Phase 1 Mechanical ROA

Module Title:

- **Safe Operation of a Centre Lathe**

Module No: MS5

- **Planning A Task Module No: MS6**

Presentation Title:
The Centre Lathe & Turning Operations

Introduction

- During this presentation the various parts of the Centre Lathe will be described and explained
- Essential H&S points will be explored and explained
- At the end of the presentation you will have a gained essential knowledge on the safe operation of the Centre Lathe

Agenda

- Overview of the machine
- Health & Safety – Safe operation
- Headstock – Assembly
- Apron – Assembly
- Tailstock – Assembly
- Job planning & Strategy
- Turning Tools
- Speeds & Feeds
- House-Keeping & Maintenance

Health & Safety

- ***YOU*** **are responsible for your own safety and proper machine operation.**
- **Any machine tool can be dangerous if used improperly. As you are new to engineering, get in the habit right from the start of rigorously following good safety practices. Here are some tips:**
- **Always wear light eye protection (LEP) The lathe can throw off sharp, hot metal chips at considerable speed as well as spin off spirals of metal that can be quite hazardous. Don't take chances with your eyes.**
- **Wear short sleeve shirts, if possible, or shirts with snugly fitting cuffs if long sleeve. Loose sleeves can catch on rotating work and quickly pull your hand or arm into harm's way.**
- **Wear steel toe cap safety boots - to protect your feet from sharp metal chips on the shop floor and from tools and heavy parts that may get dropped.**
- **Remove wrist watches, necklaces, chains and other jewelry. It's a good idea even to remove any rings since it can catch on rotating work and severely damage your ring finger and hand.**
- **Tie back long hair so it can't get caught in the rotating work. Think about what happens to your face if your hair gets entangled.**
- **Do not attempt to operate unless you know how to stop and isolate the machine in both normal and emergency situations**

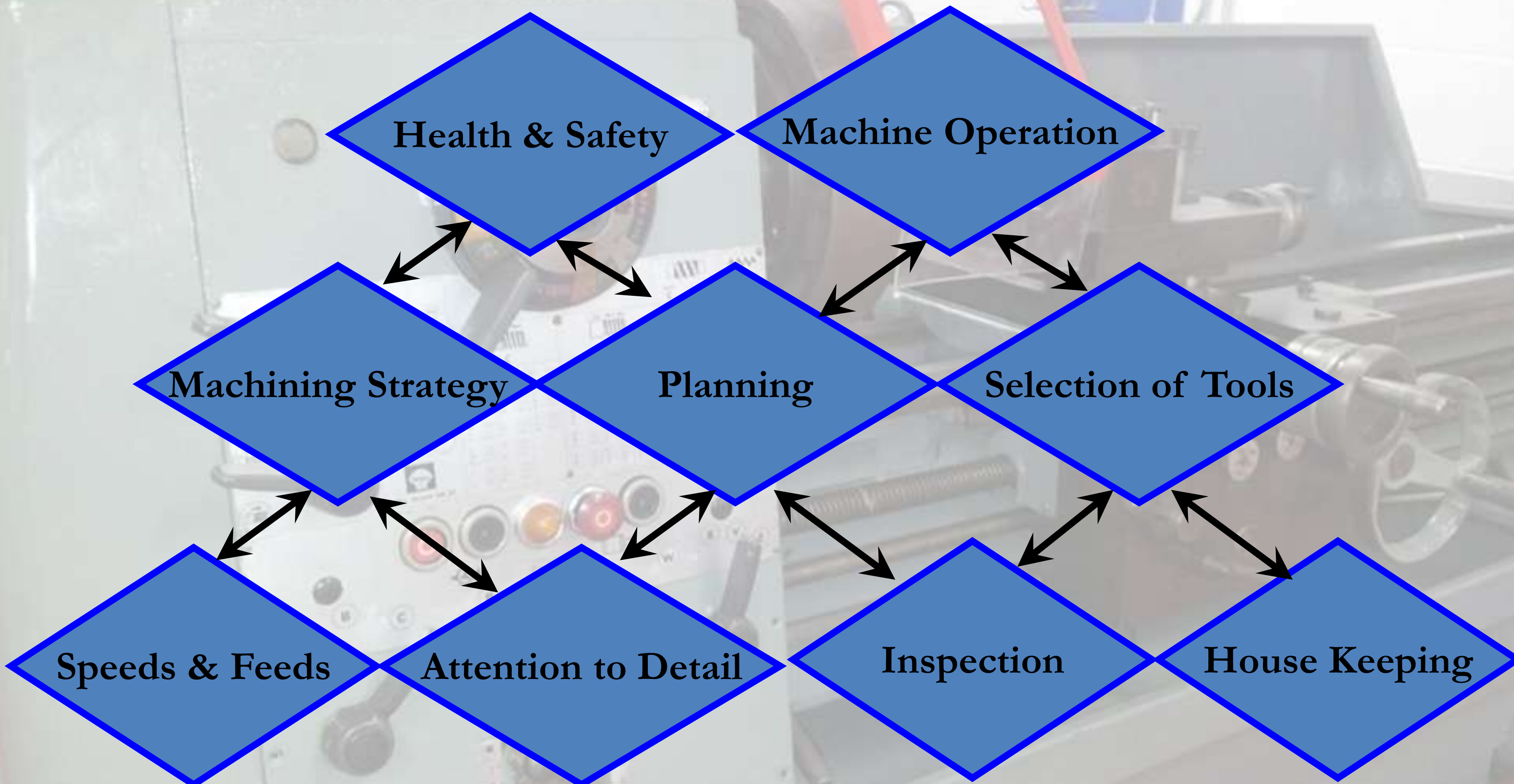
Health & Safety Cont'd

- **Always double check to make sure your work is securely clamped before starting the lathe. Start the lathe at low speed and increase the speed gradually.**
- **Get in the habit of always removing the chuck key immediately after use. Some users recommend never removing your hand from the chuck key when it is in the chuck. The chuck key can be a lethal projectile if the lathe is started with the chuck key in the chuck.**
- **Ensure that the Guard is in good working order.**
- **Keep your fingers clear of the rotating work and cutting tools. This sounds obvious, but you can often be tempted to break away metal spirals as they form at the cutting tool.**
- **Avoid reaching over the spinning chuck.**
- **Do not use emery cloth or files.**
- **Report any faults or damage immediately**
- **Always leave the work area clean and tidy**

Overview

- Centre Lathes are used extensively within many industrial sectors like
- Electronics,
- Petro-Chem
- Precision Engineering,
- Maintenance

Operational Flow



Tips for Successful Turning
The 3 R’s

- Rigidity – Ensure that the workpiece is secured in the chuck with only the required length protruding
- Rigidity – Ensure long sections are supported by centres or other methods e.g. steadies
- Rigidity – Ensure the tool is clamped securely in the tool-post with minimum overhang

Glossary of Terms

- **Apron - Front part of the carriage assembly on which the carriage hand-wheel is mounted**
- **Bed- Main supporting casting running the length of the lathe**
- **Between Centres- 1. A dimension representing the maximum length of a workpiece that can be turned between centres. A 160x250 lathe is 250 between centres; a 160x300 lathe is 300 between centres. 2. A method of holding a work-piece by mounting it between a centre in the headstock spindle and a centre in the tailstock spindle (see Centre).**
- **Carriage - Assembly that moves the tool-post and cutting tool along the bed slide-ways**
- **Carriage Handwheel - A wheel with a handle used to move the carriage by hand along the bed by means of a rack and pinion drive**
- **Centre - A precision ground tapered cylinder with a 60º pointed tip and a Morse Taper shaft. Used in the tailstock to support the end of a long work-piece. May also be used in the headstock spindle to support work between centres at both ends.**
- **Centre Drill - 1. A short, stubby drill used to form a pilot hole for drilling and a shallow countersunk hole for mounting the end of a workpiece on a centre.
  2. The process of drilling a workpiece with a centre drill**

Glossary of Terms Cont’d

- **Centreline - An imaginary line extending from the centre of the spindle through the centre of the tailstock ram, representing the central axis of the lathe around which the work rotates.**
- **Apron - Front part of the carriage assembly on which the carriage hand-wheel is mounted**
- **Chuck - A clamping device for holding work in the lathe or for holding drills in the tailstock.**
- **Compound Slide - Movable platform on which the tool-post is mounted - can be set at an angle to the work-piece to produce angular features.**
- **Cross-slide Platform that moves perpendicular to the lathe axis under control of the cross-slide hand-wheel or feed**
- **Drive Dog - An "L"-shaped adaptor, usually made of cast iron, with a hole for the work-piece and locking bolt in the short end. Used to clamp a work-piece and apply rotational force to it while the work-piece is mounted between centers along with a drive-plate. The dog engages with a pin on the drive-plate to apply the force to the work-piece.**

Glossary of Terms Cont'd

- **Face-Plate - A metal plate with a flat face that is mounted on the lathe to hole irregular shaped work.**
- **Facing -A lathe operation in which metal is removed from the end of a work-piece to create a smooth perpendicular surface, or face.**
- **Feed – A drive mechanism which automatically move the saddle along the workpiece and the top-slide across the workpiece. The feed is engaged by the feed handle on the apron which engages the feed shaft.**
- **Gibb - A length of steel or brass with a diamond-shaped cross-section that engages with one side of dovetail and can be adjusted by means of screws to take up any slack in the dovetail slide. Used to adjust the dovetail for optimum tightness and to compensate for wear.**
- **Half-nut - A nut formed from two halves which clamp around the lead-screw under control of the half-nut lever to move the carriage under power driven from the lead-screw. Mainly used for screw-cutting operations.**
- **Headstock -The main casting mounted on the left end of the bed, in which the spindle is mounted. Houses the spindle speed change gears.**

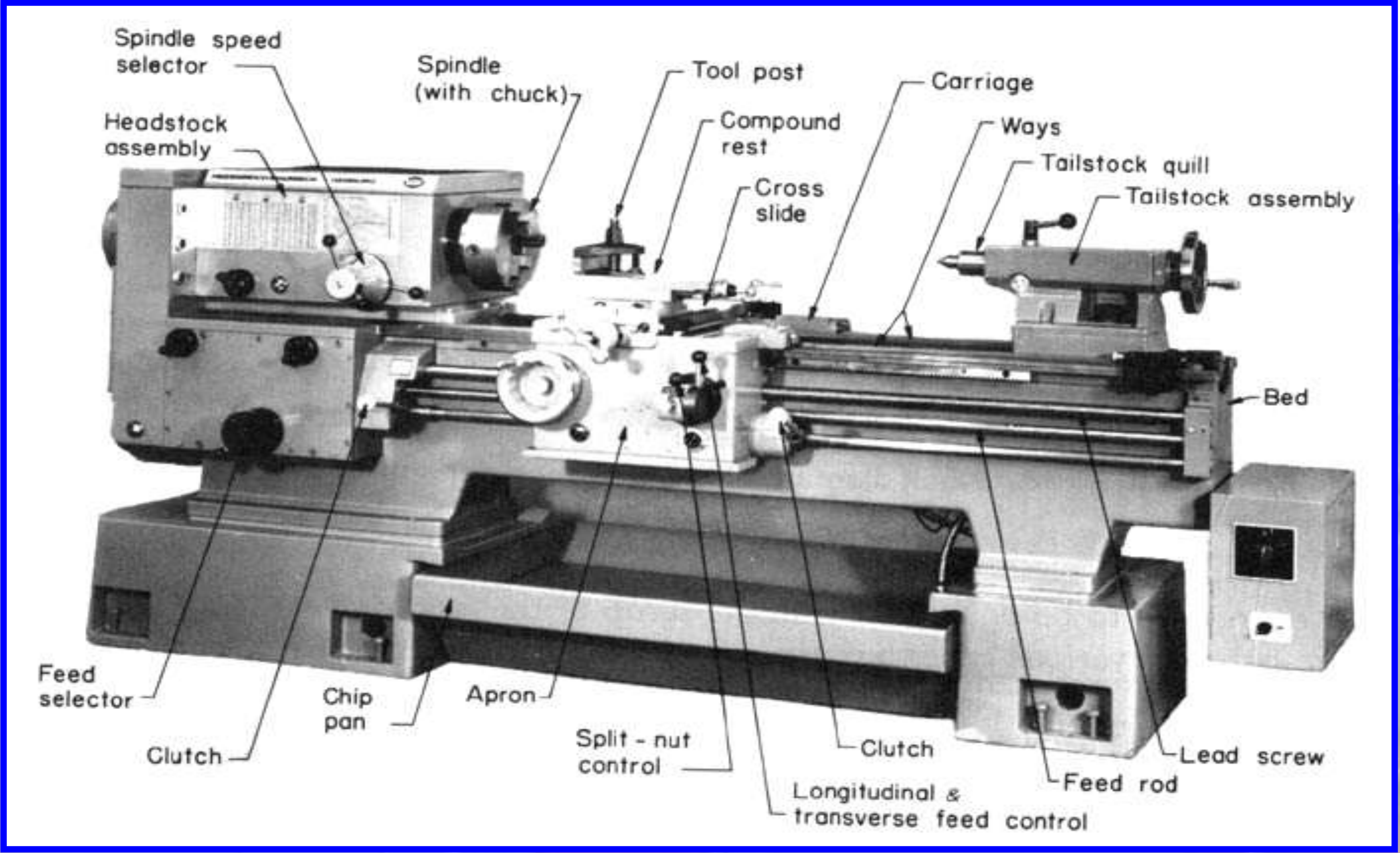
Glossary of Terms Cont’d

- **Lead-Screw - Precision screw that runs the length of the bed. Used to drive the carriage under power for turning and thread cutting operations. Smaller lead-screws are used within the cross-slide and compound to move those parts by precise amounts.**
- **Morse Taper - A taper of specific dimensions used to mate matching male and female parts such that they lock together tightly and concentrically. Tapers are of various sizes such as #1, #2, #3, etc. with larger numbers representing larger sizes.**
- **Saddle - A casting, shaped like an "H" when viewed from above, which rides along the ways. Along with the apron, it is one of the two main components that make up the carriage.**
- **Spindle - Main rotating shaft on which the chuck or other work holding device is mounted. It is mounted in precision bearings and passes through the headstock.**
- **Spindle Clutch Lever - This lever controls the spindle’s rotation and direction.**
- **Swing - A dimension representing the largest diameter workpiece that a lathe can rotate. A 200mm max swing, meaning that the maximum size workpiece that can rotate without hitting the bed is 200mm in diameter.**
- **Tailstock - Cast iron assembly that can slide along the ways and be locked in place. Used to hold long work in place or to mount a drill chuck for drilling into the end of the work.**

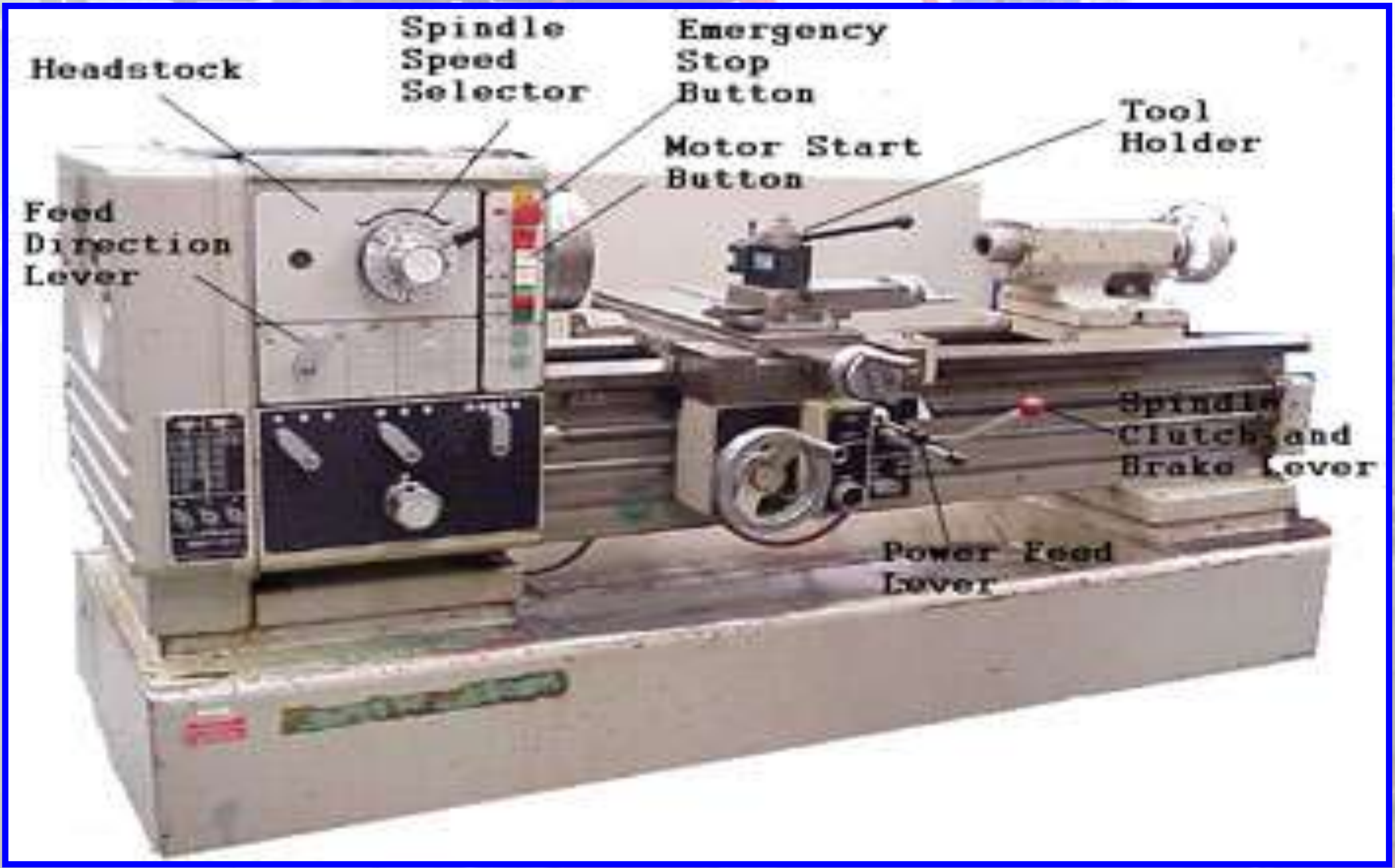
Glossary of Terms Cont'd

- **Tailstock Handwheel - A wheel with a handle used to move the tailstock ram in and out of the tailstock casting.**
- **Tailstock Ram - A piston-type shaft that can be moved in and out of the tailstock by turning the tailstock hand-wheel. Has a tapered internal bore to accept a standard Morse Taper shank**
- **Tool - A cutting tool used to remove metal from a workpiece; usually made of High Speed Steel or carbide.**
- **Tool Blank - A piece of High Speed Steel from which a cutting tool is ground on a bench grinder. Typically 5/16" square by 2 1/2" long for mini-lathe use.**
- **Tool Post - A holding device mounted on the compound into which the cutting tool is clamped**
- **Turning - A lathe operation in which metal is removed from the outside diameter of the workpiece, thus reducing its diameter to a desired size.**
- **Ways - Precision ground surfaces along the top of the bed on which the saddle rides. The ways are precisely aligned with the centerline of the lathe.**

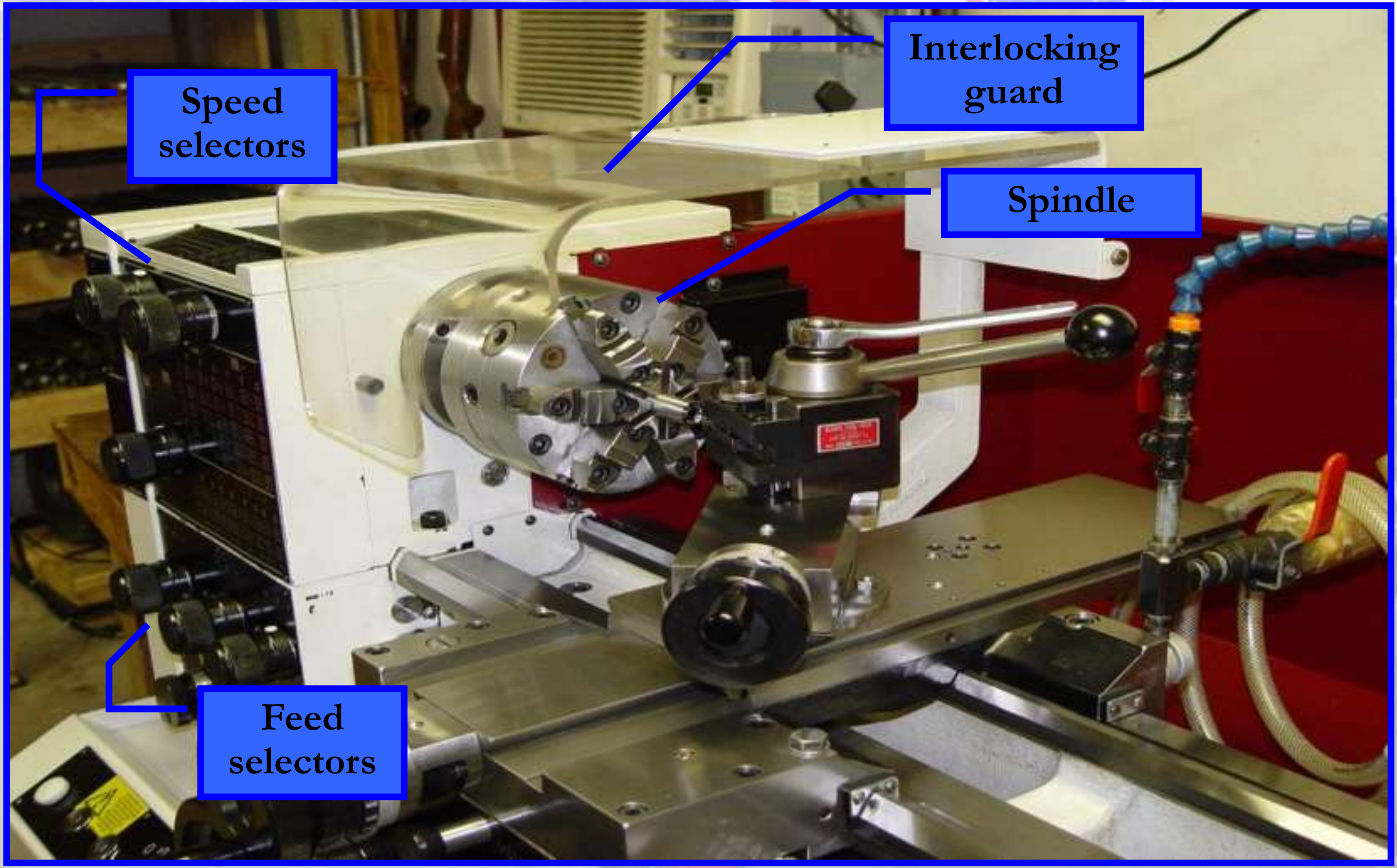
Basic Overview



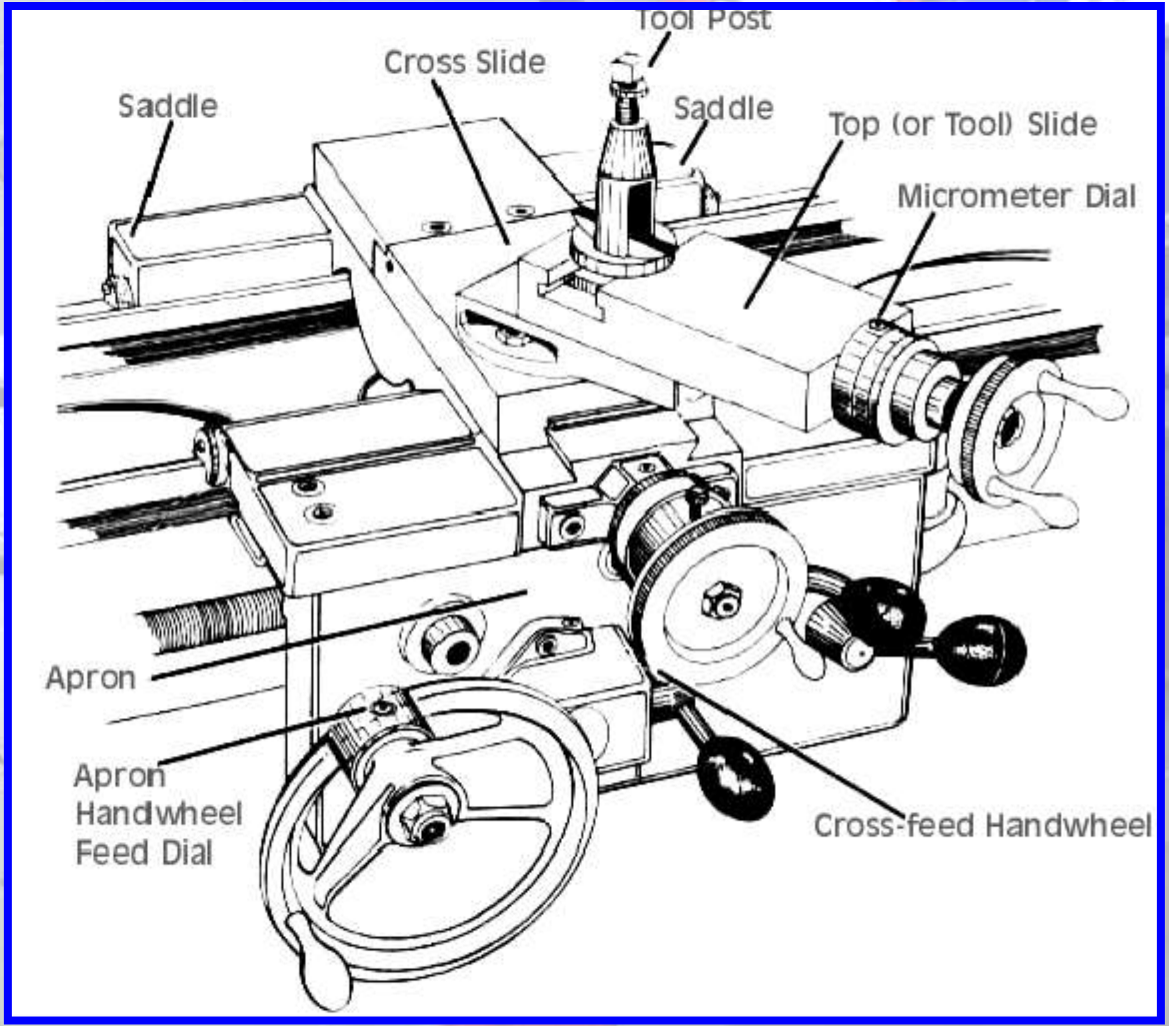
Basic Overview



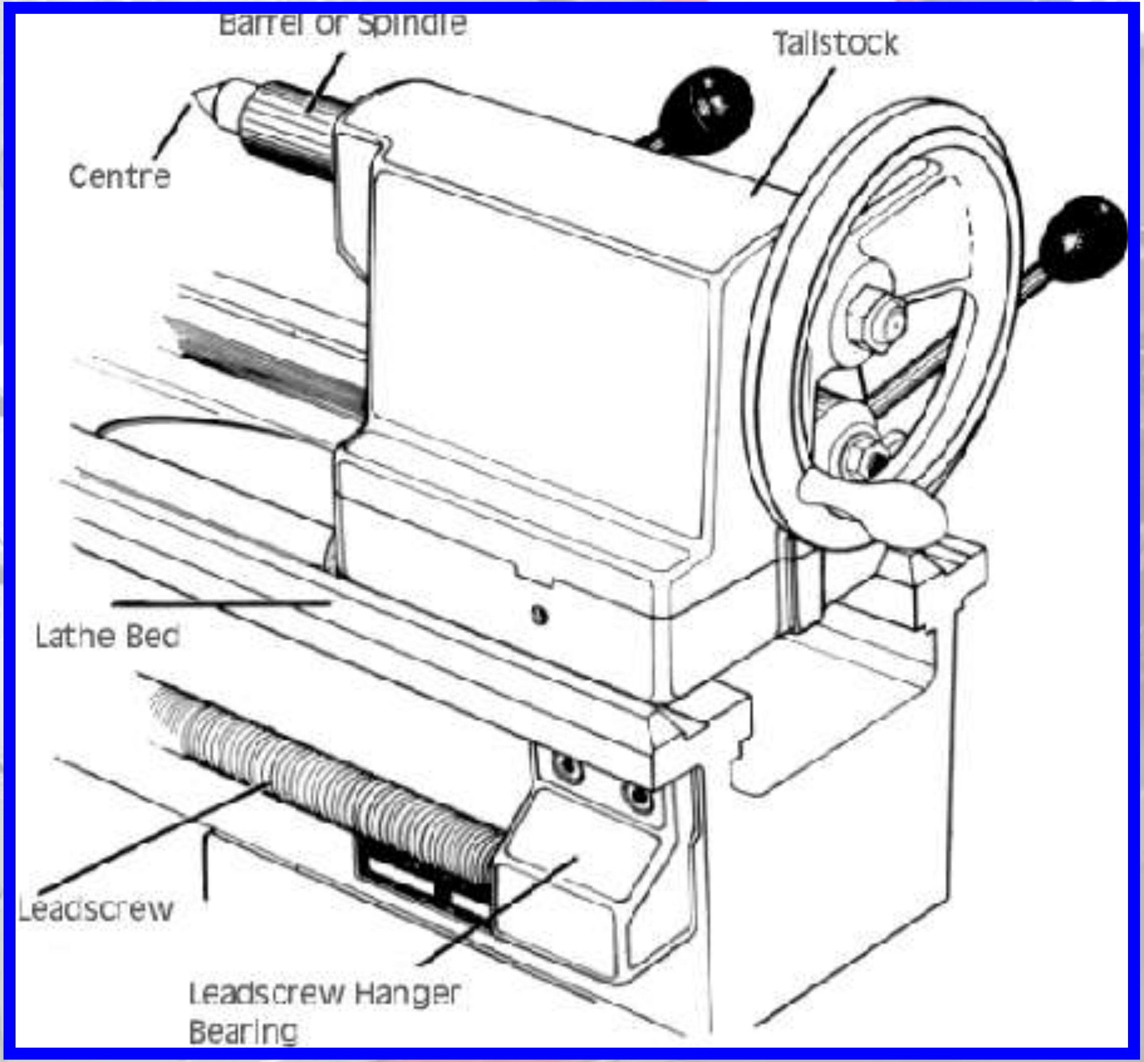
Headstock


Speed selectors
Interlocking guard
Spindle
Feed selectors

Apron Assembly

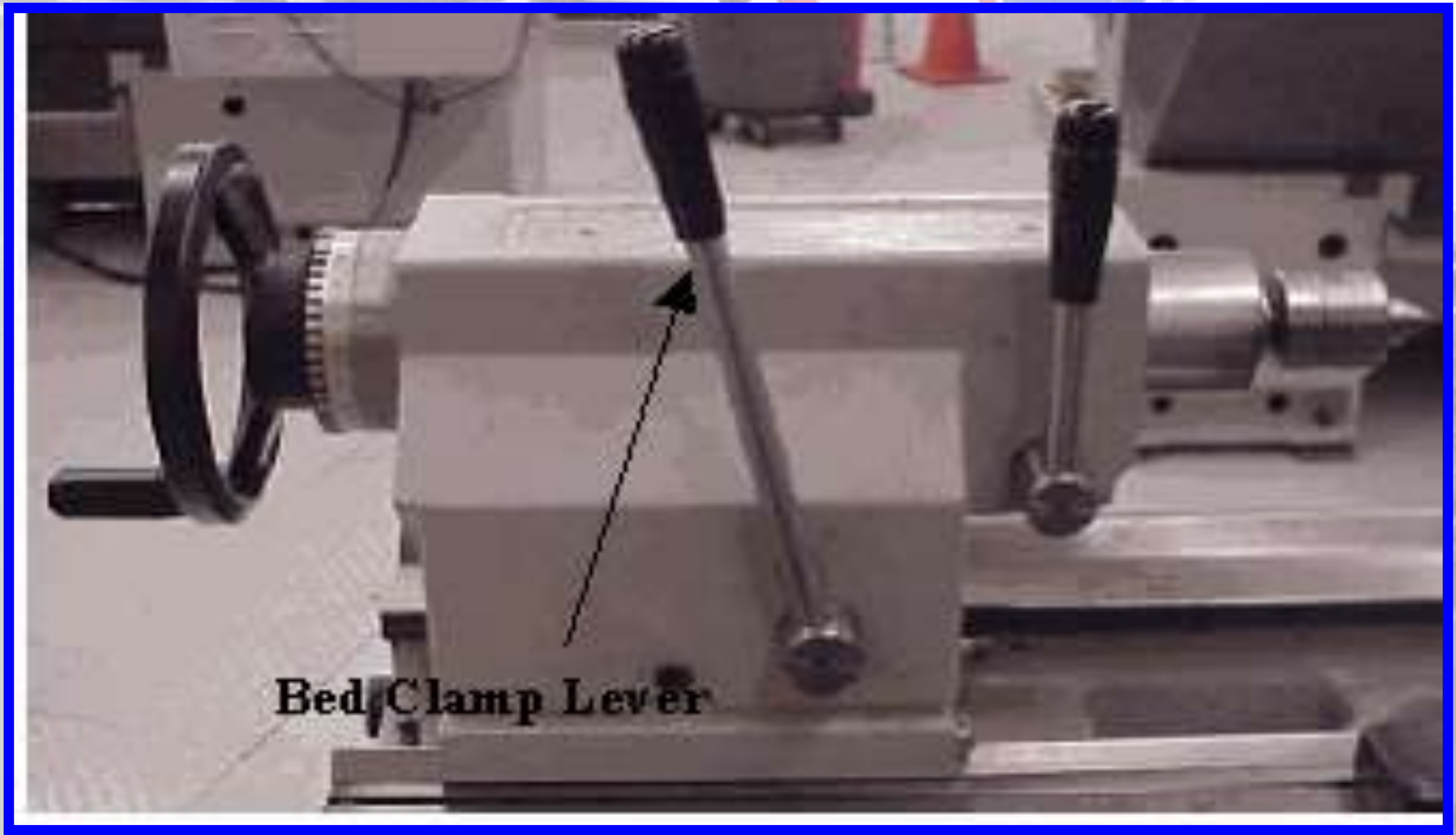


Tailstock



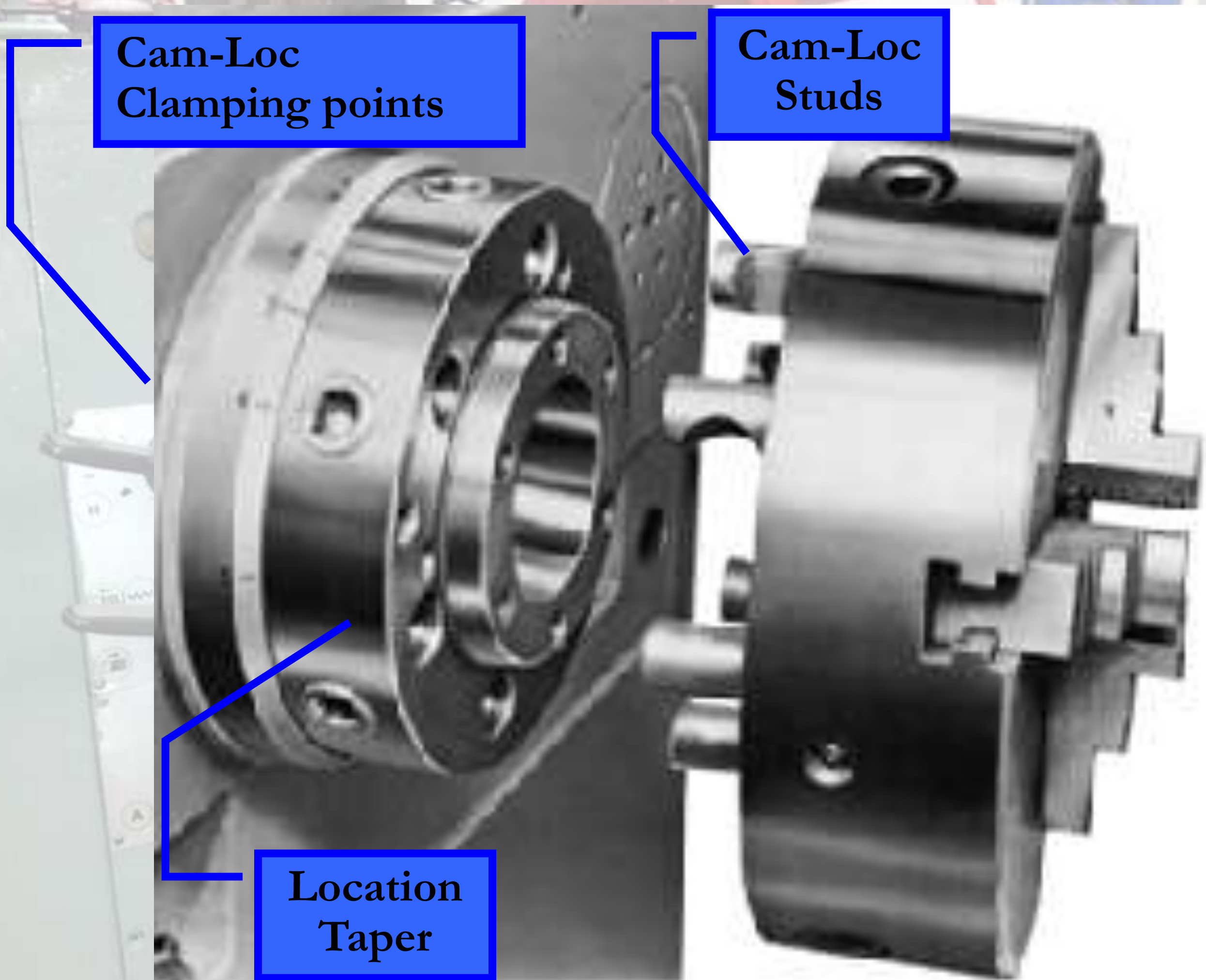
Barrel or Spindle
Tailstock
Centre
Lathe Bed
Leadscrew
Leadscrew Hanger
Bearing

Tailstock



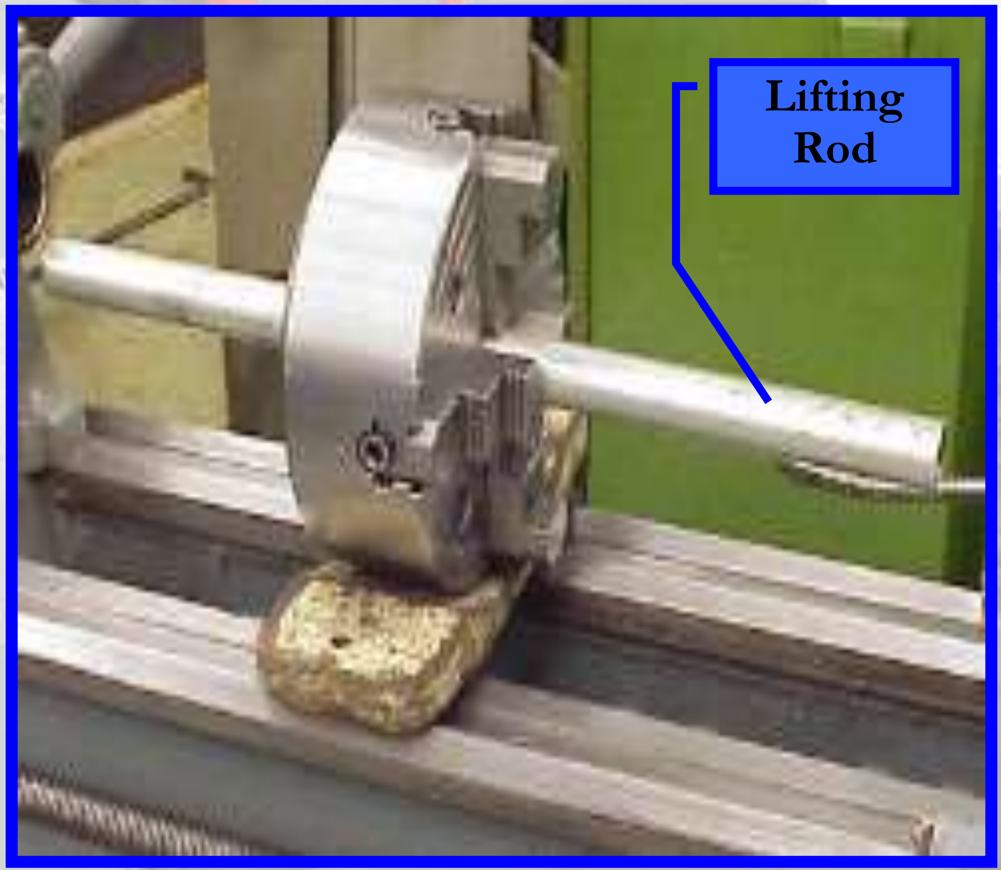
The bed clamp and spindle clamp levers on the tailstock

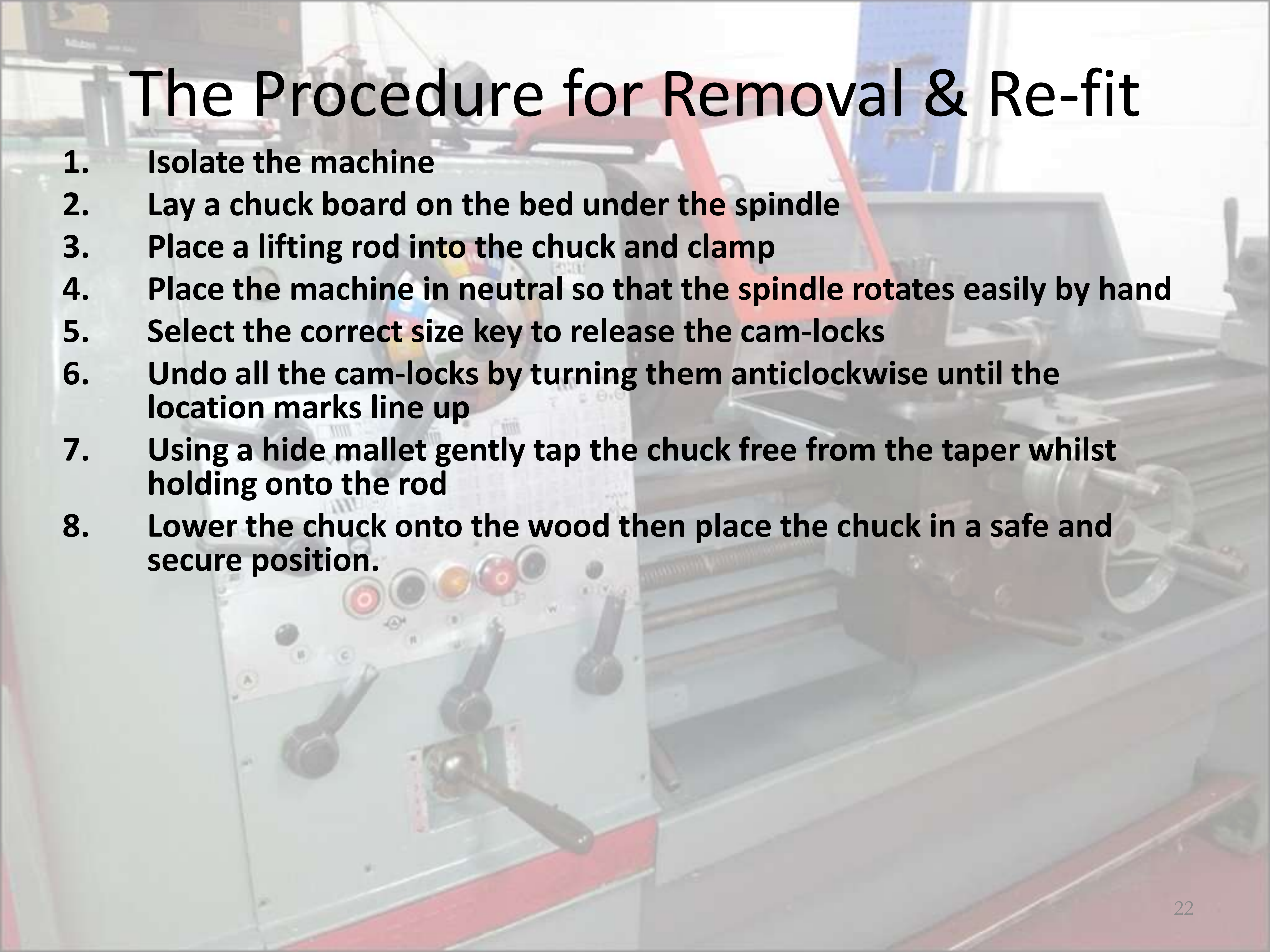
The Chuck



Above Shows how the chuck fits on to the headstock via the cam-loc studs. The chuck is then located precisely onto the nose taper

The Chuck Removal & Re-fit





The Procedure for Removal & Re-fit

1. **Isolate the machine**
2. **Lay a chuck board on the bed under the spindle**
3. **Place a lifting rod into the chuck and clamp**
4. **Place the machine in neutral so that the spindle rotates easily by hand**
5. **Select the correct size key to release the cam-locks**
6. **Undo all the cam-locks by turning them anticlockwise until the location marks line up**
7. **Using a hide mallet gently tap the chuck free from the taper whilst holding onto the rod**
8. **Lower the chuck onto the wood then place the chuck in a safe and secure position.**

9. **Clean the spindle nose - removing any swarf or debris**
10. **Select the - Chuck , Collet, Faceplate, Drive plate required for the task**
11. **Place a lifting rod into the chuck and tighten**
12. **Lift the chuck onto the chuck board using the rod**
13. **Clean the location faces & taper ensuring they are free from swarf & debris**
14. **Place the rod down the spindle and lever the chuck into position ensuring the alignment marks on the chuck and the spindle meet**
15. **Evenly tighten the cam-locks by turning clockwise- when fully tightened the marks must be positioned between the vee's**
16. **Remove the chuck board & lifting rod and store safely**

Changing the Chuck Jaws

The jaws and the chuck jaw slots are numbered 1,2, and 3. The jaws must be inserted into the slots having the corresponding number.

DO NOT INTERCHANGE JAWS FROM ONE CHUCK SLOT TO ANOTHER.

Turn the scroll until the scroll thread start on the outside edge of the scroll plate does not quite enter jaw slot Number 1 (Figure 2).

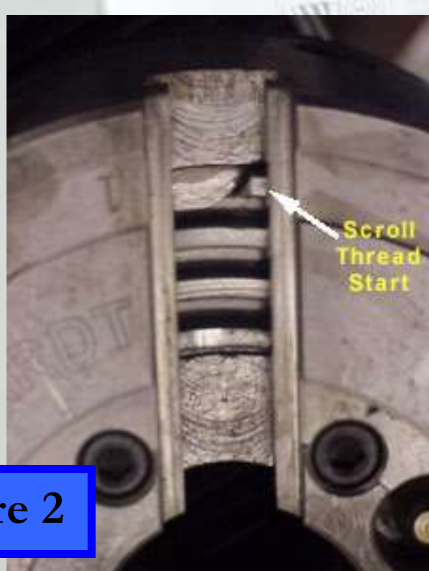


Figure 2

Enter jaw number 1 in the slot numbered 1 when the scroll thread start is in this position.

Changing the Chuck Jaws Cont'd

Enter Jaw Number 1 in slot number 1 (Figure 3). Turn the scroll until the scroll thread start on the outside edge of the scroll plate does not quite enter Jaw Slot Number 2. Enter Jaw Number 2 in Slot Number 2. Turn the scroll until the scroll thread start on the outside edge of the scroll plate does not quite enter Jaw Slot Number 3. Enter Jaw Number 3 in Slot Number 3.

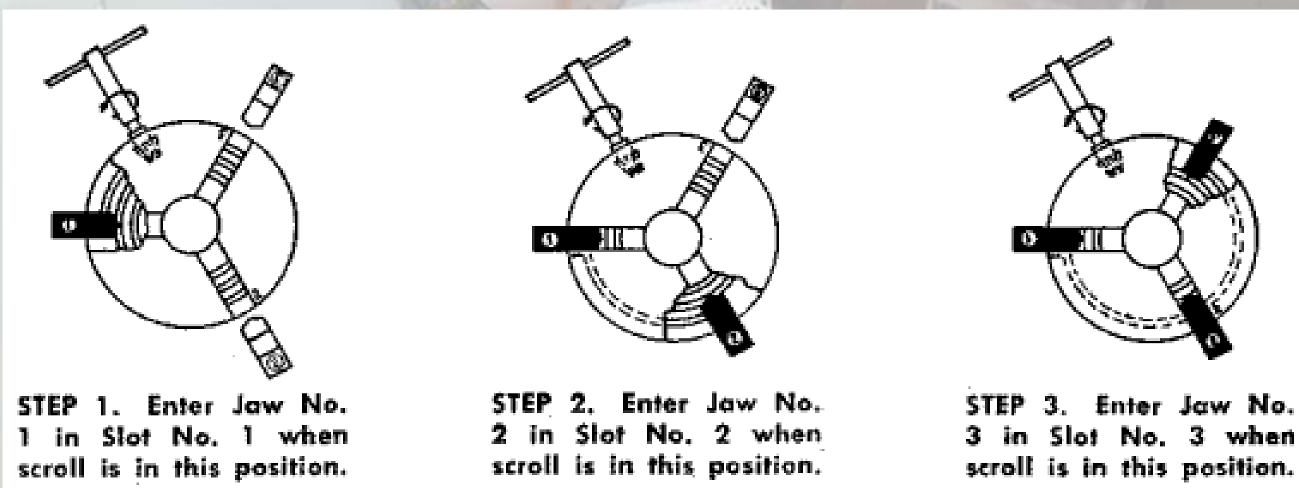


Figure 3

The chuck jaws must slide into the chuck easily. NEVER use force. If the jaw must be forced, it is because it is either misaligned or dirt and chips are lodged in the jaw or scroll. Remove the chuck jaws and carefully clean the jaw and the scroll again.

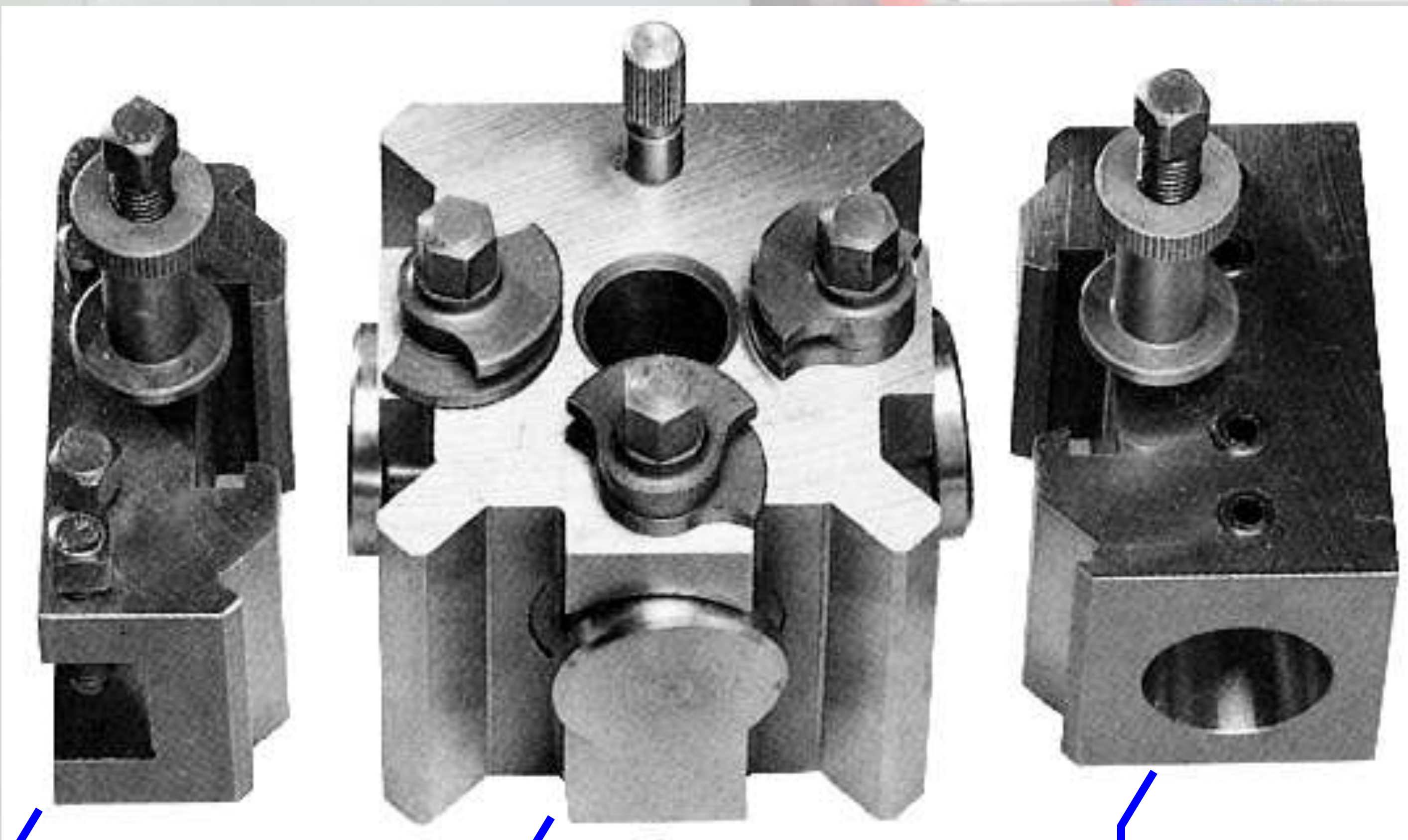
Cutting Tools

There are many high speed steel cutting tools used for turning operations. Most of the cutting tools used in industry employ some type of carbide as a base material. It is when we need odd or different shape cutting tools that you will see high speed steel single-point cutting tool being ground in industry. Regardless of the shape of the single-point cutting tool, it must have the correct relief and rake angles to cut correctly. The following slides deals mainly with the different shapes of high speed steel single-point cutting tools. The relief and rake angles are covered further in the presentation. Some typical shapes of single-point cutting tools are shown in the up-coming figures. Study their shapes and uses.

When using the Quick Change Tool Post Its recommended that several turning tools are set-up ready. The selected tools may include

- Rough turning/facing
- Finishing turning tool
- Chamfer tool
- Parting off tool

Quick Change Tool-Post



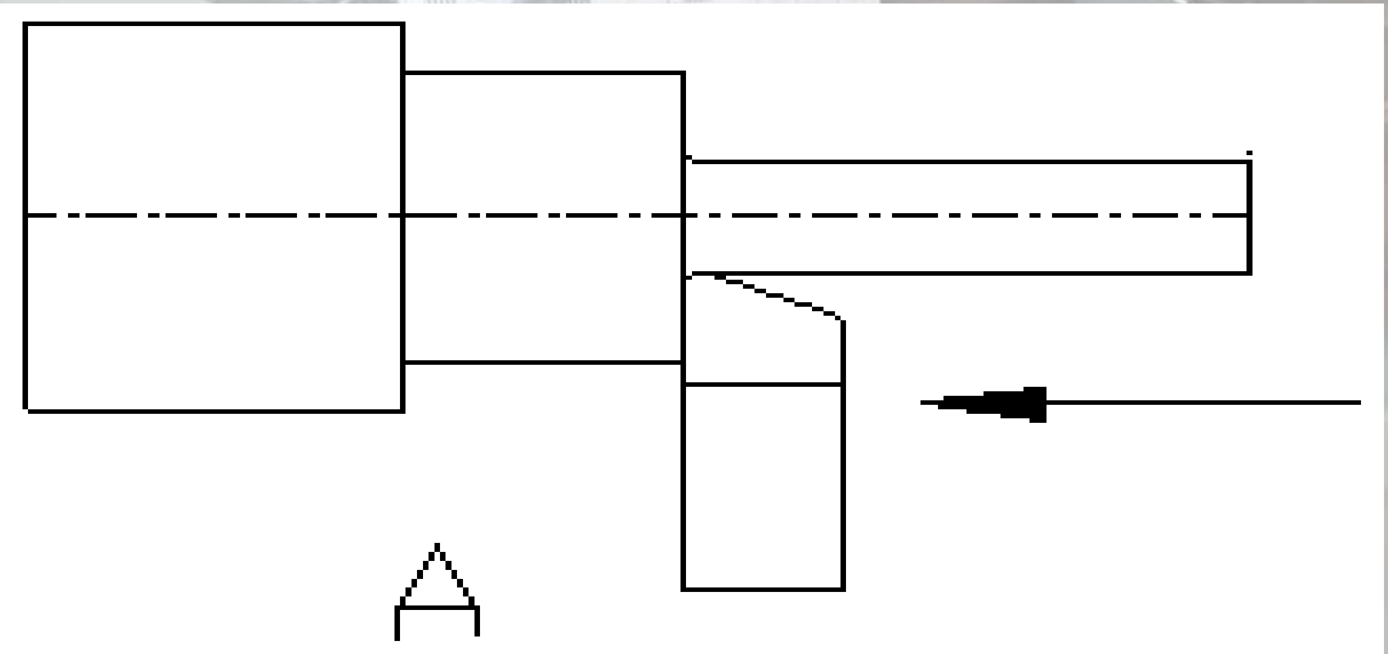
Standard Tool Holder

QC Post

Boring Tool Holder

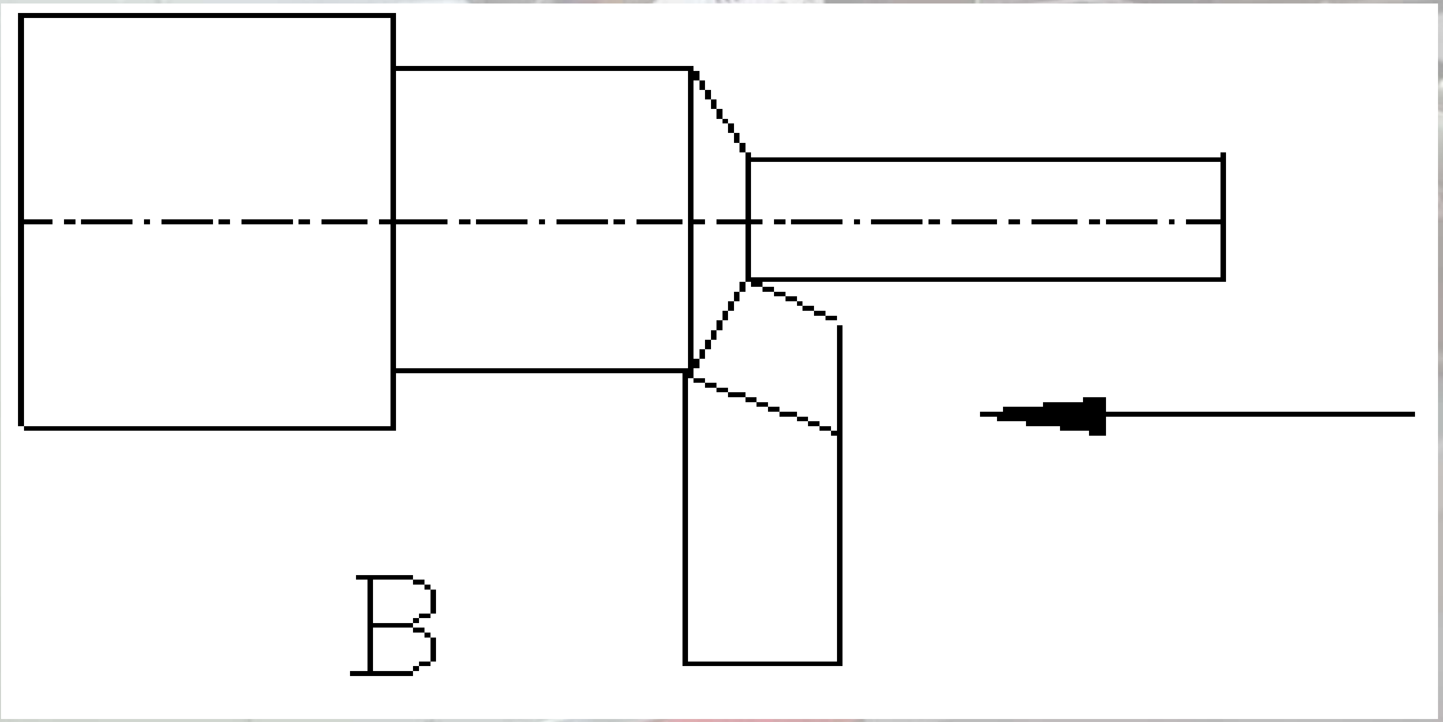
Cutting Tools

The tool in Figure A is used to turn to a semi-square shoulder.
This tool, because of the square side cutting edge angle, directs the cutting force straight back, opposite the cutting direction. It can be used for roughing if there is sufficient material behind the cutting edge.



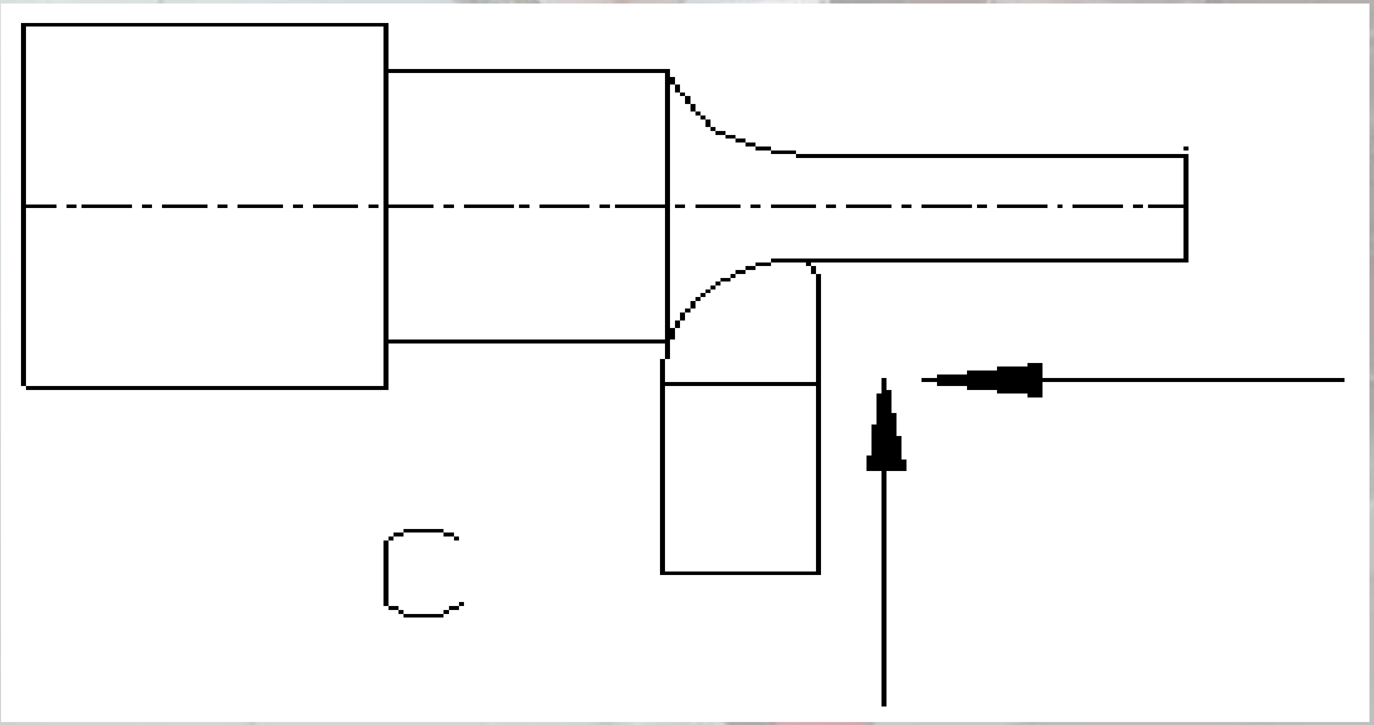
Cutting Tools

The tool in Figure B is a standard turning tool with a lead angle. The lead angle allows for heavy roughing cuts. You can also turn the tool to accomplish a semi-square shoulder.



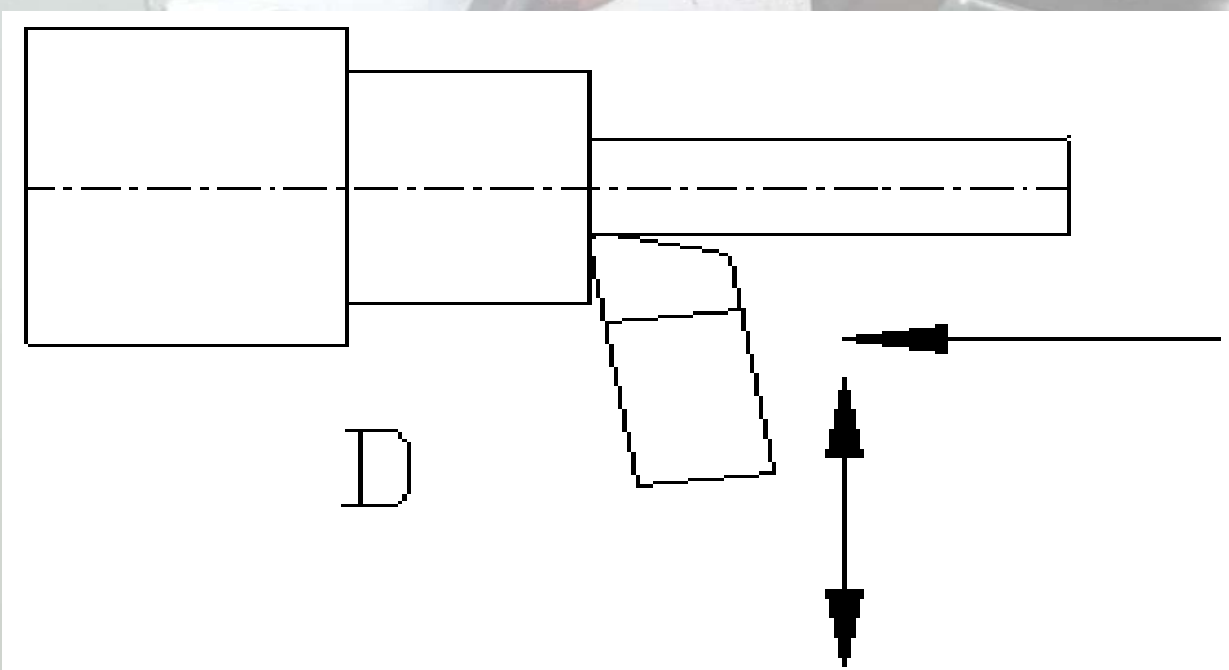
Cutting Tools

The turning tool in Figure C has a very large nose radius. The large nose radius will allow for fine finishes on either light or heavy cuts. This tool can also be used with varying radii to form a corner radius.



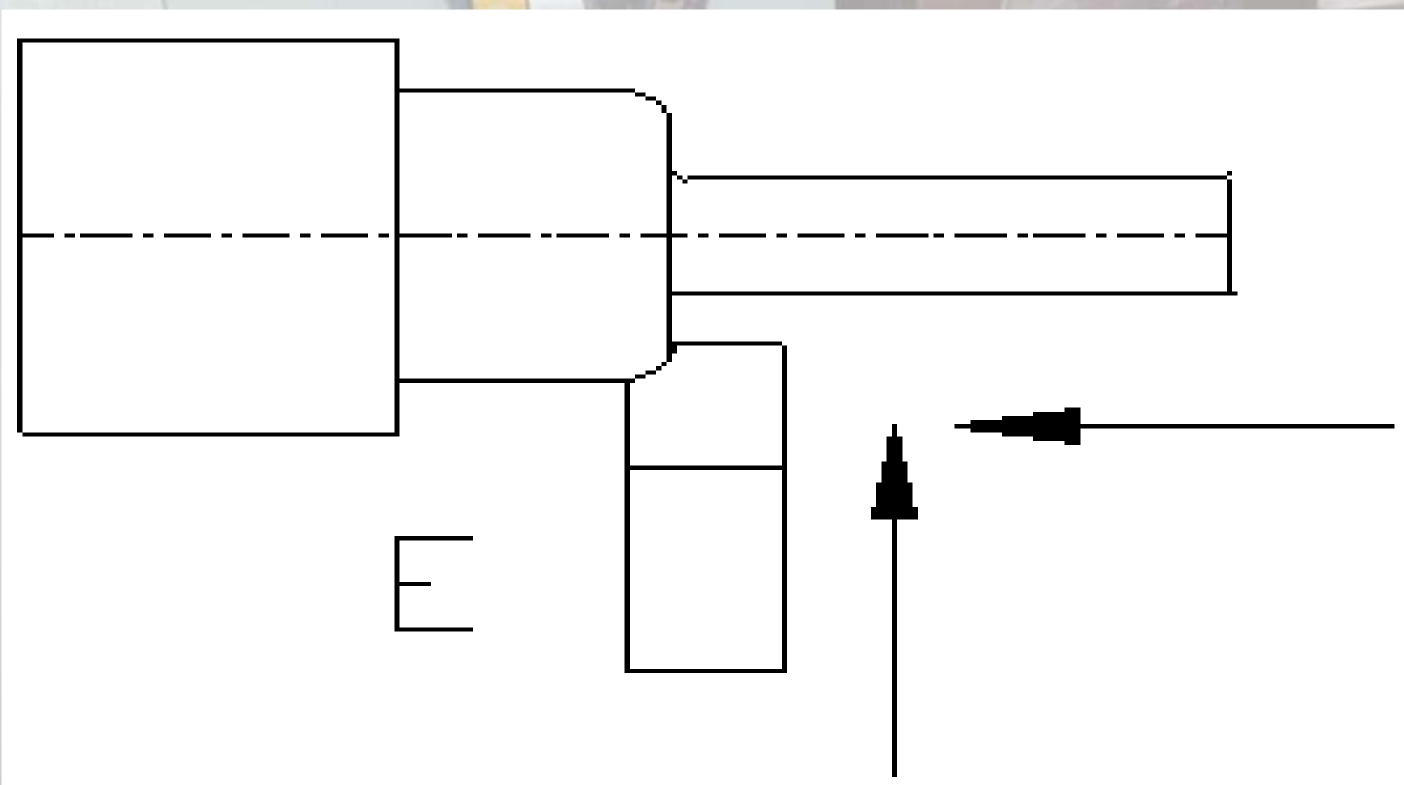
Cutting Tools

The tool at Figure D has the nose leading the side cutting edge. In this position, the tool is set to take light finishing cuts on the diameter and the face of the shoulder.



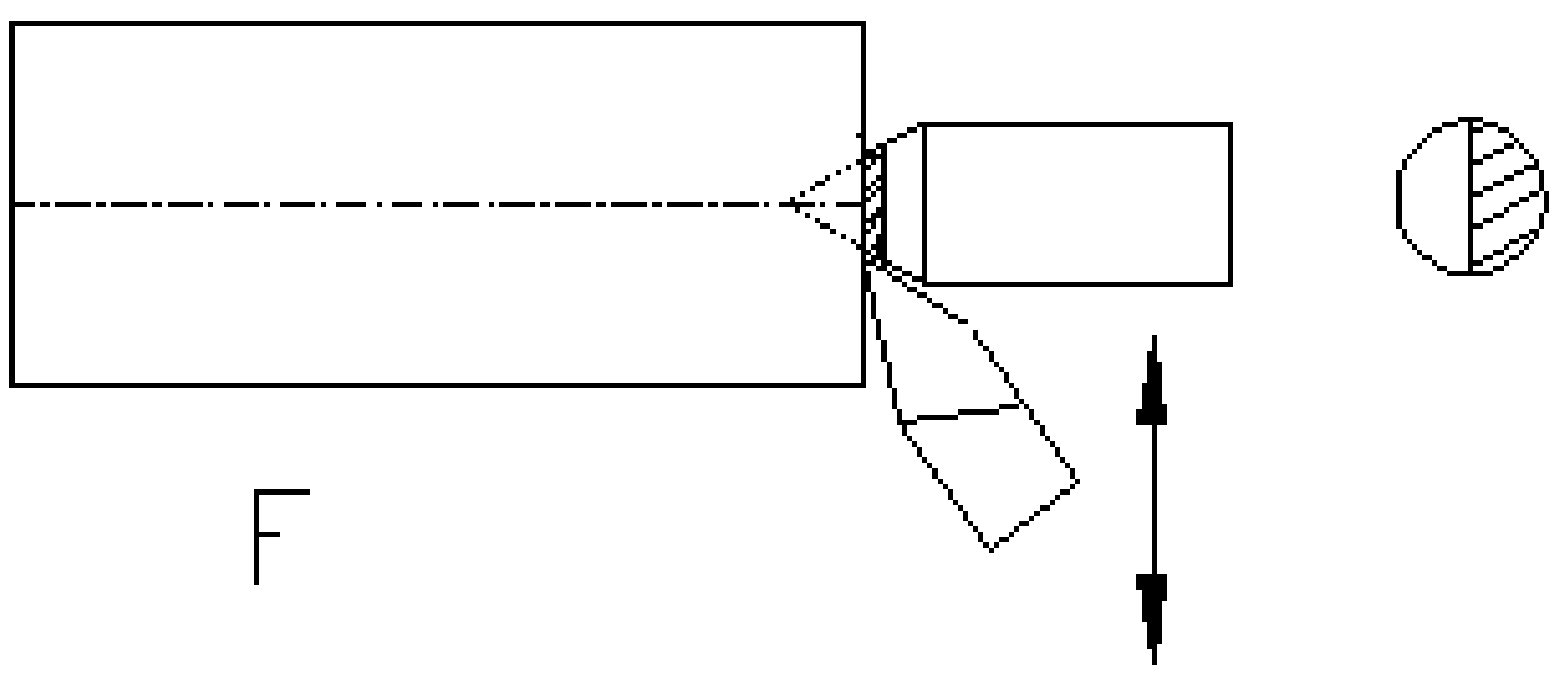
Cutting Tools

The tool in Figure E is a form tool. The form that is ground into the tool is reproduced on the part.



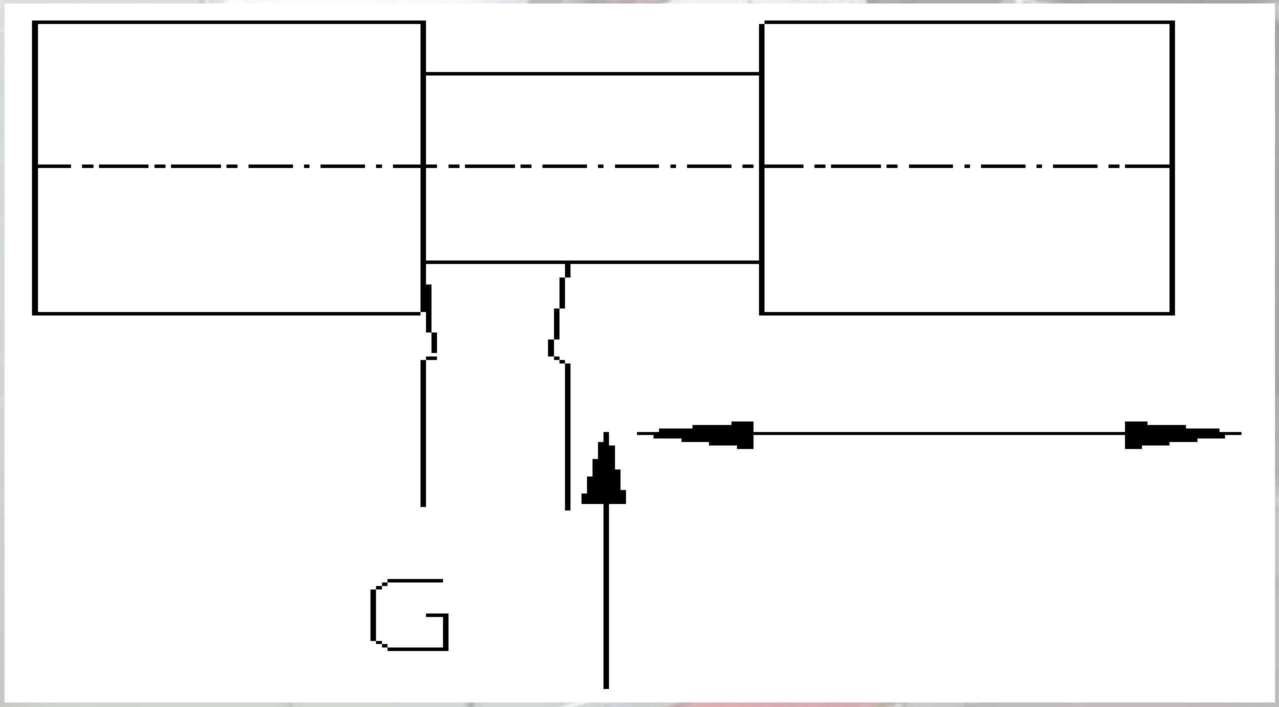
Cutting Tools

The tool at Figure F is a facing tool. The tool can be used to face the end of the workpiece held by a half-center. A half center is a solid tailstock center that has half of the tip ground away for tool clearance.



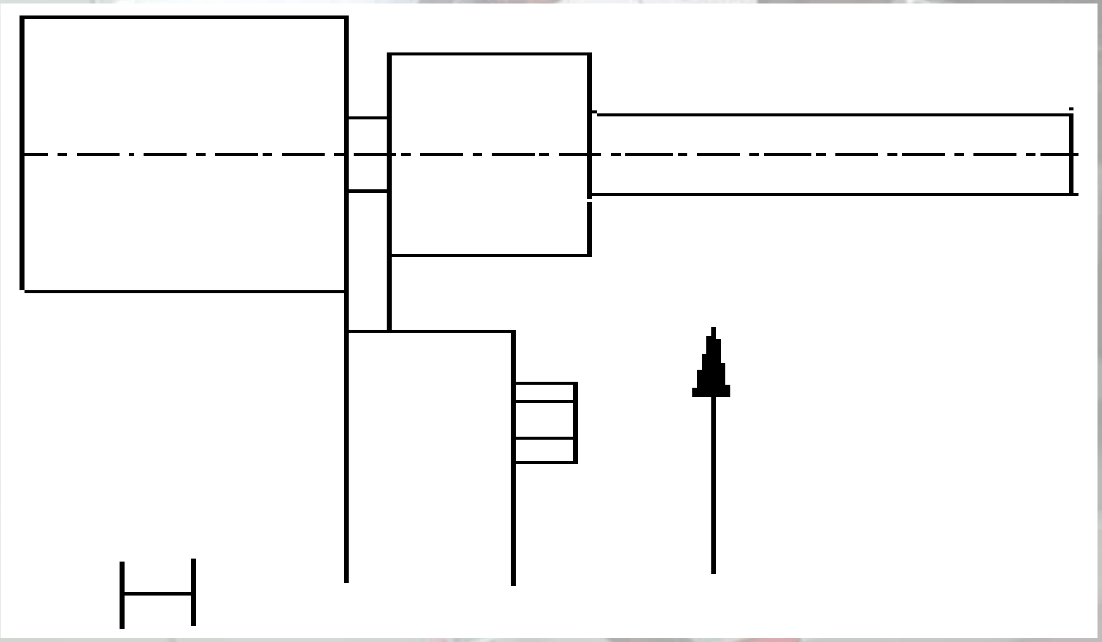
Cutting Tools

The tool in Figure G is called an under-cutting or grooving tool. It is used to cut grooves as shown in the figure. With the proper clearances, the tool can plunge, or cut to left or to the right.



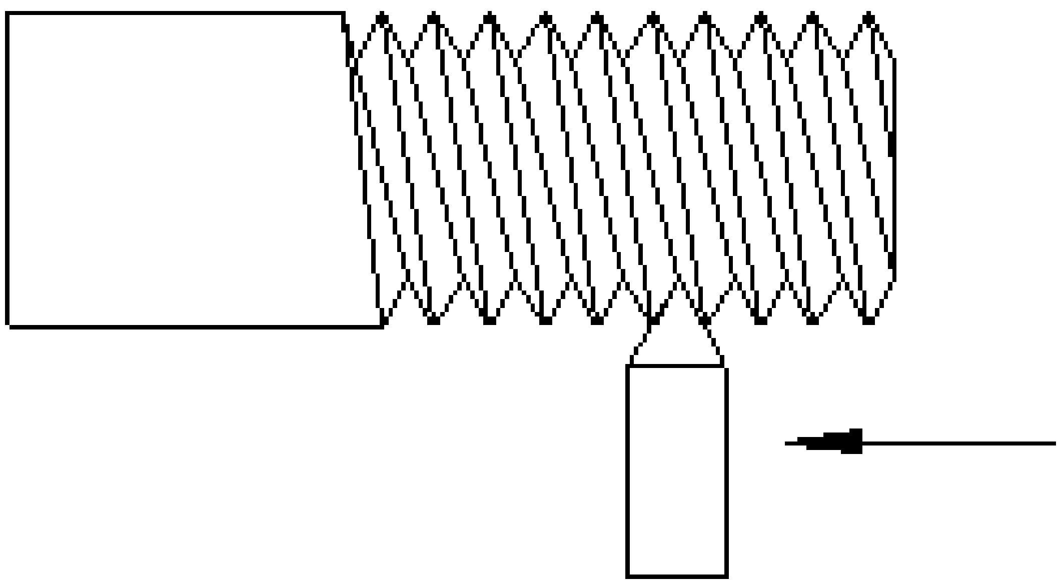
Cutting Tools

The tool in Figure H is a cut-off or parting tool. This tool is used to cut off stock to finished length while the part is being held in a chuck. This parting tool employs a preformed blade and holder.



Cutting Tools

The tool in Figure I is a 60-degree threading tool. The threading tool is another type of form tool.



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Speeds & Feeds
Feed Rate Calculations

There are three main factors that make up cutting conditions

- **Spindle Speed**

The rate in RPM that the spindle rotates

- **Feed Rate**

The rate IPM/MPM the rate that the tool advances per revolution

- **Depth of Cut**

Known as "Chip Load" the size of the chip that the tool can withstand

Speeds & Feeds Cont'd

We will concentrate on feed rate factors as they affect single point lathe tooling. The feed rate table for turning is given in terms of inches per revolution (IPR). Inches per revolution or (MPR) Meters per revolution is the rate at which the tool will advance for every revolution of the workpiece (Figure 1). The feed rate is determined by the size of the chip that the tool can withstand. The feed rate in inches per tooth is also known as chip load. Because turning tools have only one cutting edge, the chip load or feed rate per revolution is the feed rate setting of the quick-change gearbox on the lathe (Figure 2).

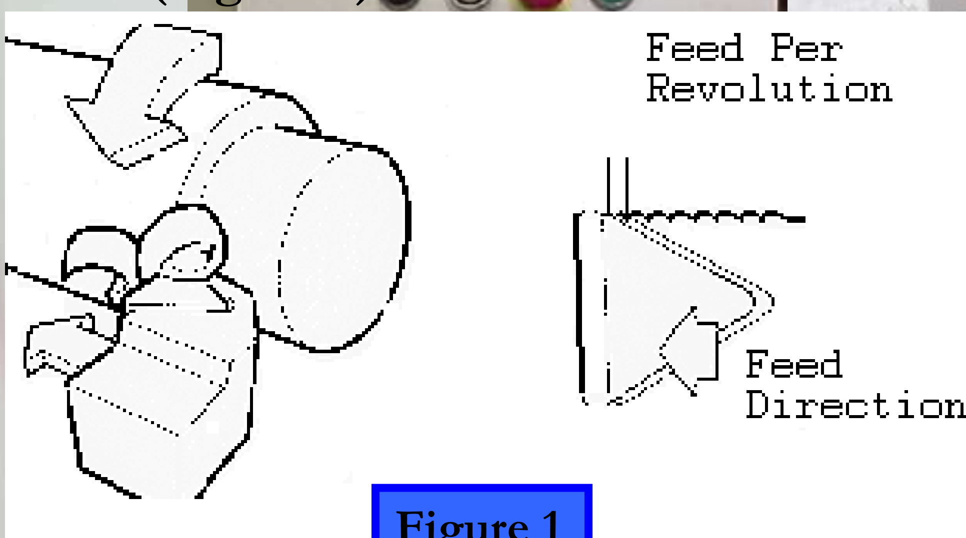

Figure 1

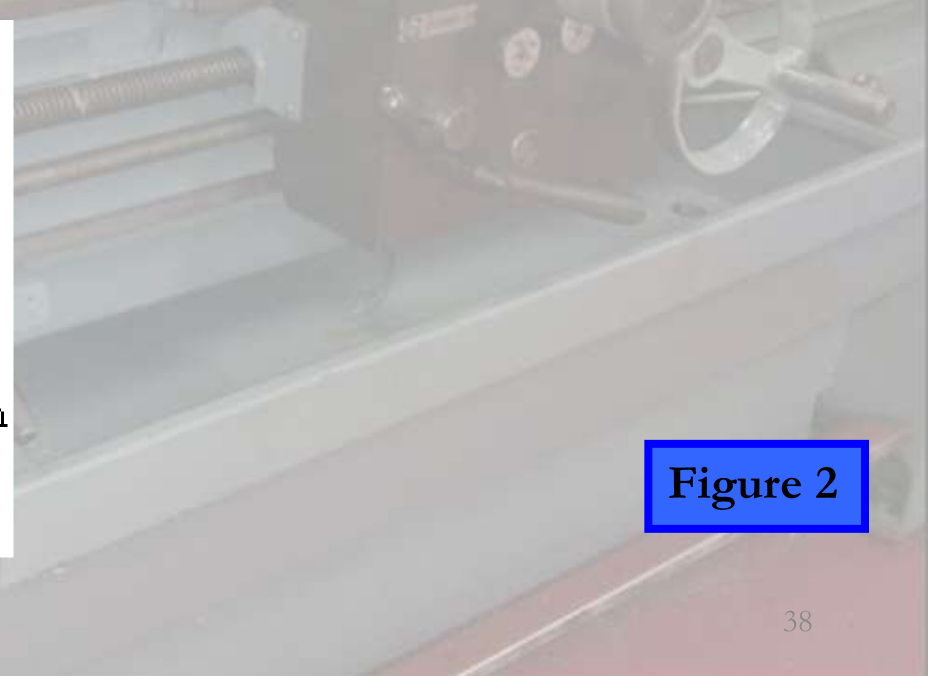

Figure 2

Speeds & Feeds Cont'd

The feed mechanisms move the tool along the ways of the lathe automatically. Through the use of gear settings we can control the rate of the feed. Lathe feed settings are generally configured in two ways: levers and quick change gear boxes Figure 2

The feed selection type in Figure 2 uses a series of three or four levers to obtain a particular feed selection. The operator looks at a chart on the lathe for a particular feed setting Figure 3. The chart tells the operator which levers need to be positioned for the individual feed setting.

To obtain the feed setting of 0.01 per revolution shown in Figure 3 the operator would need to set the levers to an LCR6 setting pattern. On the quick change gear box shown in Figure 2, the operator would slide the gear lever into the position shown on the feed chart positioned above the feed levers.

On all lathes, no matter what configuration, there is a feed direction lever or feed change knob. Figure 4. The feed direction lever reverses the lead screw or feed rod to obtain a change in the direction of feed.

Speeds & Feeds Cont'd

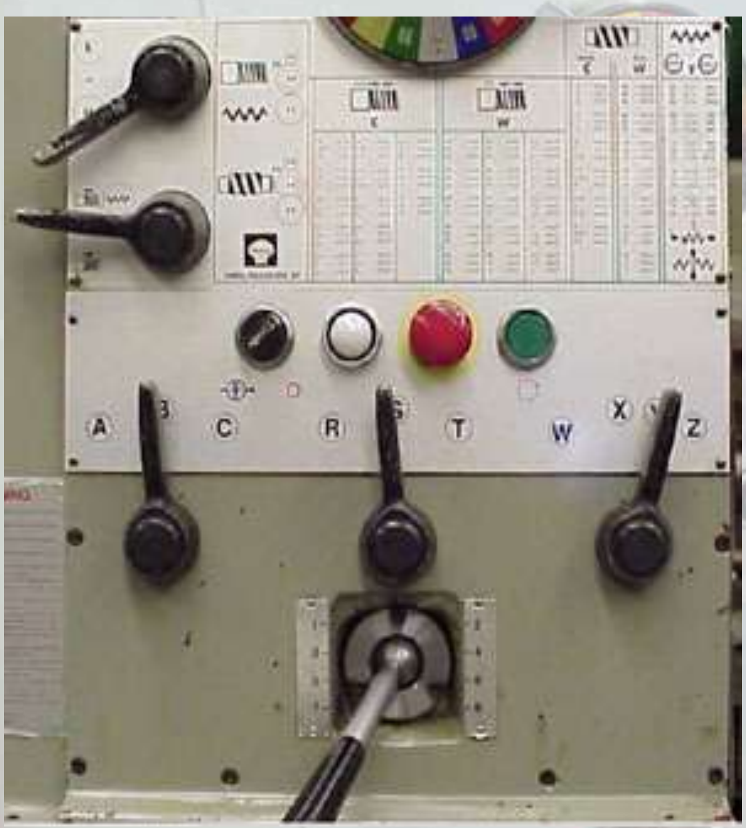

Figure 2

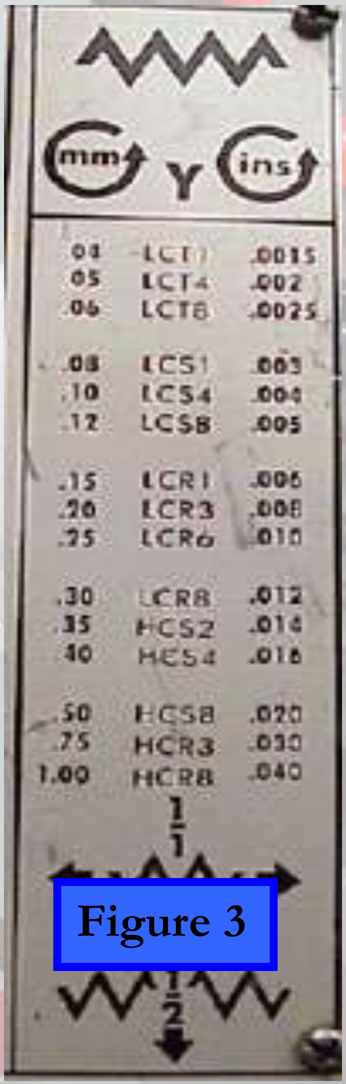

Figure 3

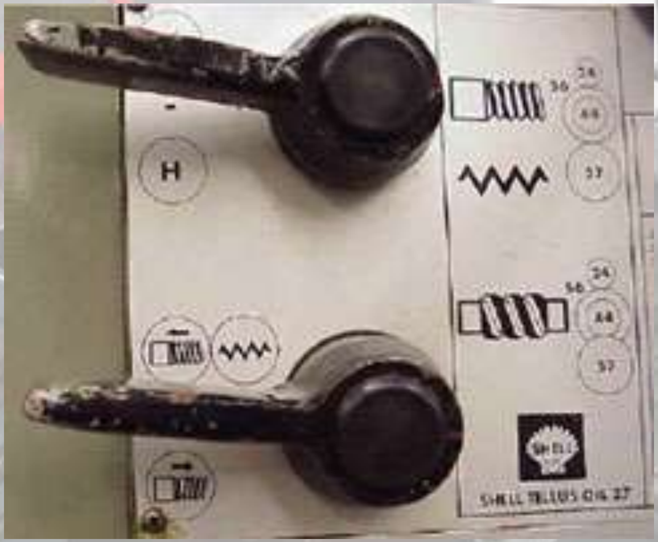

Figure 4

Speeds & Feeds Cont'd

Material	High-Speed Steel		Carbide	
	Roughing	Finishing	Roughing	Finishing
Low Carbon Steel	0.010 to 0.020	0.002 to 0.008	0.008 to 0.035	0.006 to 0.010
Med. Carbon Steel	0.008 to 0.018	0.002 to 0.008	0.008 to 0.030	0.006 to 0.010
High Carbon Steel	0.008 to 0.015	0.002 to 0.008	0.008 to 0.030	0.006 to 0.010
Cast Iron	0.010 to 0.025	0.003 to 0.010	0.010 to 0.040	0.008 to 0.012
Bronze	0.015 to 0.025	0.003 to 0.010	0.010 to 0.040	0.008 to 0.012
Aluminum	0.015 to 0.030	0.003 to 0.012	0.015 to 0.045	0.008 to 0.012

Figure 5

Recommended Feed Rate Selection in Inches Per Revolution for Turning

Speeds & Feeds Cont'd

While the recommended feed rates found in Figure 5 represent good fundamental machining practice, but they are only recommended values. Deviations from these values may be necessary due to certain circumstances, such as long, small diameter workpieces. The feed rate used on small diameter workpieces may need to be reduced. The work-holding technique has a great deal to do with the feed rate selection. Setups, which lack rigidity, may require a slower feed rate. The distance that the unsupported part sticks out of the chuck must be kept to a minimum to assure proper rigidity. The required workpiece finish will also affect the feed rate selection. Finer finish requirements on the part will require a slower feed rate selection. When using carbide-turning tools, the available horsepower and the rigidity of the spindle bearings will always influence the feed rate.

Speeds & Feeds
RPM Calculations

There are rules and principles of cutting speeds and R.P.M. calculations that apply to all metal cutting operations. The operating speed for all metal cutting operations is based on the cutting tool material and the hardness of the material to be cut

Cutting speed is the speed at the outside edge of the part as it is rotating. This is also known as surface speed. Surface speed, surface footage, and surface area are all directly related. Two wheels can illustrate this. Take two wheels, one wheel which is three feet in diameter and the other wheel which is one foot in diameter, roll each wheel one complete turn (Figure 1).

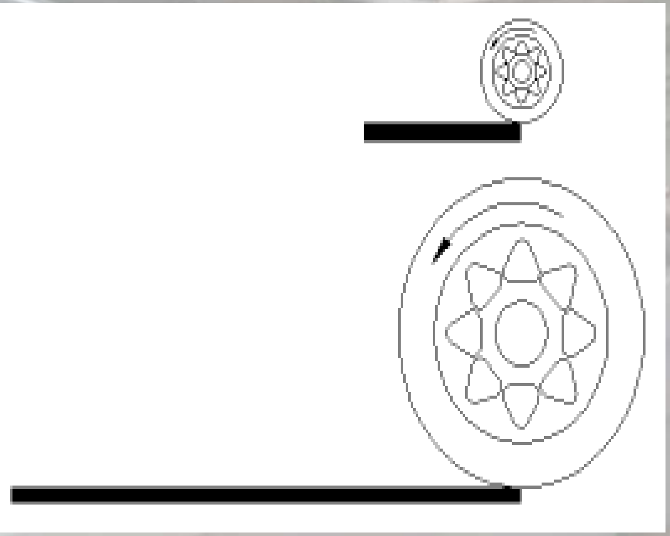

Figure 1

Speeds & Feeds

Which wheel traveled farther? The larger wheel traveled farther because it has a larger circumference and has more surface area. Cutting speeds work on the same principle. If two round pieces of different sizes are turning at the same revolutions per minute (RPM), the larger piece has a greater surface speed. Surface speed is measured in surface feet per minute (SFPM). All cutting speeds work on the surface footage principle. Again, cutting speeds depend primarily on the kind of material you are cutting and the kind of cutting tool you are using. The hardness of the work material has a great deal to do with the recommended cutting speed. The harder the work material, the slower the cutting speed. The softer the work material, the faster the recommended cutting speed (Figure 2).

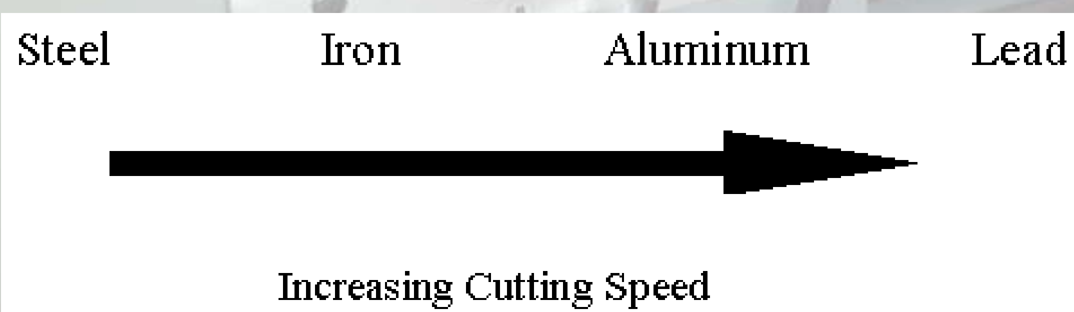

Figure 2

Speeds & Feeds

The hardness of the cutting tool material has a great deal to do with the recommended cutting speed. The harder the cutting tool material, the faster the cutting speed (figure 3). The softer the cutting tool material, the slower the recommended cutting speed.

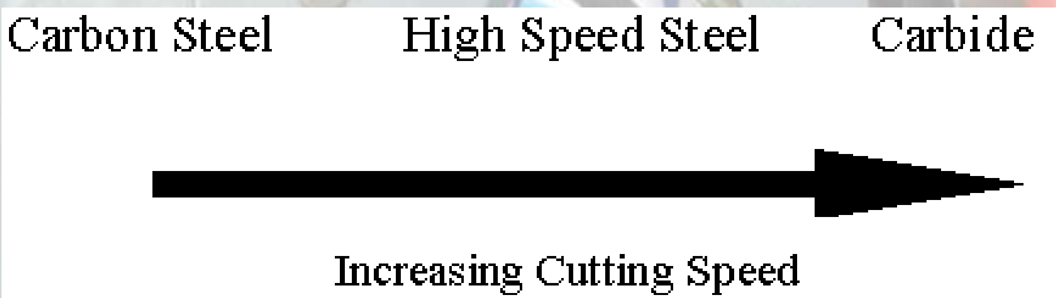

Figure 3

The depth of the cut and the feed rate will also affect the cutting speed, but not to as great an extent as the work hardness. These three factors, cutting speed, feed rate and depth of cut, are known as cutting conditions. Cutting conditions are determined by the machinability rating. Machinability is the comparing of materials on their ability to be machined. From machinability ratings we can derive recommended cutting speeds. Recommended cutting speeds are given in charts. These charts can be found in Machinery's Handbook, a textbook. In Table 4 you will find a typical recommended cutting speed chart.

Speeds & Feeds Cont'd

The dial type mechanism for speed changes uses a rotary motion to change the gears in the headstock. Dial types usually consist of an inner and outer ring. When the inner and outer rings are aligned in the proper configuration, the R.P.M. is set to a certain speed. The dial type speed selection in Figure 6 uses a color coding as the method of alignment for R.P.M. selection. Other dial type speed selections work similarly, but use a different method of alignment for R.P.M. selection. In Figure 6 you will notice the outside ring sets the high, medium and low range, while the inside ring sets the individual speed within that particular range.

Figure 6

Centre Drilling

- Lock the Jacobs chuck in the Tailstock.
- Select the appropriate size centre drill and secure it in the Jacobs chuck.
- “TIP” Ensure that at least 75% of the centre drill body is held in the chuck.
- Ensure that the spindle of the tailstock retracted and position the tip of the centre drill close to the job
- Set the spindle speed to around 600-800 Rpm depending on the material type and size.
- Advance the centre drill into the workpiece around ¾ of the way up the conical section. “TIP” Use a pecking method to centre drill.

Centre Drilling Cont'd

- Retract the spindle then retract the Tailstock.
- Stop the spindle.

Planning a Project