
TECHNICAL MANUAL

OPERATOR'S, ORGANIZATIONAL, DIRECT SUPPORT
AND GENERAL SUPPORT MAINTENANCE MANUAL
INCLUDING REPAIR PARTS LIST
FOR

LATHE, ENGINE

BENCH TYPE 12"

HOUDAILLE INDUSTRIES, INC.

(POWERMATIC DIVISION)

(NSN 3416-00-449-7188)

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HEADQUARTERS, DEPARTMENT OF THE ARMY

APRIL 1983

WARNING

Do not wear gloves while operating lathe.

WARNING

Remove chuck wrench immediately after use. If not removed, starting the spindle can cause it to be thrown off the chuck and could result in serious injury.

WARNING

Do not change tools with spindle rotating under power.

WARNING

Clear chips with a brush or chip rake. Chips are razor sharp and may cause serious injury if cleared with bare hands.

TECHNICAL MANUAL

No. 9-3416-233-14&P

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, DC, 18 April 1983

**OPERATOR'S, ORGANIZATIONAL, DIRECT SUPPORT
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(INCLUDING REPAIRS PARTS LIST)
FOR
LATHE, ENGINE
BENCH TYPE 12"
(NSN 3416-00-449-7188)**

REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS

You can help improve this manual if you find any mistakes or if you know of a way to improve the procedures, please let us know. Mail your letter, DA Form 2028 (Recommended Changes to Publications and Blank Forms), or DA Form 2028-2 located in back of this manual direct to: Commander, US Army Armament Materiel Readiness Command, ATTN: DRSAR-MASSE, Rock Island, IL 61299. A reply will be furnished to you.

NOTE

This manual is published for the purpose of identifying an authorized commercial manual for the use of the personnel to whom this equipment is issued.

Manufactured by: Houdaille Industries, Inc.
Powermatic Division
Morrison Road
PO Box 70, McMinnville, TN 37110

Procured under Contract No. DAAA09-76-C-6383

This technical manual is an authentication of the manufacturers' commercial literature and does not conform with the format and content specified in AR 310-3, Military Publications. This technical manual does, however, contain available information that is essential to the operation and maintenance of the equipment.

**INSTRUCTIONS FOR REQUISITIONING PARTS
NOT IDENTIFIED BY NSN**

When requisitioning parts not identified by National Stock Number, it is mandatory that the following information be furnished the supply officer.

- 1 - Manufacturer's Federal Supply Code Number. 94389
- 2 - Manufacturer's Part Number exactly as listed herein.
- 3 - Nomenclature exactly as listed herein, including dimensions, if necessary.
- 4 - Manufacturer's Model Number. Bench Type 12"
- 5 - Manufacturer's Serial Number (End Item).
- 6 - Any other information such as Type, Frame Number, and Electrical Characteristics, if applicable.
- 7 - If DD Form 1348 is used, fill in all blocks except 4, 5, 6, and Remarks field in accordance with AR 725-50.

Complete Form as Follows:

(a) In blocks 4, 5, 6, list manufacturer's Federal Supply Code Number - 94389 followed by a colon and manufacturer's Part Number for the repair part.

(b) Complete Remarks field as follows:

Noun: (nomenclature of repair part)
 For: NSN: 3416-00-449-7188
 Manufacturer: Houdaille Industries Inc., Powermatic Division
 Morrison Road P.O. Box 70 McMinnville, TN 37110
 Model: Bench Type 12"
 Serial: (of end item)

Any other pertinent information such as Frame Number, Type, Dimensions, etc.

LATHE SAFETY INSTRUCTIONS

1. **Read, understand, and follow** the safety and operating instructions found in this manual. Know the limitations and hazards associated with a lathe. A safety rules decal is installed on the belt guard of this machine to serve as a reminder of basic safety practice.
2. **Grounding the Lathe:** Make certain that the machine frame is electrically grounded and that a grounding lead is included in the incoming electrical service. In cases where a cord and plug are used, make certain that the grounding lug connects to a suitable ground. Follow the grounding procedure indicated by the National Electric Code.
3. **Eye Safety:** Wear an approved safety face shield, goggles or glasses to protect eyes when operating the lathe.
4. **Personal Protection:** Before operating the machine, remove ties, rings, watches and other jewelry and roll up sleeves above the elbow. Remove all outer loose clothing and confine long hair. Protective footwear should be worn. Hearing protectors should be used where noise exceeds the level of exposure allowed in Section 1910.95 of the OSHA regulations.
5. **Work Area:** Keep the floor around the machine clean and free of tools, tooling, stock, scrap and other foreign material, and oil, grease or coolant to minimize the danger of tripping or slipping. Be sure the machine is free of chips, tools, and everything else not required for the task to be performed. The use of anti-skid floor strips are recommended on the floor area where the operator normally stands. Each work area should be marked off. Make certain the work area is well lighted and ventilated. Provide for adequate work space around the machine.
6. **Guards:** Keep all machine guards in place at all times when the machine is in use. Do not operate the machine with the guards off.
7. **Do not Overreach:** Maintain a balanced stance and keep your body under control at all times.
8. **Maintain Tools in Top Condition:** Keep tools sharp and clean for safe and best performance. Dull tools can increase the feed force required and can cause tear-outs and chatter. Broken tools or tools that are not securely locked into a holder can be thrown out of the lathe or cause the work piece to be pulled free from the holding device and cause severe or fatal injury. Check the condition and adjustment of tools and chucks when used, before taking a cut. Make sure centers, when used, fit properly without shake.
9. **Use the Proper Speed and Feed:** A table is provided in the operating instruction manual as a guide in selecting the correct speed and feed rate for a variety of materials. Adjust speed on variable speed models only with the power on and the motor running.
10. **Remove Chuck Wrenches:** When a chuck wrench is used, remove it immediately after using it to lock or unlock a part piece in the chuck.
11. **Hand Safety:** Keep hands away from the spindle and work piece when the machine is under power. Never clear chips when the spindle is under power and never use the hands to clear chips.
12. **Spindle Rotation:** Be sure the rotation of the spindle is correct for the tool being used.
13. **Machine Adjustments:** Make all machine adjustments with power off except speed on a variable speed model.
14. **Machine Capacity:** Do not attempt to use the machine beyond its stated capacity or for operations requiring more than the rated horsepower of the motor. This type use will reduce the productive life of the machine and could cause the breakage of parts which could result in personal injury.
15. **Avoid Accidental Starting:** Make certain the motor switch is in the Off position before connecting power to the machine.
16. **Careless Acts:** Give the work you are doing your undivided attention. Looking around, carrying on a conversation, and horseplay are careless acts that can result in serious injury.
17. **Job Completion:** If the operator leaves the machine area for any reason, the lathe should be turned off and the spindle come to a complete stop before he departs. In addition, if the operation is complete, he should clean the machine and work area. Never clean the machine with power on and never clear chips with the hands; use a brush or chip rake.
18. **Disconnect Machine:** Before performing any service or maintenance.

19. **Replacement Parts:** Use only authorized replacement parts and accessories.
 20. **Misuse:** Do not use the lathe for other than its intended use.
 Do not equip a 12" lathe with a motor larger than 2 horsepower with speed greater than 1800 RPM, unless specifically authorized to do so in writing.

**SPECIFICATIONS
 12" ENGINE LATHE**

Capacities:

Swing over bed	12" (304.8 mm)
Swing over cross slide	7-1/4" (184.15 mm)
Center distance (threaded spdl. nose).....	35" (889 mm)
(L00 or D1-4).....	34" (863.6 mm)

Headstock:

Speed range (direct drive)	350-2000 r.p.m.
(back gear)	55-300 r.p.m.
Hold through spindle	1-3/8 (34.93 mm)
Draw-in collet capacity	1/16 - 1-1/16 (1.59-26.99 mm)
Nose mounted collet capacity	1-1/2 (38.1 mm)
Headstock center taper	#3 Morse
Spindle nose	2-1/4-8 N, (L00 or D1-4)

Threads and feeds:

Gear box thread range	4-224 threads/in.
Longitudinal feed range	0018-.10 in/rev. (.045-2.54 mm/rev)
Cross feed range	0004-.25 (.01-6.35 mm/rev)

Cross slide and compound:

Cross slide travel	6-1/4 (158.75 mm)
Compound slide travel	2-1/4 (57.15 mm)
Compound swivel graduation.....	0-90° both directions
Tool post opening	3/8 x 3/4 (9.52 x 19.05 mm)
Tool height	1" (25.4 mm)

Bed:

Width across ways	6-15/16 (176.22 mm)
Length of bed	55" (1397 mm)

Tailstock:

Quill travel	3-1/2 (88.9 mm)
Quill graduations	1/16 (1.58 mm)
Tailstock center taper	#3 Morse
Tailstock set-over, max	11/16 (17.46 mm)

Motor	2HP (149 KW)
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RECEIVING THE LATHE

Uncrate the machine and accessories and check for completeness of order and any shipping damage. Report any damage to carrier and distributor.

The standard equipment carton contains the following items:

- | | |
|--|------------------------------------|
| 1 Tool Post for a 3/8 x 3/4 tool holder. | 1 Spindle adapter sleeve. |
| 1 Tool Post wrench. | 1 60° Tooth gear. |
| 1 Tailstock wrench. | Maintenance Manual and Parts list. |
| 1 Compound wrench. | Operating instructions. |
| 2 60° centers. | |

Carefully read instruction manuals before operating machine.

Clean the protective coating with solvent and coat all machine surfaces with a film of machine oil to prevent rusting.

OPERATING MANUAL

In order to become proficient in the use of an engine lathe, the operator should first learn the location and function of all controls. He should then operate each control except the variable speed handwheel with power off in order to get the feel of how it operates.

Fig. 1 is a general overall view of 12" (304.8-mm) lathe showing the location and names of the major components and controls.

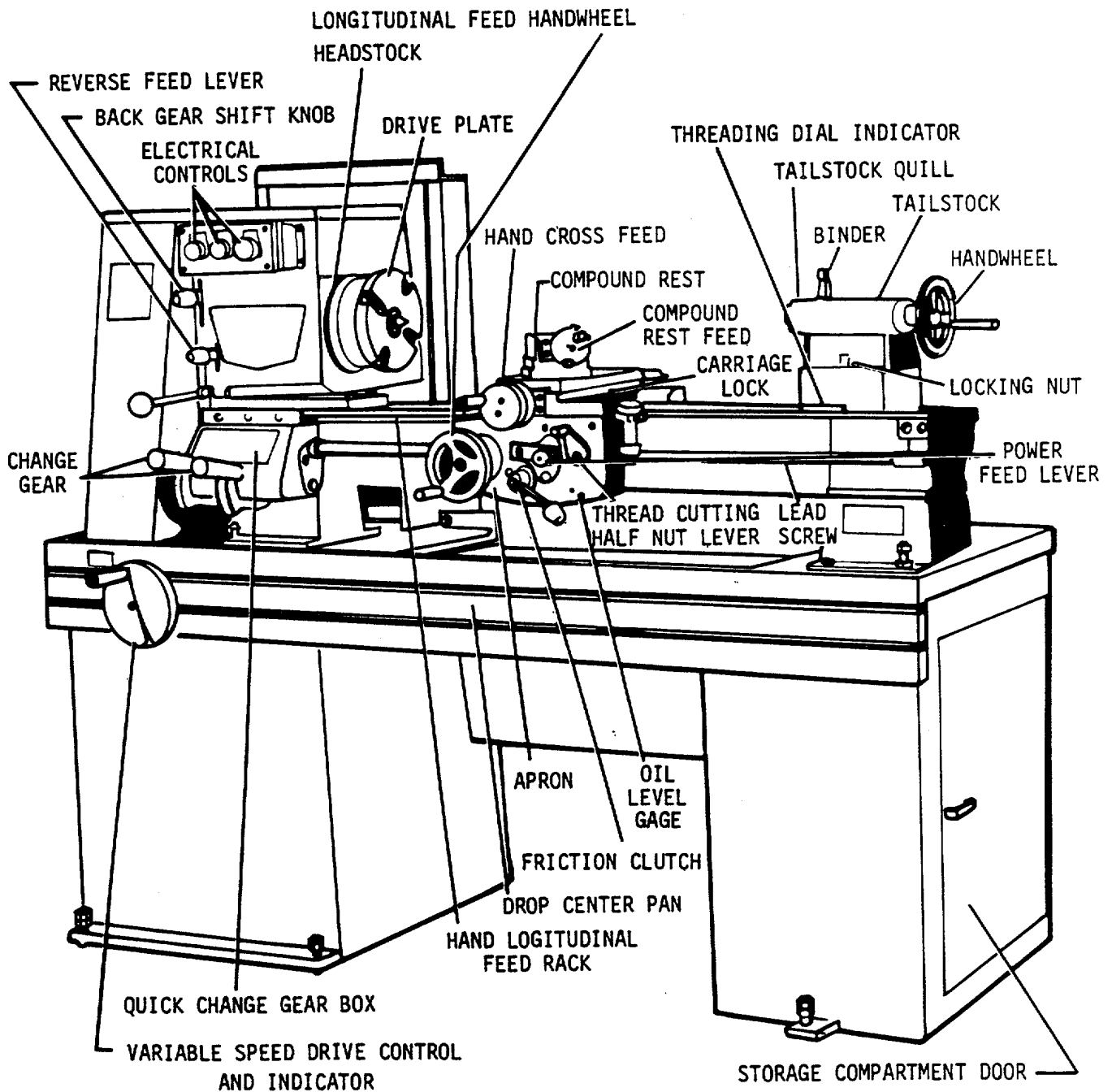


Figure 1.

Headstock:

The headstock is a transmission housing which supports the spindle of the lathe and its driving gears. The spindle nose may be one of three types-threaded, type L, or type D1 as shown in fig. 2. NOTE: On machines equipped with threaded spindles do not reverse the spindle until it has come to a complete stop. Quick reversing can cause a chuck or drive plate to spin off and result in serious injury. **Caution:** Never leave a chuck wrench in the chuck. An accidental start could throw the wrench from chuck causing serious injury.

The spindle has an internal through hole 1 3/8 (34.925 mm) diameter, the front of which is ground on a taper to support a center sleeve with an internal No. 3 Morse Taper. The center sleeve and a No. 3 Morse Taper center are provided as standard equipment.

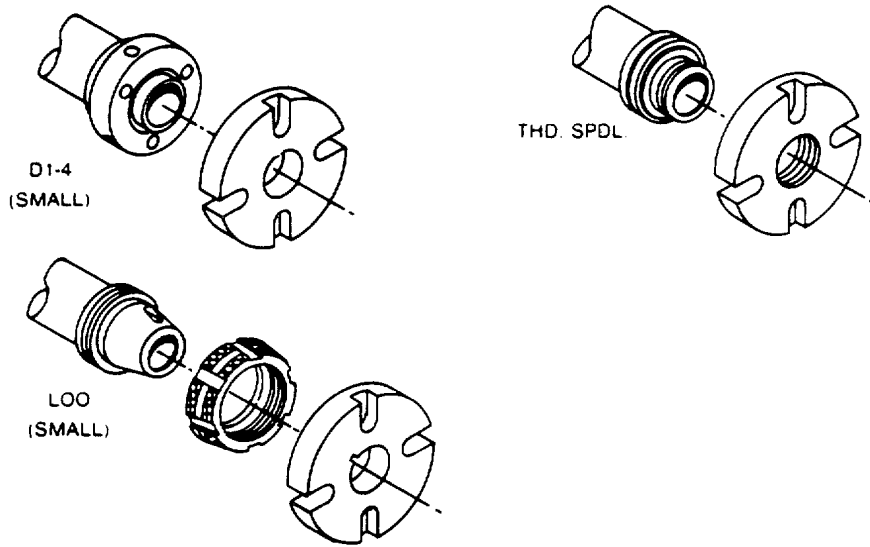


Figure 2.

The headstock provides two speed ranges: Direct drive, and back gear. To position the drive for back gear, lift up the back gear lever and pull forward until the gears mesh and the lever drops into its forward detent position. Pull out the clutch in the driving sheave on the left end of spindle. For direct drive, reverse the procedure moving the shift lever to its back detent position and re-engaging the clutch in the spindle sheave. Do not attempt to shift ranges with the spindle under power.

The headstock also supports the reverse gear assembly which reverses the direction of rotation of the gearbox to the spindle. There are three detent positions of this lever. With the spindle rotating in its normal counterclockwise direction

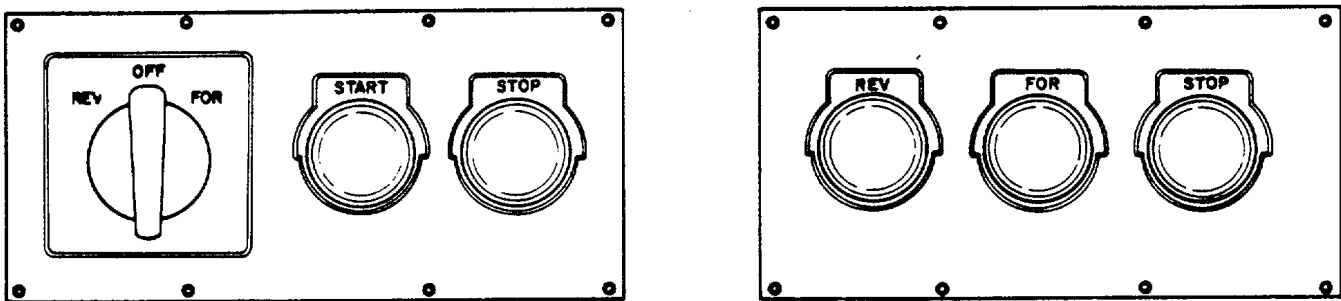


Figure 3.

with the lever in its up position. (righthand thread position) feed direction, when engaged, will cause saddle motion towards the tailstock or cross slide away from the operator. In its middle position, no gears are engaged. In its down position, (lefthand thread position) feed direction, when engaged, will cause saddle motion towards the headstock or cross slide towards the operator. To shift the reverse gear lever, push it to the left to unlock the detent, then raise or lower it to the desired position and release the handle.

The lathe electrical controls are located at the top front of the headstock. The machine can be equipped with one of three basic control types: Manual, semi-magnetics, and full magnetics. The control panels for each of these are shown in fig. 3. The name plate information on each switch identifies its function. Check for proper direction of spindle rotation by momentarily starting the spindle and turning it off. In forward, the spindle should turn counterclockwise as the operator faces the spindle nose. If it does not, have a qualified electrician correct the problem as indicated in the maintenance manual.

Machines with semi-magnetics or full magnetics can be equipped with a spindle brake as shown in fig. 1. Depressing the lever drops out the main starter and mechanically applies a brake shoe against the spindle sheave stopping the spindle.

End Gearing:

The end gearing shown in fig. 4 carries the feed drive from the reverse gearing to the gearbox. There are two change gears used; one with 30 teeth and the other with 60 teeth to provide the full feed and threading range of the gearbox. The change gear not in use is stored on the top gear stud of the end gear train. The plate on the front of the gearbox indicates the thread and feed range provided by each change gear.

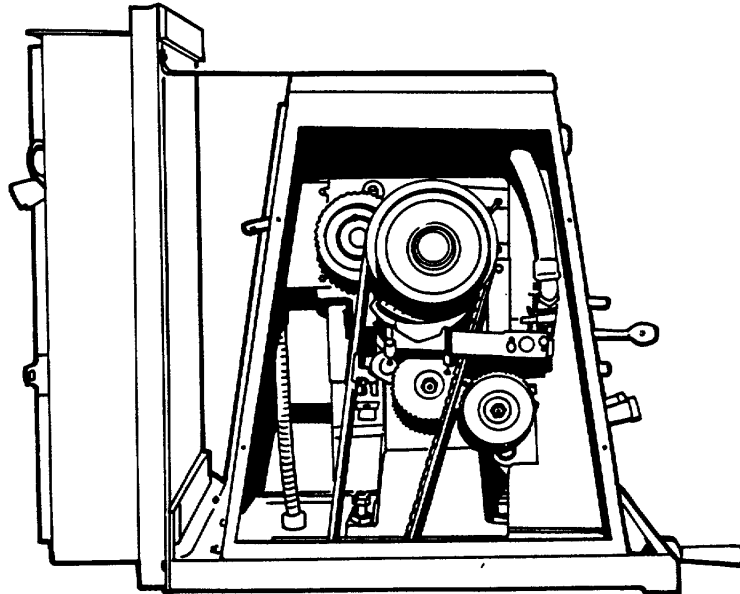


Figure 4.

Gearbox:

The input gear on the gearbox is a safety type designed to automatically disengage in threading if the torque required exceeds a pre-determined level.

A feed and thread chart (fig. 5) on the front of the gearbox indicates the position that each of the two levers is to be in for the desired feed or thread position. To change position, pull out the plunger handle, lower the lever, slide it to the new position, raise the lever and detent it into position. The positions shown in fig. 5 will give either a saddle feed of 0.0174 in/Rev. or move the saddle to cut 23 threads per inch with the 36 tooth change gear installed.

The gearing arrangement in the gearbox provides a feed range of 0.100 to 0.0018 and a thread range from 4 to 224 threads/in. Special threads can be achieved by using special change gears and end gearing arrangements such as the optional metric transposing kit.

SCREW CUTTING AND TURRET LATHES		STUD GEAR		THREADS PER INCH FEEDS IN INCHES PER REV								AUTOMATIC CROSS FEED 25 TIMES LONGITUDINAL FEED	
		30	60	4	4 1/2	5	5 1/2	5 3/4	6	6 1/2	7		
	A	1000	0800	0800	0720	0660	0600	0540	0480	0420	0360	0300	0240
A	B	0500	0443	0400	0364	0340	0333	0306	0288	0266	0246	0228	0210
B	C	0250	0222	0200	0182	0174	0166	0154	0144	0134	0124	0114	0104
C	D	0125	0111	0100	0091	0087	0083	0077	0072	0067	0062	0057	0052
D	E	0062	0055	0050	0045	0043	0041	0038	0036	0034	0032	0030	0028
E		0031	0027	0025	0023	0021	0020	0019	0018	0017	0016	0015	0014

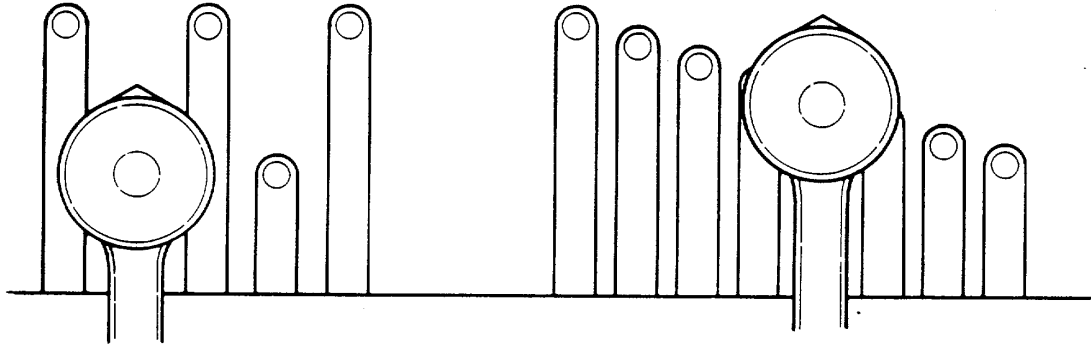


Figure 5.

Headstock Pedestal:

The headstock pedestal (fig. 6) houses the variable speed drive components, the speed adjusting handwheel, and a separate electrical compartment. Note: Do not remove the rear access cover to the electrical compartment unless the machine is disconnected from its power source. On magnetic models, the starter and control transformer are housed in the electrical compartment. The infinitely variable speed control handle is used to vary the speed from 55-300 RPM, in back gear or 350-2,000 RPM in direct drive. Adjust the speed only with the main drive motor on. The speed dial is geared

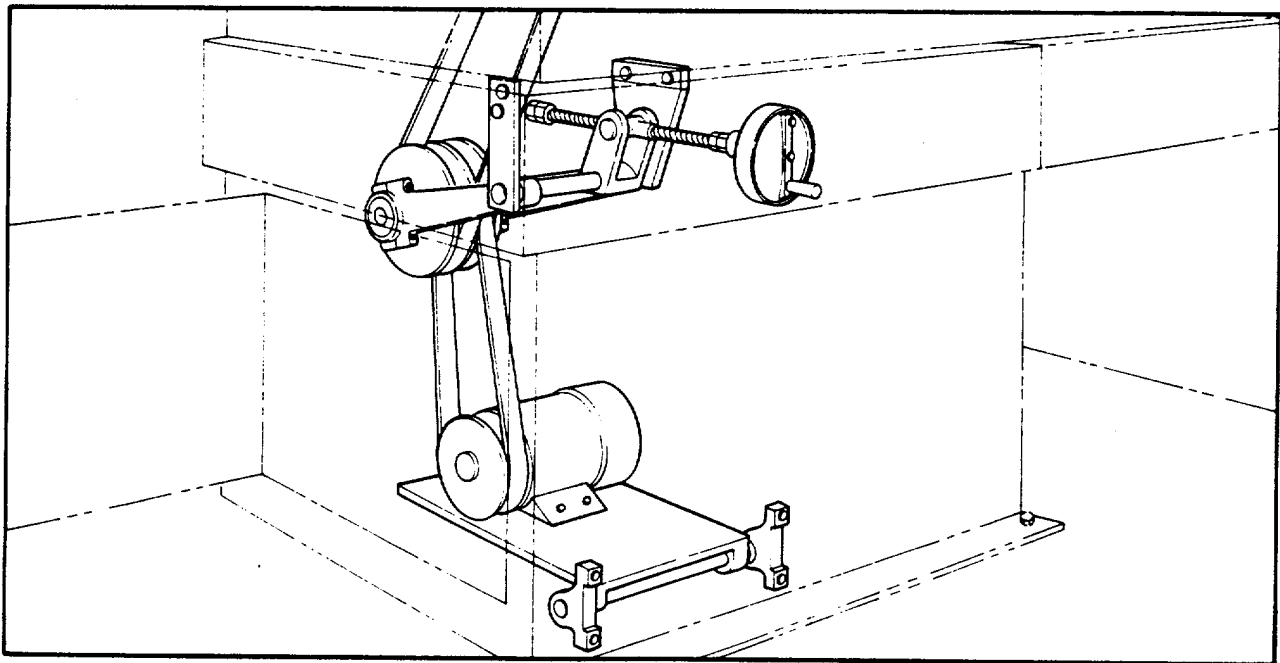


Figure 6.

to the hand wheel to rotate at a slower rate and shows both speed ranges. Do not attempt to change speeds by rotating the dial itself.

Apron Control:

The apron assembly includes the gearing to pickup power from the lead screw to move the saddle along the bed or to power the cross slide. An apron handwheel is provided to move the saddle manually along the bed. The direction of movement will be the same as the top side of the handwheel. If the handwheel is rotated clockwise, the apron will be moved to the right; counterclockwise rotation will produce motion to the left.

The feed shift lever has three positions: In the bottom position, cross feed gearing is engaged; in the top position, saddle feed gearing is engaged; in the middle position, feed gearing is disengaged. The lever must be in this position for threading. To change positions, pull out on the knob and rotate lever to the desired position.

The feed clutch lever is rotated upward to engage the feed clutch. The clutch is set to slip on an overload of the capacity of apron gearing. Push the lever down to disengage the feed. An oil-level gage is provided to indicate the oil level in the apron. Check the oil level daily and do not operate the apron unless there is oil visible in the gage window.

To engage the half nut for threading, the half nut lever is rotated clockwise. The Interlock system in the apron will block rotation of the half nut lever unless the feed lever is in the middle, neutral position, and if the half nut is engaged, the feed lever cannot be shifted out of its neutral position.

The purpose of the threading dial (fig. 7) on the right side of the apron is to indicate the proper timing of reengagement of the half nut in threading. Four witness marks are stamped on the face of the threading dial. (See

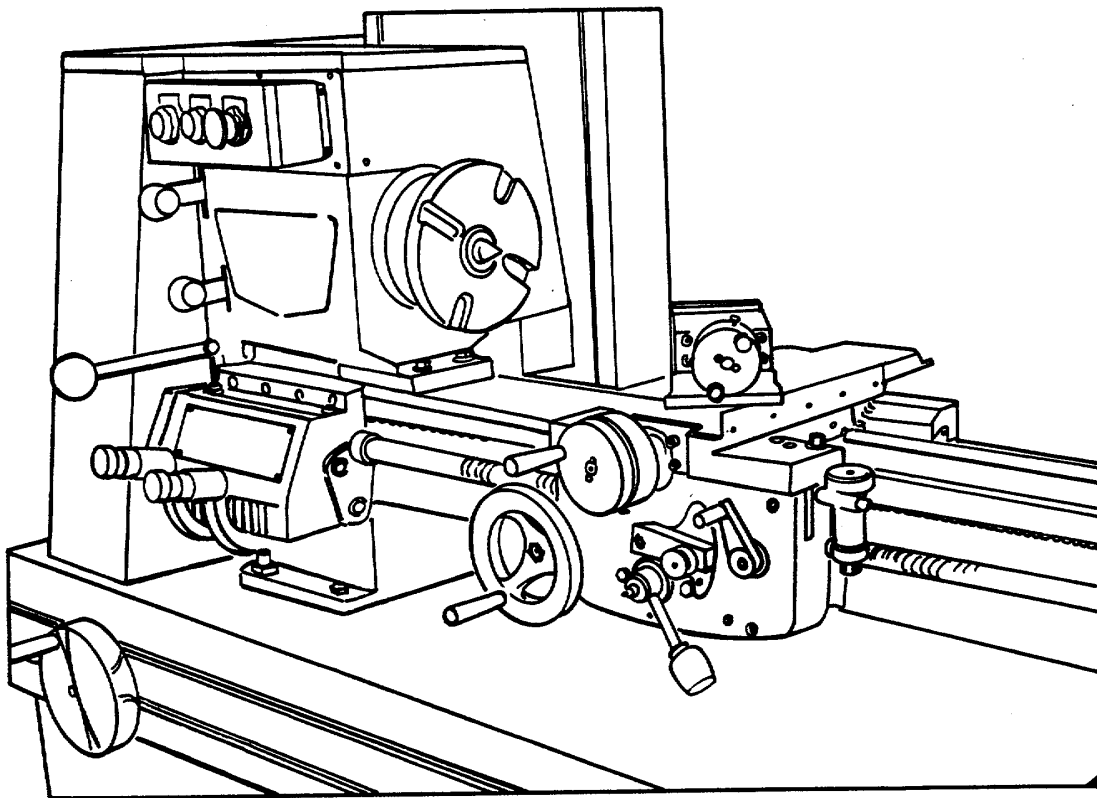


Figure 7.

section of Threading Instructions on its use in cutting threads.) The dial is geared to the lead screw to rotate once for each 16 revolutions on the lead screw.

Saddle and Compound Assembly:

The saddle is gibbed to the bed to prevent it from lifting up under a heavy feed load. A saddle lock is provided so that in facing operations it can be locked to the bed and avoid being forced out of position with heavy feed loads.

The cross-feed handwheel is used to position the cross-feed slide manually. Clockwise rotation will cause the slide to move away from the operator; counterclockwise rotation will move the slide towards the operator. The cross-feed dial is direct reading in that it indicates the change in diameter that will result from the cut. Actual movement of the slide is one-half of that indicated on the dial.

The swivel and top slide combine to allow angled movement for chamfering, threading, and accurate length adjustments when facing or grooving. The top of the bottom slide is graduated in degrees from 0-90° in each direction to permit accurate angular location of the slide movement. To set the slide at an angle, loosen the nuts on each side of the swivel, rotate it to the desired angle and retighten the nuts. A compound wrench is provided as standard equipment. The box end fits the tool holder locking screw.

When the top slide handwheel is rotated clockwise, the top slide will move away from the operator and when rotated counterclockwise, the slide will move towards the operator. The top slide dial is direct reading so that when adjusted for a change in diameter it will read the actual change made by the cut. Actual slide movement is one-half of that indicated on the dial. The top slide has a tee-slot cut into it to accept various tool posts and manual turrets.

The lathe comes equipped with a standard tool holder which will accept optional tool holders. The choice of tool holders or a turret is made on the basis of the operation to be performed.

Tailstock:

The basic function of the tailstock (fig. 8) is to support the right hand work being done between centers. The tailstock comes equipped with end of a No. 3 Morse Taper center. A second function of the tailstock is its use in drilling operations. It can also be used for tapering operations using the set over method. Controls are shown in fig. 1.

The quill clamp lever locks the quill in a desired position. To reposition the quill, unlock it using the clamp lever and rotate the handwheel. Clockwise rotation will cause the quill to move towards the headstock, counterclockwise rotation will cause it to move away from the headstock. The quill is graduated in 1/16 (1.588 mm) divisions for use in drilling, counterboring and similar operations. After repositioning the quill, lock it in position. The quill tang driver slots cut into the side so that a drift key can be used to remove drills and centers but automatic kickout of the drill or center will occur when the quill is fully retracted into the tailstock top.

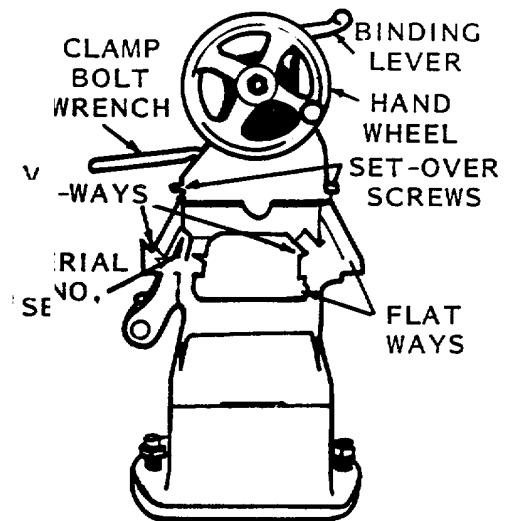


Figure 8.

The tailstock assembly is locked to the bed by a center clamp. To reposition the whole tailstock assembly, loosen the locking nut, slide the tailstock to a new position, and retighten the nut. A tailstock wrench is provided as standard equipment. Note: When using a dead center in the tailstock for between center work, always lubricate the center with a good lubricant otherwise galling can occur.

Tailstock Pedestal:

The tailstock pedestal supports the right-hand end of the lathe and has a right-hand end access door and shelves on some models for storing tools, chucks and similar accessories.

Center Pan:

The purpose of the center pan is to collect chips and coolant, and cutting oil. The pan slides out toward the front for easier removal of chips.

Optional Accessories:

Splash Guard (fig. 9): A splash guard is attached at the rear of the lathe to help to prevent chips and coolant from being thrown out the back of the machine and to inhibit debris striking an adjacent operator or bystander.

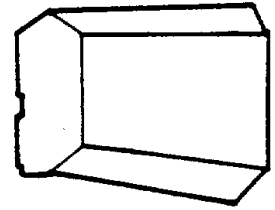


Figure 9.

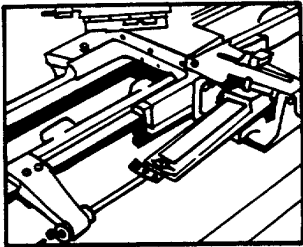


Figure 10.

Taper Attachment (fig. 10) :The basic purpose of a taper attachment is to provide a quick and accurate method of doing tapering operations. The maximum taper length to be done at one setting is 10" (254 mm) and the included angles can be set from 0-20°. The angle indicated on the scale is the included angle to be cut. The use of this attachment will be explained in the section on making taper cuts.

Steady rest (fig. 11) A steady rest is a device for supporting long or thin work pieces. It has three adjustable jaws for centering the workpiece. Once adjusted the jaws can be locked in position. It is mounted to the bed with a center clamp. The tailstock wrench fits the nut used to lock it to the bed. The top half of the steady rest can be swung open for easy loading and unloading of workpieces by unclamping eye bolt and swinging the top portion out of position.

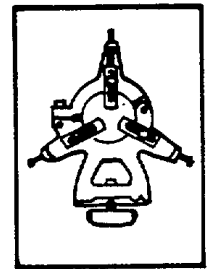


Figure 11.

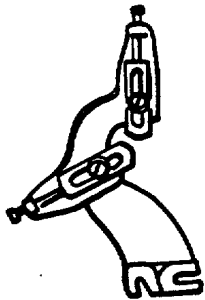


Figure 12.

Follow Rest (fig. 12): A follow rest is a device used when turning long thin stock to support it behind the tool. The assembly bolts to the side of the saddle and moves with it during the cut. The assembly has two jaws which are adjustable and can be locked in position. With the tool positioned to cut just ahead of the jaws, the jaws are adjusted to ride on the surface turned by the tool and prevent the work from being deflected by the cutting action.

Lever Operated Tailstock (fig. 13): When a tailstock is, equipped with a lever operated attachment, the quill is moved in and out with the use of a lever. The purpose of the attachment is to permit the use of taps and die heads for threading operations and can be used when drilling smaller holes to allow a better feel of the drilling operation and rapid drill retraction. Because of its floating type action when a tap or die is engaged the quill will follow the lead of the thread until the spindle is stopped and reversed. It also makes woodpecker-type drill operations easier when clearing chips is a necessity in deep holes.

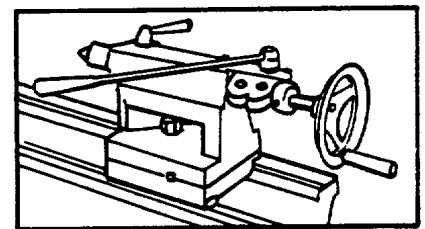


Figure 13.

Draw-In Collet Attachment (fig. 14): The draw-in collet attachment consists of a handwheel, a draw tube, and a collet adapter which fit into the taper of the spindle nose. It is used with type 5c collets with a diameter range of 1/16" (1.588 mm) to 1 1/16" (26.988 mm). The collet is fitted into the adapter and is drawn into it by engaging the draw tube internal thread to the collet by rotating the handwheel at the left end of the spindle.

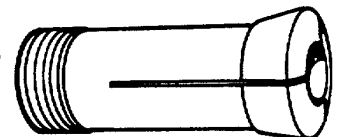


Figure 14.
Figure 14.

Production Collet Attachment (fig. 15): The production collet attachment is similar to the draw-in type except that when adjusted the collet can be opened to release the part or closed to clamp the part by use of a lever. Collet type 5c are used with a diameter range of 1/16" (1.588 mm) to 1 1/16" (26.988 mm). Collets are installed in the spindle nose adapter and drawn in with the draw tube. The lever is placed in the back lock position and with the stock installed in the collet the draw tube handwheel is rotated to lock the stock in the collet. Pulling the handle forward will release the stock.

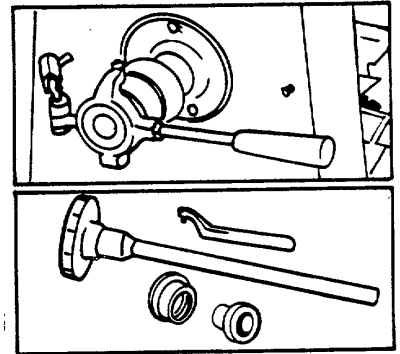
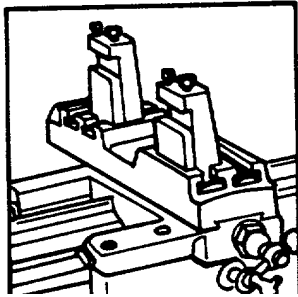


Figure 15.



Double-Connected Rest (fig. 16): A double-connected cross slide has a tee-slot block at the front and rear so that tools or turrets can be installed in both locations. Its use is in production operations similar to those performed on turret lathes where multiple operations are done such as forming, grooving, chamfering, cutoff as similar cuts.

Figure 16.

Threading Stop (fig. 17): With a threading stop installed between the saddle and cross slide, the cross slide can be used to clear the threading tool on multiple pass operations to generate a thread and be returned to its original position against a positive stop. With this device, single point threading at its best is possible using only one side of the threading tool to create the thread.

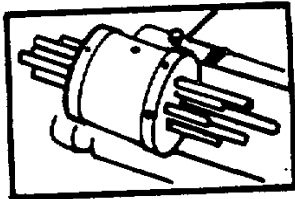
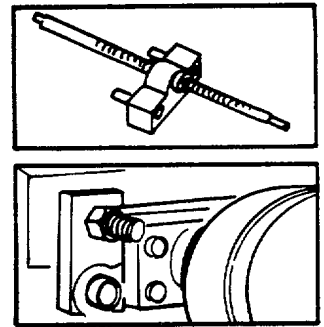


Figure 18.

Multiple Saddle Stop (fig. 18) :On production operations where multiple accurate length positions are to be maintained, a multiple position saddle stop can be used. It provides six infinitely adjustable positive stops which can be pre-set and indexed in the planned sequence of operations. It is often used in conjunction with a hand turret to repetitively position the saddle for each tool in the turret. The attachment clamps to the front vee and the stops go against the left wing of the saddle.

Coolant Attachment (fig. 19) A coolant attachment consists of a 7 1/2 gallon coolant reservoir with a pump mounted on it and the connecting hose, nozzle bracket, and nozzle. All steels and most other metals are cut more efficiently by using coolant, cutting oils, or special fluids which help to keep the tool and workpiece cooler.

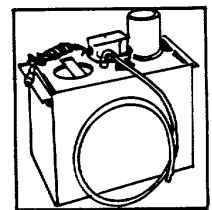


Figure 19.

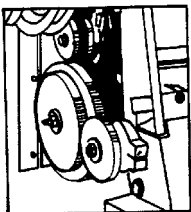


Figure 20.

Metric Transposing Gearing: The metric transposing gear set will convert the lathe to cut the metric threads indicated in fig. 20. Follow the end gearing and gearbox setup shown in the chart to cut the desired thread. On metric threading, do not disengage the half nut on multiple passes; reverse the spindle to return the saddle to the starting point.

Ram Type Turret (fig. 21): A ram type turret attachment can be mounted to the bed in the place of a tailstock. Turrets of this type are usually six sided and index on the return stroke. The ram is advanced or retracted by a capstan type handwheel. Counterclockwise rotation of the handwheel advances the ram; clockwise rotation retracts the ram. Adjustable stops are provided to preset the forward stopping position of each turret index. The turret is bored out to accept commercial turret tooling on the lathe by putting an adjustable boring bar in the spindle of the lathe. By this method the location of the tooling holes are on center with the lathe. With a turret, a multiplicity of operations can be performed with the same setup for repetitive parts.

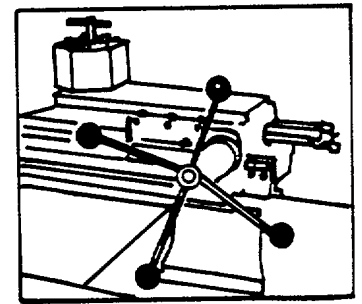
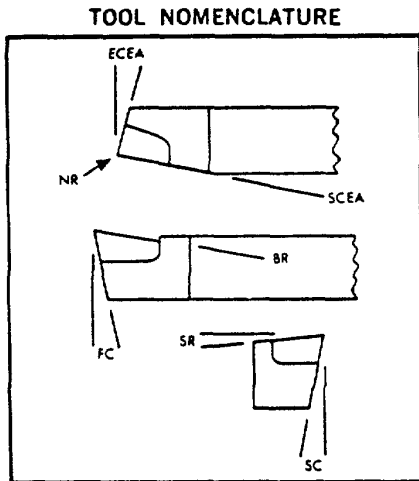


Figure 21.

Cutting Tool Geometry: Shown in fig. 22 are the names of the important angles on tools. Clearance or relief angles are usually 5 degrees or less to avoid rubbing or heeling of the tool. It should be kept in mind on boring that curvature of the



- | | |
|--------------------|---------------------------------|
| SR -- Side Rake | NR -- NOSE Radius |
| BR -- Back Rake | SCEA -- Side Cutting Edge Angle |
| SC -- Side Relief | ECEA -- End Cutting Edge Angle |
| FC -- Front Relief | |

Figure 22.

hole may require a larger relief angle in order for the heel or bottom of the tool not to contact the work before the cutting edge does. In threading also the lead of the thread may require additional side relief in order to avoid heeling of the tool. Listed in fig. 23 are tool rake angles used with various materials. As a general rule, the smaller the cutting angle the lower the power required to remove the material and the lower the radial force tending to force the tool or workpiece away

MATERIAL	SR	BR	MATERIAL	SR	BR
PLAIN CARBON STEEL	6	0			
ALLOY STEEL	-5	-5			
TOOL STEEL	+5 to -5	0 to -5			
STAINLESS STEEL	0 to -5	+5 to -5			
CAST IRON	6	0			
TITANIUM	+5 to -5	0 to -5			
ZIRCONIUM	12	12			
COPPER	6 to 12	3 to 6			
COPPER ALLOYS	-5 to 12	-5 to 12			
ALUMINUM	6 to 12	6 to 12			
MAGNESIUM	6 to 12	6 to 12			
PLASTICS	0 to 20	0 to 12			

Figure 23.

from each other. However, the smaller the cutting angle the less strength in the cutting edge and therefore the shorter the time between regrinding.

Surface finish is affected by both feed rate and the nose radius on the tool. Unless an extremely coarse feed rate is used on finishing cuts, a nose radius of 1/32 (.794 mm) is usually large enough to produce a fine finish and yet minimize the power required and the tendency to chatter on thin or small diameter workpieces. Larger radius turning tools tend to burnish rather than cut because of the long feathering out area.

Tool Selection:

There are a number of tool holders which are designed for specific operations. There are many more types of holders available for various operations and for use in turrets.

The holder is selected for the operation to be performed such as right hand turning, threading, or cut-off. However, the tool material, feed rate, and spindle speed vary with the material to be cut, the depth of cut and the acceptable finish. Tool material commonly used on lathes are high speed steel, Stellite, tungsten carbides, combination carbides, coated carbides, and oxides. Small shops and schools continue to use high speed steel tools because of their relative low cost and easy resharpening. For production work, the carbide type tools are much preferred because of the higher surface speeds allowable and faster metal removal.

Listed in fig. 24 are a variety of materials and the speed and feeds that can be used as starting point.

Figure 24.

SPEED & FEED CHART											
MATERIAL	MACHINABILITY	HIGH SPEED		CARBIDE		MATERIAL	MACHINABILITY	HIGH SPEED		CARBIDE	
		SPEED FT/MIN	FEED IN/REV	SPEED FT/MIN	FEED IN/REV			SPEED FT/MIN	FEED IN/REV	SPEED FT/MIN	FEED IN/REV
Plain & Low Alloy						Nickel base					
Steels						R-Monel	45	80	.015	270	.015
12L13	160	195	.015	700	.020	Inconel	30	20	.010	80	.010
B1112	100	165	.015	620	.020	Hastelloy C	20	20	.015	100	.010
C1020 CD	80	120	.015	485	.020	Rene 41	15	12	.010	70	.010
C1137 CD	71	135	.015	525	.020	Waspaloy	12	20	.010	75	.010
C1045 HR	50	95	.015	400	.020	Titanium					
C1095A	60	70	.015	365	.020	A55	30	70	.015	220	.015
4140 HR	60	50	.015	430	.020	C120	20	45	.010	135	.010
4340 HR	52	90	.015	400	.020	MST	9	30	.010	125	.010
4640 HR	55	90	.015	400	.020	CopperAlloy					
8617 HR	70	115	.015	475	.020	Yellow Brass		200	.015	500	.020
Nltraloy 135	47	85	.015	400	.015	Naval Brass	90	300	.015	500	.020
Stressproof	50	50	.010	280	.015	Commercial Brass		300	.015	650	.020
52100	46	95	.015	425	.020	PhospherBronze	60	100	.015	200	.020
E9310 CD	41	40	.010	250	.015	Aluminum Bronze	60	100	.015	200	.020
Beryllium Copper						Beryllium Copper	60	100	.015	200	.020
Tool Steels (Annealed)						Aluminum Alloys					
01		72	.015	335	.015	2014 T6	140	600	.015	2000	.020
A2		72	.015	335	.015	6061 T6	190	600	.015	2000	.020
S-5		90	.015	400	.015	7075-T6	120	600	.015	2000	.020
M2		65	.015	325	.015	4032-T6	110	600	.015	2000	.020
T15						319F	160	600	.015	2000	.020
Stainless Steels						355-T6	160	600	.015	2000	.020
405	60	120	.015	525	.015	Magnesium		800	.015	2000	.020
414		80	.015	375	.015	Plastics					
302	50	90	.015	350	.015	Styrene		250	.015	400	.015
350		75	.015	350	.015	Bakelite		500	.012	750	.012
17-7	20	75	.015	350	.015	Nylon		300	.010	500	.015
Cast steel 1020		120	.015	485	.020	Teflon		300	.010	500	.015
Cast Irons						Lucite		250	.008	450	.010
Grey Iron Class 30	40	80	.015	340	.015						
Nodular Iron	60	125	.015	345	.015						
Ni-resist	45	75	.015	285	.015						
Malleable	110	160	.015	500	.015						

Engine Lathe Operations:

In turning operation (fig. 25), the part may be supported between centers or held in a chuck or collet. When turning between centers, install the dog plate on the spindle nose and the center sleeve and center in the spindle nose. Install a center in the tailstock; either a solid or rotating type. Lock the dog on to the work piece near the left end of the stock. Place the center of the stock in the headstock center. Note: When installing centers or center sleeves, be sure they and the tapered hole in which they go are wiped clean of all foreign matter. Slide the tailstock with its quill retracted as much as possible up to the point where it is near the right end of the stock but far enough away to allow the work piece to be removed. Lock the tailstock in position and advance the quill to engage the tailstock center in the work piece center. In the work piece center. Be sure if a dead center is used to coat its tip with a heavy duty center oil. Lock the quill position.

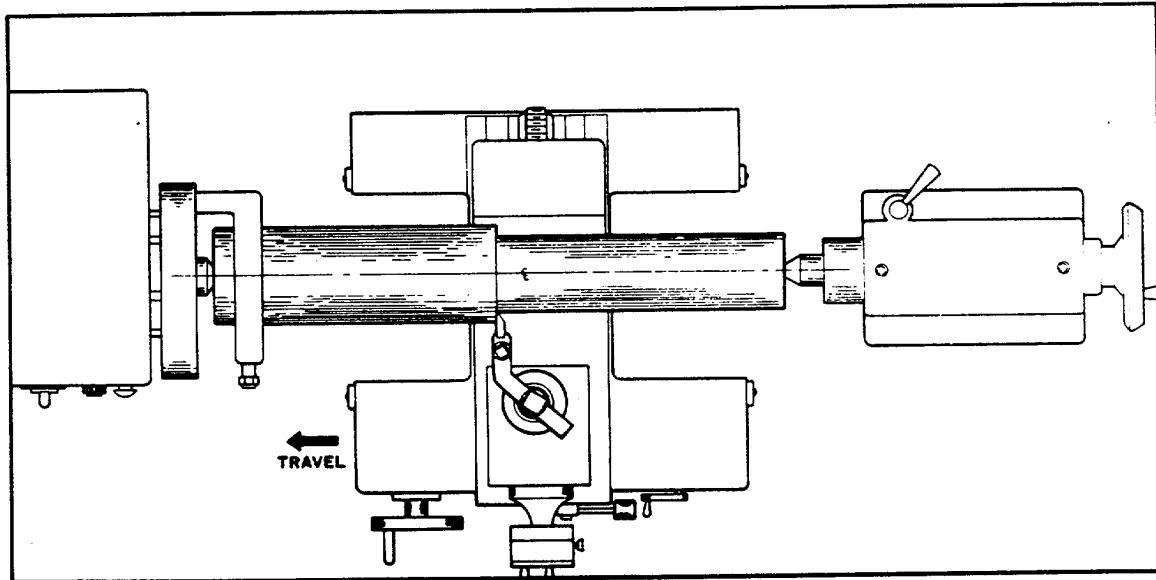


Figure 25.

Using the speed and feed chart on page 14 or a good reference, determine the feed and speed to be used for the job to be done. Fig. 27 on page 16 will determine if coolant is to be used. Position the gear box and reverse gear quadrant for the feed direction and advance per revolution. Make sure the tool clears the work by rotating the work manually. Check for the proper setup of the back gear and sheave for the speed range to be used. Start the machine and adjust to the proper speed setting. If the operation is turning, advance tool to touch off on the diameter of the piece. Zero the cross feed dial. Move off past the end of the work piece and advance the cross slide enough to clean up on the work piece. Rezero the dial. Engage the feed and take a cleanup cut long enough to gauge the diameter. Disengage the feed and then move the carriage to the right so that the tool clears the end of the work piece. Stop the spindle and measure the turned diameter, subtract the finished diameter from the measurement and the difference will be the amount the cross feed dial must be moved to position the tool for a finished cut. If much material must be removed, it should be removed in a series of equal steps leaving $1/32"$ (.794 mm) on the diameter for a finished cut. The surface speed and feed rates given in the table are for roughing cuts, and for finish cuts the speed can be increased roughly 40% as the feed rate and depth of cut is reduced to improve the surface finish.

If coolant splash or chips coming off the machine represent a hazard to the operator or others in the immediate area, a shield should be used to remove the hazard.

Never remove chips with the machine running; stop the lathe and use a brush or chip rake. Never remove or brush away chips with your hand.

For parts that are long in relationship to their diameter, a steady rest or follow rest may have to be used to avoid chatter and/or part deflection.

Facing Operations:

Facing operations (fig. 26) are performed in the same way as turning operation in that the machine is first set up for the work to be done with the drive motor off. The work can be held in a chuck, fastened to a face plate or mounted in a special fixture.

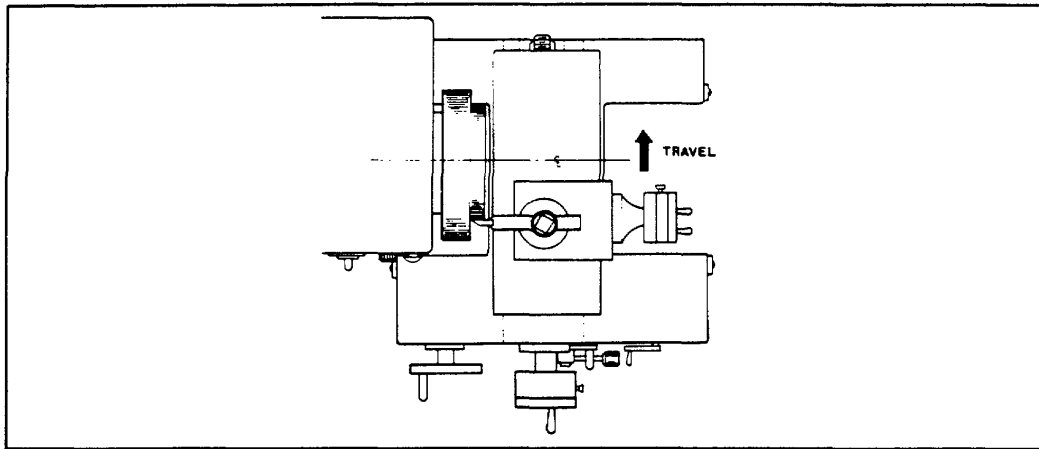


Figure 26.

In facing, selecting the correct surface speed rate is more of a problem since the diameter is constantly changing.

$$SFM \sim \frac{1}{4} \qquad N \sim \frac{4}{D} SFM$$

N is the spindle RPM and D is the diameter in inches. One method to be used is to determine the largest diameter of the surface to be faced and use it to determine the spindle RPM. Another method can be used since the lathe is equipped with a variable speed mechanism. Determine the maximum and minimum diameter to be faced and use these values to calculate the maximum and minimum spindle RPM and adjust the speed gradually as the cross slide feeds the tool across the surface. With this method, time to face a surface will be reduced and there will be more consistency in the finish.

For controlling thickness or step in facing cuts, consider positioning the compound rest at 90° so that the compound dial can be used to measure the tool advance. Caution: The compound dial is direct reading on diameter when used in facing the amount to move the dial must be doubled. Lock the saddle to the bed with the binder provided for heavy facing cuts.

TYPE OPERATION	MATERIAL	COOLANT RECOMMENDATION	DILUTION RATIO
GENERAL TURNING	ALLOY STEELS	DRY	---
	NON FERROUS	DRY	---
	HIGH TEMP. ALLOYS	CHEMICAL COOLANT	30/1
FINISH TURNING	FERROUS ALLOYS	CHEMICAL COOLANT	50/1
THREADING	FERROUS ALLOYS	CUTTING OIL	---
PRODUCTION TURNING	ALLOY STEELS	DRY OR SOL. OIL.	20/1
HEAVY DUTY TURNING	STEEL	DRY	---
	CHILLED IRON	ALL BLAST	---
LOW SPEED (H.S.S.)	FERROUS	E.P. SOLUBLE	15/1

Figure 27.

Threading:

There are two methods of single point turning of threads on a lathe. In one method, the compound rest is perpendicular to the diameter of the thread and the thread is plunged by advancing the tool straight in a series of cuts. In the second method, the compound is set at half the included thread angle and is advanced in a series of cuts along the half thread angle. The second method is preferred since there is cutting pressure on only one side of the tool. The plunge method when used on soft materials can result in thread surface tear out.

In setting up for a threading operation, first set the gear box levers in the proper position for the thread to be cut. Position the reverse gear shifter lever for the thread to be cut for a right hand thread or for a left hand thread. Using table in (fig. 29) and the surface speed formula, determine the RPM to be used. Fig. 30 lists the amount and number of passes to be used. With the part piece Installed In the lathe set the threading tool with a threading tool gage.

Start the lathe spindle and advance the tool with the cross slide handwheel to touch off of the work. Zero the cross feed dial. Back off the tool and move it past the end of the part. Bring the cross slide back to zero and advance the compound rest by the amount of the first pass. If the threads per inch can be divided by 8, the half nut lever can be re-engaged at any point on the threading dial, if divisible by 4 it can be re-engaged at the four lines on the dial; if divisible by 2 it can only be re-engaged at the lines marked 1 and 2. If the thread is an odd number, the lever must be re-engaged at the same line each time in order to pick up the thread. When cutting metric threads, the half nut lever can not be disengaged without losing the timing between the spindle and the tool. (fig. 28)

At the end of each threading section there must be a neck provided whose width is approximately 1-1/2 times the pitch to provide for stopping the spindle or disengaging the half nut.

Engage the half nut lever and the apron will move the saddle at the threading rate. When the tool reaches the neck area, disengage the half nut if possible, retract the cross slide to clear the tool, move the saddle back to the starting point, advance the cross slide back to zero and advance the compound rest for the next cut. Re-engage the half nut lever for the second pass and repeat the process for subsequent cuts. If the half nut lever cannot be disengaged, the reversing controls will have to be used to stop the spindle. Move the cross slide out to clear the tool and reverse the spindle direction to move the tool back to the starting point.

Kind of Thread	Example	Reading on Thread Dial
Multiples of 8	8, 16, 24, 32, 40, 48, etc.	Any Place on Dial
Even Pitches	4, 6, 8, 10, 12, 14	Any Mark on Dial
Odd Pitches	5, 7, 9, 11, 13, 23 and 27	Opposite Marks, Two Only
Half Pitches	4½, 5½, 6½, 11½, 13½	Any Mark, One Mark Only
Quarter Pitches	5¾ and 6¾	Dial Not Used

Figure 28.

Taper Turning:

Three methods of turning external tapers can be used on an engine lathe. These are:

1. Using the compound rest for short or steep tapers.
2. Using the taper attachment for tapers up to a 20° included angle not exceeding 10' (254 mm) In length.
3. Using tailstock set over for up to the take between centers not requiring the tailstock offset to exceed 9/16 (14.288 mm).

Internal tapers can be machined using either 1 or 2 methods listed above.

THREADING SPEEDS	
MATERIAL	SURFACE FEET PER MINUTE
AISI-1141	220
1040	200
4140	180
1117	260
CAST IRON	160 - 240
17-7 PH	80
440C	90
302	120
A-286	85
J1570	30
BRASS	250 - 440
ALUMINUM	300 - 600
TITANIUM	80

Figure 29.

THREADS PER INCH	NUMBER ROUGH PASSES	INFEEED		PERMISSIBLE TOOL RADIUS	PITCH
		AT 90°	AT 29°		
4	14	0.1534	0.175	0.028	0.250
5	12	0.1227	0.140	0.025	0.200
6	12	0.1022	0.117	0.020	0.166
7	10	0.0876	0.101	0.017	0.143
8	9	0.0767	0.0879	0.015	0.125
9	8	0.0682	0.0767	0.013	0.111
10	8	0.0613	0.0705	0.012	0.100
12	7	0.0511	0.0585	0.010	0.0833
13	7	0.0472	0.0540	0.009	0.0769
14	7	0.0438	0.0501	0.009	0.0714
16	6	0.0383	0.0437	0.007	0.0625
18	5	0.0341	0.0390	0.007	0.0555
20	5	0.0306	0.0350	0.006	0.0500
24	4	0.0256	0.0293	0.005	0.0416
28	3	0.0219	0.0252	0.004	0.0357
32	3	0.0191	0.0218	0.004	0.0313

Figure 30.

In all cases in order to machine an accurate taper some method of gagging it such as a plug or taper gage or measurement will have to be used. One of the easiest methods of checking tapers (fig. 31) is to use an indicator mounted on the compound against the work piece and a measured length or saddle movement. If the length can be 10" (254 mm), the tangent of the half angle of the taper will be measured directly by noting the movement of the indicator over that length dividing it by 10 and looking up the value in a trigonometry table. ($\text{Tan } 1/2 \text{ angle} = \frac{\text{indicator movement}}{10}$). By the same method on a 1" (25.4 mm) movement of the saddle, the indicator reading is equal to the tangent of 1/2 the included angle.

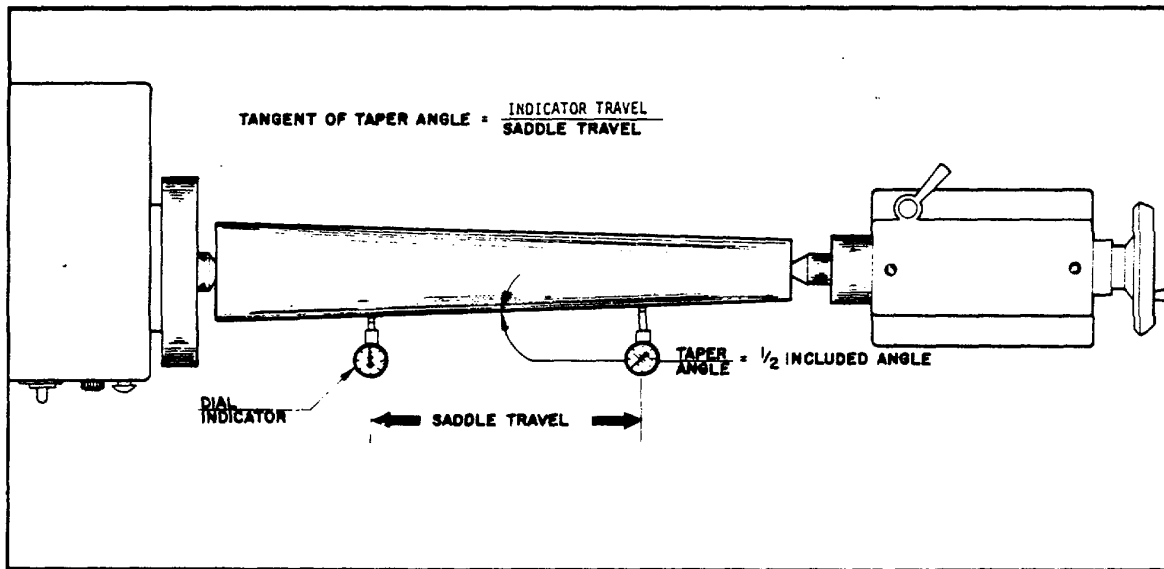


Figure 31.

Drilling, Reaming, Tapping:

The tailstock of a lathe can be used for drilling and reaming operations and when equipped as a lever operated type it can be used for tapping. A ram type turret can be used for all three operations. The following tables are listed for your convenience in selection of the proper speeds and feeds for these types of operations when using a tailstock or a ram type turret.

DRILLING FEEDS - SPEED - HORSE POWER REQUIRED

SIZE OF DRILL	FEED PER REVOLUTION	BRONZE BRASS	COPPER	ALUMINUM	MALLEABLE IRON	CAST IRON			STEEL CASTING	STEEL					CAST IRON		STEEL	
						MACHINED SURFACE	SCALE SURFACE	DEEP HOLES		VERY HARD BRINELL 402-444	HARD BRINELL 302-387	MEDIUM BRINELL 202-293	SOFT BRINELL 101-196	DEAD SOFT BRINELL UNDER 100	CUTTING HP	FEED HP	CUTTING HP	FEED HP
FT. PER MIN.		250	150	300	80	100	80	80	40	40	50	60	70	80	HP	HP	HP	HP
INCHES		RPM	RPM	RPM	RPM	RPM	RPM	RPM	RPM	RPM	RPM	RPM	RPM	RPM				
1/16	.003	15279	9167	18320	4889	6111	4889	4889	2445	2445	3056	3667	4278	4889	.07	.0043	.18	.0076
3/32	.0035	10186	6111	12212	3282	4077	3282	3282	1628	1628	2039	2446	2852	3262	.11	.0044	.27	.0079
1/8	.004	7639	4583	9160	2445	3056	2445	2445	1222	1222	1528	1833	2139	2445	.14	.0045	.36	.0081
5/32	.0045	8111	3667	7328	1956	2445	1956	1956	976	976	1223	1467	1711	1956	.18	.0048	.45	.0084
3/16	.005	5083	3056	6106	1630	2037	1630	1630	815	815	1019	1222	1426	1630	.22	.0047	.54	.0087
7/32	.0055	4365	2619	5234	1398	1747	1398	1398	696	696	874	1048	1222	1398	.25	.0049	.63	.0089
1/4	.006	3820	2292	4575	1222	1528	1222	1222	611	611	764	917	1070	1222	.29	.0050	.72	.0092
9/32	.0065	3295	2037	4071	1067	1359	1067	1067	542	542	680	815	950	1067	.33	.0051	.81	.0095
5/16	.007	3056	1833	3680	978	1222	978	978	489	489	611	733	856	978	.37	.0053	.89	.0097
11/32	.0075	2778	1667	3330	889	1111	889	889	444	444	555	667	778	889	.40	.0054	.96	.0100
3/8	.008	2546	1528	3050	815	1019	815	815	407	407	509	611	713	815	.44	.0055	1.07	.0102
13/32	.0085	2350	1410	2818	752	940	752	752	376	376	470	564	658	752	.47	.0056	1.16	.0104
7/16	.009	2183	1310	2614	696	873	696	696	349	349	437	524	611	696	.50	.0057	1.25	.0106
15/32	.0095	2037	1222	2442	652	815	652	652	326	326	408	489	570	652	.54	.0058	1.34	.0107
1/2	.010	1910	1146	2287	611	764	611	611	306	306	382	458	535	611	.57	.0059	1.43	.0109
17/32	.0102	1798	1079	2157	575	719	575	575	288	288	360	431	503	575	.60	.0060	1.51	.0111
9/16	.0105	1698	1019	2035	543	679	543	543	271	271	340	407	475	543	.64	.0061	1.60	.0112
19/32	.0107	1608	965	1930	515	643	515	515	257	257	322	382	450	515	.68	.0062	1.69	.0114
5/8	.011	1528	917	1830	489	611	489	489	244	244	306	367	428	489	.72	.00624	1.78	.0115
21/32	.0112	1455	873	1746	466	582	466	466	233	233	291	349	407	466	.75	.0063	1.87	.0117
11/16	.0115	1389	833	1665	444	556	444	444	222	222	278	333	389	444	.79	.0064	1.96	.0118
23/32	.0117	1329	797	1594	425	532	425	425	213	213	266	319	372	425	.83	.0065	2.05	.0120
3/4	.012	1273	764	1525	407	509	407	407	204	204	255	306	357	407	.87	.0066	2.14	.0121
25/32	.0122	1222	733	1467	391	489	391	391	196	196	245	293	342	391	.90	.00665	2.22	.0122
13/16	.0125	1175	706	1408	376	470	376	376	188	188	235	282	329	376	.94	.0067	2.31	.0123
7/8	.013	1081	666	1307	349	438	349	349	176	176	218	262	306	349	1.01	.0068	2.49	.0126
15/16	.0135	1019	611	1221	326	407	326	326	163	163	204	244	285	326	1.09	.0069	2.67	.0128
1	.014	955	573	1143	306	382	306	306	153	153	191	229	267	306	1.16	.0070	2.85	.0130

TAPPING AND THREADING FORMULA FOR CALCULATING HORSEPOWER REQUIREMENTS

HP = PPV x SFM x M x TD

PPV = Power Pitch Value See Chart
 SFM = Surface Feet Per Minute See Chart
 M = Material Factor See Chart

TD = Tool Dullness Factor See Chart
 HP = Horsepower
 RPM = Revolutions Per Minute

TAPPING AND THREADING FACTORS CHART	
Threads Per Inch	Power Pitch Value° PPV
32	0.002
27	0.0034
24	0.004
20	0.006
18	0.007
16	0.009
14	0.011
13	0.012
12	0.014
111	0.015
11	0.016
10	0.020
9	0.025
8	0.030
7	0.035
6	0.040

*Multiply PPV by 2.2 for Double or Taper Pipe Threads
 TD - Use (1.5 Factor) for Tool Dullness

MATERIAL AND SPEED FACTORS CHART		
MATERIAL	FACTOR - M	SPEED - S. F. M.
Aluminum	0.5	100
Bakelite	0.6	75
Brass	0.6	90
Bronze	0.6	50
Bronze Mang.	1.0	40
Copper	0.5	80
Alum. Die Cast	0.6	80
Fiber	0.5	75
Zinc Die Cast	0.6	80
Cast Iron	0.6	70
Malleable Iron	0.6	45
Magnesium	0.5	100
Steel Cast	1.4	35
Steel Fr. Mach.	1.0	50
Steel Chromium	1.7	30
Steel Alloy	1.7	25
Steel Stainless	1.7	20

REVOLUTIONS PER MINUTE CALCULATION
 R. P. M. - 3.82 x S. F. M. - Dia.

**REAMING SPEEDS - HIGH SPEED STEEL TOOLS
MATERIALS - RPM**

	Brass	Bronze	Malleable Iron	Cast Iron Class 30	Steel Casting	STEEL				
						Very Hard Br 400-425	Hard BR 300-375	Medium Br 225-200	Soft Br 100-200	Dead Soft Br Under 100
1/8	3500	1600	2200	2100	1700	640	800	1200	1900	2080
1/4	1700	800	1100	1050	850	320	400	600	950	1040
3/8	1200	530	730	700	600	210	270	430	640	700
1/2	880	400	550	520	440	160	190	320	480	520
5/8	700	320	440	410	350	130	150	250	380	410
3/4	580	270	370	350	280	105	130	200	315	345
7/8	500	230	315	300	240	90	115	170	270	300
1	440	200	275	260	210	80	100	150	240	260

NOTE: For Carbide Reamers Use 3 Times Chart Speeds

Counterboring & Spotfacing - High Speed Steel Tools - Surface Ft/Min

	325	100	50	50	40	30	45	55	65	110
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NOTE: For Carbide Spotfacers Use 4 Times Chart Values

TROUBLE-SHOOTING HINTS

TROUBLE	PROBABLE CAUSE	REMEDY
Lathe Won't Start	<ol style="list-style-type: none"> 1. Bad motor. 2. Bad switch. 3. Loose wire. 4. Bad contacts. 5. Bad coil. 6. Heater contacts open. 	<ol style="list-style-type: none"> 1. Replace motor. 2. Replace switch. 3. Tighten connections. 4. Replace contacts. 5. Replace coil. 6. Wait until contacts close.
Lathe Not Turning True. (cutting slight taper)	<ol style="list-style-type: none"> 1. Lathe not properly leveled. 2. Tailstock not set on witness line. 	<ol style="list-style-type: none"> 1. Level machine. 2. Readjust tailstock.
Back Gearing Noisy.	<ol style="list-style-type: none"> 1. Back gear lever out of adjustment. 2. No lubrication. 	<ol style="list-style-type: none"> 1. Readjust eccentric pin. 2. Recoat with open gear grease.
Reverse Gear Noisy.	<ol style="list-style-type: none"> 1. Stops not adjusted properly. 2. No lubrication. 	<ol style="list-style-type: none"> 1. Readjust stops. 2. Recoat with open gear grease.
Spindle Bearings Running Hot.	Improper bearing adjustment.	Consult factory.
Spindle Slows Down or Stops Under Load.	<ol style="list-style-type: none"> 1. Improper belt adjustment. 2. Bad motor. 	<ol style="list-style-type: none"> 1. Readjust motor base. 2. Replace motor.
Saddle Stops Feeding.	Friction clutch out of adjustment.	Readjust friction clutch.
Cross Slide Stops Feeding.	Friction clutch out of adjustment.	Readjust friction clutch.
Lathe Faces Out of Square.	Cross slide gibs are loose.	Readjust gibs.
Lead on Thread Varies.	Worn lead screw.	Replace lead screw.
Speed Dial Does Not Rotate.	Gears not in mesh.	Adjust idler stud.
Spindle Noisy.	<ol style="list-style-type: none"> 1. Bad spindle bearings. 2. Bad sheave bearings. 	<ol style="list-style-type: none"> 1. Replace bearings. 2. Replace bearings.
Chatter on Outside Diameter	Loose carriage gibs.	Readjust gibs.

Calculations for cutting threads are not listed on threading chart on 12" lathes.

- T = Desired threads per inch to be cut.
- S = Number of teeth in stud gear to obtain desired threads per inch.
- t = Threading chart position to obtain desired threads.
- K = Constant required to make desired threads per inch a whole number. (Not used when desired threads per inch is already a whole number.)

To determine if desired threads per inch can be cut without compound end gearing:

60K

Factor TK and cancel all factors possible in numerator and denominator. Desired thread can probably be cut if the only remaining factors in the denominator are 2,3,5,7,11,13 and 23 providing listed factors occur only once with the exception of 2.

A. EXAMPLE: Desired thread to be cut - 5-1/3 t.p.i.

$$\frac{60}{5-1/3} \frac{(3)}{(3)} = \frac{180}{16} = \frac{2 \times 2 \times 3 \times 3 \times 5}{2 \times 2 \times 2 \times 2} = \frac{3 \times 3 \times 5}{2 \times 2}$$

To determine thread position "T" on gear box, select threading chart column from following table.

Largest remaining factor in denominator	Column
2	1
3	2 or 6
5	3
7	8
11	4
13	7
23	5

Select thread number on chart between T and T/2 in column selected above.

- (A) EXAMPLE: Largest remaining factor in denominator is 2.
- Thread chart column No. 1 is selected from table I.
 - T:= 5-1/3 and T/2 = 2-2/3
 - t = 4 chosen from Row No. 1, Column No. 1

To determine number of teeth in stud gear, use the following formula:

$$S = \frac{60tK}{TK}$$

- (A) EXAMPLE: $S = \frac{(60) (4) (3)}{(5-1/3) (3)} = 45$

NOTE: Answer must be whole number to cut non-listed threads per inch without using compound end gearing. If compound end gearing is required, refer to a machinist handbook. Thread cutting, change gears for lathes.

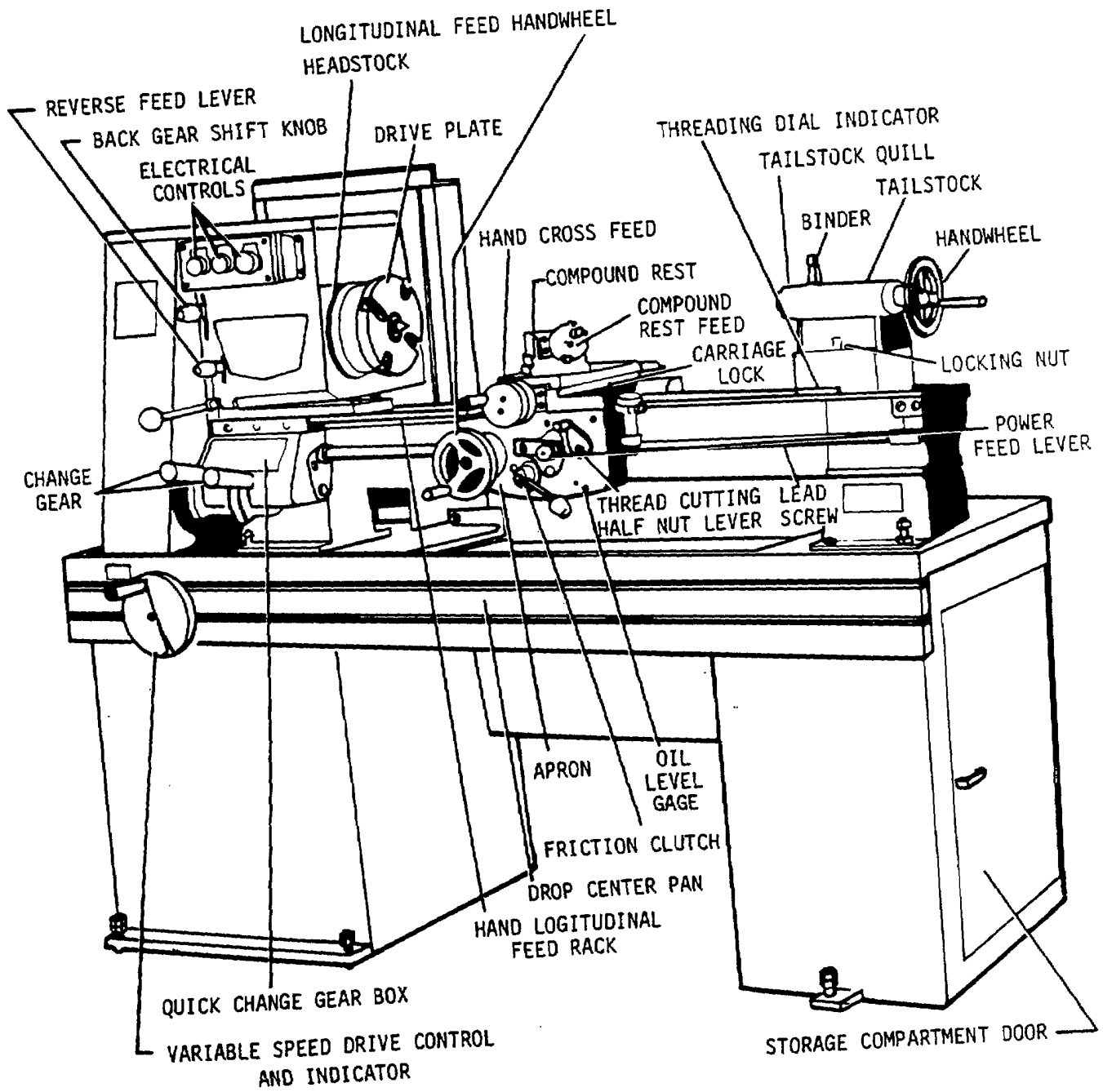


Figure 32.

INSTALLATION OF THE LATHE

The machine should be left on the skid until it has been moved to the location where it is to be installed. Remove the 4 bolts that hold the machine to the skid. Use great care in lifting the machine from the skid and placing it in location. Serious damage will result if the machine is dropped or the lead screw is bent. If an overhead crane is used, make sure the capacity is at least 2000 pounds and use blocks to prevent the cables from touching the lead screw. If a fork lift is used, the forks should be positioned as far apart as possible and clearance should be maintained so that the face of the forks does not contact the apron or lead screw. Place the machine on a solid level floor, preferably concrete. In a dry, well lighted area. Be sure to allow adequate space around the machine for operation and maintenance. Mark the location of the 6 mounting holes and drill in the concrete for installation of 1/2" bolts. Use lag screws or bolts in expansion shields or a similar holding device.

LEVELING THE LATHE

It is of greatest importance that the lathe be level, if it is not, the lathe bed will be twisted, throwing the lathe out of true. It is impossible to do accurate work on a lathe that is not level. A lathe bed that is not level will in time acquire a permanent warp damaging it beyond repair. Use a precision machinist's level (0.005 in/ft. graduations) and adjust leveling screws to within one graduation. To level the machine, raise the two leveling screws on the left end of the headstock pedestal until they clear the floor. Lower the two leveling screws on the right end of the headstock pedestal and the two screws in the tailstock pedestal until only these four screws contact the floor. Place the precision level across the top of the V ways on the headstock end as shown in fig. 1. Adjust the leveling jack in the front or back of the right end of the headstock pedestal to bring that end of the bed to a level condition. Move the precision level to the tailstock end of the bed and adjust the front or back leveling screw in the tailstock pedestal to bring that end of the bed to a level condition. Return the level to the headstock end and readjust. If required. Continue to move the level back and forth between the two positions until no adjustment is required. The jam nuts on the leveling jack screws must be snugged down when making adjustments or the level will be affected. Lock the jam nuts on the four jack screws used for leveling. Adjust the two jack screws at the left end of the headstock until they contact the floor and lock their jam nuts. Recheck the level at both ends of the bed and correct if necessary. It is not necessary to level the bed parallel to its long axis. Recheck the level of the bed on a regular basis and correct if necessary in order to maintain accuracy.

ELECTRICAL CONNECTIONS

Before making electrical connections or performing any maintenance, disconnect source power lines. A separate fused line disconnect switch should be installed. All electrical work should be done by a qualified electrician and in accordance with the National Electrical Code and other applicable local codes. Connect a separate ground from the frame of the machine to a good earth ground. If the machine was ordered with electrical-controls and motor. It will be completely wired in flexible conduit and it will only be necessary to attach the power lines to the leads in the electrical compartment in the rear of the headstock pedestal. Access to the electrical compartment is gained through removal of panel secured by 6 button head screws.

Check the label on the machine to insure that the power characteristics of the power line, voltage and number of phases, agree with each other. Connect the power lines and check rotation of motor. The motor must rotate clockwise when viewed from the shaft end. Rotation may be reversed by transposing any 2 incoming power leads.

VARIABLE SPEED DRIVE

Spindle speeds are infinitely adjustable through two ranges, back gear and direct drive by means of a handwheel on the front of the headstock pedestal. A speed dial beside the handwheel indicates the spindle speeds which range from 55-310 RPM in back gear to 340-2000 RPM in direct drive. All speed changes must be made with the motor running.

Power is transmitted from the motor to the spindle pulley through a floating center sheave variable speed drive and two variable speed belts. The belt tension is controlled by adjusting the nuts on the motor base tension rod. If the control handwheel is difficult to turn, the belt tension is too great and the motor base must be raised. If the belts exhibit a loose action, the motor base must be lowered to increase tension.

The minimum and maximum speeds are set by adjustment of the stop nuts on the variable speed control screw actuated by the handwheel. The spindle belt will be flush with the outside diameter of the variable speed sheaves at maximum speed and the motor belt will be flush with the outside diameter at minimum speed.

To replace the belts, loosen the upper adjusting nut on the motor tension rod. Slip the lower belt off the motor sheave and

the upper belt off the spindle sheave. Remove the 4 socket head cap screws that hold the 2 split bearing caps on the variable speed sheave assembly. Lower the shaft assembly and remove the belts. Reverse the procedure to reassemble. An adjustment in motor tension will be required because of variation in new belt lengths.

HEADSTOCK (fig. 33)

The spindle drive mechanism includes the handwheel, pulley, pinion, large back gear, small back gear, and bull gear. For direct drive raise the back gear shifter knob slightly and push in to disengage the back gears and push the handwheel in to connect the pulley to the spindle. For back gear drive pull the handwheel out to disconnect the pulley from the spindle, raise the back gear shifter knob slightly and pull out to engage the back gears with the spindle gears.

The main spindle bearings are manufactured in matched sets with a specified built-in preload and are assembled and locked in place with accurately ground inner and outer spacers. These bearings are lubricated at the factory for life and, if the machine is properly used, will require no attention from the user. The user should insure that at no time is coolant or other foreign matter forced past the labyrinth seal into the bearings, and that no heavy shock loads are applied to the spindle.

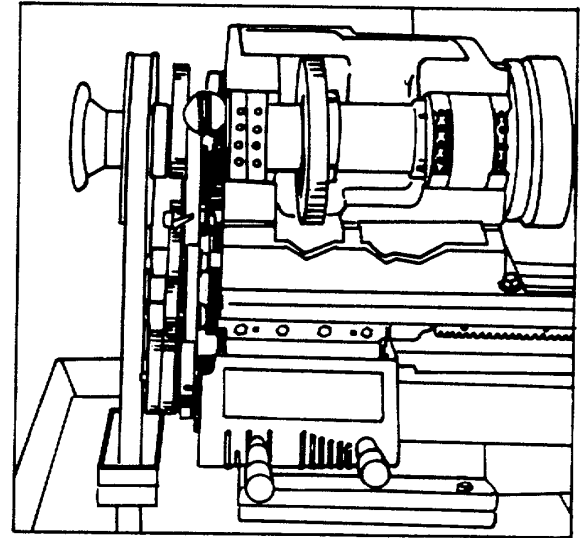


Figure 33.

THE BACK GEARS (fig. 34)

The back gear mechanism is totally enclosed and operated by a convenient shifter lever with knob located at the front of the headstock. The special ductile iron gears having as much as triple the strength of cast iron gears are mounted on a large diameter shaft which turns inside an eccentric quill. The gears are taper pin locked to the shaft to insure rigidity. The shaft is recessed to contain grease lubrication and should be lubricated every forty (40) hours of back gear operation with all purpose grease or similar thru the grease fitting at the rear of the headstock. The back gear lever actuates the eccentric quill thereby swinging the gears into the mesh. Lifting the knob or lever slightly and pulling forward the back gears become engaged and locked in position. A slight rotation of the spindle by hand will aid in meshing the gears easily. The back gears are disengaged by raising the lever or knob and pushing back. The back gear shifter lever is connected to the back gear quill by an eccentric pin which is slotted and locked in position by a socket set screw. The depth of mesh of the back gears with the spindle gears can be adjusted by loosening the socket set screw and turning the eccentric pin with an off-set screw driver.

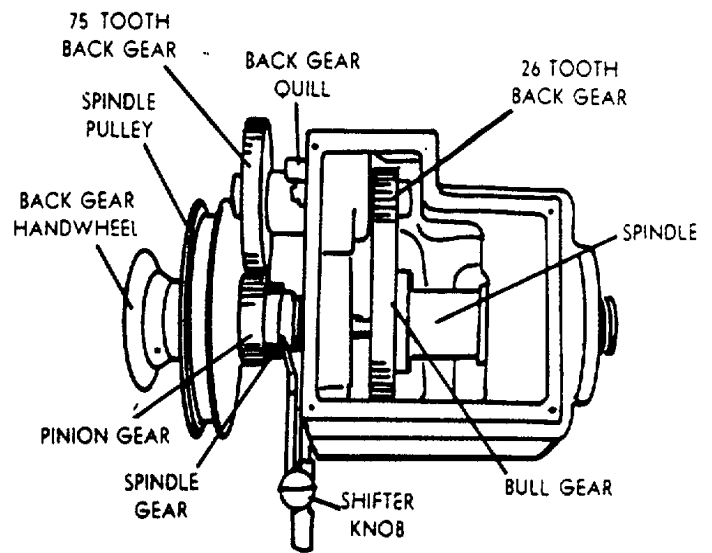


Figure 34.

CAUTION

NEVER ENGAGE BACK GEARS WHILE LATHE IS IN OPERATION OR WHEN SPINDLE IS IN MOTION.

When slower turning speed, or greater power than could be obtained from a direct drive is required, the back gears are used. To engage the back gear drive first pull back or disengage back gear handwheel at back of spindle. This enables pulley and pinion gear to turn free on spindle. Then engage the back gears by pulling shifter lever forward so that the power is transmitted through the pulley and pinion gear to the large back gear, and from the small back gear to the bull gear. The bull gear, being keyed to the lathe spindle, turns it.

THE LATHE BED

The Logan Lathe bed is an extra heavy one-piece casting of special alloy construction to give maximum wear and to withstand all strains. Extra width, extra heavy walls, heavier and closer spaced box type cross ribs combine to give greater strength and make a solid foundation for the lathe mechanisms. Thorough seasoning before and between machining operation make it warp free. To insure extreme accuracy the two prismatic V-ways and two flat ways which are employed, have been flame hardened and precision ground. In order to retain this accuracy, the instructions for setting up the lathe must be followed and periodic checks of lathe for level should be made.

TAILSTOCK

The tailstock slides on the inner V and flat ways of the bed. It is locked in position along the bed by tightening the clamp nut with the tailstock wrench furnished with the machine.

The tailstock spindle is fed out by clockwise rotation of the handwheel and retracted by counterclockwise rotation. Retracting the spindle to the end of its travel ejects the No. 3 Morse taper center from its socket.

The spindle is graduated up to 4" on 12" lathes in sixteenth inch graduations for accuracy in boring and drilling. Lock spindle in place by turning the binding lever to the right.

For turning tapers, the tailstock may be set over 9/16" from the center 'in either direction. Loosen the tailstock clamp nut and adjust to the desired position by means of the square head set-over screws on either side of the tailstock. The tailstock may be returned to approximately true alignment with the headstock spindle by means of the witness mark on the end. To obtain exact alignment, it is necessary to adjust the set-over screws until a light cut on a test bar produces identical diameters at the two ends of the bar.

Apply a few drops of oil daily to the oilers on the tailstock.

LATHE CENTERS

The lathe centers in both the headstock and tailstock are standard No. 3 Morse taper centers. A tapered socket in the tailstock spindle holds its center directly, while an adapter sleeve is required in the headstock spindle. To convert the lathe for collet work, the headstock adapter sleeve and center are knocked out and replaced by a collet adapter and collet.

Before inserting a center into a spindle, both the center and the socket should be wiped free of oil and dirt which would interfere with accuracy.

POWER FEEDS

Power for longitudinal and cross feeds and for thread cutting is taken from the spindle thru the reverse gears, gear train and quick change gear box. As assembled at the factory with a 30 tooth stud gear mounted on the reverse gear bracket pivot, threads from 8 to 224 per inch or longitudinal feeds from .0500 to .0018 inches per spindle revolution may be selected by properly placing the levers on the gear box. For threads from 4 to 7 per inch and longitudinal feeds from .1000 to .0572, the 30 tooth stud gear is replaced by the 60 tooth gear furnished with the machine. Power cross feeds are .25 times the longitudinal feeds shown on the chart on the quick change gear box.

The position of the feed reverse lever is determined by the requirements of the job. Assuming top-coming rotation of the spindle, the feed reverse lever will be positioned as follows:

Up for feeding toward the headstock and for cutting left-hand threads. Down for feeding away from the headstock and for cutting right-hand threads. Center to disconnect the power feed from the spindle.

All other adjustments for the various thread or feed requirements are made by the two levers on the quick change gear box. As an example, assume that it is required to cut 18 threads per inch. Locate 18 on the gear box chart (fig. 35) The stud gear is to be 30 tooth which is set up on the lathe when received. Set left hand lever in position B and set right hand lever directly under the column in which 18 appears. Similarly, if a longitudinal feed of .005 inches per revolution of the spindle is required, set the left hand lever in position D and the right hand lever under the column in which .005 appears.

SCREW CUTTING AND TURRET LATHES		STUD GEAR		THREADS PER INCH FEEDS IN INCHES PER REV										AUTOMATIC CROSS FEED .25 TIMES LONGITUDINAL FEED			
		30	60	4	4½	5	5½	5¾	6	6½	7						
LEVER POSITIONS A B C D E		A	B	8 0500	9 0444	10 0400	11 0364	11½ 0348	12 0333	13 0308	14 0286						
		B	C	16 0250	18 0222	20 0200	22 0182	23 0174	24 0168	26 0154	28 0143						
		C	D	32 0125	36 0111	40 0100	44 0091	46 0087	48 0083	52 0077	56 0072						
		D	E	64 0062	72 0055	80 0050	88 0045	92 0043	96 0041	104 0038	112 0036						
		E		128 0031	144 0027	160 0025	176 0023	184 0021	192 0020	208 0019	224 0018						

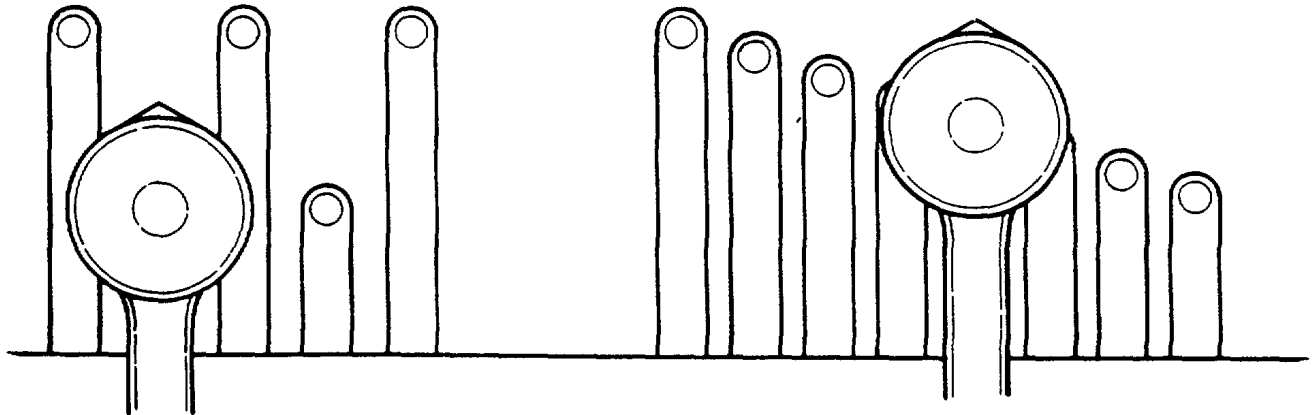


Figure 35.

Neither the quick change gear box selector levers nor the feed reverse lever should be shifted while the spindle is in motion. It may be necessary, however, to rotate the spindle by hand when shifting these levers.

A safety gear is mounted on the quick change gear box input shaft. It prevents breakage in the gear box and gear train due to overload when cutting threads from 4 to approximately 48 TPI. A clicking sound warns the operator of an overload condition and the drive is automatically reengaged after the condition has been corrected.

After each 200 hours of power feed operation, remove the guard cover and coat the faces of the gears in the gear train with an open gear lubricant. After each 40 hours of power feed operation, lubricate the two fittings on the gear train studs with Bardahl All Purpose Grease or equivalent. Fill the oil cups on the quick change gear box daily with machine oil. Clean and oil the lead screw threads frequently.

CARRIAGE (fig. 36)

The carriage of the 12" lathe is made up of six assemblies: the saddle, the apron, the friction clutch, the threading dial, the compound rest assembly, and the tool post.

THE APRON is mounted under the front of the saddle and contains the longitudinal hand feed mechanism, the power feed mechanism and the half-nut mechanism.

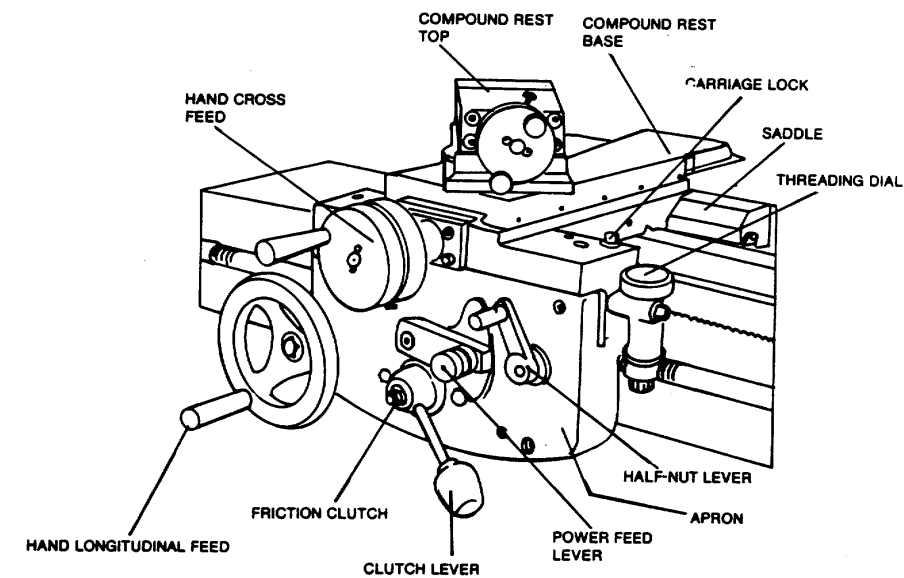
The handwheel on the front of the apron moves the carriage longitudinally by means of gears and a pinion engaging a rack on the bed.

The power feed selector lever is located in the center of the apron and can be located in three positions:

Up for power longitudinal feed, down for power cross feed and center for threading.

THE FRICTION CLUTCH prevents overloading the power feed mechanism and is engaged by lifting the clutch lever (located below the power feed lever) and disengaged by pushing it down. Tension on the clutch is provided by a spring washer and is adjusted at the factory to feed the carriage longitudinally with a thrust of 800 pounds. The thrust can be increased or decreased by tightening or loosening the inner of the two nuts at the center of the clutch lever, being careful to tighten the locking nut against the inner nut after the adjustment has been made.

The half-nut lever is located at the right side of the apron and engages the half-nuts with the headscrew for longitudinal motion in thread cutting. The half-nuts can be engaged only when the power feed lever is in the threading position, and the power feed selector lever can be moved from threading position only when the half-nut is disengaged.



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Figure 36.

Power is transmitted from the quick change gear box to the apron thru the keyway in the leadscrew when the power feed mechanism is used. To minimize wear and thereby retain their accuracy, the half-nuts and leadscrew should be used only for thread cutting.

Apply a few drops of machine oil daily to the oiler in the handwheel bracket and to the oiler in the end of the shaft above it.

Maintain the level of oil in the apron to the gage mark thru the oil cup at the right side of the apron.

THE THREADING DIAL is located on the right end of the saddle and indicates the proper position at which to engage the half-nut lever during threading operations so that the tool will enter the same groove for each cut. When cutting even-numbered threads, the half-nuts may be engaged at any mark on the threading dial. When cutting odd-numbered threads (7, 11, 13, etc., per inch), the half-nuts may be engaged at either the 1 or the 2 mark. When cutting half-numbered threads (4-1/2, 11-1/2, etc., per inch), the half-nuts must be engaged at the same point on the dial for each cut.

THE SADDLE moves longitudinally on a V-way and a flat way and is held down to the bed by gibs which bear on the underside of the front and back ways. The two front gibs, one under each end of the saddle wings, are machined to bear on the underside of the front V-way and are drawn up tightly by hexagon cap screws.

The back gib is adjustable by means of two socket set screws. This gib should be set tightly enough to give a firm sliding fit between the carriage and the bed making certain that the pressure is equalized to avoid any tipping or lifting action.

Felt wipers are furnished at both ends of the saddle for both front and back ways. The saddle is locked to the bed when desired by the lock screw on the right front saddle wing. The top flat surfaces on the saddle are precision ground for mounting gages, indicators, etc.

The compound rest base moves across the top of the saddle on dovetailed ways to form the cross-slide. The cross-slide moves transversely on top of the saddle guided by dovetail ways. The slide is equipped with a gib which is adjusted by means of set screws along the side of the slide. After adjusting the gib, test the cross-slide for feel—there should be a slight drag but no bind. Excessive drag does not improve machine performance.

The position of the cross-slide is adjusted by means of an Acme thread screw and dial. A micrometer collar on the dial is graduated in thousandths of an inch and may be rotated to any position desired for zero start. The dial can be adjusted to remove end play as follows:

Remove the two socket head screws in the cross-feed handle plate. Rotate the handle plate 30 degrees clockwise relative to the cross-feed screw and reinstall the screws. Test for end play and repeat the procedure if necessary.

Apply a few drops of machine oil daily to the dovetail slide surfaces, to the feed screw oiler located on the cross-slide behind the compound and to the oiler in the dial bracket.

THE COMPOUND SLIDE is mounted on top of the cross-slide on a swivel base. Graduations for angle settings of the compound slide are engraved on the top surface of the cross-slide. Two hex nuts in recesses in the swivel base, clamp the compound slide at any desired angle.

The compound slide moves on top of the swivel base guided by dovetail ways. It is equipped with a gib which is adjusted by means of set screws along its side. After adjusting the gib, test the compound slide for feel—there should be a slight drag but no bind. Excessive drag does not improve machine performance.

The position of the compound slide is adjusted by means of a thread screw and dial. A micrometer collar on the dial is graduated in thousandths of an inch and may be rotated to any position desired for zero start. The dial can be adjusted to remove end play as follows:

Remove the two socket head screws in the cross-feed handle plate. Rotate the handle plate 30 degrees clockwise relative to the cross-feed screw and reinstall the screws. Test for end play and repeat the procedure if necessary.

Apply a few drops of machine oil daily to the dovetail slide surfaces and to the oiler in the dial bracket.

THE TOOL POST ASSEMBLY fits into a T slot in the compound rest and clamps the tool holder by means of a square head screw. A tool post wrench is furnished with the machine.

POINTS OF LUBRICATION (fig. 37)

1. LUBRICATE BACK GEAR SHAFT THRU ZERK FITTING IN REAR OF HEADSTOCK EVERY EIGHT(8) HOURS OF BACK GEAR OPERATION USING ALL PURPOSE GREASE OR A SIMILAR LUBRICANT.
2. OIL HOLE IN REVERSE GEAR BRACKET.
3. LUBRICATE TWO ZERK FITTINGS THRU HOLES IN COVER USING ALL PURPOSE GREASE OR A SIMILAR LUBRICANT.
4. OILER AT FRONT OF COMPOUND REST.
5. OILER IN CROSS SLIDE.
6. OILER AT FRONT CROSS SLIDE.
7. OIL CUP IN HANDWHEEL HUB.
8. OILER IN FRONT OF APRON.
9. OIL CUP IN GEAR BOX.
10. OIL CUP ON GEAR BOX.
11. OILER IN TAILSTOCK
12. OILER ON TAILSTOCK.
13. OIL CUP IN LEAD SCREW BRACKET.
14. FILL APRON WITH OIL THRU THIS OIL CUP
15. APRON DRAIN PLUG.

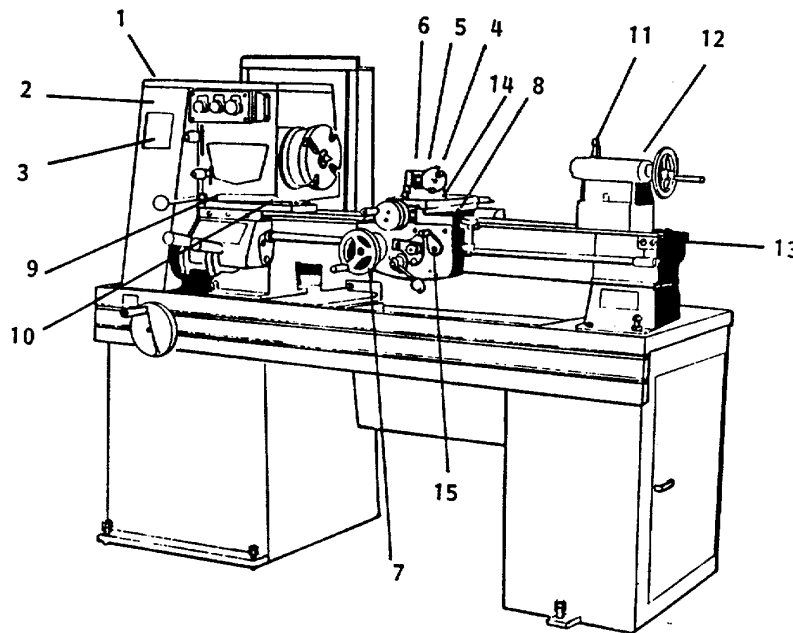


Figure 37.

KEEP THE FOLLOWING SURFACES CLEAN, FREE FROM CHIPS AND COVERED WITH A FILM OF OIL:

- THE LEAD SCREW
- CROSS SLIDE
- COMPOUND SLIDE
- LATHE BEDWAYS, BOTH V AND FLAT
- OUTSIDE OF TAILSTOCK SPINDLE.

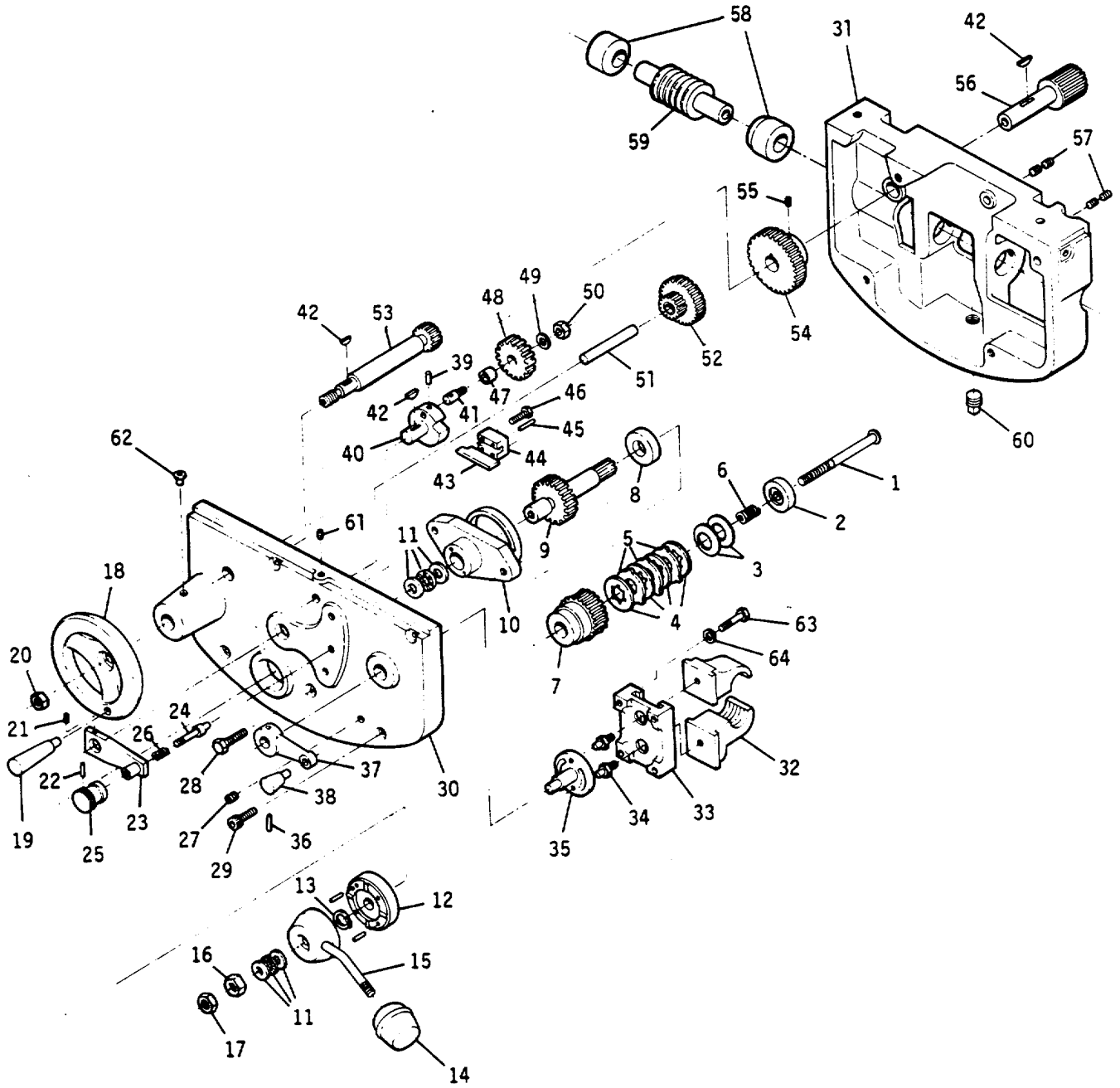
A SMALL AMOUNT OF STANDARD OIL AMOVIS-5X GREASE SHOULD BE KEPT ON THE TEETH OF THE GEAR IN THE GEAR TRAIN AND ON THE TEETH OF THE BACK GEARS.

THE DESIGN OF THE LATHE PROVIDES FOR CORRECT LUBRICATION WITH A MINIMUM OF ATTENTION, THE BALL BEARINGS IN THE HEADSTOCK ARE SEALED IN GREASE AND REQUIRE NO FURTHER LUBRICATION FOR THE LIFE OF THE BEARINGS. AT MANY POINTS THERE ARE SELF LUBRICATING BRONZE BEARINGS, WHERE IN ORDINARY CONSTRUCTION PLAIN BEARINGS WITH OIL HOLES ARE USED.

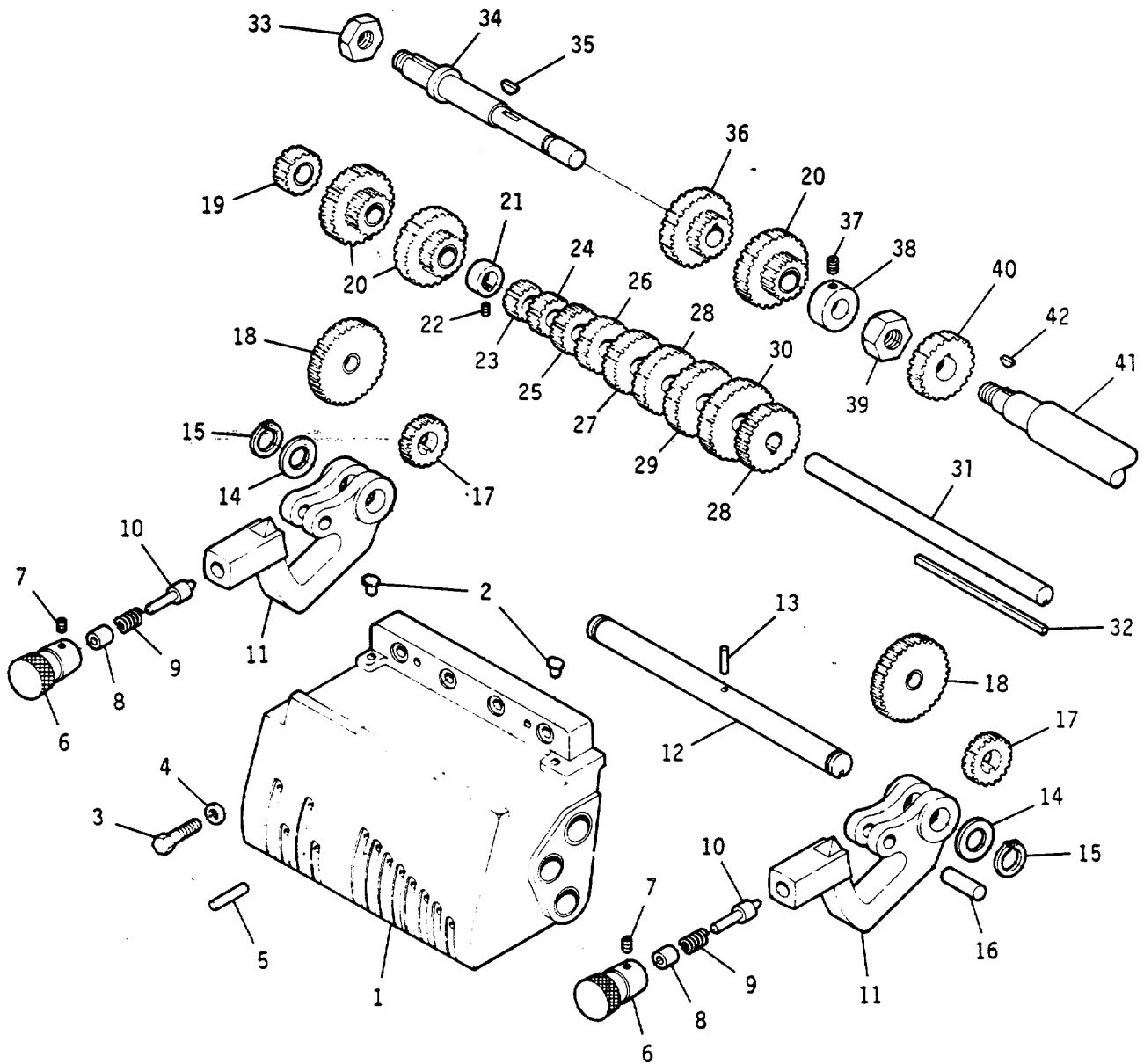
THOSE POINTS ON THE LATHE REQUIRING REGULAR LUBRICATION SHOULD BE GONE OVER EVERY TIME THE LATHE IS USED AND IN A DEFINITE ORDER SO THAT NO PARTS WILL BE MISSED. USE A GOOD MACHINE OIL NO HEAVIER THAN SAE No. 10 UNLESS A LUBRICANT IS SPECIFIED, WIPING AWAY EXCESS OIL THAT WOULD CAUSE DIRT TO ADHERE TO THE LATHE. USE THE LUBRICANT RECOMMENDED OR A SIMILAR ONE. DO NOT ATTEMPT TO LUBRICATE THE LATHE WHILE IT IS RUNNING.

TROUBLESHOOTING HINTS

TROUBLE	PROBABLE CAUSE	REMEDY
Lathe Won't Start	<ol style="list-style-type: none"> 1. Bad motor. 2. Bad switch. 3. Loose wire. 4. Bad contacts. 5. Bad coil. 6. Heater contacts open. 	<ol style="list-style-type: none"> 1. Replace motor. 2. Replace switch. 3. Tighten connections. 4. Replace contacts. 5. Replace coil. 6. Wait until contacts close.
Lathe Not Turning True. (cutting slight taper)	<ol style="list-style-type: none"> 1. Lathe not properly leveled. 2. Tailstock not set on witness line. 	<ol style="list-style-type: none"> 1. Level machine. 2. Readjust tailstock.
Back Gearing Noisy.	<ol style="list-style-type: none"> 1. Back gear lever out of adjustment. 2. No lubrication. 	<ol style="list-style-type: none"> 1. Readjust eccentric pin. 2. Recoat with open gear grease.
Reverse Gear Noisy.	<ol style="list-style-type: none"> 1. Stops not adjusted properly. 2. No lubrication. 	<ol style="list-style-type: none"> 1. Readjust stops. 2. Recoat with open gear grease.
Spindle Bearings Running Hot.	<ol style="list-style-type: none"> 1. Improper bearing adjustment. 	<ol style="list-style-type: none"> 1. Consult factory.
Spindle Slows Down or Stops Under Load.	<ol style="list-style-type: none"> 1. Improper belt adjustment. 2. Bad motor. 	<ol style="list-style-type: none"> 1. Readjust motor base. 2. Replace motor.
Saddle Stops Feeding.	Friction clutch out of adjustment.	Readjust friction clutch.
Cross Slide Stops Feeding.	Friction clutch out of adjustment.	Readjust friction clutch.
Lathe Faces Out of Square.	Cross slide gibs are loose.	Readjust gibs.
Lead on Thread Varies.	Worn Leadscrew.	Replace leadscrew.
Speed dial Does Not Rotate.	Gears not in mesh.	Adjust idler stud.
Spindle Noisy.	<ol style="list-style-type: none"> 1. Bad spindle bearings. 2. Bad sheave bearings. 	<ol style="list-style-type: none"> 1. Replace bearings. 2. Replace bearings.
Chatter on Outside Diameter	Loose carriage gibs.	Readjust gibs.

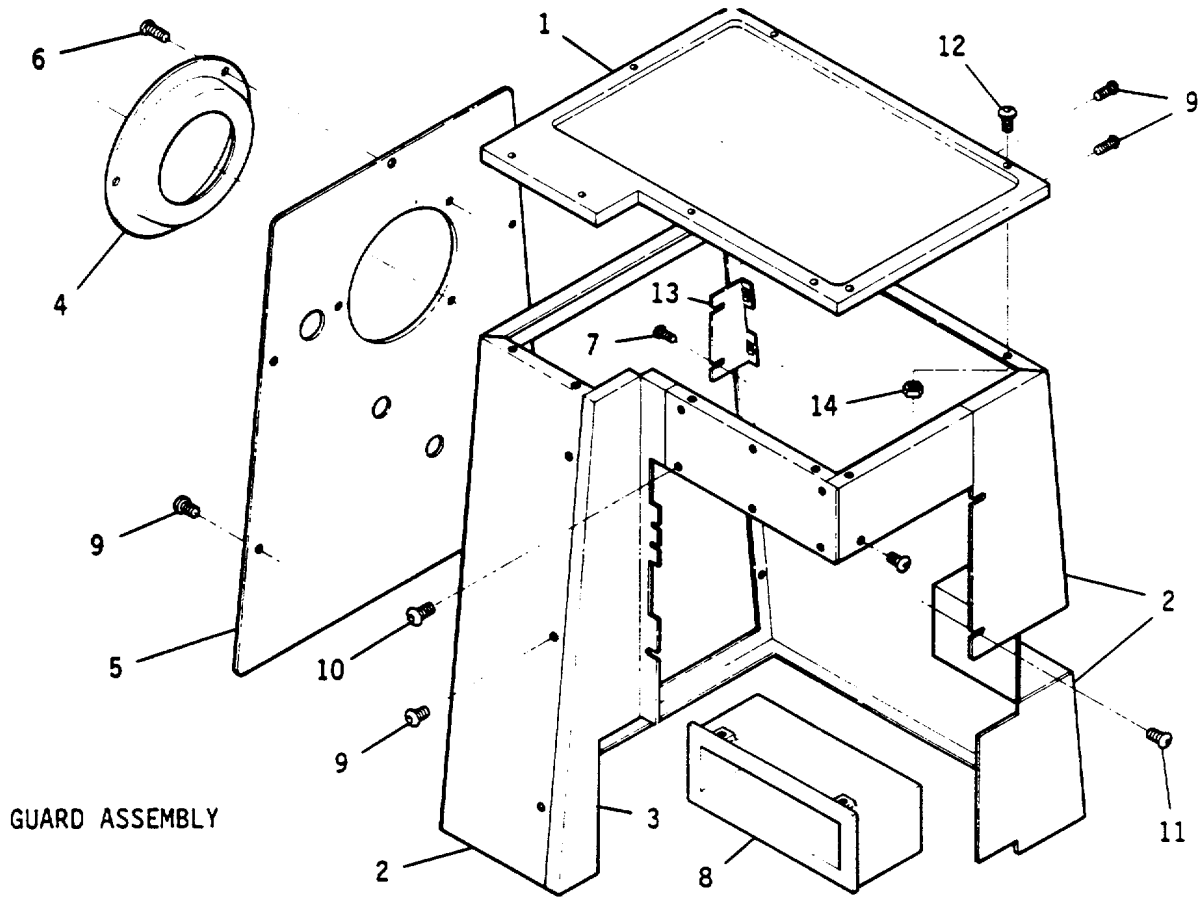


AUTOMATIC APRON ASSEMBLY				AUTOMATIC APRON ASSEMBLY			
ITEM NO.	PART NO.	DESCRIPTION	QTY.	ITEM NO	PART NO.	DESCRIPTION	QTY.
	2020003	ASSY, APRON (INCLUDES ITEMS 1 THRU 64)	1	61	6714003	SCREW. 1/4-20 X 3/8 SOC SET CUP PT.	1
	2095021	ASSY.. CLUTCH AND WORM WHEEL (INCLUDES ITEMS 1 THRU 14)	1	62	6607010	OILER, 1/4 GITS #521 BALL	2
1	3700053	SHAFT, CLUTCH	1	63	6714050	SCREW. 1/4-20 HEX HD. CAP	4
2	3659009	RETAINER, CLUTCH	1	64	6861100	WASHER LOCK	4
3	3838013	WASHER BELLEVILLE	2				
4	3127010	DISC, CLUTCH	4				
5	3127009	DISC, CLUTCH	3				
6	3755234	SPRING	1				
7	3237111	GEAR, WORM	1				
8	3845005	RING, THRUST	1				
9	3237112	GEAR, SLEEVE	1				
10	3064229	BRACKET, BEARING	1				
11	6064018	BEARING. 3/8 X 11/16 X 9/32 THRUST	2				
12	2834001	WASHER, FRICTION	1				
13	6670011	RING. RETAINING #5100-37	1				
14	3406201	KNOB, 3/8-16 WHITE	1				
15	2426004	ASSY, LEVER AND HUB	1				
16	6566001	NUT, 3/8-24 HEX	1				
17	6566004	NUT, 3/8.24 JAM	1				
18	3271044	HANDWHEEL	1				
19	3268030	HANDLE	1				
20	6517006	NUT 7/16-14 JAM	1				
	2426003	ASSY. SHIFT LEVER (INCLUDES ITEMS 21 THRU 26)	1				
21	6760001	SCREW, 10-32 X 1/4 SOC. SET CUP PT.	1				
22	6624007	PIN, 3/32 X 1 GROOVE	1				
23	3426021	LEVER SHIFT	1				
24	3601015	PLUNGER	1				
25	3406038	KNOB	1				
26	3755230	SPRING	1				
27	6638017	PLUG. 1/8-21 SOC. HEX PIPE	1				
28	6715035	SCREW, 5/16-18 X 3/4 HEX HOD. CAP	2				
	2020002	ASSY. APRON (INCLUDES ITEMS 29 THRU 31)	1				
29	6715174	SCREW, 5/16-18 X 7/8 SOC. HO. CAP	4				
30	3022001	APRON FRONT	1				
31	3022002	APRON BACK	1				
	2526004	ASSY HALF-NUT (INCLUDES ITEMS 32 THRU 34)	1				
32	3526038	NUT HALF	1				
33	3595248	PLATE, HALF-NUT	1				
34	3582037	PIN HALF NUT	2				
	2426005	ASSY, CAM SHAFT LEVER (INCLUDES ITEMS 35 THRU 38)	1				
35	2709025	ASSY, CAM SHAFT	1				
36	6624009	PIN. 1/8 X 1 GROOVE	1				
37	3426022	LEVER CAM SHAFT	1				
38	3268029	HANDLE	1				
	2184001	ASSY, ECCENTRIC (INCLUDES ITEMS 39 THRU 41)	1				
39	6624008	PIN, 3/32 X 1/2 GROOVE	1				
40	3157007	ECCENTRIC	1				
41	3773038	STUD	1				
42	6420000	KEY 1/8 X 1/2 03 WOODRUFF	3				
43	3448023	LOCK	1				
44	3253041	GUIDE, LOCK	1				
45	6624017	PIN	1				
46	6714048	SCREW. 1/4-20 X 1 1/2 HEX HO. CAP	2				
	2240014	ASSY GEAR (INCLUDES ITEMS 47 and 48)	1				
47	6095109	BUSHING, GEAR	1				
48	3237106	GEAR	1				
49	6861107	WASHER 1/4	1				
50	6514008	NUT. 1/4-20 JAM	1				
51	3700058	SHAFT	1				
52	2240013	ASSYDOUBLE GEAR	1				
53	3237142	GEAR, HANDWHEEL PINION	1				
54	3237141	GEAR	1				
55	6714004	SCREW, 1/4-20 X 1/4 SOC SET	1				
56	3237143	GEAR RACK PINION	1				
57	6714006	SCREW, 1/4-20 X 3/16 SOC. SET CUP PT.	4				
58	3046013	BEARING	2				
59	3865005	GEAR WORM	1				
60	6638003	PLUG 3/8-18 SQ. PIPE	1				



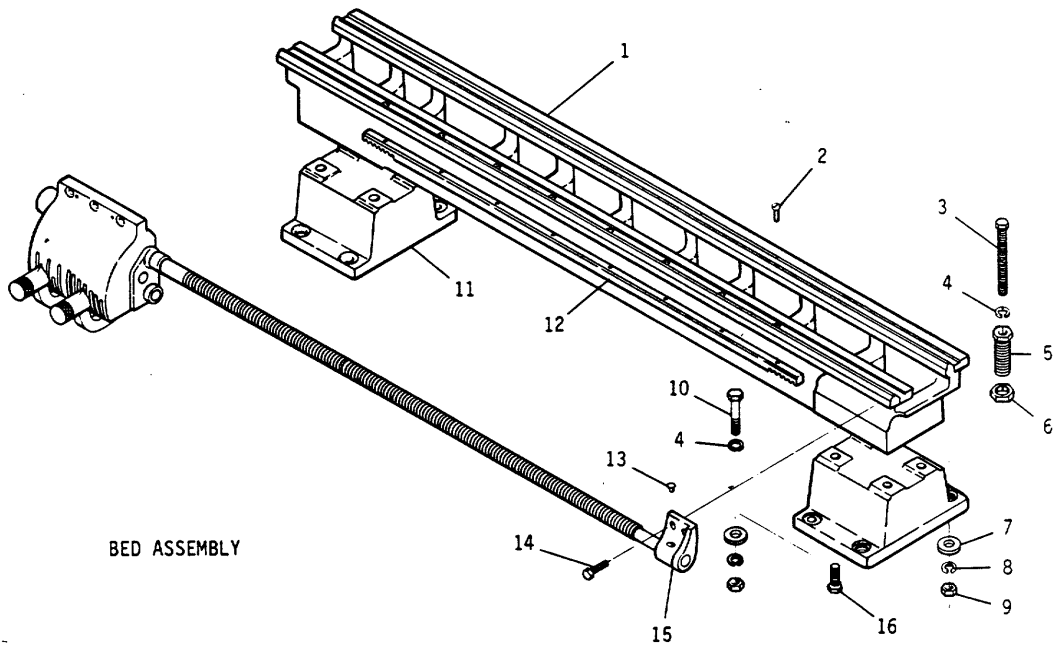
GEAR BOX ASSEMBLY

GEAR BOX ASSEMBLY			
ITEM NO.	PART NO.	DESCRIPTION	QTY.
	2241004	ASSY., GEAR BOX (INCL. ITEMS 1 THRU 42)	1
1	2241003	ASSY. GEAR BOX	1
2	6607011	OIL CUP	2
3	6715034	SCREW, 5116-18 x 1-1/4 HEX HD. . CAP	4
4	3837029	WASHER	4
5	6624012	PIN 1/4 x 1 GROOVED	2
	2601012	ASSY, GEARBOX PLUNGER (INCLUDES ITEMS 6 THRU 10)	2
6	3406043	KNOB	1
7	6714003	SCREW 1/4-20 x 3/8	1
8	3070044	BUSHING	1
9	3755231	SPRING	1
10	3601016	PLUNGER	1
11	3426029	LEVER	2
12	3700065	SHAFT	1
13	6624010	PIN 3132 x 3/8	1
14	3837233	WASHER	2
15	6670002	RING, #5100 75 RETAINING	2
16	3582038	PIN	2
17	3237195	GEAR	2
18	2240023	ASSY., GEAR	2
19	2240022	ASSY., GEAR	1
20	2240029	ASSY., GEAR	3
21	3743007	SPACER	1
22	6760075	SCREW, 10-32 x 3/16 SOC SET CUP PT.	1
23	3237196	GEAR	1
24	3237197	GEAR	1
25	3237198	GEAR	1
26	3237199	GEAR	1
27	3237200	GEAR	1
28	3237201	GEAR	2
29	3237202	GEAR	1
30	3237203	GEAR	1
31	3700066	SHAFT	1
32	3388052	KEY	1
33	6568009	NUT, 1/2-20 JAM	1
34	3700067	SHAFT	1
35	6420016	KEY #6 WOODRUFF	1
36	2240028	ASSY., GEAR	1
37	6714004	SCREW 1/4 20 x 1/4	1
38	3096082	SPACER	1
39	6567001	NUT 7/16-20 HEX	1
40	3237206	GEAR	1
41	3689050	LEAD SCREW	1
42	6420000	KEY, WOODRUFF	1



GUARD ASSEMBLY

GUARD ASSEMBLY



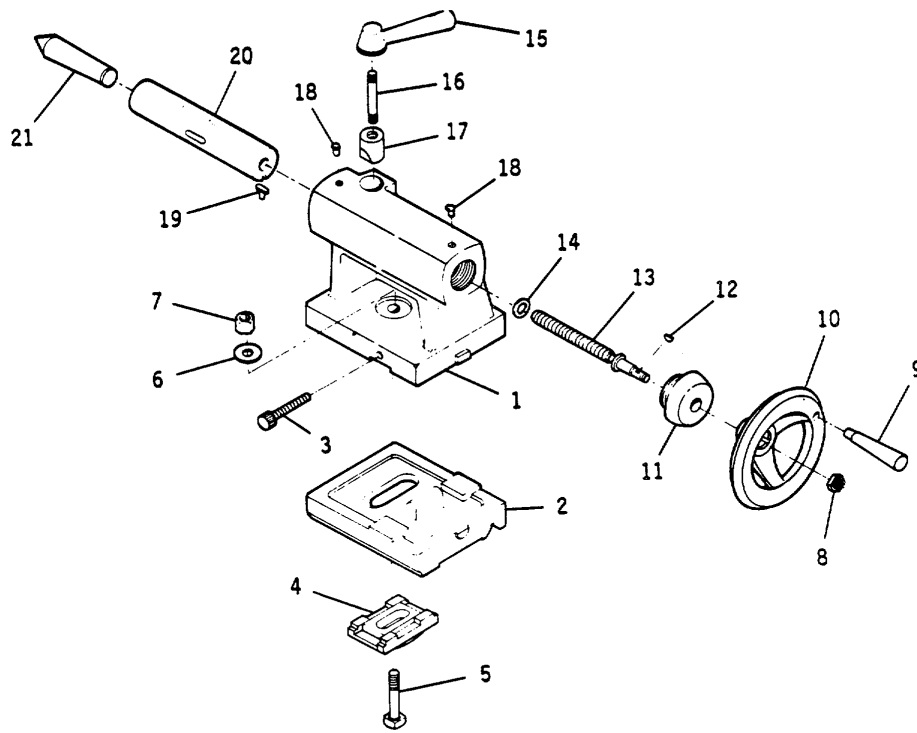
BED ASSEMBLY

BED ASSEMBLY

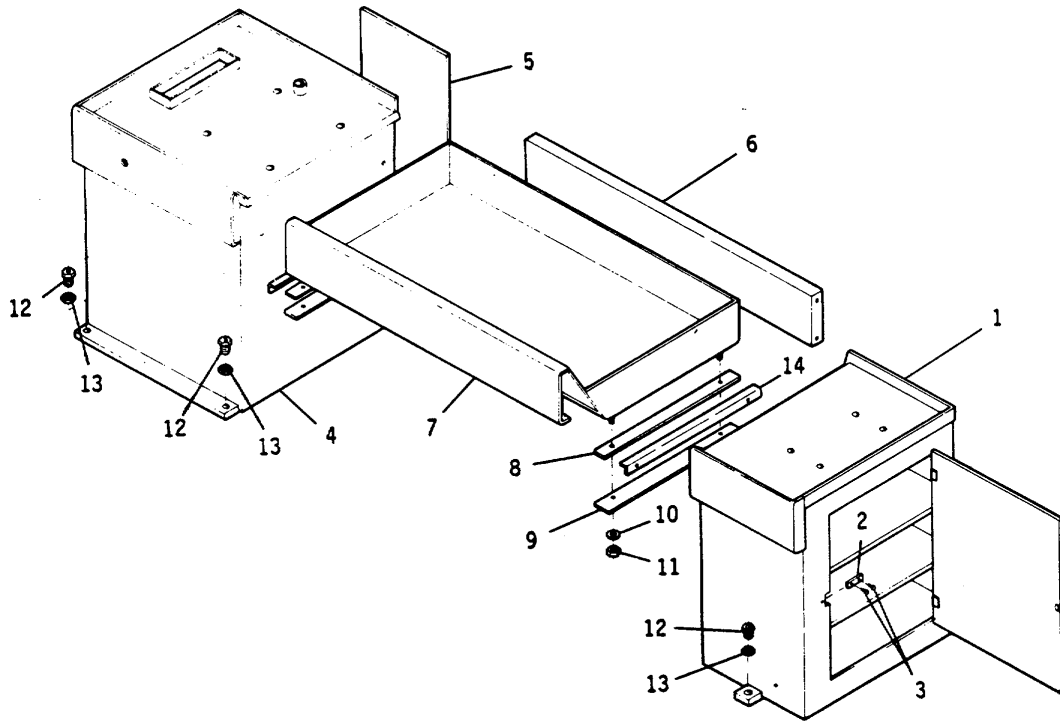
GUARD ASSEMBLY			
ITEM NO.	PART NO.	DESCRIPTION	QTY.
	2250100	GUARD ASSY. (INCL. ITEMS 1 THRU 14)	1
1	3104105	COVER	1
2	2250108	GUARD WELOMENT ASSY.	1
3	2250099	FRONT GUARD ASSY.	1
4	3328060	INSERT PAN	1
5	3104126	END COVER	1
6	6714085	SCREW, BUTTON HD.	3
7	6714082	SCREW, 1/4 20 X 3/8 BUTTON HO.	2
8	2060023	CONTROL BOX	1
9	6710062	SCREW, 10-24 X 3/8 BUTTON HD.	13
10	6710063	SCREW, 10-24 X 1/2 BUTTON HD.	6
11	6714082	SCREW, 1/4-20 X 3/8 BUTTON HD.	2
12	6710107	SCREW, 10-24 X 1" BUTTON HD.	8
13	2250098	BACK GUARD BRKT.	1
14	6510008	NUT 10-24 WELD	6
GUARD ASSEMBLY			
ITEM NO.	PART NO.	DESCRIPTION	QTY.
	2049002	ASSY., BED (INCLUDES ITEMS 1 THRU 12)	1
1	3047002	BED	1
2	3690206	SCREW, 10-32 X 1/2 FILLISTER HO.	8
3	6716167	SCREW, 3/8-16 X 3 3/4 HEX HD. CAP	4
4	3837034	WASHER, 25/64 X 3/4 X 3/32 FLAT	8
5	3690066	SCREW, 7/8-14 X 1 3/4	4
6	6574005	NUT, 7/8-14 HEX JAM	4
7	3837035	WASHER, 3/8 X 1 3/8 X 3/16 FLAT	8
8	6861300	WASHER, 3/8 LOCK	8
9	6516001	NUT, 3/8-16 HEX	8
10	6716040	SCREW, 3/8-16 X 2 1/2 HEX HD. CAP	4
11	3781002	SUPPORT. BED	2
12	3650013	RACK	1
13	6607011	OILER. #00361 GITS	1
14	6716031	SCREW. 3/8-16 X I HEX HD. CAP	2
15	3063259	BRACKET, LEAD SCREW	1
16	6716039	SCREW, 3/8-16 X 1 1/4 HEX HD. CAP	8

HEADSTOCK ASSEMBLY				HEADSTOCK ASSEMBLY			
ITEM NO.	PART NO.	DESCRIPTION	QTY.	ITEM NO	PART NO.	DESCRIPTION	QTY.
	2279005	HEADSTOCK ASSY. (INCLUDES ITEMS 1 THRU 86)		56	3755245	SPRING	1
1	3278004	HEADSTOCK	1	57	3582065	PIN	1
2	2104023	COVER, HEADSTOCK	1	58	3585015	PIN, SHOULDER	1
3	3686003	SEAL, GREASE		59	3426030	LEVER	1
4	3078062	BEARING, CAP	1	60	6609001	FITTING GREASE	1
5	6715174	SCREW, 5116-18 x 7/8 SOC. HD. CAP	4	61	6515007	NUT, JAM	1
6	6060129	BEARING	2	62	6715163	SCREW, SOC. SET HALF-DOG	1
7	3735064	SPACER	1	63	6638002	PLUG 1/4" PIPE	1
8	3735065	SPACER	1	64	3388055	KEY	1
9	3528020	NUT	1	65	3388058	KEY	1
10	6714003	SCREW, 114-20 x 318 SOC. SET	1	66	3388057	KEY	1
11	3598028	PLUG	3	67		SPINDLE AS NEEDED AS SHOWN IN ILLUSTRATION	1
12	3237209	GEAR, BULL	1	68	6760082	SCREW, 10 32 x 5/16 SOC. HD. CAP	1
13	6715116	SCREW SOC. SET HALF-DOG	1	69	3386008	KEY	1
14	6060130	BEARING	2	70	3526050	NUT DRAW	1
15	6863001	WASHER, SPRING	2	71	6670106	RING, RETAINING	1
16	3735063	SPACER	1	72	3193024	FACE PLATE	1
17	3528022	NUT, LOCK	1	73	3728040	SLEEVE	1
18	6714003	SCREW, 1/4-20 x 3/8 SOC. SET	1	74	3081210	CENTER	1
19	3096086	COLLAR	1	75	3237208	GEAR, SPINDLE	1
	2240025	BACK GEAR ASSY. (INCLUDES ITEMS 20 THRU 26)	1	76	3837235	WASHER FIBER	2
20	3237185	GEAR BACK	1	77	2719046	PULLEY	1
21	6627011	PIN, #4 x 2' TAPER	1	78	6607009	OIL CUP	1
22	3640011	QUILL	1	79	6670105	RING, #5108-200 TRU ARC	1
23	3582062	PIN ECCENTRIC	1	80	6714006	SCREW, 1/4-20 x 3/16 SOC. SET	1
24	6627012	PIN, #4 x 1-1/4' TAPER	1	81	3755241	SPRING	1
25	3700063	SHAFT	1	82	6054005	BALL 3/16' STEEL	1
26	3237186	GEAR BACK	1	83	3271058	HANDWHEEL	1
	2240026	GEAR REVERSE ASSY. (INCLUDES ITEMS 27 THRU 47)	1	84	6670106	RING, RETAINING	1
27	3700064	SHAFT	1				
28	3388050	KEY	1				
29	6664018	"O"-RING	2				
30	3063331	BRACKET	1				
31	6716138	SCREW, 3/8-16 x 5/16 BUTTON HD.	1				
32	3406201	KNOB	1				
33	3426028	LEVER	1				
34	3582068	PIN	2				
35	6622012	KEY 1/16 x 3/8 COTTER	4				
36	3755237	SPRING, PLUNGER	1				
37	3601028	PLUNGER	1				
38	3773048	STUD	2				
39	2240021	GEAR REVERSE ASSY.	2				
40	6861400	LOCKWASHER 7116	2				
41	6567006	NUT 7/16-20 JAM	2				
42	6716141	SCREW, 3/8-16 x 5/8 HEX HD. CAP	1				
43	6861301	WASHER 3/8' FLAT	1				
44	3237189	GEAR	1				
45	3743006	SPACER	1				
46	3237188	GEAR	1				
47	3854204	WIPER	1				
48	6760075	SCREW, 10-32 x 3/16 SOC. SET	2				
49	6760080	SCREW, 10-32 x 5/8 SOC. SET	2				
50	3582064	PIN, STOP	2				
51	6710031	SCREW, 10-24 x 3/4 x RD. HD.	2				
52	3448022	LOCK	1				
53	3406201	KNOB	1				
54	6716159	SCREW, 3/8-16 x 5116 FLAT HD.	1				
55	3582066	PIN	1				

SADDLE COMPOUND REST & TOOL POST ASSEMBLIES				SADDLE COMPOUND REST & TOOL POST ASSEMBLIES			
ITEM NO.	PART NO.	DESCRIPTION	QTY.	ITEM NO	PART NO.	DESCRIPTION	QTY.
	2680007	ASSY., SADDLE (INCLUDES ITEMS 1 THRU 53)	1	50	3595296	PLATE	1
	2690027	ASSY. CROSSFEED SCREW (INCLUDES ITEMS 1 THRU 19)	1	51	6706014	SCREW, 6-32 x 1/2 SOC. HD. CAP	2
	2690036	ASSY. SCREW & NUT (INCLUDES ITEMS 1 AND 2)	1	52	3268029	HANDLE	2
1	3695050	SCREW	1	53	6515007	NUT 5116-18 JAM	2
2	3526057	NUT	1	54	6746029	SCREW, 6-32 x 1/2	4
3	3237207	GEAR	1	55	3854006	WIPER, FRONT	2
4	6760075	SCREW, 10-32 x 3/16 SOC. SET	1	56	3854008	FELT, FRONT	2
5	6420013	Key #304	2	57	3854004	WIPER, REAR	2
6	3096084	COLLAR	1	58	3854007	FELT, REAR	2
7	6095116	BUSHING	1		2607003	ASSY. TOOL POST (INCLUDES ITEMS 59 THRU 63)	1
8	6607012	OILER #523 GITS	1	59	3695041	SCREW	1
9	6714025	SCREW, 1/4-20 x 7/8 SOC. HD. CAP	4	60	3661007	RING	1
10	3063340	BRACKET	1	61	3055064	BLOCK	1
11	3070057	BUSHING	1	62	3607009	POST TOOL	1
12	3695043	SCREW, LOCKING	1	63	3849001	WEDGE	1
13	3598034	PLUG	1				
14	3125017	DIAL CROSSFEED	1				
15	3755244	SPRING	3				
16	6054005	BALL, 3116 STEEL	3				
17	3595295	PLATE	1				
18	6706014	SCREW, 6-32 x 1/2 SOC. HD. CAP	2				
19	3268030	HANDLE	1				
20	3680008	SADDLE	1				
21	3244070	GIB FRONT	2				
22	6716037	SCREW 3/8-16 x 2	2				
23	3448025	LOCK SADDLE	1				
24	3244064	GIB	1				
25	3058203	BOLT	2				
26	3104103	COVER	1				
27	6715174	SCREW, 5/16-18 x 7/8 SOC. HD. CAP	2				
	2042153	ASSY. COMPOUND REST BASE (INCLUDES ITEMS 28 THRU 31)	1				
28	6607012	OILER #523 BALL GITS	1				
29	3582060	PIN SWIVEL	1				
30	3042310	BASE	1				
31	6764042	SCREW, 1/4-23 x 7/8 NYLOK SOC. SET	5				
	2658012	ASSY. COMPOUND REST (INCLUDES ITEMS 32 THRU 53)1	1				
	2690043	ASSY. SCREW & NUT (INCLUDES ITEMS 32 AND 33)	1				
32	3526040	NUT	1				
33	3695051	SCREW	1				
34	6420013	KEY #304 WOODRUFF	1				
35	3096085	COLLAR	1				
36	6764042	SCREW, 1/4-28 x 7/8 SOC. SET	4				
37	3730032	TOP, COMPOUND REST	1				
38	3793003	SWIVEL	1				
39	6714003	SCREW 1/4-20 x 3/8 SOC. SET	1				
40	3244065	GIB	1				
41	6607010	OILER, 1/4	1				
42	6714015	SCREW, 1/4-20 x 1/2 SOC. HD. CAP	4				
43	3063342	BRACKET COMPOUND REST	1				
44	3070055	BUSHING	1				
45	3695043	SCREW, LOCKING	1				
46	3598035	PLUG	1				
47	3125018	DIAL COMPOUND	1				
48	3755244	SPRING	3				
49	6054005	BALL 3/16 STEEL	3				



TAILHOOK ASSEMBLY

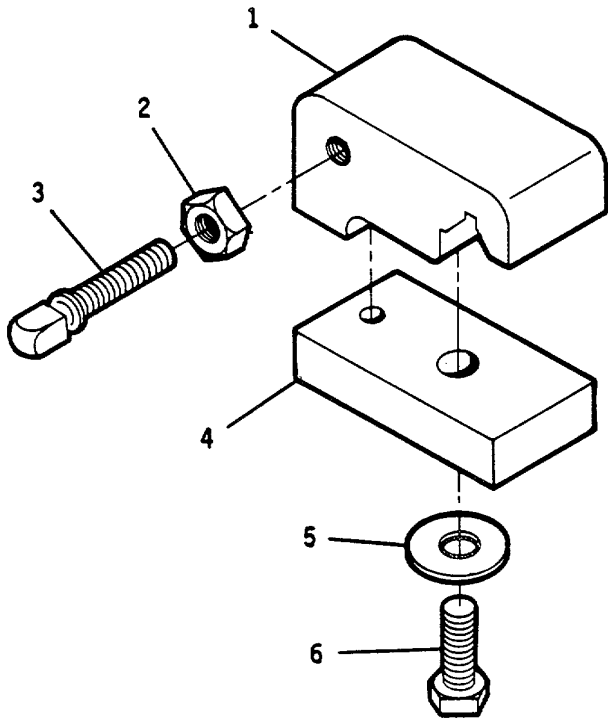


PEDESTAL AND PAN ASSEMBLIES

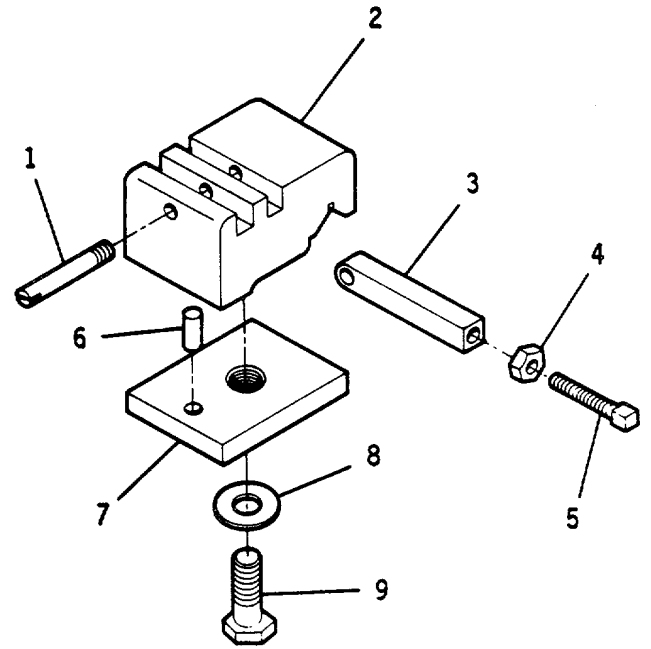
TAILSTOCK ASSEMBLY			
ITEM NO.	PART NO.	DESCRIPTION	QTY.
	2800009	TAILSTOCK ASSY. (INCLUDES ITEMS 1 THRU 21)1	
	2800010	TAILSTOCK AND BASE ASSY. (INCLUDES ITEMS 1 THRU 3)	1
1	3799003	TAILSTOCK	1
2	3042312	BASE	1
3	6715137	SCREW, 5/16"-18 x 2" SOC. SET CUP PT.	2
4	3092025	CLAMP	1
5	6718087	SCREW, 1/2'-13 x 4-1/2" SQ. HD. MACH.	1
6	6861602	WASHER, 9/16"	1
7	3526029	NUT, TAILSTOCK	1
8	6566004	NUT, 3/8'-24 JAM	1
9	3268030	HANDLE	1
10	3271045	HANDWHEEL	1
11	3659010	RETAINER, SCREW	1
12	6420013	KEY, #304 WOODRUFF	1
13	3689048	SCREW	1
14	3837028	WASHER	1
15	3426040	LEVER, TAILSTOCK	1
16	3773040	STUD	1
17	3598025	PLUG, BINDING	1
18	6607010	OILER	2
19	3387010	KEY, SPINDLE	1
20	3749061	SPINDLE, TAILSTOCK	1
21	3081210	CENTER	1

PEDESTAL AND PAN ASSEMBLIES			
ITEM NO.	PART NO.	DESCRIPTION	QTY.
1	2588008	PEDESTAL, TAILSTOCK	1
2	3769001	STRIKE, DOOR	2
3	6714083	SCREW, BUTTON HEAD	4
4	2588009	PEDESTAL, HEADSTOCK	1
5	3578094	PANEL, ELECTRICAL MTG. (SMALL)	1
	3578105	PANEL, ELECTRICAL MTG. (LARGE)	1
6	3064299	BRACKET, PEDESTAL CONNECTING	1
7	2577012	ASSY., PAN	1
8	3737017	SPACER, GUIDE	2
9	3770027	GUIDE, PAN	2
10	6861100	LOCKWASHER, 1/4' PLAIN HELICAL STEEL	4
11	6514001	NUT, 1/4' - 20 PLAIN HEX STEEL	4
12	3690038	SCREW	6
13	6574005	NUT	6
14	3791002	BRACE	2

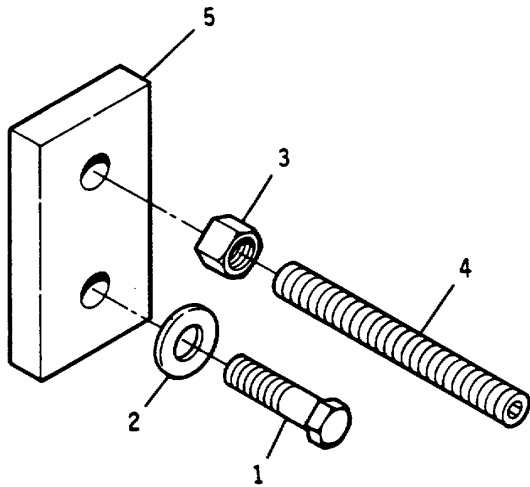
VARIABLE SPEED DRIVE ASSEMBLY				VARIABLE SPEED DRIVE ASSEMBLY			
ITEM NO.	PART NO.	DESCRIPTION	QTY.	ITEM NO	PART NO.	DESCRIPTION	QTY.
	2268023	ASSY., HANDLE V.S. AND INDICATOR (INCLUDES ITEMS 1 THRU 15)	1	45	3716033	PULLEY, MOTOR	1
	2271025	ASSY., HANDWHEEL (INCLUDES ITEMS 1 THRU 3)	1	46	6714004	SCREW, SET	2
1	3271059	HANDWHEEL	1	47	3063337	BRACKET	1
2	3582063	PIN	1	48	6715037	SCREW	4
3	3268037	HANDLE	1	49	6861200	WASHER, LOCK	4
	2240027	ASSY., GEAR IDLER (INCLUDES ITEMS 4 THRU 6)	1	50	6515001	NUT	4
4	3301034	HUB	1	51	6086023	SCREW	4
5	3237177	GEAR	1	52	6861200	WASHER, LOCK	4
6	3237180	GEAR	1	53	6515001	NUT	4
	2116005	ASSY., DIAL INDICATOR (INCLUDES ITEMS 7 THRU 10)	1	54	3063333	BRACKET	2
7	3148006	DRUM, DIAL	1	55	3070054	BUSHING	2
8	3728035	SLEEVE	1	56	3670091	ROD, HINGE	1
9	6680024	RIVET, 1/8w x 3/8" SOUTHCO FLAT HEAD DRIVE	3	57	6714003	SCREW, SET	2
10	3237180	GEAR	1	58	6518001	NUT	2
11	6574005	NUT, JAM	1	59	6861602	WASHER	2
12	6670004	RING, #5100-87 RETAINING	1	60	3837228	WASHER	2
13	6670021	RING, #5100-25 RETAINING	1	61	3773050	STUD	1
14	6708002	SCREW, 8 - 32 x 114" SOC. SET	1	62	3063335	BRACKET	1
15	6862102	WASHER, 7/8" x 1-1/8" x 1/16" NYLON	1				
	2073003	ASSY., BUSHING (INCLUDES ITEMS 16 THRU 19)	1				
16	3728034	SLEEVE	1				
17	6095131	BEARING, 1/2" x 5/8" x 3/8"	2				
18	3237177	GEAR	1				
19	6670004	RING, #5100-87 RETAINING	1				
	2690028	ASSY., SCREW CONTROL (INCLUDES ITEMS 20 THRU 25)	1				
20	3096069	COLLAR	1				
21	6624009	PIN, 1/8' x 1' GROOVED	1				
22	6518008	NUT, 1/2' - 13' JAM	4				
23	3695049	SCREW, SPEED CONTROL	1				
24	6714062	SCREW, 1/4w - 20 x 5/8" RD. HD. MACH.	1				
25	6714003	SCREW, 1/4" - 20 x 3/8" SOC. SET	1				
26	3741025	SPACER, LOCK NUT	2				
27	3526056	NUT, SWIVEL	1				
	2719048	ASSY., SHEAVE (INCLUDES ITEMS 28 THRU 35)	1				
28	6638017	PLUG, 1/8' HEX. SOC. PIPE	1				
29	6620018	PIN, 1/4' x 2-3/4" ROLL	2				
30	3719065	SHEAVE	1				
31	3719064	SHEAVE	2				
32	3700068	SHAFT	1				
33	6607009	CUP, #543 OIL GITS	1				
34	3735062	COLLAR	1				
35	6715014	SCREW, SET	1				
	2025027	ASSY., ARM AND SHEAVE (INCLUDES ITEMS 36 THRU 43)	1				
36	2025025	ARM	1				
37	2025024	ARM	1				
38	6627011	PIN, #4 x 1-3/4~ TAPER	2				
39	6060128	BEARING	2				
40	6077125	BELT, 1922 V 386	1				
41	3700062	SHAFT	1				
42	6077124	BELT, 1922 V 721	1				
43	6714017	SCREW	4				
44	3042314	BASE, MOTOR	1				



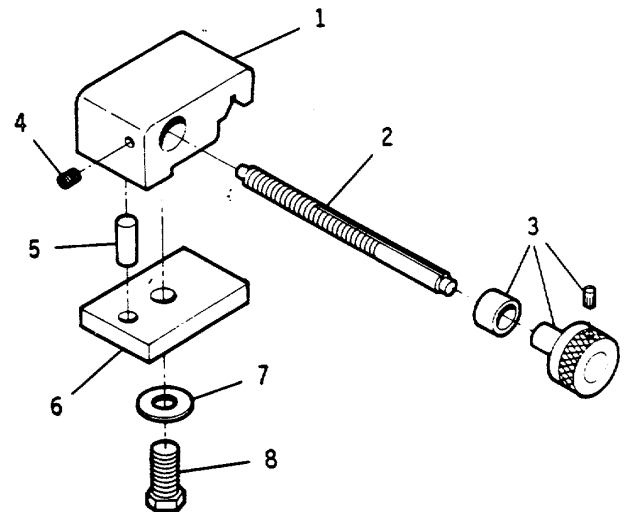
CARRIAGE STOP



DOUBLE CARRIAGE STOP

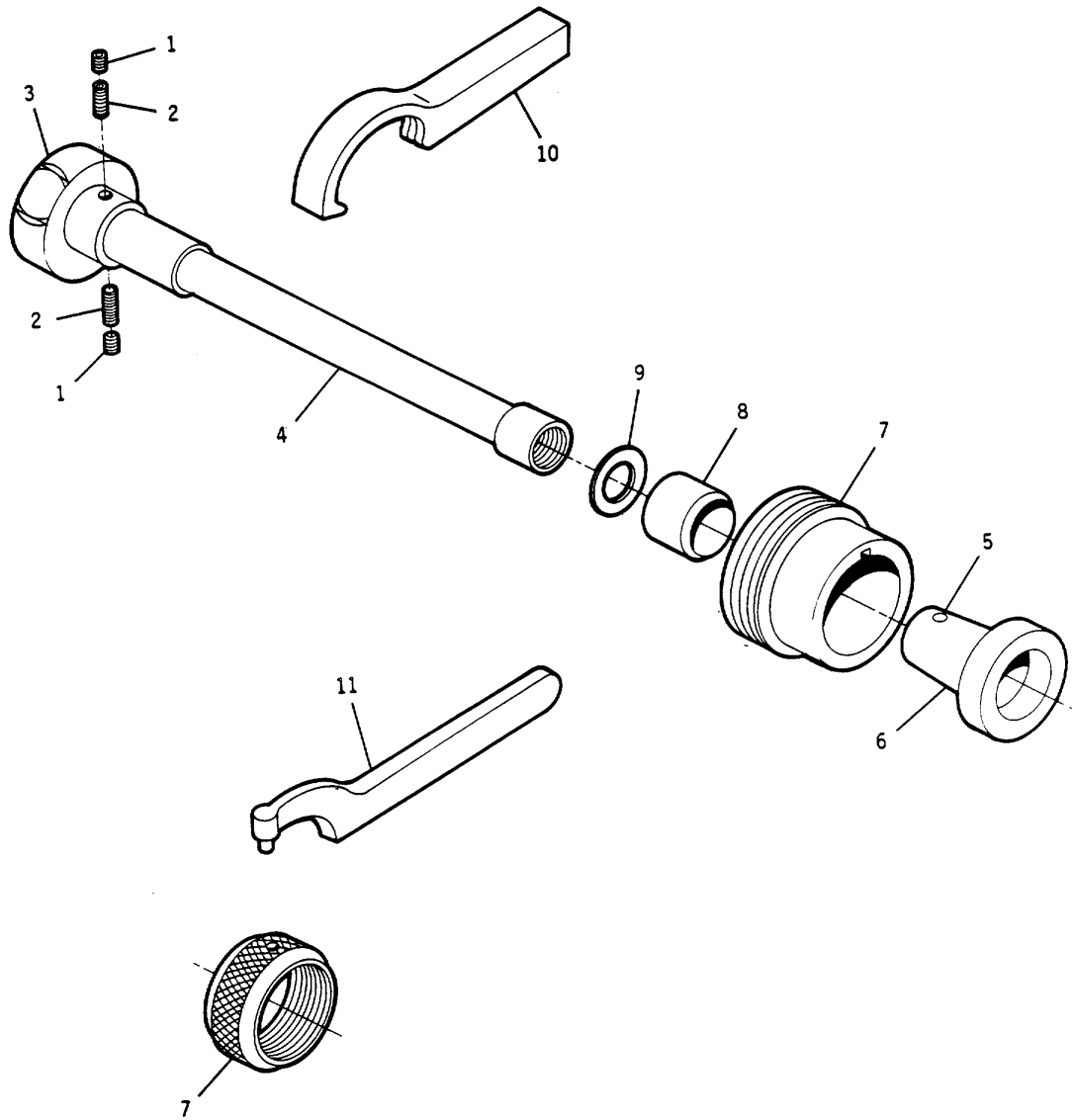


THREADING STOP



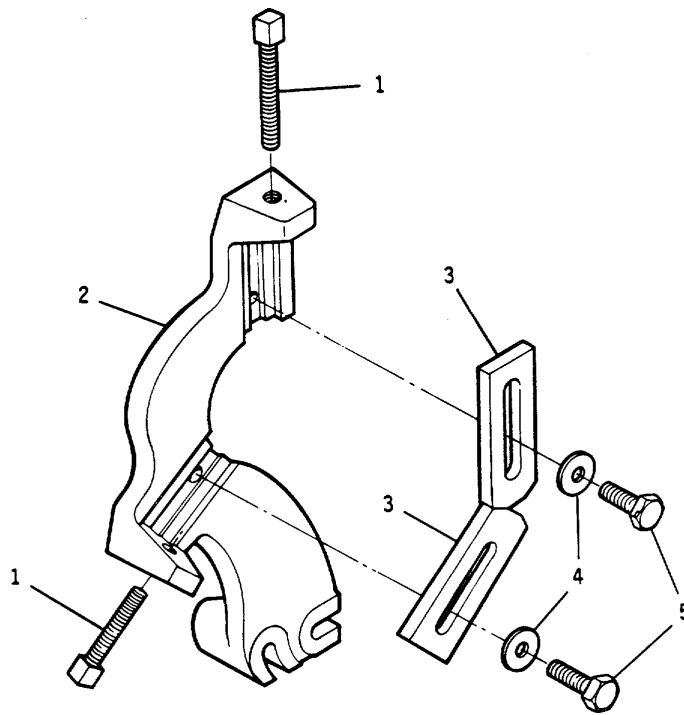
MICROMETER CARRIAGE STOP

<i>CARRIAGE STOP</i>			
ITEM NO.	PART NO.	DESCRIPTION	QTY.
	2761011	SINGLE CARRIAGE STOP (INCLUDES ITEMS 1 THRU 7)	1
1	3761031	STOP	1
2	6516009	NUT, 3/8-16 JAM	1
3	3695041	SCREW, TOOL POST	1
4	32440862	GIB	1
5	6861401	WASHER 7116	1
6	6716039	SCREW, 3/8-16 x 1-1/4 HEX HD. CAP	1
<i>DOUBLE CARRIAGE STOP</i>			
ITEM NO.	PART NO.	DESCRIPTION	QTY.
	2761010	CARRIAGE STOP, DOUBLE (INCLUDES ITEMS 1 THRU 9)	1
1	3582051	PIN, HINGE	1
2	3761033	STOP	1
3	3025065	ARM STOP	2
4	6564002	NUT, 1/4-28 JAM	2
5	6764040	SCREW, 1/4-28 x 1 SQ. HD. SET	2
6	6624014	PIN, 114 x 3/4 GROOVED	1
7	3244062	GIB	1
8	6861401	WASHER 7116	1
9	6716031	SCREW, 3/8-16 x 1 HEX HD. CAP	1
<i>THREADING STOP</i>			
ITEM NO.	PART NO.	DESCRIPTION	QTY.
	2761014	THREADED CARRIAGE STOP (INCLUDES ITEMS 1 THRU 5)	1
1	6716031	SCREW, 3/8-16 x 1 HEX HD. CAP	1
2	6861309	WASHER, 3/8	1
3	6516008	NUT, 3/8-16 ELASTIC STOP	1
4	6716142	SCREW, 3/8-16 x 2-1/2	1
5	3420013	LATCH	1
<i>MICROMETER CARRIAGE STOP</i>			
ITEM NO.	PART NO.	DESCRIPTION	QTY.
	2761012	MICROMETER CARRIAGE STOP (INCLUDES ITEMS 1 THRU 8)	1
1	3761032	BODY, STOP	1
2	3690056	SCREW	1
3	3406039	KNOB	1
4	6714006	SCREW, 114-20 x 3/16 SOC. SET CUP PT.	1
5	6624014	PIN, 1/4 x 3/4 GROOVE	1
6	3244062	GIB	1
7	6861401	WASHER, 7/16	1
8	6716039	SCREW, 3/8-16 x 1-1/4 HEX HD. CAP	1

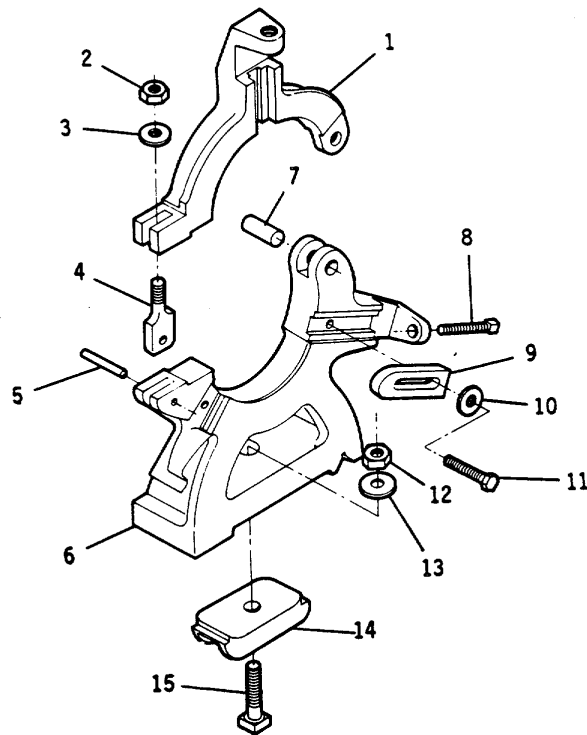


DRAW-IN COLLET ATTACHMENT

<i>DRAW-IN COLLET ATTACHMENT (L00 SPINDLE)</i>			
ITEM NO.	PART NO.	DESCRIPTION	QTY.
	2091011	COLLET ATTACHMENT (INCLUDES ITEMS 1 THRU 10)	1
	2271028	ASSY., HANDWHEEL (INCLUDES ITEMS 1 THRU 4)	1
1	6715015	SCREW, 5/16-18 x 1/4	2
2	6715189	SCREW, 5/16-18 x 5/32 HOLLOW LOCK	2
3	3271056	HANDWHEEL	1
4	3044119	BAR DRAW	1
	2004003	ASSY., ADAPTER (INCLUDES ITEMS 5 & 6)	1
5	3582050	PIN	1
6	3005023	ADAPTER	1
7	3078057	CAP, SPINDLE NOSE	1
8	3728030	SLEEVE	1
9	3837229	WASHER FIBER	1
10	3868017	WRENCH SPANNER	1
<i>DRAW-IN COLLET ATTACHMENT (D1-4" SPINDLE)</i>			
ITEM NO.	PART NO.	DESCRIPTION	QTY.
	2091038	COLLET ATTACHMENT (INCLUDES ITEMS 1 THRU 10)	1
	2271034	ASSY., HANDWHEEL (INCLUDES ITEMS 1 THRU 4)	1
1	6715015	SCREW, 5/16-18 x 1/4 SOC. SET	2
2	6715189	SCREW, 5/16-18 x 5/32 HOLLOW LOCK	2
3	3271056	HANDWHEEL	1
4	3044186	BAR, DRAW	1
	2004003	ASSY., ADAPTER (INCLUDES ITEMS 5 & 6)	1
5	3582050	PIN	1
6	3005023	ADAPTER	1
7	3078057	CAP, SPINDLE NOSE	1
8	3728030	SLEEVE	1
9	3837229	WASHER, FIBER	1
10	3868017	WRENCH, SPANNER	1
<i>DRAW-IN COLLET ATTACHMENT (THREADED SPINDLE)</i>			
ITEM NO.	PART NO.	DESCRIPTION	QTY.
	2091009	COLLET ATTACHMENT (INCLUDES ITEMS 1 THRU 11)	1
	2271027	ASSY., HANDWHEEL (INCLUDES ITEMS 1 THRU 4)	1
1	6715015	SCREW, 5/16-18 x 1/4 SOC. SET	2
2	6715189	SCREW, 5/16-18 x 5/32 HOLLOW LOCK	2
3	3271056	HANDWHEEL	1
4	3044118	BAR, DRAW	1
	2004003	ASSY., ADAPTER (INCLUDES ITEMS 5 & 6)	1
5	3582050	PIN	1
6	3005023	ADAPTER	1
7	3078056	CAP, SPINDLE NOSE	1
8	3728030	SLEEVE	1
9	383722	WASHER, FIBER	1
10	3868017	WRENCH, SPANNER	1
11	6960043	WRENCH, SPANNER	1



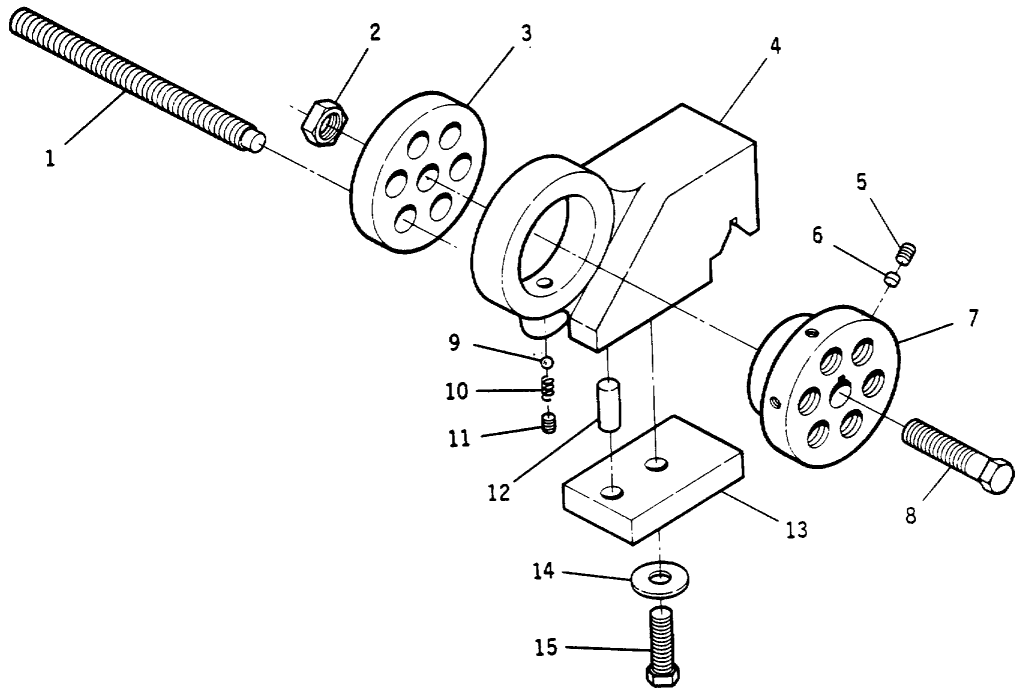
FOLLOWER REST



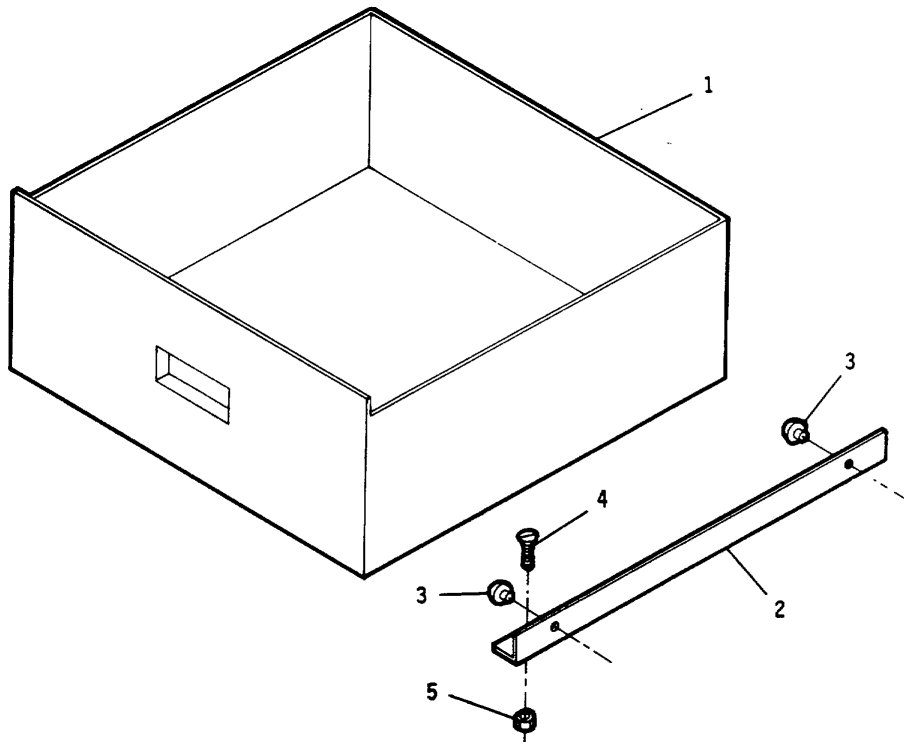
STEADY REST ASSEMBLY

<i>FOLLOWER REST</i>			
ITEM NO.	PART NO.	DESCRIPTION	QTY.
	2658015	FOLLOWER REST (INCLUDES ITEMS 1 THRU 5)	1
1	6715098	SCREW, 5/16-18 x 2 SQ. HD. SET	2
2	3063371	BRACKET	1
3	3350014	JAW	2
4	6861101	WASHER, 114	2
5	6714048	SCREW, 1/4-20 x 1 HEX HD. CAP	2

<i>STEADY REST ASSEMBLY</i>			
ITEM NO.	PART NO.	DESCRIPTION	QTY.
	2658016	ASSY., CENTER REST (INCLUDES ITEMS 1 THRU 15)	1
1	3063369	BRACKET STEADY REST TOP	1
2	6515001	NUT, 5/16-18 HEX	1
3	6861309	WASHER, 3/8	1
4	3689053	SCREW	1
5	6624016	PIN, 3/16 x 1 GROOVED	1
6	3042324	BASE, STEADY REST	1
7	6620016	PIN, 5/16 x 1 ROLL	1
8	6715101	SCREW, 5/16-18 x 2-3/4 SQ. HD. SET	3
9	3350015	JAWS	3
10	6861101	WASHER, 114	3
11	6714047	SCREW, 1/4-20 x 1-1/4 HEX HD. CAP	3
12	6516001	NUT, 3/8-16 HEX	1
13	6861201	WASHER	1
14	3092030	CLAMP	1
15	6716140	SCREW 3/8-16 x 2-1/2 SQ. HD. MACH.	1

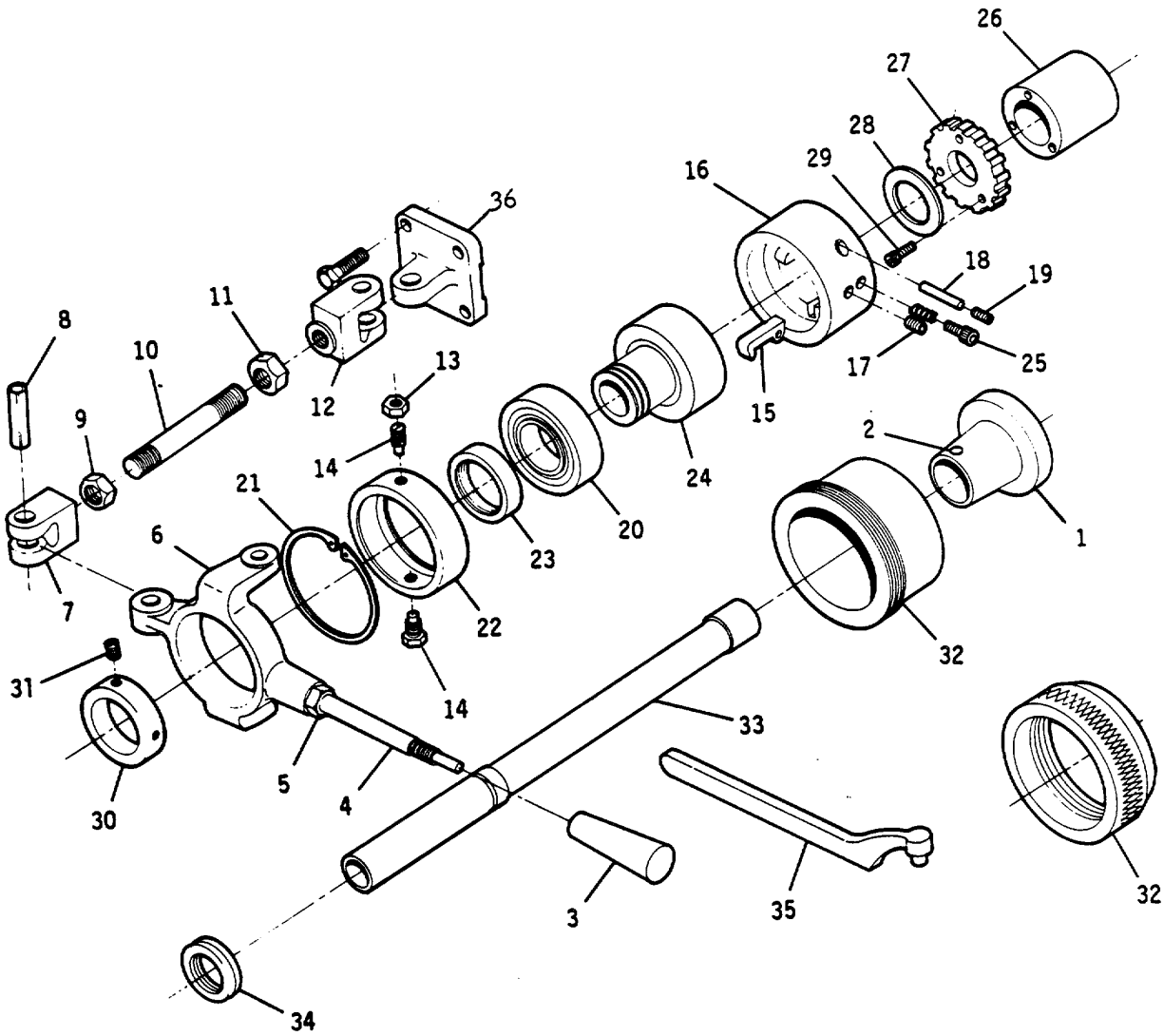


MULTIPLE CARRIAGE STOP



THREE DRAWERS KIT

<i>MULTIPLE CARRIAGE STOP</i>			
ITEM NO.	PART NO.	DESCRIPTION	QTY.
	2761018	MULTIPLE CARRIAGE STOP (INCLUDES ITEMS 1 THRU 15)	1
1	3695059	SCREW STOP	6
2	6516009	NUT, 318-16 JAM	1
3	3595270	PLATE, THRUST	1
4	3063406	BODY	1
5	6714004	SCREW, 1/4-20 x 1/4 SOC. SET	6
6	3598028	PLUG	6
7	3595269	PLATE	1
8	6716032	SCREW, 3/18-16 x 1-1/2 HEX HD. CAP	1
9	6054005	BALL, 3/16 STEEL	1
10	3755241	SPRING	1
11	6714003	SCREW, 114-20 x 3/8 SOC. SET	1
12	6624014	PIN, 1/4 x 3/4 GROOVED	1
13	3244062	GIB	1
14	6861401	WASHER, 7/16	1
15	6716039	SCREW, 318-16 x 1-1/4 HEX HD. CAP	1
<i>THREE DRAWERS KIT</i>			
ITEM NO.	PART NO.	DESCRIPTION	QTY.
	2138004	ASSY., KIT DRAWER (INCLUDES ITEMS 1 THRU 5)	1
1	2138003	ASSY., DRAWER	3
2	3253043	GUIDE	6
3	6098012	BUTTON	12
4	6710034	SCREW, 10-24 x 1/2 RD. HD. MACH.	12
5	6510001	NUT, 10-24 HEX	12



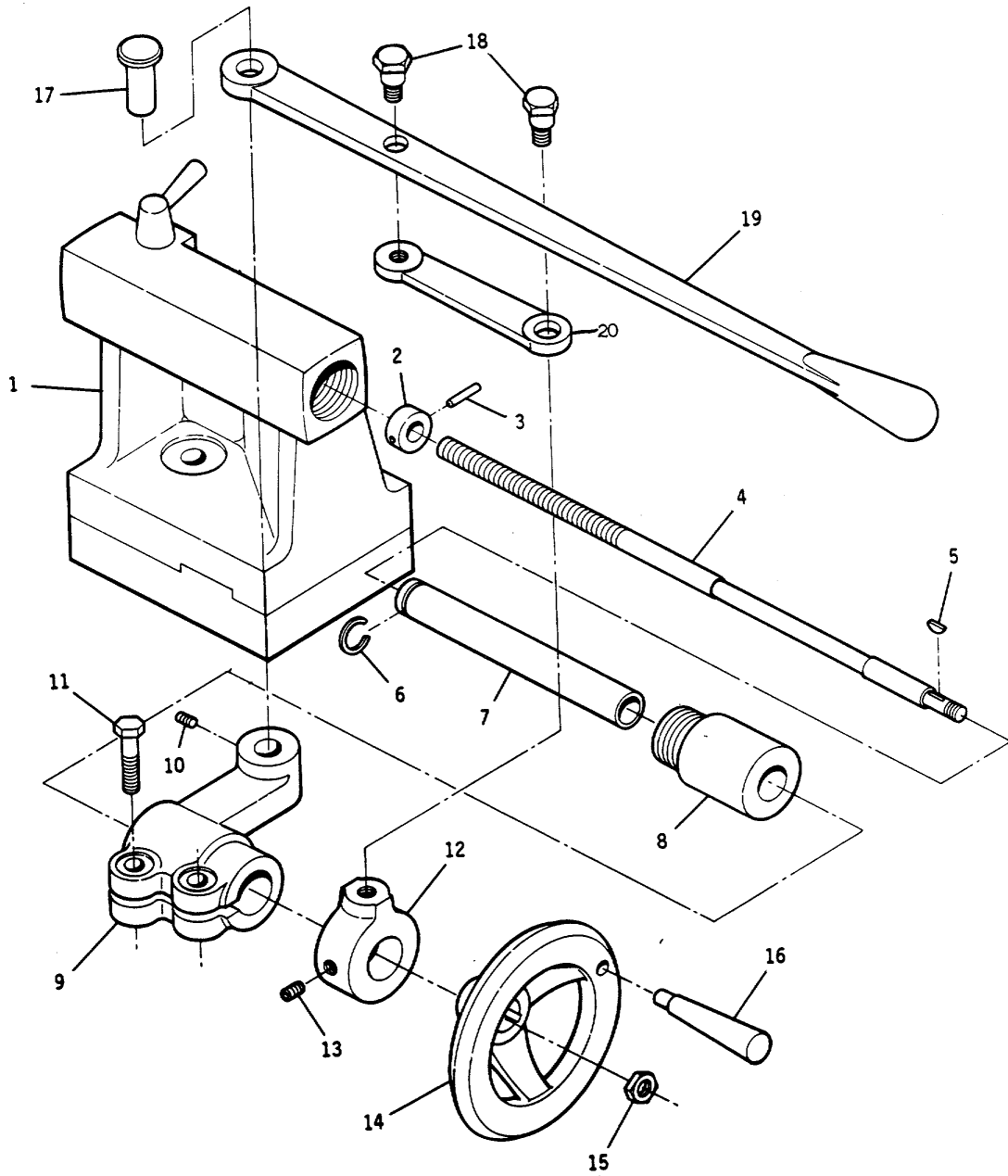
PRODUCTION COLLET ATTACHMENT

PRODUCTION COLLET ATTACHMENT (D1-4" SPINDLE)			
ITEM NO.	PART NO.	DESCRIPTION	QTY.
	2091039	PRODUCTION COLLET ATTACHMENT (INCLUDES ITEMS 1 THRU 36)	1
1	2004003	ADAPTER (INCLUDES ITEMS 1 AND 2)	1
	3005023	ADAPTER	1
2	3582050	PIN	1
	2091040	COLLET (INCLUDES ITEMS 3 THRU 36)	1
	2426007	ASSY., HAND AND LINK LEVER (INCLUDES ITEMS 3 THRU 14)	1
3	3406206	KNOB, WHITE	1
4	3700061	SHAFT	1
5	6518008	NUT, 1/2-13 HEX	1
6	3063315	LEVER	1
7	3936009	YOKE	1
8	6620015	PIN, 1/2 X 1 3/4 ROLL	1
9	6568011	NUT, 1/2-20 JAM L.H.	1
10	3773055	STUD, ADJ.	1
11	6568009	NUT, 1/2-20 JAM	1
12	3936010	YOKE	1
13	6515007	NUT, 5/16-18 JAM	2
14	3696003	SCREW, SOC. SET	2
	2298027	ASSY FINGER HOUSING (INCLUDES ITEMS 15 THRU 19)	1
15	3212011	FINGER	3
16	3298218	HOUSING	1
17	6715013	SCREW. 5/16-18 X 3/8 SOC. SET CUP PT.	2
18	6623045	PIN. 3/16-1 3/4 DOWEL	3
19	6760075	SCREW, 10-32 X 3/16 SOC. SET	6
	2211002	ASSY. FINGER CLOSER (INCLUDES 20 ITEMS THRU 24)	1
20	6060123	BEARING	1
21	6670100	RING, RETAINING	2
22	3298217	HOUSING, BEARING RING	1
23	3526041	NUT, TAKE UP	1
24	3212010	FINGER CLOSER	1
25	6706013	SCREW, 6-32 X 3/8 SOC. HO. CAP	4
26	3526049	NUT, LOCK	1
27	3661009	RING, LOCK	1
28	3837038	WASHER	1
29	6760031	SCREW, 10-32 X 1/2 SOC. HD. CAP	3
30	3096075	COLLAR, STOP	1
31	6714006	SCREW, 1/4-20 X 3/16 SOC. SET	2
32	3078056	CAP, NOSE	1
33	3044187	BAR, DRAW	1
34	6670102	RING	1
35	6960044	WRENCH	1
36	2063057	BRACKET, MTG.	1

PRODUCTION COLLET ATTACHMENT (L00 SPINDLE)			
ITEM NO	PART NO.	DESCRIPTION	QTY.
	2091027	PRODUCTION COLLET ATTACHMENT (INCLUDES ITEMS 1 THRU 36)	1
1	2004003	ADAPTER (INCLUDES ITEMS 1 AND 2)	1
	3005023	ADAPTER	1
2	3582050	PIN	1
	2091026	COLLET (INCLUDES ITEMS 3 THRU 36)	1
	2426007	ASSY., HAND AND LINK LEVER (INCLUDES ITEMS 3 THRU 14)	1
3	3406206	KNOB , WHITE	1
4	3700061	SHAFT	1
5	6518008	NUT, 1/2 13 HEX	1
6	3063315	LEVER	1
7	3936009	YOKE	1
8	6620015	PIN, 1/2 X 1 3/4 ROLL	1
9	6568011	NUT, 1/2-20 JAM L.H.	1
10	3773055	STUD, ADJ.	1
11	6568009	NUT, 1/2-20 JAM	1
12	3936010	YOKE	1
13	6515007	NUT. 5/16-18 JAM	2
14	3696003	SCREW, SOC. SET	2
	2298027	ASSY., FINGER HOUSING (INCLUDES ITEMS 15 THRU 19)	1
15	3212011	FINGER	3
16	3298218	HOUSING	1
17	6715013	SCREW. 5/16-18 X 3/8 SOC. SET CUD PT	2
18	6623045	PIN. 3/16-1 3/4 DOWEL	3
19	6760075	SCREW. 10-32 x 3/16 SOC SET	6
	2211002	ASSY., FINGER CLOSER (INCLUDES ITEMS 20 THRU 24)	1
20	6060123	BEARING	1
21	6670100	RING. RETAINING	2
22	3298217	HOUSING. BEARING RING	1
23	3526041	NUT, TAKE UP	1
24	3212010	FINGER, CLOSER	1
25	6706013	SCREW. 6-32 X 3/8 SOC. HD. CAP	4
26	3526049	NUT, LOCK	1
27	3661009	RING, LOCK	1
28	3837038	WASHER	1
29	6760031	SCREW. 10-32 X 1/2 SOC. HD. CAP	3
30	3096075	COLLAR, STOP	1
31	6714006	SCREW. 1/4.20 X 3/16 SOC. SET	2
32	3078057	CAP, NOSE	1
33	3044120	BAR, DRAW	1
34	6670102	RING	1
35	6960044	WRENCH	1
36	2063057	BRACKET, MTG.	1

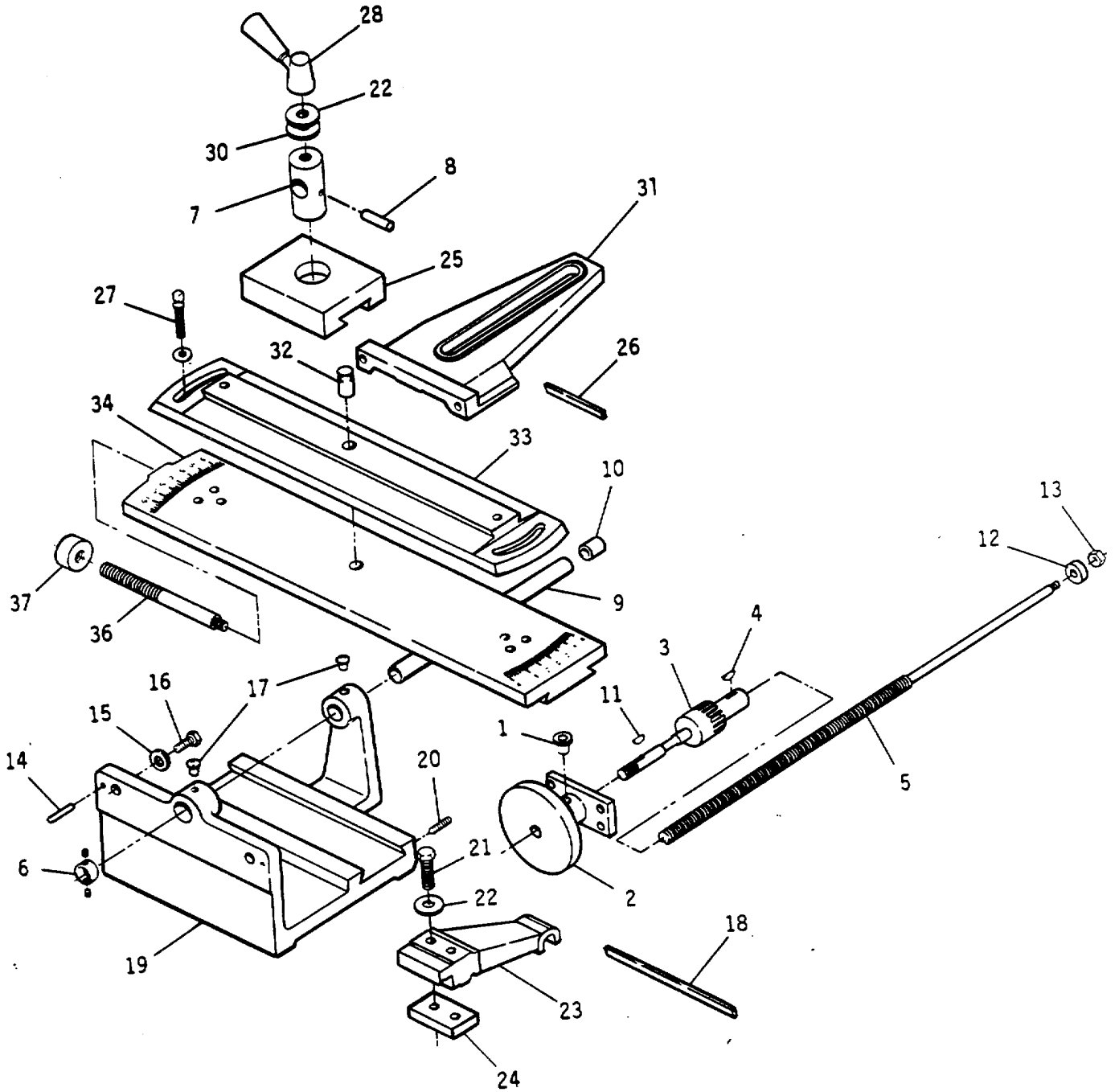
PRODUCTION COLLET ATTACHMENT (THREADED SPINDLE)			
ITEM NO.	PART NO.	DESCRIPTION	QTY.
	2091029	PRODUCTION COLLET ATTACHMENT (INCLUDES ITEMS 1 THRU 36)	1
1	2004003	ADAPTER (INCLUDES ITEMS 1 AND 2)	1
	3005023	ADAPTER	1
2	3582050	PIN	1
	2091028	COLLET (INCLUDES ITEMS 3 THRU 36)	1
	2426007	ASSY., HAND AND LINK LEVER (INCLUDES ITEMS 3 THRU 14)	1
3	3406206	KNOB , WHITE	1
4	3700061	SHAFT	1
5	6518008	NUT, 1/2-13 HEX	1
6	3063315	LEVER	1
7	3936009	YOKE	1
8	6620015	PIN. 1/2 X 1 3/4 ROLL	1
9	6568011	NUT, 1/2-20 JAM L.H.	1
10	3773055	STUD, AOJ.	1
11	6568009	NUT, 1/2-20 JAM	1
12	3936010	YOKE	1
13	6515007	NUT, 5/16-18 JAM	2
14	3696003	SCREW, SOC. SET	2
	2298027	ASSY., FINGER HOUSING' (INCLUDES ITEMS 15 THRU 19)	1
15	3212011	FINGER	3

PRODUCTION COLLET ATTACHMENT (THREADED SPINDLE)			
ITEM NO	PART NO.	DESCRIPTION	QTY.
16	3298218	HOUSING	1
17	6715013	SCREW, 5/16-18 X 3/8 SOC. SET CUP PT.	2
18	6623045	PIN. 3/16-1 3/4 DOWEL	3
19	6760075	SCREW. 10-32 X 3/16 SOC. SET	6
	2211002	ASSY., FINGER CLOSER (INCLUDES ITEMS 20 THRU 24)	1
20	6060123	BEARING	1
21	6670100	RING, RETAINING	2
22	3298217	HOUSING, BEARING RING	1
23	3526041	NUT, TAKE UP	1
24	3212010	FINGER, CLOSER	1
25	6706013	SCREW, 6-32 X 3/8 SOC HO. CAP	4
26	3526049	NUT. LOCK	1
27	3661009	RING, LOCK	1
28	3837038	WASHER	1
29	6760031	SCREW, 10-32 X 1/2 SOC. HD. CAP	3
30	3096075	COLLAR, STOP	1
31	6714006	SCREW, 1/4-20 X 3/16 SOC. SET	2
32	3078056	CAP, NOSE	1
33	3044117	BAR, DRAW	1
34	6670102	RING	1
35	6960044	WRENCH	1
36	2063057	BRACKET, MTG.	1



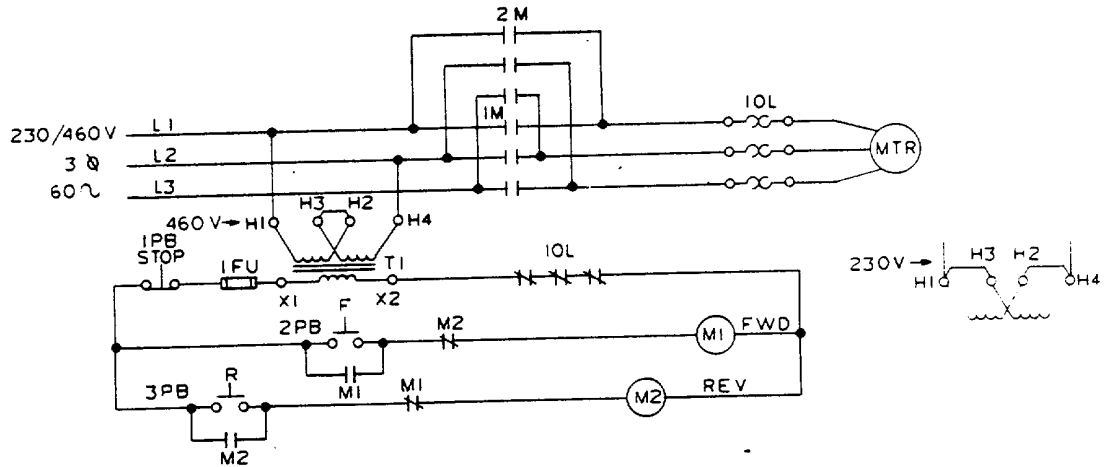
TRAILSTOCK LEVER 12"

<i>TAILSTOCK LEVER 12"</i>			
ITEM NO.	PART NO.	DESCRIPTION	QTY.
	2800013	ASSY., TAILSTOCK LEVER (INCLUDES ITEMS 1 THRU 20)	1
	2800014	ASSY., TAILSTOCK AND SPINDLE (INCLUDES ITEMS 1 THRU 4 AND ITEM 7)	1
1	2800010	TAILSTOCK	1
2	3096074	COLLAR	1
3	6627002	PIN, #0 x 314 TAPER	1
4	3695046	SCREW	1
5	6420013	KEY, 3/32 x 1/2 WOODRUFF	1
6	6670104	RING, 7/8 TRUARC	1
7	3749063	SPINDLE	1
8	3598030	PLUG	1
9	3063311	BRACKET	1
10	6714004	SCREW, 1/4-20 x 1/4 SOC. SET	1
11	6716031	SCREW, 3/8-16 x 1 HEX HD. CAP	2
12	3096076	COLLAR, STOP	1
13	6716003	SCREW, 318-16 x 3/8 SOC. SET	1
14	3271045	HANDWHEEL	1
15	6566004	NUT, 3/8 24 JAM	1
16	3268030	HANDLE	1
17	3582053	PIN	1
18	3582054	PIN	2
19	3268034	HANDLE	1
20	3445007	LINK	1

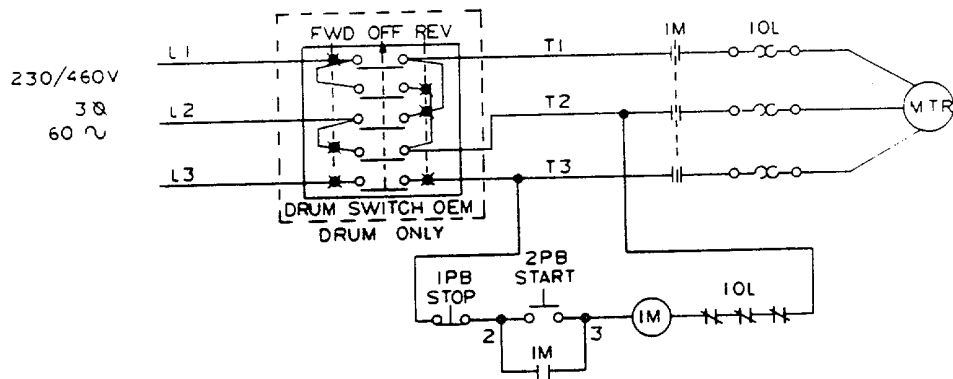


TAPER ATTACHMENT (TELESCOPIC)

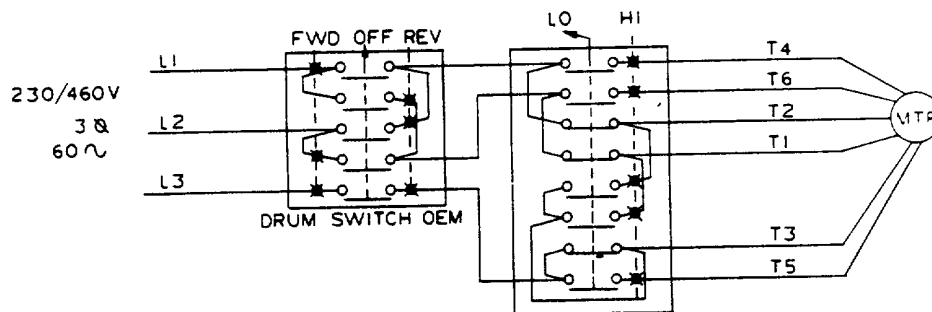
TAPER ATTACHMENT (TELESCOPIC)			
ITEM NO.	PART NO.	DESCRIPTION	QTY.
	2799004	TAPER ATTACHMENT (TELESCOPIC) (INCLUDES ITEMS 1 THRU 37)	1
	2240036	ASSY., GEAR & SLEEVE (INCLUDES ITEMS 1 THRU 4)	1
1	6607012	CUP OIL	1
2	3063367	BRACKET, CROSSFEED	1
3	3237231	GEAR	1
4	3388060	KEY	1
	2690032	ASSY., CROSSFEED SCREW (INCLUDES ITEMS 5 THRU 6)	1
5	3689036	SCREW, TELESCOPING	1
6	3096084	COLLAR	1
	2298028	ASSY., HOUSING SCREW (INCLUDES ITEMS 7 THRU 10)	1
7	3448056	LOCK SLIDE	1
8	6627020	PIN, #2 x 1-1/4 TAPER	1
9	3298228	HOUSING, SCREW	1
10	6095135	BUSHING, 7/16 x 9/16 x 5/8 OIL LESS	1
11	6420013	KEY, WOODRUFF	1
12	3837041	WASHER	1
13	6565002	NUT, 5/16-24 JAM	2
14	6623012	PIN, 1/4 x 1 DOWEL	2
15	6861309	WASHER, 3/8	2
16	6716032	SCREW, 3/8-16 x 1-1/2 HEX HD. CAP	2
17	6607L010	CUP, OIL	2
18	3244072	GIB	1
19	3063377	BRACKET	1
20	6764039	SCREW, 1/4-28 x 3/4 SOC. SET NYLOK	7
21	6716037	SCREW, 3/8-16 x 2 HEX HD. CAP	2
22	3837037	WASHER	5
23	3063375	BRACKET, BED	1
24	3003029	CLAMP	1
25	3730036	SLIDE	1
26	3244071	GIB	1
27	3689038	SCREW, 3/8-16	2
28	3426041	LEVER	1
29	3773056	STUD	1
30	3735060	SPACER	1
31	3186023	EXTENSION, CROSS SLIDE	1
32	3582070	PIN	1
33	3793005	SWIVEL	1
34	3042326	BASE, SWIVEL	1
35	6714015	SCREW, 1/4-20 x 1/2 SOC. HD. CAP	1
36	3773057	STUD	1
37	3626064	NUT	2



0940086



0940079



0940105

WIRING SCHEMATIC REV
MAG. WITH 110V CONT.
0940086

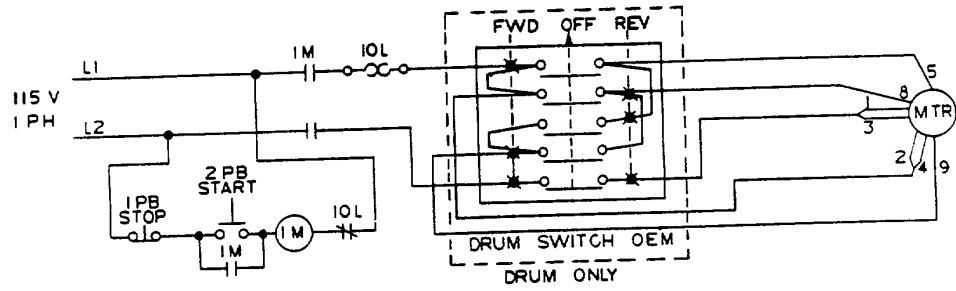
REF	QTY.	PART NO.	DESCRIPTION
1M		6816145	STARTER, REV. MAG., (FOR 115V CONT)
2M	1	68143	STARTER REV. MAG., (FOR 24V CONT)
TI	1	6831070	TRANSFORMER, 40/480V-115V, 50VA (FOR 115V CONT)
1PB	1	6831069	TRANSFORMER, 40/460V-24V, 75VA (FOR 24V CONT)
		6821066	OPERATOR, SWITCH, P.B.
2PB	1	6321061	CONTACT, SWITCH,
		6821063	OPERATOR, SWITCH
3PB		6821002	CONTACT, SWITCH,

SCHEMATIC, MAG, W/REV
0940079

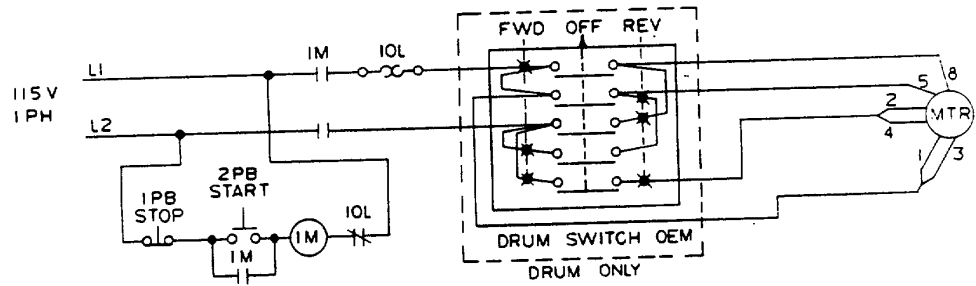
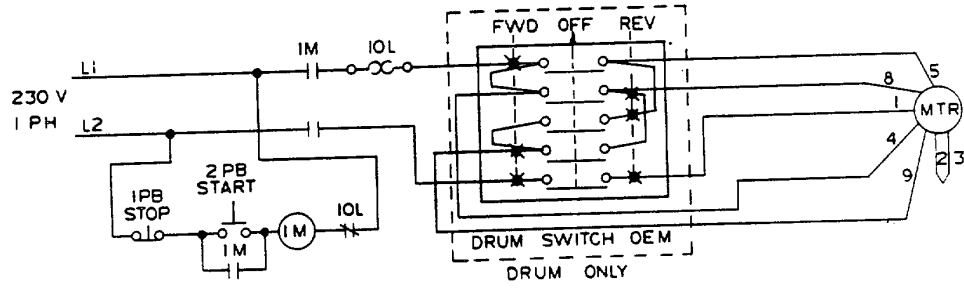
REF	QTY.	PART NO.	DESCRIPTION
SS	1	6821204	SWITCH, REV.
IM	1	6816116	STARTER, MAG.,
IPB	1	6821066	OPERATOR, SWITCH, P.B
2PB		6321061	CONTACT, SWITCH,
		6821063	OPERATOR, SWITCH, P.B
		6821002	CONTACT SWITCH

REV DRUM & 2 SPEED
DRUM 0940105

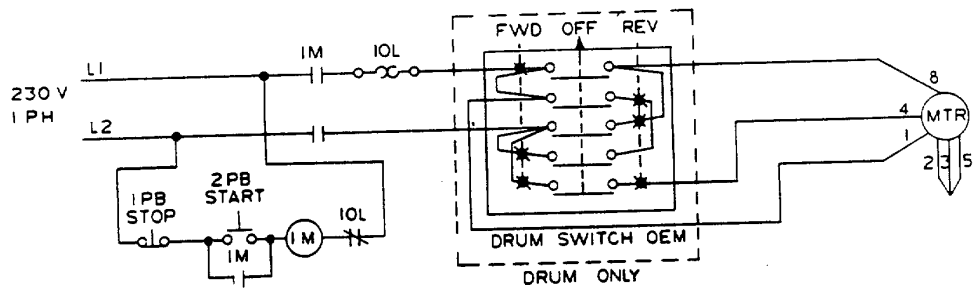
REF	QTY.	PART NO.	DESCRIPTION
1SS	1	6821204	SWITCH, REV. DRUM,
2SS	1	6821176	SWITCH, 2 SPEED DRUM
MTR	1	6471622	MOTOR, ELEC., 2 HP., 3PH., 1800 RPM, 230/460V, 145T, TEFC
		6471624	MOTOR ELEC., 2HP., 3PH., 1800RPM, 200V, 145T, TEFT
		6471625	MOTOR, ELEC., 2HP., 1PHJ., 1800RPM, 115/230V, 145T, TEFC
		6473016	MOTOR, ELEC., 2&1HP., 3PH., 1800 RPM & 900 RPM, 230V, 182T, TEFC
		6473017	MOTOR, ELEC., 3 & 1HP., 3PH., 1800 & 900 RPM, 460V, 182T, TEFC



0940084



0940082

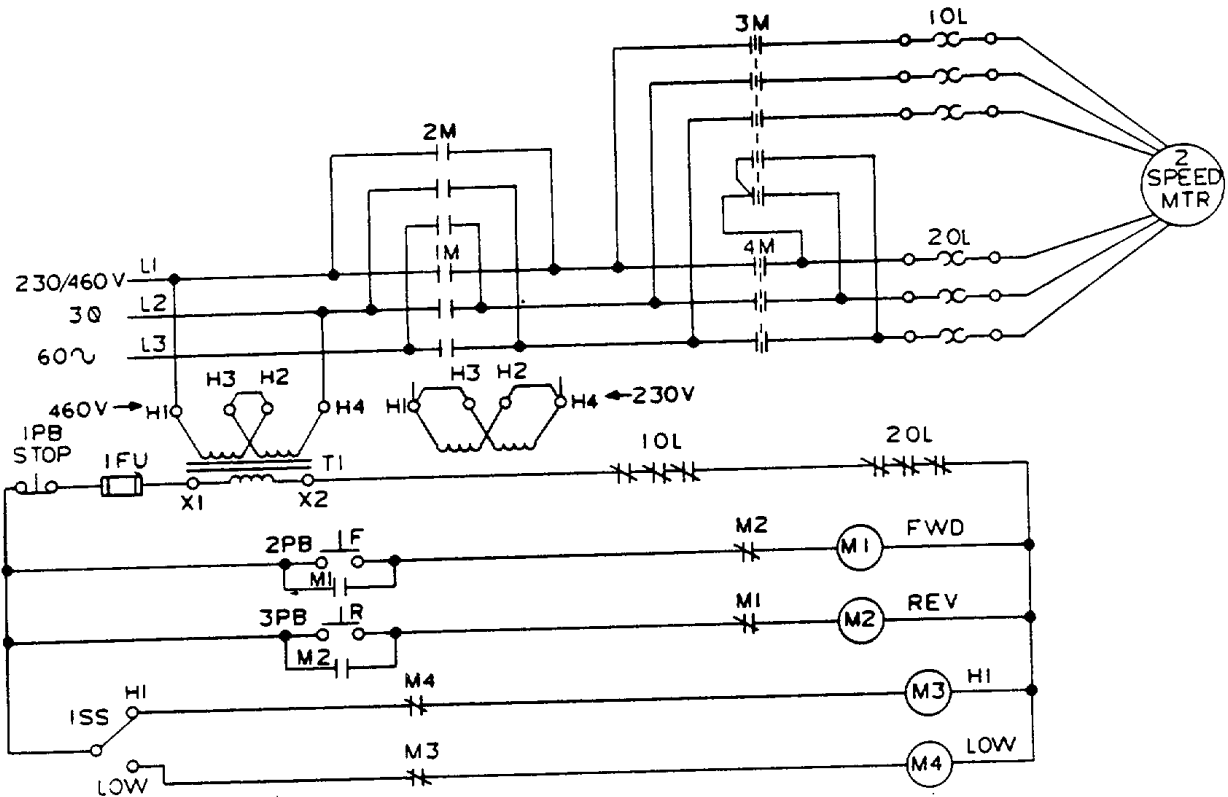


*CAPACITOR RUN MOTOR
SCHEMATIC, 1PH. MAG.
W/REV. DRUM 0940084*

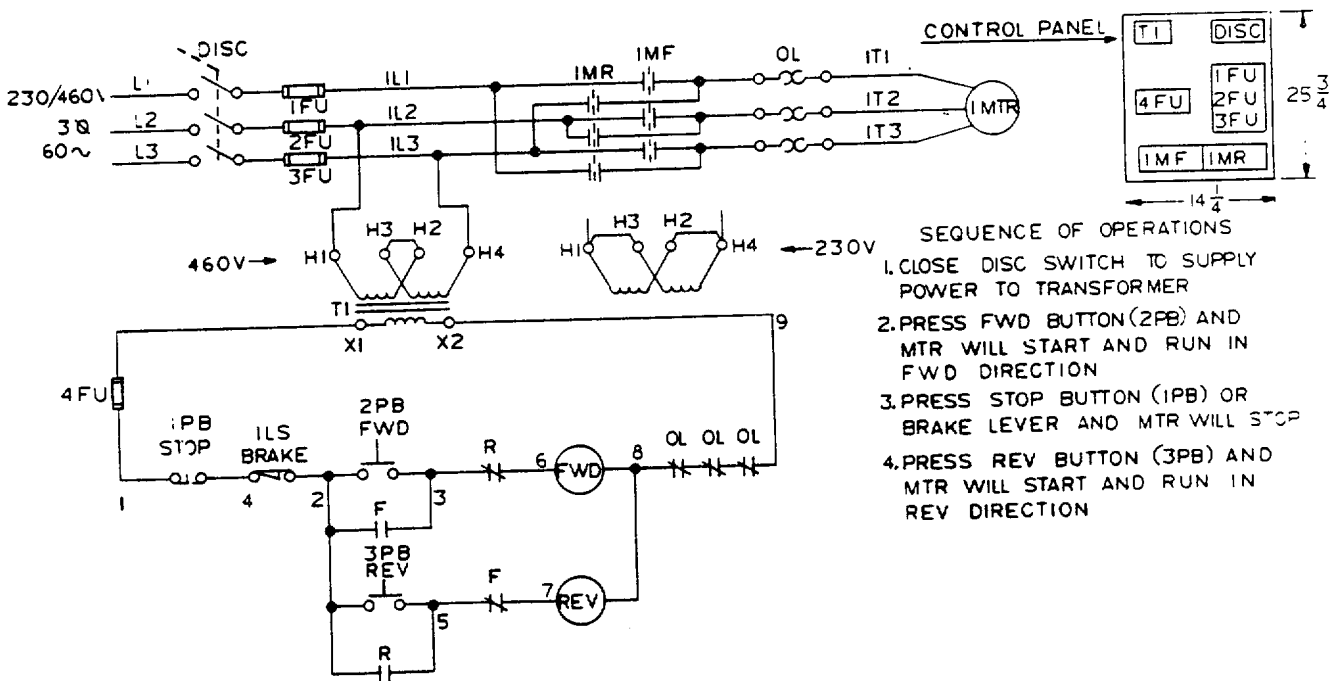
REF	QTY.	PART NO.	DESCRIPTION
SS	1	6821175	SWITCH, REV. DRUM, (FOR 230V)
		6821198	SWITCH, REV. DRUM, (FOR 115V)
1 M	1	6816109	STARTER, MAG.
1 PB	1	6821066	OPERATOR, SWITCH. P.B.
		6821061	CONTACT, SWITCH,
2 PB	1	6821063	OPERATOR, SWITCH, P.B.
		6821002	CONTACT, SWITCH,

*CAPACITOR START MOTOR
SCHEMATIC, 1PH. MAG.
W/REV. DRUM 0940082*

REF	QTY.	PART NO.	DESCRIPTION
SS	1	6821175	SWITCH, REV. DRUM, (FOR 230V)
		6821198	SWITCH, REV. DRUM, (FOR 115V)
1M	1	6816109	STARTER, MAG.
1PB	1	6821066	OPERATOR, SWITCH, P. B.
		6821061	CONTACT, SWITCH.
2PB	1	6821063	OPERATOR, SWITCH, P B.
		6821002	CONTACT, SWITCH,



0940075



0940080

WIRING, SCHEMATIC
TWO SPEED W/REV. MAG.
FOR 110V 0940075

REF	QTY.	PART NO.	DESCRIPTION
1M	1	6816143	STARTER, REV. MAG., (FOR 24V CONT.)
2M		6816145	STARTER, REV. MAG., (FOR 115V CONT.)
3M	1	6816149	STARTER, 2 SPEED, (FOR 24V CONT.)
4M		6816150	STARTER, 2 SPEED, (FOR 115V CONT.)
		6821179	OPERATOR, SELECTOR,
1SS	1	6821061	CONTACT, SWITCH,
		6821002	CONTACT, SWITCH,
1PB	1	6821066	OPERATOR, SWITCH, PB.
		6821061	CONTACT, SWITCH,
2PB	1	6821063	OPERATOR, SWITCH, RB.
3PB		6821002	CONTACT, SWITCH,

SCHEMATIC, JIC REVERSE
0940080

REF	QTY.	PART NO.	DESCRIPTION
1M	1	6816158	STARTER, COMBINATION,
1PB 2PB 3PB	1	6821163	SWITCH, RB. STATION,
1LS	1	6821096	SWITCH, LIMIT, MICRO #BZEG2RN

Calculations for cutting threads not listed on threading chart on 12" and 14" lathes.

- T = Desired threads per in to be cut.
- S = Number of teeth in stud gear to obtain desired threads per inch.
- t = Threading chart position to obtain desired threads.
- K = Constant required to make desired threads per inch a whole number. (Not used when desired threads per inch is already a whole number.)

To determine if desired threads per inch can be cut without compound end gearing:

60K

Factor TK and cancel all factors possible in numerator and denominator. Desired thread can probably be cut if the only remaining factors in the denominator are 2, 3, 5, 7, 11, 13 and 23 providing listed factors occur only once with the exception of 2.

A. EXAMPLE: Desired thread to be cut - 5-1/3 t.p.i.

$$\frac{60}{5-1/3} \frac{(3)}{(3)} \frac{180}{16} \frac{2 \times 2 \times 3 \times 3 \times 5}{2 \times 2 \times 2 \times 2} = \frac{3 \times 3 \times 5}{2 \times 2}$$

To determine thread position "T" on gear box, select threading chart column from following table.

(1) Largest remaining factor in denominator

	21	Column
	3	2 or 6
	5	3
7	7	8
	11	4
	13	7
	23	5

Select thread number on chart between T and -in column selected above.

(A) EXAMPLE: Largest remaining factor in denominator is 2.
 Δ Thread chart column No. 1 is selected from table I.
 T:= 5-1/3 and - = 2-2/3
 Δ t = 4 chosen from Row No. 1, Column No. 1

To determine number of teeth in stud gear, use the following formula:

$$S = \frac{60tK}{TK}$$

(A) EXAMPLE: $S = \frac{(60)(4)(3)}{(5 - 1/3)(3)} = 45$

NOTE: Answer must be whole number to cut non-listed threads per inch without using compound end gearing. If compound end gearing is required, refer to Machinery's Handbook under, "Thread cutting, change gears for lathes."

By Order of the Secretary of the Army:

Official:

ROBERT M. JOYCE
Major General, United States Army
The Adjutant General

E. C. MEYER
General, United States Army
Chief of Staff

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THE METRIC SYSTEM AND EQUIVALENTS

LINEAR MEASURE

1 Centimeter = 10 Millimeters = 0.01 Meters = 0.3937 Inches
 1 Meter = 100 Centimeters = 1000 Millimeters = 39.37 Inches
 1 kilometer = 1000 Meters = 0.621 Miles

WEIGHTS

1 Gram = 0.001 Kilograms = 1000 Milligrams = 0.035 Ounces
 1 Kilogram = 1000 Grams = 2.2 Lb.
 1 Metric Ton = 1000 Kilograms = 1 Megagram = 1.1 Short Tons

LIQUID MEASURE

1 Milliliter = 0.001 Liters = 0.0338 Fluid Ounces
 1 Liter = 1000 Milliliters 33.82 Fluid Ounces

SQUARE MEASURE

1 Sq. Centimeter = 100 Sq. Millimeters = 0.155 Sq. Inches
 1 Sq. Meter = 10,000 Sq. Centimeters = 10.76 Sq. Feet
 1 Sq. Kilometer = 1,000,000 Sq. Meters = 0.386 Sq. Miles

CUBIC MEASURE

1 Cu. Centimeter = 1000 Cu. Millimeters = 0.06 Cu. Inches
 1 Cu. Meter = 1,000,000 Cu. Centimeters = 35.31 Cu. Feet

TEMPERATURE

$5/9 (^{\circ}\text{F} - 32) = ^{\circ}\text{C}$
 212° Fahrenheit is equivalent to 100° Celsius
 90° Fahrenheit is equivalent to 32.2° Celsius
 32° Fahrenheit is equivalent to 0° Celsius
 $9/5 (^{\circ}\text{C} + 32) = ^{\circ}\text{F}$

APPROXIMATE CONVERSION FACTORS

TO CHANGE

Inches
 Feet
 Yards
 Miles
 Square Inches
 Square Feet
 Square Yards
 Square Miles
 Acres
 Cubic Feet
 Cubic Yards
 Fluid Ounces
 Pints
 Quarts
 Gallons
 Ounces
 Pounds
 Short Tons
 Pound-Feet
 Pounds per Square Inch
 Miles per Gallon
 Miles per Hour

TO

Centimeters
 Meters
 Meters
 Kilometers
 Square Centimeters
 Square Meters
 Square Kilometers
 Square Hectometers
 Cubic Meters
 Cubic Meters
 Milliliters
 Liters
 Liters
 Liters
 Grams
 Kilograms
 Metric Tons
 Newton-Meters
 Kilopascals
 Kilometers per Liter
 Kilometers per Hour

MULTIPLY BY

2.540
 0.305
 0.914
 1.609
 6.451
 0.093
 0.836
 2.590
 0.405
 0.028
 0.765
 29.573
 0.473
 0.946
 3.785
 28.349
 0.454
 0.907
 1.356
 6.895
 0.425
 1.609

TO CHANGE

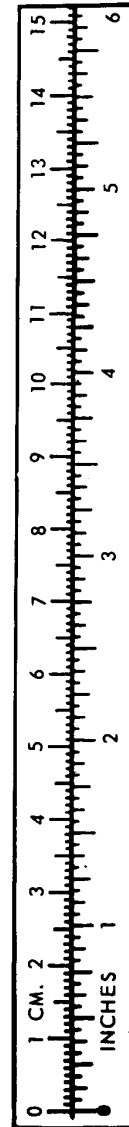
Centimeters
 Meters
 Meters
 Kilometers
 Square Centimeters
 Square Meters
 Square Meters
 Square Kilometers
 Square Hectometers
 Cubic Meters
 Cubic Meters
 Milliliters
 Liters
 Liters
 Liters
 Grams
 Kilograms
 Metric Tons
 Newton-Meters
 Kilopascals
 Kilometers per Liter
 Kilometers per Hour

TO

Inches
 Feet
 Yards
 Miles
 Square Inches
 Square Feet
 Square Yards
 Square Miles
 Acres
 Cubic Feet
 Cubic Yards
 Fluid Ounces
 Pints
 Quarts
 Gallons
 Ounces
 Pounds
 Short Tons
 Pound-Feet
 Pounds per Square Inch
 Miles per Gallon
 Miles per Hour

MULTIPLY BY

0.394
 3.280
 1.094
 0.621
 0.155
 10.764
 1.196
 0.386
 2.471
 35.315
 1.308
 0.034
 2.113
 1.057
 0.264
 0.035
 2.205
 1.102
 0.738
 0.145
 2.354
 0.621



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