WARCO

THE WARCO 220 LATHE

OPERATOR'S HANDBOOK

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SAFETY AND ACCIDENT PREVENTION

SAFETY ALERT SYMBOL. Throughout this handbook the symbol is used to denote items or operations that could involve danger to the operator, or to other persons nearby. Please read these messages carefully, have a full understanding of their importance and always abide by their requirements.

INTRODUCTION

Your new 220 lathe is a robust and highly accurate machine tool. Whilst it is very modern in design it is still in many ways a traditional type of lathe and is used in the conventional manner.

With proper maintenance and correct operation and use this machine can provide you with years of accurate service.

Some purchasers of the lathe will be experienced in the use of similar machines; others may not be at all familiar with the processes involved in the operation of a lathe. This manual seeks to offer advice both to those whose knowledge is limited and to the experienced operator to give details of methods that can be used to obtain the best from this particular machine.

Please read this manual carefully and familiarise yourself with all the controls, their purpose, and safety of operation before attempting to use the machine.

SPECIFICATION AND FEATURES

Motor	½ HP, single phase (optional three phase)	
CAPACITY	mm	in.
Swing over bed	220	8.625
Swing over cross slide	134	5.25
Height of centre	110	4.313
Distance between centres	508	20.0
HEADSTOCK		
Spindle bore	20	0.75
Spindle taper in nose	No.3 MT	
Spindle speeds, nine	range 125 to 2000rpm (slow speed option available)	
CARRIAGE AND COMPOUND SLIDE		
Cross slide travel	100	4.0
Compound slide travel	70	2.75
Cutting tool (max section)	16	0.625
THREADS AND FEEDS		
Imperial pitches, 22	range 6 to 48 per inch	
Metric pitches, 22	range 0.4mm to 10mm	
Longitudinal feeds, imperial, three	0.004/0.006/0.008	
Longitudinal feeds, metric, three	0.1/0.15/0.20	
WEIGHTS AND MEASUREMENTS		
Overall length	1200	47.25
Overall width	500	19.688
Overall height	400	15.75
Net weight (approx)	125kg (275 lb)	
TAILSTOCK		
Internal taper	No.2 MT	
Quill travel	60	2.375
Set over (+ or -)	10	0.375

STANDARD EQUIPMENT:

Change gear set for metric and imperial screwcutting

Chuck guard

Dual graduated friction dials for metric and imperial

Four-way index tool post

Full electrics, including no volt release push button ON/OFF switch, emergency stop switch and cam operated cut-out switches to chuck guard and gear train/belt cover

Full length rear splash back

Induction hardened and ground bedway

No.3MT and 2MT dead centres

Three-jaw self-centring chuck with reversible jaws

OPTIONAL ACCESSORIES:

Cabinet stand

Collet attachment

Coolant system

Faceplate

Fixed steady

Four-jaw independent chuck

Index attachment

Vertical slide with vice

Bracket for portable electric drill

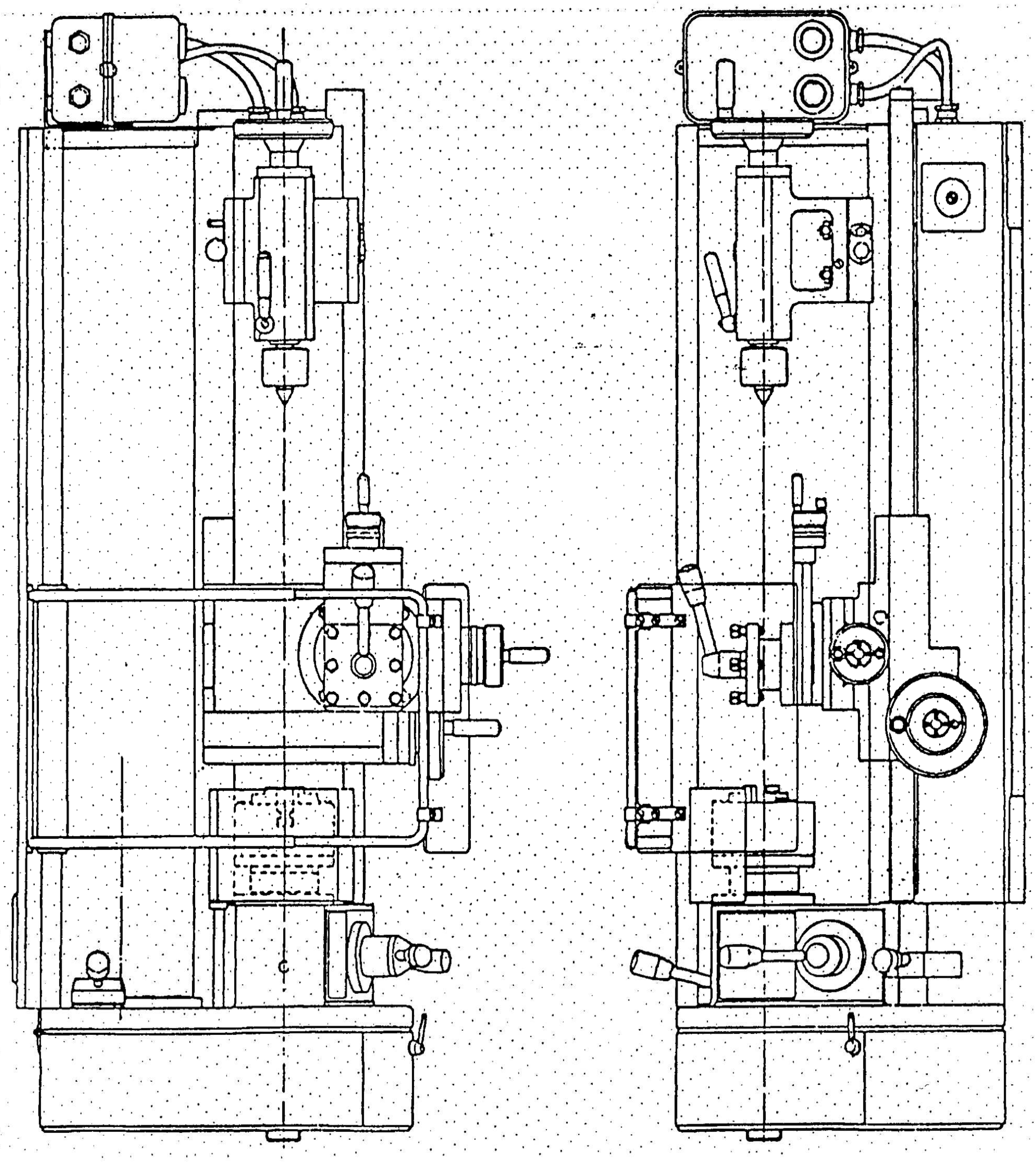


Figure 1 General Arrangement

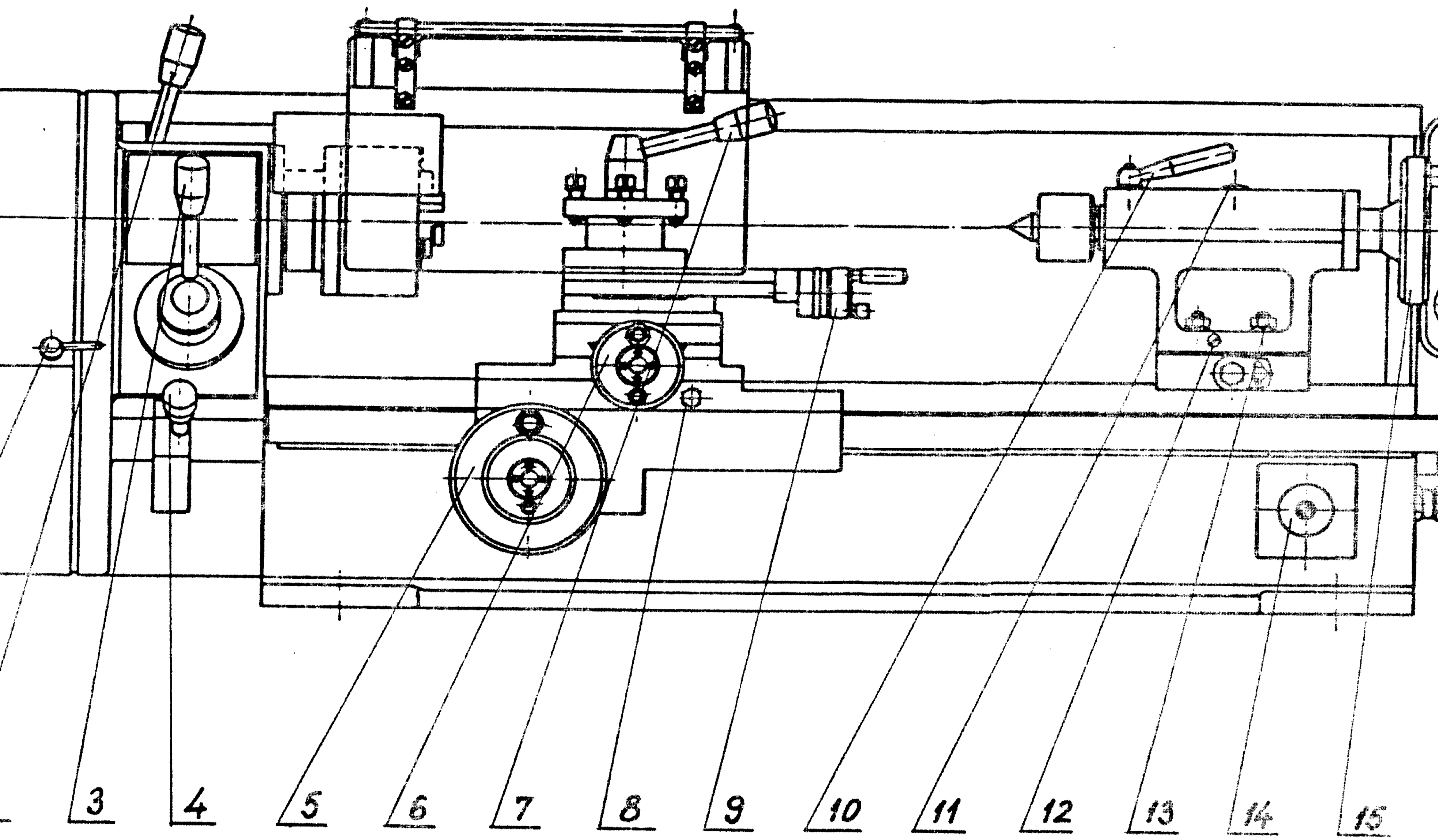


Fig. 1

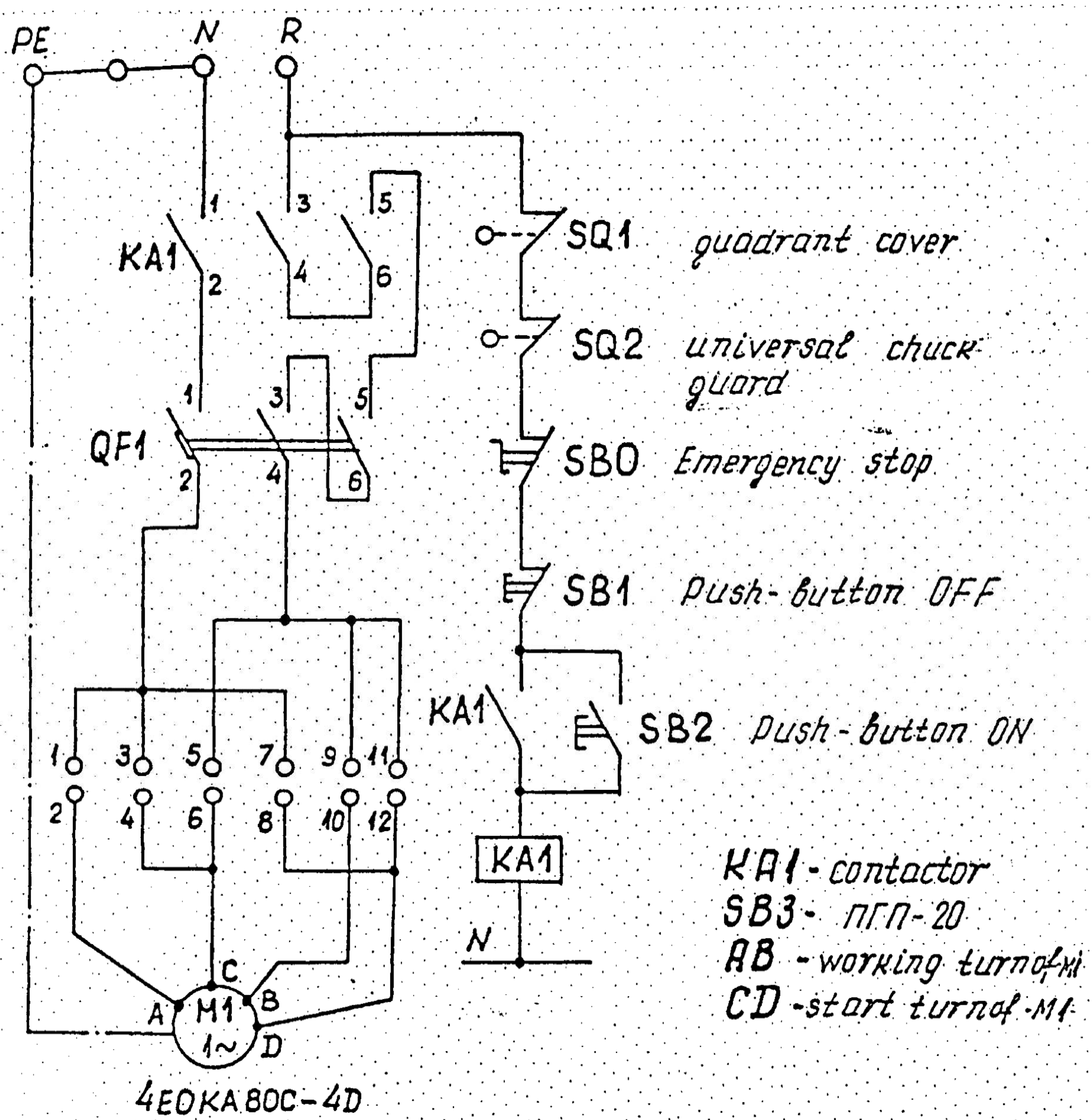
DESCRIPTION

The Warco 220 lathe is built to a very high specification and incorporates features normally associated with full size production machines. The bedway is hardened and ground and has a flat surface with dovetail edges to provide mounting contact and support over the entire bed length. A large area saddle gives maximum toolpost and vertical slide support. Stainless steel feedscrews are provided, with friction dials having both metric and imperial graduations. Metric and imperial screw thread cutting is a standard feature.

Referring to Figure 1, which shows a general arrangement of the lathe, the following items are depicted:

1	Lever for closing quadrant cover
2	Belt tensioning lever
3	Main forward and reverse switch
4	Lever for self-act feed and screw cutting
5	Handwheel for moving carriage
6	Handwheel for moving cross slide
7	Removable handle for tool post
8	Locking bolt for carriage
9	Top slide handwheel
10	Quill lock on tailstock
11	Tailstock clamping lever
12	Tailstock adjusting screw (one each side)
13	Clamping nuts for sideways movement of tailstock
14	EMERGENCY STOP button
15	Handwheel for tailstock
16	START button
17	STOP button

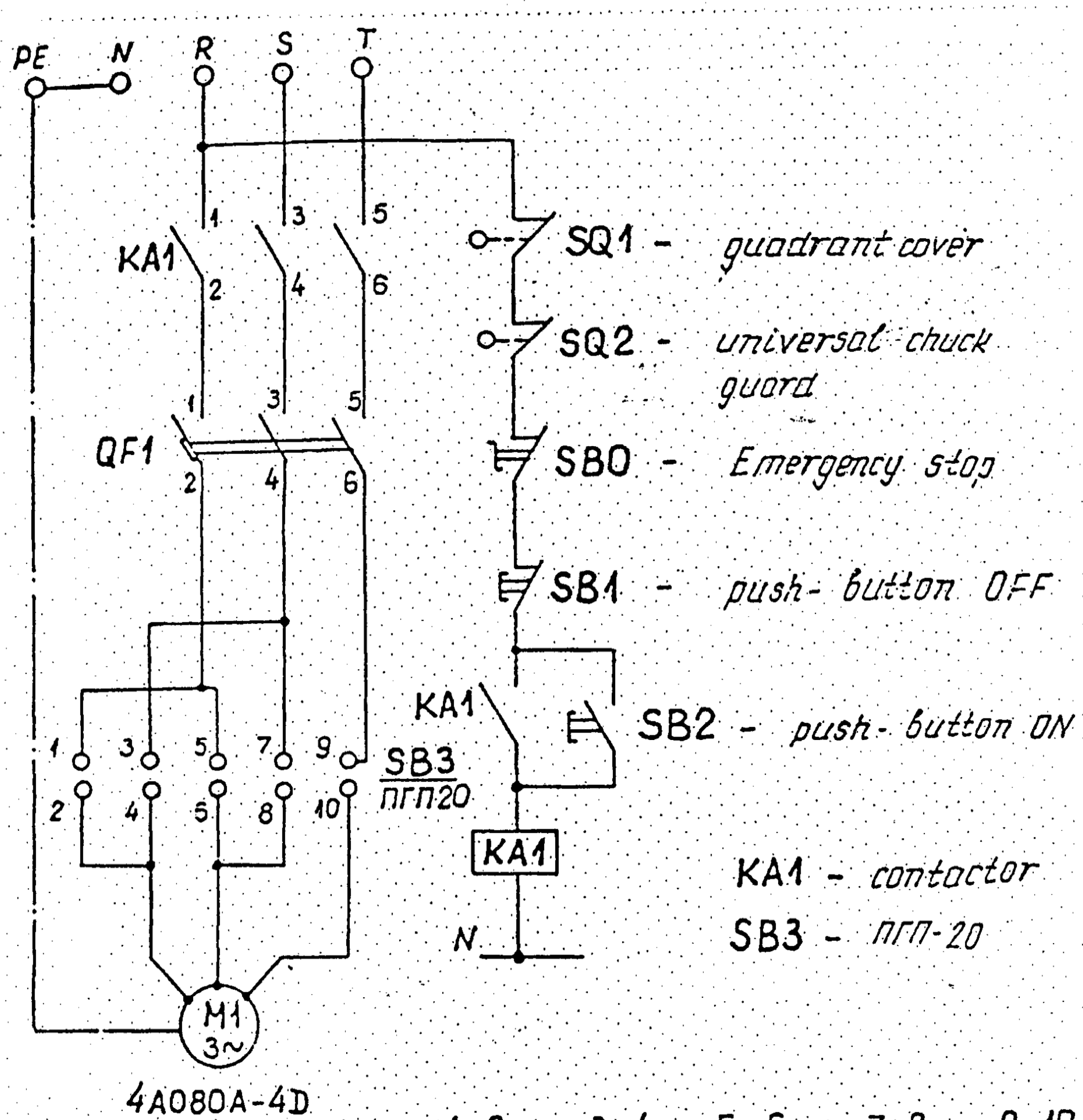
Note that the unit carrying the START and STOP buttons (items 16 and 17) may on some machines be located at the headstock end.

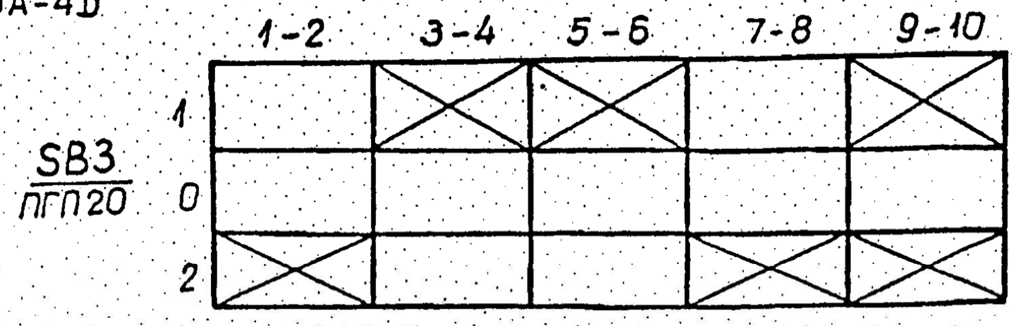


SB3
ПГП-20

	1-2	3-4	5-6	7-8	9-10	11-12	13-14
1	X	X			X	X	
0							
2	X		X	X	X		

Figure 2 Circuit Diagram - Single Phase Supply





Connecting diagram of ПГП

Figure 3 Circuit Diagram - Three Phase Supply

ELECTRICAL SYSTEM

The lathe is supplied with an electrical control box with push button switches for START (green) and STOP (red). Pressing the START button arms the circuit to the motor, but which will not start until the circuit is completed by operation of the handle on the machine headstock. Movement of the handle to the right sets the machine rotating in an anti-clockwise direction (when viewed from the tailstock end); this is generally referred to as 'forward' drive and is the normal rotation used for most operations. Movement of the handle to the left provides 'reverse' drive by changing the direction of rotation. When the handle is placed in the upright position rotation ceases. The circuit is still armed, however, until the red STOP button is pressed to unlatch the holding relay and render the handle selections ineffective.

Located at the right hand end of the lathe bed is a large red EMERGENCY STOP switch, colloquially referred to as the 'panic button'. As its name implies, it is intended to be used in the event of an emergency situation developing, such as the work or tool becoming jammed or should an accident occur to the operator. When operated, this switch breaks the supply to the control unit, thus causing the 'start' circuit to become unlatched.

Use of the EMERGENCY STOP button does not affect the setting of the drive selector handle at the headstock. Therefore as soon as possible after use of the switch the handle must be returned to the upright (no drive) position.

> Never attempt to start the lathe by pre-selecting the direction of drive and then using the START button. Always arm the motor circuit with the START button and then select the direction of drive.

Microswitches are incorporated under the cover of the quadrant casing and on the universal chuck guard. If either of these covers is in the open position, the microswitch contacts are also open and no current can flow to the 'start' circuit. Close the cover and chuck guard before operating the START button.

Electrical circuit diagrams are shown at Figure 2 (single phase) and Figure 3 (three phase).

SPEEDS AND FEEDS

The drive from the motor to the spindle employs a two-stage belt and pulley system (Figure 4). Changing the positions of the belts on the stepped pulleys gives a range of nine spindle speeds. The intermediate pulley axle is provided with a sliding movement to allow the tension on the drive belts to be relaxed when speed changing is required. This sliding movement is controlled by a hand lever located on the upper right face of the drive guard towards the rear of the machine. One movement of the lever, either side of vertical, operates a cam to push the pulley axle towards the centre line of the motor/spindle drive. The lever is returned to the vertical position to tighten the belts fully once the required speed selection has been made.

While the lathe is supplied with the drive belt tension correctly set, after a period of use the belts will tend to stretch a little and lose some of their tension. A screw adjuster is provided between the cam and pulley axle to enable the correct tension to be restored. Correct tension can be sensed by pressing a finger on the drive belt, without undue pressure, when a displacement of 10 to 12 mm should be noted. If there is more than this amount of movement, then the

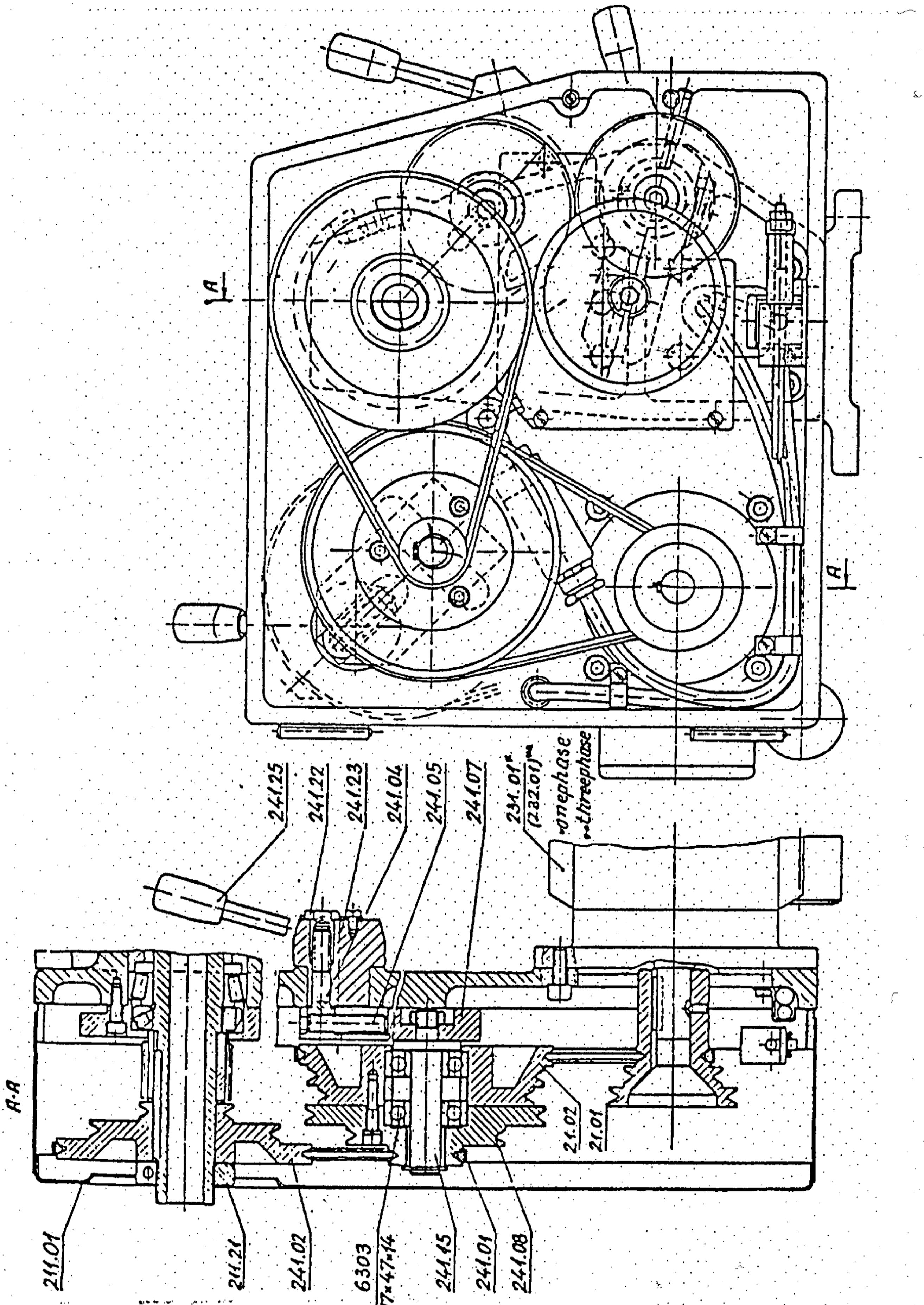


Figure 4 Drive Arrangement

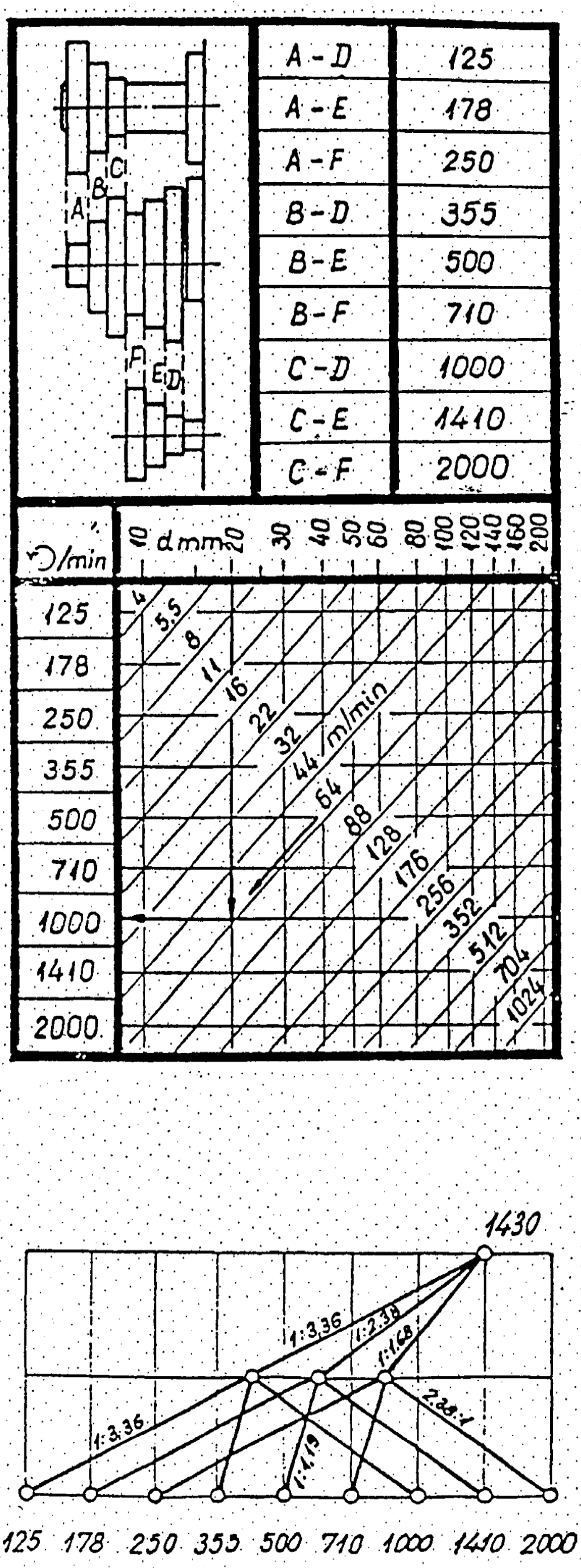


Figure 5 Speed Selection Chart

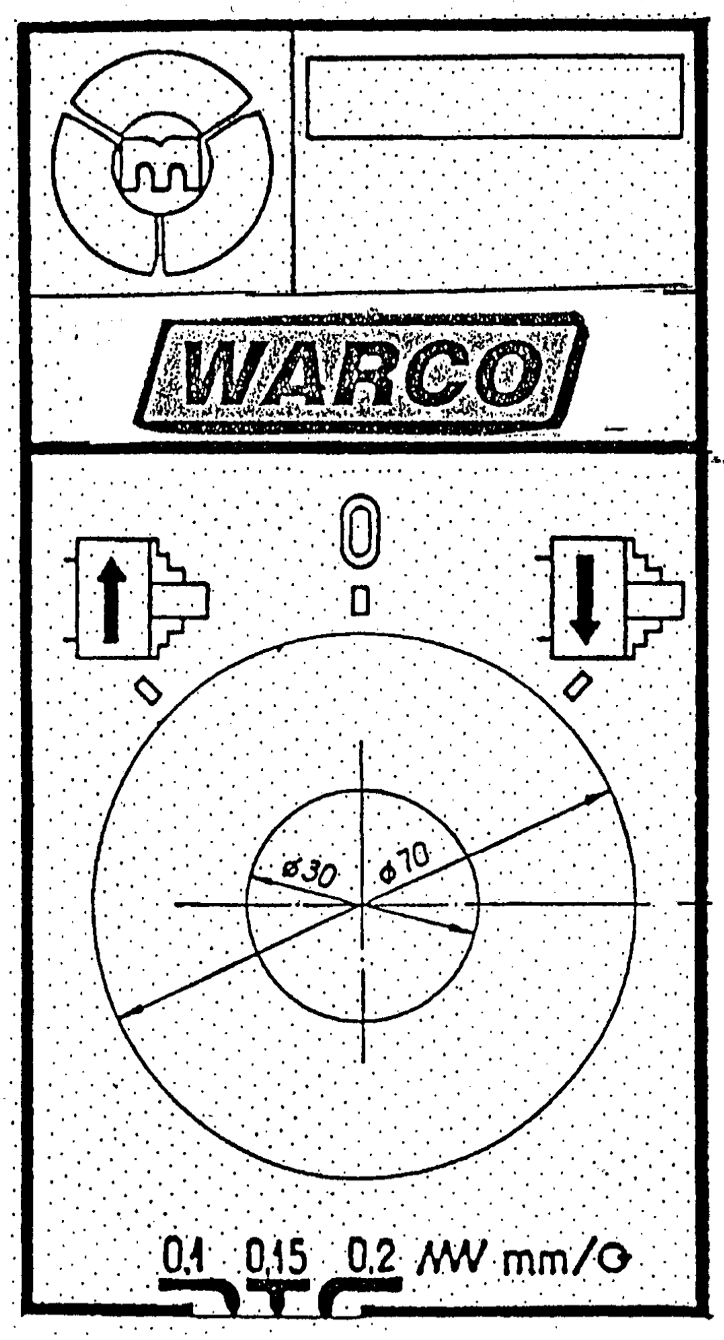


Figure 6 Forward/Reverse and Rate of Feed Selection Label

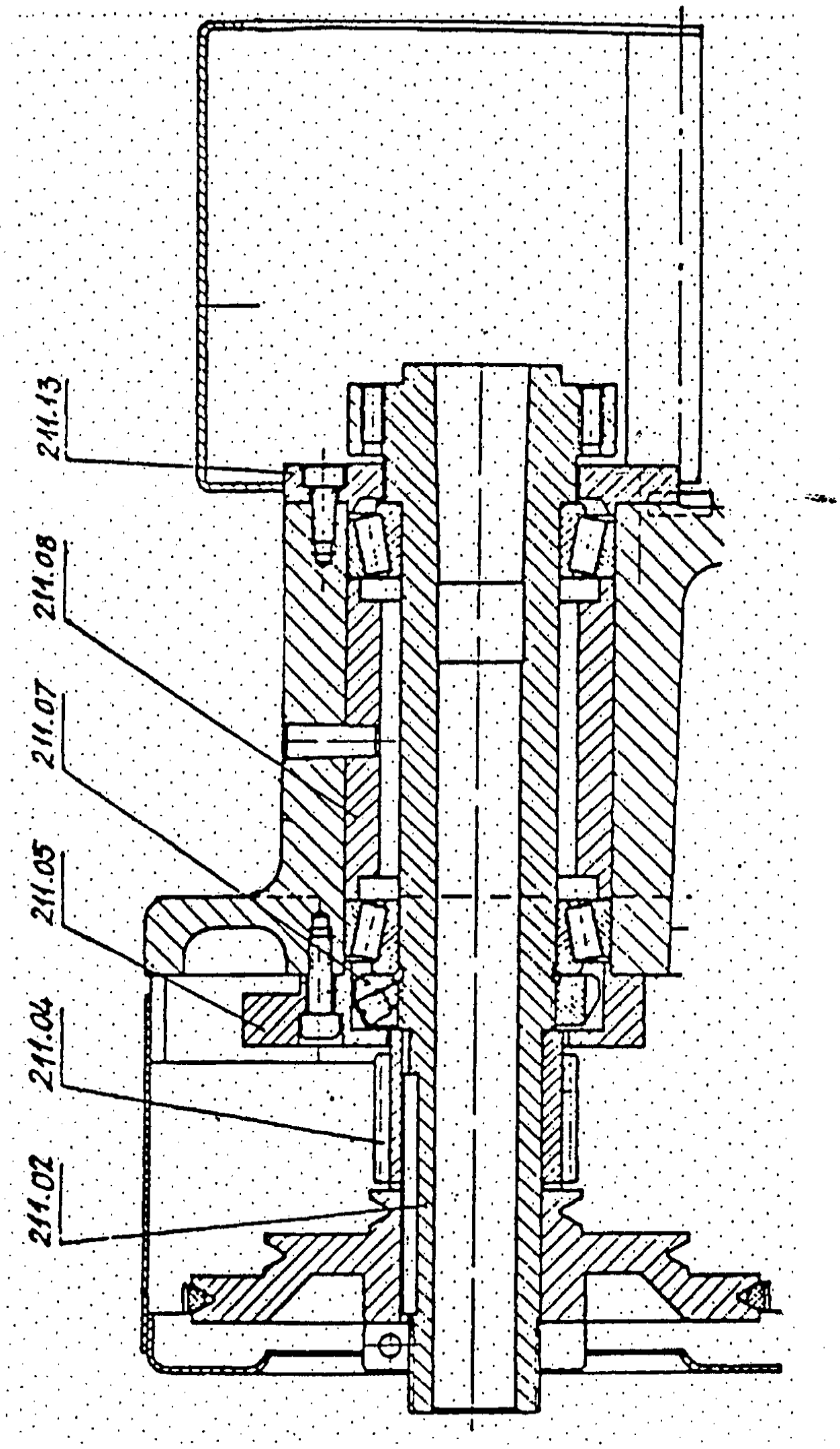


Figure 7 Spindle Assembly

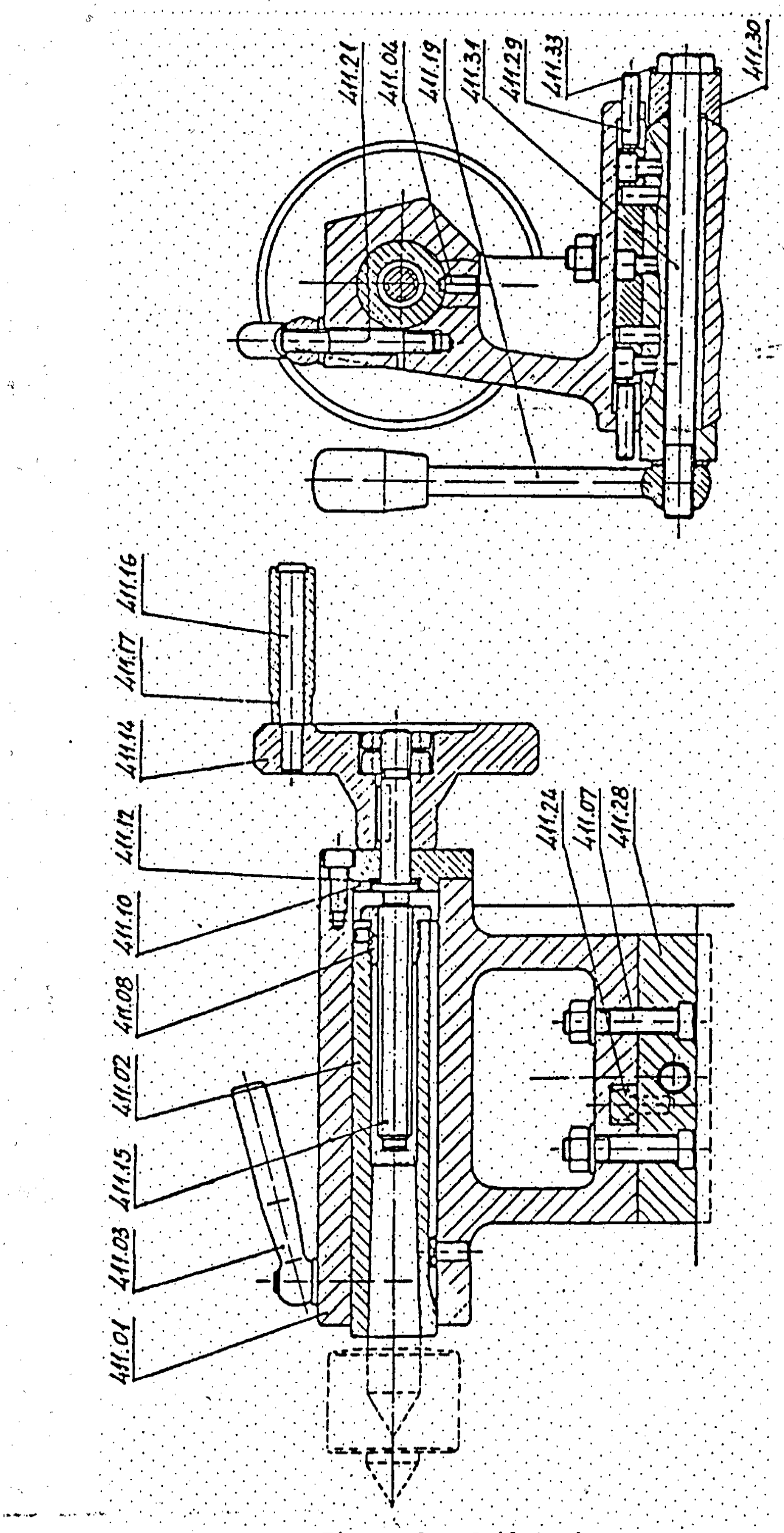


Figure 8 Tailstock

adjuster screw should be turned anticlockwise (unscrewed) to pull the axle the required amount. It is possible that the tension in the belts will differ slightly; in this case, since there is no independent adjustment, a compromise tension will be necessary but this should not be widely different from the desired figure.

Good machining results depend to some extent on the correct rotational speed for the lathe spindle according to the type of metal being machined and its effective cutting diameter. The larger the diameter of the material then the slower the spindle speed should be. Similarly if a harder material is to be turned then this too will require a slower speed. For example, if mild steel of 50mm (2 inch) diameter is being turned then this will require a slower speed than if the diameter were 12mm (½ inch) diameter. However, brass of 50mm diameter will require a spindle speed higher than that used for the equivalent piece of steel. A chart (Figure 5) is fixed to the front of the quadrant cover that gives a guide to the speeds suitable for the various diameters.

There are three different speeds, or rate of feed, for normal turning operations when the tool is traversed along the length of the work. These speeds are selected and engaged by a lever located below the forward/reverse lever on the headstock cover. The lever is moved down to engage the feed and sideways to the position required to achieve the speed indicated on the casing (Figure 6), which shows the amount of feed per revolution of the spindle. The most suitable rate of feed for the material being machined will probably best be found by trial and error. A smoother finish is more generally obtained with a finer feed but again, with the softer metals, a faster feed can often be used.

HEADSTOCK (Figure 7)

The headstock spindle, or mandrel, runs in two taper roller bearings that are pre-tensioned on manufacture and packed with heavy-duty grease and in normal use will not require any attention.

The mandrel nose is stepped for location of chucks and faceplate and these are retained by six cap head screws. This provides a very secure type of fitting which prevents the chuck from unscrewing when the machine is operated in reverse drive.

At the rear of the headstock the final drive pulley and pick-off gear for the screw cutting gear train are keyed to the mandrel.

The spindle is bored through 20mm (¾ inch) to accommodate long bars up to this diameter and there is a No.3 Morse taper socket at the mandrel nose for centres and other accessories.

TAILSTOCK (Figure 8)

The tailstock provides a means for holding work and tooling at the opposite end of the lathe to the headstock and may be positioned anywhere between the saddle and the bed end; at its extreme position it provides a between centres distance of 508mm (20 inches). Unlike the headstock, however, its centre member (the quill) is non-rotating.

It has three controls; at the rear the larger handle locks the tailstock in position on the lathe bed, while the smaller lever locks the quill in position

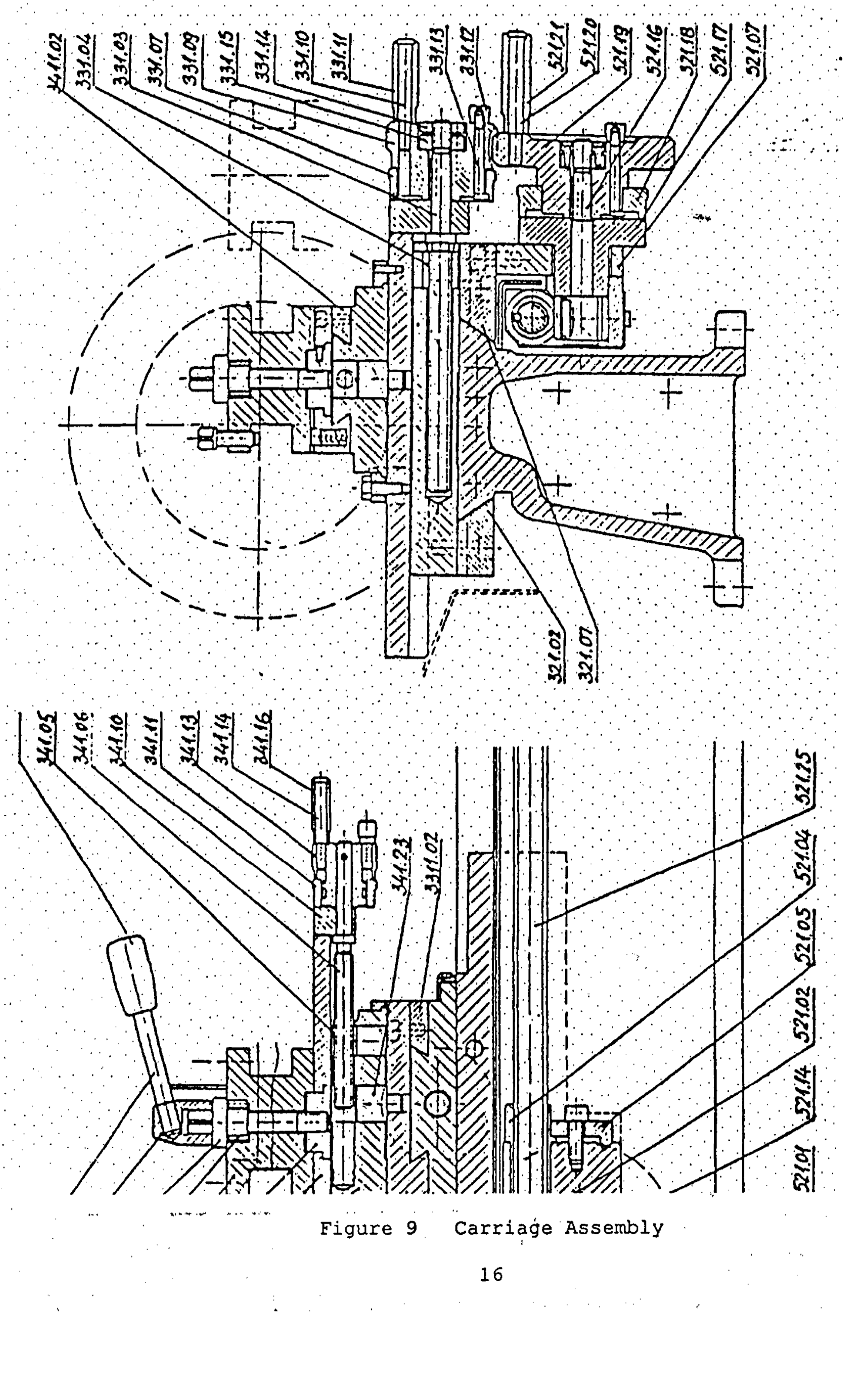


Figure 9 Carriage Assembly

when using a centre or for a similar operation. The third control is a handwheel, which drives a screw acting on the quill to extend and retract it; a key prevents the quill from rotating as the wheel is turned. The quill has a No.2 Morse taper socket to receive centres, drill chucks, drills and other accessories. These items are self-ejected when the quill is fully retracted by the action of the end of the taper shank coming into contact with the drive screw. This obviates the need to use a drift or similar tool when changing tapered tooling.

For turning long tapers the tailstock can be set over on its base. There are two locking bolts which are first released and then the amount of set-over is controlled by two long grub screws, the one on the side to which the set-over is required is first released and then the other adjusted to push the tailstock over the desired amount. The first screw is then re-tightened, followed by the locking bolts to secure the position. When returning the tailstock to its centre position it will be necessary to check and perhaps make further adjustments to ensure that accuracy is obtained for any subsequent work.

CARRIAGE (Figure 9)

The carriage assembly comprises three slides, the lower of which has a sliding movement along the lathe bed. To the front of the carriage is attached the apron assembly with the handwheel for rapid movement of the carriage along the lathe bed. The handwheel drives a pinion acting on the leadscrew that, in effect, becomes a rack in this mode of operation. In screw cutting and fine feed operations the handwheel shaft remains stationary, the pinion acting as a screw follower to drive the carriage along the bed. Adjustment clearance along the dovetails of the lathe bed is provided by a moveable strip at the front of the carriage to which the apron is attached. The strip incorporates both clamping and adjusting screws.

The cross slide has a range of movement of 100mm (4in) and has manual feed only via a handwheel and feed screw. The handwheel dial is calibrated in both metric and imperial units. Slide adjustment is again provided by a moveable dovetail strip.

The top or compound slide is located on a centre pivot on the cross slide to give a full 360ø of movement, its base being clamped to the cross slide through a graduated clamping ring. Slide travel is 70mm (2¾in.) through a manual feed similar to the cross slide and having similar slide adjustment.

A four-way indexing tool post is attached to the top slide and this can be set in any required position. The tool post handle locates over a square drive clamping nut and once the tool is set in position the handle may be removed.

STANDARD EQUIPMENT AND ACCESSORIES

Three-Jaw Chuck

The three-jaw self-centering chuck is supplied as standard equipment and is complemented by a range of additional accessory items, each of which is described in detail.

The chuck is conventional in style and operation and can hold round or hexagon stock accurately and firmly. Hand tightening only, using the chuck key supplied, is all that is required to exert sufficient force to secure the work. Under no circumstances should additional leverage be applied to the chuck key or any other means used to obtain additional tightness from the chuck jaws.

A fitted backplate provides the means of attachment for the chuck to the lathe. It is secured to the chuck rear face by three bolts and to the lathe spindle by six cap head screws (Allen screws). In order to remove the chuck from the lathe it is first necessary to separate it from its backplate. It is advisable to mark the chuck and backplate in some way to ensure that the original relationship is retained when they are re-assembled.

The jaws may be removed completely from the chuck body and replaced by a set of outside jaws for holding larger diameter work. It should be noted that the outside jaws have a reduced gripping surface and therefore should only be used when the work diameter is outside the range of adjustment of the normal jaw set. Both sets have the individual jaws numbered to correspond to the markings on the chuck body and must always be replaced in their correct locations and in the correct sequence. Start with jaw No.1 and observe the action of the scroll screw through the jaw slideway when the chuck key is turned. When the lead-in for the screw appears for No.1 jaw, turn the key back about a quarter of a turn, lightly press the No.1 jaw down to the screw to engage the jaw then continue turning until the lead-in is observed at the No.2 slot. Similarly fit jaws No.2 and No.3.

From time to time the jaws should be removed and cleaned and at the same time the threads in the scroll screw should also be cleaned. The locating recess in the backplate must be wiped clean, preferably each time the chuck is removed, as small particles of swarf will tend to get trapped causing rapid wear and lack of concentricity.

Four-Jaw Chuck

Unlike the three-jaw chuck the jaws on the four-jaw chuck have individual adjusting screws and each jaw is set independently of the others; thus it is not self-centering and makes it possible to hold square and rectangular bar stock, as well as irregularly shaped work pieces. Because of the individual action of the jaw setting screws it is possible for the jaw to exert more pressure on the work piece. Also unlike the three-jaw, which has a replacement jaw set for large diameter work, the jaws of the four-jaw are reversible in their slides.

Due to the independent action of the jaws some initial difficulty may be experienced in setting the work to run true. This is usually overcome quite readily with just a small amount of practice setting. The approach is to set the work as accurately as possible by eye, referring to the steps on the chuck jaw in relation to the engraved rings on the face of the chuck body. Having achieved an initial setting the lathe spindle is rotated by hand with the work revolving close to, but not actually touching, a scriber point, lathe tool, or similar pointer held in the tool post. As the work is rotated it will be readily seen where the work passes closest to the pointer. By loosening the jaw immediately opposite the closest point by a small amount, and tightening the jaw nearest, the work piece will be moved bodily towards the centre. It may be necessary to do this a number of times, at any of the jaw positions, in order to achieve maximum accuracy. A much greater accuracy can be obtained by using a dial test indicator (DTI) against the work to detect the out-of-centre errors.

The DTI indications will be found much easier to observe in addition to providing the enhanced accuracy.

With the feature of the jaws on a four-jaw chuck being reversible, a wide combination of settings is possible, whether all internal, all external or a mixture of any. This is particularly useful when it is necessary to hold irregular shapes. Another aspect of the feature is that work may be deliberately set off centre if required. It should be noted in these applications, however, that an off-centre setting will usually result in the work being out of balance and vibration will result, particularly if a higher speed is required. It is usual in this case to reduce the spindle speed slightly from the normal desired cutting speed for the material in order to reduce the vibration induced.

The method of fitting the four-jaw chuck to the lathe spindle nose is identical to that of the three-jaw, using a dedicated backplate and cap head screws. Similarly, attention to cleanliness should be given when removing and refitting the chuck. The jaw setting screws should be kept lightly oiled.

> Caution: The four-jaw chuck is bulkier and heavier than the three-jaw and care should be taken to ensure that it does not drop on to the lathe bed, or the operator, during removal or refitting. A piece of thin wood over the bed will help to prevent damage should the chuck be allowed to fall.

Faceplate

The faceplate is used for machining large and awkward shapes, such as castings, and items that may be too large for either of the chucks. It is attached to the lathe spindle with cap head screws in a similar manner to the chucks but without a separate backplate. It is checked for accuracy and balance before leaving the factory and no built-in adjustment is provided.

The work piece to be machined is attached to the faceplate through the three tee-slots or the three plain slots, or a combination of either. For reasons of safety, it is essential that the work be secured in at least three places, preferably equally spaced over the work area. Obviously, the shape and size of the work piece in relation to the slots and the desired centre will dictate the actual clamping positions. Always use correctly made tee-bolts in the tee-slots for clamping. The use of ordinary bolts could cause the casting to fracture due to the bolt heads not providing a sufficient load spread.

The faceplate can also be used as a driving plate, when work is needed to be turned between centres, by fitting an extended bolt firmly through one of the open slots to engage with a projection or dog clamp on the work.

Fixed Steady (Figure 10)

Where the work piece is long and overhangs the chuck jaws by a considerable amount, it is necessary to have some form of support to the free end of the work. It is not always practicable or desirable to provide a centre recess for tailstock support and an alternative is the three-point, or fixed, steady. This device clamps to the dovetails of the lathe bed and should be located as close as is practical to the point where the actual cutting is to take place.

The top of the steady is hinged at the rear and may be swung back, or removed completely, for easy insertion of the work piece. The capacity of the steady

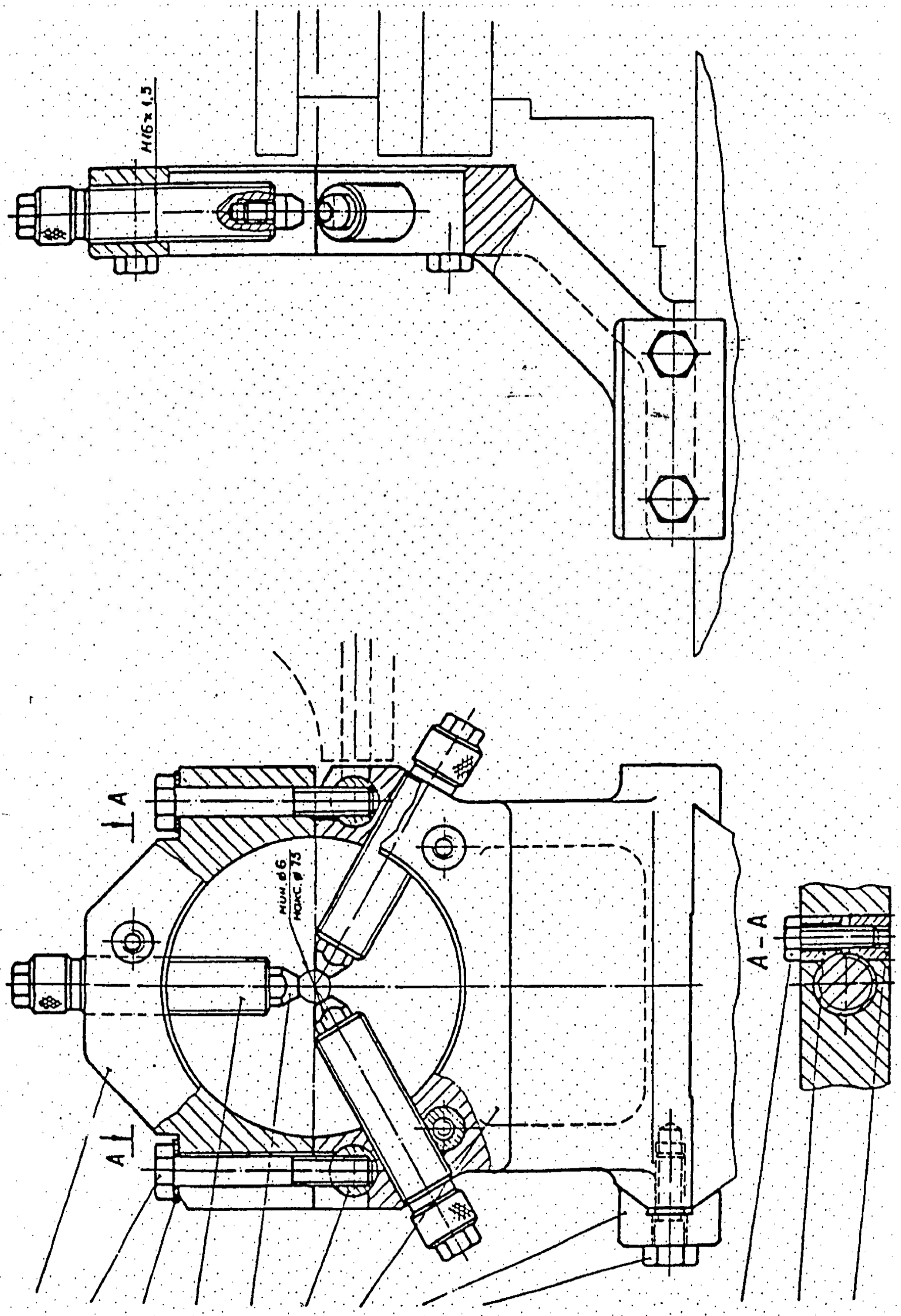


Figure 10 Fixed Steady

ranges from a minimum diameter of 6mm (¼in.) to a maximum of 75mm (3in.) and adjustment of the jaws to take up the diameter of the work is made by releasing the clamp screws and turning the knurled ends of the jaw screws; re-tighten the clamp screws when the required adjustment has been made. The jaws have replaceable bronze tips to give minimum friction when correctly adjusted. Care must be taken not to over-tighten the screws as undue friction will be generated and the work may be distorted. A light smear of oil should be placed on the work where the jaws make contact to prevent overheating and/or damage to the material.

Vertical Slide (Figure 11)

Light milling operations may be undertaken on the lathe through the facility of the vertical slide, which provides an additional range of movement (vertical) to the carriage assembly. It consists of a slotted table, similar to the lathe cross slide, and is bolted to the cross slide through a substantial right-angled bracket. This bracket has a circular recess on the front edge (nearest the operator) to clear the lathe top slide. The handle on the top of the assembly allows the table to be raised and lowered and carries a dial graduated in both metric and imperial units.

The table has three tee-slots arranged vertically with a removable special machine vice. The jaws of the vice may be clamped at any position on the table face, or may be removed altogether to allow the work to be clamped direct in the tee-slots. The fact that the lower jaw of the vice is separate from the main body gives an increased flexibility over the usual one-piece type. The lower jaw has a vee-groove opposite the normal gripping face so that it may be reversed to grip round bar or irregular shaped material.

The vertical slide may also be used for purposes other than milling. For example it may be preferable to clamp the work to the slide for drilling and/or boring operations. This allows for the use of larger drills and boring tools than could be accommodated in the tailstock. More accurate bores can sometimes be obtained by use of a boring bar mounted between lathe centres and the work clamped to the vertical slide.

Collet Attachment (Figure 12)

The collet chuck provides a very accurate method of holding round or hexagon bar and is most useful where a number of similar components are to be made from the same size stock material; it allows rapid securing of the bar by the simple action of closing a single lever.

The device consists of three major parts; the collet holder, the main body and the cap. When assembling the unit it may be found easier to clamp the main body first and then fit the collet holder.

The collet holder is attached to the lathe spindle by using three of the six cap screws that are used for securing the faceplate and chucks.

The main body clamps over the end of the lathe spindle and necessitates the removal of the indexing device, if fitted. As the body is pushed over the collet holder it presses down a trigger in the holder to tighten the collet.

The third item is the cap, which is screwed to the attachment after fitting the collet. Collets are available in a range of sizes for both metric and imperial sizes of bar.

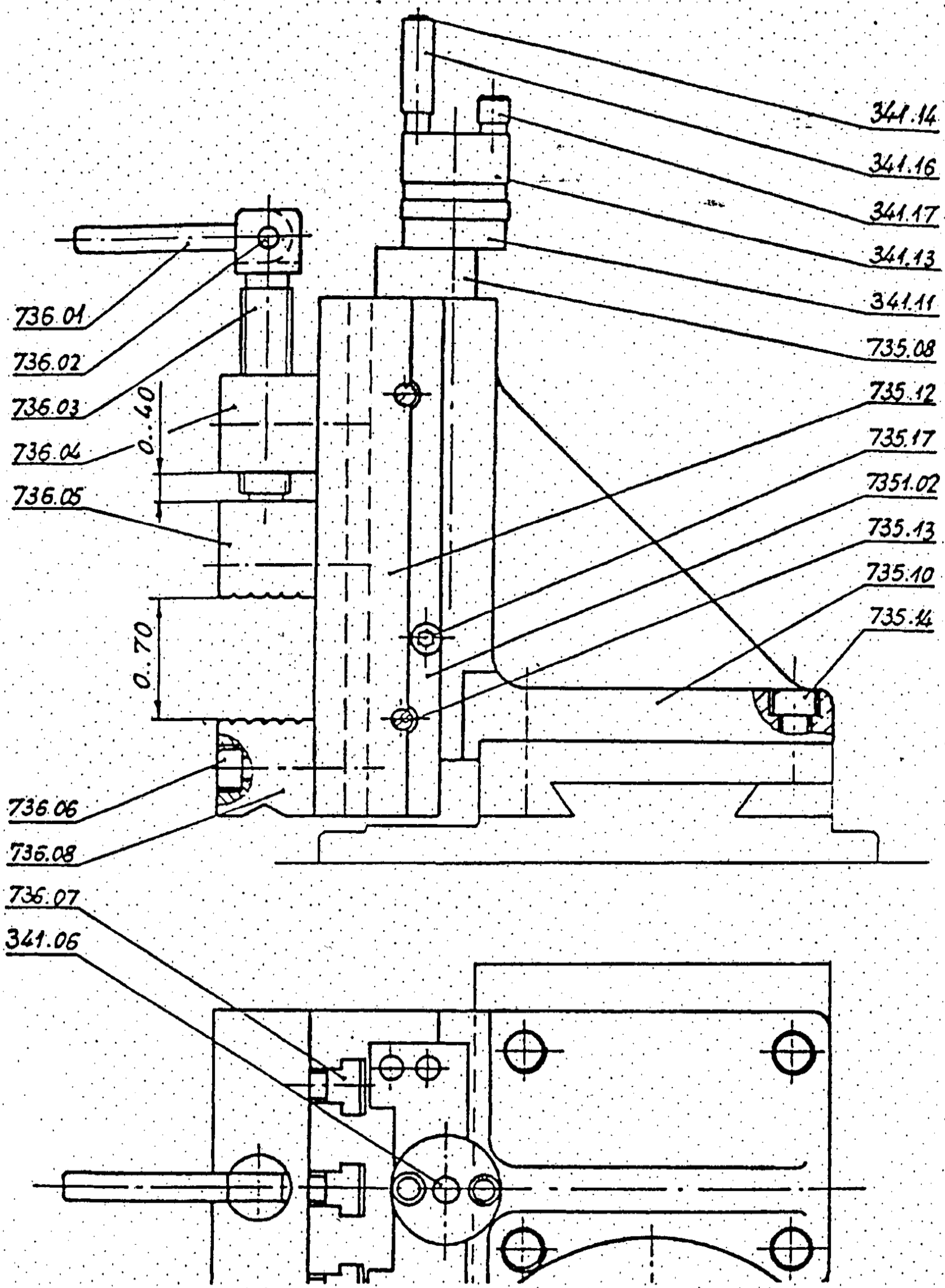


Figure 11 Vertical Slide

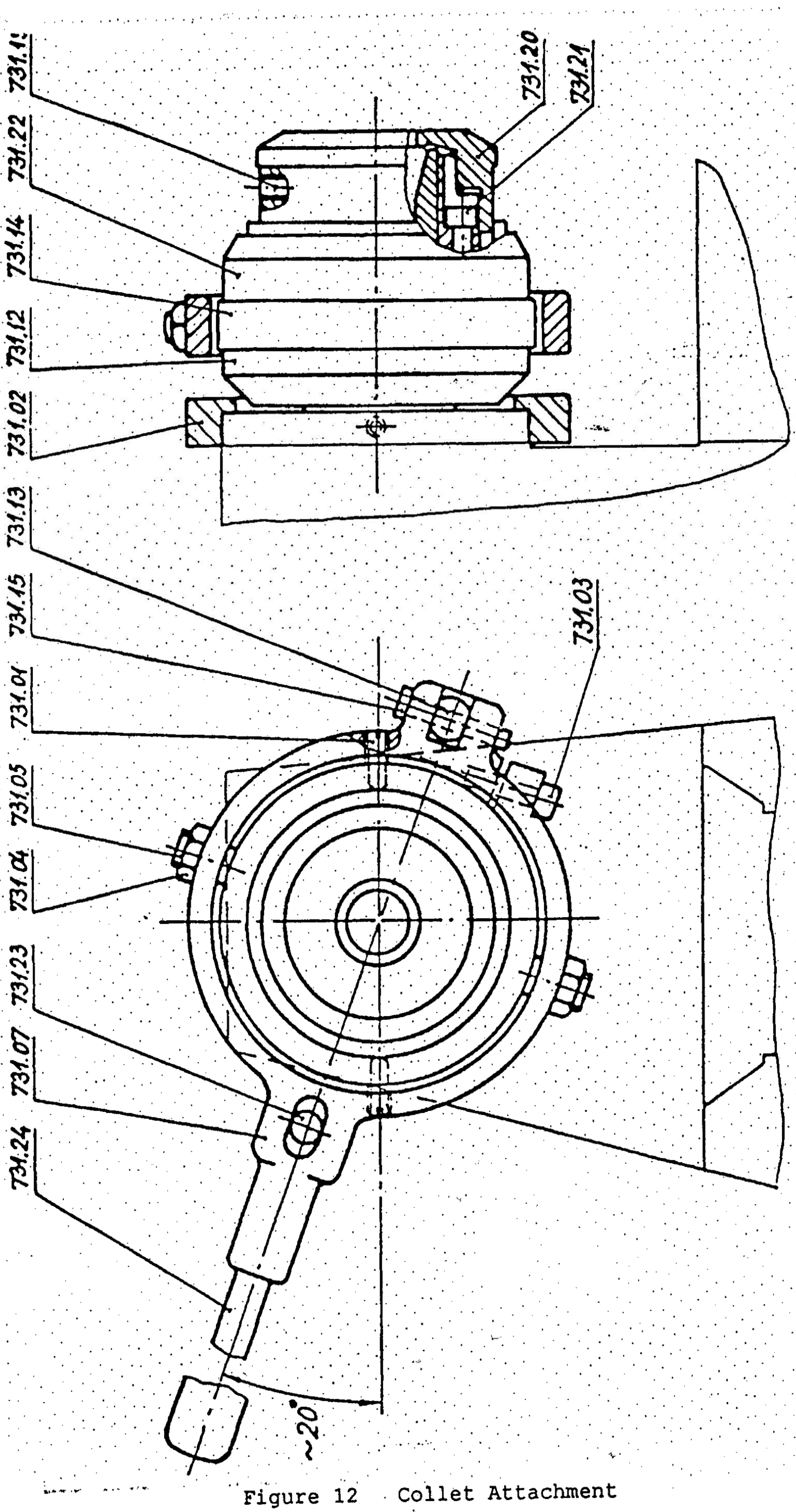


Figure 12 Collet Attachment

Changing from one collet size to another is accomplished by simply unscrewing the cap and sliding out the collet. The replacement collet is then entered in the holder and the cap re-tightened. Only hand pressure is required for tightening purposes.

In use the bar is clamped in the collet by simply pulling the handle towards the quadrant cover and released by pushing the handle towards the tailstock.

Index Attachment (Figure 13)

Provision is made for an indexing device on the mandrel nose, consisting of a series of detent holes on the periphery and a detachable spring-loaded detent plunger located on a bracket under the nose. The twelve holes provide accurate divisions of 30°.

The device is of particular use to the model engineer and hobbyist as it permits correct spacing of holes on any pitch circle up to the maximum capacity of the lathe. It can be used in conjunction with a centre punch or scriber mounted in the tool post or with a separate drilling attachment fixed to the cross slide. To maintain accuracy and ensure positive location of the detent plunger it is necessary to keep the detent holes clear of any swarf. The mechanism should be lightly oiled.

Bracket for Portable Drill (Figure 14)

A simple bracket is available to facilitate the fitting of a portable electric drill to the lathe. The bracket features a split clamp to locate over the nose of most types of small portable electric drill. The tail of the bracket clamps in the lathe toolpost. A rigid and constant fixing is therefore provided for radial drilling when used in conjunction with the index attachment.

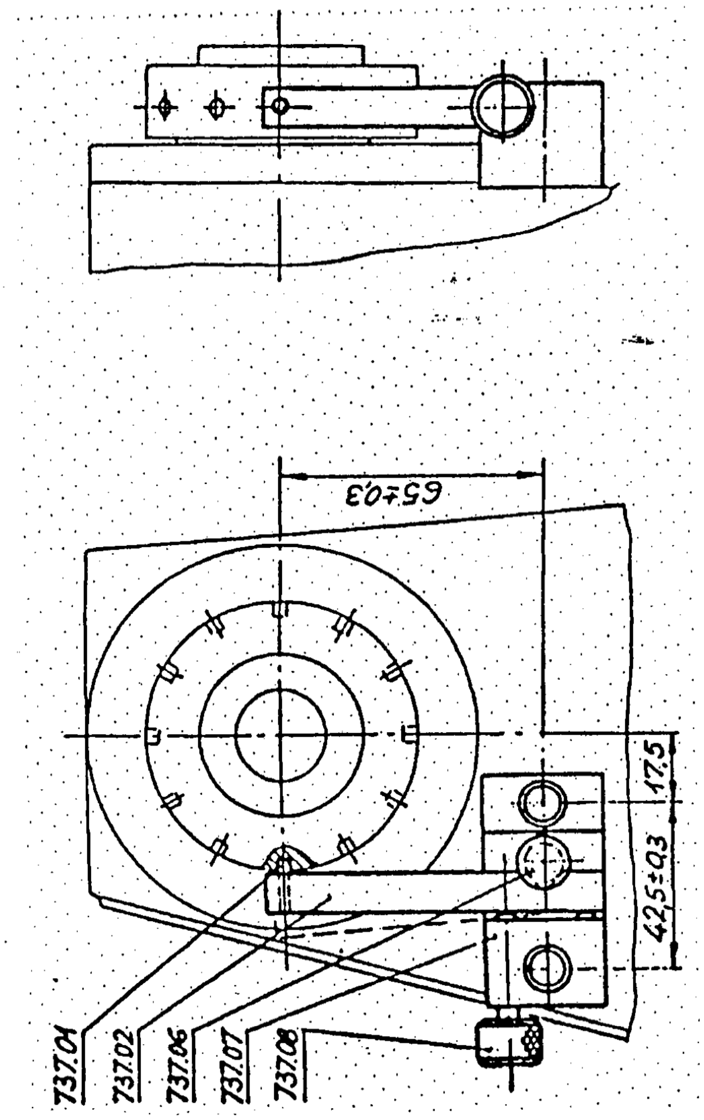


Figure 13 Indexing Attachment

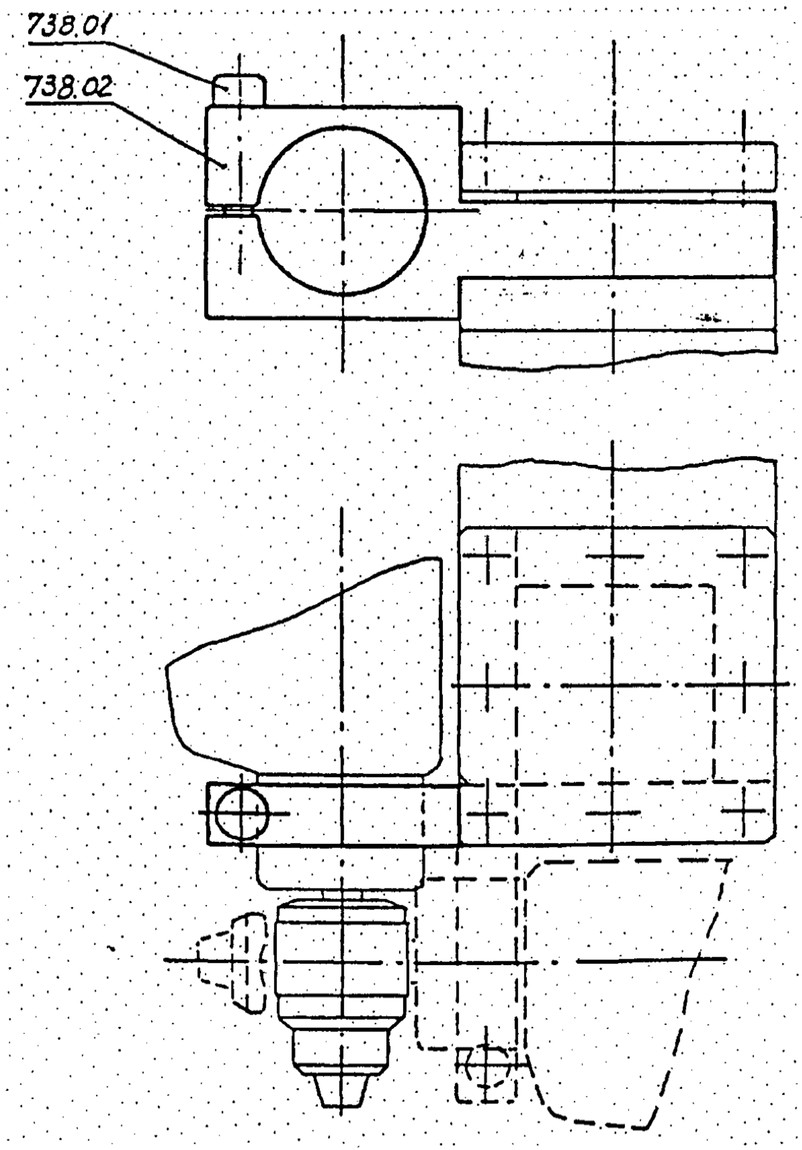


Figure 14 Portable Drill Clamp

INSTALLATION

Before attempting to install the machine read these instructions carefully.

> The lathe weighs 125 kg (275 lb) as delivered and the use of lifting gear is strongly recommended to effect safe installation. The use of a workshop crane and slings, overhead hoist or block and tackle equipment may be required. The complete machine is too heavy for single-handed manual lifting to be attempted.

In the event of there being no lifting gear available then the machine should be dismantled into manageable components to permit manual installation.

Unpacking

As delivered the machine is bolted to a wooden pallet and enclosed in a wooden packing case.

Remove the steel straps that secure the corners of the case, then lever off the top of the case. Similarly remove the sides of the case and place the removed sections clear of the working area.

The four bolts that secure the machine to the pallet will be used to mount the machine to the bench or cabinet stand. Remove these items and retain for use when completing the mounting.

Assembly

Check that the intended location of the assembled machine is level and free from obstruction.

The lathe can be mounted on a specially made stand, available as part of the range of optional equipment, or on a rigid wooden bench. Although the construction of the machine is such that normal levelling procedures are unnecessary, nonetheless every effort should be made to keep it as level as possible.

This should be borne in mind especially when preparing a wooden bench that will carry the lathe. In particular, the top of the bench must have sufficient strength to support the machine. It will also be necessary to place a metal plate under each mounting foot on the lathe bed, each plate to be pre-drilled 9mm diameter to accept the holding down bolts. These plates should be about 75mm (3in.) square and of minimum thickness 3mm ($^1/_8$in.). Similar plates, or large diameter washers, will also be required under the bench top to prevent the nuts drawing through into the woodwork as they are tightened. Although not essential, the plates and washers could with advantage be fixed to the wood surfaces using an epoxy resin once the exact positions have been determined. Extra rigidity may be obtained by bolting the bench to the wall, although this is usually not considered to be entirely essential.

The lathe should be bolted firmly but without excessive force to the bench using 8mm ($^3/_8$in.) diameter bolts through all four bolt holes. As far as is practicable the tension on all four bolts should be the same.

An oil resistant surface to the top of the bench, such as a plastic laminate or drip tray, should be provided to prevent the ingress of cutting fluids and other oils into the wood itself.

Where the optional cabinet stand is to be used, to ensure rigidity, it should for preference be bolted to the floor using minimum 8mm ($^3/_8$in.) foundation bolts. These may be located through the pre-drilled holes in the base of the cabinet stand or, alternatively, placed outside the slots in the stand base and cross straps used to secure the stand. The latter method is preferred if the floor is not truly level and packing is required to obtain the correct level.

A set of four machine mounting pads is available for situations where the machine can not be rigidly bolted to the floor. These pads incorporate a threaded adjustment to compensate for uneven flooring.

Carefully position the lifting slings about the ends of the lathe bed to provide the most direct lift when the hoist is operated. Begin lifting and be prepared to check any tendency to swing as the machine clears the pallet. Continue lifting until the base of the machine just clears the top of the cabinet stand or bench. Guide it carefully into position, then lower and secure with the four bolts removed when unpacking.

The nylon washers supplied with the fixings are best placed on the underside of the cabinet stand to minimise the tendency for cutting fluids or oil leaking through into the cabinet.

The lathe should be bolted firmly but without excessive force to the stand through all four bolt holes. As far as is practicable the tension on all four bolts should be the same.

Electrical Installation

Fit a suitable connector to the mains lead on the machine to permit connection to your mains supply. Single-phase machines must be connected to a supply having a rating of at least 13 amps. A normal domestic socket of this rating is suitable, but it is preferable that this socket should also be switched.

Do not switch on the supply to operate the machine until after the following cleaning and oiling has been completed.

Initial Cleaning and Oiling

When the lathe is supplied it is covered by a heavy grease-like material, which has been applied to protect the surfaces during transit and storage. Before operating the machine it is necessary to remove completely all this protective material. White spirit is an effective solvent for the grease but paraffin (kerosene) may also be used. Clean lint-free rags soaked in the solvent will remove grease from the accessible surfaces but a small brush will be found to give better cleaning in the more awkward corners and crevices. Particular attention should be paid to the mandrel as difficulty may be experienced later with mounting chucks etc if the preservative is not completely removed. The parts inside the quadrant cover should also receive attention as the self-act mechanism is friction driven and any foreign matter left on it could cause slipping to take place.

> Abide by all the usual precautions when using solvents and ensure that there is no solvent left on the machine when cleaning is complete.

Caution: Avoid getting any solvent on the drive belts or other rubber based parts. The action of the solvent would rapidly decrease the life of the component.

Apply a thin coat of lubricating oil to all exposed bright surfaces, paying particular attention to the mandrel nose, tailstock barrel and slideways. Apply lubricating oil to the oiling points depicted in Figure 17, Servicing and Maintenance.

Check the tension of the drive belts and rotate the mandrel by hand to confirm free movement. Check that all controls and movements operate smoothly throughout their entire range.

OPERATING THE MACHINE

A machine such as the Warco 220 lathe is perfectly safe provided it is used with reasonable care. However, there are a number of safety precautions - common to most workshop operations - which need to be taken. Therefore, before carrying out any form of machining operation the following safety considerations must be observed.

Wear protective goggles or shatterproof spectacles to protect the eyes from particles of swarf and dust that will be generated. In the event of any foreign matter entering the eye, stop the machine immediately and do not delay seeking first aid.

Do not wear loose items of clothing that could become entangled with the machine. Similarly, long hair should be tied back and any items of jewellery or other adornment removed. Long sleeved garments are preferred to provide some protection for the lower arms.

Do not wear light shoes or slippers when operating the machine. Wear boots or shoes, preferably with hard toecaps, which will protect against injury if heavy metal objects are dropped.

Always ensure that chuck keys are removed from chucks before starting the lathe.

Check that the work piece or cutters are securely mounted in the chuck or collet.

Check that the tool holder and cutter or work piece is securely clamped to the table or machine vice.

Do not leave pieces of metal, tools etc laying on the bed of the lathe in such a position that they can move into a rotating work piece, or be allowed to fall on to the operator's foot.

Avoid reaching over the lathe when the work or cutter is revolving; where filing or hand turning operations are necessary take the utmost care to prevent accidents. NEVER use a file or other hand tool without a properly fitted handle.

Be aware of and, as far as possible, keep hands clear of sharp cutting tools which are held in the tool post. The tool post will hold up to four tools at one time and when so fitted it is inevitable that cutting edges will protrude at awkward angles. It is recommended that safety caps be made for cutting tools and those tools fitted but not in immediate use be covered to minimise the risk of injury. Modelling clay or masking/insulating tape make effective covers.

Ensure that the working area around and over the lathe bed is adequately lit to prevent accidents through being unable to see.

Always wash after using any machine tool, particularly where cutting oils have been used, to avoid any danger of skin diseases. The use of a barrier cream before starting work is recommended.

GENERAL OPERATING DETAILS

At the start of each day's use apply the oil gun to all the lubricating points and ensure that the table and slideways are clean.

Observe all the safety requirements detailed above and select the drive belt configuration to give the rotational speed required for the material being worked and the cutting tool being used.

After completing operations for the day, disconnect the electricity supply to the machine and remove and store any cutting tools that have been used. Remove the work piece from the chuck, or clamps or machine vice (unless further operations need to be performed at the same settings on the following day, when it may be left in position). Remove all swarf from the machine, check that all cutting fluid has been drained, and then thoroughly clean the working areas. Apply a film of oil to the working surfaces, and then cover the machine to keep out dust.

TURNING OPERATIONS

Most turning operations will require the cutting tool to be mounted in the tool post and traversed along the work through the motion of the saddle. This motion may be achieved either directly through the handwheel or using one of the three automatic feeds. Rotation of the handwheel in a clockwise direction moves the carriage from right to left along the lathe bed.

A suitable cutting tool must be clamped securely in the tool post and it must be set so that the tip of the tool is at exactly centre height. A quick check of tool cutting height can be made by comparing it with a lathe centre held in either the mandrel or the tailstock. The experienced operator will probably make his own setting gauge to determine tool setting height. The following simple procedure will also be found to be effective:

1. With the lathe power switched off, position the tool tip close to the work but not touching it.

2. Insert a small steel rule vertically between the work and the tool tip, adjusting the cross slide as necessary until the rule is lightly trapped.

3. Observe the angle taken up by the rule; it should be vertical when the tool tip is exactly at centre height. If the tool tip is above centre height the top of the rule will lean towards the rear of the lathe, or to the front if the tip height is too low.

Usually the error will be on the low side and packing or shims will be required to bring the tip up to correct working height. In the unlikely event that an unpacked cutting tool is above centre height at the tip, it will be necessary to re-grind the tool and repeat the procedure.

Care should be taken when re-grinding lathe tools to maintain the correct angles on the tool faces. These angles are derived to obtain the maximum efficiency of cut and for clearance of swarf and chips from the work. It is not practical to describe here the various shapes and angles required for different cutting actions and materials; if the operator is unsure of the cutting tool required then reference should be made to a suitable textbook. Ready shaped tools are widely available should the operator not wish to attempt making his own.

Short lengths of cut can also be achieved by using the top slide (also referred to as the compound slide) but this needs to be set parallel with the lathe axis to ensure a parallel cut. In most cases the graduated dial on the base of the top slide, when set to zero, will produce an alignment of sufficient accuracy. Setting over the top slide to any of the graduations will produce a tapered cut at the indicated angle. Where more precise cutting is required, for example against a known taper, then the use of a DTI clamped in the tool-post will be required. This latter method is also useful for ensuring true parallelism for straight turning.

For machining across the work, known as facing operations, only the cross slide is used to traverse the tool - the other movements should be inhibited by locking the saddle and top slide. Tool settings are generally the same as for longitudinal turning.

Both the cross slide and top slide have graduated dials concentric with their feed screws and these are marked in both metric and imperial measurements. Each graduation represents one-fiftieth of a millimetre or one-thousandth of an inch according to the scale used; it follows that the larger markings represent multiples of these figures. These graduations allow accurate work to be accomplished without continual reference to other measuring facilities.

Note: Remember that in the case of advancing the cross slide each graduation on the dial represents the amount being machined from one side of the work only and the actual metal removed is double the amount indicated. For example, assume that a bar has been turned to a diameter of 20mm then, if the dial is advanced by 1mm, the resulting cut diameter will be 18mm.

A similar effect will be experienced when using the top slide at anything other than longitudinal machining. The amount of metal removed is proportional to the dial setting but is also related to the angle of set-over that has been made. The actual depth of cut could be determined by calculation or reference to mathematical tables, but in this case it is often more practical to proceed slowly and measure the result after each cut.

DRILLING AND BORING

In addition to the external turning and facing of material the generation of bores and recesses can be readily accomplished on the lathe. Small holes will normally be made using drill bits while the larger holes would normally be bored. Regardless of the diameter of the hole it will be found that boring operations will give a greater accuracy than if a drill bit alone were used.

Centering

Prior to any drilling or boring operation taking place a deep centre recess is usually required. For this purpose a centre drill, or slocombe drill as it is otherwise known, will be required. This type of drill bit is usually double ended with a narrow pilot tip and a main body of larger diameter. This configuration gives a drill bit of exceptional stiffness to provide the best possible accuracy. The drills are available in a range of sizes.

The more common usage will be when the work is to be held in the chuck or on the faceplate and the drill is to be held in a chuck at the tailstock. The position of the tailstock is adjusted along the lathe bed as required and locked by the lever at the rear. Rotating the handwheel at the rear of the tailstock moves the quill or chuck towards or away from the work.

With the work accurately set to the required centre, the centre drill is brought up to the work and carefully fed into it until the pilot tip is completely recessed in the work. Continue drilling until the cone on the main body is in the work to approximately a third or half its diameter. The actual depth will depend on the required diameter of the following drill bit, although it is permissible to go to the full diameter of the body. Do not go any further as the centre drill has only very short flutes for the clearance of swarf. A breakage of the drill will damage the work and the broken tip may prove difficult to remove.

Drilling

Drilling in the lathe is usually undertaken by mounting the drill bit in the tailstock. Drills up to 12mm (½ inch) diameter can be accommodated in the tailstock chuck but larger drills, with taper shanks, would be fitted direct in the No.2 Morse taper recess in the tailstock quill. A drill sleeve adapter may be used to allow for the use of drills having No.1 Morse taper shanks but, since these drills are usually of a working diameter that will fit in the drill chuck, its use would not normally be necessary.

Once the centre has been made, work can commence with the required size of drill bit. As with turning operations it must be remembered that speeds and feeds are proportional to the diameter and material being worked. With the larger sizes of drill it is often easier and advisable to start with a smaller sized drill, experience and convenience will dictate the size to be used, then follow with the enlarged size. It may be advantageous to use a series of drills of increasing size, particularly where holes of greater depth are required; for instance, should a 12mm diameter hole be required it may be prudent to start with a 6mm drill, followed by 9mm and then 12mm. When using drills to enlarge through holes, particular care should be taken with the feed pressure as the drill nears the point of breaking through to prevent the drill from snatching: damage to the work piece or drill could result should the drill be allowed to snatch. This applies particularly to the drilling of non-ferrous metals such as brass, copper and bronze.

Cutting fluids should be used with drilling operations in the same manner as in turning operations.

Reaming

Where greater accuracy of a hole size is required the use of a reamer is necessary. The hole is first drilled slightly under size, preferably leaving only about a tenth of a millimetre (a few thousandths of an inch) of metal to be removed by the reamer, though this may be dictated by the drills available. The correct type of machine reamer should be used and the lathe must be run at a slow speed for the operation to be wholly successful. Plenty of cutting fluid should be used if the material demands its use.

Boring

During drilling there is often a tendency for the drill to wander off line. This is due to a number of factors but the use of a centre drill helps alleviate this to some extent. It may be more noticeable where a series of drills are used to open out to a larger size, when the pressure on the less rigid lead drill may cause it to flex and wander. Subsequent larger drills then tend to follow the pilot bore and increase the amount of error.

To obtain really accurate holes then boring operations are called for. The hole is started in the normal way by drilling and opening out to a reasonable size. A boring tool is then mounted in the tool post and metal removed from the inside of the hole in a similar manner to a normal turning operation. The difference in this case is that the handle for the cross slide is wound out to increase the depth of cut and to take further cuts. As before the dials on the cross slide handle can be used to indicate the amount of metal being removed. Generally it is better to use a slightly slower rotational speed than when external turning and cutting fluids applied as necessary.

Where the work piece is of an awkward weight or shape such that it cannot be mounted satisfactorily either in the chuck or on the faceplate, it can be bolted to the cross slide for boring. This may be effected either by a cutting tool or boring head mounted on the lathe spindle or, if a through hole is required, by a between centres boring bar. As its name suggests, this type of boring bar is mounted between the lathe centres and driven from the lathe headstock and is a very accurate method. It has the disadvantage, though, that the tool bit must be adjusted accurately to obtain the required depth of cut and no built-in indication of depth is available. Once the correct settings for the tool and work are achieved, the cross slide should be locked for this operation and the cut is made by traversing the saddle over the lathe bed.

The boring head referred to above is not part of the lathe standard equipment or accessory range and therefore its detailed use is outside the scope of these instructions.

THREADING

It is often necessary to undertake threading operations in the lathe for which two standard methods are available. The first is similar to hand threading in that taps and dies are used, although more accurately aligned, and the second method is known as screwcutting - where the thread is generated by a cutting tool held in the tool post. Both methods require some knowledge of threads to be cut as they vary in pitch (the number of threads over a given length), depth and flank angles. It is necessary therefore to refer to one of the many available thread charts that give this information.

Using Dies

Where a male thread is required, that is a thread on the outside diameter of the component, the use of a die is most common. The die is mounted in a special sliding die holder, which is located in the tailstock taper. The tailstock is positioned so that the die is just clear of the work and the lathe spindle rotated very slowly, preferably by hand - especially for the smaller, finer threads. As the die contacts the work it will engage and start to cut; it will then be pulled along the work by its own cutting action and must not be pushed with the tailstock feed. As with hand threading it is advisable to proceed slowly, stopping the cut after two or three rotations, and reversing a part of a turn to break any chips that form before proceeding. Removal of the die from the work is a simple matter of reversing the rotation to cause the die to unscrew from the thread it has generated.

When using this method it is worth remembering two factors, the correct diameter for the thread and the tendency for soft metals to clog the die and damage the thread being cut. The first factor is easy to remember, as generally the quoted diameter of the thread will be the diameter that the component will first be machined to. However, where a thread such as British Association (BA) or pipe (BSP) is required, for instance, such a thread does not conform to the rule and the correct diameter will have to be obtained by reference to a suitable chart. When cutting the softer metals, such as soft bronze and some grades of aluminium, the effect of metal build-up on the die can be minimised to a degree. This may be accomplished by reducing the diameter of the work very slightly, perhaps no more than 5% of the thread depth - the actual amount being calculated from the relevant thread chart. When threading any metal other than cast iron a suitable thread cutting compound should be used.

Using Taps

A tap is used to make internal threads in a component, which it does by cutting into a pre-drilled hole of the correct size. There are three standard types of tap, of any thread form, and they are taper, second and plug (or bottoming) and refer to the sequence in which they are used. In most cases, starting with the taper tap it is possible to go straight to the plug tap to finish the thread. similarly, where the hole may not be very deep, it is equally possible to start with the second cut rather than the taper.

The internal, or root, diameter of the thread is the one to be considered when selecting the size of drill required to prepare the hole. Reference to the appropriate thread chart will provide the recommended drill size for the particular thread. Note that this is a recommended size and that the actual size used may be varied slightly to allow for type of material and ease of cutting. It is not uncommon to increase the diameter of the hole to give an effective thread depth of 70% of the tabled value where circumstances demand.

The tap is usually held in the tailstock chuck with the work rotating on the lathe spindle, or a sliding tap holder similar to the die holder may be used if preferred. It is also possible to reverse the situation with the work at the tailstock and the tap held in the headstock chuck. Again the work may be bolted to the cross slide and tapped from the headstock if the work lends itself to this method.

once the hole is correctly drilled the point of the tap is brought up to the work until it is felt to be just touching. If the tailstock chuck is to be used, then it is left loose and not clamped to the lathe bed; this is to enable the tailstock to be slid bodily but gently by hand to follow the thread of the tap as it cuts into the work. The lathe spindle should again be rotated very slowly, preferably by hand, and the procedure of reversing by part of a turn at frequent intervals to clear chips is essential. A broken tap in the work is almost impossible to remove! Once the full depth of the hole has been reached by the tap it may be withdrawn by reversing the lathe rotation. The next or final depth tap can then be used in a similar manner.

The flutes of the tap must at all times be kept free of swarf and a good cutting compound should always be used, both to ease the cutting action and to help with the clearance of swarf.

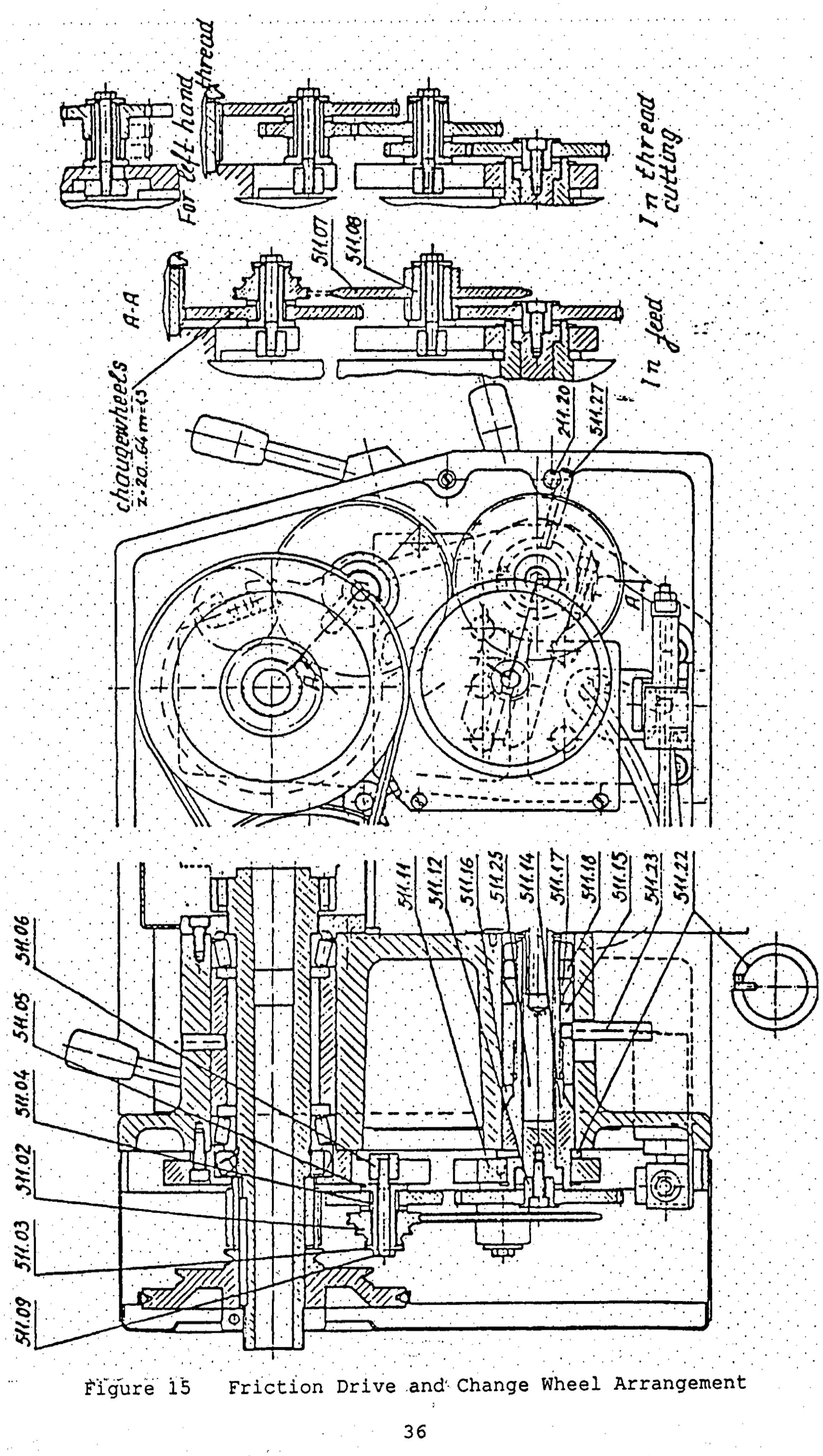
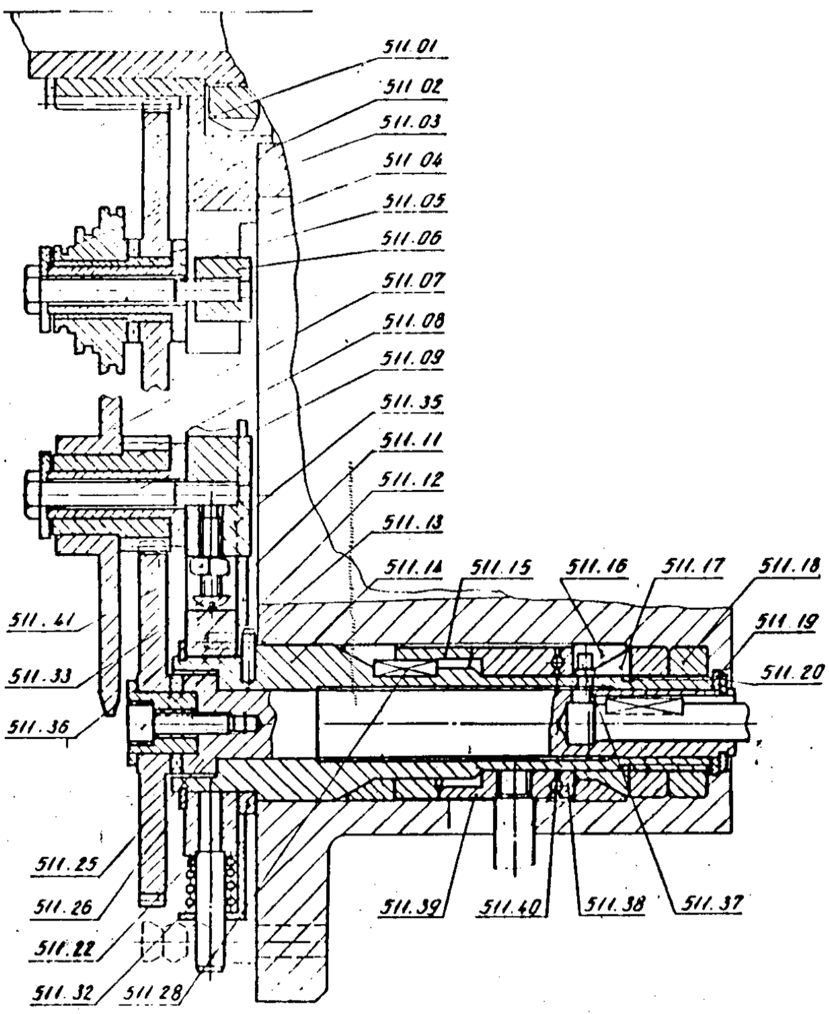


Figure 15   Friction Drive and Change Wheel Arrangement



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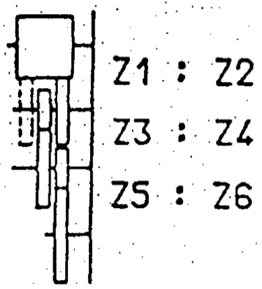

inch threads

~/1"	Z1	Z2	Z3	Z4	Z5	Z6
3	32	63	50	36	60	20
3,25	32	63	50	30	60	26
(3,5)	32	63	50	35	60	(24)
4	32	63	50	48	60	20
4,5	32	63	50	30	60	36
5	32	63	45	36	50	25
6	32	63	50	30	60	48
7	32	63	50	35	60	48
8	32	63	50	30	45	48
9	32	60		36	50	63
10	32	60		40	50	63
11	32	60		44	50	63
(11,5)	32	60	60	(46)	50	63
12	32	40		48	50	63
13	32	50		26	25	63
14	32	63	50	35	30	48
16	32	60	50	48	45	63
18	32	60		36	25	63
19	32	40		38	25	63
20	32	50		40	25	63
22	32	50		44	25	63
24	32	50		48	25	63
27	32	60	50	36	20	63
28	32	48	25	63	30	35
32	32	60	45	48	25	63
36	32	60	30	63	25	36
40	32	60	30	63	25	40

metric threads

~ mm	Z1	Z2	Z3	Z4	Z5	Z6
0,4	32	50	30	60	20	64
0,5	32	40	30	60	20	64
0,6	32	40	30	50	20	64
0,7	32	40	35	50	20	64
0,75	32	40	30	50	25	64
0,8	32	40		50	20	64
1	32	40	20	50		64
1,25	32	40	25	50		64
1,5	32	40	30	50		64
1,75	32	40	35	50		64
2	32	40		50		64
2,5	32	64	50	45		40
3	32	64	45	50		30
3,5	32	64	35	60		20
4	32	64	50	45		25
4,5	32	64	45	50		20
5	32	64	50	45		20
6	32	64	50	40	60	25
7	32	64	60	30	35	20
8	32	64	60	30	50	25
9	32	64	60	30	45	20
10	32	64	60	30	50	20
12	32	64	60	25	50	20

Module threads

~ m	Z1	Z2	Z3	Z4	Z5	Z6
0,2	32	40	30	50	20	61
0,25	32	40	30	50	25	61
0,3	32	40	20	50	45	61
0,4	32	40		50	30	61
0,5	32	40	30	50		61
0,6	32	40		50	45	61
0,7	32	50	35	61	60	40
0,75	32	61	45	50		40
0,8	32	50		25	30	61
1	32	60		20	30	61
1,25	32	61	50	40	45	30

Figure 16 Change Wheel Selection Chart

An alternative method of holding a tap, especially when greater sensitivity of feel is required, is to hold the tap in an ordinary tap wrench with the work remaining stationary. To ensure that the tap is correctly lined up with the work it may be held against a centre in the tailstock and very light pressure maintained to keep the alignment. A similar method may be used with a standard diestock if a suitable holder is not available for use in the lathe; in this case the open end of the tailstock quill can provide the backing for the diestock.

Screwcutting

The term screwcutting generally refers to the use of a specially shaped single-point tool held in the tool post to do the thread forming. The correct thread pitch is derived from the amount of movement of the lathe carriage and determined by a selection of gears on the quadrant (Figure 15). The depth of thread cut is obtained by advancing the cutting tool by the required amount.

The gears are set up to the pitch required according to the chart inside the lathe quadrant cover and reproduced here as Figure 16. A cutting tool shaped to the angle of the thread form to be cut is mounted in the tool post and is allowed to traverse along the work. The angular setting of the tool is important and may vary with the thread being cut; not all threads have the same angle and again these may be determined by reference to the appropriate thread chart.

For convenience the chart designations of the gears are Z1 to Z6, with Z1 being the driver gear on the lathe spindle and Z6 being the driven gear on the leadscrew. The sequence for assembling the gears is as follows:

1. Place gear Z6 on its stub shaft and secure to the leadscrew recess with the centre locking screw.

2. Assemble gears Z5 and Z4 on their stub shaft with a short spacer on the outside. Fit the assembled gear and shaft to the slot in the lower quadrant, with Z5 in mesh with Z6, and lightly clamp. Where a single gear is called for at this point it takes up the Z5 position with a spare gear of smaller diameter occupying the Z4 position to act as a spacer. Note that this spare gear must not mesh with or foul any other gear in the set-up.

3. Similarly assemble gears Z3 and Z2 to the upper quadrant slot with Z2 in mesh with Z1. In this instance, however, in the single gear case the spare spacing gear may occupy either the inner or outer positions as determined by the remainder of the gear train.

Having selected the range of gears and positions from the chart they are mounted on their stub axles on the quadrant and lightly brought into mesh with their fixings left slightly loose. The correct mesh should be neither too tight nor too loose and may be readily determined with pieces of thin aluminium foil (cooking foil). The strip of foil is inserted between the meshing gears and the lathe spindle is then rotated by hand; the foil should deform to the shape of the gear teeth but without any tears or bruising and this will indicate the correct tooth clearance. Tighten the stub axle retainers and the quadrant locking screws then close the quadrant cover.

Screwcutting operations should be carried out with the lathe running at a low speed, at least until operator experience is gained. The tool is fed into the work a little at a time, noting the reading on the cross slide dial. The automatic feed can then be engaged and the carriage traversed until the required length of thread is obtained. At this point the tool is withdrawn by winding back the cross slide and the lathe is reversed to drive the carriage back to the starting position. The tool is then fed back in to its original position plus the extra amount required for the next cut. The operation is repeated until the full thread depth is obtained.

A similar procedure is used when cutting internal threads but with a tool shaped like a miniature boring tool with the correct thread angles ground on. As an alternative a shaped tool bit in a boring bar may be used if the hole diameter is sufficient to allow this. Whatever type of cutter is used it must be remembered that the movement of the cross slide will be in the opposite sense to that used for cutting external threads. If it is possible to do so, it is recommended that an internal thread be chased down with a tap of the correct size to ensure a smooth thread face.

The more experienced operator may prefer to set over the top slide of the lathe to half the thread angle and advance the tool using the top slide only. This means that the cutting tool will cut only on the leading edge and this generally produces a smoother thread. If using this method then allowance must be made for the angularity of the tool when noting the amount of in-feed.

While the combinations on the chart cover the most commonly used range of thread pitches, it is not exhaustive and other pitches may be calculated and set up using the following formulae:

1. For metric threads, the pitch (t) is obtained from

$$t = \frac{Z1}{Z2} \times \frac{Z3}{Z4} \times \frac{Z5}{Z6} \times 4 \text{ (mm)}$$

2. For module threads, the module (m) is obtained from

$$m = \frac{61}{48} \times \frac{Z1}{Z2} \times \frac{Z3}{Z4} \times \frac{Z5}{Z6} \text{ (mm)}$$

3. For imperial threads, the number of threads per inch (i) is obtained from

$$i = \frac{7 \times 25.4}{28.0035} \times \frac{Z2}{Z1} \times \frac{Z4}{Z3} \times \frac{Z6}{Z5}$$

The range of change gear wheels required for cutting metric and module threads is 20, 25, 30, 35, 40, 45, 50, 60, 61 and 64 teeth. The additional gears required for cutting imperial threads are 26, 36, 38, 44, 48 and 63 teeth. Note that for 3.5 TPI and 11.5 TPI (shown in parenthesis on the chart) 24 and 46 tooth wheels are also required.

When selecting change gears for unlisted pitches the following basic relationships should be borne in mind:

Z1 and Z2	should total at least 72 teeth
Z2 less Z2	should total at least 4 teeth

Z3 and Z4 less Z2 — should total at least 17 teeth

Z3 and Z5 less Z5 — should total at least 17 teeth

Z5 and Z6 — should total at least 52 teeth

The values thus obtained will ensure the availability of adequate centre distances for correct meshing and clearances.

Cutting left-hand threads of either type is accomplished by adding an extra gear into the gear train. This has the effect of reversing the direction of carriage travel in relation to the spindle rotation.

MILLING OPERATIONS

Use of the vertical slide enables the lathe to be used for light milling operations and these will normally involve using an end mill or slot drill mounted in either the three-jaw chuck or a collet. Other arrangements are also possible, of course, using other forms of cutter and method of cutter holding. A fly cutter, or single point tool, may be used in place of an end mill where larger surfaces need to be machined. Other examples could be a slitting saw or facing cutter mounted on a stub arbor, or a side and face cutter mounted between centres on a suitable arbor.

The design of the vertical slide is such that when it is attached to the cross slide its squareness to the lathe axis is virtually assured. It is, however, wise to check that it is square when bolted up. A simple method to check for squareness would be to fit the lathe faceplate and place a bar, which is known to be parallel over its length, between the faceplate and the table of the vertical slide until it is lightly trapped. Visual examination of the bar will indicate whether it touches along the full length of the bar, or width of table or faceplate as applicable. If full contact is not apparent then a small amount of adjustment may be obtained by releasing the slide clamp screws, bodily moving the slide and re-clamping.

The components of the vice are also so designed that squareness with the table is usually achieved automatically, but they too should be checked before using it. This is simply done with an engineer's square held against the vice jaw and the edge of the slide table. Should it be found to be slightly out of line it can be adjusted by slackening the clamping bolts of the errant item and moving it a fraction before re-clamping.

Machining of the work can make use of all three movements available, vertically and transversely over the face of the cutter and inwards towards the cutter for increased depth of cut. The question of cutting speeds is just as important as with turning and generally the same rules apply but with one major difference; whereas when turning the larger diameter of material requires a slower speed, in milling it the larger cutter diameter that requires the lower speed. The requirements for cutting hard and soft materials still apply. Never try to hurry milling operations: the cutter will cut very easily when conditions are right but will tend to judder if the cut taken is too heavy or the speed too slow and will tend to scream if the cut is taken too fast. As with all other cutting operations, of whatever nature, it is essential for the cutting edge to be sharp.

Regardless of the nature of the cut, and its direction, the other movements which are available and not in use should be locked. This will minimise the risk of excessive vibration developing and will also prevent the work from being 'pushed away' from the cutter in the other planes, resulting in an out-of-square cut. The conditions for use of cutting fluids and coolants when milling is the same as for turning and other operations, that is it depends largely on the type of material being worked.

MAINTENANCE

Regular maintenance will ensure that the machine will continue to perform at its best and maintain its accuracy. There is not a great deal of maintenance required on the lathe but it is important to keep it clean. Swarf should be brushed off using a brush with hairs of a medium hardness, after which all surfaces should be rubbed over with a clean dry cloth. Painted surfaces can be cleaned by rubbing with a cloth moistened with neat washing-up liquid followed by wiping with a dry cloth. Bright surfaces can be wiped with a dry cloth to which is added a small amount of light oil. If the machine is to be out of service for any length of time then a spray of Duck Oil or WD40 is recommended.

Note: Cleaning the machine by means of compressed air is not recommended as this can drive small particles of swarf and other debris into the slideways and cause premature and unnecessary wear.

The following procedures should be undertaken by the operator at the suggested intervals.

Daily

1. Apply the oil gun to all the oiling points (Figure 17) before starting work each day.

2. Keep the work area clean, especially the bed and slideways, and remove all swarf and cutting fluid at the end of the day's work. If the machine is located in an area where condensation and rust are a problem, apply a moisture repellent oil to the exposed surfaces.

Weekly

1. Clean the feed screws and apply a fresh coating of oil.

2. Check the sliding surfaces for any abrasions; clean and apply a fresh coating of oil.

Monthly

1. Check the slideways for smooth operation. Remove any slackness by adjusting the gib strip screws.

Yearly

Check general condition, paying particular attention to electric cables, connectors and switches, which should be free from damage, wear or insecurity.

Note: The foregoing schedule is based on the assumption that the machine is in regular use throughout the year. If use is intermittent, the schedule may be varied at the discretion of the operator and the service attentions postponed or combined. However, they should not be overlooked.

Slide Adjustment

The slides can be adjusted to compensate for wear by means of the gib strips; the adjustment procedure is the same for each of the slides. Loosen the locknuts on each of the adjusting screws on the slide requiring adjustment. With the slide set at its approximate central position and starting at the centre screw and working outwards, turn the screws to increase slightly the pressure on the gib strips. Only very small amounts of adjustment will be required; the slides should move smoothly with no evident slackness or resistance at any point. When the correct setting is achieved, re-tighten the locknuts ensuring that the settings of the screws are not disturbed.

If at any time when adjusting or working an extra resistance is felt on any of the slides it should be investigated. The most likely cause is the presence of swarf or some other foreign body in the slide and this should be removed and the settings re-checked.

The saddle has cleaning wipers to prevent swarf from entering. These will tend to become clogged after a time when they should be removed, cleaned and replaced. They may be removed by releasing the three screws that hold them in position. If wear has taken place, or if they have become contaminated with grit or dust from emery or any other polishing medium, they should be discarded and replaced with new ones.

The spindle main bearings are adjusted before the lathe leaves the factory and no further adjustment should be required. Only after extensive use or bearing failure necessitating replacement will it be necessary to disturb the spindle settings. Similarly there is no adjustment to any of the leadscrews; if excessive wear is experienced on any of these components they are easily replaced.

Lubrication Chart

Lubrication is confined to general oiling and greasing and any light machine oil (see Note 2) or medium grease will suffice. The following chart gives some indication of the quantities required.

Spindles for feed and screw cutting gears	One to two drops of oil when the machine is used.
Quadrant locking lever Spindle for belt tensioning lever Spindle of master switch lever	One to two drops of oil per month if the machine is in regular use. If used only occasionally, then one drop only when used.
Shaft of feed mechanism	Two drops of oil at each end of the shaft before commencing operations.
Gear on carriage handwheel	This is grease packed. About four times a year the guard should be removed and repacked with grease if required.
Spindle of carriage handwheel	One or two drops of oil in the hole in the flange when the lathe is used.

Top slide slideways	One or two drops of oil when the lathe is used.
Cross slide leadscrew bearings Top slide leadscrew bearings	One or two drops of oil when the lathe is used. The leadscrew itself should be oiled at the same time with several drops of oil.
Carriage slideways	A general coating of oil over the entire bed before using the lathe. This may be wiped on with a clean cloth or a few drops may be placed on the bed either side of the carriage. Traversing the carriage over its full travel will then spread the oil.
Leadscrew	Oil liberally along its length when the lathe is used.
Leadcrew bearings	One or two drops of oil on the flange at monthly intervals.
Tailstock leadscrew	One drop of oil at monthly intervals. Extend the quill and apply a coating of oil to its circumference and along its exposed length.

Note: 1. Surplus oil should be cleaned from the lathe after it has been used.

2. The use of a special graphited slideway lubricant is recommended in preference to oil. These patent lubricants give better protection and are usually supplied in aerosol sprays; a single application when the lathe is used is sufficient.

3. Paintwork can be protected with a clear silicon spray as used for protection of motor car interiors. Its use makes general cleaning of the paintwork easier.

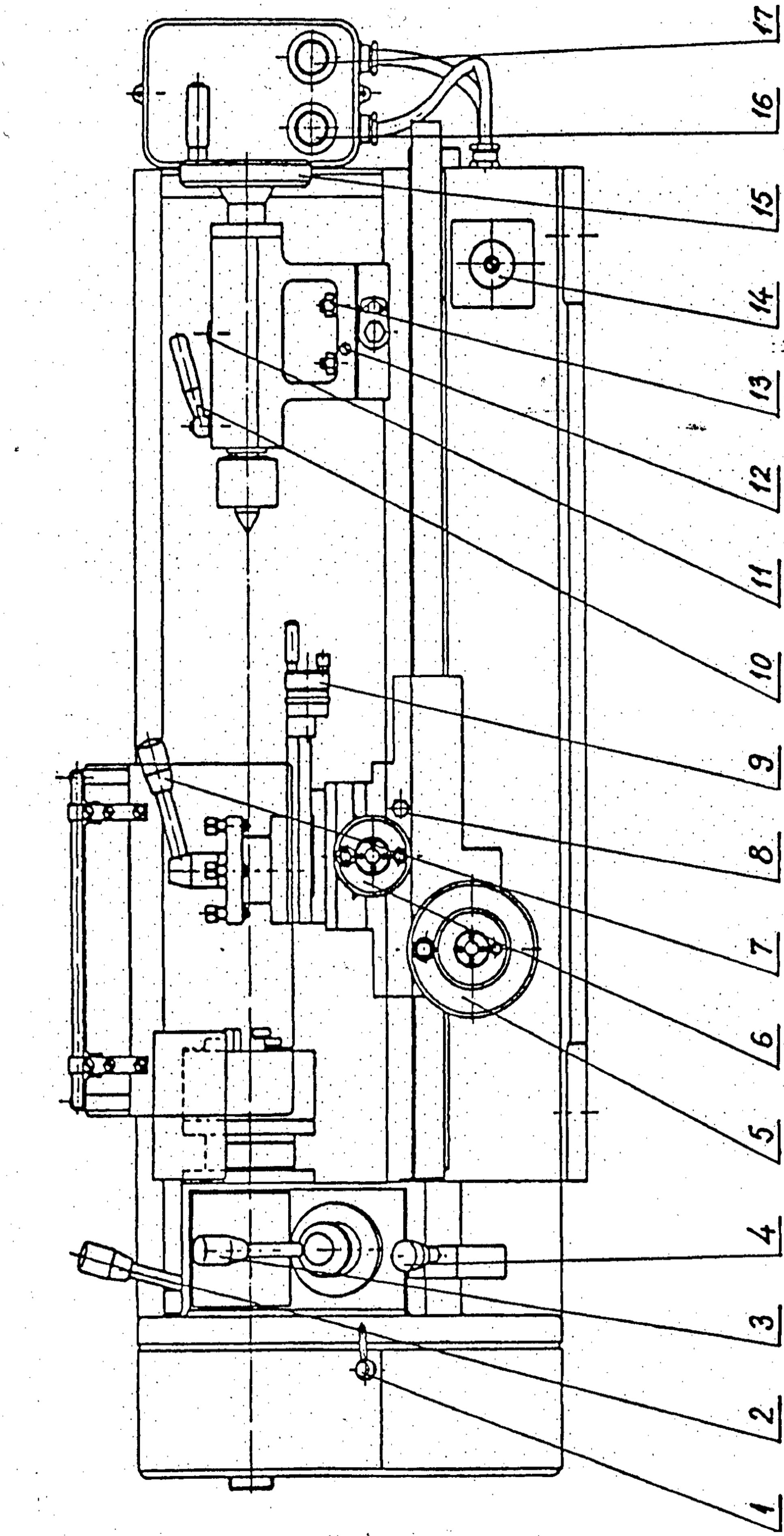

Figure 17 Lubrication Diagram

FAULT FINDING

Any malfunction should be investigated immediately and rectified. Any overheating or unusual noises from any source will indicate that some fault condition exists. The following details the most likely problems that may be experienced and the suggested remedy. Any faults not covered here should be referred to your dealer or direct to the distributor and advice sought.

Motor does not run when switched on.

Supply fuse blown - check and replace if necessary.

Faulty connection at socket or junction box - check and re-make connection.

Supply voltage incorrect - check and adjust (if applicable).

Overload relay tripped (the relay trips automatically if an excessive current is experienced) - press the reset button on the relay to restore the supply.

Motor overheats and produces no power or power is diminished.

An overload condition exists - reduce the rate of feed, depth of cut or cutting speed.

Vee belt tension too high - adjust for correct tension.

Supply voltage too high - adjust.

Incorrect power fuse allowing excess current to motor - switch off and replace with correct fuse.

Magnetic switch contacts eroded - renew.

Overload relay inoperative or open circuit - re-connect or renew.

Motor unserviceable - renew.

Spindle bearings becoming hot.

Prolonged use at high speed - allow to cool and resume with light cuts.

Spindle bearings too tight (tightness of rotation may be felt by hand) - refer to dealer.

Main spindle revolves but lacks power.

Vee belt tension too loose - adjust for correct tension.

Motor faulty - renew.

Carriage movement erratic producing chatter marks.

Check rate of feed and depth of cut and adjust.

Check tension on gib strip adjustment screws - tighten if necessary.

Chatter marks other than through table movement.

Spindle bearings ??

Bearing covers ??

Taper slides ??

Cutter arbor or chuck insecure in drive socket - tighten.

Cutter damaged or in need of sharpening - renew or re-sharpen.

Work piece insecurely held - tighten or rearrange clamp bolts.

Lack of accuracy in cut.

Work piece out of balance or insecurely held - re-clamp to give more secure work holding.

Incorrect setting of gib strips on slide movement - check and reset correct movement.

Use of hammer to reposition work piece on table, thus transferring blows through work piece to table and feedscrew - DO NOT USE HAMMER TO POSITION WORK.

APPENDIX TO THE WARCO 220 LATHE MANUAL
PROGRAMMING THE EUROTHERM 601 VARIABLE SPEED CONTROLLER

This Appendix provides clarification of certain aspects of the programming procedures outlined in the manual supplied with the control unit.

1. First turn on the power. With power on, the display should read "rdy" (rdy means the system is 'ready for use'). The "rdy" display implies that you can now program the software to meet your specific requirements.

2. Press "M": The display will show "P1".

3. To increase the P number to the required parameter number, press the □ button, which will increase the value, or press the □ button to decrease the value. If starting at P1 then pressing □ will scroll progressively through d3 to d2 to d1 to P15 and then back to P1. These "d" codes are the 'diagnostics', but note that you cannot change diagnostics values, only read them.

4. Press "M" to read the currently stored contents of the selected parameter. The figure could relate to frequency (P1/P2), time in seconds (P3/P4), or a percentage of overall inverter output (P5).

5. Press □ or □ again to change that value to your required value.

6. When you have set the required value, press "E" to save the value and return to the "P" settings.

7. Repeat the above steps from step No.2 as many times as may be needed to program all the required parameters - note that most can be left at the factory pre-set value.

8. To exit the programming mode completely, press "E" a second time. The display should then return to "rdy".

Should you, for any reason, wish to reset the 601 to the factory settings:

1. Turn the controller off at the mains. Wait for the display to extinguish.

2. Press the □ and □ buttons simultaneously as you again turn on the power. The display should show "rSt" for 'Reset'.

3. Press M to get the 'Ready' display again. You will now have to reprogram the parameters to set your own preferences. Note that the factory defaults are all safe easy values. The minimum frequency is 0, the maximum is 50Hz, and the acceleration and deceleration times ('ramp up/down') are 10 seconds. The 'base' frequency is the local mains frequency (i.e. 50Hz).

Basic Motor Control (i.e. start, stop, forward, reverse, and speed up, slow down) is achieved in two ways - 'local' mode or 'remote' mode. Local mode implies that you will be using the four buttons on the 601 keypad, remote mode implies that the software will be accessed from an independent control panel/pendant, wired to the control terminal rail within the 601.

LOCAL (LOC) MODE - remember it is not possible to program the software when in Local mode.

1. To enter 'Local' mode, press the ▯ and ▯ buttons simultaneously until the display starts flashing "LOC", but stop pressing them immediately they flash "LOC" or the display will revert back to "rdy".

2. The green button will start the motor. The red button will stop the motor. The ▯ and ▯ buttons will increase and decrease the output frequency to the motor, thereby increasing or decreasing its speed.

3. Press the "M" and ▯ buttons simultaneously for FORWARD rotation.

4. Press the "M" and ▯ buttons simultaneously for **REVERSE** rotation.

5. If at any time you wish to transfer from "LOC" mode to "rdy" mode, press the ▯ and ▯ buttons simultaneously.

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