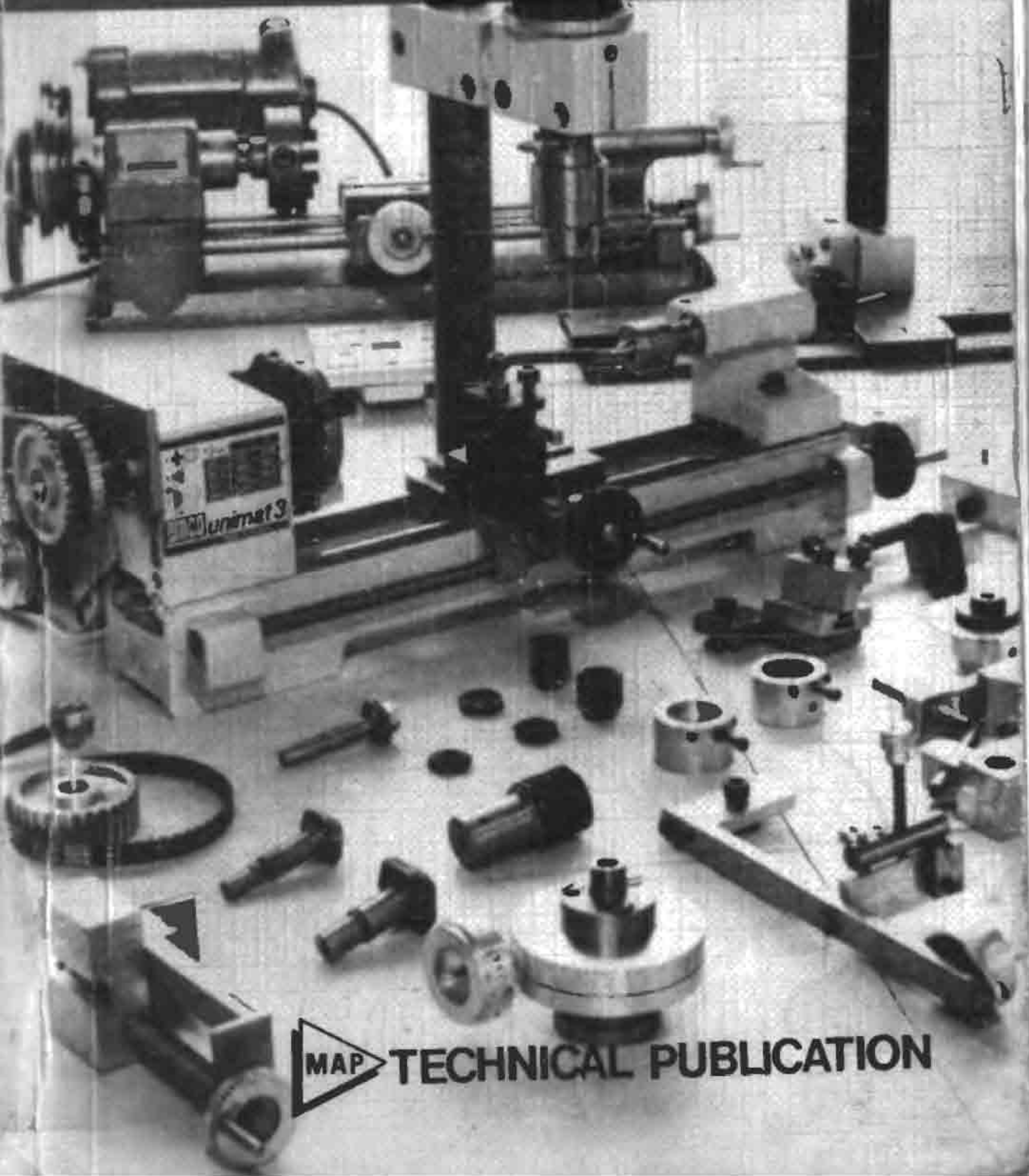
king the most of the unimat

Rex Tingey



MAP TECHNICAL PUBLICATION

MAKING THE MOST OF THE UNIMAT

including SL and Mk 3

Rex Tingey

Model and Allied Publications

Argus Books Ltd

14 St James Road, Watford, Herts, England

Model & Allied Publications,
Argus Books Ltd,
14 St James Road, Watford,
Herts, England.

First Published 1979

ISBN 0 85242 676 3

Printed in England by Garrod & Lofthouse Ltd., Bedford.

CONTENTS

FOREWORD

In November 1975 I became the owner of a Unimat SL lathe, this being bought due to interest in radio controlled models — aeroplanes, helicopters, hovercraft and racing cars — and it was hoped that the small machine tool would enable fabrication of accessories, such as silencers, for the small internal combustion engines so that they could be adapted to suit these various purposes.

However, the fascination for the accomplishments of the small lathe and accessory tools took over my leisure life, and great pleasure was discovered in using the machine to its limits and in self-improving the Unimat. That is, in using it to improve itself by making accessories and attachments to improve its limited scope and to transform its performance.

There seemed little point in keeping this expansion of scope to myself, and so I photographed odds and ends as they were made, and started to write up the order of manufacture as the various things progressed, finally completing drawings; all to be sent to the Editor of *Model Engineer*, where Martin Evans was kind enough to accept them for publication. The first of these articles appeared in August 1976 (A Vertical Slide) and have continued to appear off and on through to the present date.

Besides the articles about the lathe, itself, I have also written about a number of steam engines constructed solely with the assistance of the Unimat 3 or the SL model. The latest being a 2½ in gauge locomotive, *Sugar*, a coal-fired live-steam model, which is quite easily constructed on the small lathe.

It is surprising that the Unimat has been regarded by many people as a toy, rather than as the workhorse it really is, and little or no regard has been paid to this machine tool in the model engineering world. Even the manufacturers themselves tended to underrate the scope and capacity of their own product in both the advertising and in the small kits of model parts. The Unimat 3 is at the present time commanding more respect.

This book is a collection of the articles around the Unimats, which have appeared in *Model Engineer*. There are some minor alterations to the text and the drawings, and they are in a more logical sequence than when first published. I wish to thank Martin Evans for his help in the past, and to thank the present Editor of *Model Engineer*, Les Porter, for his permission to reproduce from the magazine.

It is hoped that this book will be taken as a 'sister' book to 'The Book of the Unimat' by D. J. Laidlaw-Dickson, which gives all the basic facts and workings of the Unimat models. This book is for the more advanced Unimat owner, and model engineer, who will want to improve the scope of his machine tool, often beyond expectation!

Rex L. Tingey
January 1979.

I. MAINTAINING THE UNIMAT LATHES

The Unimat 3 differs in size from the SL model mainly in the height of centres above the bed and cross-slide, and the greater distance available between centres, as can be readily seen from the photographs. Construction differs mainly in the use of a cast iron bed which is far more rigid than the two round bars of the SL. Apart from this extra rigidity a Unimat SL, with all my modifications incorporated, can perform just as well as a 3, within its limitations of size.

The Unimat 3 is not easy to clean and service as it traps swarf in its bed casting and other intricacies, and has no cleaning slots for the lead and cross-slide screws, so that fine swarf and metal dust often finds its way between thread and nut, which then bind and grind; the part must be immediately dismantled and cleaned out to avoid wear. The fitting of metal aprons and felt or rubber traps is never to be recommended on a small precision lathe, as they cause more wear

Centre height above cross-slide of the Unimat 3.

Centre height above cross-slide of the Unimat SL.

than they prevent with a mixture of lubricant and metal dust entering the soft material within minutes of use, turning them into abrasive strips.

Maintaining the Unimat 3

After working with the lathe for about 100 hours, using the recommended lubricants and care, it is a sound idea to strip it right down to its component parts and clean off all surfaces, using one of the cleaning sprays, which replace the toxic C.T.C., and a piece of terry towelling. You may be surprised to find that the cross-slide carriage travels along the bed held in place with only a plastic strip each side, beneath, with assistance from a big square locking nut.

To remove the lead-screw it is necessary to loosen the screw, underneath at the handwheel end, which holds in the bush, and to tap out with a $\frac{1}{4}$ in brass drift from the headstock end. Then screw it right out of the fixed nut of the cross-slide carriage, remembering that it is threaded left-hand. Remove the head-stock block, two hex cap head screws underneath, and, after removing the cross-slide by winding it right off, slide the carriage to a convenient under-hole in the bed and dismantle it from beneath, to clean up all the parts. There is a separate dovetail plate which will fall out from the cross-slide; it replaces quite easily with its slot on to one adjusting screw's end.

Assemble the carriage on to the bed, nothing else fitted, tighten the screws underneath and slide from one end of the bed to the other and lubricate. You will feel that the carriage is freer in the centre of the bed, where all the work takes place, than at the ends where it will feel quite tight. This is merely a running-in effect where microscopic roughnesses have been smoothed off the cast iron bearers. Should this eventually become a problem of wear this could be eliminated by making slips of crocus paper to fit under the plastic bearing strips, of the same size, to be pushed up and down the bed to even out the wear up to the ends; then removing the slips and cleaning off. The only other likely wear points are the cross-slide dovetails, where wear can be adjusted out, and the feed-screw and nut, which will require a new carriage and feed-screw to be fitted.

Oil the feed-screws and the bush and assemble the carriage and cross-slide feeds, with the slide and the dovetail tension plate in place, making any necessary adjustment. Tighten the carriage locking screw and nut to the correct running tension.

The main spindle ball-races will require no oiling, but feel that they are running smoothly; they should need no attention for at least a year. If they ever need dismantling then use the correct circlip pliers, and it will be found that the back race pops out under tension from spring washers. Clean off the ways underneath before replacing the headstock block with its two screws.

The motor should need no attention, but the intermediate drive on the drive plate should be regreased by first removing the circlip, lifting off the pulley wheel and cleaning up before regreasing with a good motor grease. The tailstock can be oiled by simply removing the two back screws, oiling well in the holes and replacing the screws. Always take care that the ways beneath the tailstock are clean and free from swarf, or work will not run true. Oil all the hand-wheels, run them in and out and clean off surplus oil.

The vertical head should need little attention apart from the oiling of the movement by lubrication in the annular bottom spring cup. The bearings are of the sealed type and should need no attention as swarf should not jump this high! Keep a weather eye on the grub screw at the front of this unit as it does tend to work loose and to give a torque twist to the motor plate when drilling and milling.

Grinding operations are best kept away from the lathe, altogether, as there is always a great deal of abrasive dust generated which is extremely difficult to keep out of the works and can do a great deal of damage.

When using the machine in the vertical mode always remove the chucks from the main spindle nose or they get in the way of the motor casing, brought down by the vertical movement.

Always clamp the work on to the top of the cross-slide for drilling operations, even when drilling straightforward holes in flat workpieces. Unclamped work will bend expensive twist drills and slash unwary fingers, with no warning at all. For all the cleaning up jobs on the lathe use a $\frac{1}{2}$ in paintbrush, and lubricate with 3 in One oil after every job.

Maintaining the Unimat SL

Wear Points

The faster moving parts, being enclosed and fully lubricated, give no real problems of wear, it is the slower moving parts which are vulnerable. Most wear occurs to the thread of the platform carrying the cross-slide. The platform is made from aluminium alloy and the threaded spindle is of steel, swarf sticks to the thread and is wound into the platform causing the tapping in the softer metal to wear. The columns show virtually no wear. The threaded spindle of the cross-slide is running in cast iron and gives less wear. Constant lubrication of the slow moving parts can prevent, or slow down, most of the wear, and the hastening of wear is caused by grit during grinding operations not being immediately removed, before further work is carried out.

Drilling 12 mm dia silver steel.

Measuring the backlash between the threaded drive and the platform.

Weak Points

The weak points of the lathe are the long main columns and the shorter cross-slide columns which are quite flexible and cause tool dig-in, vibration and chatter, which are undesirable and lead to wear. The tailstock is a little flexible, but this helps centre drilling, and is only a nuisance when recentring a workpiece.

Damage Points

Points vulnerable to damage are the front of the cross-slide and the platform which are easily accidentally driven into the moving chuck or workpiece, and the chuck itself. The back column can similarly be damaged near the chuck. But it is the jaws of the chuck which matter more as they can readily break off a tooth or two within the scroll, and the jaws of the 4-jaw chuck can be broken in a different manner.

The drive belts, as supplied, are particularly vulnerable to swarf damage where a small piece of metal becomes embedded in the rubber and quickly leads to a split belt.

The drive shaft may seem vulnerable but, being a tube, is very strong and acts as a torque tube, absorbing rotary shocks.

Improvements

Three simple improvements can be made to the Unimat to improve performance. Fit 12 mm dia silver steel in place of the columns supplied. Silver steel is made to far better tolerance and the slightly longer bar is more rigid on the frame. Just drill each end with a ¼ in drill and countersink, allow the extra length at the headstock end.

Second, replace the cross-slide column, tailstock side, with ⅜ in silver steel after reaming through. Leave the threaded rod and other pillar in place and ream through the carriage and slide, pushing out the 8 mm column with the reamer as you go. This thicker column takes away from the cross-slide much of the flexibility.

Thirdly, if your Unimat is recent and fitted with the black plastic handwheels, discard these after making a set of aluminium wheels to the same dimensions. When fitting use a brass washer between surfaces to prevent binding. Calibrate with the 40 division index plate with 4 main divisions and 9 in between, representing 2 thou each. The little handle can be pulled from the plastic wheels and fitted. Knurl the outer surfaces just lightly or you will wear out fingertips.

Checking the Unimat

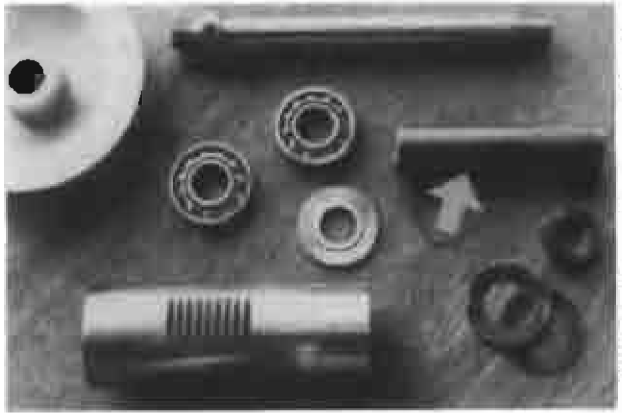
The Verdict Junior Dial Indicator is inexpensive and a useful instrument for checking most aspects of the smaller lathe. The Junior indicates from 0 to 16 thou, it has automatic reversal, its ball point is friction loaded to avoid damage, and it is scaled on both sides. The magnetic stand is unnecessary; instead make the T-nut fitting, as shown in the photograph, and cut a length of good ¼ in dia silver steel as a further part of the instrumentation; keep the kit of parts in a box with a drop of oil.

In day-to-day use the instrument is used to check the centre line of the lathe whenever the headstock is replaced after being disturbed, and also for ensuring that the head is square in the vertical mode, for drilling and milling.

When maintenance is being carried out use the Verdict Junior for checking the concentricity of the 3-jaw chuck, the drill chuck and the nose of the main spindle, also check the centre line, headstock to tailstock. Use the indicator on the head in the vertical mode to check the flatness of the cross-slide surface and the movement of the cross-slide along the columns. Any backlash in the cross-slide and carriage screws can be checked using the indicator fixed to the silver steel held in a chuck, point impinging on carriage or slide.

To check the columns obtain a micrometer, preferably one with the extra vernier sleeve, reading to a tenth of a thousandth of an inch, or

Parts for the dial indicator set-ups. Measuring concentricity of the chuck, the headstock positioning and backlash in the cross-slide.



Left: The drive dismantled; the distance bush is arrowed.

Opposite page: Turning a thou off the nose of the spindle.

Below right: Reaming through the carriage and cross-slide, in situ.

metric to .002 mm. These cost a little more than the .001 in or .01 mm micrometer but provide the extra accuracy when required.

Maintenance

Carry out a basic maintenance routine every time the lathe is used, cleaning out all swarf with a ½ in paint brush, loosening the carriage screws, oiling the columns and winding the carriage along the bars. If soluble oil has been used, apply rather more light machine oil to float out any water-oil mixture. The brush is used for cleaning swarf from the threads; and old towelling is also an efficient swarf remover.

After every twenty hours of use a more thorough servicing is required. Take off the handwheels, headstock and tailstock, unscrew the nuts and bolts securing the columns and screw out the threaded rod. Pull the columns through the platform, loosen the two front grub screws beneath the platform, push out the cross-slide columns and remove the threaded rod. Unscrew the clamping bolts.

Using a cleaning agent, such as C.T.C., clean out all the slots and holes, wiping through with the edge of a rag. Clean the threaded rods and all bearing surfaces. Wipe the bed down, taking care that the machined surfaces for the columns are particularly clear and clean. Reassemble the lathe, and oil all the moving parts, moving them whilst oiling. When reassembling the handwheels use a set procedure to ensure that the wheels are free to use, but tight enough to eliminate play.

Screw on the handwheel as tight as it will go, tighten the clamping screw, fit the locknut loosely then back off the handwheel exactly four divisions. Tighten the locknut completely with a spanner, loosen the clamping screw, oil the bearing and turn the wheel to check.

Major Overhaul

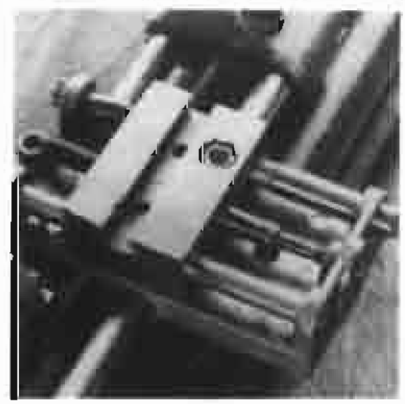
After 100 hours of use, approximately monthly, the lathe needs a

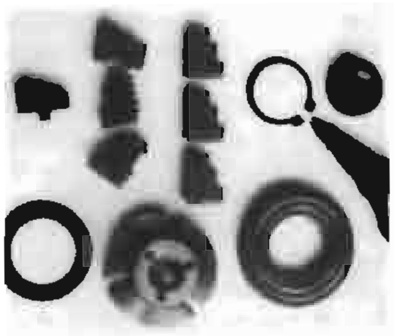
complete overhaul. Remove the drive belts, loosen the drive sleeve in the headstock, take out the screw and pull out the drive plate complete. Loosen the clamping screws and separate the mandrel, intermediate drive and motor from the drive plate. Slip a tommy bar in behind the spindle nose and put the nose end into a vice fitted with alloy clams. Tighten up to the tommy bar and loosen the large nut at the pulley end with a 19 mm A.F. spanner. Dismantle completely and clean off the grease. The bearings will probably come out separate from their shells, but the shells will come out out of the sleeve and off the main spindle with a little effort. Put the bearings into a grease solvent, paraffin will do, and clean them up. I use a small glass beaker for this job so that I can see what is coming out, usually more swarf than expected!

Dry the bearings and regrease using a lithium based motor grease, such as Shell Retinax A, put some excess grease into the sleeve and reassemble. If there is any play in the spindle dismantle and reassemble, checking with the exploded view in the handbook. My Unimat developed a loose spindle after only a few hours use, when new. I had 2 thou taken off one end of the long inner sleeve, called the distance bush in the handbook, and this cured the problem, possibly a 'running in' fault, which has not recurred. The job needs to be carried out on a big lathe.

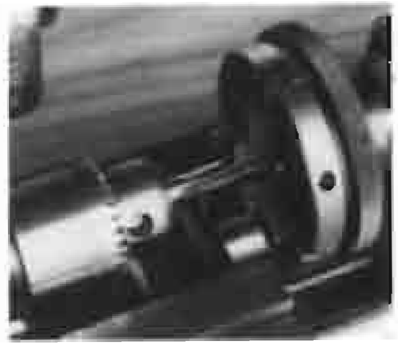
Clean out the intermediate drive bearings and regrease. Clean the ends of the motor and run one drop of oil into each end. Reassemble all the parts on the drive plate, put on the belts and replace in the headstock casting; run the spindle fast, for a few minutes, to drive out the surplus grease. Check the flatness of the flange at the nose of the spindle with the Verdict Junior, and take off just a thou if necessary.

Dismantle the 3-jaw chuck using the circlip pliers; the type that expand the circlip are required. Clean out the scroll and check the teeth of the jaws. Lightly grease the moving parts (oil would centrifuge out) but leave the scroll dry to avoid holding swarf.





Parts of the 3-jaw chuck, also some broken jaws.



Lightly reaming the chuck jaws to obtain concentricity.

Reassemble and check on the headstock for concentricity. The main cause of eccentricity with this chuck is simply that it is not seating properly either on its backplate or on the main spindle, due to a minor defect such as a burr in the metal, or a piece of swarf. New jaws can be readily fitted, either hard jaws, or soft jaws which are supplied without the steps cut and can be machined to your own requirements. Old jaws which are turning eccentric can be remedied by holding the chuck on the tailstock, slowly turning a reamer in the drill chuck, and running it through whilst gradually closing the jaws.

Spares

The first major item that will be replaced is probably the platform, as the only way to eliminate backlash is to replace with a new one, replacing the threaded drive spindle at the same time, as this will have slight, differential, wear. I also keep a main spindle, but despite all the knocks it has not been required, although it is useful as a second check for chuck concentricity.

It is wise to hold some ball races as spares. Keep one E13, the thrust bearing for the main spindle, and two EL6 races for the intermediate drives. Get a set of hard jaws for the 3-jaw chuck, and a length of silver steel, 12 mm, in case of damage. The M4 countersunk screws and the M6 hex cap head screws are easily lost, so keep a few of these spare. Belts are a sound investment as they always break on a bank holiday weekend.

Finally, a word on the mounting of the lathe bed. Do not fix the Unimat securely to a bench but mount it on 1 in wood. A piece 2 ft x 8 in is just about right, but cut out a piece for the flywheel if the improved drive is fitted, and secure with four screws, with the front about $\frac{1}{2}$ in. This gives a different feel to the Unimat in both the horizontal and vertical use. It is heavy and safe enough to sit on a table surface as a lathe, and will not overbalance when used for milling or drilling. Yet it enables a set-up to be adjusted for

convenience of work angle, or even turned right round, and the whole can be tipped up for swarf removal, and put in a box for protection when not in use.

Rejuvenated Carriage

If you have found wear in the threads of the carriage and threaded rod and replaced them, it is a simple matter to repair the old ones. Just fit a $\frac{1}{8}$ in dia phosphor-bronze bush, drilled No. 12, to the reamed-out carriage, secure it with Loctite, and tap with the left hand $\frac{3}{16}$ in BSF taps. After tapping, saw through one side for the swarf trap.

Make a new threaded rod from $\frac{3}{16}$ in mild steel. Hold the part to be threaded M5 firmly in the vice jaws and tap with the left hand $\frac{3}{16}$ in BSF die wide open; use plenty of Rocol RTD and back off every one-third of a turn. Relax the die and repeat; made this way there should be no torn threads. Make a boss to support the threads in the steady and turn down the 5 mm close to the 3-jaw, thread the end M5.

You will have had to fit a new carriage and rod to make these, but they are now your cheap new spares for future use. Remember, when you fit them, that one-fortieth of a handwheel division now moves the carriage a little more than one thou, instead of a little less, as before.

Dismantle and clean up the tailstock, grease and reassemble. The only problem with the tailstock is the drive screw which develops backlash over the first quarter of an inch, where it is used most. When this matters in working, such as drilling phosphor bronze, the tailstock should be extended past the play in thread.

Grinding

After any lengthy grinding session, where no protection has been given to the front of the headstock, give a major overhaul, and always give the minor servicing after grinding even with protection.

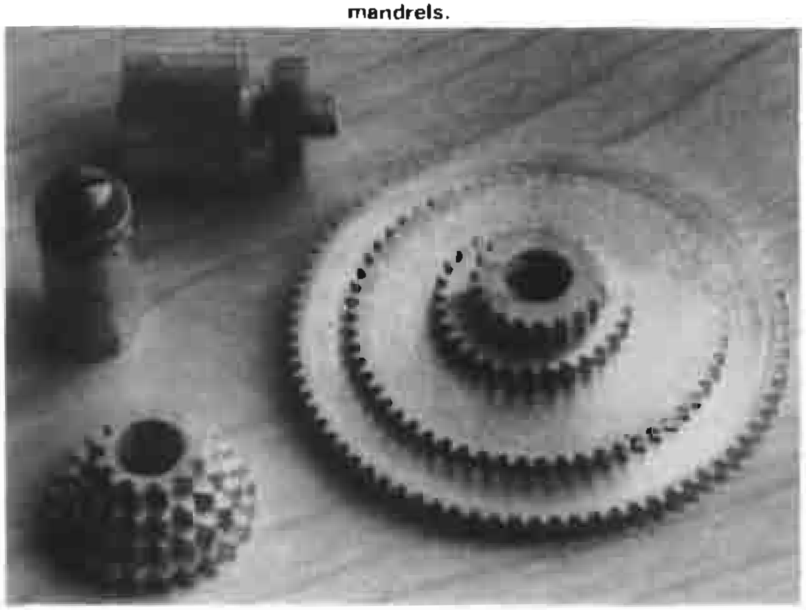
Rejuvenated carriage.

II. CUTTING GEARS

This method of gear cutting was devised when I was making a small traction engine, at the working limits of the Unimat, and wished to make gearwheels of various sizes of diameter and tooth. The system was devised to be very flexible and make the gears as cheaply as possible. The indexing attachment with the range of four plates is required, as is the threading attachment for cutting the worm wheels. It is suitable for both the SL and the Unimat 3.

Two main principles had to be discarded; that of calculating with diametrical pitch (D.P.) and the use of helical hobs. Substituted were the cutting of a tooth (or gap) of a certain size, and the use of a straight toothed hob to cut it.

A set of driving and change gears for a scaled-down "Minnie", with their mandrels.



Cutting gears with the home-made hob.

Using the hob to cut a rack.

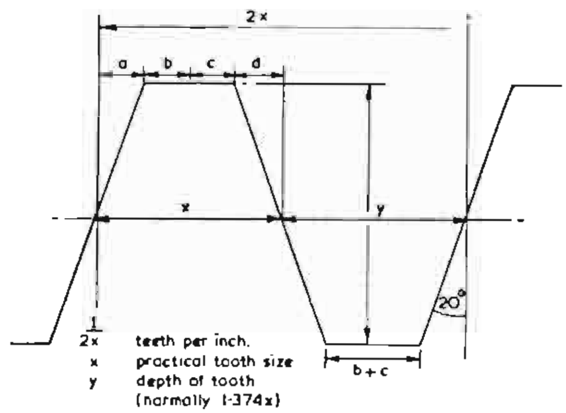
The advantage of using a straight toothed hob with, say, five rows of cutters is that the cutter can be used to cut teeth in any diameter wheel made to accommodate that size of tooth around its periphery, because while the part of the hob immediately radial is cutting a perfect space, the rest of the hob is modifying two already cut and two about to be cut, and the amount of modification depends on the diameter of the blank. With a helical hob the cutter is run continuously with the blank and the cutter modifies teeth to a curve. This method modifies the teeth to a series of flat planes which seem to run together very nicely.

The disadvantage in cutting teeth of a certain size is that the normal D.P. system cannot be used and gear wheels end up with odd-sized diameters, due to pi. However, the modern calculator enables tables to be readily drawn up to show what diameter of blank is required and the working radius of the finished gear wheel. The odd measurements are, after all, only distance between two points, and the advantage of a given size of tooth is that you can keep it simple to correspond to threads per inch. Thus the old-fashioned BSF or Whitworth bolt can be used as a cutting guide for making hobs, and the bolts themselves can be used as simple worms in conjunction with home-made pinions.

Included is a method for cutting gears to run with the modern toothed belt drive. Once certain problems are realised it is quite straightforward to cut the teeth for this drive.

Geometry of the Hob

The geometry of the hob is shown in the diagram; the hob takes care of the geometry of the modified tooth that it cuts. x is a distance halfway down the tooth, and if there are ten teeth to the inch then x =



GEOMETRY OF THE CUTTER TEETH

.05 in. If a = b = c = d, then y = 1.374x; this gives a normal short tooth; y can be increased to 1.5x to give a slightly longer tooth and allow the hob to wear and be sharpened; figures for both are tabulated. The tables are worked out for the four tooth sizes, and two differing y figures, to the equation:

$$\frac{\text{number of teeth required}}{\text{teeth per inch} \times \text{pi}} + (2 \times \tfrac{1}{2}y) = \text{diameter of blank}$$

The length of the bottom of the groove between the teeth where y = 1.374 is b + c = ½x, but where y = 1.5 the bottom of the groove is .454x. The hobs have a central cutter, cutting a space, with two cutters either side modifying the spaces either side, mainly above x dependent on the curve of the blank. If a tooth were to be cut instead of a space, the outer edges of the two cutters are then not radial and would cut under the x line and produce a 'hollow' tooth shape, and the type of shape cut varies considerably from large to small gears.

The Hobs

The first job is to make the hobs. My four correspond to 1 in, ¾ in and ½ in Whitworth and ½ in BSF. This gives the selection of eight, ten, twelve and sixteen teeth per inch. These cutters are made from ¾ in silver steel, boring them ¼ in and using ¼ in dia rod as an axle for making and using them. They are secured with 4 BA Allen grub screws. A lathe tool is required to cut the 40 degree angle, and this is best made from a ¼ in square HSS tool blank, using a grinding wheel; it can be made from silver steel then hardened and tempered, but the tool has a lot of hard work to do in cutting the hobs and the HSS needs far less attention. The tool should have an angle of 40 deg between its two faces, which are backed off in the downward direction. The top surface is relieved back and to the left; when used the tool is fed in to match the left side of the cut, advanced, and further cutting made to the right. The tool is pointed, but the cut made flat bottomed.

The other tools needed for making the hobs are a ⅛ in × ½ in Woodruffe cutter for grooving, and a disc grinding wheel for backing off the cutting edges. The Unimat people can supply a set of grinding wheels to fit the standard adaptor; they are not on the latest lists but if you order No 1191 you may still get them. You will also require a simple depth gauge, which I will describe later.

To make the hobs first cut a length of silver steel approximately five times the overall tooth size plus ⅛ in for the Allen grub screw, so for eight teeth per inch cut a ¾ in length; you can economise by omitting the extra length for the grub screw and placing this at the bottom of one of the grooves instead. Face both ends in the 3-jaw chuck, drill with a No 3 centre drill as far as the flutes allow and then drill right through with a ¼ in drill. Drill a No 32 hole for the grub screw and tap 4 BA. Run a ¼ in reamer through the bore, fit a ⅛ in long grub screw and secure the blank to a piece of ¼ in silver steel rod turning between centres.

Take a light cut from the surface to ensure that it is co-axial, then turn the securing screw end down below tooth level. With the 40 degree tool make four shallow cuts for between the teeth. To measure these the handwheel divisions can be used, fifty divisions equalling 1/10 in, but check with a rule before continuing; keep the appropriate Whitworth or BSF bolt handy as a quick check. Working from left to right cut the two grooves either side of the central tooth to the correct depth using the geometry as explained, and a depth gauge. The width of the bottom of the cut can be regulated with the hand wheel divisions. Next cut the other two grooves to form the five teeth, matching the others, and finish by cutting the two outer surfaces to a 20 degree angle.

To make the teeth into cutters set the work on the ¼ in steel in the 3-jaw chuck on the indexing head with the 48-division wheel. Use the Woodruffe cutter to make six slots across the grooves (eight teeth each on the dividing wheel). Feed in no more than five or six handwheel divisions, then run the saddle across; a greater feed overheats and soon blunts the cutter. Replace the Woodruffe cutter with the disc grinding wheel, set the dividing head four teeth back and grind off about two-thirds of tooth area. Set the dividing head three more teeth back and back off finely almost to the cutting edge.

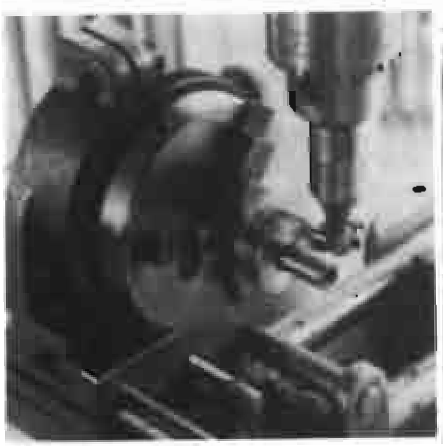
Remove the set screw and push the hob on to a piece of ⅜ in copper pipe whose end has been cut and squeezed together and place on an asbestos board. Have a pair of pliers and a can of cold water handy. With a blowtorch heat up the hob to cherry red, pick up the copper pipe with the pliers, hob upright or it will fall off, and give a final

blow to ensure even redness, then dunk in the water. Include the copper pipe in the dunking or you will get a surprise when you pick it up. Take the hob from the water and replace the water with cold. With a sharp file vigorously file the flat bottomed grooves where it should make no impression but remove a little blackening. With emery cloth clean the ends to clean metal including the extra surface for the set screw, push the other end on to the copper pipe to reheat. This time hold the pipe with the pliers and heat only the copper until the grooves and cleaned parts go to a nice yellow, as if you had varnished the hob, then dunk into the water. The hob is now finished, there is little need to clean off the blackening, and you will have burnt off the burrs with the first blow.

It would be best to make the four sizes at one go, turning them one after the other, then hardening and tempering; in this way the four hobs could be made in the time it would take to make two at different times, and they will be more accurate. Slight inaccuracies are not over-important, as long as the two gears are cut with the same hob they will run together. It is better initially to make the longer size of teeth as they will shorten with sharpening. So far I have only used the hobs with alloy and brass and the cutters show no signs of blunting, but to sharpen them the leading edges of the teeth would need a light stoning by hand, and then the hob should be turned at speed and the tops of the teeth run lightly against a flat stone. There is no reason why the cutters should not cut teeth in mild steel blanks, but greater care must be taken to avoid overheating by using less of a cut, and the hobs will need more attention by sharpening.

Gearwheels

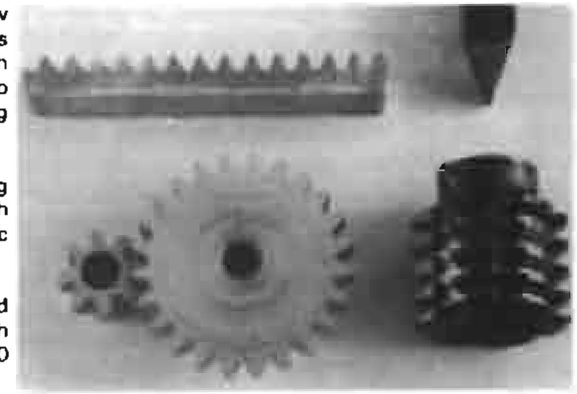
To make a gearwheel, first cut the blank. This is most easily cut from bar material with a diameter a little larger than the gear requires. Use the table to find the size of blank you need for the size and number of



Opposite page below left: Slotting across the grooved hob with a Woodruffe cutter to form the cutting teeth.

Below right: Backing off the cutting teeth of the hob with a disc grinding wheel.

Right: Two gears and a rack, together with the hob and the 40 deg tool.



teeth. The effective radius of the finished gear is given in the last part of the table; this is the radius which can be drawn as a circle touching another circle to represent two gears in mesh without worrying about the teeth. This is useful for positioning two gear centres on a surface, such as the hornplates of a traction engine.

Take the blank and rub down one side flat on emery cloth on a flat surface to remove sawcuts. Chuck the blank, finished side in, in the 3-jaw and turn to a finish as much of the outer surface as the jaws will allow; enough of the centre of the blank has to be finished to take the mandrel, the rest can be finished on the mandrel. Use a centre drill in the drill chuck in the tailstock to give a good hole right through, and follow with a drill the size of your mandrel collar. Fit the blank on to the mandrel and secure, chuck the mandrel and finish the front surface, turn down the edge of the blank to the correct diameter using a vernier caliper.

Select the correct dividing wheel for the indexing attachment; the Unimat has four sizes of dividing wheel; the table shows the capabilities of these up to times two. Using this hob method to cut sixty teeth with the thirty-tooth dividing wheel you find that after cutting round once making the first thirty teeth, that the other thirty teeth are almost finished, and require the minimum of cutting. With the indexing attachment on the cross-slide secure the blank, on the mandrel, in the chuck, and have the hob in the drill chuck, driven, on the vertical column. Bring the cross-slide right over towards you and the headstock down the column until the hob presents its middle row of cutters to the horizontal centre of the blank; finalise by adjusting the headstock spindle. Turn the carriage handwheel until the hob can cut into the blank, and cut through by means of the cross-slide handwheel. Smaller teeth can be made with just one cut, forward and back, and then the next index cut; lock up with the index clamping screw whilst cutting. Larger teeth, and teeth in harder materials, will need more than one cut, in which case note the carriage handwheel

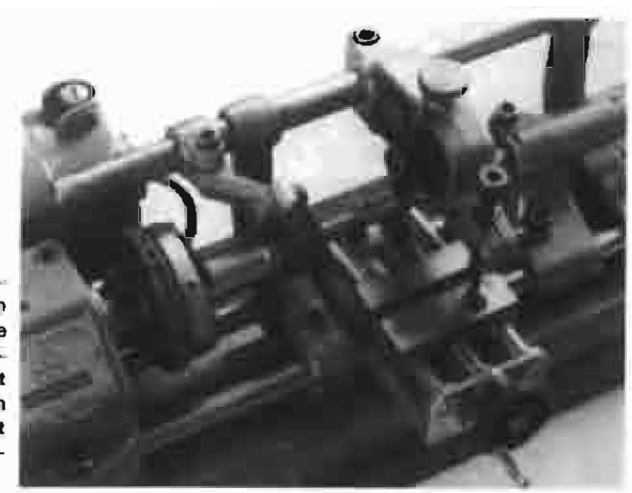
No of Teeth	Diameter of Blank y = 1.374x				Diameter of Blank y = 1.5x				¼ × D.P. of Gear Wheel			
Teeth per inch	8	10	12	16	8	10	12	16	8	10	12	16
5	.238	.228	.19	.143	.293	.234	.195	.147	.1	.08	.066	.05
6	.325	.26	.217	.163	.333	.266	.222	.167	.12	.096	.08	.06
8	.405	.323	.27	.202	.412	.33	.275	.206	.16	.138	.106	.08
9	.444	.335	.296	.222	.452	.362	.301	.226	.18	.145	.119	.09
10	.484	.387	.323	.242	.492	.394	.328	.246	.199	.16	.133	.1
12	.564	.45	.376	.282	.572	.457	.381	.286	.239	.19	.159	.12
15	.683	.546	.455	.342	.69	.553	.46	.346	.299	.24	.199	.15
16	.723	.578	.48	.362	.73	.585	.487	.366	.319	.255	.212	.16
18	.80	.642	.535	.401	.81	.648	.54	.405	.358	.286	.239	.18
20	.882	.705	.588	.441	.89	.712	.593	.445	.398	.318	.265	.199
24	1.04	.833	.694	.52	1.05	.839	.70	.525	.478	.382	.318	.24
30	1.28	1.02	.853	.64	1.29	1.03	.859	.644	.597	.477	.398	.299
36	1.52	1.21	1.02	.76	1.53	1.22	1.02	.763	.716	.573	.478	.36
40	1.68	1.35	1.12	.84	1.69	1.35	1.13	.843	.796	.636	.53	.398
48	2.0	1.6	1.33	1.0	2.01	1.6	1.34	1.0	.955	.764	.636	.477
60	2.47	1.98	1.65	1.24	2.40	1.99	1.66	1.24	1.19	.955	.795	.596
72	2.95	2.36	1.97	1.48	2.96	2.37	1.98	1.48	1.43	1.15	.955	.716
80	3.27	2.62	2.18	1.64	3.28	2.62	2.19	1.64	1.59	1.27	1.06	.795
96	3.9	3.13	2.6	1.95	3.92	3.13	2.69	1.96	1.9	1.53	1.27	.955

setting for each cut and the final position; write them down and keep handy — you may be interrupted halfway. Remove the completed gear from the mandrel and rub off the burrs on flat emery cloth.

To make the set of change and driving gears for my traction engine, I cut the blanks from 2¾ in, 1½ in and ¾ in dural rod using the small power hacksaw I had just designed and made, its advantage being that the blanks are cut square and almost smooth so they require the minimum of finishing; they are parallel sided and waste is minimised. All were turned and drilled 9 mm then fitted to mandrels with 9 mm collars. Two mandrels were needed; a larger mandrel which butted against the face of the 3-jaw chuck, and a smaller one, less accurate, for the smaller gears where the larger mandrel would impede cutting. Both were of dural rod, and both stamped with a line of 'ones' to be put in against the No 1 jaw position (not the jaw itself as this becomes No 2 when reversed). It should be noted that there is no point in marking up work for jaw positions with the Unimat unless the back plate of the 3-jaw chuck is also marked up for the No 1 position. Every time the indexing or threading attachment is used off comes the back plate, and which way does it go back? So stamp the back plate with a 1 opposite the No 1 jaw position; use it, and your mandrels will never wobble.

Wormwheels

Whilst devising a way to fit non-standard threading leaders to the threading attachment I found the way to make multiple-start worms on the Unimat. I had made a leader from a 1 in Whitworth bolt by sawing off the head, drilling through ¼ in, fitting an Allen grub screw



Making a two-start worm with the threading attachment using a 1 in Whitworth bolt thread as leader.

and securing it co-axially with a length of drilled ⅜ in brass rod on to silver steel rod centred in the lathe. The follower of the bolt thread was a piece of ¼ in brass plate filed on one edge. After cutting one lot of coarse thread on the small diameter brass it became immediately obvious that by simply turning the bolt, relatively, through 180 degrees a two-start worm would result; in both cases the end of the bolt butts firmly against the jaws of the chuck. By using the angle between the chuck jaws as a guide a three-start worm could be made at 120 degrees per start.

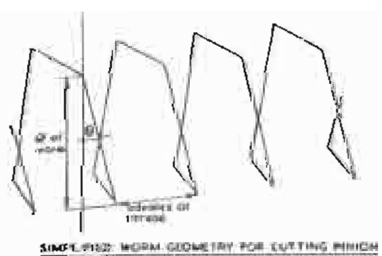
Since the 1 in Whitworth bolt has eight threads per inch the two-start worm became sixteen threads per inch, and a pinion of sixteen teeth per inch was needed to run with it. The cutter for this was a hob of ¾ in dia. In theory the cutter should be of a similar diameter to the worm so that the pinion embraces the worm. However, since the pinion was to be comparatively thin the ¾ in hob proved satisfactory.

To enable the pinion to run at 90 degrees to the worm the teeth have to be cut at the correct angle. To determine this angle it is simplest to imagine the worm as square in section, then each side of the square will advance by one quarter of the complete advance of the start. It can then be seen that the angle of the teeth of a pinion to mesh with that particular diameter of worm can be found from:

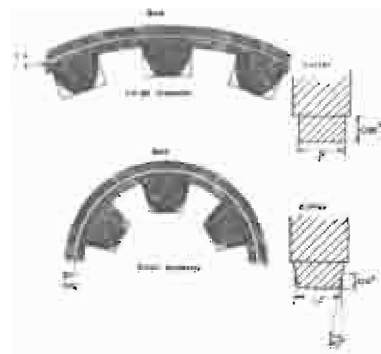
$$\tan.(\theta) = \frac{.25 \times \text{thread advance}}{\text{diameter of worm}}$$

A worm of outside diameter ⅜ in cut to 8 t.p.i. (the number of starts are not involved) will have a thread advance of ⅛ in; a quarter of this is 1/32 in .03125 over .375 equals .083R; this is tan. theta. On the calculator this represents an angle of 4.75 degrees, the angle to cut the teeth. This calculation gives a compromise angle which runs very well in practice, giving a good tight fit and some adjustment for future wear.

A steering worm and pinion for a small traction engine, with the hob and feeder used.



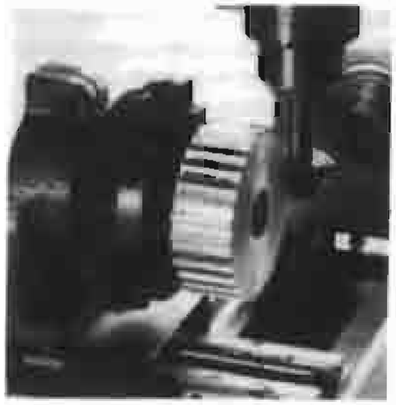
To cut the teeth of the pinion, set up the blank as before, but this time bring the centre line of the vertical headstock to correspond to the lathe centre line, check with the tailstock, and tighten up. Now turn the headstock the correct deviation from upright, initially using the 5 degree markings, then correct using the flat side of a rectangular protractor on the cross-slide. Bring the blank across and check with the worm that the angle is in the right direction and not cutting incorrectly by a further x degrees. Then cut the worm by feeding the blank on to the cutting hob; do not cut across as the pinion should be hollow for the worm. The worm, by the way, should have been cut with your 40 degree tool, not the one supplied with the threading attachment.

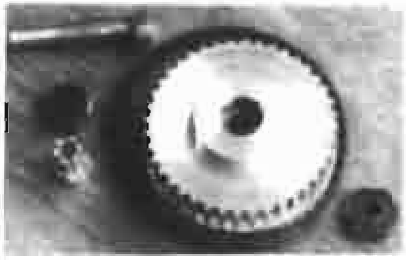


Cutting angled teeth in a worm pinion.

The Toothed Belt Drive

The toothed belt drive provides the same positive drive as gears in mesh but with the flexibility of positioning that the pulley and belt system provides. When transmitting power with a reciprocating motion, as in a power hacksaw, the drive belts from the Unimat slip and stretch on the final drive, but redesigning for the toothed belt overcomes these problems, although there are some small difficulties encountered. I had no information on the belt other than that it was reinforced within the continuous belt part with non-stretch nylon cords, and that these cords became the diametrical pitch of the belt around wheels. I had a toothed belt on a radio controlled stock car, and this size (100 x LO31) is readily obtainable from model shops. There are five teeth to the inch; the teeth are a tenth of an inch long, and a twentieth of an inch high.





Above: A toothed belt system. The smaller drive gear requires a flange to prevent the belt running off.

Left: Cutting drive wheel teeth.

On manipulating the belt it can be seen that whilst the teeth remain almost stable the size and shape of the spaces can be made to vary quite a lot; with diminishing diameters the gaps compress but the teeth do not. This is shown in the diagram. Cutters for making gear wheels to be driven by the belt cut only one groove and are not hobs. Two cutters are necessary, one for wheels of twelve teeth or less, and another for greater diameters. The cutter for the larger diameters has straight sides, but the one for the smaller has to have angled sides to cut away rather more of the wheel's teeth and allow for the compression of the spaces.

The size of the blank is worked out to accommodae multiples of one tooth plus one space around the circumference, and, although the non-stretch nylon cords should cause a reduction of the straightforward diameter, in practice the effect can be ignored unless the belt is to be run without much tension. The formula for the diameter of blank is:

$$\text{Diameter of blank} = \frac{\text{Number of teeth required}}{5 \times \text{pi}}$$

The cutters are made from 1/4 in slices of the 3/4 in silver steel, with a 1/4 in bore, but they are turned and formed into cutters on a mandrel made from 3/8 in dia mild steel turned with a 1/4 in collar, 3/16 in long to take the cutters. Hardening and tempering, using the copper as before, is carried out in the same way. The cutters are used to cut the blanks with exactly the same methods.

When the blanks are cut to gear-wheels check their accuracy with the toothed belt held tightly in place, after removing burrs from the circumference. Position the gears and belt so that the tensioning gives no more than a deviation of 1/4 in on a 2 in length of belt as a straight. When running gears with a toothed belt one of the gears should be

rimmed to contain the belt and stop it running off. With a small gear driving a large through a toothed belt it is sufficient to rim the small gear; this can be done simply with the use of co-axial flanges secured either side of the cut gear.

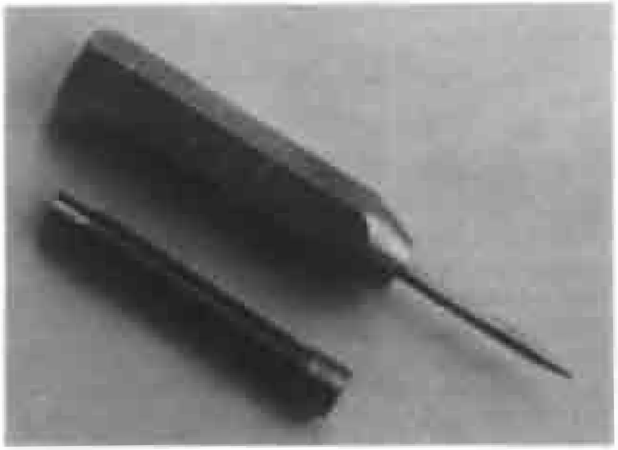
A Simple Depth Gauge

When making hobs and cutters for gear-wheels it helps greatly to have a depth gauge on hand for getting the depth of the grooves just right. A simple but accurate depth gauge can be made by relying on the 40 t.p.i. Model Engineer taps and dies; either 3/16 in or 1/4 in are needed. The 40 threads per inch give a measurement of .025 in to each complete turn of the gauge, and by using the faces of the hexagon 4 thou is measured as near as you will want it. The one I made was with the 3/16 in × 40, but for the 1/4 in × 40 just use the larger sizes of hexagon brass and mild steel rod.

Take a 1½ in length of 5/16 in A.F. hexagon brass and chuck in the 3-jaw. Turn both ends to a finish down to 1⅜ in and with a No 1 centre drill, drill into one end as far as the flutes will allow, follow this with a No 51 drill right through, then drill No 21 to a depth of 1¼ in. With the M.E. 3/16 in × 40 second tap, in the drill chuck in the tailstock, tap as far as you can, loosening the spindle in the headstock for advancement. Remove the tap and the swarf and tap again with the plug. Turn a taper on the hexagon until only a thin face of metal remains to the thread. Reverse in the chuck and take off the back corners.

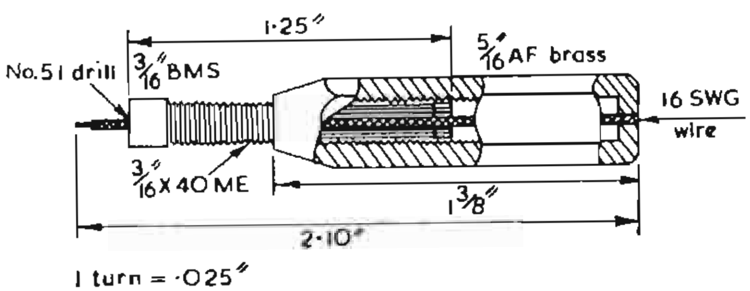
Face the ends of a length of 3/16 in silver steel or b.m.s. and turn the end eighth of an inch down to .9 in, centre drill the end then drill 1 3/16 in deep with a No 51 drill. Get 1¼ in protruding from the chuck and with the 3/16 in × 40 die in the tailstock dieholder thread 1 in past the turned down end first with the die wide open, then again with the die not quite relaxed, using plenty of tapping compound. Try the hexagon on, it should screw quite tightly with the fingers. Put a pointed lathe tool in the tool holder on the cross-slide, bring the point up to the threads, and, by turning the carriage handwheel, score a line through the threads. Remove, and measuring off 1¼ in, wrap a 3/4 in wide piece of thin alloy around the threads and chuck in the drill chuck. Part off the 1¼ in and face the anvil. Push a No 51 drill through the bore to clean it, screw about 3/8 in into the hexagon brass. Take a length of 16 s.w.g. wire (use the stuff that model shops sell as piano wire in straight 3 ft lengths; they may not know the gauge so take a vernier caliper with you) and twiddle the end to a tapered point on the grinding wheel; blunt off the point straight across.

Push the blunt end into the gauge to protrude at the anvil. If all is well remove the wire and clean off to tin with Comsol at the 2 in to 2.1 in position; rub down flush. Smear the hole in the hexagon brass



Components of the simple depth gauge.

with Comsol paste and push in the wire to 2.1 in. With a flame, solder the wire in place, touching with Comsol wire to fill in. Allow to cool and with a small hacksaw cut off the surplus wire, put the hex in a vice and finish with a fine flat file. Remove the threaded part and clean up with C.T.C. Smear the threads with grease and screw right home, unscrew and lightly clean off surplus lubricant. To zero the gauge rest the anvil on a dead flat surface and hold it still, turn the hexagon and you will feel the needle lift the anvil as you pass the zero point, back off the hex until the needle coincides with the anvil and then mark the position of the line cut into the threads on to the taper of the hexagon. To finish off stamp .025 on the brass, on the side opposite the line, to remind you. To protect the little gauge get one of those small tubular boxes that tool merchants get their small twist drills in; it accommodates the gauge nicely.



DEPTH GAUGE

III. AN IMPROVED DRIVE FOR THE UNIMAT SL

The standard drive for the Unimat SL consists of a rubber drive belt from the motor pulley to the spindle pulley, with the option of one or two reduction pulleys driven by small rubber belts for slower drives. This works well under small load conditions, but when a tool is applied to the work the belts tend to stretch and slip, particularly the longer final drive belt. This gives a loss of torque at the spindle, and the only way to keep a good drive is to increase turning speed so that a flywheel effect is maintained with the weight of the chuck and workpiece turning. The lower the drive speed the less the flywheel effect and the more the belts stretch and slip, which is self-defeating since the lower speed is intended to give a more powerful drive.

My design overcomes these problems and makes the Unimat a more efficient machine tool without affecting any of the drive capabilities of the old model, so that grinding and small hole drilling can still be carried out as before, without any dismantling.

The improved drive consists of the addition of a flywheel assisting a gear drive coupled by a toothed nylon belt. This drive through toothed gears is very positive and with the new standard drive position B it is impossible to stop the drill chuck turning on the main spindle with the hand. Now an electronic speed control may be fitted in the motor lead to give a controllable range of drive for all turning conditions and materials. The drive was derived from that of the small power hacksaw, which is simply made; the same sized toothed belt is used as it can be readily bought from model shops as a spare for a radio controlled stock car, size 100 x LO31.

The principle of the improved drive is that the motor is used to drive a flywheel, via a rubber belt, and the improved torque of the fast-moving flywheel is conveyed positively by a toothed drive to the slower-moving main spindle, giving even greater turning force. The ratio between the drive spindle and the flywheel is 30 to 7, approximately 4.3 to 1, which was determined empirically by sizes and turning centres of the lathe. In operation the drive is quite powerful so that if a tool jams in, or a workpiece jumps from the

chuck, the effects can be quite shattering, but, with luck, the worst that will happen will be a few teeth sheared from the nylon belt by the small gearwheel, but the jaws of the 3-jaw chuck can easily break a tooth or two within the scroll with the force. If the slow drive plate is used instead of the standard motor drive plate there are a few thou less between the spindle centres which gives a little slackness to the belt and enables the teeth to jump if a jam occurs, but the motor must be switched off immediately or the belt will rip. Keep a spare belt handy.

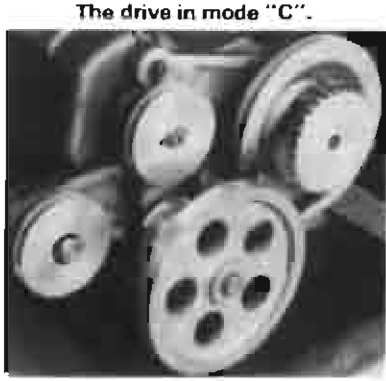
Flywheel and Spindle

First make the flywheel spindle — this replaces the shorter spindle of the intermediate pulley group — using the original pulley and twin ball races. The spindle is turned from $\frac{3}{8}$ in dia mild steel, or use silver steel if the b.m.s. stock measures undersize. Chuck the end for the flywheel and turn the rest down to 6 mm, thread $\frac{1}{2}$ in at the end with a 6 mm die to take the metric nut, and make another nut from $\frac{7}{16}$ in hex brass to act as a locknut, drill No 7 and tap for 6 mm. If you have no I.S.O. Metric taps and dies use 0 BA and make both nuts.

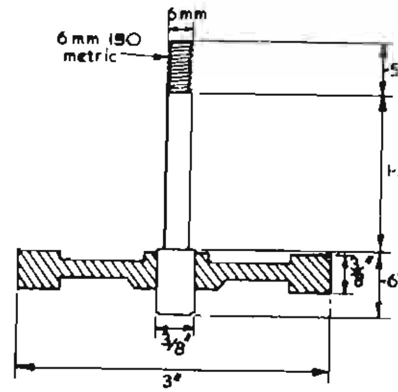
I made the flywheel from an old zinc alloy wheel from my scrapbox. This is perhaps a little large at 3 in dia, a brass blank of $2\frac{1}{2}$ in would make a better size. Drill a hole, $\frac{3}{8}$ in dia, in the centre, clean the hole and the spindle with C.T.C. and Loctite 601 the flywheel blank on to the spindle. Allow an hour for the Loctite to cure. With Loctite it is useful to remember that if a mistake occurs, say the flywheel slips half off the spindle when setting, do not despair, simply heat the lot to over 200°C and the parts will separate easily; use a big soldering iron. Face the flywheel in the lathe, holding first the 6 mm, then reversing and holding the $\frac{3}{8}$ in for the other face; turn the outer edge true.

To make the small toothed wheel it is necessary to make a 6 mm mandrel for turning and tooth cutting, and a seven division index

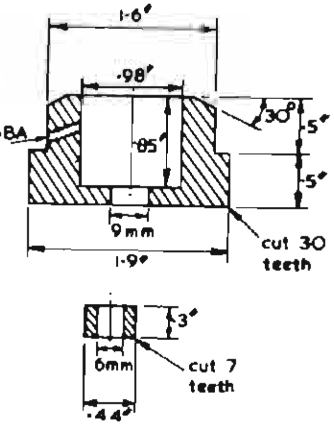
The drive in mode "C".



The parts required to make the new drive.



FLYWHEEL & SPINDLE



GEARWHEELS

plate for the dividing attachment. The mandrel is made from a piece of $\frac{1}{4}$ in dia mild steel with a collar turned 6 mm and the end threaded 2 BA for a retaining nut; make it about 2 in long to allow clearance for the chuck jaws when tooth cutting. For the index plate make a blank, to the same dimensions as the 48-tooth dividing wheel, from a piece of $1\frac{1}{2}$ in dia dural; leave the flange complete for cutting the seven teeth. On a piece of card draw a 5 in circle, with a concentric 11 mm and a 5 mm circle. Using a protractor divide the large circle into seven parts of 51.5 degrees, which is accurate to half a degree. Place the blank over the drawing using the inner circles as guides and scribe off the seven points; file a cut with a triangular file at each point. Remove the backplate from the 3-jaw chuck and place the chuck over the hub of the new plate. With a long centre punch mark the position of the three screw holes, drill them No 29 and tap through with a 4 mm I.S.O. Metric tap.

Small Gear

Make the small gear to the dimensions shown, secure the blank on the mandrel in the 3-jaw chuck on the dividing head with the seven-division plate in place and cut the teeth. Use the sloping sided cutter as described in a previous article. Fit the belt around the teeth, and the teeth will be slightly too large as the pitch line is within the continuous part of the belt. Turn down the teeth, using the mandrel in the drill chuck, 2 thou at a time, until the belt fits precisely. Loctite to the shaft with 601 up against the flywheel.

Large Drive Gear

The main spindle drive gearwheel fits directly over the drive pulley hub and its securing nut. It is made a tight push fit and then locked by means of a grub screw. It can be made from 2 in dia dural or from

brass. Drill a 9 mm hole right through with the material held in the 3-jaw chuck, jaws reversed. Bore out to the dimensions shown, face off, then reverse in the chuck, jaws normal, gripping by the new bore. Turn the outside and rear face, then reverse again and with the headstock at 30 degrees take off the corner to fit the curved inside surface of the pulley wheel. Drill a hole for the grub screw No 43 and tap 6 BA. Try the wheel for fit, if burrs and bits interrupt the fit run the lathe fast and gently grip the hub with a strip of medium emery cloth until the wheel is a close fit; use a smear of silicone grease.

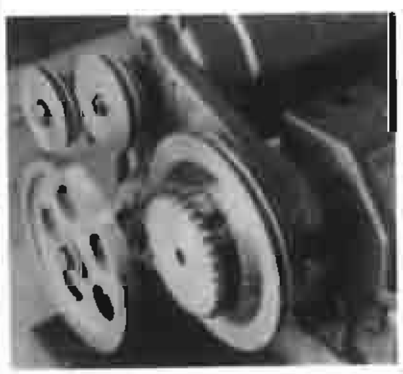
With the 30-division index plate in the dividing attachment and the 3-jaw chuck in place, grip the wheel by the bore to cut the square teeth. Use the straight-sided cutter for this wheel, and cut a deep tooth. When complete try the belt and, as before, take off 2 thou at a time until the belt fits.

Fit the wheel on to the hub and secure with an Allen grub screw, make a file cut on the pulley to accommodate the Allen key, and deepen the mark the grub screw makes on the pulley hub with the tip of a drill. This is a good non-slip drive easily removable for the cleaning and regreasing of the main spindle.

Remove the intermediate pulleys and ball races from their spindle and reassemble them on the new flywheel spindle; fit the additional nut or the flywheel drives the assembly out of nut and bearings, tighten into the drive plate. The small gear is now flanged on one side by the flywheel hub and on the other by the smaller pulley, which is necessary for correct drive, so that the belt does not run off. Stretch a rubber belt over the flywheel on to the large pulley then to the smallest motor pulley. Fit the toothed belt over the flywheel on to the

Left: In the vertical position using electronic control.

Below: Another view of the improved drive.



small wheel, turn the flywheel whilst stretching the belt across to the big wheel; the belt does not stretch so it has to be manoeuvred with movement of both wheels. Switch on the motor and try the drive, if the intermediate pulley slips on the flywheel shaft a grub screw will be needed in the central pulley and secured.

At this stage centre up a piece of ½ in dia steel, make sure the head and tail are locked up securely, and with a sharp knife tool in the toolpost, take off the eccentric, then advance the tool into the work 6 or 7 thou and turn off a bright curl of metal right along without a falter from the little motor. Then try another mode of drive. If you have the slow motion drive plate, reverse the motor pulley and fit another belt from the small motor pulley to the large second intermediate pulley, then from the small second intermediate pulley to the large pulley on the flywheel shaft fit the other small belt. Switch on this slow drive and take just a thou off the steel with a first-class finish. Reverse the motor pulley back and, with the rubber belt middle to flywheel middle, turn a piece of dural or brass at this higher sped and powerful drive.

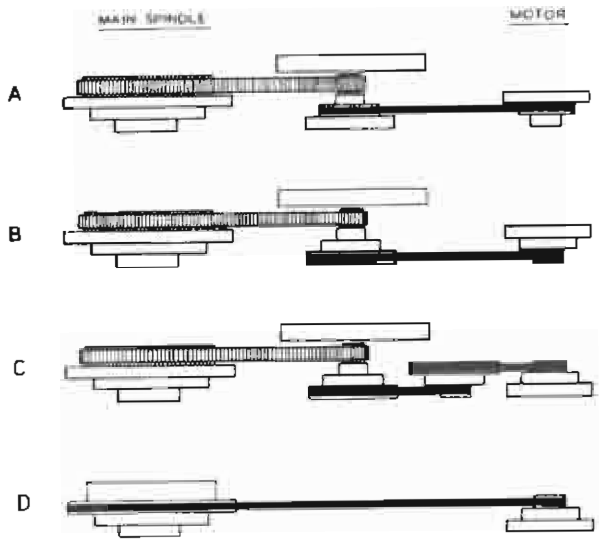
Electronic Speed Control

With the power available I felt it would be advantageous to fit an electronic speed controller and get a more controlled range of running speeds. I carried out tests with an ammeter which showed that under heavy load conditions the same power became available to the motor even when the motor was only pulsing round, as when running under bypass power.

With the controller fitted I carried out a series of tests with various materials and at different speeds and modes of new drive; I have tabulated the results as a guide. All the spindle speeds shown on the tables are approximate figures for the main spindle with no load applied; when a tool is applied the speed drops until the motor is driving at the necessary power.

This improved drive transforms the Unimat into a cleaner-working efficient machine without impairing its vertical and horizontal capabilities. The design is such that the modification can easily be removed with only an indentation on the hub to show where it has been. The only improvement may be to fit a guard if you have small children about.

Finally, a word on cutting lubricants for working and cooling with the small lathe. These are most easily dispensed on to the work by means of polythene washbottles, the sort used in laboratories. They provide the right requirement by squeezing; when not in use loosen the cap slightly so as not to squirt fluid when picking up the bottle. When cleaning up the Unimat after use the soluble oil will float out on the surface of light machine oil.



TURNING X = electronic control used

STEEL use soluble oil 5:1

Diameter	Turning mode	Tool	Depth	Finish
1 in to ½ in	C220	knife	4 thou	good
	B240 X	knife	4 thou	good
	B300 X	point	6 thou	poor
	Bslowest X	knife	1 thou	very good
½ in down	C220	round	4 thou	poor
	B660	knife	4 thou	good
	B660	point	6 thou	poor
	B240 X	knife	1 thou	very good

DURAL turn dry — boring use paraffin

3 in to 1½ in	B660	knife	4 thou	excellent
1½ in down	B660	knife	6 thou	excellent
	B660	round	6 thou	good

BRASS turn and bore dry

3 in to 1½ in	B660	knife or	6 thou	excellent
1½ in down	B660	round	10 thou	excellent

PHOSPHOR BRONZE turn dry or use soluble oil 20:1

1½ in down	B660	knife	6 thou	good
	B660	round	6 thou	very good

Speeds shown are no-load speeds — r.p.m. drops under load.

DRILLING

STEEL

Diameter	Speed	Remarks
Above ¼ in	B400 down X	use soluble oil 5:1
¼ in to 3/32 in	B660	use cutting oil
below 3/32 in	D	use cutting oil

DURAL

Above ¼ in	B660	use paraffin and
below ¼ in	A1850	clear flutes often

BRASS

Above ¼ in	B660 X	dry, slow on break-
below ¼ in	A1850 X	through

PHOSPHOR BRONZE

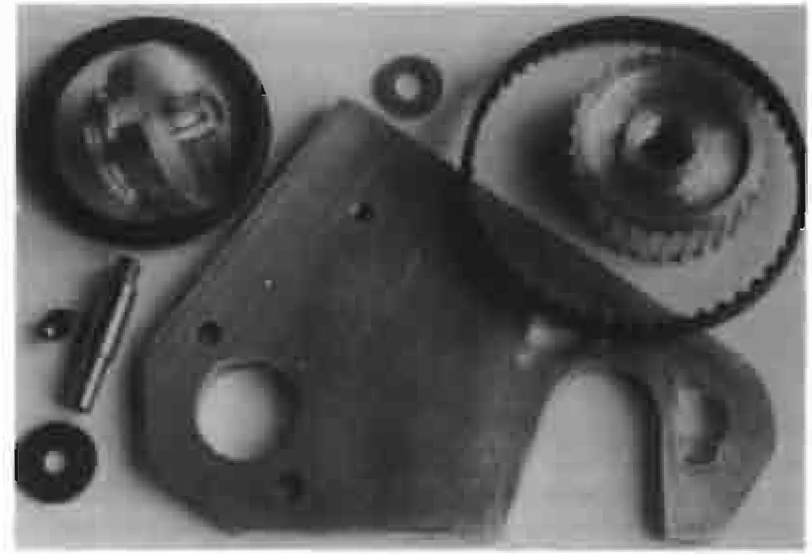
Above ⅛ in	C200 X	use soluble oil 20:1
below ⅛ in	C400 or D X	mainly as coolant

IV. IMPROVED DRIVE FOR THE UNIMAT 3

The rubber belt drive of the Unimat 3 is an improvement over that of the SL model, and yet in both the modes AC1 and BC1, which are the major useful modes for turning, milling and drilling, the belt snaps with surprising ease under a sudden load, such as can easily occur when turning alloy or drilling phosphor bronze. Drive belts are not cheap or always readily obtainable. A simple answer is to use a Hoover drive belt, $3\frac{1}{2}$ in OD, which is oversize in section and more flexible than the Unimat one, but it stretches and easily flies off, the guard case cannot be closed with it fitted, and the lubricants cause the belt to melt slightly and to cover surfaces and hands with black, sticky rubber. The real answer is to convert to a nylon toothed belt drive.

With the Unimat 3 the drive components are mounted on a flat plate which, in turn, is mounted on to the headstock by two bolt heads holding against slotted holes. The motor is mounted on to the plate, all the plate itself carries is the intermediate drive component, so all that need be made is the plate with a new intermediate drive component, this time for a toothed belt drive, and a new toothed gear for the main spindle in place of the pulley, as fitted.

In use the new plate can permanently take the place of the old and still give drives AC1 and AC2, with the main spindle pulley back in place, toothed wheel removed, leaving the new AB belt in place. With the toothed belt and gear the BC1 and BC2 become a single position giving 890 r.p.m. with no load, and on switch position I this becomes 530 r.p.m. If a variable electronic speed control is fitted, with the switch in position II and the control in the controlled position, speeds from 460 r.p.m. down to 1 r.p.m., with excellent power, are obtainable. In fact with the toothed belt fitted there will be few times when it will be necessary to revert to the original system; and the toothed belts, in use, last for months. When the teeth become worn after many hours of use a sudden jam or dig-in may cause the smaller toothed wheel to shear part of the toothed surface free from the pitch cords, but this has not happened to me, with the Unimat 3, yet.



Parts of the improved drive.

The components are easy to make and assemble, the only snag with this machine is that the drive spindle in the vertical mode has an M12 x 1 thread, with its own smaller centre in the pulley, so that if the improved drive is required for milling and drilling then a separate toothed drive gear wheel has to be made for the smaller thread diameter as well as the M14 x 1 for the main drive spindle.

An alteration to my design drawings is to make the plate from $\frac{3}{16}$ in BMS flatstock instead of from $\frac{1}{4}$ in thick alloy. To match, turn and thread the bottom of the intermediate drive spindle only $\frac{3}{16}$ in, leaving the extra $\frac{1}{16}$ in on the spindle itself, and fit a thicker washer on the bottom of the spindle to keep the levels right. The steel plate would be stronger, easier to fit on the screw heads, and less likely to tear under these same heads. It would require a little more effort and time in the making.

Main Spindle Wheel

The spindle gear wheel is turned from 2 in diameter duralumin stock first cutting then finishing both ends in the three-jaw chuck, jaws reversed, drill a $\frac{1}{4}$ in hole through and bring up the tailstock with the live centre. Turn out the recess, $\frac{1}{8}$ in deep, the sole purpose of which is to provide something for the chuck to grip while tooth cutting, etc. Hold the recess and turn the outside down to size, drill through 13 mm and the first 5 mm to 14 mm. Set up the indexing attachment with the 30 tooth plate in place and, using the home-made cutter described previously, cut the 1/10 in slots at one tooth intervals around the

wheel carefully using the cross-slide wheel division setting and the carriage setting to cut to the correct depth and to avoid chopping bits from the chuck face.

Fit up the threading attachment and turn at a low speed, with the 1 mm leader in place, to make the M14 x 1 internal thread. Dismantle and screw the wheel on to the nose of the main spindle to carefully turn down the teeth until the belt fits perfectly.

The belt used is designated 100 x LO31 and has 50 teeth 1/20th of an inch high and 1/10 in long with 50 same size spaces between. It is .31 in wide, and can be obtained from model shops as a spare for a radio-controlled stock car, or from Mardave R/C Racing, Rookery Lane, Groby, Leics. The 100 refers to the size of the pitch line — 10 in, and the L means a light duty belt.

The Drive Plate

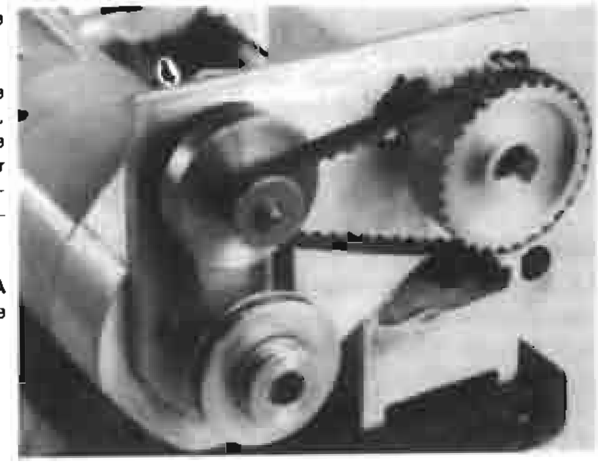
Mark and cut out the plate in outline first, before carefully marking out, with just the scriber in soft alloy, or with marking-out blue first on the steel. The first line to mark is the line between the centres of the two big circles, parallel to the angled side, as the other measurements are derived from this line. Mark the other two lines of the triangle which position the two circles and the hole for the intermediate spindle. When all is marked centre punch and drill out, finally cutting out the main spindle cutaway and filing the peripheral extensions to the 12 mm hole using a ¼ in round file. Tap the spindle hole with an 0 BA first taper in the drill chuck in the vertical mode, turning the pulley by hand to get a perfectly straight thread at 90 degrees to the plate, held flat on the cross-slide.

Intermediate Drive

For the intermediate drive first make the pulley by cutting the correct length of 1¼ in diameter duralumin, drilling through 6 mm in the lathe, holding in the 3-jaw chuck and centring in the tailstock with the running centre to make the pulley groove with a round tool in the toolpost. Reverse and hold by the pulley to turn the rest down to 1/64 in under ½ in. Turn the end down clean, reverse and hold by the thinner part to turn the bottom end down and to drill 3/8 in for the phosphor bronze bearing.

Reverse and hold by the pulley, with the indexing attachment in place fitted with a suitable plate to cut the 8 teeth required (24, 36 or 40). Cut the teeth with the cutter made with slightly angled sides to allow for the compression of the belt teeth around the small diameter.

The size of this pulley to motor pulley gives an intermediate drive ratio of 1.5:1 approximately, and the toothed drive gear gives a final drive ratio of 3.75:1. The pulley needs a smaller belt than that provided: the small belt for the Unimat SL is ideal, otherwise the



Right: Drive in the standard position.

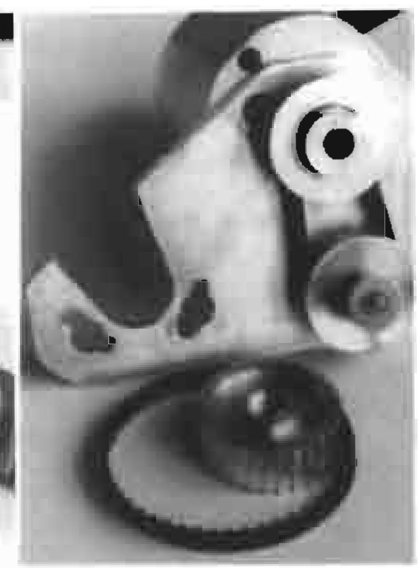
Below left: the toothed wheels, the vertical drive has the smaller bore. Note threading bush in position.

Below right: A view of the drive plate.

Hoover small drive belt is easily obtainable and cheap (OD 2 3/8 in).

Make the two bearings from 3/16 in and 1/8 in diameter phosphor bronze rod passed through the main spindle, drilled and parted off with newly-sharpened parting-off tool. Loctite the bearings in place with 601. Cut a slice of brass for the flywheel, face both ends, drill through to fit a mandrel and turn the outside down true. Replace in the 3-jaw chuck to drill through 31/64 in before Loctiting on to the pulley assembly.

Turn the spindle from 5/16 in diameter silver steel taking the top ½ in down to 6 mm and then drilling the end and tapping 6 BA. Reverse to



turn $\frac{1}{4}$ in of the other end down to 6 mm, then tap this 0 BA in the lathe. Grease the spindle with a motor grease before inserting into the pulley assembly to check the fit. Drill out two washers to size, as shown, cut the 6 BA cheesehead screw to size and, fitting the spindle into the plate, tightened well, assemble the parts of the intermediate drive. Fit the motor and belt drive the pulley for ten minutes, to run it in.

Assembly

Fit the plate to the headstock, loosening the screws a little more than usual, screw the drive gear wheel on to the main spindle and lift the motor to fit the toothed belt. Lower the motor and push down to apply a little tension to the belt before tightening the two hexagon head bolts. The belt should feel tight but springy under the thumb; any inherent looseness at this stage will need adjustment by filing out the securing bolt positions to allow more movement to apply tension. If the drawing has been followed and the plate made correctly this will not be necessary.

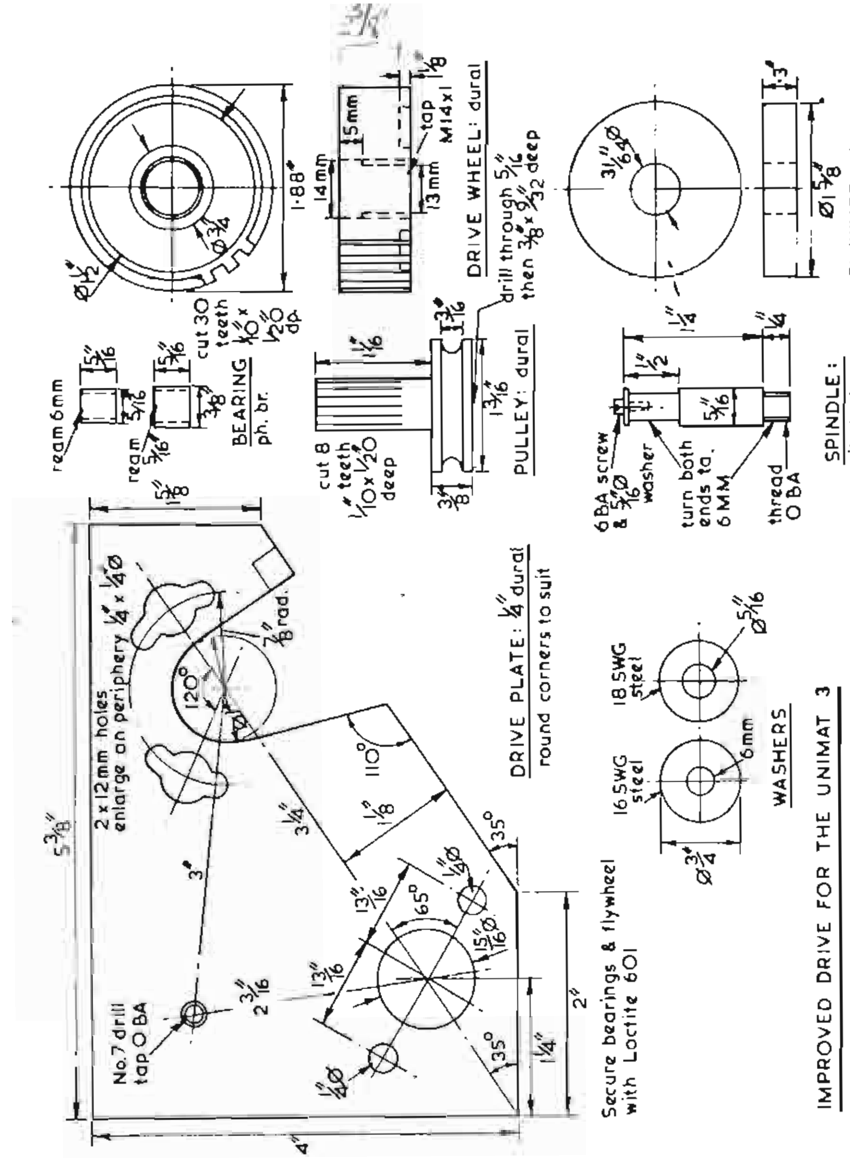
Running

A test that can now be carried out is to fit a piece of $\frac{3}{4}$ in alloy into the chuck, a knife tool into the toolpost, switch on the improved drive and bring the tool hard into the workpiece where it will cut away metal as never before.

In use it will be found that there is little need to revert to other modes with the lathe, using the toothed drive for all purposes. The speeds for various materials and diameters being varied either by the loads imposed on the motor, either by depth of cut of speed of feed, or when circumstances dictate, the use of electronic control.

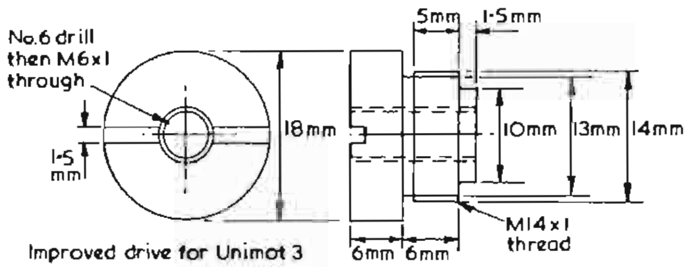
Practice will soon determine the depth of cut or speed of feed which is most suitable for a particular material and diameter. The positive drive is most pleasant to use, and it eliminates, to a great extent, the chatter patterns which occur with fine cuts, and the tool dig-in stoppages with less positive drives. A problem now can be

The vertical improved drive.



overheating of the workpiece due to better cutting and lack of efficient cooling, so lubrication becomes very necessary, using the laboratory wash-bottle to provide this, as I have recommended previously. In particular, with soft alloys, chips of metal welding on to the tool tip can be a problem.

To re-adapt the drive back to normal all that is necessary is to remove the toothed gear from the main spindle and fit the old pulley



Improved drive for Unimat 3

THREADING ADAPTOR:—brass

and the position between this and the motor pulley are again available for the rubber belt. In the vertical mode, if the toothed gear with an M12 x 1 centre has not been fitted then the rubber belt drive can be used as usual.

The flywheel is belt-driven by the motor in all circumstances as this gives a better torque to the drive, and it also, with the toothed belt system, prevents sudden shocks and stops from being transmitted fully back to the motor.

If, as I have previously suggested, a foot switch is used to control the motor there is no necessity to make the circular cut-outs on the drive plate for swivelling the motor when used in the vertical mode since there is no need for the switch to be available. The foot switch is a safety precaution, anyway, as it leaves both hands free in an emergency, and it was never a good idea to reach over a turning chuck to find a switch! If it is felt that the circular cut-outs are required then mill them before drilling the motor hole to size, moving the plate around a temporary axis for milling. Otherwise it is a simple matter to just make two more holes for the motor for this position. When fitting the motor to plain holes the two swivel plates can be temporarily discarded.

Tapping and Threading

When using the threading attachment with the Unimat there is no need to change the plate back and to fit the special pulley. Make the brass adaptor to screw into the end of the toothed drive wheel, which will take the leaders, and make a more positive drive at the available slower speeds and a better and easier task.

For tapping and threading with standard taps and dies a tailstock die-holder helps to thread true; and use the taps in the drill chuck for true tapping in the lathe, horizontal or vertical, both operations being eased by using the toothed drive wheel as a knob.

V. ACCESSORIES

This chapter presents a range of useful accessories for both the Unimat SL and the 3. The items have been left in their original form, and some improvement in design may be noted in those for the 3 compared with those for the SL.

A Slitting Saw Mandrel

Slitting saws can be purchased in a variety of diameters and thicknesses and are useful for many purposes on the lathe, from cutting away to decorative grooving. Slitting saws are made with several different hole sizes. Up to the largest size the Unimat owner will use, $2\frac{1}{2}$ in dia, the centre hole can vary from $\frac{1}{4}$ in to 1 in. In the bunch of saws I have one is $\frac{1}{4}$ in and the others are $\frac{5}{8}$ in, $\frac{7}{8}$ in or 1 in hole, and so I made the mandrel to accommodate these larger sizes and use a $\frac{1}{4}$ in mandrel for the other.

The mandrel is made from a piece of $1\frac{1}{4}$ in dia aluminium alloy, and screws directly on to the nose of the spindle. First set up the threading attachment with the 1 mm leader, then chuck the piece in the 3-jaw. Centre drill and drill through 4 mm, bring up the tailstock with a live centre and face back to the workpiece, turn down the step. Drill through 7 mm, and, with a boring tool in the toolpost, bore right through to 11 mm. Take the first 3 mm out to 12.5 mm, then thread right through 12 mm. Try the grinding wheel bolt in the thread. Lightly face off again, then remove the work to drill a 4 mm hole, 9 mm deep, on the outer surface, for a tommy bar; screw the work on to the spindle nose, faced side to the headstock. Turn the outer surface concentric and face back. Take the first 3 mm of the thread out to 12.5 mm. Turn down the steps to match the saw centres. A dial caliper is useful here to compare the steps, as they are turned, with the saw centres to ascertain exactly how far there is to go; the saw blade should snap into place. It may be necessary to turn up a large hollow washer for the bigger saws, but the one from the grinding wheel mandrel can be used for most, together with the bolt.

The slitting saw mandrel with a 1½ in dia cutter.

To adapt the mandrel for the Model 3 it would be necessary to modify the threaded end to fit a 14 mm x 1 mm nose.

A Tailstock Die Holder (SL)

This is made in the same way as the slitting saw mandrel, but instead of being stepped back, after fitting to the spindle nose, a hole is bored out to take a 13/16 in die.

For the Unimat owner it is the only sensible way to thread, it provides a dead square setting for the die to work, and avoids irregularities. It is used in conjunction with the square-toothed gear on the pulley hub to provide positive rotation and backing off by hand; the belt is slipped off. A good inch of material can be threaded into the tailstock tube.

The hole is bored out to 0.828 in, 0.255 in deep, after facing. The holder is fitted to the tailstock and the screw hole drilled down vertically with a No 33 drill, for the 4 BA hex cap head screw. At 45 degrees each side drill for the 4 BA set screws.

The smaller ISO Metric dies are 20 mm in diameter, and a thin shim should be rounded and placed at the bottom of the holder to compensate. In use the headstock spindle tube is loosened to provide the feed.

A Large Bore Live Centre

The centre with the Unimat SL is only 8.5 mm at its widest diameter, so any hole over 3/16 in cannot be centred in the tailstock. This accessory overcomes this limitation to enable bores up to 13/16 in to be centred with the tailstock.

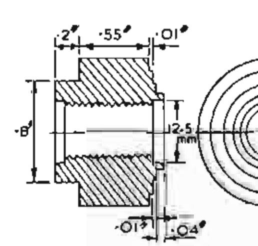
The centre is all of steel, the turning head being made from a ½ in Whitworth bolt, and the shaft from 5/16 in dia b.m.s. It runs on a single ball accommodated in the angles left by the tip of a drill and by a centre drill.

Cut the bolt to leave just over 1 in of shaft, and find the centre of the cut end, centre pop and drill with a centre drill, No 3, as far as the flutes allow, holding the head of the bolt deep in the 3-jaw. Face off the cut end and drill 0.7 in deep with a ¼ in drill; use a good drill for this and run the work fast for the last little bit of the bore to make it smooth at the bottom. Bring the tailstock along with a centre to turn the shaft concentric, outside.

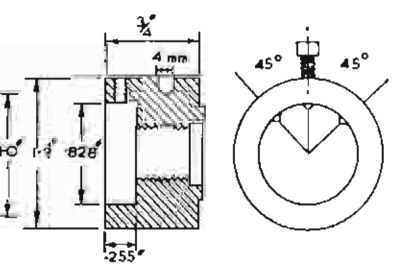
Hold the bolt by the shaft and turn the headstock to 40 degrees and take the head down straight at the sides to a curve to just leave the front surface as a point. Cut a piece of 5/16 in dia mild steel and face each end down to a length of 1¼ in. With a No 1 centre drill centre each end just up to the shaft of the drill. Chuck 12 mm of one end in the 3-jaw, centre with the tailstock and with a knife tool turn down 0.65 in of the shaft to 0.248 in. Hold this in the drill chuck and turn down the 12 mm to 0.281 in.

Clean out both parts, put a drop of oil into the head, drop in the 3/16 in ball and slide the shaft in; it should turn freely, even under pressure.

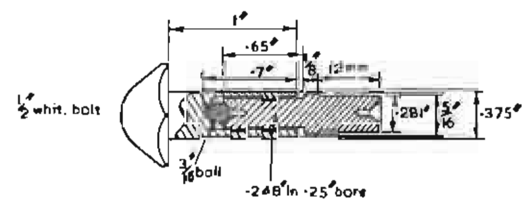
This centre enables concentricity of work to be maintained more



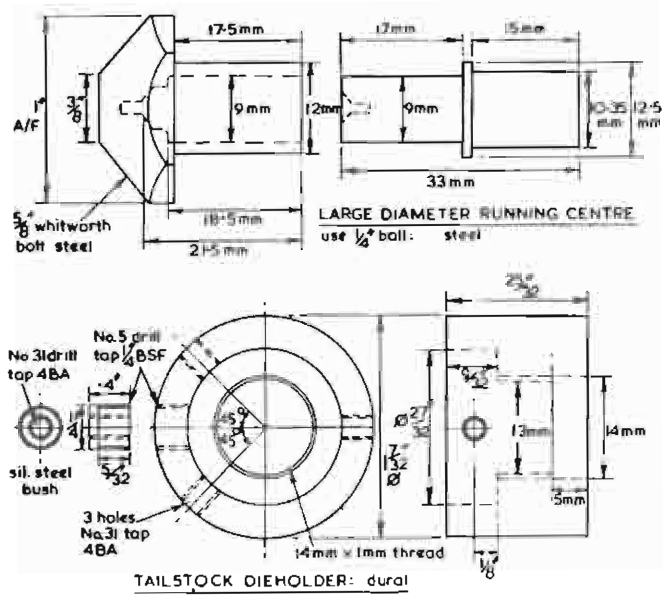
SLITTING SAW MANDREL



TAILSTOCK DIE HOLDER



LARGE BORE LIVE CENTRE



Unimat 3

accurately with larger bores since the larger bore can be made first and the outside turned from it, instead of the outside having to be turned first and then the bore being made unsupported by the tailstock.

Large Diameter Running Centre (3)

A simple to make and useful accessory is a large diameter running centre for turning the outsides of jobs already bored. By boring jobs first and then proceeding to turn the outside better concentricity of work can be obtained than when doing the job in the reverse order, and using this accessory is easier than plugging the bore and recentring. The centre works from the tailstock ram, fitting into the hole, and runs on a single ball bearing, well lubricated. The centre is constructed from a short 5/8 in Whitworth bolt, and will work into bores up to just over 1 in from just under where the standard dead centres leave off.

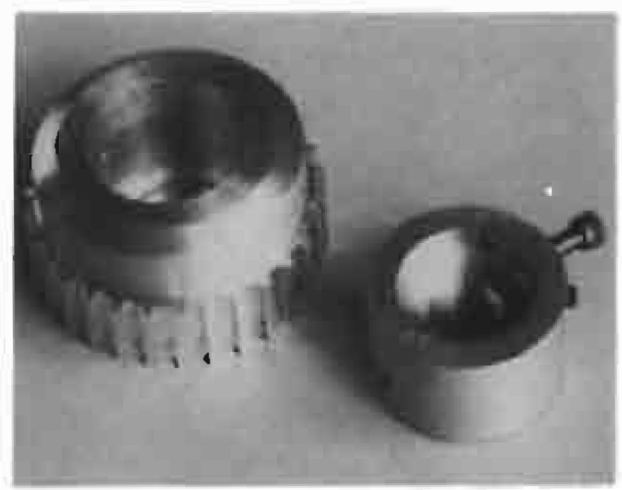
The bolt is held by the head in the 3-jaw chuck and the end is drilled with a No 2 centre drill to be held by the live centre for turning down the outside to get rid of the thread (so avoid high tensile bolts). Drill to an approximate depth, 4 mm, then drill accurately to depth, 9 mm. Put the No 3 Centre drill in the drill chuck, protruding just the right amount, and drill in up to the drill chuck; this is the seat for the ball. Use soluble oil at 10:1 dilution for all the drilling and turning of this job.

Turn a piece of 1/2 in diameter mild steel down to fit the hole in the tailstock, to be the same length as on the standard centres, take off the corner, and lightly groove the inner part. Reverse in the chuck and centre drill to centre up and turn down this end to fit the 9 mm hole, taking off the sharp corner and redrilling with the No 3 to take the ball bearing. Wash out with a cleaning agent before lubricating, fitting the ball, and assembling. If you have made it right the oiled head will pop back out, and the same should happen when the body is inserted into the tailstock.

Tailstock Dieholders (3)

When making fittings of threaded parts which need to be accurate it is essential to have the threads cut clean and straight, and by using a tailstock dieholder it is possible to make accurate threads so that when work is screwed together it remains concentric and in line. When tapping the tap can be held in the drill chuck, but a die needs to be adjusted, first cut being well open, yet remaining concentric with the work. For either job the Unimat should not of course, be driven but the headstock pulley used as a handwheel to turn the work, and the tap or die advanced, initially, by means of the tailstock handwheel until the thread is established, when the tailstock bed-lock can be loosened and the thread self-fed.

Cut a piece of 1 1/4 in diameter duralumin, or light alloy, rod, as a 13/16 in slice and turn one end flat in the 3-jaw chuck, jaws reversed, and last 1/4 in of the outside to true. Reverse in the chuck and drill through 1/4 in to bring up the centre in the tailstock and turn most of this end flat and the last 1/4 in of the outside true. Drill through with a 13 mm drill held in the 4-jaw chuck, and with a boring tool in the toolpost



The die-holder and toothed wheel.

Left: The die-holder in the tailstock threading a ¼in dia rod. Below: The four accessories for the Unimat lathe.

bore out the first 5 mm to 14 mm diameter. Thread through with an internal tool and the 1 mm leader and follower, using the threading attachment. If you wish to also make a dieholder to take 13/16 in dies repeat this procedure with a piece of 1¼ in duralumin.

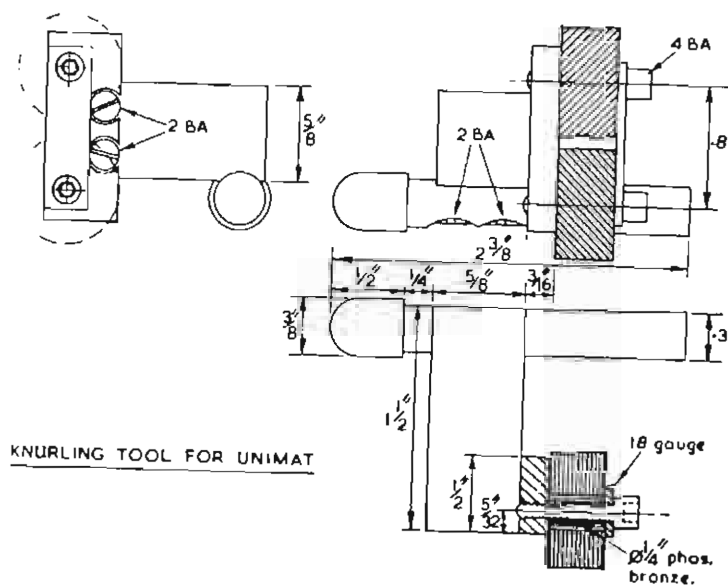
Screw the part on to the nose of the mains spindle to bore the recess for the die, take off the sharp corners and take down the outside nice and clean. Remove the work from the headstock and screw it on to the tailstock, to use the vertical head for the drilling of the holes to be tapped for the screws, after marking a line around for positioning.

The large hole is tapped ¼ in B.S.F. (or ¼ in x 32 M.E.) to take a silver steel bush as the alloy otherwise quickly strips threads in this position and doing this job. Fit 4 B.A. grub screws, and a 4 B.A. hex socket head screw to the lower, balance hole, so that a ¼ in B.S.F. die can be fitted to the dieholder for threading the bush in the lathe. Thread the silver steel, centre drill and drill No 31, 5/16 in deep, to tap 4 B.A., with the motor on position I part off. Clean off, Loctite with 601 and screw the bush into place. Fit the one hex cap head screw and the grub screw, now, into the balance hole, all 4 B.A. The hex cap head screw needs pointing at the end; fit two nuts, locked together to help turning the end to a point in the lathe.

In use the die is fitted into the holder, first opened right up, and the balance screw is used, where necessary, to centralise the die. On steels it is essential to use some for of threading lubricant, such as Rocol Tapping Compound, and to continuously reverse direction to break up the chip.

A Knurling Tool

The knurling tool rests and swivels on the T-slot of the Unimat cross-slide, and self-centres on to the work to be knurled. The knurling wheels can be obtained from Reeves and Co, and are ¾ in dia by ⅜ in with a ¼ in bore. The ones I use are a fine spiral, in a pair, one left hand one right.



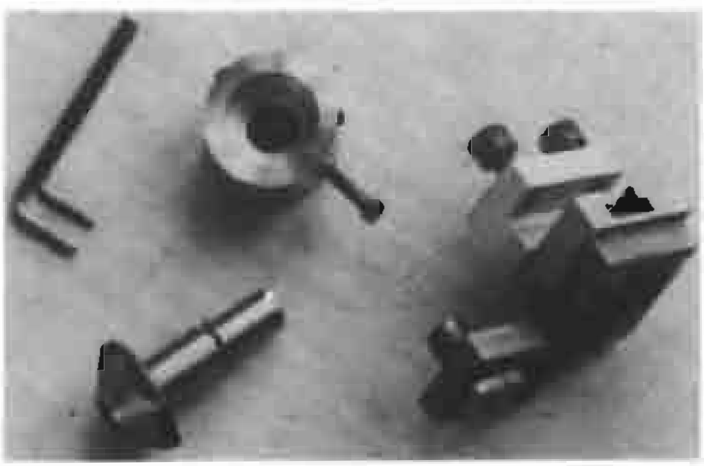
KNURLING TOOL FOR UNIMAT

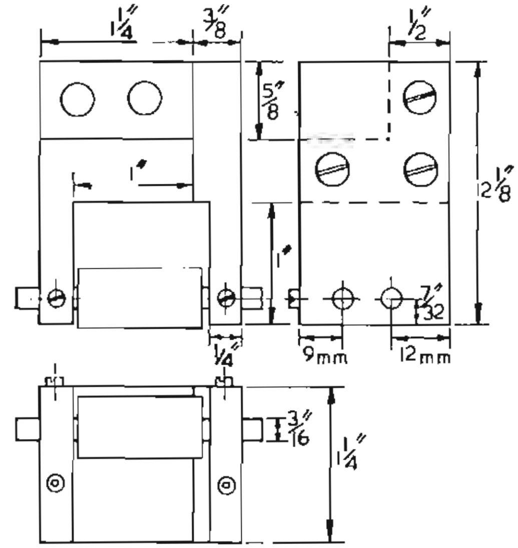
Left: Large diameter centre in use.

Below: The three accessories for the 3.

The knurls are mounted on a piece of $\frac{3}{16}$ in mild steel, with phosphor bronze bearings secured with 4 B.A. hex cap head screws, and a keep plate of 18 gauge steel. The bearings should be about ten thou longer than the bore to allow float for the knurl to find continuity of pattern. The bar is mounted on a short length of aluminium alloy, $\frac{3}{8}$ in square, with 2 B.A. countersunk screws. These screws and mating surfaces are cleaned and secured with Loctite 601.

The swivel bar is made from a piece of $\frac{3}{8}$ in dia b.m.s. The main part is turned down until it does not quite fall into the T-slot of the cross-slide, approximately 0.33 in; the end is left as a stop. Drill two holes No 12 and countersink, drill the dural No 24 to correspond and





A SMALL ROUNDING OFF JIG

tap 2 B.A. File a flat on the back of the round to fit the dural block and try the swivel bar in place. If all is well clean up with C.T.C. and secure the bar and screws in place with Loctite 601.

Oil the knurls, place the tool on the cross-slide and approach the workpiece, which should be centred with the tailstock, and gently allow the knurls to self-centre on the turning work; then move the cross-slide forward until the required depth of knurling is achieved. Only attempt to knurl soft materials on the Unimat, such as aluminium alloys, soft brass or plastics.

Rounding-off Jig

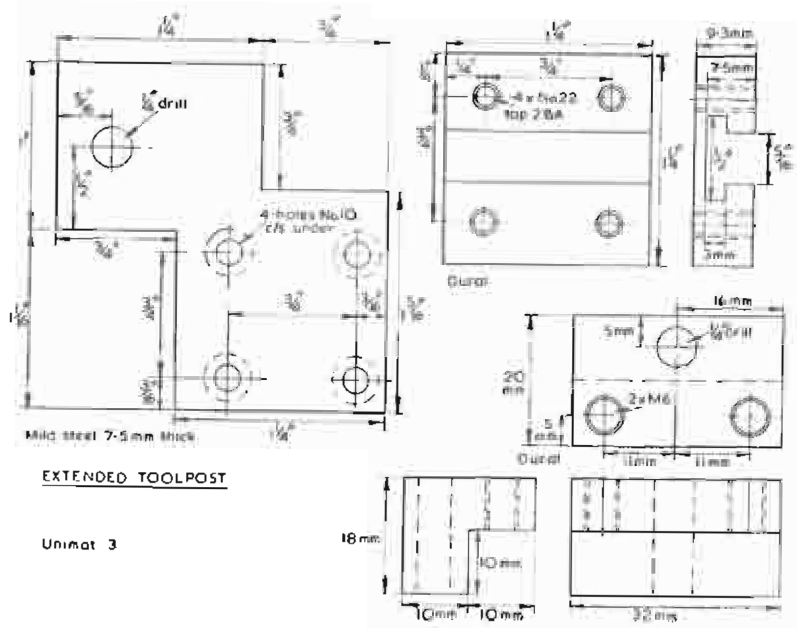
This jig was designed for rounding off Gauge 1 outside cylinders on the Unimat lathe, but it is suitable for other small lathes. Essentially the jig consists of a strong alloy fork with a $1\frac{1}{8}$ in gap in which an alloy cylinder turns about an axis; the alloy cylinder is turned to a finish which closely fits the bore of the steam cylinder which is to be rounded off on the outside. The whole lot is clamped to the cross-slide of the small lathe and presented, parallel to the centre line, to a mill turning between centres. The square faces of the steam cylinder are slowly fed to the cutter and the corner rounded off to a semicircle. The jig gives access both above and below to provide a continuous feed of workpiece. The side of the jig can be used to round off connecting rods and coupling rods.

The jig is made from a block of $1\frac{1}{4}$ in square dural and a piece of $\frac{3}{8}$ in thick dural. Cut the pieces to size and finish one side of the block

and one surface of the other as flat as possible, using emery cloth on a flat surface; a piece of glass is ideal for this. Mark out the three holes on the $\frac{1}{8}$ in piece and centre pop, clamp the two finished surfaces together and drill just over 1 in deep with a No 34 drill, remove the side and drill it through with a No 27 drill: countersink. Mark up the block and saw out the two pieces, filing the angles clean (cut out the two pieces carefully, as they will be useful for packing on the cross-slide or milling table). Drill the two clamping holes with a $\frac{1}{4}$ in drill. Cut away or file out $\frac{1}{8}$ in of the side plate to give a bigger gap in the fork, and cut away any of the side plate thought to be surplus. Tap the three holes 4 B.A. and assemble; use a shorter screw for the rear hole so that it will not obstruct the $\frac{1}{4}$ in securing hole.

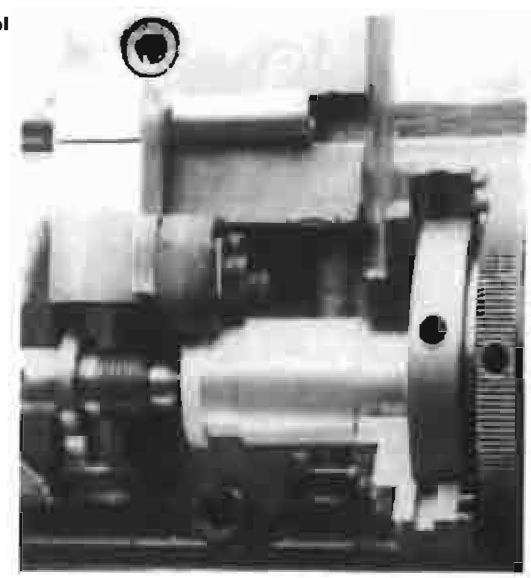
Clamp the jig to the cross-slide using the T-nuts from the milling table or from the vice. Check that it is flat to the surface and parallel to the bars. If all is well, remove the jig, take out the screws and clean up with C.T.C.; re-secure using Loctite or similar. When the retaining compound has cured, re-clamp the jig to the cross-slide and drill through the front at centre height with a $\frac{1}{16}$ in drill. Turn the jig upside down and clamp to the cross-slide with a clamping claw using a packing piece approximately 3 mm thick, then drill through again. Remove to drill and tap for the locking screws. Drill through the front to the lower holes with a No 34 drill, tap 4 B.A. and fit two short Allen grub screws; they should not protrude when clamped on to the axle. Drill through the top to the upper holes with a No 44 drill and tap 6 B.A., fit two cheesehead screws. Cut a piece of $\frac{1}{16}$ in silver steel, $2\frac{1}{8}$ in long, for the axle.

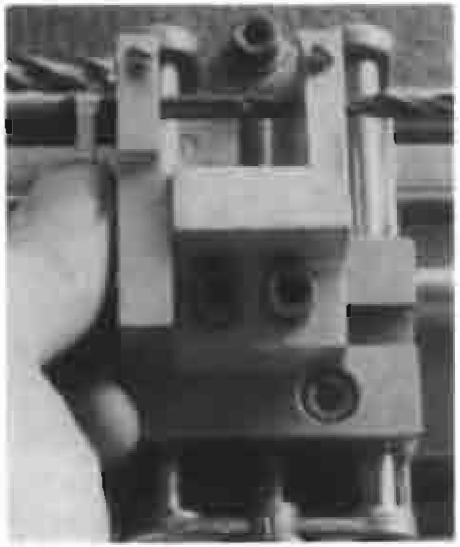
To use the jig for rounding off a cylinder with a half-inch bore, first turn a length of dural rod to fit the bore exactly. Drill the rod through in the lathe with a $\frac{1}{16}$ in drill, fit the rod into the bore and fit the lot into the jig, pushing the axle through and securing with the screws. Chuck



Opposite page, top left: Tailstock dieholder in use. Top right: Turning the dieholder on the nose.

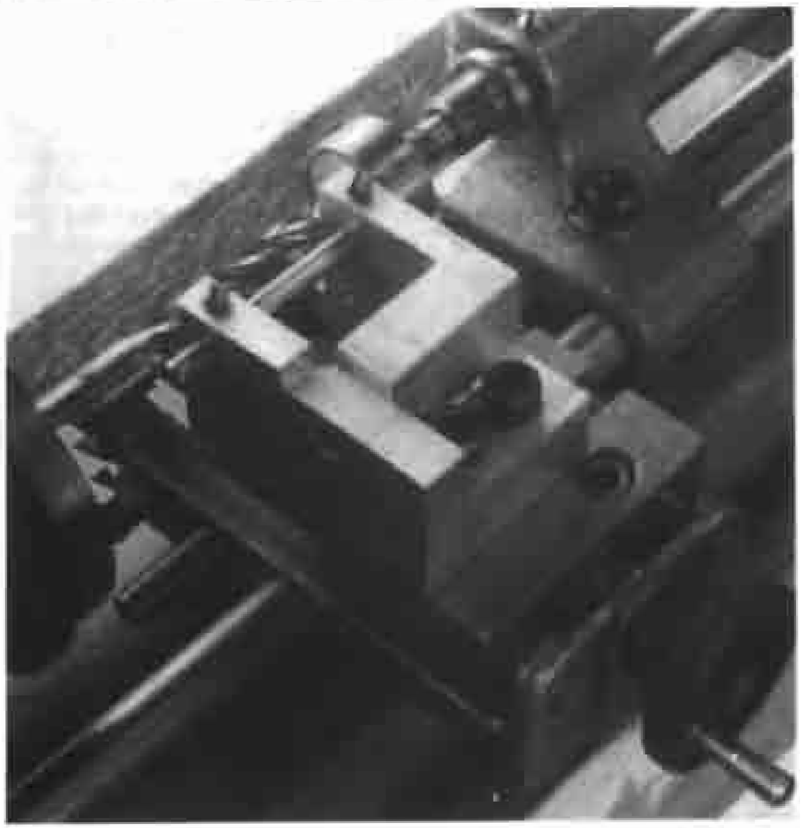
Right: The knurling tool at work.





Left: The side of the jig being used to round off the end of a connecting rod.

Below: The jig set up in the lathe. Note the long end mill between centres.

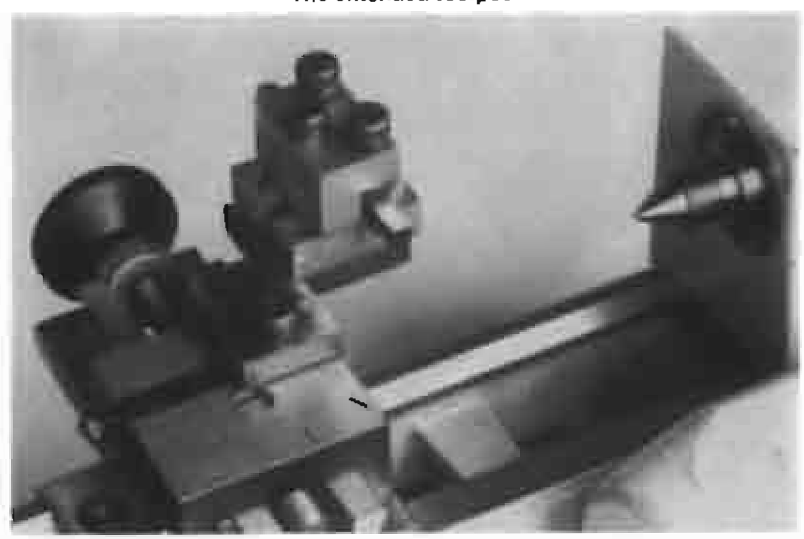


a long $\frac{3}{16}$ in dia end mill in the 3-jaw and secure the end of the cutter with a centre in the tailstock. Set the lathe to turn at 850 r.p.m. Now when the jig sets the workpiece against the turning endmill, by means of the cross-slide handwheel, the cylinder block will be seized and pulled violently into the mill. To prevent this the work must be held firmly when starting a cut, and always pulled towards the operator when cutting; always against the turning cutter. In this way you are always pulling against the direction of rotation and can have full control.

Start with the square corners using the top hole of the jig; they can be rounded one at a time. When they are nicely round put the block in the bottom hole, readjust the cross-slide, and finish off turning right through — the jig gives access for fingers below and above, always pulling against the direction of rotation, and switching off before returning for another cut. Before using the jig would be a good time to fit a foot switch to the lathe in place of, or in addition to, the switch that is fitted, which can rarely be found rapidly when needed. The foot can remain in contact with the footswitch and leave both hands to deal with emergencies. If one cannot be easily purchased then make it from two foot-size pieces of plywood and a hinge, using a 'push-on' 'push-off' switch. Fit a small block to limit movement.

When rounding off connecting or coupling rods use the projecting ends of the axle and a shorter end mill, not secured in the tailstock, then the work can be brought very close to the tool. Odd sizes of hole in connecting rods can be accommodated by using the blunt end of an appropriate number drill as an axis.

The extended toolpost.



The jig is capable of turning out some nicely finished surfaces, but remember, if the work is turned the wrong way, or inadvertently let go, the mill makes a nasty mess of the flat surface, and the little lathe gets a nasty jolt.

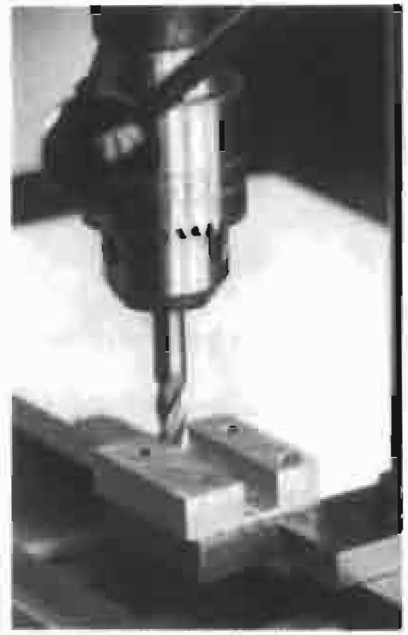
'Round the Corner' Toolpost (3)

A shortcoming of the Unimat 3 is the short reach of the cross-slide in the backward direction, and the better turning circle cannot be fully exploited because a tool cannot be used in the standard toolpost to turn down the outside of anything much larger than 2 in diameter. This accessory overcomes the problem for the 3, a similar accessory for the Model SL is described in the chapter on the Increased Swing.

The round-the-corner toolpost has a base of 7.5 mm thick steel, fitting on to the cross-slide of the lathe and held by a T-nut and hex cap head screw. On to the base an alloy plate, with a T-slot cut, is screwed and firmly adhered, into this T-slot another T-nut and bolt holds a bottomless toolholder in various positions, to hold a tool between itself and the alloy plate: the tool is held by the usual two screws.

To make this accessory, cut the steel base out and drill for the four countersunk screws and the hole for the securing bolt and T-nut. Flycut the end of a piece of $1\frac{1}{4}$ in square dural, cut off the slice and drill and tap for the four screws to secure, flycut side down, on to the steel base using Loctite 601 and the four countersunk screws. Mill the

Turning a 3 in flywheel using the extended toolpost.



End-milling the slot.

Cutting the T-slot.

top of the block, in situ, to be the correct thickness, and parallel with the cross-slide top, then mill the $\frac{3}{16}$ in wide groove with a $\frac{1}{4}$ in end mill. Make the T of the slot with an $\frac{1}{2}$ in x $\frac{1}{8}$ in Woodruff cutter. Cut the L-shaped toolholder from $\frac{3}{4}$ in square alloy and drill the securing hole $\frac{1}{4}$ in, and the other two holes to be tapped for the tool locking screws.

In use the toolpost is straightforward, and gives good access and plenty of room for turning the largest diameters of workpiece accommodated by the lathe.

VI. A VERTICAL SLIDE

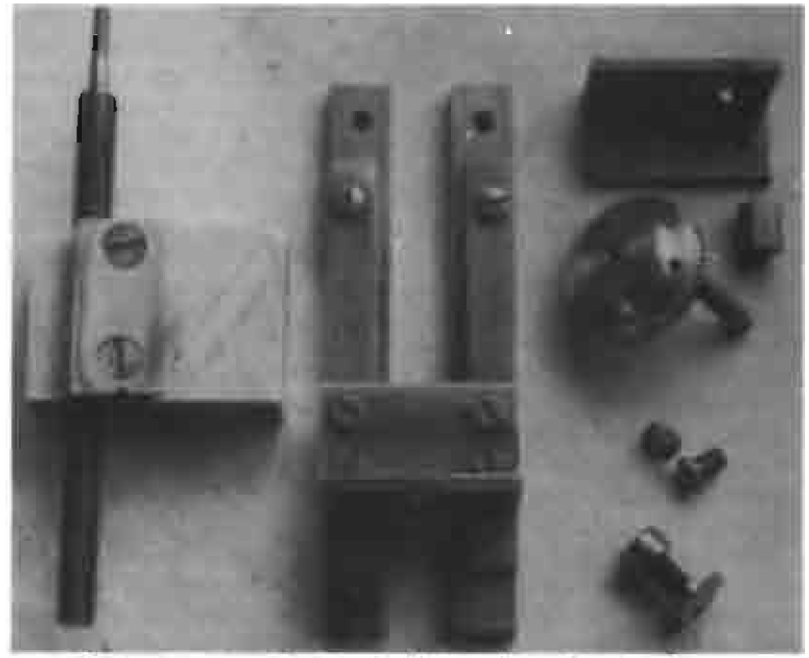
A vertical slide is not listed as an accessory for either the SL or the Unimat 3, but this device can greatly help in overcoming certain limitations of the horizontal centre-lathe. The vertical slide presents a different centre-height to cross-slide relationship, it can present a side or vertical workface much larger than otherwise possible, and it also provides a vertical movement of the work, relative to the headstock, for particular requirements of a job. This small slide is easily made from materials in the workshop, no special castings being required, and it can be used on other small lathes.

The Slide

The important component is the slide, which must be rigid except in the direction of movement; this consists of two columns and a centre slide of $\frac{1}{2}$ in x $\frac{3}{16}$ in mild steel (use the standard b.m.s. section from suppliers). The centre slide is held within the columns by $\frac{1}{8}$ in mild steel at the back and by a slide block at the front. The slide block is of dural, finished flat on its rear surface.

1 in x 1 in x $\frac{1}{8}$ in steel angle is used to mount the slide vertically to the cross-slide. Check that the angle is 90 degrees, ends of bars and sheared bars are often not right angled, and surface outer sides, emery cloth on a flat plate is sufficient, check with an engineer's square. The top of the slide is $\frac{3}{4}$ in x $\frac{3}{4}$ in x $\frac{1}{8}$ in steel angle, and when this, the 1 in angle and the columns are cut construction can begin.

Clamp the columns, top and bottom, either side of a piece of spare $\frac{1}{2}$ in x $\frac{3}{16}$ in steel, position top angle steel after marking and centre punching for holes, clamp together on the table and drill through with a No 25 drill. Tap columns 2 BA, drill out angle with a No 13 drill and countersink, screw angle into place with two $\frac{1}{4}$ in 2 BA screws. Mark the lower position of the 1 in angle with a square, mark and centre-punch angle, position and clamp to the table. Drill the four holes through with a No 34 drill, remove angle and drill out holes with a No 27 drill, tap columns and fit angle with four $\frac{13}{16}$ in 4 BA



The basic components showing the simplicity of construction.

cheesehead screws. Remove clamps and check that slide is an accurate but very tight fit along length of columns.

Make the spacers and the keep from $\frac{1}{8}$ in mild steel, drill the three holes No 25 in the spacers clamped together. Fix the spacers between the angle and columns, drill, tap and screw in the top screws.

Drill keep, two holes No 13, place over slide between the columns, mark and drill slide with the same drill. Position slide block against columns and the slide, mark and drill holes in slide block No 25 drill, $\frac{3}{8}$ in deep, plug tap 2 BA. Countersink keep and screw the block into place with $\frac{9}{16}$ in 2 BA C/S screws. This should lock the whole thing solid if you have made it correctly; just loosen the slide screws slightly, put some metal polish on the columns, secure the slide block in a vice and work the columns back and forth until, with the slide screws tightened again, the columns can just be moved with force.

Mark the slide block, bottom of the slide and keep with a file cut, take it all to pieces and clean off all traces of metal polish.

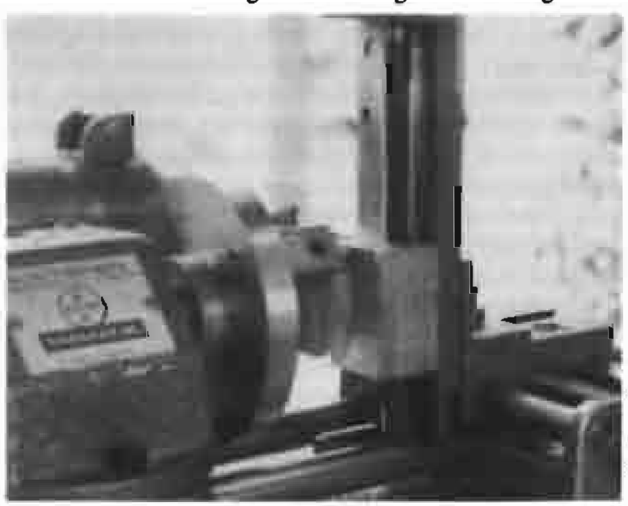
Movement

Clamp the slide block square to the cross-slide of the lathe and drill through $\frac{1}{4}$ in dia, tap through with a $\frac{5}{16}$ in BSF left hand tap, taper then plug: a right hand thread can be used but the handwheel then works in reverse (left hand taps and dies can be obtained through the

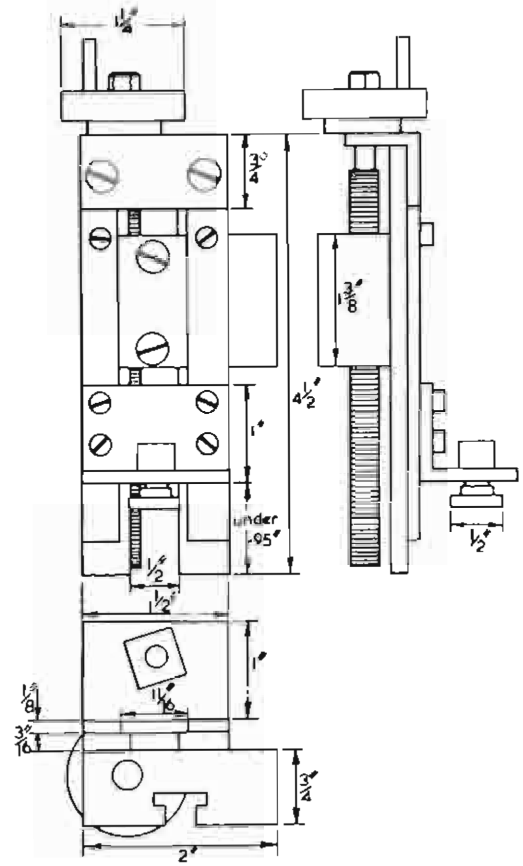
advertisements in *Model Engineer*, as mine were). The tap will almost certainly be too short so open out the first $\frac{1}{4}$ in or so with a $\frac{3}{16}$ in drill. Centre one end of a 5 in length of $\frac{3}{16}$ in mild steel rod, chuck the other end in the 3-jaw and with a No 1 centre drill, drill deep enough to take a lathe centre. Remove rod and file up two flats on the centred end up to $\frac{1}{2}$ in long. Secure the flats in a vice and with a $\frac{3}{16}$ in BSF left hand die, wide open, thread right down to the vice using lots of backing off and tapping compound. Spin the die off and loosen it in its stock, tighten the centre screw of the stock until it just starts to open the die, lock the other two screws down tight and with more backing off and tapping compound thread the rod again. Try the slide block on the thread, it should screw home but be very tight; if not, tighten the die a fraction more and rethread. Take a piece of .9 in x .5 in x 25 gauge dural and wrap the .9 in around the threaded end of the bar. Secure the dural and bar end in the 3-jaw chuck and centre the other end in the tailstock. Turn the flats down to round then turn the last .7 in down to .15 in, turn the last .5 in of this down to .141 in and thread 4 BA using the tapping compound.

Chuck a length of $\frac{1}{4}$ in phosphor bronze in the 3-jaw and turn the last $\frac{1}{8}$ in down to .220 in, part off at $\frac{1}{8}$ in. Chuck the bush and drill through with a No 25 drill. Screw the threaded rod into the slide block and push it up the columns until the rod hits the top angle, turn the rod to mark the angle, remove the angle to scribe and centre pop to drill through with a No 2 drill. Secure the bush in place with epoxy resin or retaining compound, the bush protruding into the angle.

Using dural or brass $1\frac{1}{4}$ in dia, make a handwheel to whatever design you fancy, drill centre with a No 34 drill, drill hole for the handle with the same drill, tap both 4 BA. The handwheel can be knurled or it can be grooved using the dividing head attachment, as



Flycutting the slide block. Note heavy home-made fly-cutter and face-plate.



A SMALL VERTICAL SLIDE

was mine. The blind nut is made from 2 BA brass hexagon, drilled and tapped 4 BA.

Each complete turn of the handwheel moved the slide 46 thou (this is with $\frac{3}{16}$ in BSF, other threads will give other figures), thus if the wheel is calibrated with 24 divisions, using the 48-tooth indexing wheel, each division will represent just under 2 thou which is very close to the standard divisions on the Unimat handwheels, which are insufficiently accurate anyway for absolute measurements.

Remove the 1 in angle iron and drill the hole for a cross-slide clamping screw. The Unimat uses 0 BA hexagon socket cap-head screws and a square nut with a short extension (T-nuts). The nut can be made from $\frac{1}{4}$ in x $\frac{1}{4}$ in x $\frac{1}{4}$ in mild steel; drill through the middle with a No 10 drill and tap 0 BA. Take a $\frac{3}{4}$ in long 0 BA hexagon socket caphead screw, centre-punch and centre drill the threaded end

to take a lathe centre. Screw on a hexagon nut then the square nut, chuck the cap head, bring the tailstock up, centre the end and turn down to $\frac{1}{8}$ in dia $\frac{1}{8}$ in deep to make the T-nut.

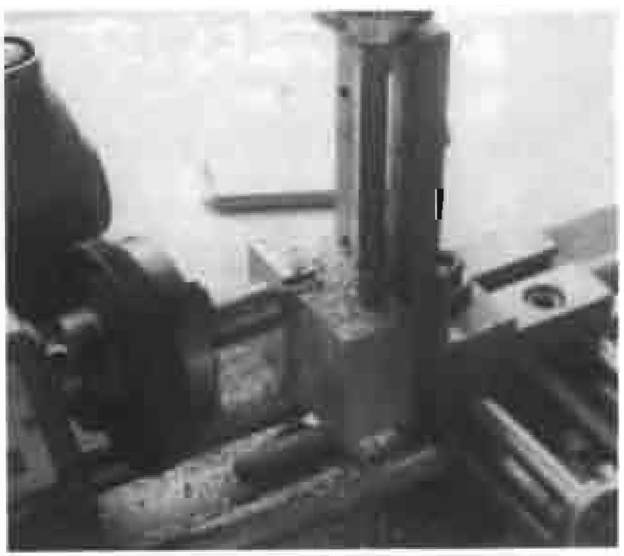
Finishing Off

Put everything together, oil well and work slide back and forth with the handwheel; it should be tight, with the same feel along its travel. Clamp the vertical-slide on to the cross-slide using a square to square it to the lathe. With an end mill cut a $\frac{3}{16}$ in groove $\frac{3}{16}$ in deep, vertically down the slide block. With a $\frac{1}{2}$ in x $\frac{1}{8}$ in Woodruff cutter bottomed on the groove cut the T-slot. I have modified my Woodruff cutters for the Unimat by turning part of the $\frac{1}{2}$ in threaded shafts down to $\frac{1}{4}$ in so they can be used in the drill chuck and get a better grip in the 3-jaw. The threaded end of the shaft is quite soft (you soon know when the hardened part is reached) and the business end of a $\frac{1}{2}$ in cutter disappears nicely into the chuck for the modification.

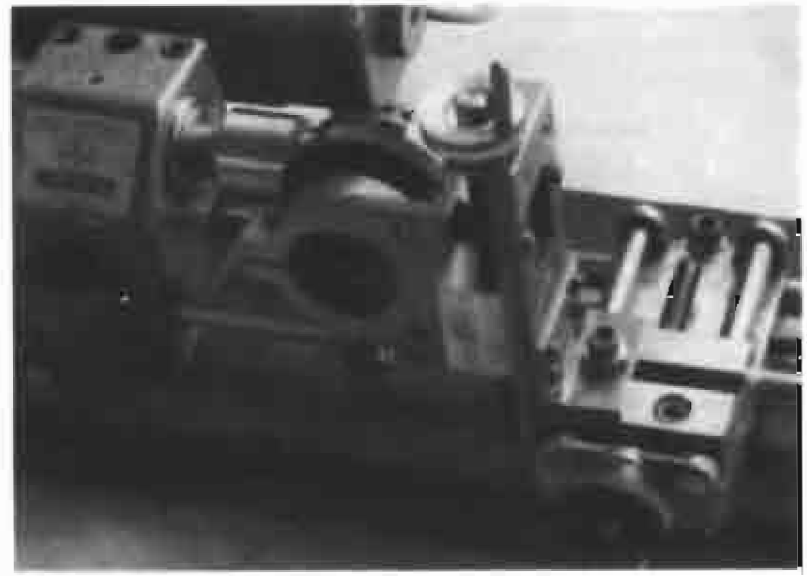
With a fly cutter on the faceplate take a skim off the surface of the slide block, and your vertical-slide is complete.

Before removing the slide mark the position of the back edge of the angle across the cross-slide so that it can be replaced square.

The vertical-slide takes some of its strength from butting against the cross-slide, but when the slide is well above centre height there is some flexibility under pressure. This flexibility occurs at the clamped angle iron and can be eliminated with a piece of $\frac{3}{4}$ in angle fitted into the 1 in angle. Drill oversize holes for ease of fitting, using longer screws to the columns and $\frac{1}{8}$ in longer clamping screw. This addition is unnecessary for the normal range of work on the small lathe.



Left: Cutting the Tee slot in the slide block with a Woodruff cutter.



The dividing head on the slide.

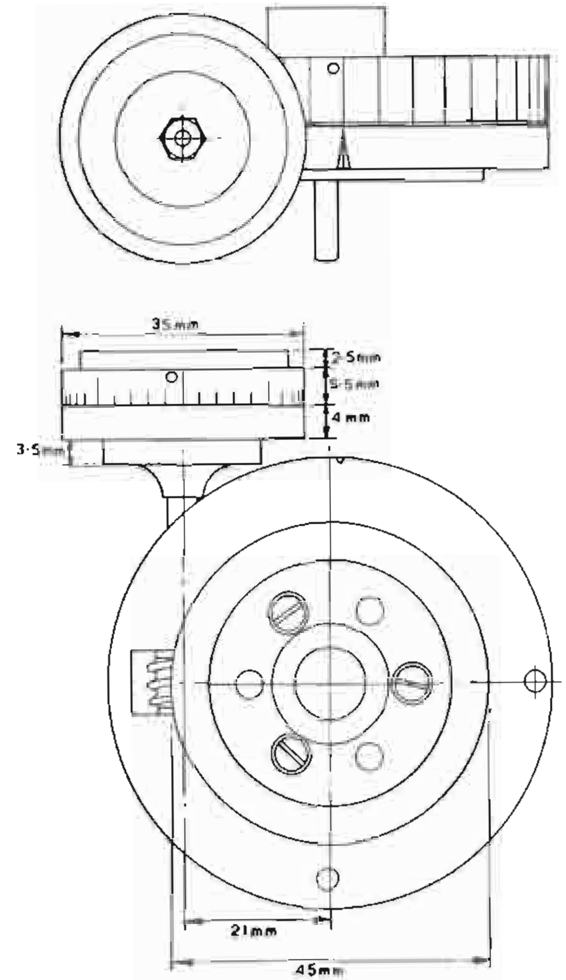
If you are happy with the completed slide unscrew the column and slide screws, clean the threads with carbon tetrachloride using a small brush, then reassemble with a touch of screw retaining compound. If any wear occurs after extensive use any worn part can easily be replaced.

An improvement to the vertical slide is to fit a grub screw into the side of the block facing the operator so that the slide can be locked in use. When subjected to vibratory workloads the screwed rod does tend to turn in the block, altering the set height. Do not have the screw tightening directly on to the thread but use a 2 BA screw with a thick disc of brass inserted first into the threaded cavity.

VII. ROTARY TABLE

The need for the cutting of an awkward number of teeth can often arise, and I realised that it was rather pointless to make an index plate with the right number of teeth for each occasion when an indexing table would cope with any job in this field. So I set about designing a rotary table for the SL, originally, but with simple modifications it can be easily adapted for the Unimat 3. However the indexing attachment for the SL must still be used when the rotary table is required with the 3. It is possible that a similar rotary table would adapt to the indexing attachment for the 3 but I have had no opportunity to make the design.
The considerations for the table were:
(a) it should take the range of accessories such as the face-plate and chucks without disturbing work that may be attached to them.
(b) It should take the 3-jaw chuck, minus the backplate, similar to the normal indexing attachment.

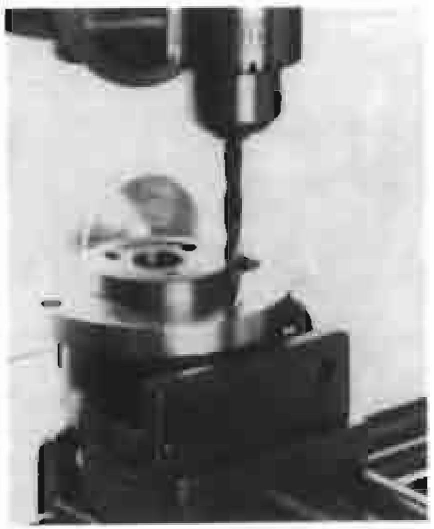
The complete rotary indexing table.



(c) It should be accurate enough to cut up to 50 teeth without significant error.
(d) It must be capable of being used in the indexing casting without hindrance to other operations in either the horizontal or vertical mode.

Using the improved drive I was able to make parts from mild steel where necessary. Aluminium alloy is used for the table and platform, but care has been taken not to run two surfaces of this alloy together since they tend to bind.

The rotary table is built on a steel hub, substituting for an index plate in the housing of the indexing attachment, with no teeth on its flange, enabling a smooth drive to be achieved within the housing.



Left: Drilling through the platform and the web of the casting.

Opposite page, bottom: The components of the rotary table

The table is attached with the usual three screws, and the undersurface has gear teeth cut in a ring. Between the table and the hub is a platform registered to the housing by a pin and containing a drive system. A worm-wheel drives the table and hub around, and the handwheel and table are calibrated against the platform.

Calibration of the table is in ten degree divisions. There are 90 teeth in the gear ring and the worm has one start so that one revolution of the handwheel moves the table 4 degrees. The handwheel has 40 calibrations so each division equals 1/10 of a degree; since the divisions are over 1/10 of an inch apart a central position can be easily found, giving a capability of accuracy to .05 of a degree, or 3 minutes of arc. When cutting a 50-tooth gear wheel this will give the correct tooth position to within .7% which exceeds the accuracy of the cutter or the hob.

It is intended that the table hub is locked in the housing after each rotary setting so that no problem of backlash should arise. I use petroleum jelly to lubricate the worm and track, and touching surfaces. A great deal of trouble needs to be taken to ensure concentricity and squareness to the centre line by using direct securing methods wherever possible in the making.

The Hub

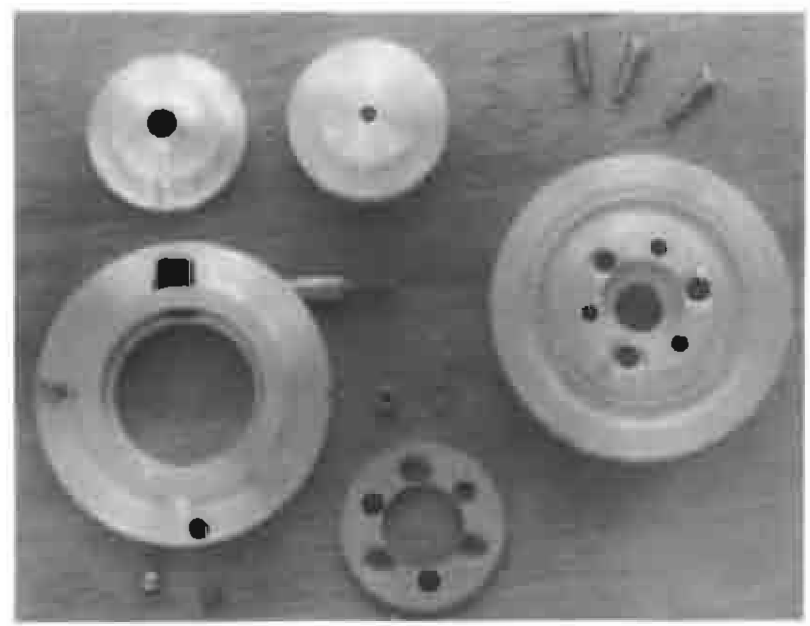
The toothless plate, or hub, to fit the indexing attachment, is made from $1\frac{3}{8}$ in dia mild steel. First chuck in the 3-jaw with jaws reversed and centre drill, No 3, to take the live centre. Turn down the first 7 mm to 17 mm (I am using the metric scale on the Vernier caliper because the Unimat is metric), face the step square then take the

tailstock back and gently turn the face of the nose to 6.5 mm; if the work moves in the chuck, further finish is unneccessary. With the jaws normal chuck the nose with the step tight against the jaws and centre drill, No 3, bring along the centre and turn the outside true, to the correct dimensions; cut in a swarf groove. Turn the bottom of the hub to leave the correct thickness of flange, as close to the live centre as you can get. Drill right through with a 7 mm drill; the hole can be left at 7 mm or bored out to 12 mm as the other plates are, but use the three point steady.

Cut the two pieces of aluminium alloy from $2\frac{1}{2}$ in dia stock. Reverse the three jaws and screw the chuck on to the 30-tooth plate in the indexing attachment and secure face up on the cross-slide. Remove one screw from the chuck, and with the head on the vertical column, secure a No 16 drill in the drill chuck and find, exactly, the hole of the removed screw. At this position, and at 10-tooth intervals, drill through the two pieces of alloy, best side down. With a No 29 drill in the drill chuck secure the hub by its flange, on the same set-up, and drill right through and tap 4 mm, ISO metric.

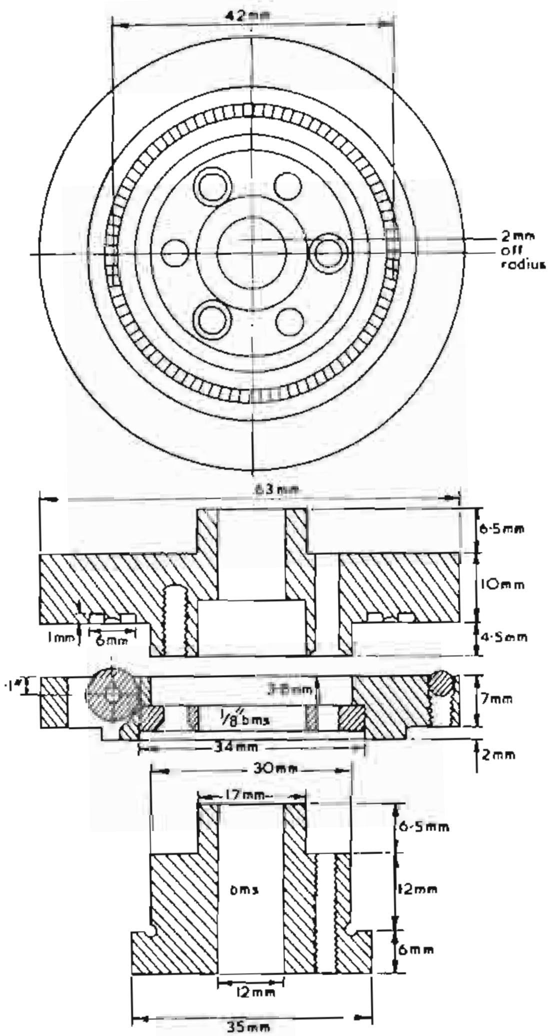
The Table

Countersink the holes in the alloy pieces deep and level. Take the thicker piece and screw the backplate of the 3-jaw to the best side, nose in; tighten up the heads well into the countersinks, and secure the backplate on to the main spindle. Face off without cutting the



screwheads, centre drill No 3, drill right through 7 mm, then bore a hole to match that in the 3-jaw chuck for its backplate. Turn a step to match the flange of the backplate.

Clean up the backplate and hole, then, using Loctite 601, secure the backplate into the hole and leave tight in a vice for 15 minutes to cure. Screw to the main spindle and take back the top surface of the table to leave the nose. Turn off any eccentricity from the outer surface and finish well. Fix a large soldering iron by its handle in a vice and slip the table and backplate over the bit to let the lot heat up for ten minutes. The backplate will slide out easily at 200°C, but wipe with an oily rag or it will set in the chuck when it is replaced.



ROTARY TABLE FOR THE UNIMAT

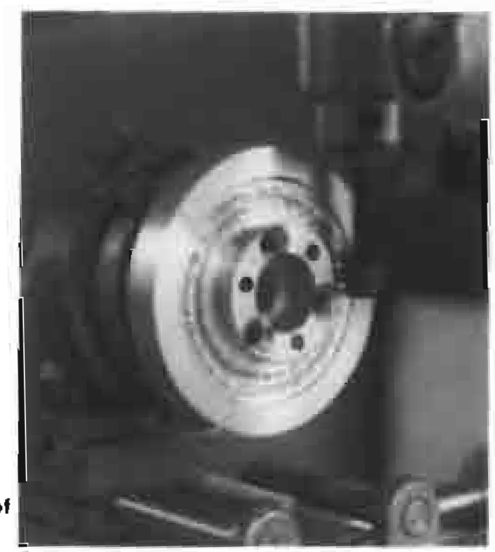
The Platform

The piece for the platform is secured to the backplate with three screws, to the best side as before, and faced. Drill through with a No 2 centre drill, and bring up the centre. Turn the outer step at the bottom of the platform. Reverse the jaws of the chuck and replace the backplate, grip the platform by the step and bore out the recess for the table. Bring up the centre and face the rest of the surface. With the jaws normal grip the recess from the inside, bring up the tailstock and get the centre running true. Take any eccentricity from the outside and finish well. Bore out the recess for the flange plate.

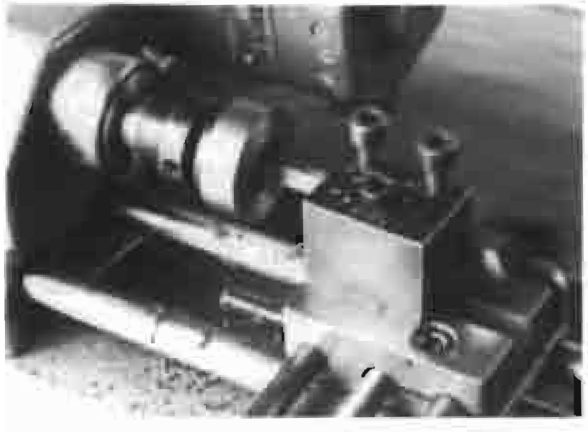
The Flange Plate

The flange plate is made from $\frac{1}{8}$ in mild steel plate. Mark out the circle and cut out as a generous octagon. Put the 3-jaw chuck in the indexing attachment with the 36-tooth plate, remove a screw and find the hole, as before. With a No 34 drill in the drill-chuck, drill holes at 12-tooth intervals in the table, $\frac{1}{4}$ in deep, tap 4 BA. Rub the octagon down on emery cloth on a flat surface and chuck to drill three similar holes but No 27 drill, and countersink. Turn the index plate six teeth and drill through No 17, repeat at 12-tooth intervals.

Fix the flange to the table with 3 x $\frac{1}{4}$ in 4 BA screws. Chuck the table by the nose in the 3-jaw on the lathe, centre drill, No 2, and bring up a centre, and turn the outer edge of the flange round to the correct dimension. Drill through 7 mm and bore out to fit the hub. Remove the flange plate and cut two tracks on the undersurface of the table to leave the centre land to be cut as an annular gear.



Cutting the second series of 30 teeth in the table.



Left: Boring the threaded hub using the grinding wheel holder on main spindle.

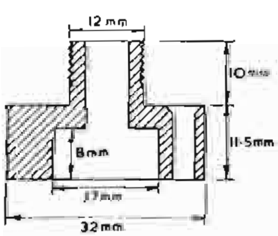
Opposite page, below: The hub, with the small 40 deg cutter, the lathe tool and the calibrating cutter.

The Ring of Teeth

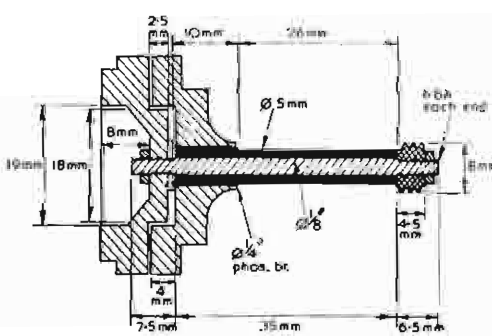
Now the 90-tooth track has to be cut. This is made with the 30-tooth index plate, in three 'goes'. To find the position for the second and third series, the 36-tooth plate is used to first make 9 equi-spaced cuts. To cut the teeth a small silver-steel cutter is needed.

Drill $\frac{1}{8}$ in of $\frac{1}{2}$ in dia silver steel through No 13 and secure on a roundhead 2 BA bolt, $1\frac{1}{4}$ in long, with a locknut and a drop of Loctite 601. Secure in the drill chuck on the main spindle, centre drill, No 1, the bolt head, and centre. With a 40 degree pointed tool bring each side to the angle, and a point. Set it in the indexing attachment with the 30-tooth plate and cut five slots with a Woodruff cutter. Turn back two teeth and grind the teeth back with a disc wheel, bring one tooth forward and back off each of the five teeth to a point.

Heat the lot to red heat and plunge into water, holding the threaded



UNIVERSAL THREADED HUB



WORM DRIVE UNIT

end with pliers. Take off the black from the end face of the cutter and gently heat the screw and nut until the cleaned face goes yellow, then plunge again. Remove the nut and discard the screw, as it will have warped with the treatment; replace with a new screw.

Cut the nine teeth using the 36-tooth plate at 4-tooth intervals, about 10 thou deep, judging with the handwheel divisions. The teeth are not cut radially but just above, to allow for the angle of the worm teeth. To judge this I use the locating plunger in the index housing. If the cutter is swung over to the plunger end and a tooth of the cutter brought central to the plunger's spindle, the cut will be radial to the index plate. Take the pillar collar up and tighten, then swing the headstock back and locate the workpiece to cut the track.

Cut the teeth .04 in deep, measured as 20 handwheel divisions. Start by locating a tooth of the cutter hard in one of the nine cuts, with the 30-tooth plate in the indexing attachment. Back out the tooth and turn to a clear part of the track, bring up the work until the tooth just touches, then cut the 30 teeth to the correct depth. Locate one of the six intermediate cuts, with the work loosened, and repeat. Find one of the remaining three cuts and make the final 30 teeth. The track now has 90 teeth with a pitch of 1.5 mm, with a little fore and aft error.

The Worm Drive Unit

For the worm drive unit, first cut the length of $\frac{1}{8}$ in dia silver steel and turn the ends down to .11 in, undercutting to .09 in where the die will not reach; thread each end 6 BA using the tailstock die holder. Cut a length of $\frac{3}{8}$ in dia silver steel for the hub, drill through No 44, tap 6 BA and screw on to the spindle. Set up the threading attachment, 1.5 mm leader in place, and chuck the spindle; lightly centre drill the end, No 1, and centre. Turn the blank down to .301 in, and with the 40

degree tool in the threading head cut the thread until there is just a flat top left on the worm. There should be just over three turns to the helix.

Remove the worm wheel and mark the outer end for replacement, with a small triangular file take each end down like a snail's shell until there are just three effective turns with an easy run-in at both ends. The three turns counter any error which there may be in the cutting of the track with three separate indexings. The error between any two teeth in the worm at any time will have the same effect in all positions.

The drive tube is made of $\frac{1}{4}$ in dia phosphor bronze. Drill through No 30 and turn 26 mm down to 5 mm. Make the stationary and hand wheels from 1 $\frac{3}{8}$ in dia dural. The stationary wheel is drilled $\frac{1}{4}$ in, and the handwheel is drilled No 44 and tapped 6 BA. The two wheels are made so that their surfaces do not run together, and a $\frac{3}{8}$ in dia brass washer is fitted between. A 6 BA locknut is needed at each end of the shaft.

Fit the assembly together and try it against the bottom of the table engaging the worm in the track. The fitting should agree with the diagram. Mark up the platform for drilling, .1 in down, using the vice and vertical column. First drill radially for $\frac{1}{8}$ in before turning to drill at the correct angle, No 25. Then drill again No 8, which may just break the surface. Drill to approximately half-way down.

With the 12 mm T-bolt fix the 3-jaw chuck to the cross-slide, chuck the platform and mill the square hole for the worm until the mill just breaks through. Pass the drive-tube into the hole, with the shaft, fit the worm and locknut and check that it fits the table leaving a gap of about 5 thou between table and platform, with the worm central in the track teeth. Use a needle file to correct the hole for the correct positioning of the worm. When all is well, Loctite the tube in place after removing the shaft; the best grade here is 270, which has better gap filling properties, and which really cures fast between bronze and dural.

Calibrate the handwheel with the 40-tooth plate; use a fine slitting saw or a pointed rotary cutter. Cut four main divisions, single degrees, four halfway marks, and then four divisions between each half and main division; these are 1/10 degree or six minutes of arc. Cut one mark into the stationary wheel and fit all together. Lock the wormwheel with its nut and apply one drop of Loctite 221 to the joint, it will 'wick' in by capillary action. Calibrate the table with 36 marks, using the 36-tooth index plate; stamp every other mark with number punches, degrees from zero.

Final Work on the Table

Lock the platform on to the indexing housing, with the hub pushed through from above, turn the drive to its position, and secure the

housing to the cross-slide. Drill down through the platform into the web of the index housing casting with a $\frac{5}{32}$ in drill. Fit a piece of 5/32 in silver steel to the platform with Loctite 601, as a registration pin. Drill the platform $\frac{1}{4}$ in deep with a $\frac{3}{16}$ in drill, diametrically opposite the wormwheel. Fit a spring and a $\frac{3}{16}$ in ball; the ball should fully compress the spring when flush with the platform.

Put all together with the zero of the handwheel opposite the gap between the table and the platform. Turn the zero of the table to be opposite the registration pin and screw the flange up tightly. Tighten the handwheel to give a firm feel, lock up with the nut and put a drop of Loctite 221 on the joint. Bring up the stationary wheel to almost touch the handwheel, turn the mark to zero and put a drop of Loctite 221 on the joint between shaft and wheel.

Mark the position of the table zero on to the platform and file a line. Apply petroleum jelly to the wormwheel whilst turning the table through 360 degrees, reverse back and forwards again, and the movement should be smooth. Remove the flange and clean off the track, re-lubricate and replace the flange. The table is complete.

Using the Table

To secure the 3-jaw through to the hub three longer M4 screws are needed, 42 mm long. I could not buy these locally and so I made them

Calibrating the table with 10 deg divisions.

The 3-jaw chuck, minus backplate, on the rotary table.

49	47	46	45	44	43	42	41	38	37	35	34	33	31
7.35	7.65	7.85	8	8.2	8.35	8.55	8.8	9.45	9.75	10.3	10.6	10.9	11.6
14.7	15.3	15.65	16	16.35	16.75	17.15	17.55	18.95	19.45	20.55	21.2	21.8	23.25
22.05	23	23.5	24	25.55	25.1	25.7	26.35	28.4	29.2	30.85	31.75	32.75	34.85
29.4	30.65	31.3	32	32.75	33.5	34.3	35.1	37.9	38.9	41.15	42.35	43.65	46.45
36.75	38.3	39.15	40	40.9	41.85	42.85	43.9	47.35	48.65	51.45	52.95	54.55	58.05
44.1	45.95	46.95	48	49.1	50.25	51.45	52.7	56.85	58.4	61.7	63.55	65.45	69.7
51.45	53.6	54.8	56	57.25	58.6	60	61.45	66.3	68.1	72	74.1	76.35	81.3
58.8	61.3	62.6	64	65.45	67	68.55	70.25	75.8	77.85	82.3	84.7	87.25	92.9
66.1	68.95	70.45	72	73.65	75.35	77.15	79	85.25	87.55	92.55	95.3	98.2	104.5
73.45	76.6	78.25	80	81.8	83.7	85.7	87.8	94.75	97.3	102.85	105.9	109.1	116.15
80.8	84.25	86.1	88	90	92.1	94.3	96.6	104.2	107.05	113.15	116.45	120	127.75
88.15	91.9	93.9	96	98.2	100.45	102.85	105.35	113.7	116.75	123.45	127.05	130.9	139.35
95.5	99.55	101.75	104	106.35	108.85	111.45	114.15	123.15	126.5	133.7	137.65	141.8	150.95
102.85	107.25	109.55	112	114.55	117.2	120	122.95	132.65	136.2	144	148.35	152.7	162.6
110.2	114.9	117.4	120	122.75	125.6	128.55	131.7	142.1	145.95	154.3	158.8	163.65	174.2
117.55	122.65	125.2	128	130.9	133.95	137.15	140.5	151.6	155.7	164.55	169.4	174.55	185.8
124.9	130.2	133.05	136	139.1	142.35	145.7	149.25	161.05	165.4	174.85	180	185.45	197.4
132.25	137.85	140.85	144	147.25	150.7	154.3	158.05	170.55	175.15	185.15	190.6	196.35	209.05
139.6	145.5	148.7	152	155.45	159.05	162.85	166.85	180	184.85	195.45	201.2	207.25	220.65
146.95	153.2	156.5	160	163.65	167.45	171.45	175.6	189.45	194.6	205.7	211.75	218.2	232.25
154.3	160.85	164.35	168	171.8	175.8	180	184.4	198.95	204.3	216	222.35	229.1	243.85
161.65	168.5	172.15	176	180	184.2	188.55	193.15	208.4	214.05	226.3	232.95	240	255.5
169	176.15	180	184	188.2	192.55	197.15	201.95	217.9	223.8	236.55	243.55	250.9	267.1
176.35	183.85	187.85	192	196.35	200.95	205.7	210.75	227.35	233.5	246.85	254.1	261.8	278.7
183.65	191.5	195.65	200	204.55	209.3	214.3	219.5	236.85	243.25	257.15	264.7	272.7	290.3
191	199.15	203.5	208	212.75	217.65	222.85	228.3	246.3	252.95	267.45	275.3	283.65	301.95
198.35	206.8	211.3	216	220.9	226.05	231.45	237.05	255.8	262.7	277.7	285.9	294.55	313.55
205.7	214.45	219.15	224	229.1	234.4	240	245.85	265.25	272.45	288	296.45	305.45	325.15
213.05	222.15	226.95	232	237.25	242.8	248.55	254.65	274.75	282.15	298.3	307.05	316.35	336.75
220.4	229.8	234.8	240	245.45	251.15	257.15	263.4	284.2	291.9	308.55	317.65	327.25	345.4
227.75	237.45	242.6	248	253.65	259.55	265.7	272.2	293.7	301.6	318.85	328.25	338.2	
235.1	245.1	250.45	256	261.8	267.9	274.3	291	303.15	311.35	329.15	338.8	349.1	
242.45	252.75	258.25	264	270	276.3	282.85	289.75	312.65	321.1	339.45	349.4		
249.8	260.45	266.1	272	278.2	284.65	291.45	298.55	322.1	330.8	349.7			
257.15	268.1	273.9	280	286.35	293	300	307.3	331.6	340.55				
264.5	275.75	281.75	288	294.55	301.4	308.55	316.1	341.05	350.25				
271.85	283.4	289.55	296	302.75	309.75	317.15	324.9	350.55					
279.2	291.05	297.4	304	310.9	318.15	325.7	333.65						
286.55	298.7	305.2	312	319.1	326.5	334.3	342.45						
293.9	306.4	313.05	320	327.25	334.9	342.85	351.2						
301.2	314.05	320.85	328	335.45	343.25	351.45							
308.55	321.7	328.7	336	343.65	351.45								
315.9	329.35	336.5	344	351.8									
323.25	337	344	352										
330.6	344.7	352.15											
337.95	352.35												
345.3													
352.65													

TABLE OF ANGULAR SETTINGS FOR CUTTING GEAR WHEELS
(for sizes not available with the index plates)

29	28	27	26	25	23	22	21	19	17	14	13	11	7
12.4	12.85	13.35	13.85	14.4	15.65	16.35	17.15	18.95	21.2	25.7	27.7	32.75	51.45
24.85	25.7	26.65	27.69	28.8	31.3	32.75	34.3	37.9	42.35	51.45	55.4	65.45	102.85
37.25	38.55	40	41.55	43.2	46.95	49.1	51.45	56.85	63.55	77.15	83.1	98.2	154.3
49.65	51.45	53.35	55.4	57.6	62.6	65.45	68.55	75.8	84.7	102.85	110.75	130.9	205.7
62.05	64.3	66.65	69.25	72	78.25	81.8	85.7	95.75	105.9	128.55	138.45	163.65	257.15
74.5	77.15	80	83.05	86.4	93.9	98.2	102.85	113.7	127.05	154.3	166.15	196.35	308.55
86.9	90	93.35	96.9	100.8	109.55	114.55	120	132.65	148.25	180	193.85	229.1	
99.3	102.85	106.65	110.75	115.2	125.2	130.9	137.15	151.55	169.4	205.7	221.55	261.8	
111.7	115.7	120	124.6	129.6	140.85	147.25	154.3	170.55	190.6	231.45	249.25	294.55	
124.15	128.55	133.35	138.45	144	156.5	163.65	171.45	189.45	211.75	257.15	276.9	327.25	
136.55	141.45	146.65	152.3	158.4	172.15	180	188.55	208.4	232.95	282.85	304.6		
149	154.3	160	166.15	172.8	187.85	196.35	205.7	227.35	254.1	308.55	332.3		
161.4	167.15	173.35	180	187.2	203.5	212.75	222.85	246.3	275.3	334.3			
173.8	180	186.65	193.85	201.6	219.15	229.1	240	265.25	296.45				
186.2	192.85	200	207.7	216	234.8	245.45	257.15	284.2	317.65				
198.6	205.7	213.35	221.55	230.4	250.45	261.8	274.3	303.15	338.8				
211.05	218.55	226.65	235.4	244.8	266.1	278.2	291.45	322.1					
233.45	231.45	240	249.45	259.2	281.75	294.55	308.55	341.05					
235.85	244.25	253.35	263.1	273.6	297.4	310.9	325.7						
248.3	257.15	266.65	276.9	288	313.05	327.25	342.85						
260.7	270	280	290.75	302.4	328.7	343.65							
273.1	282.85	293.35	304.6	316.8	344.35								
285.5	295.7	306.65	318.45	331.2									
297.95	308.55	320	332.3	345.6									
310.35	321.45	333.35	346.15										
322.75	334.3	346.65											
335.15	347.15												
347.6													

The rotary table fitted with the hub to take all components threaded 12 mm.

from ¼ in BMS. There is also an extra fitting for the table to provide a 12 mm thread similar to the main spindle so that work fitted to the chucks or faceplate can be transferred to the table with no disturbance. The fitting is made from mild steel to the dimensions shown. If the nose is turned and threaded first the grinding wheel holder can be used to secure it to the main spindle for turning with good concentricity.

To use the table grease the hub and fit into the housing, replace the circlip; fit the table on to the hub and register the pin into the web at the same time. Fit the 3-jaw chuck without its backplate, bring all the holes into line and fit the three longer screws. Loosen the housing clamp to index to the correct position, but tighten the clamp before working.

Always work forward, turning the handwheel anti-clockwise, rotating the table clockwise. The table of figures gives the angles for cutting gear teeth for sizes not available with the index plates; they are corrected to the nearest .05 of a degree, which is accurate enough for gears up to 50 teeth.

The Unimat 3

To adapt this design to take the chucks of the 3 it is simple to make the universal threaded hub with a 14 mm thread instead of the 12 mm shown in the drawing. A further way is to make the nose of the table 10 mm long and 14 mm diameter, and to thread this remembering to decrease the hole in the middle to 9 mm.

It must be noted that since the three-jaw chuck of the Unimat 3 has no separate flanged backplate (as the SL has) it will be necessary to make the hub itself with a 14 mm threaded back hole and to make the table and platform on this, fitted to the nose of the headstock. The three holes are on a PCD of 22.5 mm.

This rotary table is easy and cheap to make, considering how expensive this item can be, and provides a valuable addition to the range of accessories. It can, of course, be used in conjunction with other small lathes but using the SL indexing attachment to be complete.

VIII. A WINDING JIG

The business of winding coils requires a feed for the wire, a variable tensioning device, and a method of ensuring that the wire is spaced evenly, preferably in layers. If winding is to proceed at a reasonable number of turns wound on the former. This I solved in a rather elegant way by using an electronic calculator with a small modification, providing accurate counting with a simple coupling to the Unimat.

The Electronic Counter

The counter works by using a microswitch coupled across the 'plus' function of an electronic calculator, in this case a CBM 987R. The calculator must have a 'constant' function for addition, thus when a 1 is put into the first register the punching of the 'plus' button adds this to the second register every time. So the first punch registers as 1 again on the display, zero having been in the second register, the next punch 2, then 3 and so on. Many of the cheaper calculators perform in this way, but most of the more expensive 'scientifics' work with a different logic.

To find the positions in the circuit to which the microswitch must be coupled it is necessary to remove the back of the calculator and trace the printed circuit from the 'plus' button contacts round to terminations or other easily soldered places. With the CBM 987R twin plastic covered wires are soldered to the termination numbered 10, the wire running across the back of the board. File a corner of the plastic case for the wires.

The best type of microswitch to use would be the one fitted with a metal roller to run on the cam-plate, but the one I used, with just a plastic pip, worked well with lubrication from petroleum jelly. The microswitch is wired so that the cam will close its contacts, the other termination can be removed. The microswitch is fixed to an alloy bracket mounted under the drive plate securing bolt head; it is fixed by only one screw to the bracket so that it can be adjusted relative to the cam-plate for the best switching effect.

Winding a coil.

The cam-plate is made from brass and is secured to the middle pulley of the lathe drive wheel by a wire band, tightened via loops with a screw and nut. The plate is made and bent, leaving the cam area straight until fitted, when it is bent to be concentric with the pulley, but with a small ramp turned down to its leading edge. The 1½ in length of cam will work the display to a speed of just over 450 r.p.m., which is sufficient for coil-winding purposes. A higher speed of operation will require a greater cam-plate length to increase the 'on' period of the calculator or its clock will not cope and only record the occasional addition.

This device can be used for other purposes, for example for checking and calibrating the range of r.p.m. provided by the electronic speed controller, timing with the stopwatch. Remember that to clear figures on this calculator the 'C' button has to be pressed twice or it will be adding to what is in the hidden register. The calculator can, of course, still be used for its normal purposes after modification.

The Coil Winding Jig

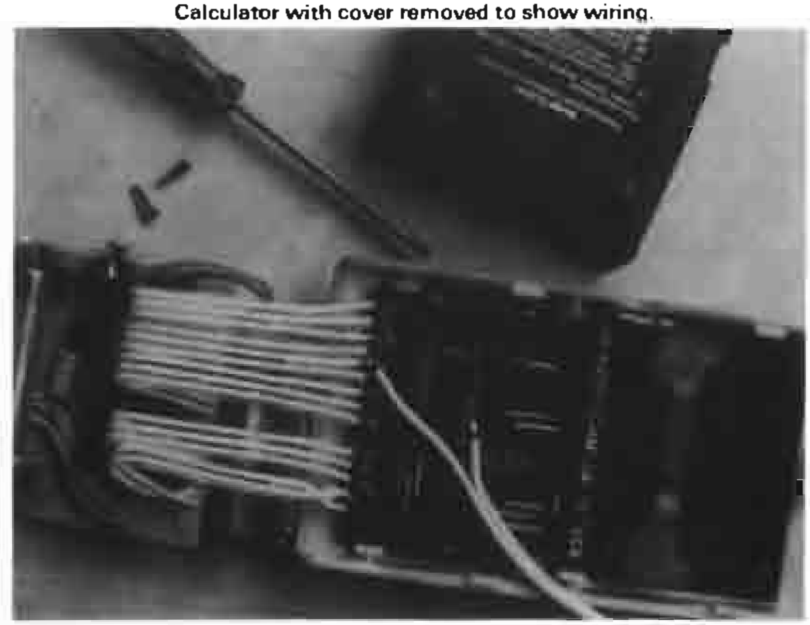
The jig consists of a mild steel bar carrying a spring-loaded tensioner and a ball-bearing roller for an easy feed. The bar is fixed to the cross-slide of the lathe with a T-nut and bolt through a light dural block.

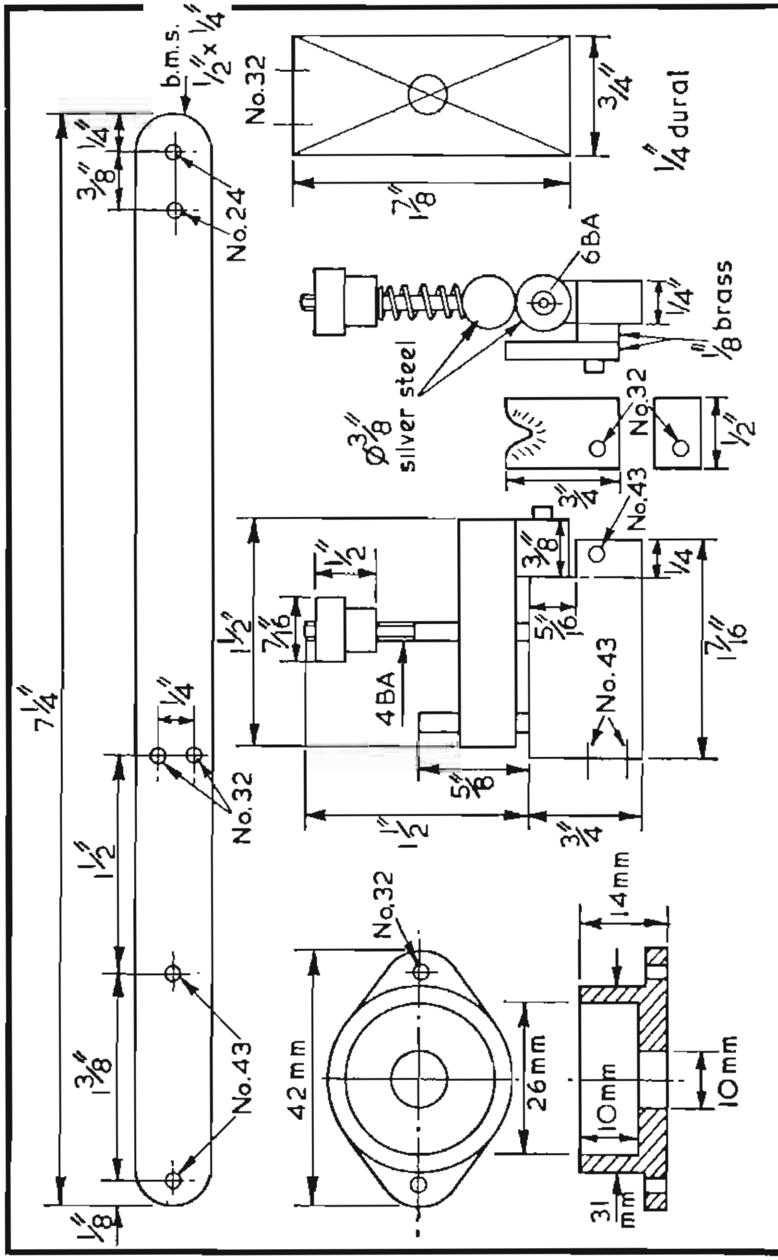
First make the mounting bar from ½ in x ¼ in stock, drilling and tapping where shown, and filing the ends round. Then make the dural block for securing the jig to the cross-slide from ¼ in x ¾ in stock with a ¼ in dia hole in the middle, drilled and tapped 4 BA at one end for securing to the steel bar with ¾ in hex cap head screws. A slight upwards tilt of the bar, towards the operator, is desirable.

The size of the ball race mount will depend upon the size of the ball race used, I use a 26 mm O.D. x 9 mm I.D. The race is used singly here as no hard driving forces are involved. The bearing mount was turned from an odd piece of 1¼ in square duralumin, first in the 4-jaw chuck to bore out for the ball race and drill through for the spindle, and then in the 3-jaw gripping inside the bore to turn down the outside, round. The flange is finished to shape with a file. Drill the flange No 32 for 6 BA clearance and tap the steel bar 6 BA. Secure the ball race in place with Loctite 601 after cleaning surfaces. Turn a 2½ in length of aluminium alloy down to 9 mm to fit the inside diameter of the bearing, and secure in place with Loctite. The light alloy eliminates any flywheel effect, as far as is possible, which might cause the reel of wire to run on after winding has stopped. The 9 mm will take the old-fashioned wooden reels with a ⅜ in hole, and also some of the modern plastic reels. For the tinplate reels with the larger holes make a spacing cylinder from nylon stock.

Nylon turns down a treat using a sharp round-nose tool, a high speed, and a cut of about 2 thou, but avoid overheating the material

Calculator with cover removed to show wiring.





A WINDING JIG FOR THE UNIMAT

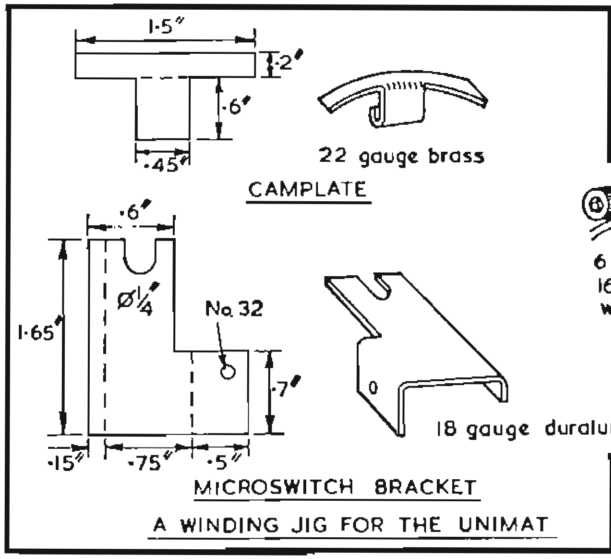
The winding components assembled.

with too great a feed rate; if the swarf comes off fluffy it is being melted off rather than cut. Drilling is difficult as overheating occurs so easily, causing the nylon to melt at the point and the drill to go awry. All that can be done to get a good hole is to start with a centre drill tip, in the lathe, and follow with a small drill, then increasing diameters until the required size is reached, using a controlled speed. Swarf should appear as a continuous, quite thick, helix. Drill the hole out first, and turn the outside concentric afterwards, holding the 'start' end in the 3-jaw chuck and the 'emergent' end with a centre in the tailstock. The spools of wire I use have a .52 in dia hole, so this is the outside diameter of my spacing cylinder.

Secure the bearing block on to the steel bar with two 6 BA screws, saw off the surplus and file the screw ends flush with the bar.

The pinch bar assembly has silver-steel bars mounted on a block made from ¾ in x ¼ in dural stock, and a brass guide plate. Cut the dural and its cut-out piece and drill the two holes to correspond with the holes in the steel bar, No 43, ¼ in deep, and tap them 6 BA. Cut the pinch bars from ⅜ in dia silver-steel and chuck the short length in the 3-jaw chuck and centre drill No 1 just up to the cone, then drill through No 32 for 6 BA clearance. Turn both ends down to a finish, then fit to the cut-out in the block and mark the position of the hole. Drill the block in the vice, No 43, ¼ in deep and tap 6 BA, also drill the hole for the guide plate securing screw with the same drill, and tap. Drill the holes for the two slide rods centrally in the top surface, No 29, ⅜ in deep at the correct positions.

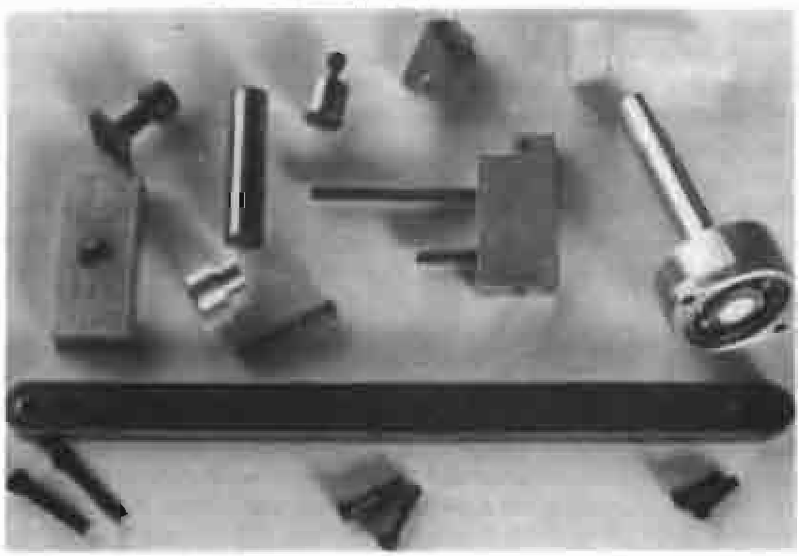
Mark the longer pinch bar and centre punch for the two holes. The prototype had a third hole for a balancing screw, but this was found to be extraneous. Drill the holes carefully in the machine vice at right-angles and in line, for the two slide rods, No 28 drill. I used No 29 silver-steel for the rods because I had this size, but if you wish to use ⅛ in dia instead, reduce the sizes of the fixing and sliding holes by one number drill (29 and 30 instead of 28 and 29). Thread ¼ in of the



silver-steel in the lathe with a 4 BA die in the tailstock die-holder, then, with a further inch, cut this off, clean up the end and Loctite it into the block with 601, with a ⅞ in length in the other hole. Cure at around 90°C to set the Loctite quickly, and retap the lower pinch bar securing screw hole to clear it of the set Loctite.

Turn the pinch wheel from ½ in dia dural, drilling through No 24 to

All the bits and pieces for the winding jig.



tap 4 BA. Fit the top pinch bar on the slides and screw on the lower pinch bar. Put on a 1 in long compression spring, the sort sold for model safety valves, and fit the pinch wheel to compress the spring to about ¾ in — the pinch wheel does not really need knurling — and check that the top bar lifts easily and straight. Cut the guide plate from 10 s.w.g. brass, together with the small distance piece. With a triangular file cut the guide 'V', and with a round needle file take off the sharp edges. Screw the parts together.

Check that the feed bearing is free, if not flush with carbon tetrachloride; my bearing mount was made from a scrap piece of dural with two holes in it, facilitating the flushing. Oil with light machine oil; also oil the slide rods.

The camplate band is made from 9½ in of 16 s.w.g. steel wire, the sort sold in model shops as piano wire. Bend ¼ in of each end into a loop around the shank of a No 30 drill, then bend the loops at 90° in a vice. Bring the loops together, forming something like a circle, and check for fit on the centre pulley, tightening up with a ¼ in x 6 BA hex cap head screw and nut. Make the camplate from 22 s.w.g. brass, as described, loosen the band to slip the camplate in place and retighten. The microswitch is fixed by a single 6 BA nut, bolt and washer. The position of the microswitch is adjusted so that it clicks on after no more than ¼ in of the camplate has struck the pip, and remains on for the rest of the camplate's travel. The loops of the camplate band must not strike the microswitch during revolutions; if they do, make smaller loops.

The counter and jig fitted to the Unimat lathe.

Left: The components required for the counter.

Adapting for the 3

To enable the winding jig to operate on the Unimat 3 it is necessary to modify only two components of the counter:

(a) The microswitch bracket should be made in a complete 'U' to fit the hole for the self-act in the headstock block. The bracket is secured with an M6 x 1 Allen head screw, with washer.

(b) The camplate band needs to be made from a piece of piano wire 6¼ in long, to fit the smaller diameter rear pulley.

Otherwise the accessory fits the 3 or the SL and operates in the same way.

The Jig in Use

In use the reel of wire is fitted to the feed roller, feeding from beneath the reel, and passed through the ends of the pinch bars, the top bar being pulled up against the spring tension, and the wire located in the guide plate. Pull about a foot of wire through the pinch bar with tension applied. The tension should be a little more than that required to release the core set from the wire having been wound around its small diameter reel. That is, it should be nice and straight; thus, a heavier gauge wire will need more tension than fine wire. Fine wire will tend to leave a fine dust of enamel in the pinch rollers if the tension is too tight.

With the tension correct fit the former into the lathe; most transformer cores will be accommodated in the 4-jaw chuck, held from the inside, and held with the tailstock by means of my large live centre. It is better to set up the lathe in the increased swing mode as the wire feeds to underneath the former and the increased height gives the operator a better view of what is happening. Tape the end of the

wire to the outside of the core and through a slot; with finer wire it is better to scrape off the enamel and tin the end with solder before proceeding as it is quite frustrating to lose the inside end of a coil after winding.

Switch on the calculator and tap the 1 button, set the speed controller to about 100 r.p.m. and switch on, using a foot switch for preference, and wind the coil, using the carriage movement to control the wind, speeding up the wind when confident. Thick wire will wind itself beautifully in layers with no help whatsoever, medium thickness wire loses this ability and needs much more guidance. Thin wire tends to wind itself in little piles, but it can be wound quite fast if a little extra guidance is given with thumb and forefinger near the coil.

This little jig makes the winding of coils very straightforward and speedy, and the one improvement that seems to be required is a method of swinging aside the microswitch so that a turn or two can be more easily unwound.

Other Calculators

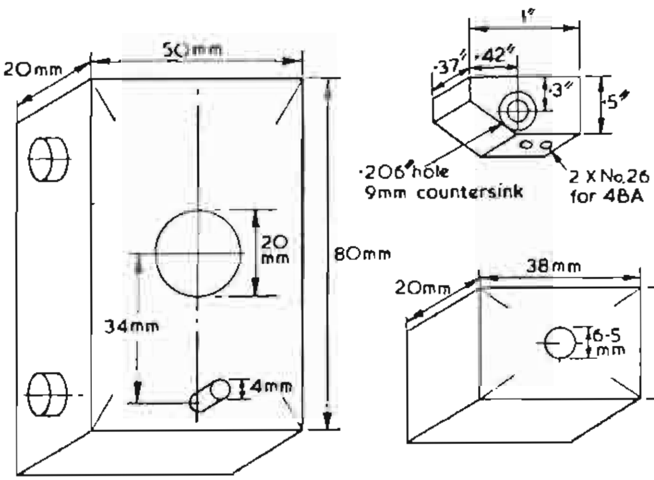
If you experience difficulty in obtaining a calculator with the function as described, an alternative is the type whose constant function is with the 'equals' button, which must be wired to the microswitch. With this type 'one' is punched, then 'plus', then every click of the microswitch (or 'equals' button) adds one to the display. But remember the display, with this other type, will always show one more than the number of turns wound, so always mentally deduct this from the display.

An old transformer and new wire for rewinding.

IX. INCREASED SWING FOR THE SL

With the toothed belt drive fitted to the Unimat, the turning of larger diameters of mild steel and cast iron becomes practicable, as well as that of the softer metals. Using the 3-jaw chuck, work a little over 2 in dia can be turned, but the platform cannot travel under this size of workpiece and only the face can be worked. With the platform close to the work the tailstock cannot be brought close enough without the help of the drill chuck to extend its reach. The boring platform can be fitted instead of the cross-slide platform but this limits the turning capacity to just over 1½ in when under the work.

An alternative is to use the 20 mm distance block under the headstock casting. This increases centre height to 56 mm, giving a capability of 112 mm dia for turning. From this, for normal work, the length of the jaw must be deducted together with a small safety factor,



HEADSTOCK BLOCK TOOLPOST BLOCK AND MOTOR MOUNT

giving a working diameter of 92 mm, or 3⅝ in. If the jaws are reversed and used to grip the work internally then a diameter up to 4 5/16 in can be turned. Unfortunately the motor gets in the way of this diameter, so that some way has to be devised to shift the motor without altering the drive configuration drastically.

A real problem with turning larger diameters is that the work tends to jump from the jaws of the chuck when the tool is applied. This can be prevented by using the tailstock, which not only holds the work in place but gives better concentricity; it is essential when working with steel. So a taller tailstock has to be devised.

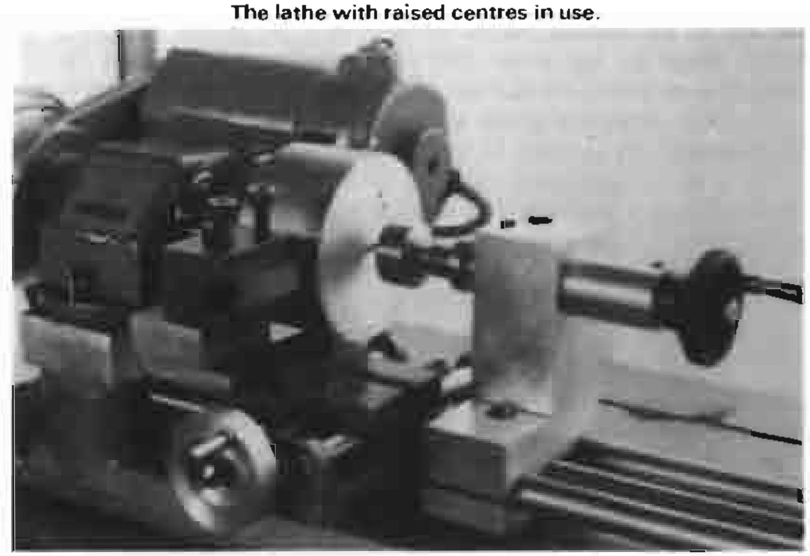
For the larger diameters, the cross-slide and platform will not get underneath and so the tailstock will still need extending with the drill chuck. However, the cross-slide cannot get into position for outside turning and so it is necessary to make an extension to get around the corner, and also to support the tool-post at the new height. For face turning a simple 20 mm block under the tool-post is sufficient to enable the tool to be presented at centre height.

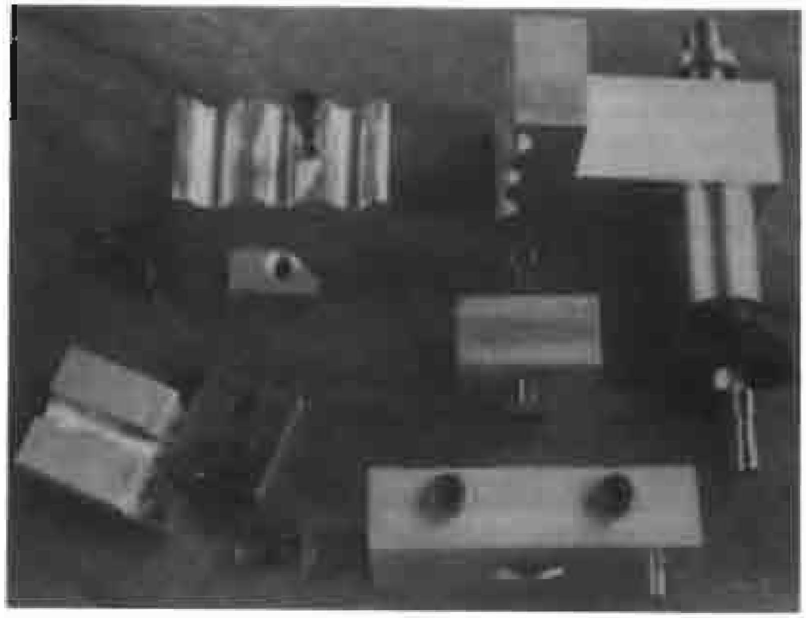
Thus the requirements for increasing the swing of the Unimat are:

(a) A modified motor mount.
(b) A 20 mm adaptor for the headstock.
(c) A 20 mm taller tailstock.
(d) A cross-slide extension and a tool-post block.

In making these bits and pieces I have had to keep in mind that the Unimat is a metric machine, but the only metric tools I possess are an Isometric set of taps and dies, a few metric twist drills and the 'other' scale on the vernier caliper.

The lathe with raised centres in use.





The Motor Mount

The motor mount modification can be fitted only to the double reduction motor bracket, and can be made from any scrap of metal to the dimensions in the drawing. To fit the block first remove the lower motor securing screw, loosen the top screw and check how much of the top of the bracket has to be filed away to enable the motor to swivel about the top screw. File the bracket and also clean up the straight upon which the new mount is to be fitted. Fit the mount to the motor and swivel the motor about its top screw until the mount is hard against the straight of the bracket. Tighten up and mark the position of the two holes through. Drill No 32, for 4 BA, tap and secure the block with two 1 in x 4 BA hex cap head bolts. In position the motor is now capable of being swivelled out simply by removing its pulley, taking out the bottom screw and loosening the top screw and replacing the screw and pulley in the new position.

Adaptor for the Headstock

The adaptor for the headstock has to be 20 mm thick because the second position for the locking bolt is at this position. In fact the standard accessory distance piece could be purchased instead of making this adaptor. I made mine from two lengths of 1 in square aluminium alloy, bolted together. The boring platform was utilised to help make the 20 mm hole with a boring bar, after drilling through.

The adaptor was then clamped to the milling table and swing milled flat, both sides, until the adaptor was 20 mm thick.

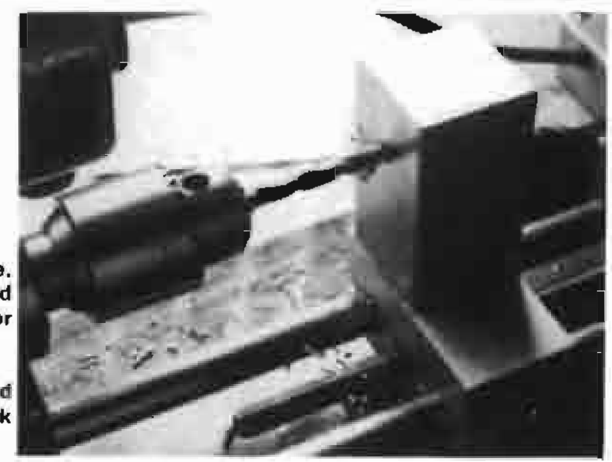
The 4 mm hole for the locating pin was drilled and a stub of 4 mm or 5/32 in silver steel secured in place with Loctite to protrude from the bottom only. The adaptor is complete.

The Tall Tailstock

To ensure a good new centre line, the new tailstock is made *in situ* wherever possible, utilising the geared forward movement of the headstock spindle for making the bores parallel and to centre.

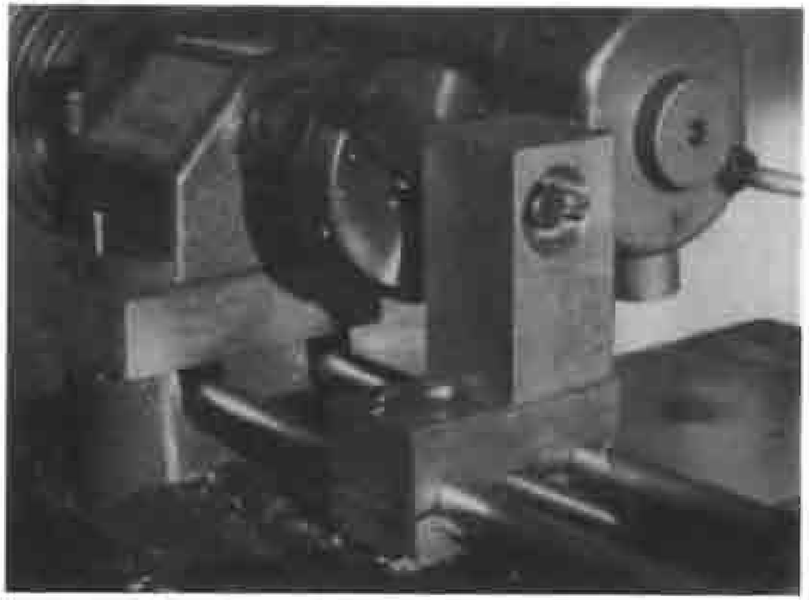
The tailstock base and upright are made from 1¼ in square aluminium alloy. Make the base first, marking out the positions of the three holes as their distance apart as the cross-slide height is used as a reference in the horizontal positioning. Clamp to the cross-slide using an engineer's square to get the piece at right-angles to the bed columns. The Unimat clamps pull their stems right out of the square head with good clamping, they are so poorly made, so make the clamping bolts from 2 in long ¼ in Whitworth coach bolts; just file a flat either side and on top of the head and there you are.

Start the first hole with a No 2 centre drill, drill right through ⅛ in, then drill through with a 11 mm drill held in the 3-jaw chuck. Use a slow speed and a little soluble oil, 50 parts of water to one of oil, squirted in the back hole; try to get a continuous curl of swarf with the amount of pressure applied. With the improved drive the bore can now be reamed by machine, at the same speed, with a 12 mm reamer. With aluminium alloy the reamer must be withdrawn and cleaned often. Bring the block over and bore the other 12 mm hole in the same way. The centre hole is just drilled to 10 mm. Drill the hole for the M6 screw right through No 6.



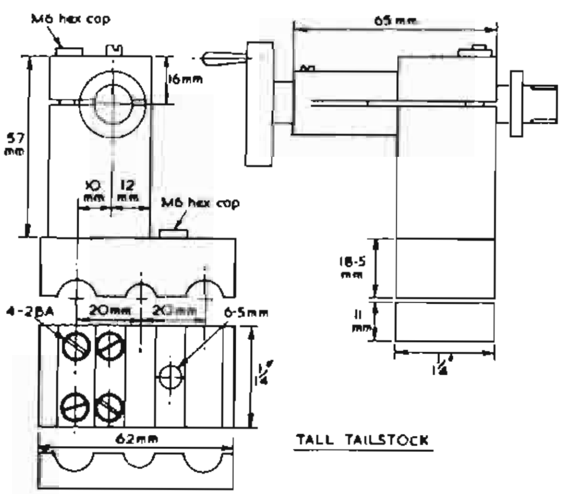
Opposite page, top: The modified parts ready for assembly.

Right: Drilling and boring tailstock upright.



Saw the block through with a standard hacksaw blade right across the bores, then carry out any easing on the rear bore, fitting and leaving the front bore intact and shining. File the bottom of the clamping half to slide easily beneath the bars, round off the bottom ends, then tap M6. Counter-drill the top half 6.5 mm through, drill again to sink the head with a 10 mm drill, 6 mm deep, and fit a 24 mm long, M6 hex cap head bolt.

Cut a piece for the upright column, square off one end and mark



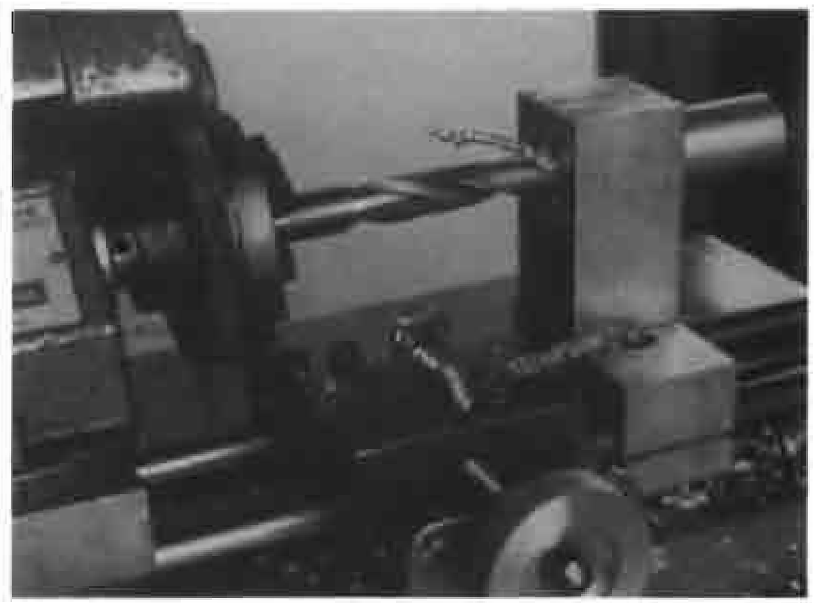
Head of page: Another view of the tailstock assembly.

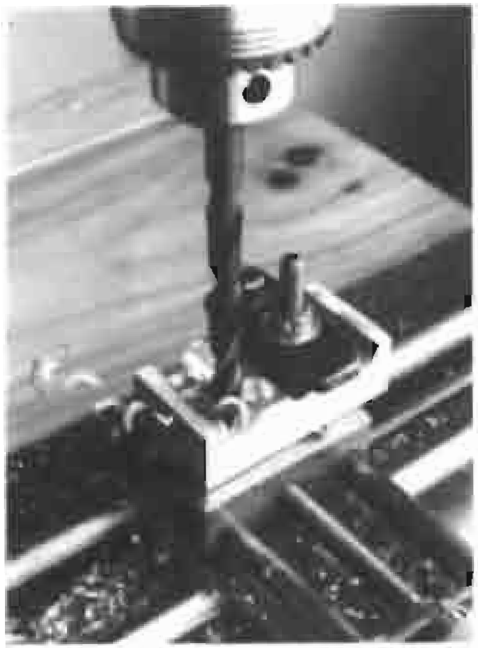
Opposite page: The first drilling of the upright.

out this and the top of the base for the 4 x 2 BA countersunk screws. Centre punch the marks and clamp the upright upside down in the vertical slide and drill No 22, $\frac{1}{2}$ in deep, to tap 2 BA. Drill the top of the base No 9 through, and countersink the underside with an 8 mm drill to enable the screw heads to be 7 mm below the surface. Clean up surfaces and screws with C.T.C., then screw together using Loctite 270 on mating surfaces and threads. Any in-built errors at this stage do not matter.

Lock the work on to the bars and, with the headstock adaptor in place, centre with a No 2 centre drill then drill through 4 mm, following with a 10 mm drill. To complete the hole make a boring tool from $\frac{3}{8}$ in mild steel rod. Cut 2 in and drill a hole at an angle of 45 degrees at one end and at 65 degrees at the other to take a $\frac{1}{8}$ in H.S.S. bit, a No 9 drill will do the trick, with a provision for a 6 BA grub screw into each hole to hold the bit in place. Chuck the 45 degree end in the 3-jaw and secure the sharpened bit in the 65 degree end, just protruding, and bore through at high speed, forwards and back. Loosen the bit and push out about .5 mm more and repeat the boring until the bar needs reversing and the 45 degree hole employed to give the extra reach. When cutting properly the bit will be making medium length flat ribbons of swarf. The bore is complete at 20 mm.

Turn a 65 mm length of dural down to 20 mm and secure in the bore with Loctite 270, with the front flat to the tailstock upright, and the back protruding. Centre drill then drill right through with a $\frac{3}{16}$ in drill. Follow with a 29/64 in then remove the tailstock and cut a

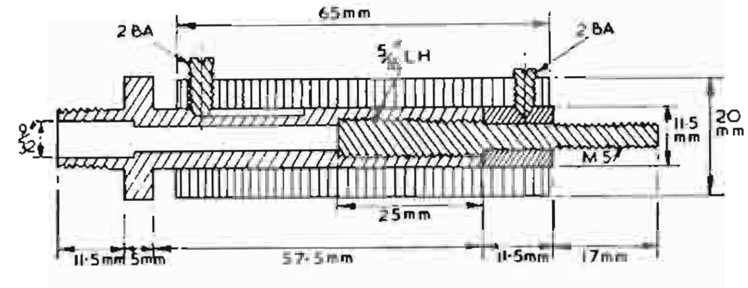




Left: Countersinking base for securing screws.

Below: Modified motor mount.

good deep slot with a standard hacksaw blade, from front to back, cutting right through the 20 mm round at the front, and just up to the end at the rear. Lock back on to the lathe bars and, with the headstock on the vertical column, drill down for the clamping screw,



MODIFIED TAILSTOCK DRIVE

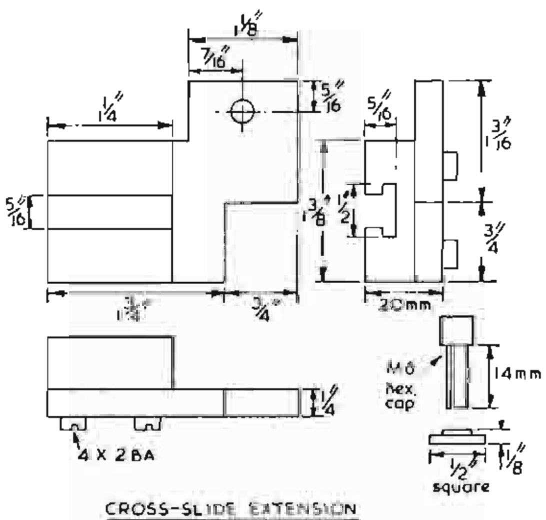
No 9, 1⅛ in deep. Counterdrill the top part of the clamp 6.5 mm through, then counterdrill for the hex cap head 10 mm, 6 mm deep. Tap the lower part M6, and fit the clamping bolt.

The rest of the tailstock is made basically from one of the old 12 mm dia bed columns. Cut a piece of about 75 mm and silver solder or braze a ¼ in thick annulus of mild steel 12 mm from one end, to form the nose plate. Centre the brazed end carefully and drill right through, ¼ in. Using the faceplate and dog, driving between centres turn the back end down to 11.5 mm. Set up the threading attachment with the 1 mm leader. Chuck the 11.5 mm in the 3-jaw and centre the nose in

Milling groove in cross-slide extension.

the tailstock to take the minimum from the nose, clean up the brazed-on ring, make the nose plate face perfect, then thread the nose. Wrap a piece of thin alloy around the threads and chuck in the 3-jaw whilst centring the other end in the tailstock. Take back the tailstock and drill in 1 in with a 17/64 in drill to tap ⅜ in BSF left hand thread.

Cut a piece of ⅜ in mild steel, centre pop one end, chuck the other in the 3-jaw and centre drill, No 1, lightly on the mark. Centre up and turn 28.5 mm down to 5 mm, and thread 7 mm of the end M5. Put ¼ in of the other end hard in a vice and with a ⅜ in BSF left hand die,



Head of page: Cutting tee-slot in cross-slide extension.

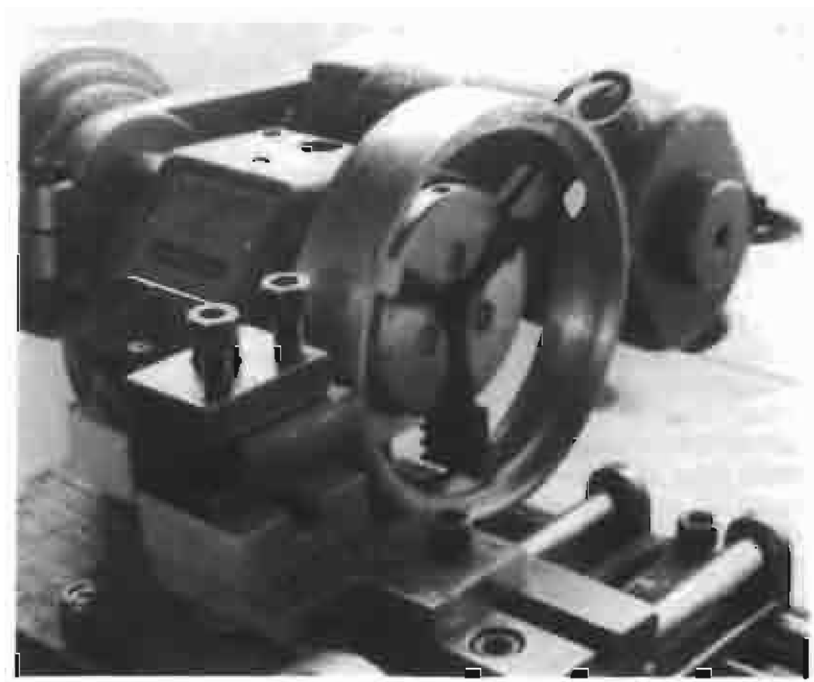
Opposite page: Turning a traction engine wheel rim.

opened up really well, thread down right to the vice. Use plenty of Rocol RTD, and back off every third of a turn. Relax the die a little and re-thread, and again until the shaft screws on, rather tight.

Make sure the threaded part is at least 25 mm long, cut off the bit mutilated in the vice, and clean up the thread start and saw cut with a file. The drive collar is made from the 12 mm steel turned down to 11.5 mm and drilled through 5 mm.

Fit the tailstock together, using a handwheel, and lock it on to the bars. With the headstock on the vertical column, central over the tailstock, drill down, No 22, for the positions of the fore and aft grub screws, so that the drill marks through to the shaft and the collar. Secure the shaft in the machine vice and mill a ¼ in long slot with a ⅛ in end or slot mill, not too deep or it will go right through. Drill a cone into the collar. Make the two grub screws from discarded bits of 2 BA threaded rod, turn the rod and the cone ends in the lathe, and cut screwdriver slots in the other ends. Thread the holes and fit the screws.

Fit all together again on the bars to drill out the nose for the centres. For this use a Letter K or a 9/32 in drill — both are a little undersize; after the initial drilling run the drill fast and make a few more passes in and out and the stems of the centres will be a good tight fit.



The cross-slide extension is made from a piece of $\frac{1}{4}$ in mild steel plate with an aluminium block to bring it up to the required new 20 mm height. The T-slot is cut *in situ* with $\frac{3}{8}$ in end mill, followed by a $\frac{1}{2}$ in x $\frac{1}{8}$ in Woodruff cutter. The tool-post block is simply a 20 mm high extension to the cross-slide. Use one of the T-screws from the clamps to secure the tool-post right through from the cross-slide.

With this kit of parts, to increase the swing of the Unimat, it is possible to turn a $3\frac{1}{2}$ in cast iron wheel, or a larger cylinder, but only if you have fitted my improved drive. A 4 in rear wheel for a traction engine can be easily turned, as shown in the photograph, improving the scope of the SL Unimat in another useful dimension.

X. AN IMPROVED VERTICAL SL

With the introduction of the Unimat 3 it was time to make a comparison with my improved Unimat SL, and I concluded that my version, with its accessories and possibilities, represented a better bet in all directions. However, the ability of the 3 to behave like a small milling machine, without the limitations of the SL, aroused my envy and I went to work to equal this capability.

The Unimat 3 has a vertical column which bolts to the centre-rear of a strong bed, enabling a complete movement of a milling table beneath the vertical head; the Unimat SL is very restricted in table movement beneath its vertical head position. The difficulty in adapting the SL is that the bed is cast in the form of an alloy shell with web strengtheners. Any drilling or cutting of either the shell or webs will weaken the bed greatly; thus any construction fitted to the centre of the bed is not possible. The only alternative is to make an under-bed fixed to the four corner screw holes, but this might tend to be massive and heavy if flexing is to be avoided. To avoid making the under-bed too massive and thick, mild steel was chosen for its construction, particularly since I had a few feet of the material standing about doing nothing, and to make the steel rigid a double layer cruciform bed was made, which is reasonably lightweight, using the 2 in x $\frac{1}{4}$ in mild steel.

Steel is quite flexible and has a useful Young's Modulus, but, whilst it can be stretched by using sufficient force, it cannot be compressed. So, if the normal flexing of a top layer of the $\frac{1}{4}$ in steel has to compress a bottom layer and vice versa, then the laminate will remain rigid. I constructed the bed like a double leaf spring, in cross form, then secured it at strategic places so that flexing would be extremely limited. At the same time a minimum of metal is used so that the whole is not too heavy. When the cross is bolted on, the bed further limits any flexing with its flat undersurface.

The position of the headstock, made vertical on this underbed, is right over the front bar when at 90 degrees and in position for

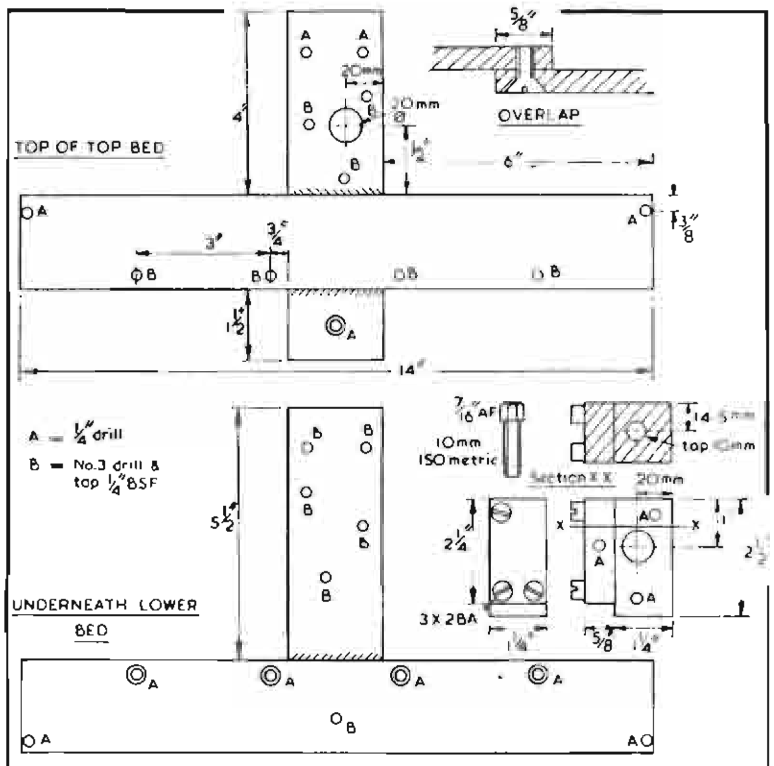
swinging from the vertical along the path of the carriage. The vertical head casting is cleaned up and calibrated for ease of operation when milling or drilling at an angle. The bed and even the vertical column can now be left permanently in position without interfering with other attachments (except the autofeed, which is not used much anyway).

The attachment is quite easy to make, using the Unimat SL for most operations.

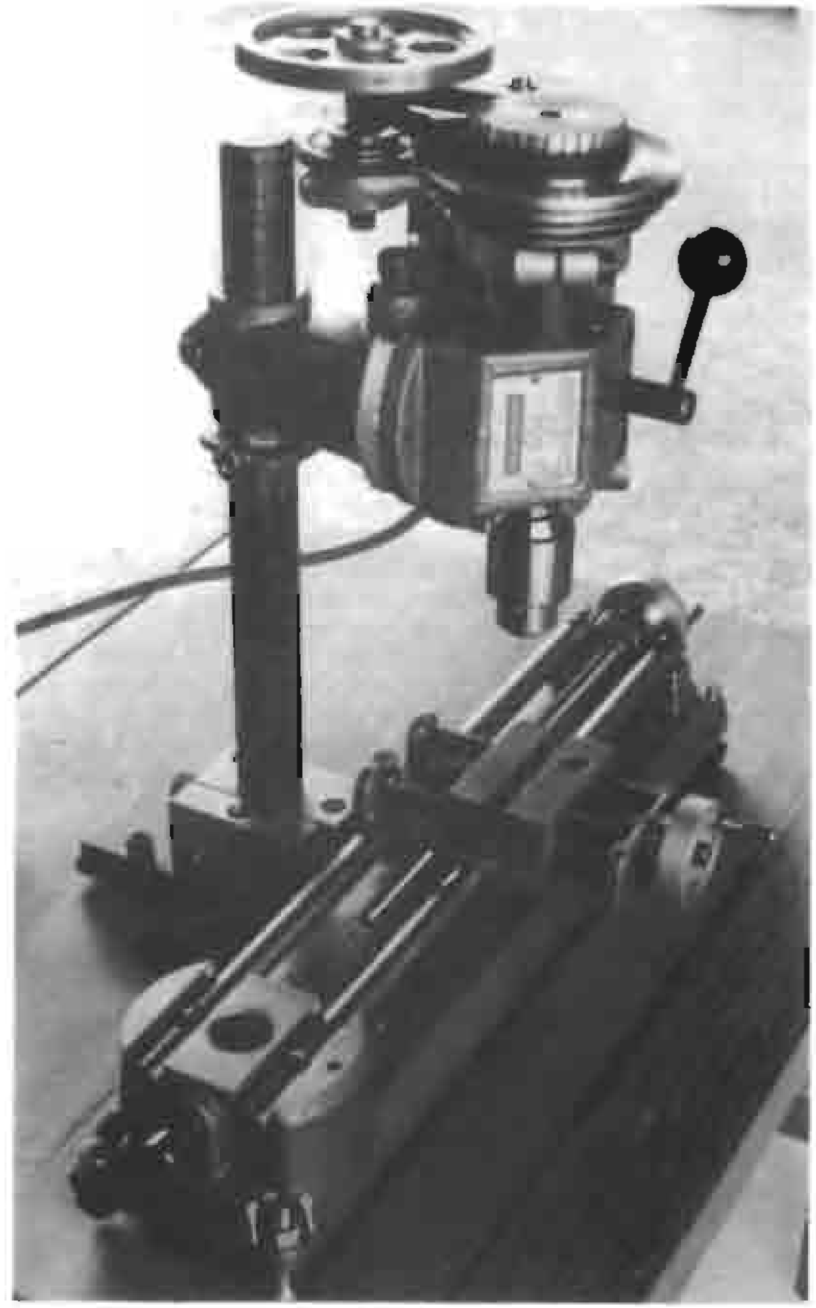
Construction

The under-bed is made from 2 in x ½ in mild steel; you will need approximately 40 inches. If you are buying by post, order 2 x 2 ft lengths. Cut the two 14 in lengths first, then the 5½ in piece, the 4 in and lastly the 1½ in, so that the possibility of being left with a piece too short to use is avoided. Clean up the ends with a file and weld or braze the cross pieces in place.

Braze the cross pieces on with B6 and Tenacity flux. First wire the extensions to the main members with 12 gauge iron wire, flattening around edges and over surfaces with a hammer, and securing the wire



AN IMPROVED VERTICAL UNIMAT


The improved verticel SL.

Left: The parts required for the new bed.

Opposite page, bottom: The new bed assembled and treated against corrosion using Corroless "S" paint

by twisting the ends together away from the flat surfaces. The whole should lay flat on the wire, each side, with the gaps closed right up.

Stand a piece of ¼ in thick asbestos on firebricks and put the cross on top. Wet around the parts to be joined and liberally apply the flux powder. Cut a piece of the braze to lay along the joint and flux over this. Get the best flame on the gas blowtorch and heat the first joint until the flux runs like black treacle, then prick in the melting braze with a pointed steel rod. Apply more braze whilst still heating until the braze is proud on the joint. Go directly to the other joint, if brazing the top first, and braze this joint. Have a bucket of 2 per cent sulphuric acid ready, and, when the cross has cooled for about ten minutes, pick it up with tongs or pliers and dunk fully in the weak acid. Clean up the back of the joints with emery cloth, then replace the cross on the asbestos, brazed side down, to repeat the brazing on the other side after fluxing. The acid bath effectively cleans out the flux which is a first-class rusting agent.

When the crosses are brazed, file off the joints flat and clean up the corners, degrease if necessary and apply the first coat of Corroless 'S' anti-rust paint. When dry take the top part and place the Unimat bed over it to mark the two back corners for the securing screws. Centre pop and drill through with a ¼ in drill to enable this part to be secured in place with two ¼ in B.S.F. hexagonal cap head screws with a nut and washer. Take the lower part and manoeuvre to get the ⅛ in overlap right, then scribe the two front corners through to be drilled and secured in place with two countersunk ¼ in B.S.F. screws from underneath, washer and nut on top. With a scriber mark firmly the relative positions of the upper and lower plates.

Remove the bed and clamp the plates together with a G-clamp at each end, carefully aligning the scribed position. Mark the centre of

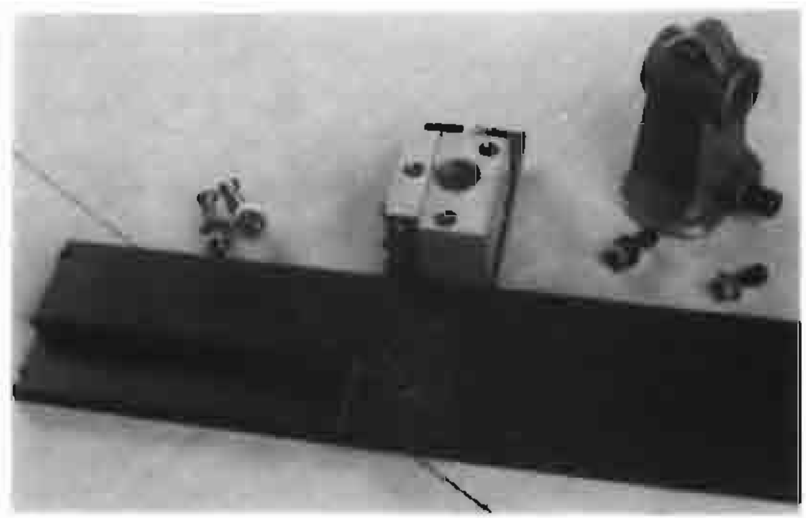
the short arm from the diagonals and centre punch. Mark the four overlap screw positions underneath and centre punch. Mark the positions of the two rearmost screws and punch. Drill through these seven holes from the centre popped sides, No 3 drill. Use a good pressure when drilling and lubricate with a little 20 to 1 soluble oil; the swarf should come away as a continuous spiral. Unclamp the two halves and drill each appropriate hole through ¼ in then countersink the one upper hole and the four lower holes. Tap the other holes ¼ in B.S.F.; use a first taper right through and plenty of Rocol RTD.

The hole for the bottom of the vertical column has to be cut in the upper part only. This is cut in the old-fashioned way with a circle of holes. Scribe the 20 mm circle in the correct position with a 16.5 mm circle concentric and centre punch a circle of dots around this inner circle approximately ⅛ in apart. Drill around with a ⅛ in drill then secure the cross in a vice to cut out the circle with a medium Abrafile in the hacksaw, and finish with a round file out to the scribed circle.

Clean out the screwholes and screw the two halves together using Loctite 221, screw lock, on the threads. A broad bladed screwdriver is needed. Paint the bed with a further coat of Corroless 'S' to keep the rust at bay, with a finish coat, if required.

The Mounting Block

The mounting block is made from 1¼ in square duralumin. The hole is bored, 20 mm diameter, using the centre height and cross-slide at exactly 90 degrees to the bars, and drill through 4 mm. Drill again with an 11 mm drill, then use a ⅛ in square bit in the boring bar to bring the hole to 20 mm. Drill the hole for the column securing bolt, with an 8.5 mm drill, radially to the 25 mm hole in the position

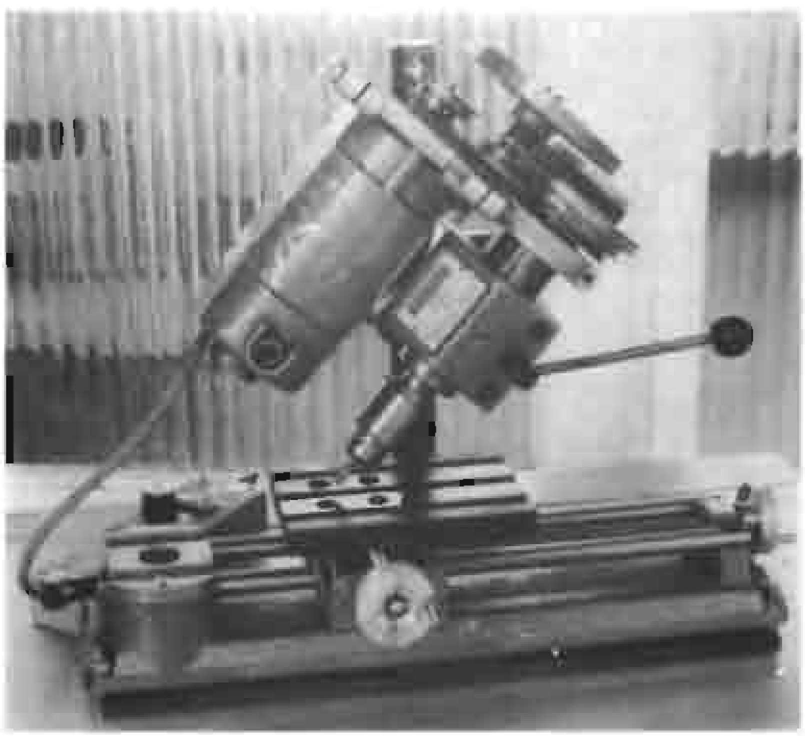


shown, and tap M10 using the first taper then the plug tap. Make the bolt from $\frac{7}{16}$ in AF hexagon brass stock: cut about $1\frac{1}{4}$ in and turn all but the first $\frac{1}{4}$ in down to 10 mm in the lathe, then thread M10.

Make the side-plate to the dimensions shown and drill the three holes for the 2 BA screws with a No 10 drill. Clamp the side-plate in position and mark through for the securing holes. Drill No 22, $\frac{1}{4}$ in deep, and tap 2 BA. Clean up carefully and screw the plate on with 1 in cheesehead screws using Loctite 601 on the surfaces and the threads.

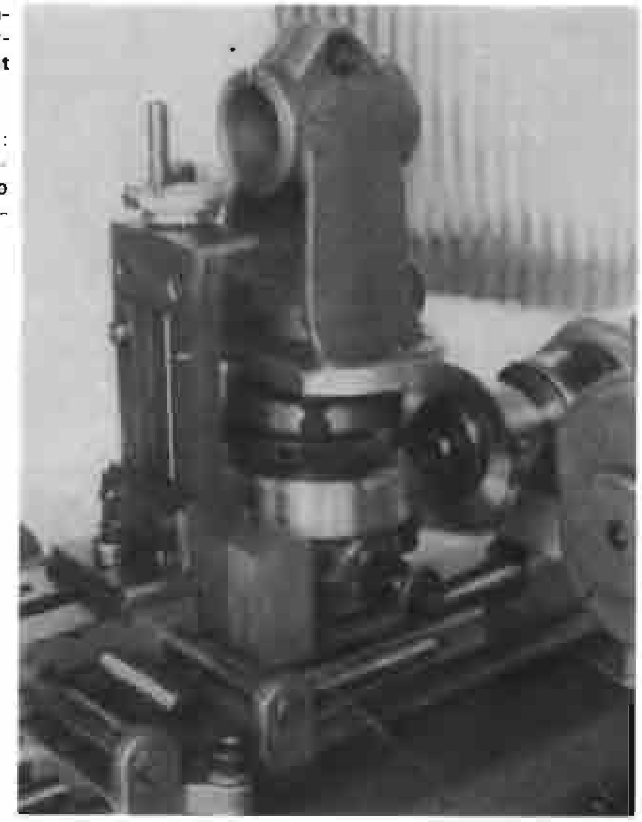
Drill the three holes with a $\frac{1}{4}$ in drill to the approximate positions in the drawing, avoiding the holes and screws. Countersink the holes with an 11.5 mm drill, $\frac{1}{4}$ in deep, to take the hexagon cap heads of the $\frac{1}{4}$ in B.S.F. bolts. Position the mounting block over the 20 mm hole in the rear of the new bed and mark through the positions of the three holes with a scriber. Centre pop and drill right through the bed, No 3. Tap right through both layers $\frac{1}{4}$ in B.S.F., using Rocol RTD and plenty of backing-off of the taps. Secure the block in place, using the appropriate Allen key, with 3 x $1\frac{1}{4}$ in B.S.F. bolts.

The underbed is secured to the Unimat bed with the four nuts, bolts and washers previously used.



Right: Calibrating the vertical mount casting.

Opposite page: Improved Unimat set up to mill at 40 degrees.



Calibrating the Casting

The headstock vertical mount casting is quite rough and, of course, uncalibrated. The first task here is to provide a good surface for the calibrating marks. This is carried out in the increased swing mode, using the taller tailstock, headstock adaptor and cross-slide extension, as previously described.

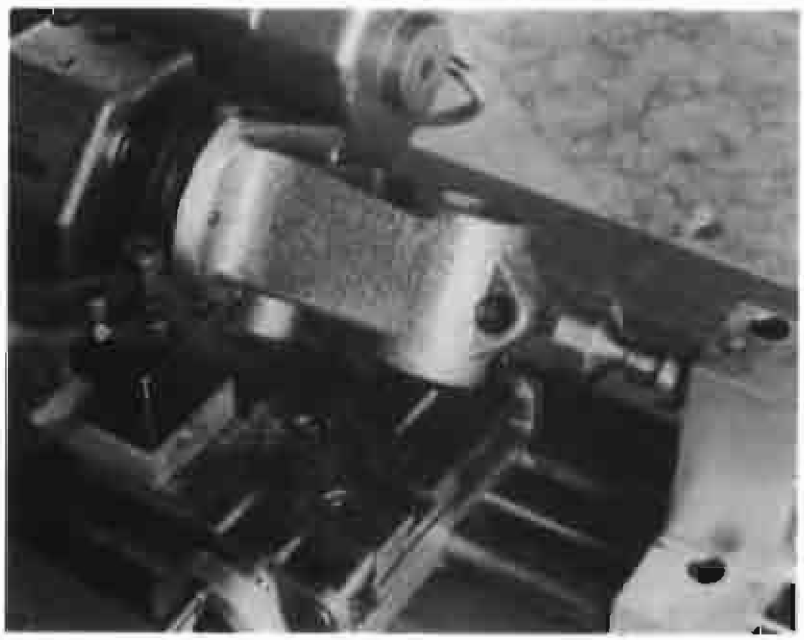
Centre punch the precise position of the central pip on the under surface of the casting, then secure it in the chuck by its 20 mm bore, with the three jaws gripping from the inside, and hold it firmly in this position with the live centre in the tailstock. Turn at the fastest controlled speed and approach the tool carefully as the central pip will knock until it is turned down. Using a cut of 2 thou a go take down the surface to be calibrated until it is clean and smooth, finishing with a 1 thou cut.

Remove the chuck and tailstock, leaving the headstock high, and fit the slitting saw holder complete with slitting saw on to the nose. I used a saw $1\frac{3}{4}$ in x .016 in but anything from .010 in to .020 in thick

will do, with a diameter from 1¼ in to 2 in. Make sure the saw is cutting in the right direction, and reverse on the holder if necessary. Secure the rotary table into the indexing attachment with the 3-jaw chuck on top, and fix this by a single T-bolt on to the vertical slide. Fix the vertical slide to the cross-slide.

Zero the scale of the rotary table and secure the casting on the chuck, gripping the 20 mm bore as before and lining up the centre mark with the slitting saw, vertical slide at the bottom of its travel. Run the saw at normal, uncontrolled, speed and cut in with the saw two complete turns of the cross-slide handwheel. Withdraw and turn the table five degrees for each cut, cutting in 1¼ turns of the handwheel for the five degrees and two turns for the ten degree marks. The surface available will take marks to 40 or 45 degrees either side of the central position.

Assemble everything and check for rigidity; any wobble will be in the vertical column fixing, and can be simply cured by fitting a mild steel washer, with a 20 mm hole, over the bottom end of the column to rest on the alloy block; this gives the securing bolt a little extra to bite on; a 20 gauge washer should be thick enough. When all is well, check that the drill chuck lines up nicely over the front bar when the head is at 90 degrees; this is a good starting point when setting up for any job. Tighten up all clamps and discover how rigid the new set-up actually is.



Opposite page: Cleaning up the vertical casting before calibration. Note improved swing accessories. Above: The headstock in the new horizontal position giving an increased surface grinding capability.

Conclusion

This modification adds about ten pounds to the weight of the Unimat, but eliminates the need for any other mounting. It makes milling and drilling much easier to set up and carry out, particularly angled work. In the new position there is always the cross-slide or milling table beneath the angled head, unlike the old. The new low holding position will also take the headstock on the adaptor, enabling taper turning and surface grinding to be carried out in a new way on this machine. The headstock of the Unimat 3 cannot be fitted in this low position.

XI. A BORING TABLE

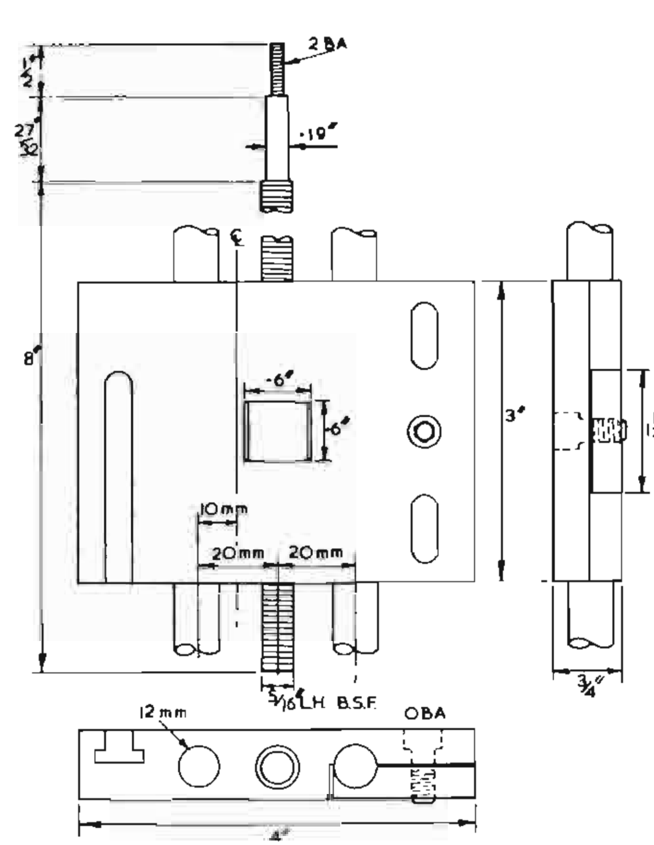
This boring table was made after trying to bore a block of dural for the cylinder block of a model aircraft engine and finding that the cross-slide position permitted a central hole to be bored only in material less than one inch square. The cross-slide is only 12 mm below centre height, and this means the size of a bore is very limited if some material is to be left around the hole.

This platform for the Unimat SL gives the new capability of enabling holes to be bored centrally in block material up to $2\frac{1}{4}$ in square using a boring bar and bit turning between centres. With a $6\frac{1}{4}$ in bar a hole can be bored through 3 in of block with precision. The platform itself is made on the Unimat SL with a bit of a struggle.

Basically the platform is a low-slung block of $\frac{3}{4}$ in thick dural with its own threaded spindle which is provided with a nut to drive the platform; this simplifies the problem of threading the platform itself. The precision of the job is supplied by two devices, the drilling and reaming of the main guide hole, and the final milling of the top surface parallel to the slide bars and across.

Cut a 4 in x 3 in piece of dural. Mark both the 4 in long edges and across what will be the under-surface at the centre, and at 20 mm either side with straight scribed lines. The surface of the cross-slide is used as a reference for the drilling of the three holes. The little lathe is going to be used to drill holes in what is a large workpiece for it to manage; the middle hole is drilled with most of the block hanging in mid-air, but as long as one of the outer holes is good and true then all will be well. You will have to lift the motor and bracket about 45 degrees around the mandrel.

Using the two clamping claws, clamp the block to the cross-slide with the bulk of the work overhanging the back of the lathe, scribed side up. Line up the scribed lines parallel with the lathe bars and clamp down tightly. Move the cross-slide until the nearest scribed line is at centre and lock the cross-slide. Drill through using a long $\frac{1}{4}$ in drill, then drill through again with a $\frac{7}{16}$ in drill using a slower speed



A BORING PLATFORM FOR THE UNIMAT

and some paraffin squirted down the $\frac{1}{4}$ in hole. If there is a chance of the block shifting position when drilling with the large drill use a $\frac{5}{16}$ in and a $\frac{3}{8}$ in drill as intermediates before the $\frac{7}{16}$ in. Loosen the cross-slide and bring the middle scribed line to centre, tighten the slide and drill through with $\frac{1}{4}$ in drill. This time the series of $\frac{1}{16}$ in steps will certainly be needed as there is great leverage at the holding clamps. It is at this stage you will realise how flexible the little lathe is. This is an oversize hole to accommodate the threaded rod and great accuracy is not essential.

Loosen the clamps and turn the workpiece around, same side up, and carefully line up with the lathe, centre and clamp up tightly. If your first hole was not very successful now is the time to revise your

methods. More lubrication, different drilling speed or pressure, perhaps you should use the mandrel to drill instead of the saddle movement; this is another chance to get the best straight in-line hole in a rather inadequate situation.

With the alloy block held in a vice, ream the two outer holes using a 12 mm straight reamer, with a little tapping compound on the taper. Decide which is the cleanest, straightest hole and cut away half the other hole, sawing through the scribed surface and the block's end. Start the sawcut on the scribed surface to just miss the inside of the hole so that you end up with most of the surface of the bore left intact. Take the piece removed and cut off 1¼ in off it for the clamp.

Dismantle the lathe and slide one lathe bar into the 12 mm bore, lubricating with machine oil. Bolt the two bars back on to the bed, the bar with the platform on at the back, and check how the cutaway fits the front bar. With some engineer's blue and a round file bring the cutaway bore to a reasonable fit on the front lathe bar, finishing with some fine emery cloth wrapped around the front bar. The surface where the cutaway bore runs on the top of the bar needs to be true or the platform will try to twist when clamped and make travel difficult. The reamed unfiled surface of the clamp produces the stability for this side of the platform.

Place the 1¼ in clamping piece in the centre under the front bar and secure it in place with a couple of small clamps. With the headstock on the column, drill vertically right through at the clamping bolt position, with a No 11 drill. Remove the piece and clamp the front bar and platform together, drill out with a ¼ in drill; counterdrill 3/16 in deep with an 11/32 in or 9 mm drill for the hex cap head. Take a ¾ in long 0 BA cap head screw, wrap thin alloy around the thread and chuck in the 3-jaw. Turn the cap head down to .34 in, and it will sink nicely in the hole. Tap the clamping piece 0 BA.

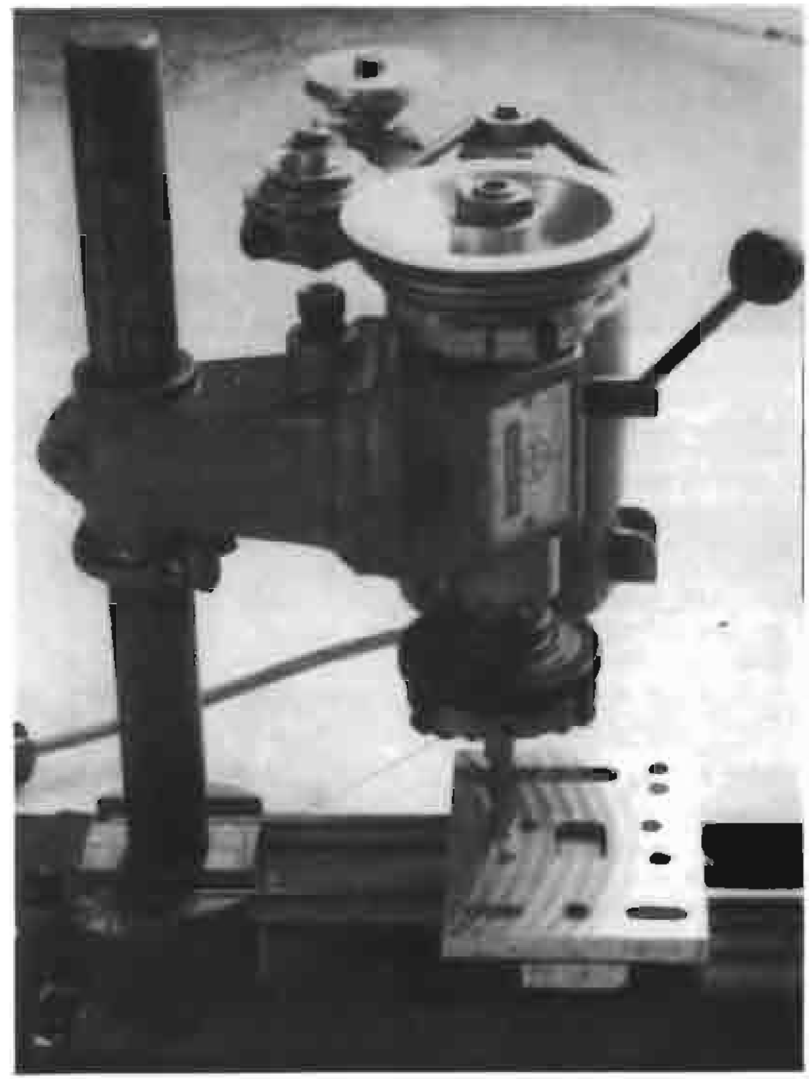
Mark up for the hole in the centre, in line with the lathe screw spindle, and drill ⅛ in holes in the corners. With the platform in a vice cut out the piece with an abrafile or similar, and square out the hole with a flat file. Make a nut from dural, a 15 mm cube, which should fit the hole tightly fore and aft, but should have a little sideways play, to help centring on the threaded rod. Drill the nut through with a ¼ in drill and tap through with a left hand 3/16 in BSF tap.

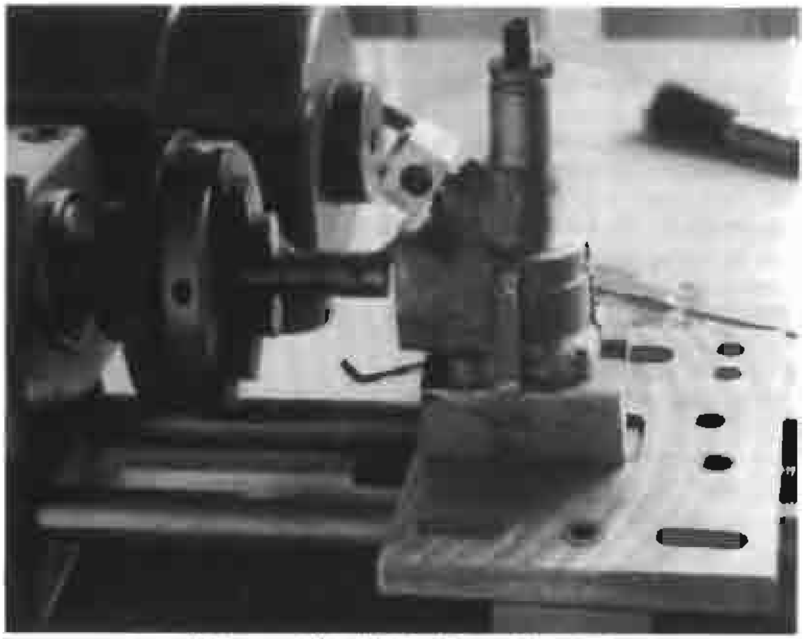
Take 10½ in of 3/16 in dia b.m.s. and chuck in the 3-jaw. Now since the lathe will only take 6¾ in between centres the tailstock cannot be used, as such, and the rod can be supported by a three point steady. A better solution, however, is to dismantle the works of the tailstock, pass the rod through the hole, use plenty of grease and a bush to support and centre the work. The bush needs to be 3/16 in inside diameter and .475 in outside. Turn it from ½ in brass or alloy rod, half an inch is plenty, and secure it in the back of the tailstock hole with

the locking screw, pump in some grease and feed the rod through, securing 1 in of the other end in the 3-jaw chuck.

1/16 in away from the jaws turn down 1½ in of the rod to .19 in, then turn 21/32 in of this nearest to the chuck, down to .185 in. Remove the rod and file two flats on the inch which was hidden in the chuck. Put the flats in a vice and thread the rod right down with a left hand 3/16

Swing milling the platform using the column collar.





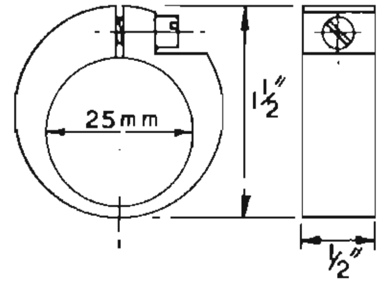
Boring out the cylinder of a small engine.

in BSF die, opened right up: use plenty of tapping compound and backing off. Repeat the operation two or three times, closing the die a little in the stock each time, until the nut screws on tight to the fingers. Cut the threaded rod off at the vice leaving half an inch of the .185 diameter to be threaded 2 BA.

The components for the platform are now all made and can be assembled on the lathe bed, using the handwheel and nut off the dismantled saddle assembly. Lubricate the bars, thread and handwheel with light oil, and with the clamp half tight run the platform back and forth; it should be as easy to run as the nut on the threaded rod will allow.

Swing Milling

The next job is to mill the platform flat to the lathe, but the platform has movement only between head and tail, there is no cross movement. To overcome this problem make a 'swing' milling attachment using the vertical column and headstock adaptor swinging around a collar clamped around the column. I made a swing collar from an old brass lathe-dog, but one can be easily made from 1½ in dia brass. Turn half an inch of this eccentric in the four-jaw chuck, boring out a hole 25 mm dia and then facing off. Cut a flat to take the clamping screw, drill the flat through No 33, then saw through the

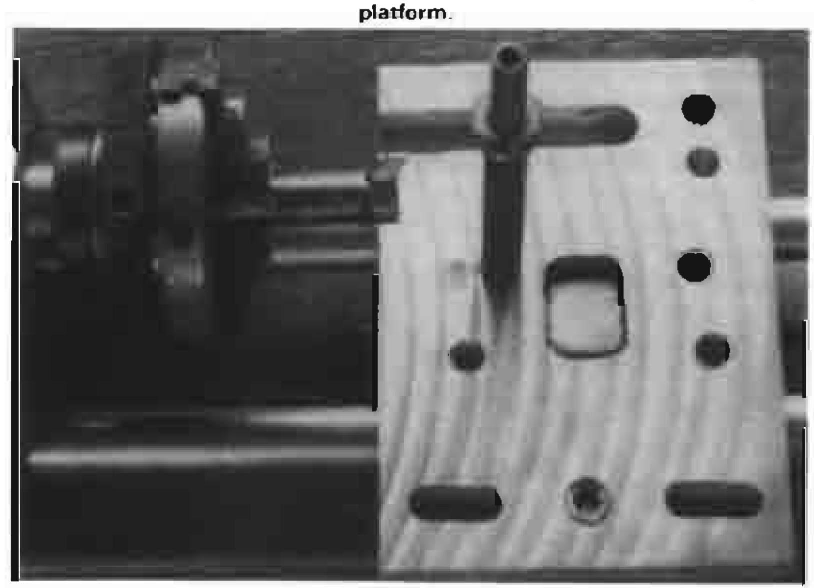


COLLAR FOR UNIMAT COLUMN

widest part of the eccentric, drill out the flatted side No 26, and tap the other side 4 BA to take a ¼ in long screw. File any rough spots off the headstock adaptor casting where it will bear on the collar. Clamp the collar on to the lower part of the column (where it is little used) and bring down the adaptor. With a small amount of fine grinding paste mate the two surfaces, dismantle and clean thoroughly with paraffin. When using the swinging action oil the column above the adaptor and at the collar, clamp the adaptor in use so that some pressure is needed to swing it.

To swing mill the boring platform, set the mandrel ¼ in forward in the headstock and set it up truly vertical on the column. With a $\frac{5}{16}$ in endmill in the 3-jaw chuck bring the adaptor down the column until

A sturdy boring tool for boring blind holes up to 1 in diameter, using the platform.



the endmill is resting on the platform. Clamp the adaptor, bring the collar up to the adaptor and tighten the screw, unclamp the adaptor to swing, and oil. The 5/16 in endmill is the optimum size for this job in this small lathe; use about 850 r.p.m.

Starting with the mill behind the platform and holding the headstock firmly swing the mill towards you and then back again over the same path. Move the platform ¼ in and repeat until all the surface has been covered. This first go will only take off any high spots, but it gives a very good idea of the direction in which the rotating mill has a mind of its own. Now, with the cutter over the back of the platform loosen the mandrel screws slightly and lower the rotating cutter about 1/64 in into the platform with the lever. Retighten the screws and mill all over the platform as before. Repeat until the platform is patterned evenly all over.

The only job left to do is to drill the holes wherever you want them, and to cut the slots. The holes I made are all tapped 0 BA and two of them are directly under the lathe centre line; useful for boring out the cylinder blocks of model aircraft engines at 90 degrees to the crankshaft line. The T-slot takes Unimat claw clamps and is made with a 3/16 in endmill 5/16 in deep, followed by a ¼ in x ⅛ in Woodruff cutter, bottomed on the groove.

Object of the Platform

The main object of the platform is to make accurate holes for cylinder bores and so on; for this job you will need boring bars. These are readily made from mild steel rod and high speed steel tool bits ⅛ in dia. Simply drill a hole in the centre of the bar with a ⅛ in drill, at 90 degrees drill a No 44 hole and tap 6 BA to take a grub screw to hold the bit in place. The bit should be ground to a D section at one end, with a slight angle. I made one .275 in dia for boring up to ½ in and a second .45 in dia for ½ in to 1 in bores. Centre drill the bars at both ends and they can be driven by a lathe dog.

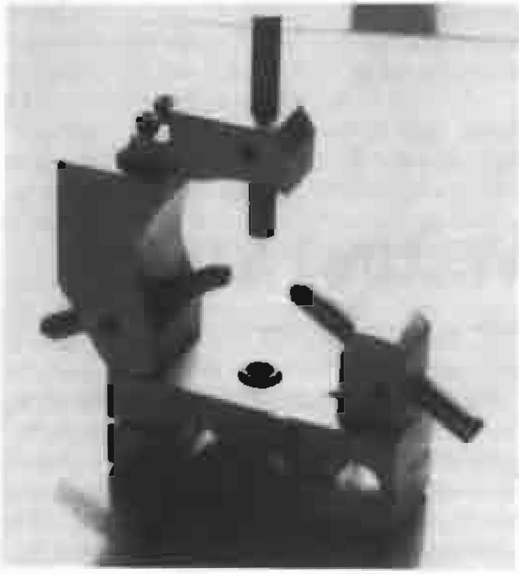
XII. A TRAVELLING STEADY

This travelling steady was designed and made for the Unimat SL after I had attempted to turn down some mild steel to a small diameter, between centres, and found that with a normal cut the metal flexed away from the tool, and with a heavier cut, sufficient to remove metal, the tool chattered, grooved the metal and turned the job oval. The answer was a three-point steady close to the tool, but the accessory sold for the Unimat is a fixed steady, which would require constant adjustment to do this job. So I made this travelling steady which stays close to the tool along its cut. Also, the standard accessory has a pass through of only 35 mm whereas my steady can accommodate material of over 2 in dia. Finally, this steady has the added refinement of phosphor bronze tipped points to give a better bearing surface and less wear.

The steady consists basically of a dural block clamped to the lathe bars and carrying further blocks of alloy in which are set three steel pins tipped with bronze. The clamped dural block is in two halves registered together by two steel pins; this allows clamping to be a little less than complete and the block to move along the bars without movement in other directions. The travel along the bars is controlled by the threaded rod of the lathe by means of an annular nut, with a left hand thread, pinned to the clamping block of the steady, drawing it along. If the steady is required to be used in the fixed mode, the nut is unpinned and the base fully clamped. Removal of the steady is simply a matter of unbolting the clamp and pulling the two halves apart from the registering pins, then running the nut back off the threaded rod. The three points are adjusted with an Allen key and a spanner for accurate contact with the turning workpiece.

The Base

First make the clamping base of the steady from a length of inch square dural bar. Mark the positions of the two 12 mm bores with centres 40 mm apart, by scribing three sides of the block. The surface

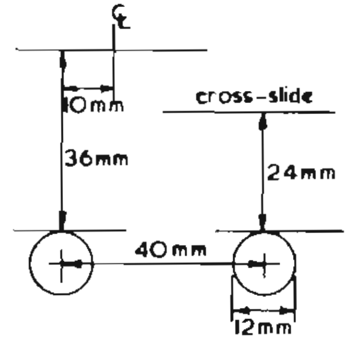


The travelling steady.

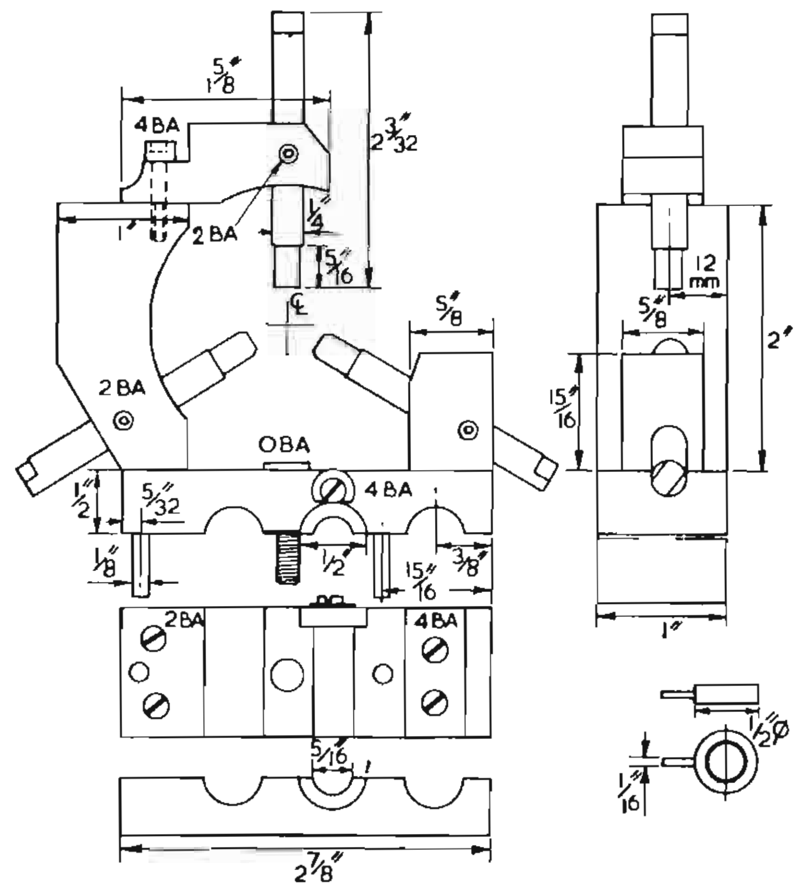
of the cross-slide is used as a reference height for boring the three holes. Clamp the block with one line uppermost and one down either side on to the cross-slide. Use two clamping claws, one either side, with the claws diagonal across the work. Adjust the scribed line parallel with the lathe centre line and tighten right down. Bring the scribed line to centre and with a No 3 centre drill in the chuck start the bore as far as the flute will allow. Drill right through with a 1/4 in drill followed by a 7/16 in in the 3-jaw chuck. Turn the block round until the other scribed line is in a similar position, clamp down parallel on the cross-slide, start with the centre drill, then drill out in the same way. Remove and scribe three lines midway between the two bores, clamp down parallel on the cross-slide start with the centre drill, then drill through with a 3/16 in drill. Before removing the block put a 1/4 in end mill in the 3-jaw chuck and mill out the first 5/32 in of the hole. Remove the block and holding it in a vice, ream out the two outer holes with a 12 mm reamer.

Mark out the top for the two 1/8 in pins and centre pop, drill the holes through with 1/8 in drill. Centre pop the top of the clamp for the clamping screw between the two back bores and drill through, No 11. Now carefully saw through the block, right across the three holes; the top half ends up thicker than the bottom half. File the sawn surfaces to a finish, then drill out the hole for the clamping screw in the top half with a 6 mm drill, then counterdrill the top for the head of the bolt with a 10 mm drill.

Locate the top half on the rear bar and check the fit on the front lathe bar, gradually file away any discrepancy of the front half-round



CROSS SECTION OF UNIMAT

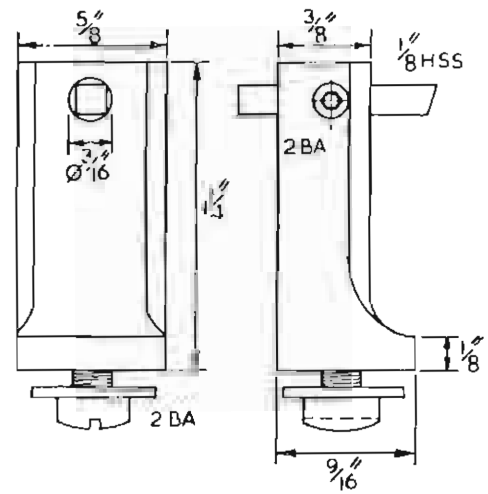


A TRAVELLING STEADY FOR THE UNIMAT

hole only with a round file. Repeat with the bottom half. Tap the lower screw hole 0 BA and lightly clamp the two halves around the bars, oil the bars and slide the clamp; there should be little play in other directions. Make the registration pins from ⅛ in dia silver steel a little over 1 in long, and push into the holes drilled for them. Always use silver steel for precision fits as b.m.s. rounds can vary by several thou even along a 12 in length. With the pins in place the clamp should slide as easily as before. Finish the top surface of the clamping block on emery cloth and a flat surface.

Cut the back upright slightly over-size, and after clamping up parallel on the cross-slide surface, flycut each end to a dead square, flat surface at the right length. Scribe a line ¼ in away from the best edge and scribe at ¼ in from each end of the line, centre pop. Drill ¾ in deep with No 25 drill and tap 2 BA. Mark the top of the clamp to correspond and drill through with No 13; countersink the under

The components of the steady.



FLY CUTTER

surface. Still inverted, scribe along the bottom of the front bore, mark the centre of the line then at 3/16 in either side of centre, centre pop these last two crosses and drill two holes through No 27, then countersink with 3/16 in drill.

Cut a piece of ⅝ in square dural for the front upright and fly-cut one end square. Hold the piece in a vice and position the two holes just drilled, inverted, on to it and with a long centre punch mark the upright for one hole only. Drill ⅜ in deep with No 34 drill and tap 4 BA, carefully remove any burrs and assemble with ¼ in 4 BA screw not completely tight. Put the upright back in the vice, line up the two parts and centre punch through the other hole. Drill and tap as before. At this stage saw off any corners you feel are unnecessary.

Main Assembly

Clean the uprights, the top of the clamp, and the register pins with a non-oily grease solvent; make sure the tapped holes are free from any tapping compound. Assemble using Loctite on threads, surfaces and pins (270 or 601 would be best); use the correct size screwdrivers to screw down really tight without tearing the heads, and hold in a vice whil§t tightening; leave aside to cure.

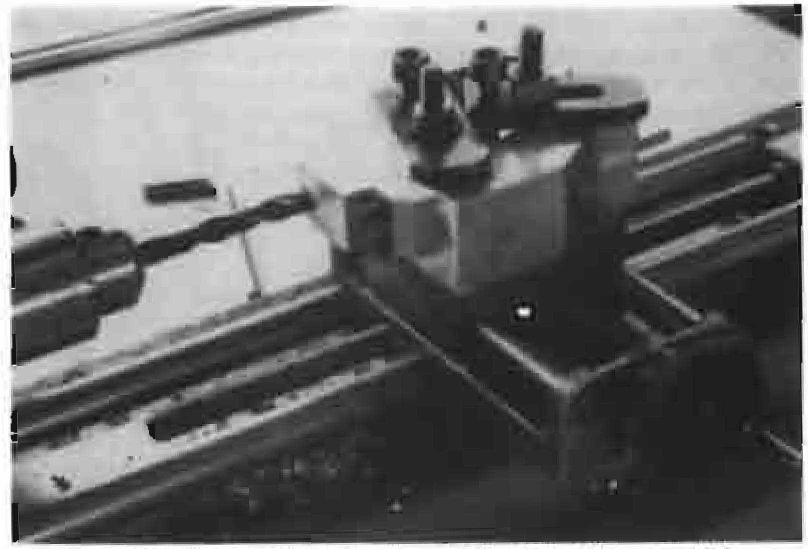
Meanwhile make the three steady pins. Cut these from ¼ in dia silver steel. Chuck each in turn in the 3-jaw and turn the ends square, put a No 3 centre drill in the tailstock chuck and drill with the pilot to just up to where the cone starts; this taps nicely 6 BA. File a ⅛ in flat on each side of the other end to take a 6 BA spanner. Cut off three lengths of ¼ in phosphor bronze and chuck each in turn in the 3-jaw.

Turn off the end square then use the No 3 centre drill as before, and tap 6 BA. Saw $\frac{3}{16}$ in off the ends of three long 6 BA screws, and with a fine file finish the cut ends. After cleaning, screw the bronze tips on to the silver steel using Loctite 221. Put the bronze tips in a vice and tighten up using a 6 BA spanner on the flats.

When cured, chuck each pin and turn the tips square, then turn the phosphor bronze down to .234 in up to the silver steel. Turn the headstock to 45 degrees and cone two of the tips to 3/32 in. Leave the third pin as it is.

Clamp the steady to the lathe bars to drill out the holes for the top block. Scribe a line $\frac{1}{4}$ in back on the top finished surface of the upright, scribe the centre and $\frac{3}{16}$ in either side, centre pop the crosses either side of centre. Using the vertical column, drill down with No 34 drill, tap 4 BA, $\frac{3}{8}$ in deep. Take a piece of $\frac{3}{8}$ in square dural for the top block and saw out a piece $\frac{1}{2}$ in x $\frac{3}{16}$ in from one end; file out to a finish. Scribe a line $\frac{1}{4}$ in in for the screw holes, mark the centre of the line and $\frac{3}{16}$ in either side, centre pop these two holes and drill through No 27. Screw on the top block with two $\frac{3}{8}$ in hex cap head screws, 4 BA. Mark the position of the back of the cap heads with a scribed line, remove the piece and saw off a diagonal at the line to accommodate the threading attachment, round off the diagonal with a file. Clean the screw holes and the screws with solvent and, using Loctite 270 or 601, screw on the top block tight with an Allen key.

The steady in use, turning down small diameter bright mild steel.



Drilling a hole in the steady for the top pin using the cross-slide as a reference.

Make a fly-cutter from $\frac{3}{8}$ in square alloy to fit on the faceplate and bore out the pass-through of the steady. Use a fast r.p.m. and a slow feed. There is no need to counterbalance this lightweight cutter, it only makes for much more vibration and tool chatter. Cut the gap to just over 2 in dia. Use the movement of the mandrel on the headstock for the feed of the cut.

Make a drawing to scale of a section through the lathe with the two bars and the centre line. Draw a 2 in circle around the centre and draw a line 90 degrees to the top of the bars, vertical through the centre. Using a protractor draw two lines from the centre 120 degrees each side of the vertical. Lay the drawing on a flat surface, place the steady correctly on the drawing and with an engineer's square, blade up, scribe the positions of the three lines at 120 degrees, front and back of each block. Then with a rule scribe the lines on the upper surface, across. These lines are used as a guide to drill holes for the three pins.

As a reference for drilling the holes use the right side of the steady down on the cross-slide surface. Line up the scribed line on the upper surface parallel with the centre line and bring the cross-slide across each time so that the drill centres on the side scribed line. Clamp down well with two claws. Drill each hole through with No 1 drill in the drill chuck; ream each hole out $\frac{1}{4}$ in. Oil the holes and push the pins through from the outside. Assemble the steady on the bars and check that the points meet at centre; it doesn't matter if they don't meet exactly. Chuck a piece of $\frac{1}{8}$ in dia rod, passing it through the

steady, and you will see what I mean. The untapered pin goes to the top, where, due to the other pins being tapered, it will still centre as well as the others but provide a larger bearing surface, preventing to better effect the lifting of the workpiece by the tool when turning.

Clamp the steady to the cross-slide to drill the holes for the grub screws which hold the pins. With the headstock on the vertical column drill the three holes, No 25, ¼ in in from the outside down through to the bore, then tap them 2 BA. Use flat ended grub screws if you can get them; if only the hollow cone ended screws are obtainable the cone must be ground off the end; hold the grub screw in a 2 BA nut for the grinding operation (the hollow cone burrs the pins which damages the bores). Use a 3/32 in Allen key for the 2 BA screws and do not overtighten; the pins are tight in their reamed bores anyway.

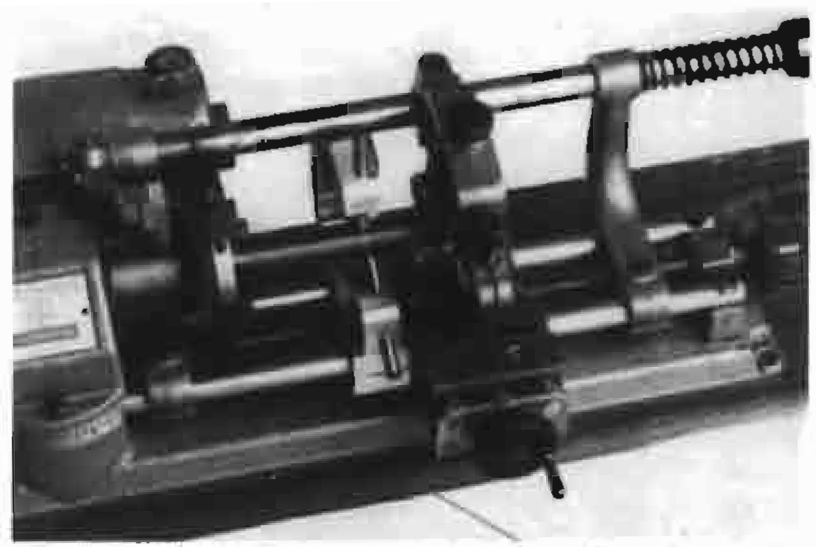
Making the Travel

To make the steady travel we have to use the existing threaded rod of the lathe for the steady has to travel with the cross-slide carriage.

The threaded rod has a left-hand metric thread, but we can use the 3/16 in left-hand thread we have used before. Working on the principle(?) that any nut of a diameter will fit any thread of a similar diameter if the nut is thin enough, we can make a nut to drive the steady. Take a 3/16 in slice of ½ in dia dural or brass and face the two ends down to 5/32 in, drill a ¼ in hole through with a No 3 centre drill in the drill chuck in the tailstock. Tap the annulus through with a 3/16 in left-hand tap in the 4-jaw chuck in the tailstock. Remove the ring and screw it on the threaded rod, tightly, as far as it will go. Then back it off counting the number of turns it takes to come off; it will be about three. Replace the nut in the 3-jaw and with a 3/16 in end mill static in the 4-jaw, mill away enough of the hole to leave half a turn more thread than you counted off when unscrewing from the threaded rod. Take out and try on the rod again. Repeat this procedure, taking off a whisker of thread each time until the ring screws right on to the threaded rod, tightly, and that is that.

Drill a 1/16 in hole into the side of the annular nut and secure into it a stub of 1/16 in steel using Loctite; fit the nut into the clamp making a file cut to take the pin. Take a 4 BA screw and epoxy a washer behind the head; when set file a flat on the washer. Drill a hole, No 32, ½ in deep above where the ring nut fits and tap 4 BA. Fit the washer and screw so that it will hold the nut in place except when the flat is turned to free it.

Assemble the steady on the bars and push it up close to the carriage, put a little grease on the nut and run it backwards up to the steady. Turn the locking screw to slip the nut into place and lock it. Tighten the clamping screw right down, then back it off by about a



Using the steady in conjunction with the threading attachment for threading copper pipe.

quarter of a turn. Oil the bars and the steady should travel happily along next to the carriage with the turn of the handwheel.

In use it is good practice to make the first adjustments to the steady pins close to the headstock to ensure the work will be held concentric when the steady is pushed out to do its job. If, after a lot of use, the bronze tips wear they can be resurfaced or replaced both very simply.

XIII. A UNIMAT WORKSHOP

My Unimat workshop is a converted porch about 7 ft by 8 ft, with a workbench, and a worktable for the lathe. The workbench carries the vice and handtools on top and the underneath holds all the materials. The tools for the lathework, plus the pliers, screwdrivers and spanners, are held in a cantilever tool box, the plastic type with two trays. Another cantilever box holds all the smaller accessories, and the lathe itself, complete with its bed, is put to rest after use in a velvet-lined box, which also houses the larger accessories. The box is an old cine camera box, built like a small cabin trunk.

Each time the lathe is finished with for the day the tools are replaced in their compartments and the cleaned-up Unimat is put away before the floor and table are cleared of swarf. The advantage of this system being that the next day is approached with a clean slate, with the knowledge that a hand reaching out for a tool will find it, and the lathe can be placed on the table ready for use, with perhaps work to be completed still in the chuck. But, with everything oiled and ready to go, enthusiasm need never wane for an early morning start.

Buying Tools

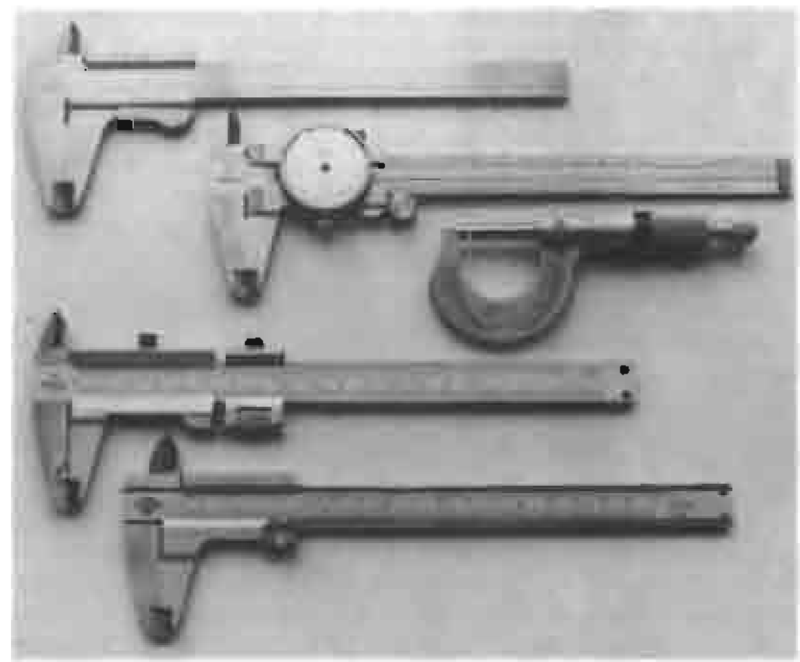
A sound principle, when buying for the workshop is to obtain materials whenever possible as a bargain, but to only buy tools when they are needed. This ensures a good supply of materials is always on hand and that the tool will be suitable for the job to be done.

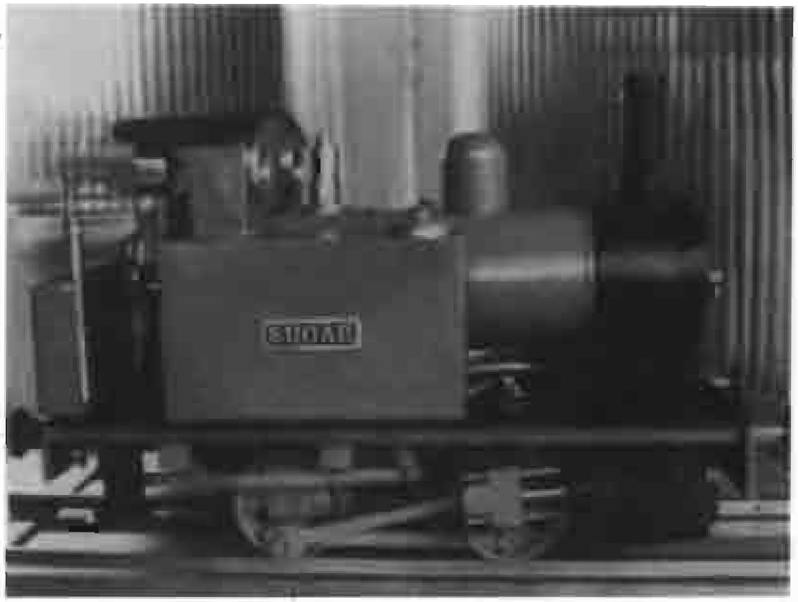
Tools are expensive, but do not be tempted into buying poor quality tools as it will prove false economy. Avoid buying sets of boxed taps and dies, each containing tap wrenches and diestocks, and some threading sizes which will never be required. On the other hand, sets of high speed drills are best bought in their steel boxed sets for a tidy workshop and working; taps and dies can be kept in a plastic sandwich box, with the taps retained in their own three-compartment boxes they are bought in, but labelled.

There are some reasonably priced Vernier calipers on the market

Right: A Boxed Unimat workshop

Below: Types of caliper and a 1st class micrometer.





for use on the workbench; there is little point in buying an expensive dial caliper type to be left on a swarf-ridden oily bench. But beware of the low-priced micrometer — a micrometer with backlash is not much more use than a clamp. When buying the micrometer it is worthwhle getting the type with the extra calibrated sleeve to tenths of a thou — it is only a little more expensive.

The vice for the Unimat workshop needs to be a small first-class engineers vice, to be fitted with home-made soft alloy clams for most jobs. Fasten the vice securely to the workbench, ensuring that the bench itself is immobilised. Fix the back of the bench to the wall in one or two places to stop the frustration of having all the effort of filing or sawing transformed into bench wobble.

Materials

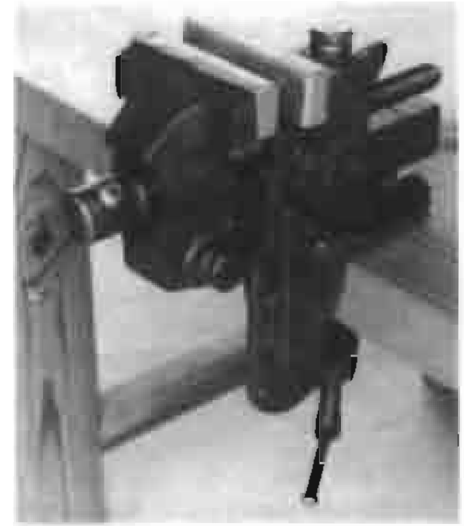
Materials are best kept in separate groups — brass from phosphor bronze, mild steel from silver steel, with stainless steel separate again. To minimize the grouping keep together:
(a) Phosphor bronze and stainless steel.
(b) Brass, duralumin and copper.
(c) Mild steel and light alloy.
(d) Silver steel in anti-rust paper.
with any bearing brass and odd bronzes in with the first group.

With the storage of mild steel, to keep it from rusting, it is usually sufficient to leave it as received in its greasy coat. Lanolin based sprays and other sorts can be bought to keep rust at bay from steel

Right: A small vice fitted with clams.

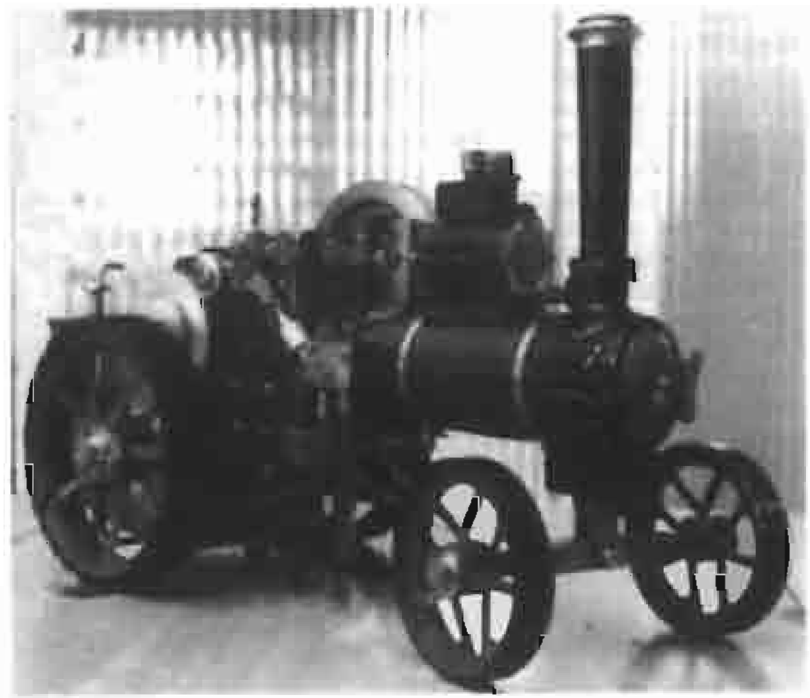
Below: "Sweet Sixteen" built on the Unimat SL.

Opposite page: "Sugar" built on the Unimat 3.



which has been cleaned-off for working.

When buying steels and other materials it is cheaper to buy in bulk, but with some materials, such as copper and silver alloys, the current prices may be based on a fluctuating world market and it should be



possible to avoid buying, even in small quantity, when expensive, and to buy in when the prices are down.

Clubs

The best way to buy materials more cheaply is to join a model engineer society, where the members can club together and buy in bulk, each, then, buying their smaller quantity at a lower price. The clubs also can offer machine shop facilities, with a range of equipment beyond the average model engineer's means. Then there is the expert advice which is always available from other members for most aspects of the work.

However, the beauty of the self-contained Unimat system is that it all fits into a small workshop, and most jobs can be carried out unaided.

Thinking it Out

In design and construction most engineering work methods can be deduced if a little thought is put into the job, beforehand, with perhaps recourse to a workshop practice textbook if necessary.

Capability of the Unimat

It took eighteen months to design and make *Sweet Sixteen*, a 16 millimetre to the foot scale, traction engine. It was built on the Unimat SL to just within its limits of working, and in fact the three inch diameter mild steel flywheel had to be made on the Unimat 3 due to chatter problems with the SL. The SL coped with the large four inch diameter rear wheels and all the gears were cut using the system described in this book.

The traction engine took a long time to make because of the problems which arose during the making, leading to the various accessories, and to writing about them. *Sweet Sixteen* is powered with a double-acting valveless steam engine unit, an original design.

Two engine units, to the same design, power *Sugar*, a 2½ in gauge 0-4-0T coal-fired live-steam locomotive, with outside cylinders. The locomotive was made on a Unimat 3 and by hand in about nine weeks. The largest turning job was the 1½ in diameter cast iron wheels. It is possible for *Sugar* to be scaled up to 3½ in gauge, with 2½ in diameter wheels, and still all be made on the Unimat.

INDEX

The Author was born in 1930 within the sound of Bow Bells and lived his formative years in Walthamstow, where he was half-educated during the uncertain years of the Second World War. Upon call-up for National Service in 1948 he joined the Royal Air Force, where he continued to serve for 22 years. His varied and interesting career with the RAF, as a photographer, included several stints of teaching at Wellesbourne and then Cosford Schools of Photography. He now works for the B.B.C. in Belfast in charge of the Colour Processing Laboratory.

Having continued many hobbies and interests, he decided, a few years ago, that in the radio-control field of flying and racing cars that the useful accessory range was rather limited, and so bought a Unimat lathe to make some parts. Finding that the available range of accessories for the Unimat was limiting he set about improving the lathe and making new accessories, since when he has become increasingly absorbed by this work and in using the lathe to its fullest extent.

He is a regular contributor to *Model Engineer* mainly of articles around the Unimat lathe.

ISBN 0 85242 676 3