works with a variety of empty holes which the average owner does not use, so why not add a few more?

PITCH	DRIVER	
	34	33
4.5	8	
4	9	
3.5		10
3	12	
2.5		14
2	18	
1.75		20
1.5	24	
1.25		28
1	36	
0.9	40	
0.8		44
0.75	48	
0.5	8	
0.4	10	
0.3		13
0.2	20	
0.1	40	

T.P.I. SELECTION

FEED GEAR

More on making taper reamers

From Mathew Dart, Vauxhall, London SW8

As a professional woodwind instrument maker and subscriber to your magazine I was interested to read the letter from Mr Summers and hope I may be able to help.

I have had to make various reamers, mostly shorter and fatter than his, but also bassoon crook mandrels (the same as making a reamer but without a cutting edge), of around 400mm long, tapering from 10mm down to 4mm or less. It would be impossible to turn such a thing in a simple between-centres set-up - unless possibly you used a travelling steady, set in front of the tool, and did it in one cut.

There are two parts to the problem; 1) how to prevent whipping on a long slender workpiece, 2) how to generate the correct taper.

My answer to 1) is to do all the turning close to the chuck - within around 50mm of it:

i) Start with 40mm or so extended from the chuck, centre drill and turn the beginning (small end) of the taper.

ii) Withdraw a further 50mm or so from the chuck, support the end with the tailstock and continue the taper. It would help to have a really accurate 3 jaw or a collet chuck but if not, drawing the stock straight out from the chuck without rotating seems to work.

iii) Repeat ii) as many times as necessary.

There are various possible answers to 2):

Offsetting the tailstock is obviously not possible if you are using a chuck.

Using the compound slide may be possible if you are far better than me (not difficult!) at setting an angle on it - the angle of a woodwind bore taper is usually very small. However, there is still the problem of the slide fouling the tailstock in step ii) above.

You could use a taper-turning attachment if you have one, I do not (or rather did not until recently) so I used:

The step-and-file method;

i) Using a calculator, work out the distance from the small end of the reamer of a series of incrementally increasing diameters. I usually use an increment of 0.2mm on the diameter depending on the angle of the taper. The distance between the steps should be around half the width of your file. Remember to include a lead-in to the intended finished bore at the small end and some extra length at the big end too. (Many of the bores I need to make

consist of several sections of differing tapers. It is easy to incorporate them all on one reamer with this method).

ii) Turn this series of steps on your workpiece using the method under 1) above. The first few steps can be turned without tailstock support, immediately after centre drilling.

iii) When the steps are done you will have the whole of the worked section between chuck and tailstock, now coat it all with marking-out blue or indelible felt-tip pen.

iv) You can now file down the steps to make a continuous taper, the blue sections will gradually narrow as you progress - check that they are all narrowing at an equal rate to indicate you are filing it all down equally. Watch out though! - the small end has less metal to remove than the big, it will take less filing to finish and it is easy to go undersize there if you do not take this into account!

I have a 'lathe file' which is a fairly coarse single cut on a steeper angle than usual - it is good for removing material quickly, but for a finer finish I like to use a smoothish double cut file when getting close. Finish with smooth file then emery cloth tape and/or wet and dry paper - I go down to 800 or 1,000 grit. You may wish to cut the steps 0.04mm or so oversize to allow for finishing, but if the reamer is one single straight taper it does not matter if it is undersize - just put it into the wood a bit deeper.

Putting a cutting edge into the resulting blank is another story - for such a long thin bore I would make it into a D-reamer (just like a D-bit) - mill,

saw and/or grind away half to leave a cutting edge. Actually you can take away less than half - about 10% of the diameter less - that leaves you with some room for re-sharpening without losing diameter. It will cut just as well and if you finish by grinding with a smallish diameter (4in. or 5in.) wheel you will have a more acute angled cutting edge.

Be very careful to keep the work cool during this - even if using a hacksaw - the work can easily bow away from the cut face, resulting in an inaccurate bore.

For fatter reamers you can mill out a quadrant; you need more land than for a metal cutting reamer or there will be problems with juddering, but more than about $\frac{2}{3}$ of the circumference is too much. There is no point making a multiple fluted reamer - in my experience they cut no better and are more work to make and sharpen.

I prefer to ream by hand with a T-handle attached, the wood being held vertically in the vice. Others I know hold the reamer in the chuck and, holding the wood in the hand with a leather glove, push it on to the reamer with the tailstock located in the other end of the bore. Use tallow or linseed oil as a lubricant. I bore the wood with a series of decreasing sized drills or D-bits to approximate the bore - thus leaving less reaming to do.

From John Hughes, Newtownabbey, Co. Antrim

Judging from the proportions of Mr Summers' reamer I can only conclude

that he is involved in the manufacture of the same, or similar woodwind instrument as I am i.e. the Uilleann or Union pipes.

In the past, I have made conical reamers by the method described here, but I am currently working on a means of reproducing the undulating tapered bores of old (proven) instruments.

Rest assured it is possible to turn tapers of these proportions on a centre lathe. I have been doing it for some years now using a long bed Myford ML 7R, fitted with a taper turning attachment of my own manufacture, running the entire length of the bed. In theory, I have the capacity to make tapers of around 28in. long, although 18in. would be the maximum I would ever need. Myford, in common with most lathe manufacturers, make a taper turning attachment for their lathes but, at 8in. long, it falls rather short of my requirements. My taper turning attachment works in the way of many others, but a description here might be in order:

A length of bright mild steel is attached via two brackets to the rear face of the lathe bed casting. The B.M.S. bar is mounted in such a way that it can be set at any angle to the bed ways of the lathe up to a maximum of plus or minus 5 deg. On the B.M.S. bar runs a follower which is connected to an extension piece attached to the cross slide, the cross slide indexing screw being removed. As the saddle progresses along the bed ways, the cross slide will move across the saddle according to the angle to which the B.M.S. bar is set. Manual

IN OUR NEXT ISSUE

Coming up in Issue No. 55 will be



BANDSAW IMPROVEMENTS

Modifications to the popular Taiwanese horizontal/vertical machine, as described by Philip Amos

BENDING HELICAL TUBES

Paul Boothby tells us how to form tubing into neat helical coils

A FACEPLATE BALANCING FIXTURE

This time saving device, which allows workpieces to be centred and balanced off the lathe, was designed by Harold Hall

Issue on sale 24th December 1998



(Contents may be changed)

indexing of the tool is done by the topslide which is rotated by 90 deg. on its mountings, and now lies parallel to the cross slide.

The taper must be machined in only one pass of the tool. As in Mr Summer's case the cut commences at a depth of $\frac{7}{32}$, it is not possible to use the lathe's own power feed, unless you can gear your feed down very slowly. I'm talking in the order of taking about six or eight hours to travel the entire length of the 14in. workpiece. I have overcome this problem merely by manually applying a gentle pressure to the saddle advance wheel (it's as much fun as watching paint dry). Some sort of gravity feed might be useful, but extreme care must be taken to ensure the gravity feed will not apply too much force whenever the tool approaches the end of its cut.

Needless to say, a travelling steady is essential. I have long since given up on conventional two point travelling steadies, as I find the tips wear and lead to inaccurate work. Here I use one of my own manufacture, and it takes the form of a $\frac{1}{2}$ in. thick steel plate, bolted and accurately doweled to the lathe saddle. Through the steel plate a $1\frac{1}{4}$ in. hole has been line-bored in order to take a brass or bronze bush, the bore of which is machined to a sliding fit on the raw material from which the reamer is being machined, in Mr Summer's case, $\frac{5}{8}$ in. diameter. The travelling steady bears on the material ahead of the tool, as I understand to be the convention with travelling steadies. The bronze bush is clamped in place in the steel plate using a pinch bolt. The travelling steady may, if the utmost accuracy is required, be made to accept a sealed ball bearing in place of the brass or bronze bush.

The above method does seem a rather long and involved way to produce a long and slender taper, but over the years I have found it the most successful for my purposes.

The Face Geared Indexing Table

From M. A. Delaney, Oakville, Ontario, Canada

I was fascinated by Mr. Morris' article (Issue 52), particularly in the 'Face Gears'. As I understand it, the method of cutting the gears maintains the point of the cutter parallel to the base of the gear. This means that the height of the crest above the base will decrease linearly with radius to zero at the centre. If two such devices are mated face to face, they will touch (theoretically) only at the outer edge; at the centre there will be a gap equal to the outer tooth depth (in this case 1.31mm). At the inside diameter of the components detailed, the gap will be $1.31 \times \frac{58}{100} = 0.76$ mm. This could be easily checked with a wax impression. The gap could be the cause of mechanical failure of the component under high clamping or tool loads. Cast iron is weak in tension.

My thought is that the axis of rotation during cutting should be tipped such that, at the centre, the point at which the crests and valleys coincide will be exactly at half the tooth depth (0.655mm) from the original top surface. The angle would be $\tan^{-1} 0.655/50 = 0.75$ deg. from the vertical, away from the shaper ram. I have no idea how such an angle would be set, but the tolerances should be directed so that first contact is made at the outside.

The angle is a function of the number of divisions, and decreases as this increases. I calculate that with 360 divisions, the tooth depth at 100mm. diameter is 0.873mm and the angle should be 0.5 deg.

I would be pleased to hear Mr. Morris' comments on my analysis and his suggestions as to the setting of the angle.

From R. Bentley, Southampton, Hants

I found the description of the locating device in Issue 52 very interesting. However, I am not happy with the method described for machining the two face gears.

It was said that the cutter, whether a milling tool or a shaper, passed across the top face of the gear and could cut two teeth at a time by passing right across the diameter. In truth, whether the cutter traverses the whole or half the diameter, the finished teeth would be in a flat plane at the root of the teeth and the crests of the teeth would form an inside cone, meeting the flat plane at the centre of the gear. Offering two gears cut in this way face to face, they would only meet at their rims when fully meshed. Their centres would be one tooth-depth apart.

Another wrong method would tilt the blank so that the tooth form cut was full depth at the rim, reducing to zero at the centre, and producing teeth in a flat plane at their crests. If a pair were to be offered up, they could not enter mesh, as the un-cut material at the centres would interfere.

The proper method would be to cant the rotary table at half of the previous angle, cutting teeth with the tips in a hollow cone and roots in an external cone. When these gears are presented to each other, starting with the rim tips just in mesh, a movement of one tooth depth will engage the teeth fully at the rim, and as the gear centres are each half of one tooth depth below the top plane, they will come together also.

Perhaps Bill Morris would like to comment on this anomaly in his very original article, and I would also be pleased if you would pass on an idea which I have had, which I would be most happy if he would care to use.

Start with THREE slices of material as a sandwich. Cut TWO sets of gears having differing numbers of teeth, for example 120 and 90 teeth.

Step forward one tooth on the (90) = 4 deg. POSITIVE. Step backwards one tooth on the (120) = 3 deg. NEGATIVE. Result is 1 deg. actual movement.

The main advantage is being able to use coarse, strong teeth. But if you cut 360 teeth on one gear and 359 or 361 on the other, you could step all round with a small increase each step. A full circle = 1 deg.. (Only joking !!).

The other advantage of using two gears is, if you select two gears with the right factors in their tooth numbers, then you get a greatly increased number of useful divisions for a dividing head.

From Leonard Woods, Köshing, Germany

Your issue No. 52 is full of interest for me. Bill Morris' Face Geared Indexing Table is of particular interest because the principle used has been the subject of an article and lively debate in another periodical to which I subscribe (Strictly I.C.).

Unless I have misunderstood Mr. Morris' article, the geometry of his face teeth is not quite correct. As described, they will only engage fully around the circumference of the gears. This may be intentional, though I don't understand why, in which case this should be regarded as additional information which may be of interest to others, not as criticism.

What woke me up was the statement that a tooth could have been cut across a diameter. Mr. Morris' teeth will have a constant depth measured from the top of the blank. Thus, as each cut nears the centre of the blank, it will 'overlap' adjacent cuts and so reduce the height of the crests. If extended to the centre, there would be no tooth at all there, just a 1.31 deep hole. For correctly formed symmetrical teeth, the depth of cut at the centre of the blank should be reduced to be half of its value at the circumference.

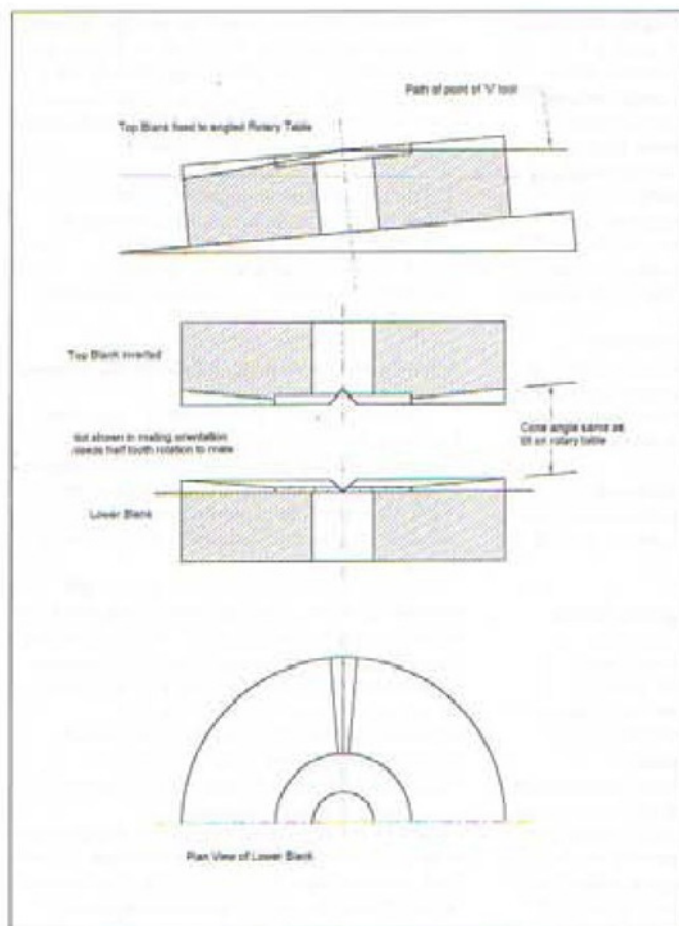
Asymmetrical teeth are also possible, in which case the cutting angle will be different for each blank.

In Germany the device is known as a 'Voith-Hirth-Verzahnung', probably because it was extensively used in the thirties for joining sections of built-up crankshafts. It is described in standard engineering text books such as 'Machinenelemente' by G. Niemann (Springer).

It is also fully described in Machinery's Hand Book in the section 'Bearings and Other Machine Elements', chapter 'Couplings and Clutches'. There it is called a 'Saw-tooth Clutch'. There are diagrams which clearly describe the geometry and tables of common tooth angles and numbers of teeth.

From Dave Edwards, Harrow, Middlesex

In Figures 1 and 2 of Bill Morris' article, the teeth are shown as a series of radial lines; however, if the teeth are cut as described using a shaper and a 90° vee tool cutting horizontally across the face of the blank, although the result will be radial lines - the peaks of the teeth will slope down towards the centre of the blank. Therefore, when the second blank is cut and inverted to



2mm wide at the periphery. I imagine that with a thin enough layer of blue, this would show as line contact.

Why did I make it this way? Well, it was clear enough that if the tooth section was the same from periphery to centre, there was no way that the teeth could engage and it was also clear that I was not mathematician enough to work out what the required angle should be and so I made a virtue out of necessity, settling for line contact only. It did not occur to me to look in my 1944 edition of Machinery's Handbook, at least, not under 'saw-tooth clutches'. Had I done so, I would have found an incorrect analysis that suggests that if the angle is incorrect there is only partial area (as opposed to

not a virtue.

b) Line contact will result in more rapid wear; and remember that the errors of face gears get less with wear. The wear will result in a gradual increase in correct area contact.

c) Line contact at the periphery maximises the self-centring properties of the table.

d) The indexing table is not a clutch and transmits no power, so the small area of contact is no disadvantage.

e) It is easy to set up the rotary table horizontal. It is not easy to set it up to a small, precise angle from the horizontal. If the angle is too small, you only get line contact anyway and if you get it too great, bearing is on the central part and the table rocks (Believe me, I have tried it.). Most amateurs will not own a clinometer reading to single minutes.

For those who wish to make the indexing table according to the proper formula, divide 90 by the number of teeth and find the tangent of the resulting number. Divide this tangent by the tangent of half the cutter angle. Find the angle whose cosine is the resulting number. Take it away from 90 and you have your clinometer reading. I have done the sums for you in the following table.

In re-cutting the teeth this morning for this reply, I raised the rotary table

assembly, the only point of contact is at the edges where the vees interlock.

For the teeth to interlock along their whole length, the crest of one set of teeth must be horizontal. For this to occur, the vee cut must be made with the rotary table tilted at an angle ('downhill' - in line with the shaper stroke) such that at full depth of cut at the outer edge, the tool runs out of the material at the centre of the blank. One half then winds up with the crest of the teeth horizontal and the trough running uphill from outer edge to centre.

The mating half must be made differently. The blank must be turned so that the face which is to have teeth must be a shallow cone dipping down from edge to centre at the same angle as the uphill trough in the first half. (Actually 1.5 deg. in the case of the 100mm dia. indexer with 120 teeth.) This one can now be cut as described in the article. This will wind up with the troughs horizontal and the peaks running downhill from edge to centre. When mated, these two parts should then fit over the full tooth length.

I'm sorry that I cannot find better descriptive words for this, and I've had trouble even drawing explanatory sketches for myself. I hope that the enclosed drawing will help a bit (cone angle is exaggerated for clarity).

Bill Morris responds

All your correspondents are correct: the teeth make contact only at the periphery if made as I have suggested and I verified this with marking blue. There was an annulus of blue about

line) contact, though the formula given is correct. Mr Delaney's analysis is

Number of teeth	Clinometer reading (Degrees and minutes)		
	90 deg. cutter	75 deg. cutter	60 deg. cutter
720	0 7.5	0 9.7	0 13
360	0 15	0 19	0 26
180	0 30	0 39	0 52
120	0 45	0 58.6	1 18
90	1 00	1 18	1 44

correct and, for a 90 deg. tooth form, the formula is simply 90/number of teeth. For other tooth angles, a correction factor has to be introduced, as shown in the full formula.

The virtues of line contact at the periphery, as I see them, are:-

a) It minimises redundant contact. I like to think that there is plenty of redundancy in the structure of my house, so that if an earthquake strikes (as they do from time to time in this part of New Zealand) and an element of the structure gives way, there will be enough other elements to share the load. In a measuring or alignment instrument, redundancy is

at the ram end by inserting a 3mm rod underneath it and rolled it towards the other end until a clinometer gave the correct reading, and then bolted down the rotary table. A similar stratagem is shown in Photo. 13 of the original article. It still took me two goes to get area contact. That's twice round 240 teeth!

I liked Mr Bentley's idea for differential indexing and may try it some day, but have had enough of teething for now...

I am always happy to hear from others who have found my articles helpful or interesting. The easiest way to reach me is via E-mail at engineer@clear.net.nz or via the Editor.

