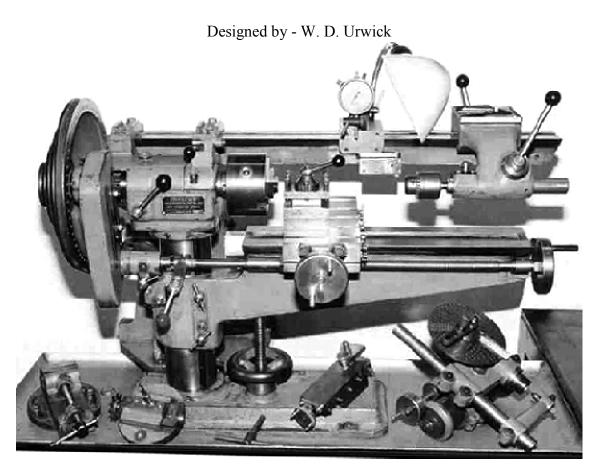
# The Metal Master Machine Tool



#### Introduction

Once in a while someone designs something really innovative which at first sight you would think it would take the world by storm. Sadly because of entrenched viewpoints, vested interest and maybe a lack of marketing skills such good ideas do not always achieve the recognition they deserve.

The Metal Master Machine tool by David Urwick is one such innovation. It is still not clear to us why this idea did not take off. The machine is ideal for the small home machinist workshop and would avoid the somewhat larger investment in cash and the space required for multiple machines to achieve the same manufacturing capability.

So in a tribute to the man who designed the machine we have produced a set of documentation to enable anyone to reproduce the machine. Some people who recognize the design for what it is have gone to the trouble to produce a set of castings for the major components and got part way through a build programme for their own version of the machine. Others have used the drawings to develop their own modern version of the machine (e.g. Alan Jackson's Stepperhead).

### History of the design, drawings and manufacturing notes.

The design was originally conceived in the early 1950s by David Urwick. The design was documented at the time and revisions made resulting in the hand drawn manufacturing set included with these notes was finalized in the 1980s.

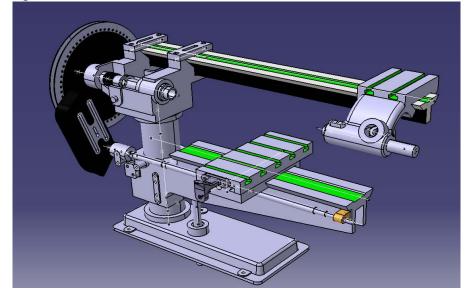
Unfortunately, information, materials and documentation related to sporadic documentation efforts have appeared and disappeared on a number of websites over the past dozen years or so. It is hoped that by pulling the various sources of information together and giving it some structure we may encourage more to have a go at making and building this truly unique machine.

The design was certainly revolutionary and it was used as a basis for the larger LabourMill machine. That machine was marketed for the small jobbing machine shop or as a millwright's machine tool.

On that basis the Urwick's Metalmaster should make an ideal machine for the model and experimental engineer. However, things mostly never turn into an ideal solution without luck, money and persistence. Remember how Dyson had to fight like crazy to ensure his designs weren't either rubbished or ripped off by someone else.

Urwick included in his machine many simple ideas that should have put it at the top of its chosen market. So remembering that not always do the fastest win the race nor the mightiest win the battle, we submit these manufacturing notes for the Urwick machine for anyone's scrutiny so they can utilise some of David's ideas or make a replica of the machine themselves.

Some have said the cost of the patterns for the castings might be prohibitive. Perhaps the use of expanded polystyrene as expendable patterns would make that easier. Production using hot knife or 3D CNC might be the way to go.



Our effort to understand the design of this machine has been the building of a 3D CAD model, some images of which appear in this collection of notes, drawings and images.

We acknowledge that work done by others is greater than ours and if we have reproduced information without proper acknowledgement please let us know and we will correct the errors and omissions.

Other descriptions of the Metal Master and some of its machine elements appeared in the following editions of the Model Engineer.

A Free-Lance Lathe by W. D. Urwick Model Engineer - 1<sup>st</sup> March 1951

A REVOLUTIONARY LATHE by W.D. Urwick Model Engineer 4<sup>th</sup> January 1974

A KEYWAY BREAKTHROUGH by David Urwick Model Engineer - 15<sup>th</sup> August 1980

**METALMASTER - A Zero Taper Machine Tool -** by David Urwick Model Engineer 2<sup>nd</sup> July 1982

Mick Colins, who bought David's own original machine, agreed with David Urwick's widow that the drawings should be made public and that each user of the drawings would make a small donation to her for doing so. It is not clear how the donation was to be made for this "shareware."

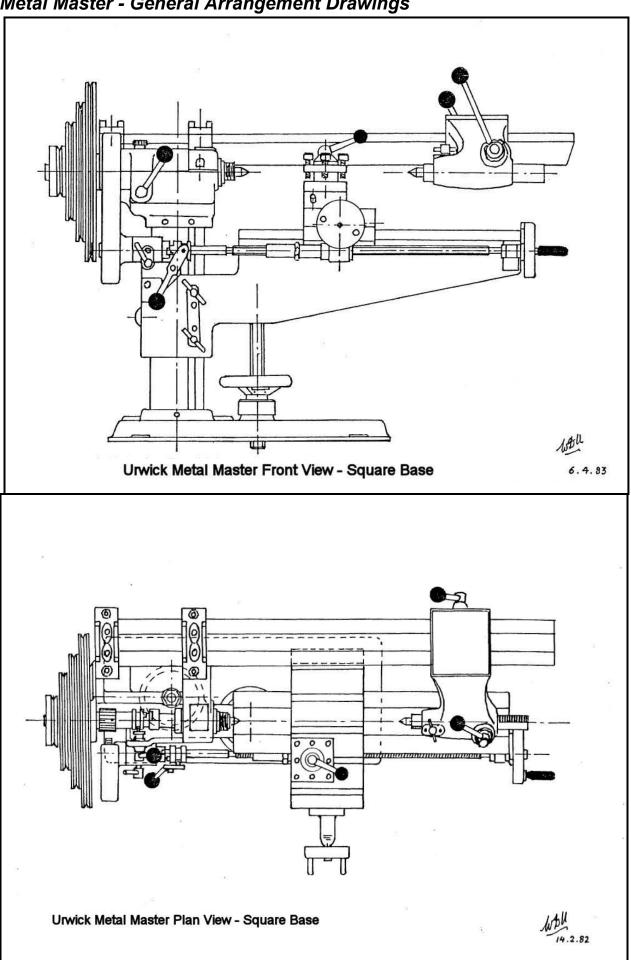
Later a member of the yahoo group re-created the core set of drawings as 2D dxf files and posted them for the group. Another member of the group made expanded polystyrene patterns to enable a set of castings to be made by the lost foam process. Some of those images have been included to assist with visualization. Another member of the group created the text files of David Urwick's notes and they are included also.

### Metal Master unique features

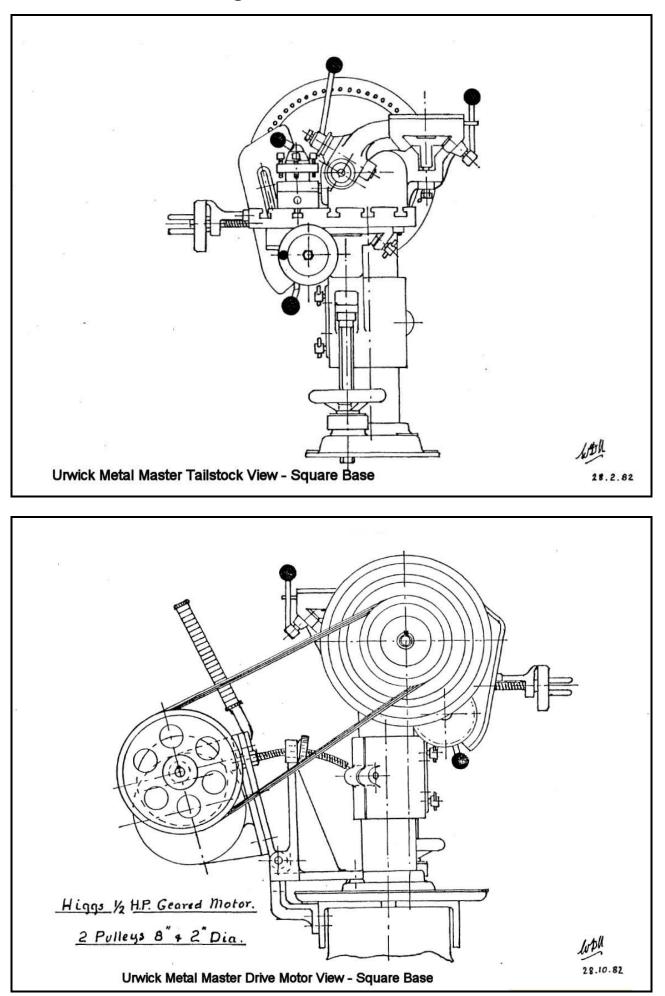
# The unique features of the Metal Master Machine Tool identified by W. D. Urwick are listed below.

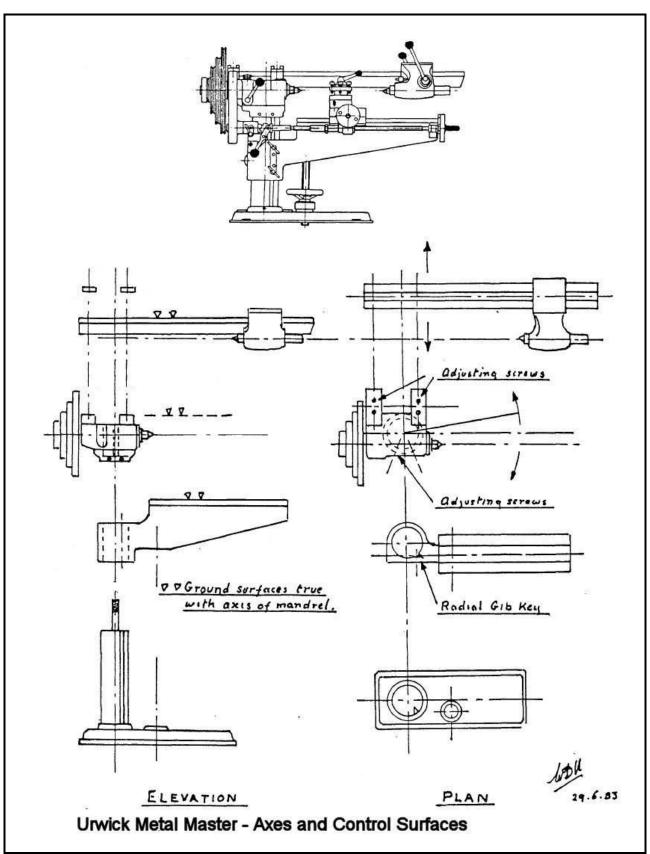
- 1. Vertical movement of the bed benefits all operations
- 2. Machine will swing 8.00" between centres or 14.00" over bed with tailstock and auxiliary bed removed
- 3. Back feed tailstock will pass right over saddle no overhang.
- 4. Tailstock fitted with zero setting depth gauge
- 5. Pulley / Flywheel / Hand wheel 11.00" diameter serves as a 60 hole dividing head with subdivisions to 360 degrees.
- 6. Large slotted work table 10" x 4.5" x 7.5" cross travel
- 7. Large indexing dials (3" & 3.5" diameter) to cross slide and leadscrew
- 8. In normal use a 4x4 tool post is used without top slide. No packing of tools is necessary.
- 9. Top slide for short tapers only
- 10. Taper turning between centres for full travel of the saddle.
- 11. Hollow mandrel passes  $\frac{3}{4}$ " stock bar
- 12. No 3 morse taper nose accepts large collets
- 13. A boring and facing head with auto feed can be used as in full scale horizontal boring practice.
- 14. An extra deep jawed machine vice can be used in view of the freedom of vertical movement and end mills, flycutters and slitting saws used as with a horizontal milling machine.
- 15. The machine can be used as a hand shaper for cutting keyways etc.
- 16. A special simple screwcutting system is used, providing a range of threads with elementary trains and a selection of metric thread to reasonable tolerance accuracy, also 19TPI.
- 17. The use of a single dog clutch on the mandrel makes it impossible to pick up the wrong thread.
- 18. The accuracy of parallel turning is under control of the operator the bed is adjusted to "zero taper" condition.
- 19. A dial test indicator (DTI) mounted on the auxiliary bed is, at all times, available to check and align work in the machine.
- 20. The entire machine can be readily dismantled into manageable pieces, put in the back of an estate car, and reassembled elsewhere ready for work, very quickly.

General Arrangement Drawings



Metal Master - General Arrangement Drawings



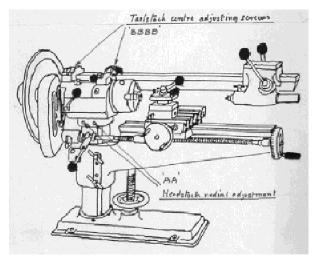


Metal Master – Design & Construction Notes (W. D. Urwick - 1983)

**General Description** 

### **General Description**

This machine should not be regarded as a special form of lathe. It represents a new conception of a general purpose machine tool made possible by a simple patented invention. This invention consists of a triangular gib key (British Patent No. 696773) which enables any member enclosing and sliding upon a column to be maintained in strict radial relationship to the axis of the column.



Within its capacity this machine will perform the duties of a milling machine, a horizontal borer, and a lathe with no special adaptation. The attachment of a hand lever also enables light shaping work, such as keyway or spline cutting, to be carried out without the usual tedious handwheel operation.

The backbone of the machine is a massive column on which the main bed, complete with cross-slide, leadscrew, and changewheel arm, can slide under the control of a vertical feedscrew. This main bed is keyed to the column by means of the gib key already mentioned and its radial relationship to the column is thereby maintained. It may be clamped by means of the key at any desired height with complete confidence in the accuracy of its alignment.

The headstock is seated on the head of the column and means are provided for rotating it within fine limits so that the mandrel may be lined up accurately with the main bed and locked in this position.

At the back of the headstock two brackets carry an auxiliary Tee section bed on which is mounted the tailstock. Again, fine adjustment is provided for setting the centres in accurate alignment.

It will be appreciated that the parallel alignment of the mandrel, main bed and auxiliary bed in the vertical plane is taken care of in the design of the machine, but that in the horizontal plane there is a radial adjustment under the control of the operator. With the aid of a test bar, adjustment is not difficult and once set, the accuracy of the machine should be retained over long periods. The ability to check over the alignment in a few moments gives added confidence where particular accuracy is required.

The drive from the motor is transmitted to the mandrel by means of a single belt driving a large four-step pulley weighing approximately 12 lbs. This pulley serves a number of purposes:

- a) it serves as a dividing head
- b) it takes the place of a back gear
- c) the momentum stored in it greatly helps to eliminate chatter, particularly in parting off operations
- d) it is very convenient as a handwheel when using taps and dies in the tailstock, the weight giving good control as the threads are cut
- e) it can be used freely as a break to stop rotation after switching off the motor, and generally for turning chucks, etc., mounted on the mandrel.

The headstock mandrel is bored to take 3/4" diameter stock and the nose is bored No. 3 Morse taper for suitable collets.

For crating and transport, the entire machine can be rapidly dismantled into a number of pieces, each of which is readily handled and packed. Re-assembly is an equally straightforward procedure.

# 2. CROSSFEED AND LEADSCREW ARRANGEMENT

Both longitudinal traverse (approx 12") and cross traverse (7") of the boring table are accomplished by solid turned hand wheels attached to the ends of the operating screws, the rims of these wheels form index dials 3 1/2" and 3" diameter respectively.

The lead screw nut is not split, nor is a rack and pinion traverse provided. For normal operation the four way tool post is mounted direct on the boring table and the feed applied by means of the leadscrew and cross feed screws. The absence of a top slide is no inconvenience on a small machine such as this and there is greater rigidity without it. A small topslide forms part of the equipment but its use should be confined to short tapers and for screwcutting.

The leadscrew nut consists of a shouldered bush which is an easy fit in a suitable hole bored through a lug on the underside of the saddle. The end of this nut protruding from the casting is threaded and a steel tube, enclosing the leadscrew, screws on to this threaded portion and locks the nut in position. When it is desired to rack the saddle with a hand lever, the leadscrew nut can be released and spun down to the remote end of the leadscrew. The steel tube referred to above also provides some protection to the leadscrew where it emerges from the saddle.

Automatic feed is applied to the leadscrew through a dog clutch keyed to the headstock end of the screw. A second dog clutch is also provided in the mandrel and its use is described in the section on screwcutting.

The use of solid nuts for both feedscrew and leadscrew means that they are floating in so far as they are supported only by their respective nuts and the thrust bearing. This arrangement gives a very smooth action and tends towards greater accuracy.

# 3. SCREWCUTTING

Though not original, the method of screwcutting on this machine is unorthodox, but very convenient. It may not be familiar.

A sleeve, permanently fitted on the mandrel, carries a 24-tooth wheel, which drives the change wheel train and also incorporates a single dog clutch by which it takes its drive from the mandrel. In screwcutting, this clutch is used to engage the change wheel train, with the result that it is impossible to pick up the wrong thread. It will be found that the changewheels spin quite easily as the saddle is traversed back to the start of the thread when this clutch is disengaged.

With one exception, the number of teeth on the changewheels are all multiples of three. The calculation necessary to determine suitable changewheels for any particular number of TPI is extremely simple, since

 $\frac{\text{No. of Driven Teeth}}{\text{No. of Driving Teeth}} = \text{TPI x 3}$ 

For example, to cut 6 TPI:

 $\frac{\text{No. of Driven Teeth}}{\text{No. of Driving Teeth}} = 18$ 

i.e. one 18 tooth wheel on leadscrew together with suitable idlers to give desired rotation.

To cut 52 teeth:

TPI x 3 = 156 = 39 x 4 = 39 x 72/18

To cut 56 teeth:

TPI x 3 = 168 = 21 x 4 x 2 = 21 x 72/18 x 18/27

Numerous metric threads can be cut by the introduction of the 38 tooth wheel included in the set. It will be appreciated that the 38 tooth wheel fitted to the leadscrew with two suitable idlers provides a 2 mm pitch and that other metric threads can readily be calculated as multiples up and down from this basis. The 38 tooth wheel also enables 19 TPI (i.e. 1/4" and 3/8" gas thread) to be cut, with a simple train.

# 4. MILLING

Apart from the removal of the toolpost or topslide, the machine requires no modification whatever to become a small milling machine.

A cross-feed of 7" and the large slotted table 10" x 4 1/2" enable quite large workpieces to be machined, but it must be borne in mind that this is a light machine and excessive cuts should be avoided.

A machine vice can conveniently be mounted on the slotted table and end mills, slitting saws and fly cutters can be used for a variety of work.

If the gib key screws are correctly adjusted, it will sometimes be found that the vertical feed can be used with advantage in certain milling operations.

A dividing head or rotary table, of course, greatly extends the range of work which can be accomplished.

# 5. TAPER TURNING

When turning up a mandrel for holding work to which it is desired to give a very slight taper, it will be found sufficient to slacken the adjusting screws of the main bed gib key. The bed than can be slewed to a small angle of taper (which can be accurately clocked) and then locked in position by means of the clamping bolt.

For such things as Morse tapers it is necessary to remove the gib key altogether. Raise the bed to full height, lock in position and lower feedscrew until the upper end emerges. Insert a piece of wood between the end of the feedscrew and the underside of the bed. Slacken off the adjusting screws until the gib key falls down the keyway in the column, when it can be removed. The bed can no be lowered and rotated to any desired degree of taper. If the taper is not too great, the automatic feed can be used an tapers turned for the full travel of the saddle. This procedure will be found to be simple and extremely accurate.

# 6. DIVIDING

The main driving pulley is provided with 60 equally spaced and numbered holes in the rim. Any of these holes can be picked up and the mandrel locked by means of a link rod, one end of which is attached to one of the slots in the changewheel carrier arm. Movement of the carrier arm allows fine adjustment of work held in the chuck before locking the mandrel in any fixed position. The link rod itself has a subdividing arrangement enabling the 60 divisions each to be divided into 6, thus giving total divisions of 360 degrees.

# 7. KEYWAY CUTTING

The machine is well adapted for small shaping operations such as keyway and spline cutting. For this purpose a hand lever can quickly be attached for racking the saddle along the bed and making the operation less tedious than is usually the case when lathes are used for this purpose. The leadscrew nut can be released from the saddle (as described in section 3) so that the latter is free to slide and a fulcrum plate can be attached at any convenient position along the bed to give the desired movement by means of a hand lever and link.

# 8. BORING HEAD

A small boring head with radial feed, operated by star wheel and trip pin, at once converts the machine into a miniature horizontal borer. This addition greatly extends the scope of the machine and makes it particularly useful for facing and boring linker ends and other awkwardly placed bosses.

The slide of the boring head is provided with five positions for the boring tool. This is to enable both internal and external work to be done with the same direction of rotation of the feedscrew and also so that the most appropriate position can be used to avoid excessive out of balance of the slide.

# 9. LARGE WORK

With the Tee bed in position work up to 8" diameter can be accepted between centres and, with care, it is possible to machine work of this size, particularly in lighter materials such as wood or aluminium.

The Tee bed can, if necessary, be removed when work 14" diameter can be swung over the bed. A suitable block or machine vice can be used to raise the tool post to centre height and pulleys or other awkward jobs can be successfully drilled and bored in an emergency. Alternatively large pieces of material or castings can be mounted on the boring table for drilling and facing operations.

# 10. VERTICAL MILLING

A vertical drill mounted on the Tee bed makes the machine into a small radial drill. The drill head may be lowered on its column until the work can e drilled on the cross-slide table and traversed under the drill as desired. If the drill is taken well out to the end of the Tee bed, quite large sheets or other work can be passed beneath this bed for drilling. Alternatively, when positioned at the inner end of the Tee bed, the radial drilling of work held in the chuck may be carried out, in conjunction with the indexing arrangements on the driving pulley. A small milling head could easily be fitted and would be a useful adjunct.

# 11. GEARCUTTING

With the dividing head fitted, gears up to 18 or 20 D.P. can be cut with blanks up to 5" diameter. The cutter may be mounted on an arbor between centres and the blank traversed beneath it and indexed as necessary. Small wormwheels may be hobbed in a similar manner.

### 12. TOPSLIDE

For normal lathe work it will be found most convenient to use the 4-way toolpost attached direct to the cross-slide. A small topslide is, however, supplied and is intended mainly for turning short tapers and for screwcutting, if it is desired to feed the tool in at the thread angle. The topslide is rectangular in form, which will be found convenient when setting with a protractor.

# 13. THE TAILSTOCK

The tailstock designed for the machine is fitted with a rack feed to the barrel. A graduated dial, with zero setting arrangement, is fitted, and this will be found useful for depthing accurately when drilling. It may also be used when boring blind holes, as a depth gauge, if it is made to follow the saddle as the tool progresses.

The barrel is locked by means of a gib key similar to that used on the column. This key can be adjusted so that there is no rotary shake in the barrel and therefore less chance of drill snatching. Only finger tight screwing down of the locking screw is necessary to hold the barrel, owning to the wedge action of the key. It is also instantly released.

Being independent of the main bed, it is seldom necessary to hold work with the barrel fully extended, since the tailstock may be passed right over the saddle and brought up close to the work.

### 14. SETTING UP

A ground test bar is required with the machine and one end of this bar should be reduced to No. 3 Morse taper to fit the mandrel nose.

Insert the test bar in the mandrel nose. Ease off the nut on the central stud passing through the headstock casting. By means of the adjusting screws, rotated the head on the column in the appropriate direction until no movement is recorded on a clock fitted in the toolpost as the saddle is traversed up and down the bed. Tighten down the nut on the central stud when this is so.

Insert centres in headstock and tailstock, bring up the latter until the two centres are touching. By means of the adjusting screws BBBB bring the centres into true alignment, at the same time keeping the Tee bed parallel with the main bed, sighting by eye.

Slide back the tailstock and introduce the test bar between centres, test with the clock in the toolpost, and correct by means of the screws BB in the outer bracket only. Tighten up the locking screws underneath each bracket.

Once set, the accuracy of the machine will be retained for long periods, but the above procedure should be used for resetting after dismantling or for checking if particularly accurate long turning work is to be done.

In any case, only a few minutes are required to check the adjustment and the operator can feel that at all times he has the accuracy of the machine under his control.

Vertical Feed Adjustment: Slacken all gib key adjusting and locking screws.

Tighten clamp bolt at rear of main bed casting until lifting screw can be lowered and bet held suspended. Slacken clamp bolt until bed just falls under its own weight.

Tighten gib key adjusting screws individually, again adjusting until the bed can just fall under its own weight.

# 15. MOTOR DRIVE

The most convenient drive for this machine is a 1/2 hp geared motor, having a final shaft speed of about 300 rpm. If this shaft is provided with two pulley 1 3/4" and 8" diameter, a satisfactory range of eight speeds can be made available with suitable belts. The motor should be mounted on a hinged plate with take up adjustments.

Detail Drawing	Part Description	<b>CL</b> 4 .	Part			
		Sheets	Qty	Material	Mass	Page
1	Column	1	1	MS		16
2	Base	1	1	CI		17
3	Headstock	4	1	CI		18
3a	Adjusting Screws (arrangement)	1				
4	Main Machine Bed	1	1	CI		21
5	Keyway Detail	1		CI		22
6	Saddle	1	1	CI		22
	Gib Key - Saddle	1	1	MS		22
7	Cross Slide	1	1	CI		24
	Gib Strip; Crosslide		1	MS		24
8	Secondary Tee Bed	1	1	CI		24
9	Brackets (Arrangement)	1	-			25
9a	Straps	2		CI		25
10	Spindle	1	1	EN24		26
10	Carrier Arm - Change wheel	1	1	CI		26
12	Leadscrew	1	1	MS		20
12	Cross Feed Screw	1	1	MS		27
	Cross Feed Screw Nut	1	1	Bronze		27
14	Headstock Driving Pulley	1	1	CI		29
14	Headstock Cover	1	1	CI		29
15	Leadscrew Cover Tube and Locknut	1	1	MS		29
10	Leadscrew Nut	1	1			29
17		1	1	Bronze CI		30
	Carrier Arm Bearing Bracket					
19	Leadscrew Driving Spindle	1	1	MS		30
20	Leadscrew Driving Spindle Collar	1	1	MS		30
21	Mandrel Sleeve and Collar	1		MS		30
22	Change Wheels	1	1	MS		31
23	Cross Slide Hand Wheel (Graduated)	1	1	MS		31
24	Leadscrew Dog Clutch details	1		MS		31
25	Cross Slide Free Screw Bracket	1	1	CI		32
26	Change Wheel Studs	1	4	MS		32
27	Leadscrew Handwheel (Graduated)	1	1	MS		32
28	Vertical Feedscrew	1		MS		32
29	Leadscrew Clutch Lever	1	1	MS		33
	Tailstock Spindle Collar		1	MS		33
	Headstock Clutch Lever		1	MS		33
30	Vertical Feed Handwheel		1	CI		34
31	Gibkey Locking Screw	1	2	MS		34
	Tailstock Barrel Locking Screw		1	MS		34
	Headstock Cover Locking Screw		1	MS		34
	Change Wheel Carrier Locking Screw		2	MS		34
32	Headstock Holding Nut	1	1	MS		35
	Tailstock Index Dial		1	MS		35
	Tailstock Operating Spindle		1	MS		35
33	Faceplate	1	1	CI or MS		35
34	Tailstock	1	1	CI		36
35	4-way Toolpost details	1	1	CI		37

# Drawings and Parts List

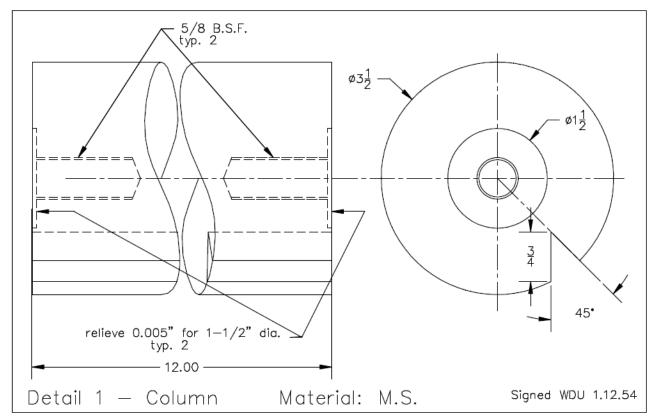
36	4-way Toolpost details	1	1	CI	37
37	Link Rod for division plate	1	1	MS	37
38	Leadscrew thrust Collar	1	1	MS	38
	Leadscrew Bearing		1	Bronze	38
	Leadscrew Hand wheel Nut		1	MS	38
	Tailstock Locking Screw		1	MS	38
39	Top Slide Base	1	1	CI	38
	Top Slide Nut		1	MS	38
40	Top Slide and gib key	1	1	CI	39
41	Top Slide Bracket	1	1	MS	40
	Top Slide Feedscrew Hand Wheel		1	MS	40
	Top slide Feedscrew		1	MS	40
42	Tool Tray	1	1	Sheet	40
43	Suds Tray	1	1	Sheet	40
44	Test Bar	1	1	Stainless?	41
	Reducing Sleeve (MT3-MT1)		1	MS	41
45	Tailstock Barrel	1	1	MS	41
	Tailstock Pinion		1	MS	41
46	Dial Test Indicator Attachment - Arrangement	1			41
47	Dial Test Indicator Attachment - Details				41
48	Machine Vice				41
The follo	owing drawings exist without notes and are also	not inclu	ded her	e.	
49	Vernier Index for Leadscrew Handwheel	1	1	MS	44
50	Racking Lever Attachment	1			44
51	Ball Turning Tool	1			45
52	Stand	1	2	CI	45
53	Clamping Jig for Small parts	1			46
54	Tail Stock Die Holder	1		MS	46
55	Motor Drive Bracket	1		CI	47
56	Collet Set	1			47
	Change Wheel Chart				50

The following notes should be read in conjunction with the detail drawings (above) to which they refer.

The Drawings and Notes

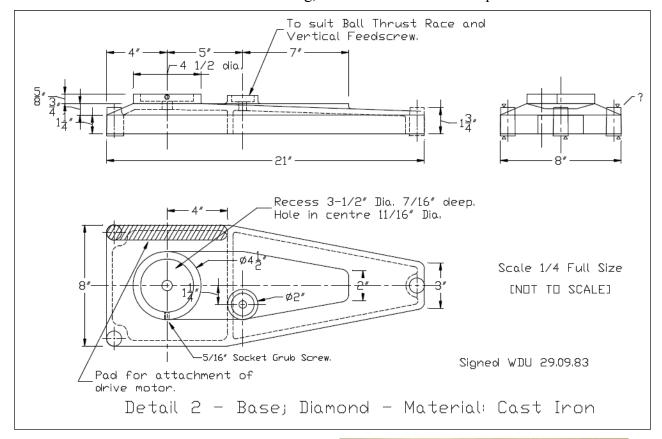
### 1. Column.

This consists of a length of 3-1/2" diameter mild steel bar, preferably ground. The keyway for the triangular key is best machined with a 45 deg. side and face milling cutter, making sure that the radial face of the keyway is truly on the diameter of the bar. Both ends of the bar are drilled and tapped 5/8" BSF for a depth of 1-1/2". The lower end is fastened to the base casting with a 5/8" BSF Hex headed setscrew and a 5/16" socket grub screw locates it in position, when the main bed has been finally lined up with the base casting. A 5/8" BSF stud of suitable length at the top end passes right through the headstock casting and is provided with a special holding down nut - detail 32.



#### 2. Base.

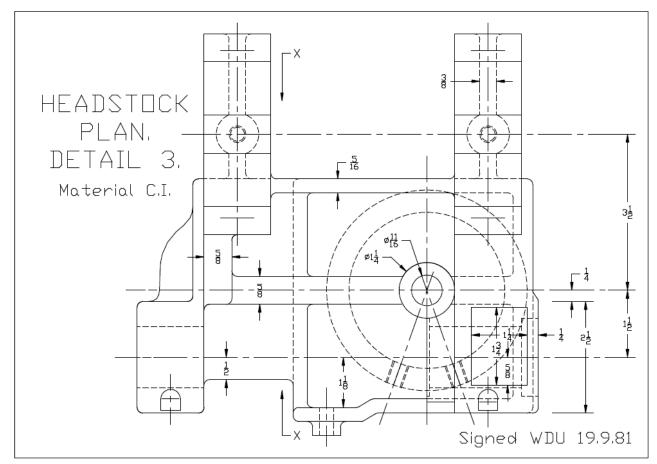
The recess for the foot of the column in this base casting should be machined an easy fit, so that the column can be rotated or extracted without difficulty and can bed down squarely on the bottom of the recess. For this purpose too, it is advisable to relieve the ends of the column for a few thou in the center as indicated. The smaller boss should be recessed to accept a suitable ball thrust race for the handwheel. A race, say 1-1/2" OD x 7/8" bore should be suitable and a 3/4" x 5 TPI Acme screw has proved satisfactory as a jack, so that a hole should be drilled in the center of the recess to clear this size. The main thing is that this screw jack shall not be stiff but easy in operation as the bed casting is raised and lowered. The two pads at the back of the casting can be used for the attachment of brackets for the motor mounting, if this kind of drive is adopted.



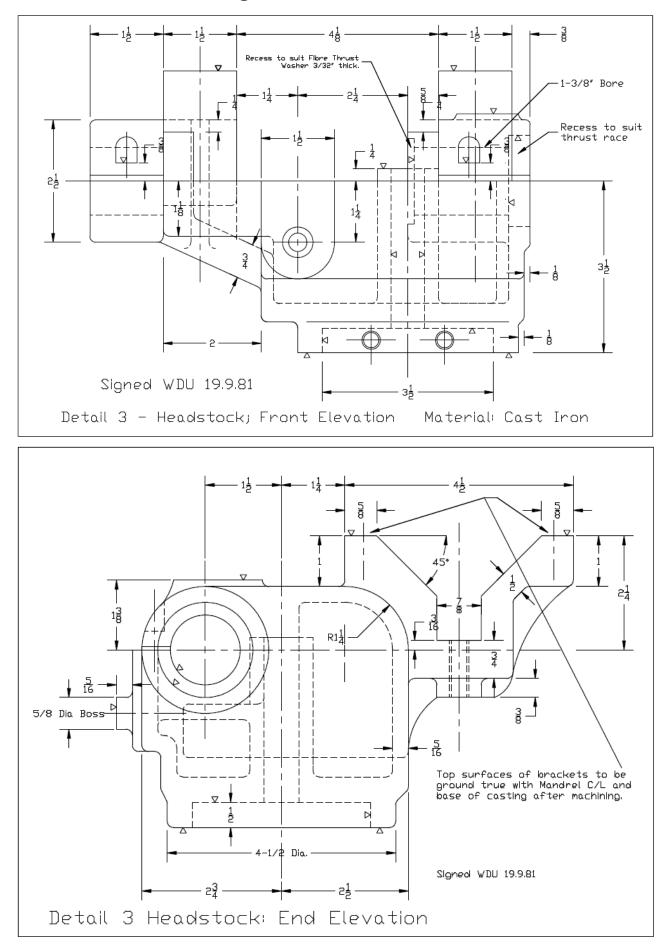


#### 3. Headstock.

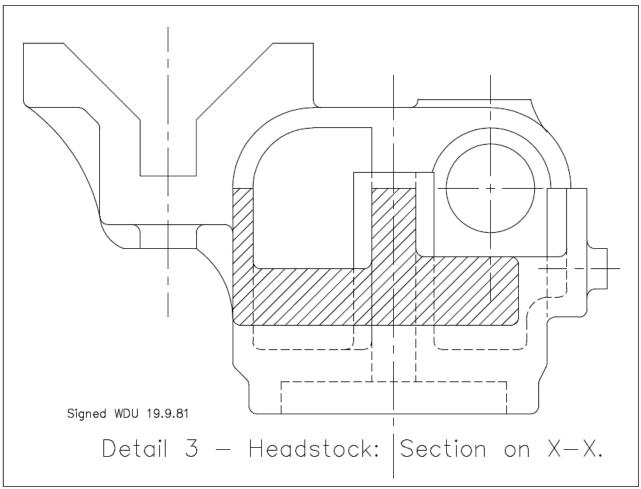
This casting is, of course, the heart of the machine. It is essential that the face of the recess, which rests on the top of the column, the bore of the mandrel and the four top faces of the brackets shall all be true with one another in the vertical plane. The top faces of the brackets should be ground true to close limits +/- .0001", 2.25" above the mandrel axis. The recess for the column head should be an easy fit to allow the head to be rotated for alignment with the main bed. The dimension of 3" from the face of the recess to the mandrel axis is not critical. The casting should be spotfaced where the 5/8" stud emerges from the top of the column, to give a true face for the holding down nut. The front bearing housing should be recessed to accept a thrust race 1-7/8" OD x 1-3/16" clear ID x 7/16" thick. Both casting and bearing shells should be split 3/32" for fibre packing strips and drilled for 5/16" setscrews.





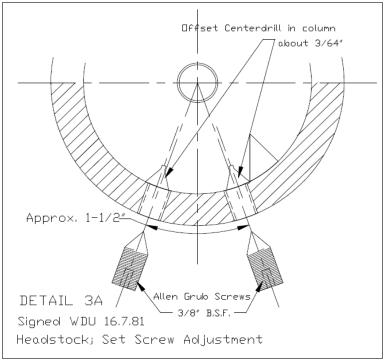


Metal Master – Design & Construction Notes (W. D. Urwick - 1983)



### 3a. Adjusting Screws.

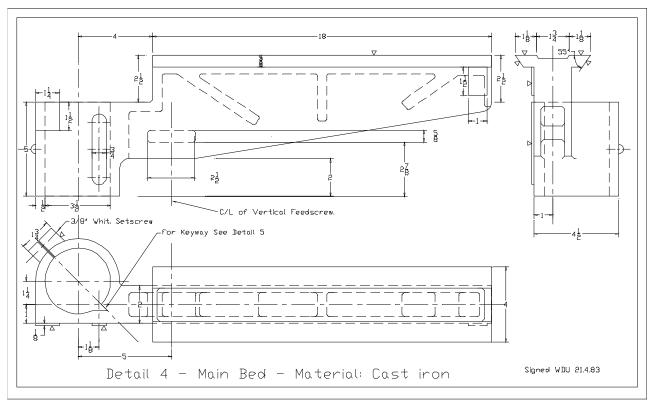
Two radial holes into the recess at the base of the headstock casting should be drilled and tapped 3/8" BSF as indicated. Before tapping, however, the headstock should be set up on the column and brought into reasonably accurate alignment with the main bed, correctly keyed to the column. The column may then be spotted with a tapping size drill through the holes. Subsequently, two centre-drill holes should be made approximately 3/64" outwards from the spotted marks. Socket grub screws pointed 60 deg. will then provide a very fine rotary adjustment of the head as either one or the other is turned. The holding down nut must be just a trifle slack whilst the adjustment is



being made and then be pulled down hard when the head is in true alignment, checked with the ground test bar in the mandrel nose and a DTI in the toolpost.

#### 4. Main Bed.

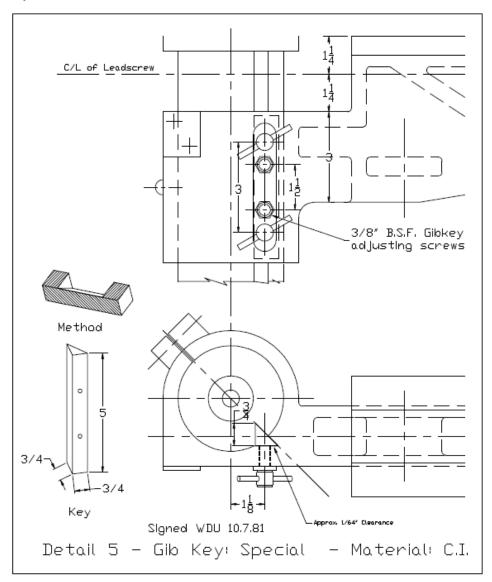
The 3-1/2" bore through the body of the casting should be a sliding fit on the column, so that it may be clamped by means of a 3/8" setscrew through the lug where it is split and adjusted for minimum sliding clearance so that it can just fall under its own weight. The Vee slide ways should be ground and true with the bore and the column. The radial face of the triangular keyway must be truly on the diameter of the bore but the other face can have about 1/32" clearance and is not a bearing face. Strengthening webs may be provided in the cored out part of the casting and a horizontal web as shown to take the head of the vertical feedscrew is necessary.





### 5. Arrangement of Key.

The key is best made from an iron casting as shown in the sketch. It can be mounted in Vee blocks for machining the central portion and the square ends later removed. The two adjusting screws may be 3/8" BSF socket screws pointed 60 deg. and fitted with lock nuts, the centre-drill dimples being spotted through with the key clamped tight. The two locking screws, also 3/8" BSF, should be finished flat. The sharp edge of the key may need rounding off to ensure that it beds down fully into the keyway on the column.



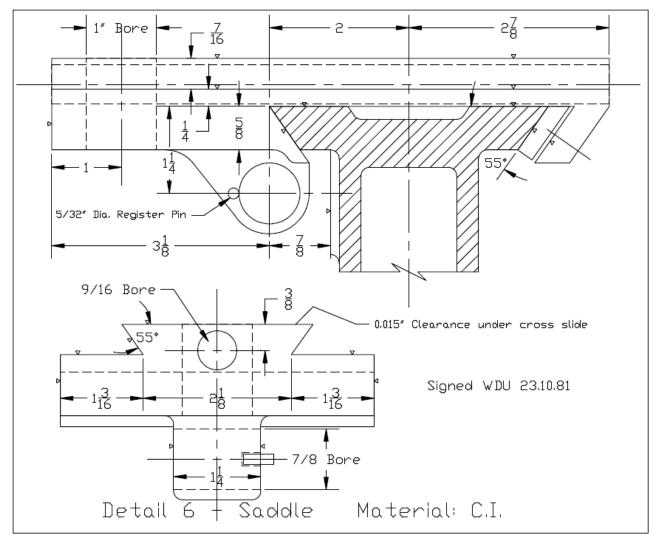
#### 6. Saddle.

The lug on the underside of the casting is bored to take the leadscrew nut (Detail 17) and both sides spotfaced. The C/L of this bore is immediately below the leading edge of the main Vee ways. The nut for the cross feed is made from a length of Phos.B. or G.M. bar and cross-drilled and tapped 10 TPI for the feed-screw. It is thus floating and can adjust itself freely to the screw, making for smooth and accurate motion.

A rack traverse and split nut is not fitted to this machine. Because the tailstock is carried on a separate bed, the main bed is much shorter than on a conventional machine and the leadscrew hand wheel is so much handier that it was felt that the complication of the rack feed could be omitted as an unnecessary expense. In fact, the practice with this machine is to use a 4 way toolpost direct on the cross slide and the lead screw and cross feeds only, without a top slide for all ordinary work. This tends to greater accuracy and the indexed hand wheels are so large that readings of 0.001" can

be read easily from a standing position in front of the machine.

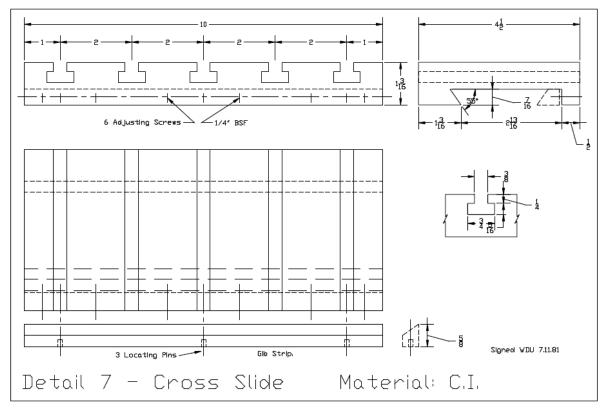
A substantial gib strip 3/16" thick holds the saddle to the main bed and is located and adjusted by means of two pointed grub screws and lock nuts, with a third flat ended screw for locking the saddle to the bed ways, when required.





#### 7. Cross-slide.

In view of the milling capabilities of this machine, a large boring table or cross-slide was desirable and this is  $10" \times 4-1/2"$  with a travel of about 7-1/2". The five Tee slots allow the machine vice to be placed in any position on the table and for other substantial pieces of equipment such as a dividing head to be mounted. Since the tailstock can be passed right over the boring table, there is no problem of overhang of the barrel and the width of the table could be increased to 5" or more with occasional advantage.

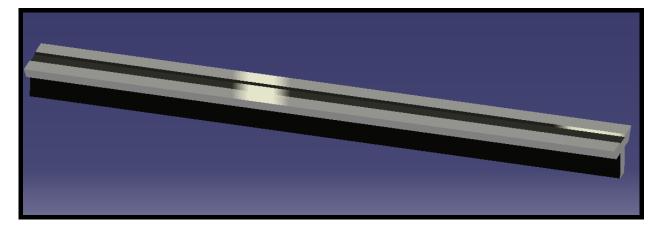


### 8. Auxiliary Tee Bed.

Since the accuracy of the machine is dependent on the truth of this bed it should be ground on the machined surfaces of the Vee slides, which are angled at 45 deg.

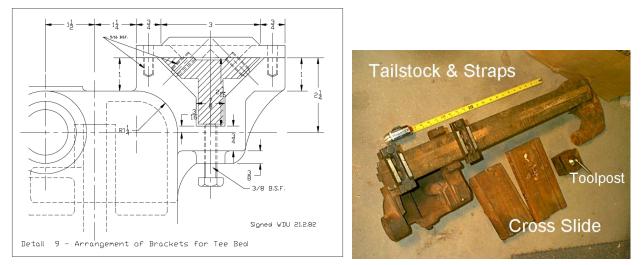
When long slender work is turned between centres there will be a tendency towards chatter from the elasticity of the cast iron. This can be considerably lessened by means of a tie rod about 3/8" dia. fitted so as to link the ends of the two beds. An even more rigid clamp can easily be made up to tie the tailstock barrel direct to a plate across the surface of the main bed. If the two are connected by means of a dog-leg link, the vertical feed can still be available, before final tightening of the bolts, for setting either work or tool centre height.





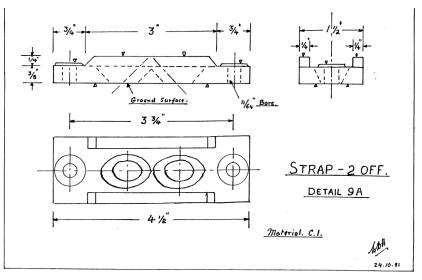
### 9. Arrangement of Brackets for Tee Bed.

As will be seen, the auxiliary Tee bed is held up against the ground surfaces of the two straps by 3/8" BSF Hex headed setscrews pressing upwards through the centre of each bracket. This takes care of the alignment of the Tee bed automatically in the vertical plane. Four socket grub screws 5/16" BSF project through the Tee bed at 45 deg. to seat on the sides of the Vee brackets. A clearance gap of about 1/8" allows the bed to be positioned in the horizontal plane for accurate alignment of the tailstock centre, in accordance with setting up procedures.



# 9a. Straps - 2 off.

The top surfaces of the strengthening ribs may be surfaced to provide a seating for the castings on the grinding machine. Also see illustration associated with Detail 34a.



### 10. Spindle.

Material should be good quality steel such as EN 24 and be given a good finish, preferably ground. The spindle runs in G.M. shells 1-3/8" OD x 1-1/16" ID and 1-3/16" ID respectively. Oil grooves can be provided. It has been found that occasional lubrication through ordinary oiling caps is all that is necessary and wear has been negligible over a period of 25 years. Thrust is taken by a large ball race in the mandrel nose bearing and a fibre washer and fine-threaded collar on the spindle at the back end of the bearing shell allow for close adjustment.

The spindle is bored 3/4" plus, running into a No. 3 Morse taper, so that large stock material can be passed through and useful sized collets employed. A reduction sleeve to No. 1 Morse taper takes normal centres, drill chucks, etc.

Both bearing housings and shells are split 3/32" and fitted with fibre packing pieces, adjusted for running fit and clamped with 5/16" BSF socket cap screws.

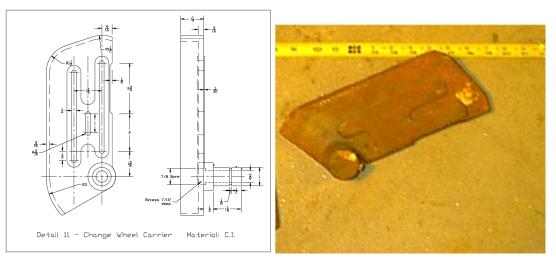
The flywheel pulley is keyed to the spindle with a key 3/16" x 1/8" x 1". A 5/16" BSF socket grubscrew secures and seats on the key through the bottom of the smallest pulley.

Spindle 1-3/16" 0.0. (eyway 3/16" x 1/16" x 2" Thrust race 1-7/8" dla. 1-3/16" clear LD. x 7/16" 2 ore thrust v Dla x 3/32" thick 20 T.P.I. 15 1<u>3</u> 11 16 16 14 15 Collar 1-5/8" Dia Spindle 1-1/16" D.D. G.M.Bearing Bushes 1-3/8" D.D. Signed WDU 26.10.81 <del>7</del>2 Nose No 3 Morse Taper Detail 10 - SPINDLE Material: En24

The function of the sliding sleeve and pinion is described under screwcutting and Detail 21.

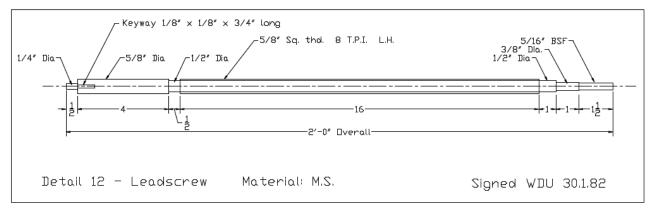
### 11. Changewheel Carrier Arm.

There is nothing calling for special comment with this component. The slots should be milled out to 1/4" to suit the flats on the changewheel studs. The central slot is opened up to 5/16" at one end, to accept the attachment of the link arm when using the pulley for dividing purposes.



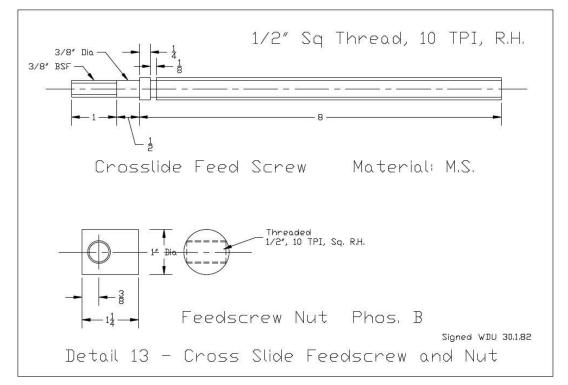
#### 12. Leadscrew.

The leadscrew is 5/8" in diameter x 8 TPI square thread L.H. to suit the special screwcutting system and the 24 tooth pinion on the spindle sleeve. The leadscrew on this machine is very much in use but it is so easily removed, together with its nut, that a spare pair could be kept for special jobs, where great accuracy was required. However, the long solid nut stands up well and I have not found the necessity for such a spare set.



### 13. Crosslide Feedscrew and Nut.

The feedscrew is threaded 10 TPI x  $\frac{1}{2}$ " square thread R.H. and operates in a self aligning Phos.B. or G.M. nut. This nut is made from a piece of 1" diameter material, cross-bored and threaded. It is a close working fit in a suitable vertical hole bored through the saddle casting and can therefore position itself in two directions to align with the placing of the thrust bearing. The screw is thus freely supported, lending itself to smooth and accurate duty.



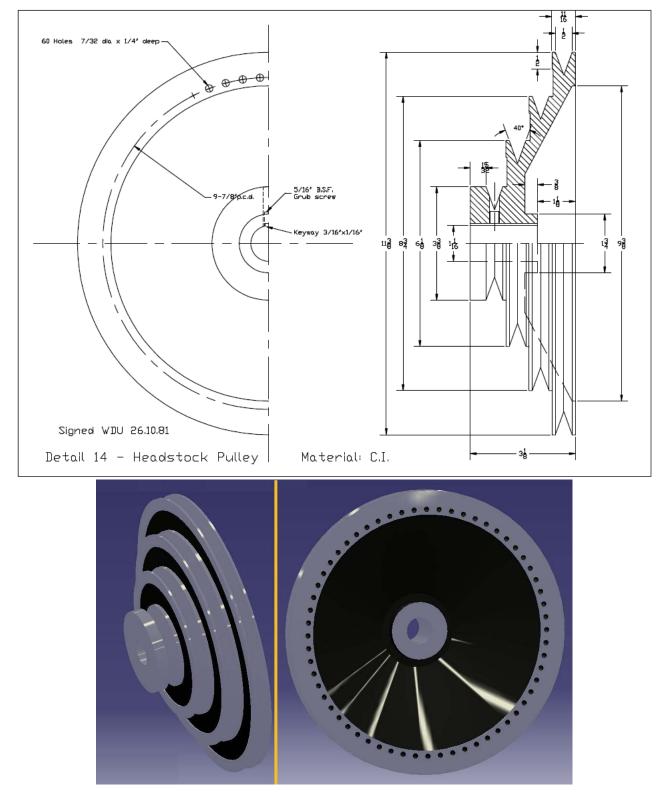
# 14. Headstock Pulley Flywheel.

The design and operation of this pulley was adopted without modification From the Exe 3-1/2" lathe. It has proved an unqualified success and is a breakaway from traditional practice. It has the following merits:

a) Its heavy weight (12 lbs.) serves to give momentum to anything held in the chuck and helps to drive the work past the tool or vice-versa and to eliminate chatter, particularly in parting-

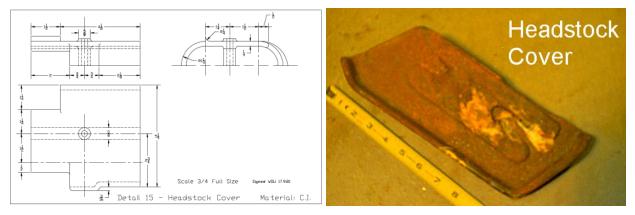
off operations.

- b) It serves as a Dividing Head, having 60 holes drilled in its outer rim, with a means of further subdivision to 360 deg.
- c) It dispenses with the need for back-gear and is quiet. If a geared motor is used as the power unit, a suitable range of speeds can be provided with a single Vee belt drive.
- d) It is invaluable for turning the chuck for screwcutting by hand, particularly for short threads up to a shoulder and for the use of taps and dies in a tailstock holder. The rack feed to the tailstock is also an advantage in this kind of work.



# 15. Headstock Cover.

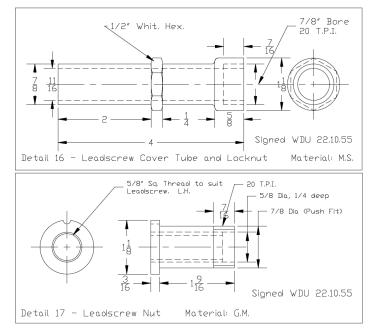
This casting calls for no special comment. It is held in position by the knurled screw, Detail 31.



# 16 & 17. Leadscrew Cover Tube and Locknut, & Leadscrew Nut.

The leadscrew nut of Phos.B. or G.M. passes through a hole bored through the lug provided on the underside of the saddle casting and is secured by the M.S. Cover Tube acting also as a locknut. A small peg prevents rotation of the nut.

If the Cover Tube is unscrewed, the leadscrew nut can be spun down to the far end of the leadscrew, leaving the saddle free to slide on the bed. A hand lever can then be fitted, with a link and fulcrum pin clamped to the bed by some suitable means, to convert the machine to a simple handshaper for cutting keyways or splines in work held in the chuck, see Detail 50.



# 18. Carrier Arm Bearing Bracket.

This casting is attached to the pad provided on the main bed casting by two 5/16" setscrews, so as to line up with the leadscrew. The casting is split and a clamping screw provided so that the carrier arm may be locked in any position to suit the changewheels in use. The head of the small column which carries the clutch lever should be finished to stand  $\frac{1}{2}$ " forward of the centre-line of the leadscrew to suit the sliding collar.

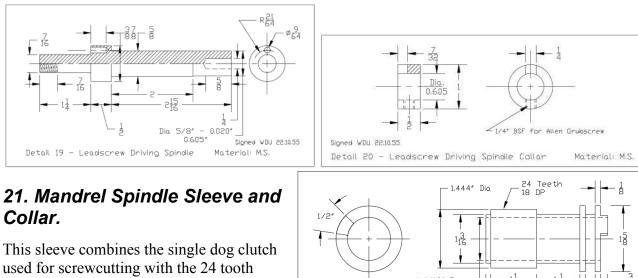
Dowel pins can be fitted to position the bracket once correct alignment with the leadscrew has been made. However, the 1/4" diameter spigot on the end of the leadscrew is purposely an easy fit in the hole in the driving spindle so as to avoid any strain on the leadscrew, no support being required at

15 1/4" B.S.F. \$ denotes linished or filed finish 2 ģ Tapped 5/16" B.S.F. 50 /16" Clearance 113 F 38 15 16 58 3 Casting Slit thru 1/16" ğ <u>13</u> 16 5/16" Dia Balt hales 500 Signed WDU 22.10.55 Detail 18 - Carrier Arm Bearing Bracket Material: M.S.

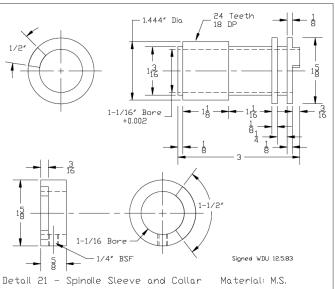
this point. The leadscrew should be freely floating on the nut and the thrust bearing only.

### 19 & 20. Leadscrew Driving Spindle and Collar.

The spindle should be a nice running fit in the boss on the carrier arm. A clearance of 0.020" allows the sliding collar and dog to move easily over the spindle when the clutch is operated.



used for screwcutting with the 24 tooth pinion which drives the changewheel train. The use of a single dog clutch makes it impossible to pick up the wrong thread and greatly simplifies screwcutting operations. Short lengths of thread up to a shoulder can readily be cut by hand with the aid of the large pulley flywheel and with complete confidence.



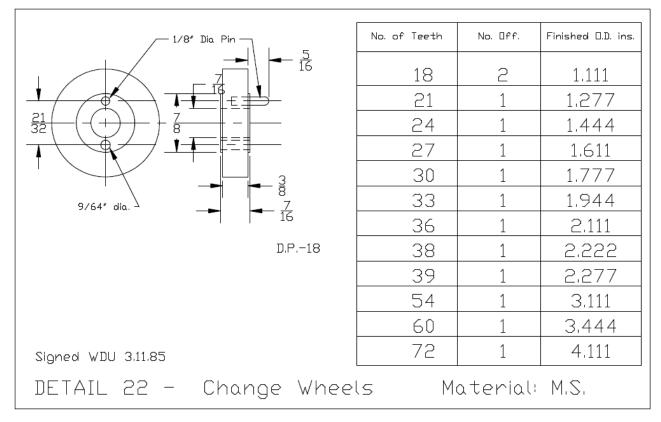
### 22. Changewheels.

This system of gears, where the number of teeth are in multiples of the number 3 instead of the usual 5, provide a very comprehensive range of screwthreads using simple trains only. The formula is very simple: - Number of driven teeth / Number of driving teeth =  $3 \times \text{TPI}$ .

A working chart for the changewheel trains is given in the Table on page 45 and this has proved to be adequate for everyday model making purposes.

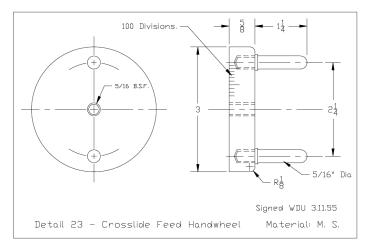
A single 38 tooth wheel is added to the range to enable 19 TPI to be cut and also because this wheel gives a useful selection of metric threads to be cut with tolerable accuracy. An additional changewheel of 50 teeth would be required if it is necessary to cut a 25 or 50 TPI thread.

An advantage of the system is that the largest wheel employed is only 72 teeth, keeping the whole train exceptionally compact.



### 23. Cross-slide Feedscrew Handwheel.

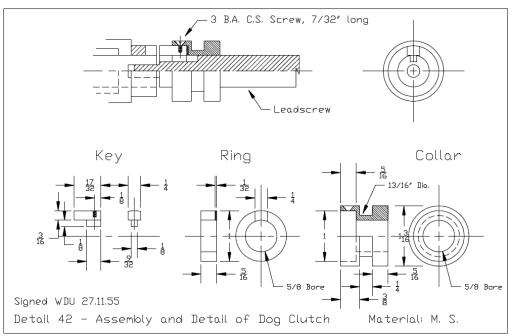
The large and heavy handwheel is helpful in giving a smooth and steady feed. The space between the indexing marks representing 0.001" is so large on a 3" diameter ring that they can be comfortably read with accuracy from a standing position in front of the machine. It would be a simple matter to fit this handwheel with a zero setting index ring and could be a useful refinement.



# 24. Assembly and Details of Dog Clutch.

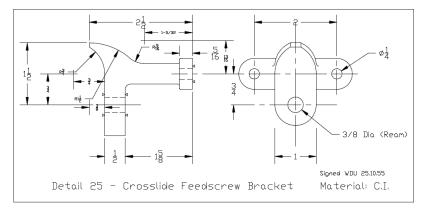
The clutch collar is keyed to the end of the leadscrew and picks up the drive from the changewheels Page 31 of 52

for autofeed to the saddle. It is left engaged during screwcutting operations.



### 25. Cross-slide Feedscrew Bracket.

This small iron casting supports the feedscrew and serves also as a thrust bearing. It should therefore be accurately spotfaced at both ends of the bore.



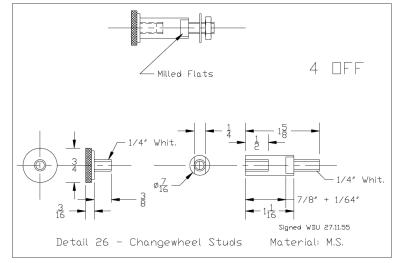
### 26. Changewheel Studs.

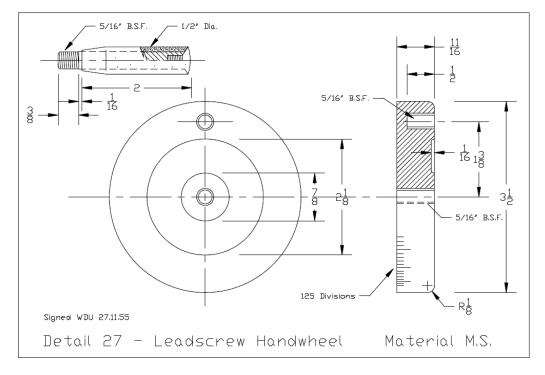
Three of these studs are normally in use, the fourth only being required for an extra idler when cutting L.H. threads.

### 27. Leadscrew Handwheel.

As with the crossfeed handwheel, this handwheel is of large diameter, 3-1/2", and is heavy to aid a smooth action. A small index marker with Vernier scale can be fitted and is occasionally useful but otherwise a pointer made from cheet matel will an

pointer made from sheet metal will suffice.

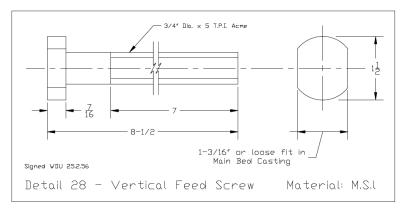




#### 28. Vertical Feedscrew.

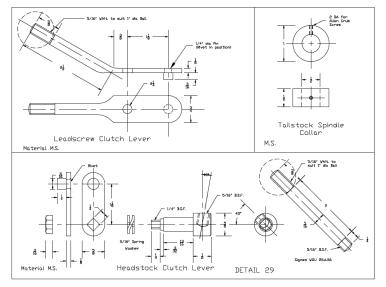
This feedscrew of 5 TPI Acme thread has proved to be about right as a screwjack to raise and lower

the bed. It is a comfortable lift without being too tedious, as a finer thread might be. It is as well to fit a steel cover under the handwheel to protect the ball thrust-race from swarf. A zero setting pointer on this cover would be extremely useful as it would mean that the bed could be returned accurately to a previously used height. The DTI can, of course, always be used for vertical micrometer movements within its range.



### 29. Clutch levers etc.

These small parts call for no comment.

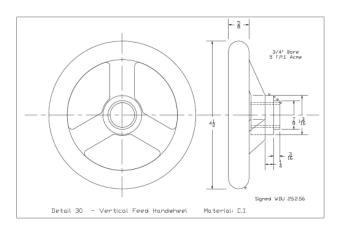


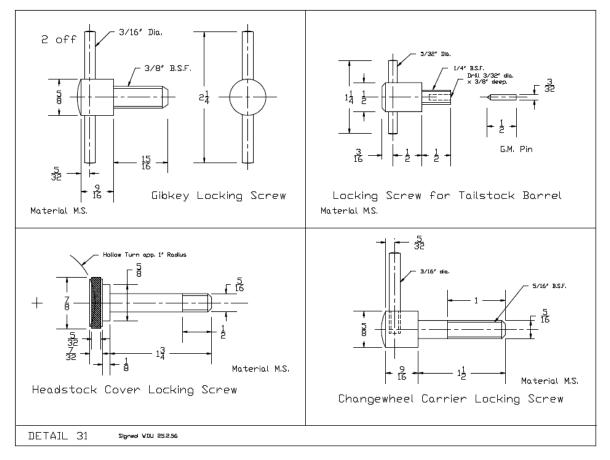
### 30. Vertical Feed Handwheel.

It may well be possible to find this item or one very like it as a stock pattern in a foundry. The dimensions are not critical.

#### 31. Various small Screws.

As the tailstock barrel locking screw is in continuous use, it is best provided with a small G.M. pad or pin to seat on the face of the triangular gib key. The key will hold the barrel very firmly indeed, owing to its wedge action in the keyway.



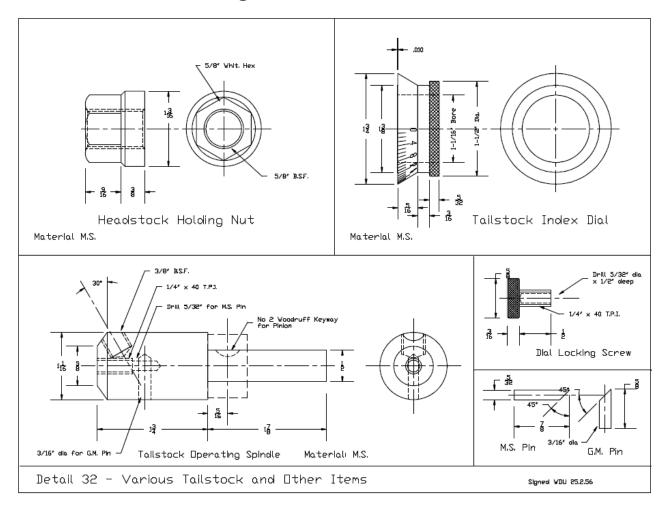


# 32. Various Tailstock and other items.

The headstock holding nut should have an accurately machined seating face, since it is tightened down in collaboration with the two adjusting screws for aligning the head and will then need no washer.

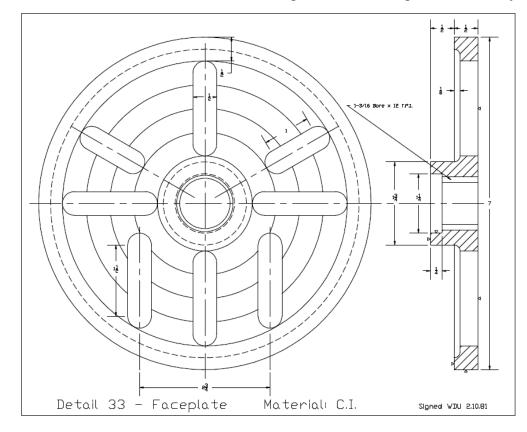
The barrel rack feed is 8 teeth per inch, so that one revolution of the tailstock indexing dial represents 3" of travel and it may be given scale divisions accordingly. The central locking screw and pin provide a simple means for zero setting of the dial. For details of the 24 tooth pinion see drawing No. 45.

Metal Master – Design & Construction Notes (W. D. Urwick - 1983)



### 33. Faceplate.

With the vertical feed available, a faceplate is an almost unnecessary accessory. Work can be set up on the boring table so much more easily and accurately, with the aid of the DTI, and machined by means of tools in the chuck or on the boring head, that a faceplate will be very rarely used.



### 34. Tailstock.

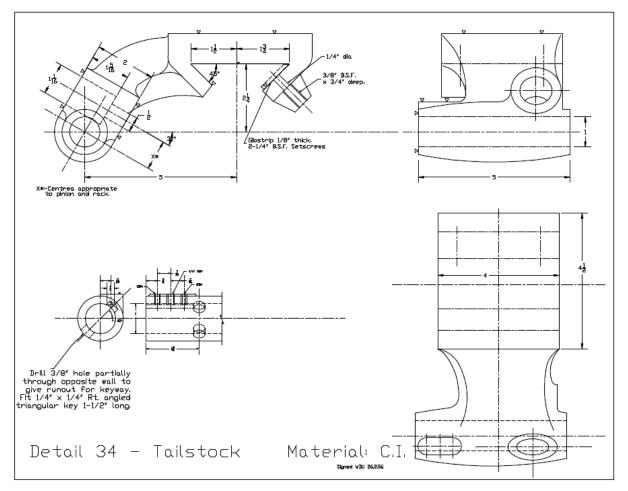
This casting needs to be machined with particular attention to the vertical dimension of 2.25" between the top sliding surface of the auxiliary Tee bed and the centre line of the barrel. This dimension should be to limits of  $\pm 0.00001$ ", but adjustment is possible, see 34a. On the original prototype machine the tailstock barrel was bored in the machine itself, so as to remove any chance of error. No doubt if the machine were to be put into production a suitable jig could be set up to ensure that the castings were interchangeable.

The horizontal distance of 5" from the barrel centre line to the midpoint of the Tee bed is not so critical because allowance for adjustment is made in the brackets supporting the auxiliary Tee bed.

The barrel housing is drilled partially through from the back to provide a runout for the tool when cutting the triangular keyway for the key. Two setscrews and locknuts can be adjusted to remove all shake and the barrel can be locked very securely with the central locking screw tightened down onto the key.

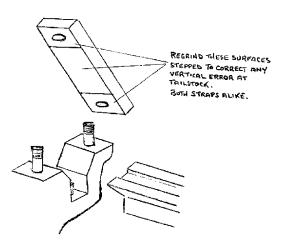
A valuable feature of this machine is that the tailstock can be passed right over the saddle and the boring table can therefore be as wide as may be found useful, with no problem of overhang of the tailstock barrel.

A simple sheet metal tool tray screwed to the flat top surface of the tailstock casting is very convenient for holding turning tools and spanners.



# 34a. Alignment of centres in vertical plane.

Any small error in the machining of the tailstock casting to the critical dimension of 2.25" between the sliding surface and the bore of the barrel will show up as a misalignment of the centres in the vertical plane. This can best be corrected by re-grinding the faces of the two strips (Detail 9a), with suitable steps between the central portion that rests on the top surface of the Tee bed and the end portions resting on the brackets. See illustration.



## 35 & 36. Four Way Toolpost.

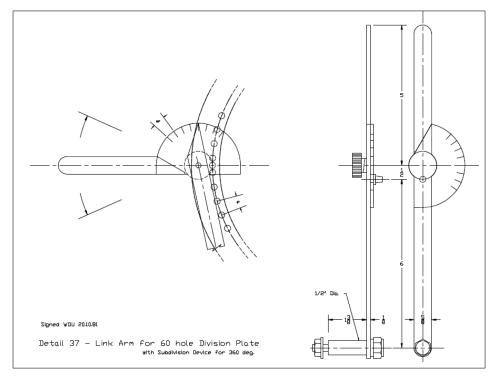
This toolpost is normally used on this machine for all general work, the topslide only being occasionally used for cutting short tapers or for feeding in the screwcutting tool at the thread angle. No packing of tools to centre height is necessary with the vertical feed always to hand and the short main bed and large feedscrew dials are more convenient to use than a topslide.

The tapered locking pin need only be sufficiently tightened down to prevent the toolpost moving about because the whole unit will be held down firmly when the main clamping arm is pulled down hard.

#### 37. Link Arm for 60 hole Division Plate.

The link arm works on a fulcrum pin attached to the Carrier Arm and can pick up any of the 60 holes in the rim of the flywheel pulley and so lock the mandrel. The subdivision device enables pieces of work in the chuck or on the faceplate to be divided into degrees of angle with considerable accuracy.

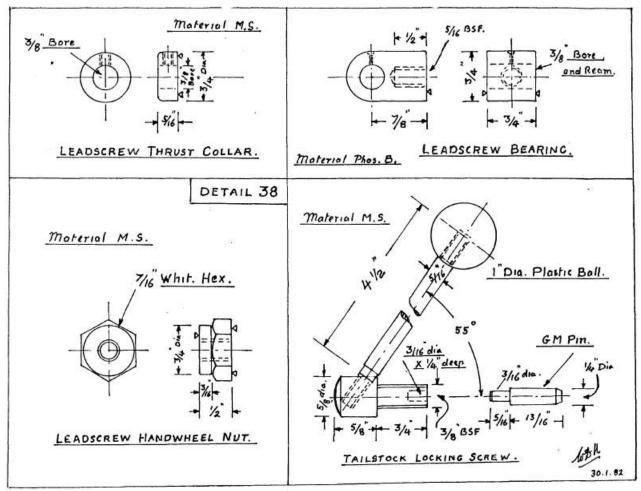
Movement of the Carrier Arm on its spindle allows a small amount of movement to a scribing tool picking up an initial zero mark on the work. The register pin on the link arm should be tapered so as to make a close spring fit in the 7/32" hole in the rim of the flywheel pulley.



#### 38. Four Small Items.

The leadscrew bearing can be made from 3/4" square Phos.B. or G.M. stock bar. The M.S. thrust collar bears on one side face of the bearing and the handwheel nut on the other, locking with the threaded hole in the handwheel itself and with a final locknut on the end of the thread. These parts can be adjusted to provide working clearance for the leadscrew and smooth action. A single 5/16" bolt passes right through the main bed casting to hold the bearing against the pad provided.

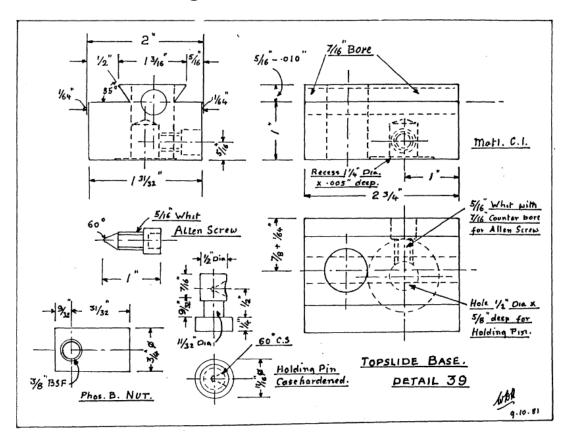
The tailstock locking screw can be given a plain crosspin for tightening purposes or it is better to fit a ball headed lever about 4-1/2" long which can project above the tool tray for easy access. The most convenient position for this lever when locked can be determined by adjustment of the length of the boss or G.M. pin. A small fixed pin in the back of the tailstock casting can limit the movement of the lever when in the unlocked position. If the lever is screwed into the head of the locking screw at an angle of about 55 deg. it will comfortably clear the back of the casting with freedom to swing.



#### 39. Topslide Base.

A similar arrangement to that of the cross-slide is used for the nut and the feedscrew, the nut being made by crossdrilling and threading a short length of 3/4" diameter Phos.B. or G.M. rod. This cylindrical piece of metal floats in a vertical hole bored in the casting and so can find its own alignment with the feedscrew and bearing. This results in a smooth and accurate action.

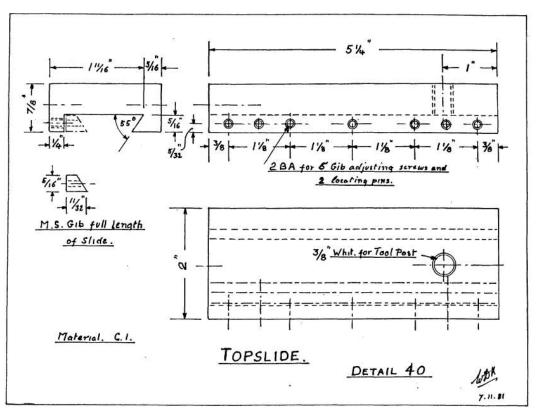
The whole topslide is clamped to the boring table by means of a taper pointed socket cap-screw, which enters a recess of similar taper 60 deg. in a special slot bolt. The recess is drilled 1/16" below the axis of the cap-screw, so that as the latter is tightened it draws up the slot bolt and clamps the topslide. The topslide can therefore be fixed in any slot and at any required angle. A protractor can be laid against the machined face of the base casting for setting to any desired angle of taper.



#### 40. Topslide.

A solid section gib strip is used for the slide in view of the amount of overhang and the possibility of spring with a thin strip. If two locating pins are provided, the adjusting screws can be flat ended to seat on the vertical back face of the gib key.

A substantial 3/8" post can be fitted with any sort of tool clamp desired. A small plate with a light spring beneath it and an adjustment screw for height has served very well.



#### 41. Topslide Feedscrew Bracket and Handwheel.

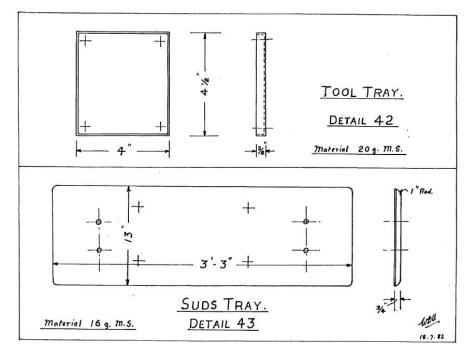
The feedscrew is threaded 3/8" BSF so as to give 20 turns of the handwheel per inch of travel. The handwheel can then have 50 divisions each representing 0.001" and these on a 1-1/2" dial will be about 3/32" apart and convenient to read.

Drill + Tap for Tis Dia Pins × 5/0" long at 3/0" radius BRACKET. 1/4 BSI 3⁄8 50 Dive υt 7/82 7/32 FEEDSCREW HANDWHEEL Drill for Cheezahead Screws. 5 1/4 BSF % 7/16 Dia FEEDSCREW TOPSLIDE DETAIL 41 123.56 Material MS.

The feedscrew bracket can be a small iron casting or milled from a piece of mild steel.

#### 42 & 43. Tool Tray & Suds Tray.

These can be fabricated from sheet metal and are best rustproofed and stove enameled.

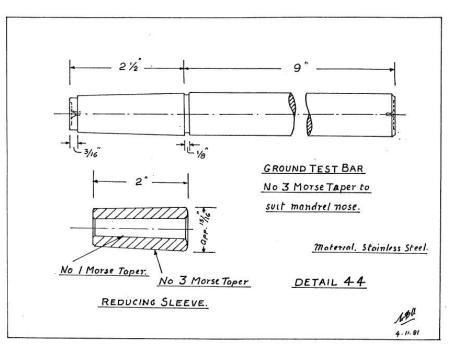


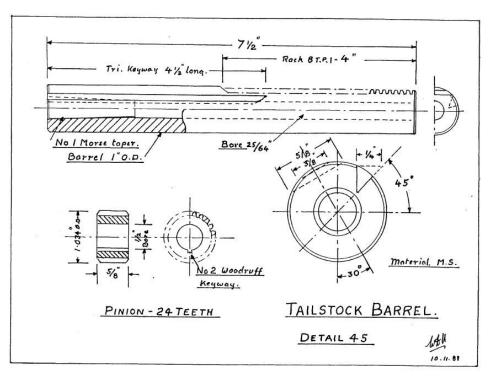
### 44. Ground Test Bar.

This test bar is best made from 1" ground stainless steel and is an essential accessory. It must have accurate centres and one end should be No. 3 Morse taper to fit the mandrel nose. It should be kept available at any time for use in lining up the machine or as a final check when the auxiliary Tee bed has been removed to allow for a workpiece greater than 8" diameter or when the main triangular key has been removed for taper turning.

#### 45. Tailstock Barrel.

The barrel is bored to pass 3/8" stock material and the nose is made to suit No. 1 Morse taper centres, drillchuck, end mills, etc. The keyway can be cut with a 45 deg. side and face cutter, care being taken to ensure that the radial face is truly on the diameter of the barrel. The rack feed is 8 TPI which, with a 24 tooth pinion, gives 3" of travel of the barrel for one revolution of the pinion. The dial can therefore be indexed in inches and the usual subdivisions.





#### 46 & 47. Dial Test Indicator and Base.

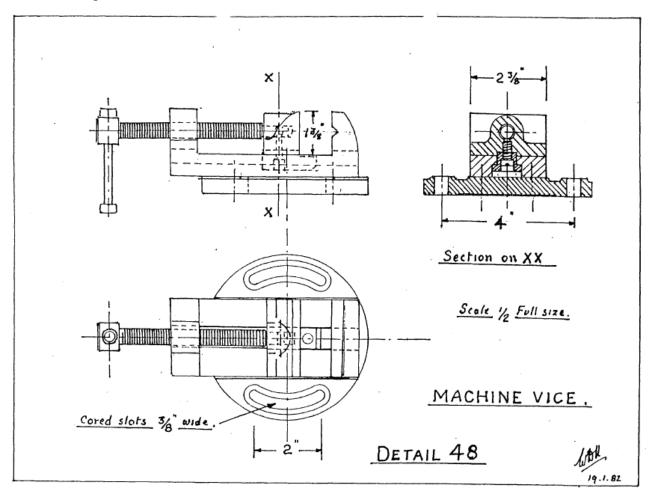
A good DTI is a necessary accessory with this machine. It is required for use in conjunction with the ground test bar for setting up to the zero-taper condition. If an attachment is made to slide on the auxiliary Tee bed and it carries the DTI on a universal arm, it can be kept in this position and will be immediately available to check every kind of work, whether round or flat, both in the chuck and on the cross-slide boring table. The vertical feed can also be indexed by means of this attachment and, in fact, the top face of the auxiliary bed becomes a kind of fixed datum line in space, to which all measurements may be referred. It is well worth making this quick fitting device

DIAL TEST INDICATOR ATTACHMENT FOR AUXILIARY BED. DETAIL 46 Under

and the time taken in its construction will be rapidly recovered by its use.

#### 48. Machine Vice.

As there is no lack of room in the vertical direction, the vice can have good deep jaws with advantage. It will be much in use and should be capable of being bolted to the boring table at any angle. This can be achieved very well by fitting the vice with a circular slotted baseplate as shown in the drawing.



# Setting Up Procedure.

The ground test bar and DTI are used for this purpose as follows.

- Insert the test bar into the No. 3 taper mandrel nose. Ease off slightly the nut on the centra stud emerging through the headstock casting. By means of the adjusting screws Detail 3a rotate the head on the column in the appropriate direction until no movement is recorded on the DTI fitted in the toolpost as the saddle is traversed along the length of the bed. Tighten down the nut on the central stud when this is so.
- 2) Insert centres in headstock and tailstock and bring up the latter until the two centres are touching. By means of the four adjusting screws seating on the inclined sides of the brackets Detail 9, bring the centres in true alignment with one another, at the same time keeping the Tee bed parallel with the main bed, sighting by eye.
- 3) Slide back the tailstock and introduce the test bar between centres. Test with the DTI in the toolpost and correct by means of the outermost adjusting screws only. When correct, tighten up the locking screws underneath each bracket.

Once set, the accuracy of the machine will be retained indefinitely but the above procedure should be used for resetting after dismantling or for checking if some particularly accurate long turning work is to be done.

In any case, only a few minutes are required to check the adjustment and the operator can feel that at all times he has the accuracy of the machine under his control.

# Vertical Feed Adjustment.

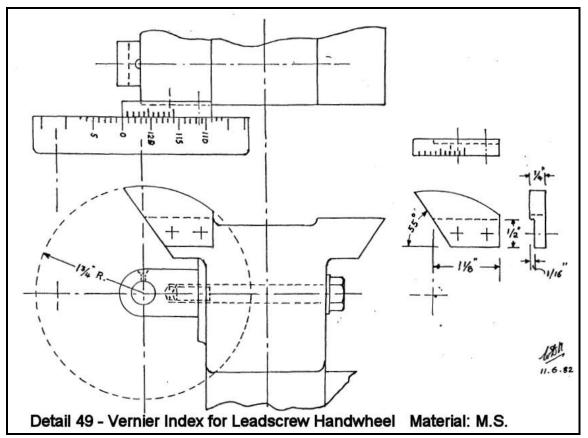
- 1) Slacken all gib key adjusting and locking screws.
- 2) Tighten the clamp bolt at the back of the bed casting, where it is split, until the lifting screw can be lowered and the bed remain suspended. Slacken the clamp bolt until the bed just falls under its own weight.
- 3) Tighten gib key adjusting screws individually, again adjusting until the bed can just fall under its own weight.

If properly fitted, the triangular key will hold the bed in radial alignment to limits of the order of 0.001" to 0.002" in a length of, say, 12". It is not necessary, in the ordinary way, to use the two locking screws to clamp the key when work is being done anywhere near the chuck. In fact, when using end mills and flycutters, the vertical feed can sometimes be found preferable to the cross feed.

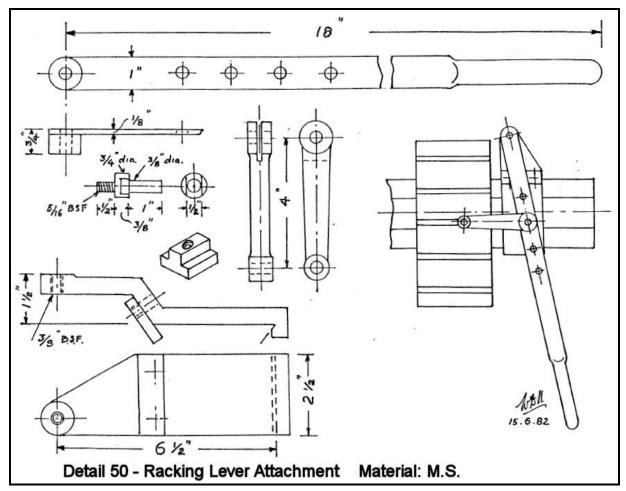
When parting off it is quite feasible to raise and lower the bed and the tool whilst actually making the cut, so as to find the most satisfactory position.

The following drawings exist without notes from David Urwick.

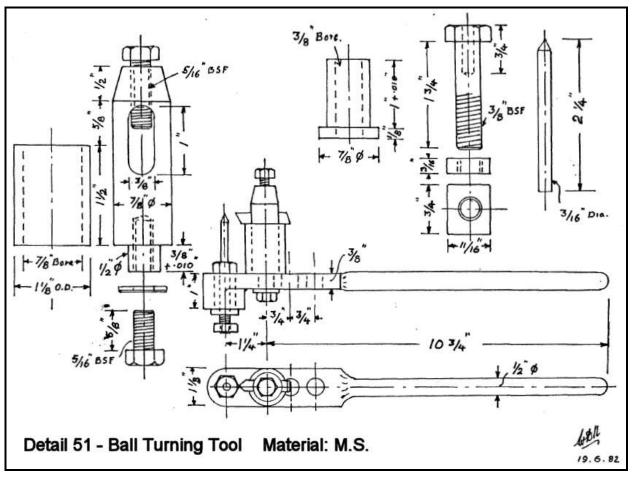
49. Vernier Index for Leadscrew Handwheel.



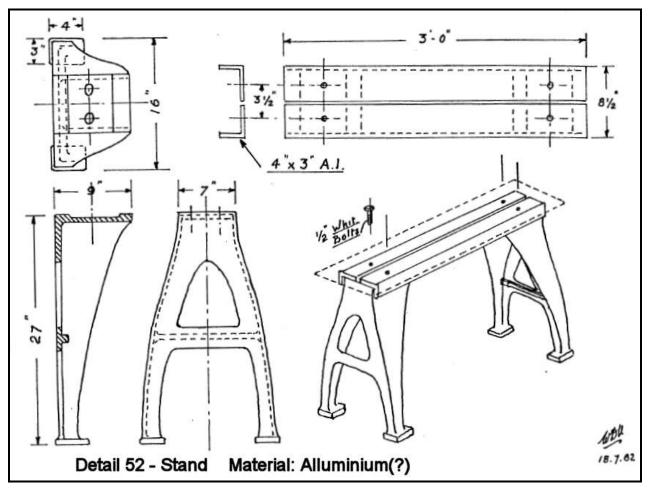
50. Racking Lever Attachment.



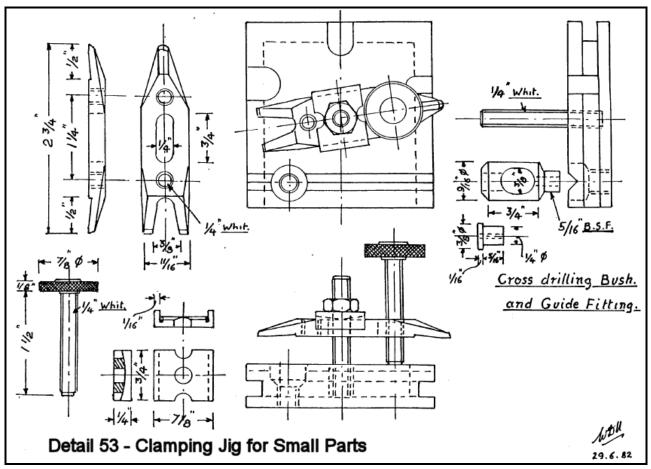
51. <u>Ball Turning Tool.</u>



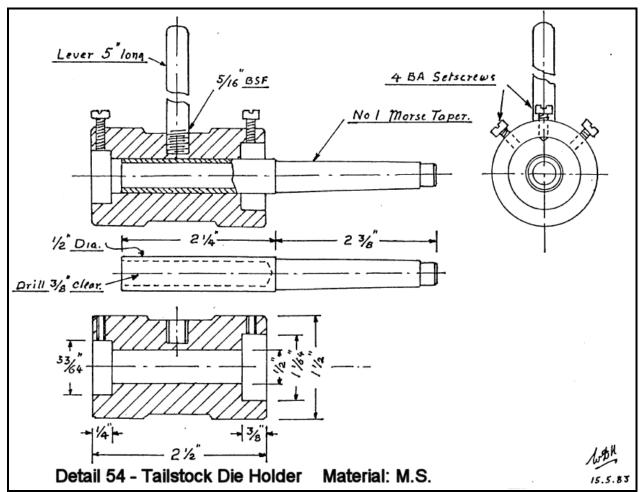
52. Stand.

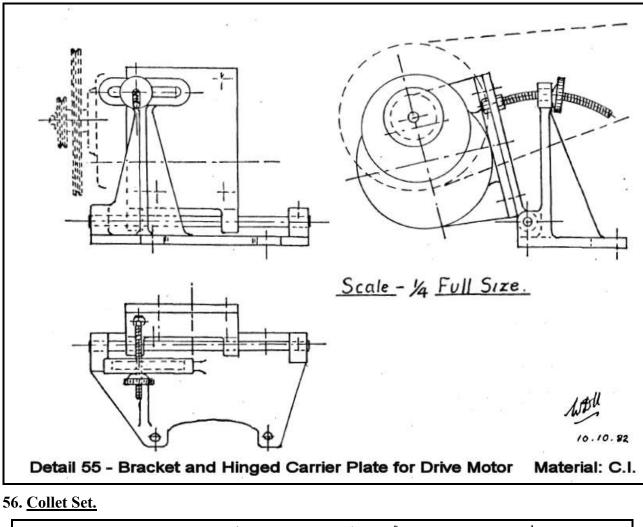


53. <u>Clamping Jig for Small Parts.</u>

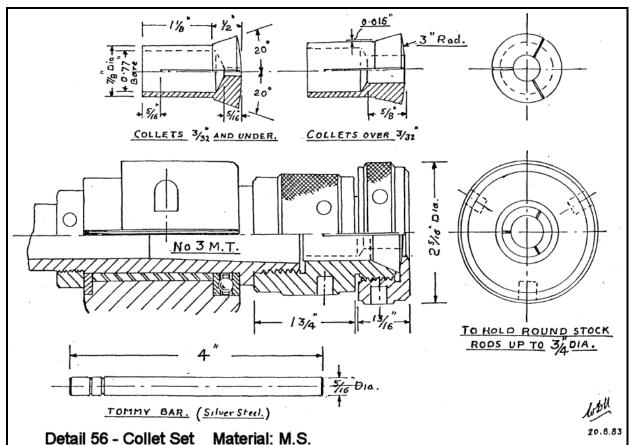


54. Tailstock Dieholder.





55. Bracket and Hinged Plate for Drive Motor.



The following drawings are listed in the Schedule of Drawings but are not included with the known set of drawings.

#### **Boring Head.**

- 1. <u>Body.</u>
- 2. <u>Slide.</u>
- 3. Feedscrew.
- 4. <u>Nut.</u>
- 5. <u>Thrust Block.</u>
- 6. Index Locknut, Thrust Locknut, and Thrust Ring.
- 7. <u>Handwheel.</u>
- 8. <u>Spider.</u>
- 9. Arrangement of Trip Pin.

#### 10. Facing Tool Holder.

Additionally, a Dividing Head is mentioned in some of the literature on the MetalMaster and is shown in at least one photograph of David Urwick's personal machine. No mention of it is made in Urwick's notes nor are any drawings included with the known set of drawings.

Change	e Wheel Chart	TPI x 3 = $\frac{A \times C}{B}$			
Threads per Inch	<b>A</b> Wheel on Leadscrew	<b>B</b> Driver	C Driven	Right Hand Idler	Left Hand Idler
4	24	36	18	1	2
5	30	36	18	1	2
6	18	-		2	3
7	21	-		2	3
8	24	-		2	3
9	27	-		2	3
10	30	-		2	3
11	33	-	1	2	3
12	36	-	1	2	3
13	39	-		2	3
14	54	27	21	1	2
15	36	24	30	1	2
16	54	27	24	1	2
18	54	-	-	2	3
19	54	24	21	1	2
20	54	27	30	1	2
22	54	27	33	1	2
24	54	27	36	1	2
26	54	27	39	1	2
28	72	18	21	1	2
30	72	24	30	1	2
32	72	18	24	1	2
36	72	18	27	1	2
40	72	18	30	1	2
44	72	18	33	1	2
48	72	18	36	1	2
52	72	18	39	1	2
56	72	18-27	21-54	1	2
60	72	18-24	30-36	0	1
64	72	18-27	24-54	0	1
Coarse Feed	72	18-21	39-54	0	1
Fine Feed	72	18-18	54-60	0	1

Pitch (mm)	Metric Threads						
0.50	72	18	38	1	2		
0.55	72	18-33	30-38	0	1		
0.70	54	21-27	38-30	0	1		
0.75	72	27	38	1	2		
1.00	72	36	38	1	2		
1.50	38	27	36	1	2		
1.75	38	21	24	1	2		
2.00	38	-	-	2	2		
2.25	38	27	24	1	2		
2.50	38	30	24	1	2		
2.75	38	33	24	1	2		
3.00	24	36	38	1	2		
3.25	24	39	38	1	2		
4.00	18	36	38	1	2		

#### The Designer Writes

With thanks to Mike Collins - who made available the material for these pages.

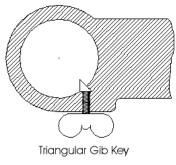
#### By W.D.URWICK. C.Eng., M.I.Mech.E. (First Published in the SIMEC Newsletter in September 1973)

Some twenty years ago I designed and built for my workshop the small general-purpose tool here described and it has proved such an unqualified success that I think the ideas behind it must interest readers of your *Newsletter*. I felt that for too long we have been constrained by the principles of Maudsley and that the model engineer particularly, requires a small machine with the greatest possible scope and capacity, which the orthodox bench lathe in miniature is far from providing.

A centre lathe makes a poor milling machine for lack of a vertical feed to the cross-slide or work table. A milling machine makes a poor lathe because of the difficulty of maintaining accuracy for turning between centres with a rise and fall cantilevered bed. A horizontal boring machine is a fine maid-of-all-work but is not much use as a lathe and is not, in any case, available in a small workshop size. All these machines, nevertheless, have a headstock, a tailstock and a work table or cross-slide and, after a great deal of thought, I managed to rearrange these components to give me the flexibility I sought.

The headstock of my machine is mounted on top of a massive column, with a cantilevered bed carried on the column beneath it and raised and lowered by a jacking screw at its point of balance. An auxiliary Vee bed carries the tailstock and is mounted in brackets behind the headstock. The top surfaces of these brackets are ground true with the mandrel and the auxiliary bed is held by screws forcing it upwards against straps seated on the ground surfaces of the brackets.

Thus, the working surfaces of the two beds, the headstock mandrel and the tailstock barrel are all strictly parallel in the vertical plane. However, when looking down on the machine from above, alignment of all these parts can be achieved by radial adjustment, with the column as centre, and this adjustment is under the control of the operator. It will be clear that, for the success of this arrangement, one component, the cantilevered bed, must retain its radial relationship with the column with extreme accuracy and this I achieved with a special triangular gib key, which I invented and patented at the time. A sketch of part of the original Patent Drawing is shown here, though the patent itself has, of course, expired.



Sketched from original 1950 patent

The startling performance of this key in maintaining accuracy has to be seen to be believed. Its very simplicity is deceptive. When raised or lowered on the jacking screw and re-clamped, the outer end of the bed can be relied upon not to deviate by more than .001" to .002" in radial alignment. One must appreciate that at this radius the key is operating at a disadvantage of about 20 to 1! An error of this order over a length of 18" is probably as good as one would expect from any orthodox light machine of this class.

The Triangular Gib Key has three great points in its favour for this particular application:

- 1. The alignment of the bed with the mandrel can be maintained to very close limits indeed, when it is raised or lowered, on account of the keyway faces themselves being radial.
- 2. When locked, the key acts as an extremely rigid clamp and being of wedge shape, can be adjusted to a very close sliding fit, like a gib strip, and yet it clears instantly on release. The sliding clearance at the key faces can be so small that, with normal work anywhere near the chuck, it is unnecessary to apply the locking screw and clamp the bed. The vertical feed can be used for milling or other purposes as freely as the cross-slide or leadscrew feeds.
- 3. If the key is removed, the whole bed can be swung radially and locked, for turning work to any desired taper. In fact, the arrangement can be summed up by saying that parallel turning is merely a case of "zero taper."

Adjusting screws are provided for truing up the mandrel, and the auxiliary bed and tailstock to fine limits and with the aid of a test bar, this radial lining up of the machine can be achieved in a matter of minutes.

In considering the general details of this machine many 3.1/2" centre lathes were considered and an attempt was made to adopt the best features that could be found amongst them. Of these lathes, undoubtedly the most original and useful of all was the 3 1/2" Exe machine, on the market in the 1930's. The headstock arrangements and screwcutting details of this beautiful little machine were adopted and no better choice could have been made. The mandrel carries at its outboard end a 12" driving pulley weighing about 12 lbs. The power unit used is a Higgs 1/2h.p. geared motor, the output shaft running at approximately 300 r.p.m. This shaft carries a 2-step driving pulley, thus giving eight mandrel speeds varying from 45 to 900 r.p.m., using a single Vee belt which can be freely thrown on and off the pulleys. However the main function of the heavy pulley on the mandrel is to give "flywheel effect" and provide momentum between workpiece and tool as the cutting operation takes place. With a light machine this momentum makes all the difference in eliminating chatter and I can turn without difficulty 8" dia. C.I. traction engine wheels or a 12" dia. aluminium pulley. The auxiliary bed is removed to accommodate large diameters above 8". I was recently able to put a taper bore in the boss of a 10" dia. marine propeller. It is very useful to be able to swing such an article, the operation itself being well within the capacity of the machine. For this job the main bed was rotated on the column to the correct taper, after the key had been

#### The Designer Writes

With thanks to Mike Collins - who made available the material for these pages.

By W.D.URWICK. C.Eng., M.I.Mech.E. (First Published in the SIMEC Newsletter in September 1973)

removed and, at this slight angle, automatic feed could still be used.

The screwcutting arrangement too is most ingenious and possibly unfamiliar. A sleeve on the mandrel carries a 24tooth wheel, which drives the changewheel train, and also incorporates a single-dog clutch by which it takes its drive from the mandrel. In screwcutting, this clutch is used to engage the changewheel train, with the result that it is impossible to pick up the wrong thread!

In addition to this, the number of teeth on the changewheels are all multiples of the number 3 instead of the usual 5. These numbers 18, 21, 24, 27, etc., break down into simple fractions far better than the usual ones and the formula with an 8 T.P.I. lead-screw is simply:

 $\frac{\text{No. of driven teeth}}{\text{No. of driving teeth}} = 3 \text{ x T.P.I.}$ 

Metric threads can also be cut with the addition of one 38tooth wheel. The number 3 and its multiples are so convenient mathematically that it is difficult to understand why the awkward system using multiples of 5 has persisted for so long.

A boring head with cross feed, operated by star wheel and trip pin, was designed to fit the mandrel nose and with this in action, the machine can, with justification, be described as a miniature horizontal borer. The boring head is in use almost as much as the chuck, for facing, boring and even internal screwcutting awkward shaped castings.

I should feel completely lost without my vertical feed. There must be a saving in time alone of the order of 20% in never having to pack tools and boring bars. When parting off, I find that I can raise or lower the tool to the best cutting height whilst actually making the cut.

After machining many hundreds of parts for models and other things, I feel that I have still not explored all the possibilities opened up by the facility of being able to feed the worktable freely in three dimensions in front of the mandrel nose.

W. D. Urwick

Malta

#### The Metalmaster - a modern review:

At some point in the early 1970s David became interested in model Stirling engines and it was as a result of an article that he wrote on his moving regenerator type in Model Engineer that I first wrote to him. A long correspondence and friendship followed and when David returned to England from his retirement home in Malta I was able to visit him at his new home in Somerset. Naturally we gravitated to his newly-built workshop where I saw not only his collection of Stirling engines but also his Metalmaster, a machine that had fascinated me ever since reading about it in the *Model Engineer* back in the fifties.

Unfortunately it wasn't working as, during the journey back from Malta, the cross-slide feed-screw nut had been lost. However, within a couple of days I had made and posted a replacement to him and the next time I visited I was able to play with the machine.

Sadly, a few years later, poor David became a victim of Parkinson's Disease and, anxious that his machine should go to an appreciative owner, he offered it to me. A fair price was agreed and I became its proud owner.

Seen here (se image on page one) with the machine are some of the accessories, including the boring head and topslide mentioned in the brochure, together with the vice designed to fit the cross-slide and a matching dividing head. The saddle fitted on the parallel auxiliary bed is my own addition and can be slid along by hand before locking in position. It was originally made to hold a fixed steady but, in addition, proves very useful for holding the lamp, the D.T.I. and the home-made tool height setter, a device similar to the old 'Unique' indicator, which can be swung out from under the saddle to sit on the tool tip.

There is little I can add to David's article re the versatility of the machine, it is certainly all that he claimed for it and can be converted to any of its functions within a couple of minutes. Its accuracy was all that he claimed for it although now, after nearly fifty years of 'amateur' use, is slightly impaired by wear at the headstock end of the bed. (In retrospect, David thought that since the tailstock was no obstacle, the saddle could have been made rather longer with some advantage) I can't really comment on the machine's rigidity since I normally use it for building small model Stirling engines and handle it like cut glass - nevertheless, recent jobs have included skimming the brake drums of my wife's Morris Minor and re-machining the base of an Indian cylinder barrel, requiring the full fourteen inch swing to accommodate the finning around the valve seats. Sumitomo tips are very satisfactory for all these straightforward turning and boring jobs.

David's geared-motor drive was becoming very noisy and has been replaced with a Sinclair C5 motor with infinitelyvariable speed control since when parting off inch and a quarter steel has become a real pleasure - albeit a slow one!

Finally, I must agree with his remarks regarding the usefulness of the vertical feed - handling a conventional lathe now feels like working with one hand tied behind my back. And the sheer versatility of the machine has given me a new hobby - that of finding new jobs for it to do. Mitering picture frames took longer than expected though, due to the need for spotless cleanliness.

Mick Collins