MACHINE TOOLS

Machine Tool

A machine tool may be defined as a power driven machine which accomplishes cutting or machining operations in it.

Examples: Lathe,

Drilling machine,

Milling machine,

Grinding machine.

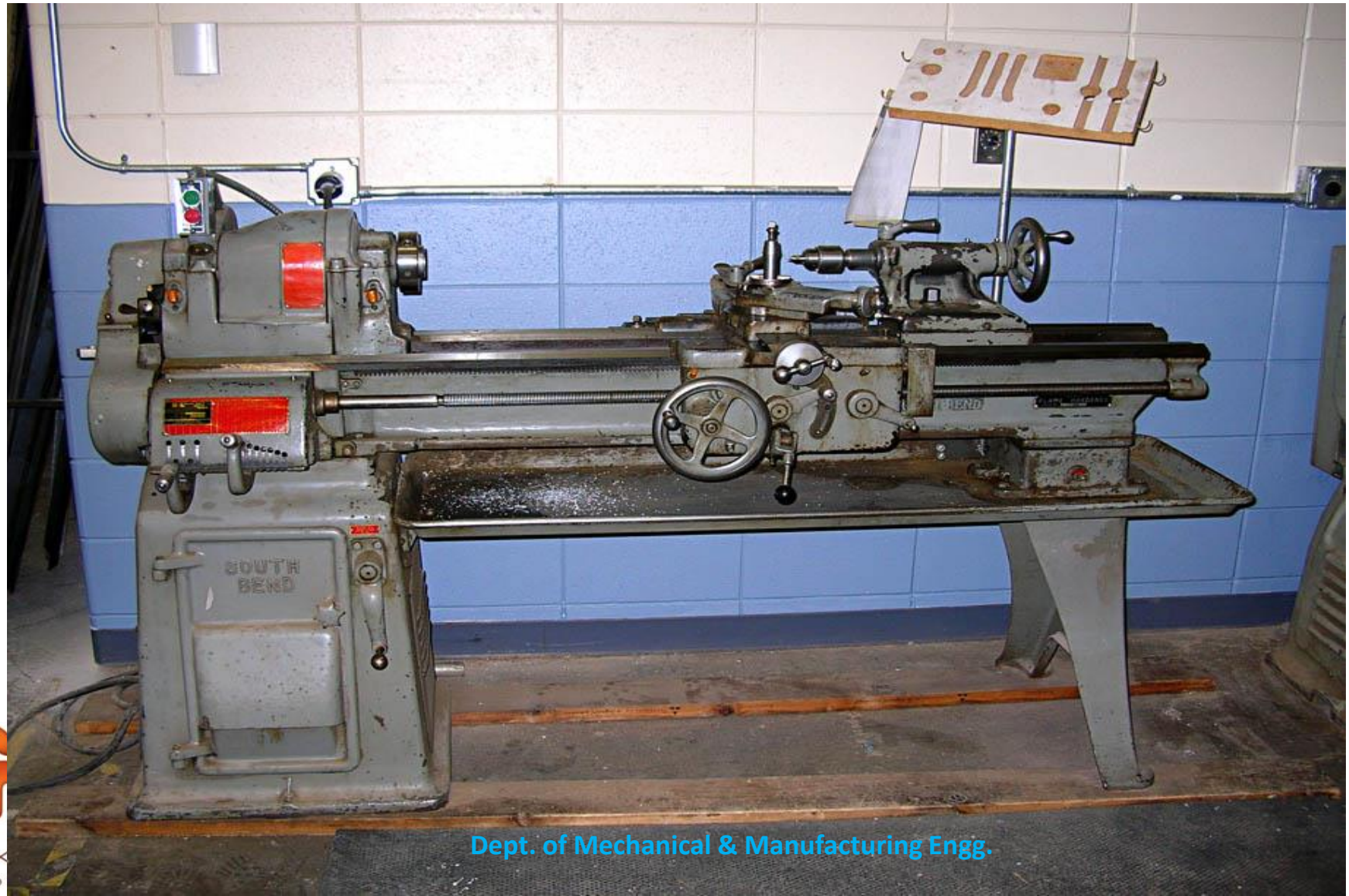
Shaping machine

Functions of Machine Tools

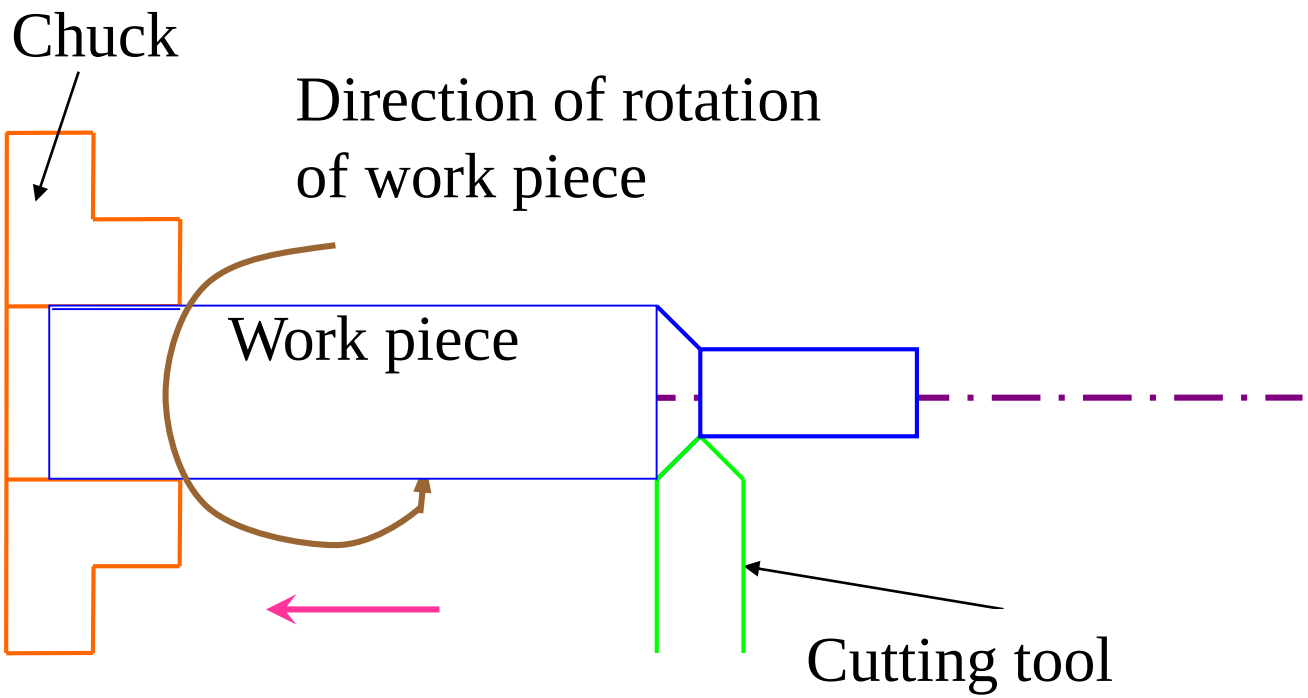
- To hold and support job/work to be machined
- To hold and support the cutting tool in position
- To move the cutting tool, work or both in a desired direction
- To regulate the cutting parameters such as speed, feed and depth of cut in order to carry out the machining operations.

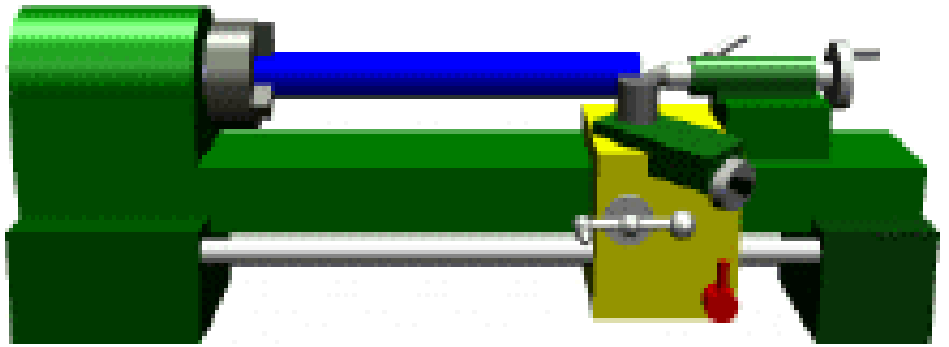
ENGINE LATHE

- Lathe is a Machine Tool used generally to produce circular objects.



Working principle of lathe

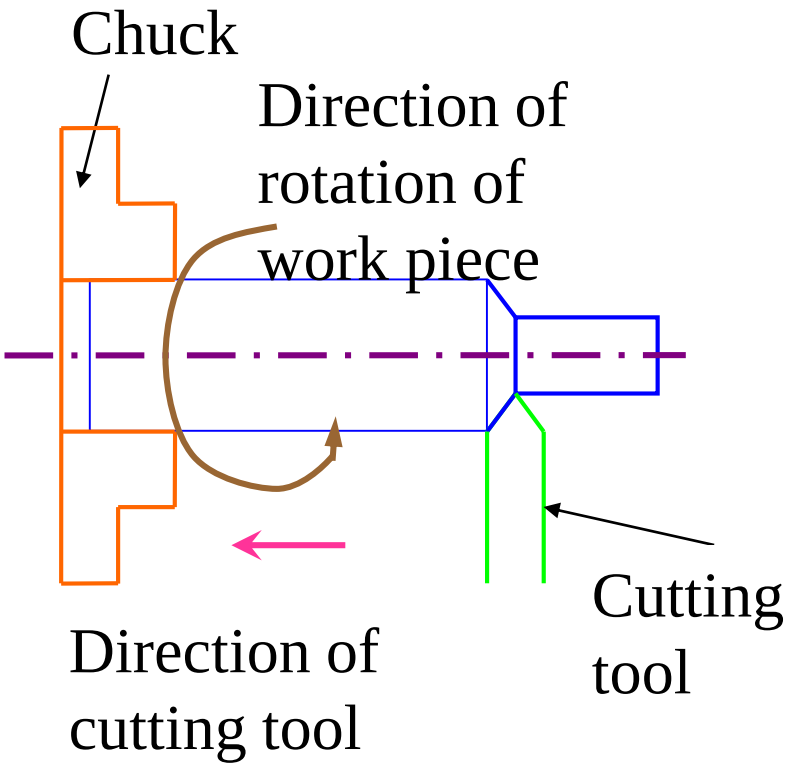


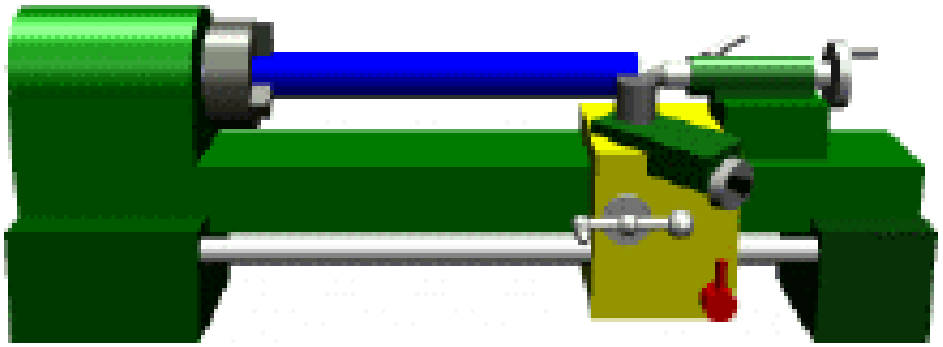


Working principle of a lathe

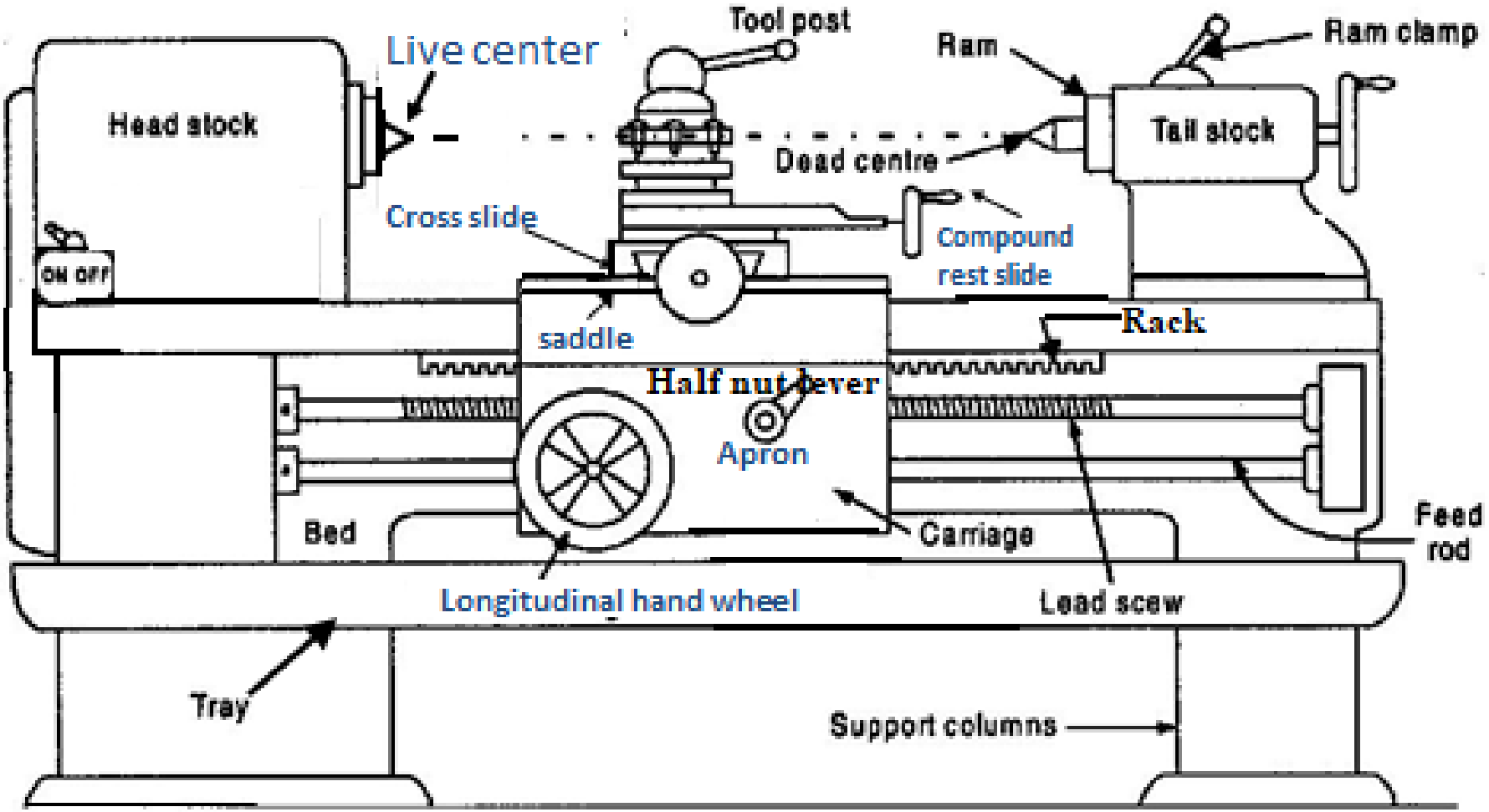
- Cutting tool can remove material in the form of chips from rotating work pieces to produce *circular objects*

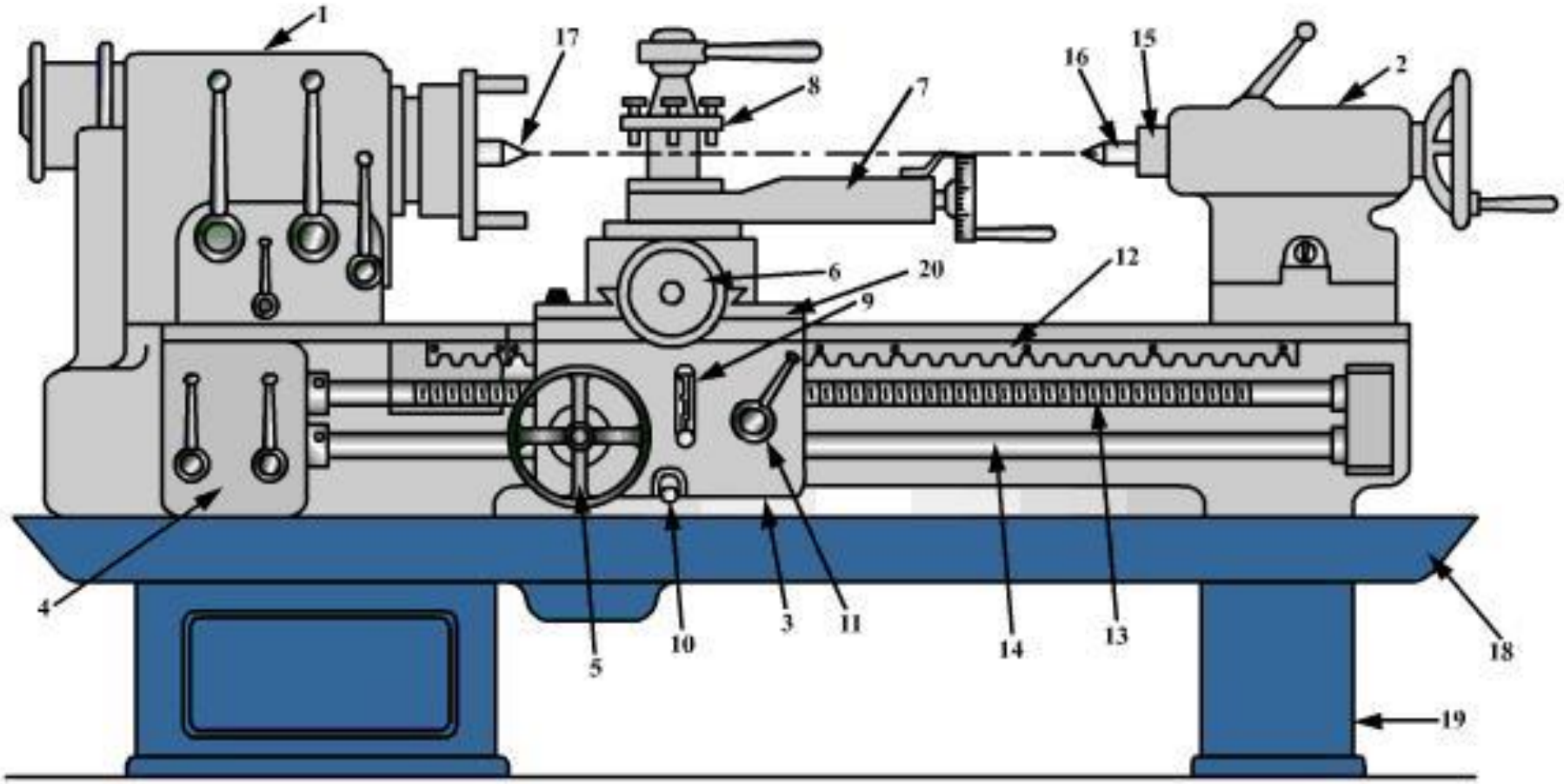
- Work piece is held rigidly by one of the *work holding devices* known as *chuck*





LATHE


Live center
Tool post
Ram
Ram clamp
Head stock
Tail stock
Dead centre
Cross slide
Compound rest slide
ON OFF
saddle
Rack
Half nut lever
Apron
Bed
Carriage
Feed rod
Longitudinal hand wheel
Lead scew
Tray
Support columns



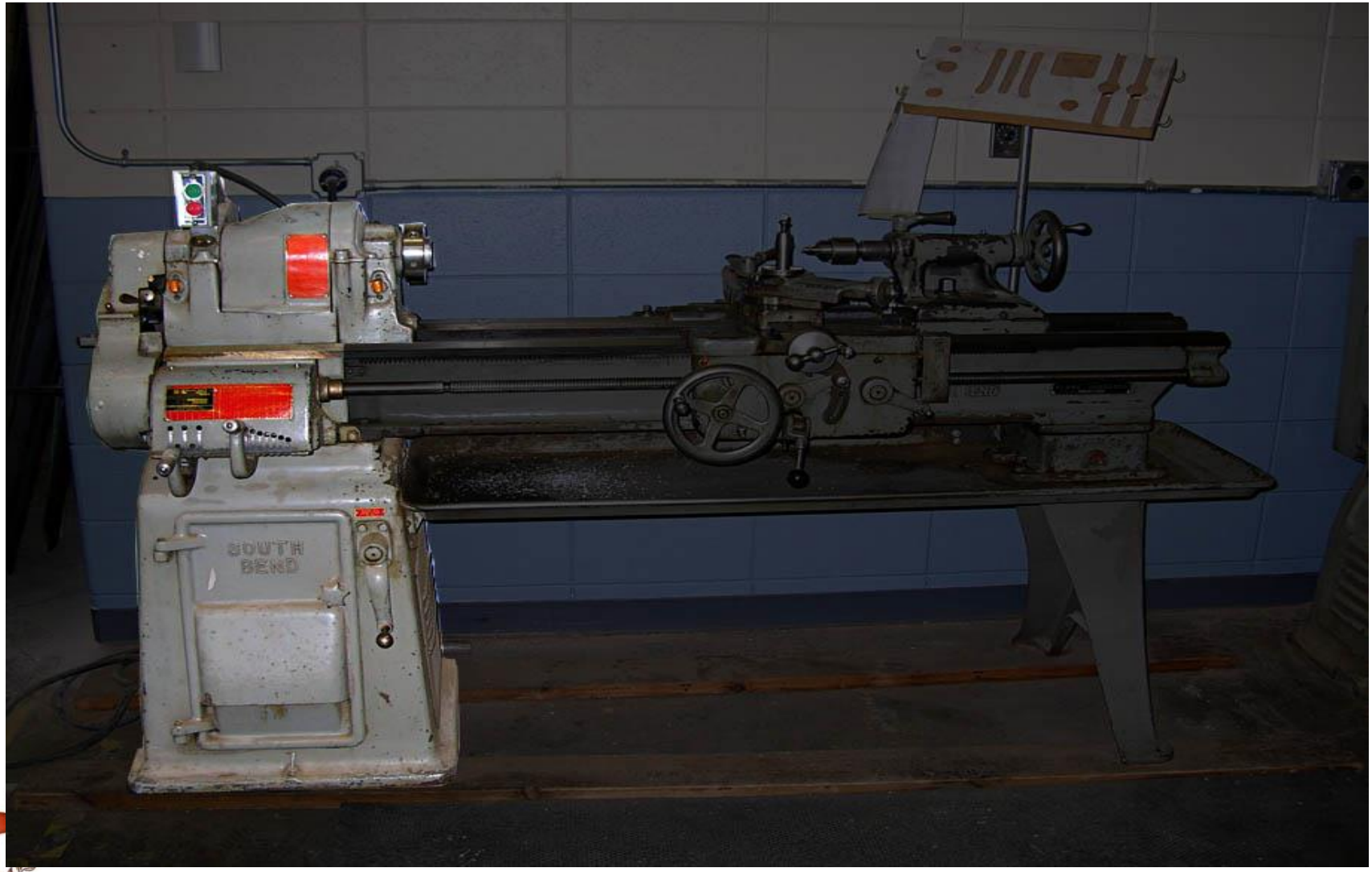
1.Head Stock, 2. Tail Stock, 3. Carriage , 4. Feed Box, 5. Longitudinal Hand Wheel, 6. Cross Feed Hand Wheel, 7. Compound Rest Slide, 8. Tool Post, 9. Direction Knob for Self, 10. Self Engaging Lever, 11.Half Nut (or) Thread Engaging Lever, 12. Rack, 13. Lead Screw, 14. Feed Rod, 15. Tailstock Spindle, 16. Dead Centre, 17. Live Centre, 18. Collecting Tray, 19. Leg, 20. Saddle.

MAJOR PARTS OF A LATHE

1] Bed
2] Head stock
3] Tail stock
4] Main drive
5] Carriage assembly consisting of
    a) Saddle
    b) Cross-slide
    c) Compound rest
    d) Tool post
    e) Apron
6] Lead screw
7] Feed rod

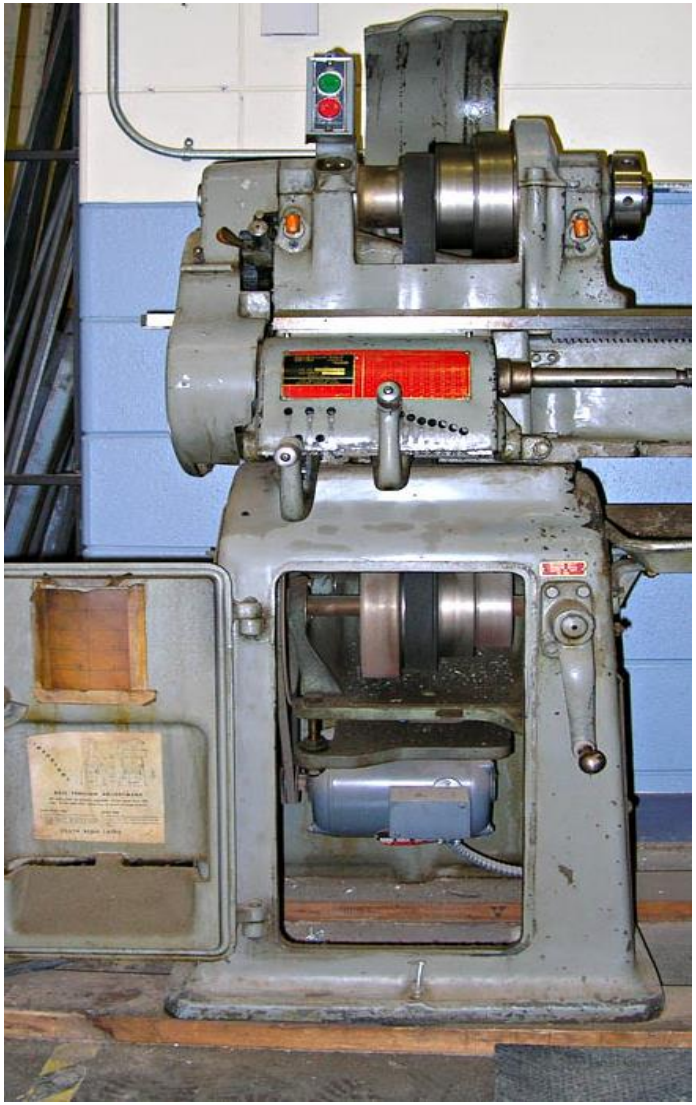
BED

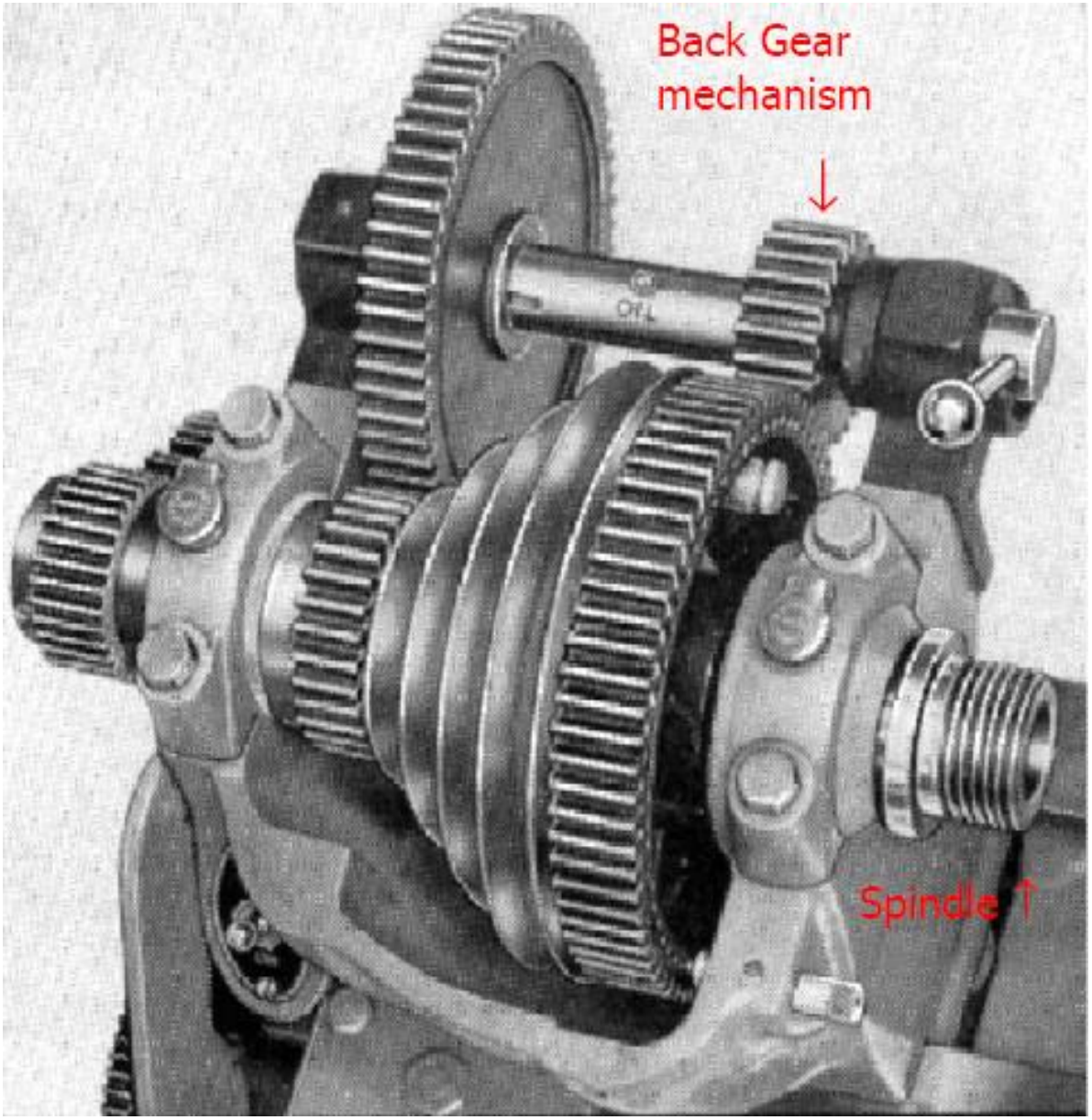
Headstock:



MAIN DRIVE

- Cone pulley drives the main spindle which is driven by the motor.
- Various spindle speeds can be obtained by *shifting the belt on different steps of the cone pulley* and also by using back gear arrangement.

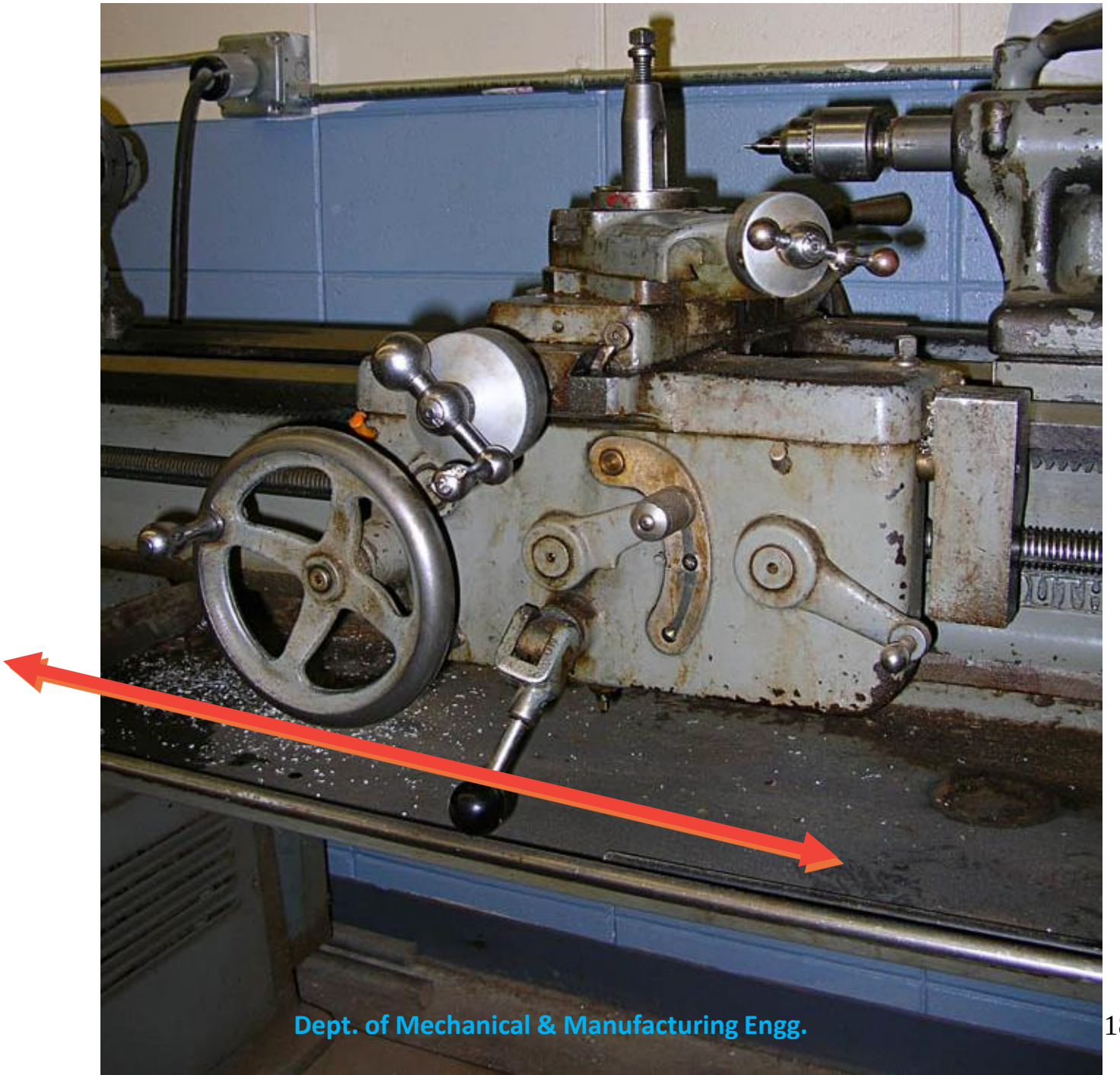



Back Gear
mechanism
Spindle

Tumbler Gear Mechanism

Tailstock:

Carriage Assembly:



Carriage assembly:

- To support the tool
- Moves over the outer guide ways longitudinally between *headstock* and *tailstock*.

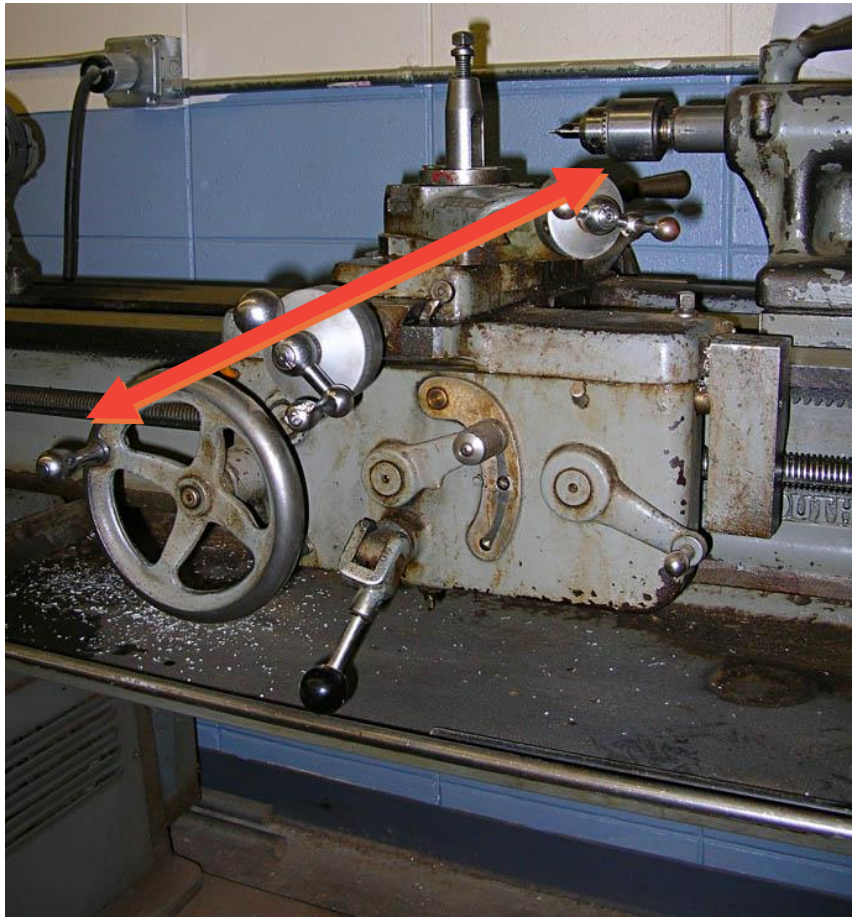
It is composed of 5 main parts:

1. ***Saddle***
2. ***Cross slide***
3. ***Compound Rest***
4. ***Apron***
5. ***Tool post***

Saddle

- H shaped casting that slides over the outer guide ways
- Serves as the base for Cross Slide, Compound Rest and Tool Post.

Cross Slide



- Mounted on the saddle
- Enables the movement of the cutting tool laterally across the lathe bed by means of cross feed hand wheel.
- It carries compound rest and tool post. It can be operated by hand or by power feed.

Compound Rest

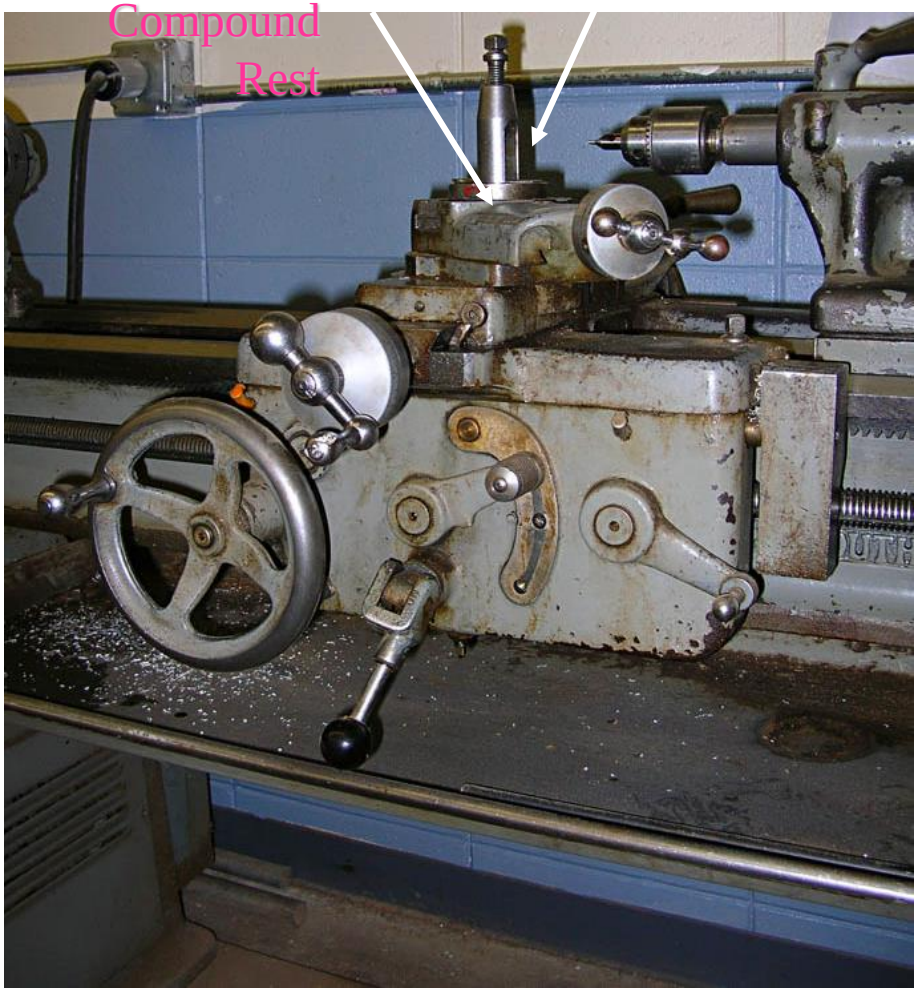
- Mounted on the top of the cross slide
- Supports the tool post.
- Swiveled to any angle in the horizontal plane
- It facilitates Taper Turning operation.

Apron

•Mounted on the front of the saddle

Tool post

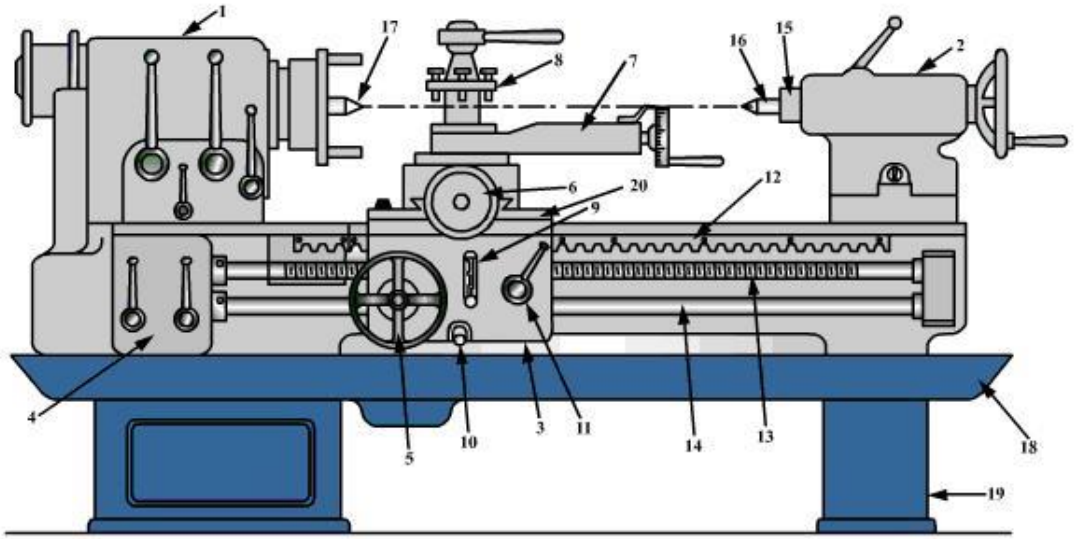
• Clamps the tool in the proper position for machining operations.



Chuck

Three Jaw Chuck

- For holding cylindrical workpiece
- Self centered.



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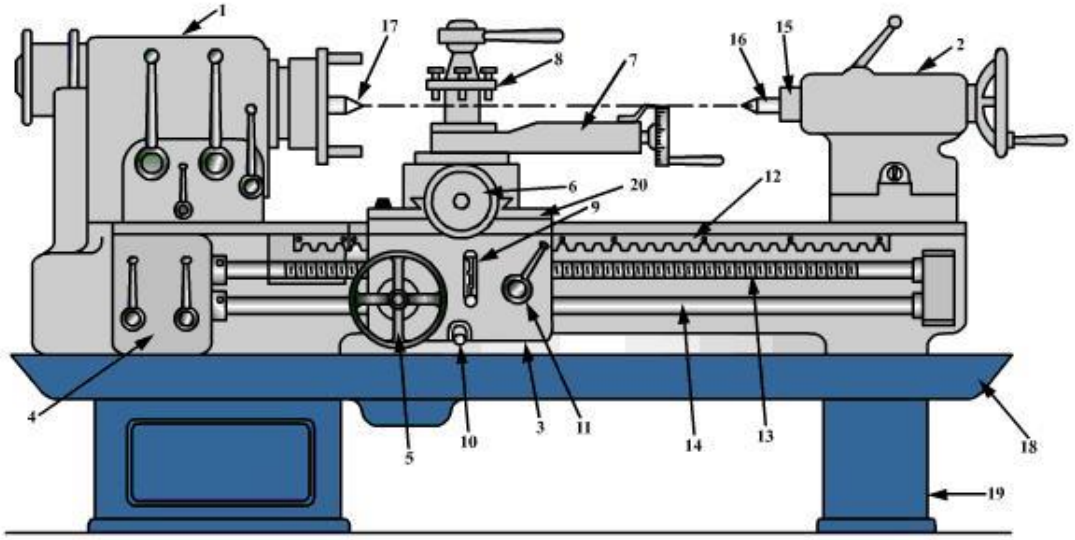
Lead Screw:

- A screw rod which moves longitudinally in front of the lathe bed.
- Rotation of the lead screw moves the carriage to and fro longitudinally during thread cutting operation.



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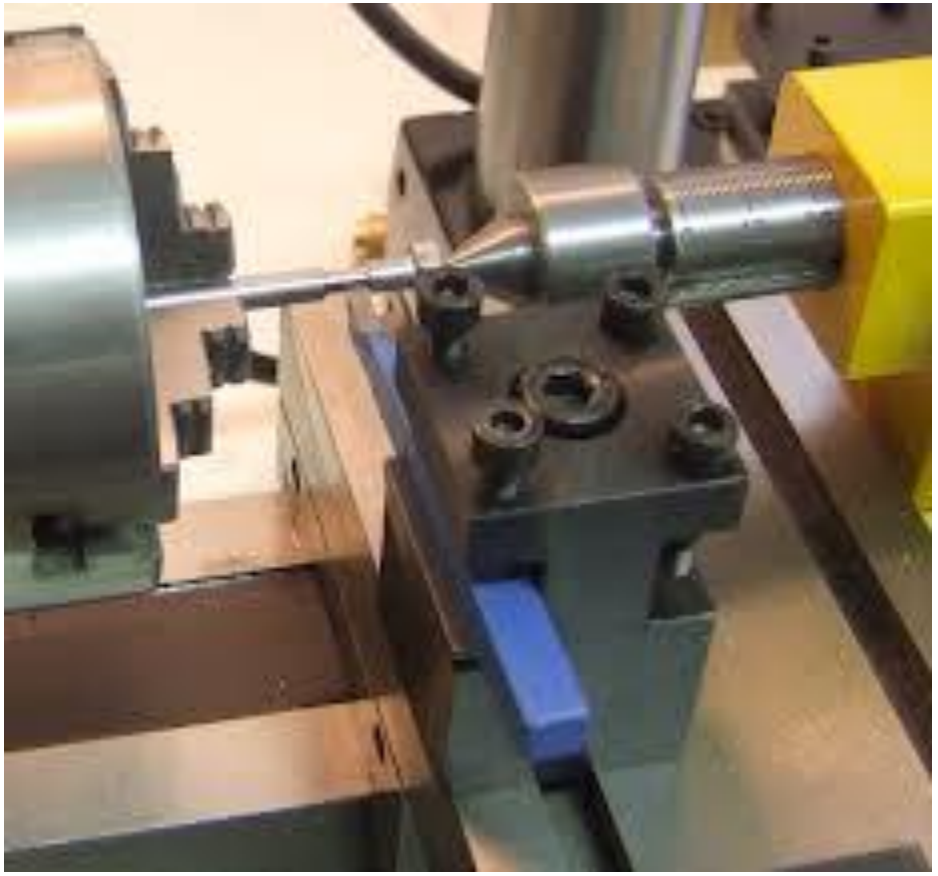
Feed rod:

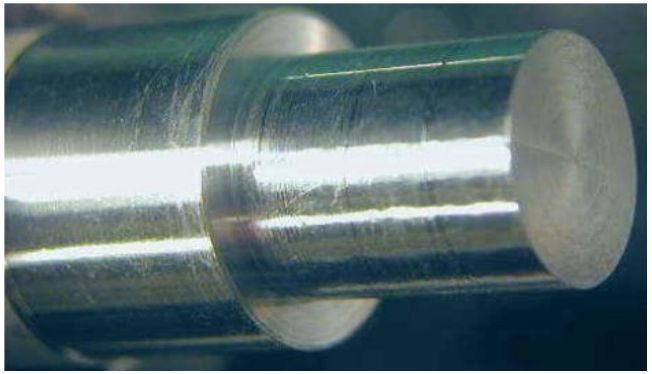
- A stationary rod mounted in front of the lathe bed
- Facilitates automatic longitudinal movement of carriage during **turning** and lateral movement of the cross slide during **facing** operations.

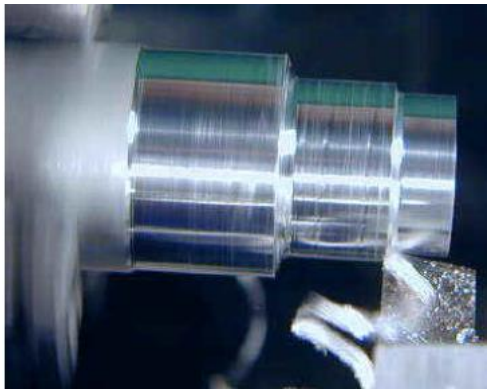
Lathe Operations

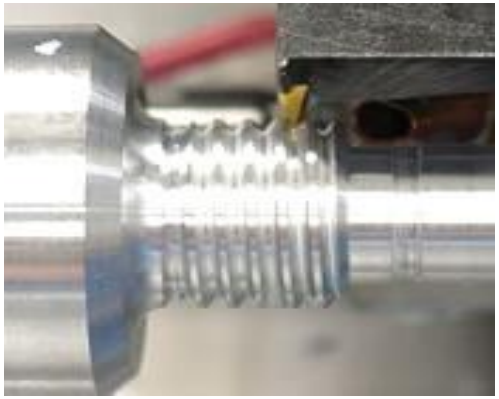
The various operations that can be performed on a lathe are:

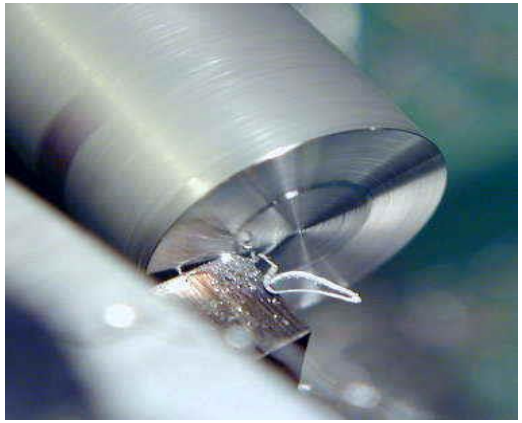
1. Turning.
2. Step turning.
3. Taper turning.
4. Facing.
5. Knurling
6. Chamfering
7. Thread cutting.

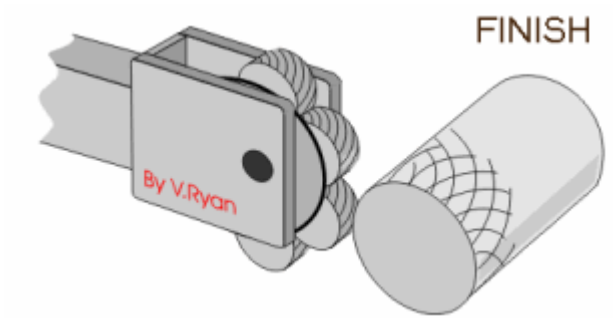




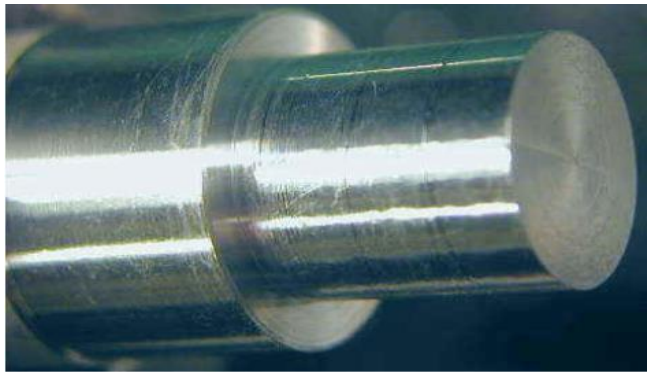


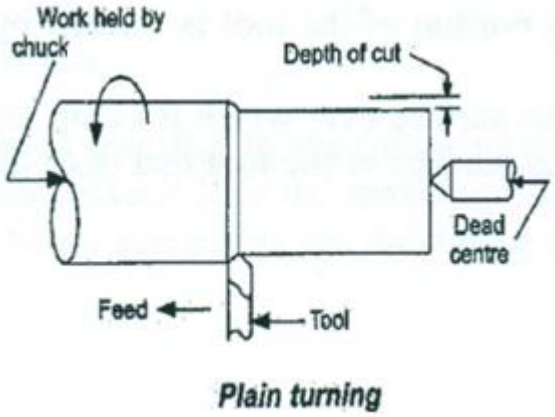





FINISH
By V.Ryan

1. Turning or Plain Turning Operation





Plain turning

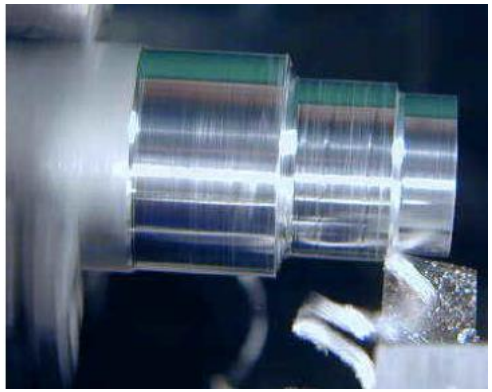
- The process of metal removal from a cylindrical job is called straight or plain turning
- **Cross slide and the apron wheel are used to perform the plain turning operation.** The workpiece is supported between the two centres which cause the rotation of the workpiece.

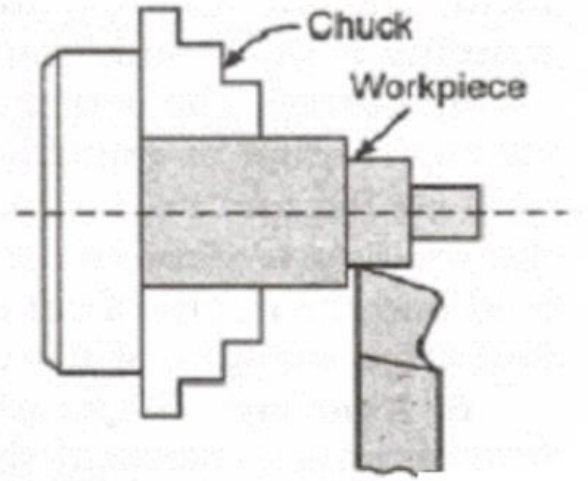
1. Turning or Plain Turning Operation

- A single point cutting tool is fed perpendicular to the axis of the workpiece with the required depth of cut using the cross slide hand wheel and is moved parallel to the axis of the workpiece towards the headstock using the carriage(Apron) hand wheel facilitating the metal removal.

- Plain turning operation is generally performed in two steps namely **Rough turning and Finish turning**

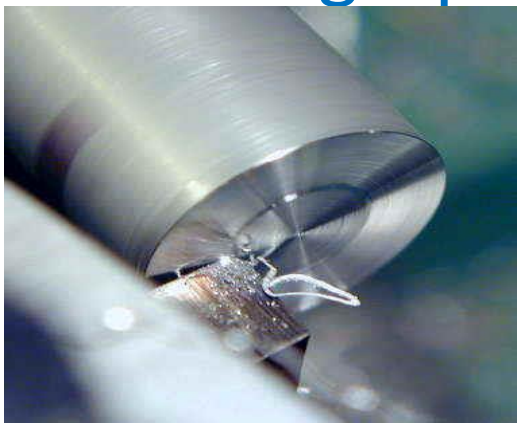
2. Step Turning Operation

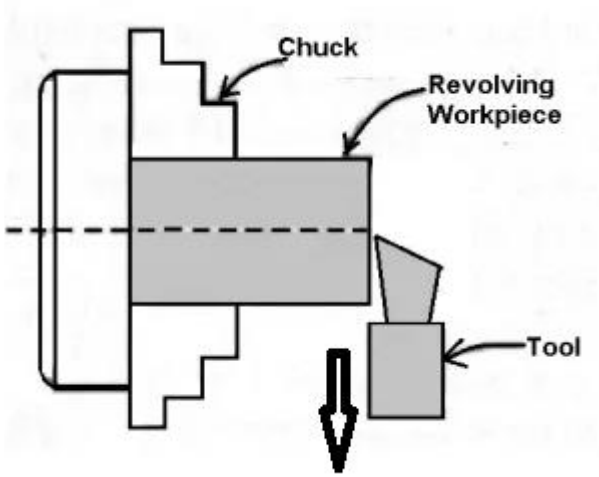




- **Step turning is an operation of producing multiple steps of different diameters on the same cylindrical specimen.** The work is held in between the lathe centers and the depth of cut to obtain the step on the cylinder is provided by cross slide movement and feed by the carriage movement.

3. Facing Operation



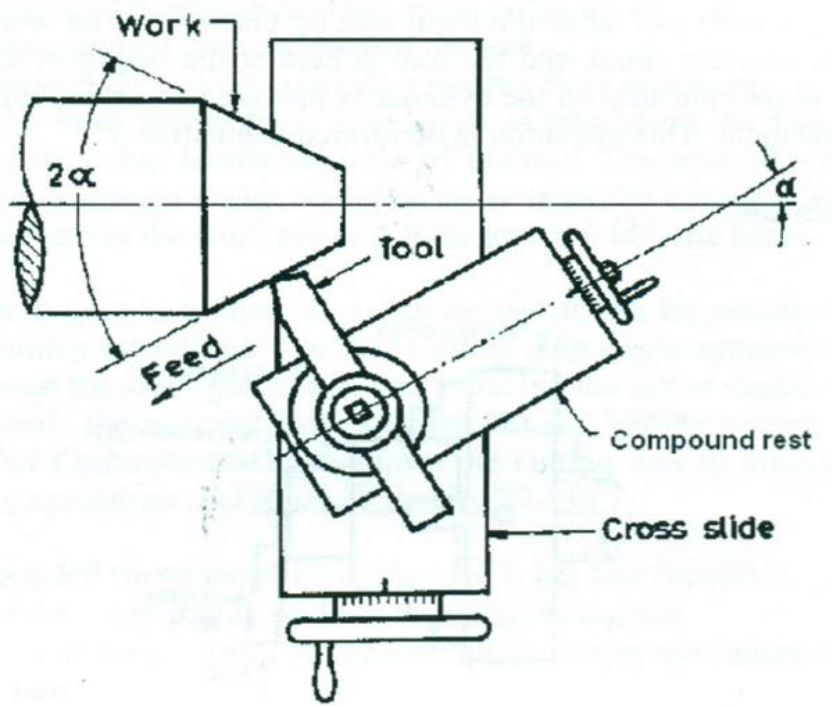


- **Facing is an operation of producing a flat surface on the ends of the work piece perpendicular to the axis. This can also be used to reduce the length of the work piece** so as to conform to the required length.
- To perform the operation the tool tip is set at the same height as that of the work piece axis and is fed **gradually by moving the cross slide in a direction perpendicular to the axis of the work piece** generally from the centre progressing towards the outer edge of the workpiece.

4. Taper Turning Operation

- **Taper turning is an operation of producing a conical surface on a cylindrical specimen.** It is achieved by gradually reducing the diameter from a cylindrical surface.
- The operation can be carried out either by rotating the job normally and feeding the tool at some angle or by rotating the job at an offset angle and feeding the tool normally. The widely used methods of taper turning are
  - **Taper turning by swivelling the compound rest and**
  - **Taper turning by tailstock set over method.**

Taper Turning by Swivelling the Compound Rest Method



- This method employs the principle of turning taper by rotating the workpiece on the lathe axis and feeding the tool at an angle to the axis of rotation of the workpiece.

Taper Turning by Swivelling the Compound Rest Method

- The tool mounted on the compound rest has a circular base graduated in degrees, which may be swivelled and clamped at any desired angle.

- Once the compound rest is set at the desired half taper angle, rotation of the compound slide wheel will cause the tool to be fed at that angle and generate the corresponding taper.
- **This method is limited to turn a short taper owing to the limited movement of the compound rest.** The movement of the tool in this method is purely controlled by hand.

Taper Turning by Swivelling the Compound Rest Method

- The taper angle by which the compound rest is to be rotated is given by the relation.

$\tan \alpha = (D-d)/2L$

where,

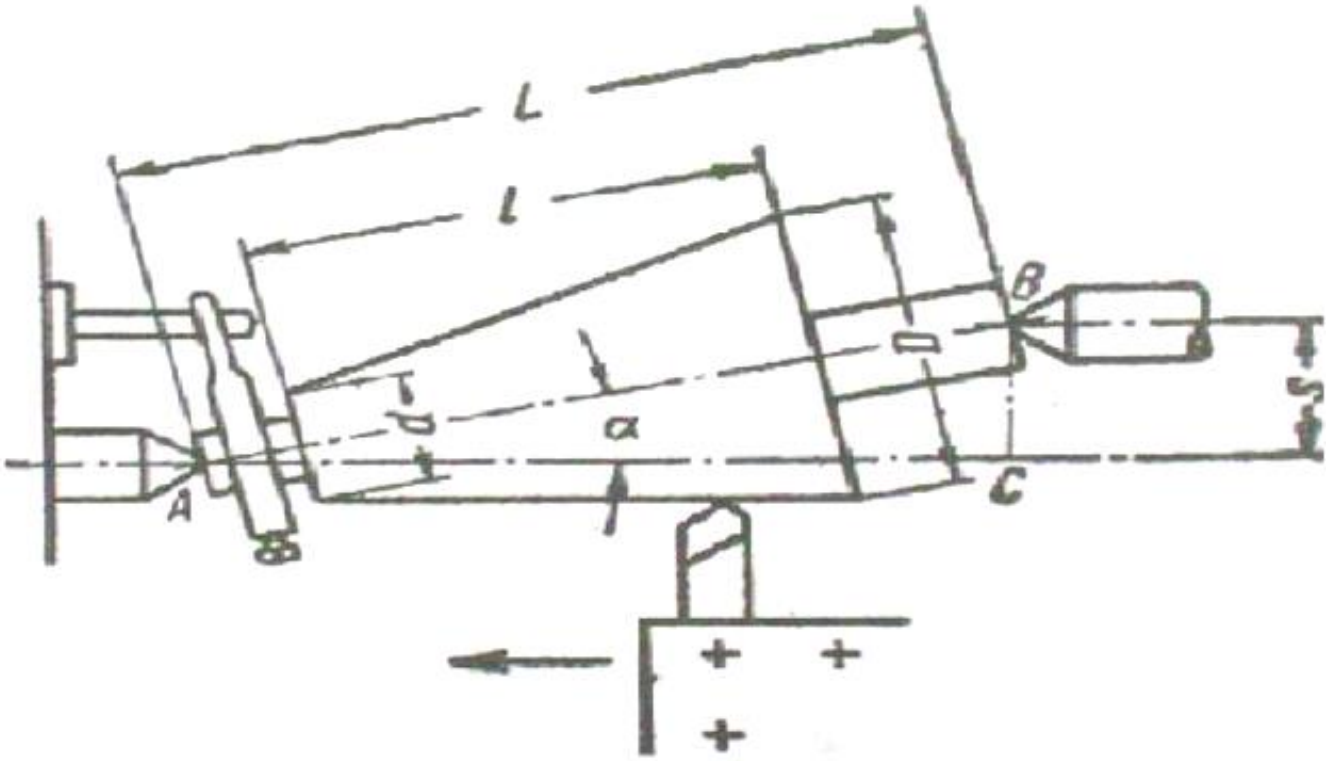
α = half taper angle (simply taper angle) in degrees.

D = larger diameter of the taper in mm.

d = smaller diameter of the taper in mm.

L = length of the taper in mm.

Taper Turning by Tail Stock Set over Method



- The principle of turning taper by this method is to shift the axis of rotation of the workpiece, at an angle to the lathe axis, and feeding the tool parallel to the lathe axis. The angle at which the axis of rotation of the workpiece is shifted is equal to half angle of the taper.

Taper Turning by Tail Stock Set over Method

- This is done by sliding the body of the tailstock on its base towards or away from the operator using the set over screws situated on either side at the base of the tailstock and a scale attached to the base of the tailstock.

- Entire carriage has to be moved parallel to the lathe bed to cut the taper. Since the amount set over being limited this method is suitable for turning small taper on long jobs.

- In this method the amount of set over required to machine a particular taper is given by the relation

Set Over = L(D-d)/2l

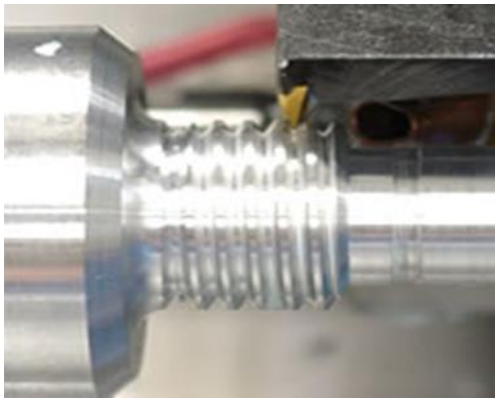
Where L= Length of the work.

l= Length of the taper.

D= Large diameter of the taper.

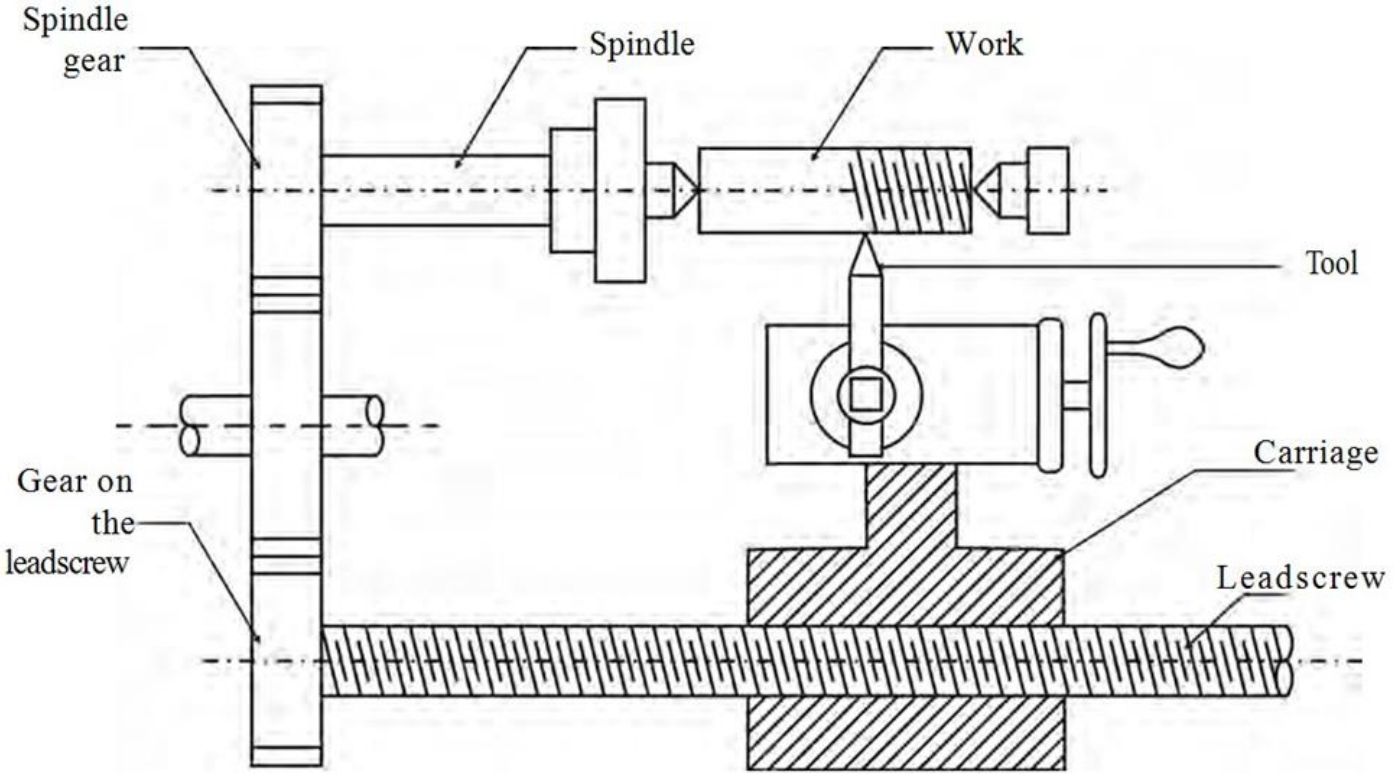
d= small diameter of the taper.

5. Thread Cutting Operation



- Thread cutting is an operation of producing a helical groove of specific shape say V or square on a cylindrical surface. The operation involves feeding the tool longitudinally when the job is revolved between the centres or by a chuck.
- **In thread cutting the longitudinal feed should be equal to the pitch of the thread to be cut per revolution of the workpiece**. In other words the tool must travel by a distance equal to the pitch of the thread per revolution of the workpiece.

5. Thread Cutting Operation



Thread cutting

- In thread cutting operation the first step is to reduce the diameter of the cylindrical specimen equal to the major diameter of the screw thread. Change gears of correct size are then fitted at the left end of the bed between the spindle and the leadscrew

5. Thread Cutting Operation

- Initially the tool is brought to the starting point of the job and a small depth of cut is given to the tool using the cross slide.

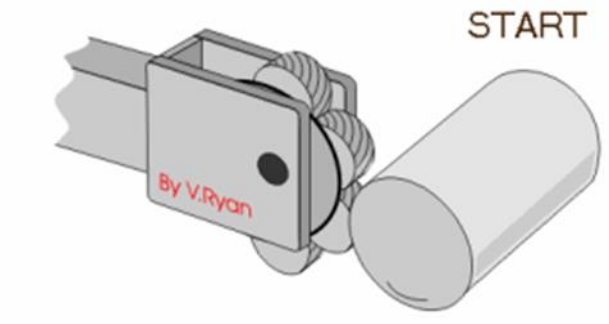
- The lathe is switched on and the carriage is engaged with the lead screw using the half nut lever which enables the tool to give the first cut.

- After the tool has produced the helical groove up to the end of the work it is quickly withdrawn using the cross slide, the half nut is disengaged and the tool is brought back to the starting position to give a fresh cut.

5. Thread Cutting Operation

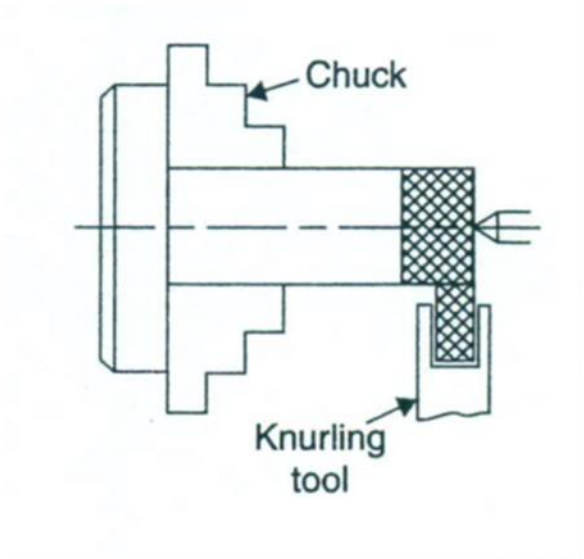
- Since several cuts are necessary before the full depth of the thread is reached, before reengaging the half nut for the next cut it is necessary to ensure that the tool will follow the same path it has traversed in the previous cut, otherwise the job will be spoiled. This is ensured by a attachment called thread chasing dial.

6. Knurling Operation



- Knurling is a slow speed operation of generating a serrated surface on a cylindrical workpiece or it is the process of embossing a diamond shaped impression pattern on the surface of a cylindrical workpiece using a special knurling tool.
- The purpose of knurling is to provide an effective gripping surface on a workpiece to prevent it from slipping when operated or held by hand.

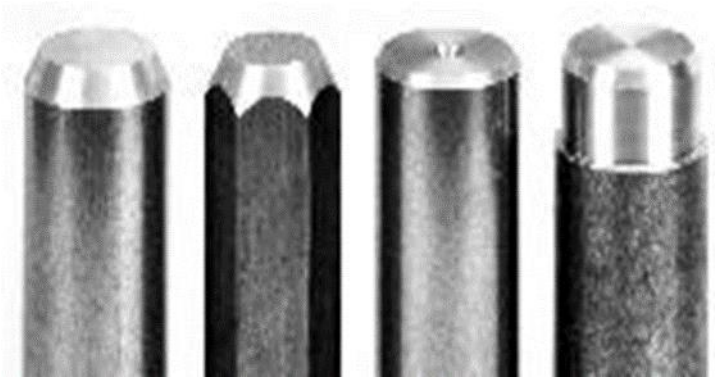
6. Knurling Operation

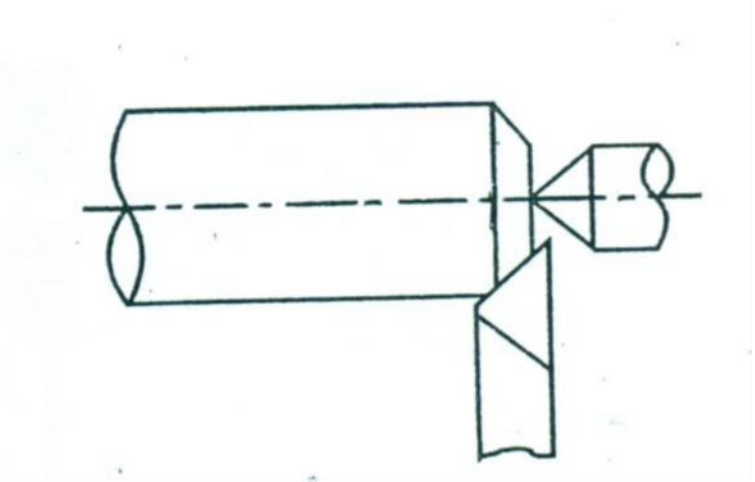


- The knurling tool consists of a set of hardened steel rollers in a holder with the teeth cut on their surface in a definite pattern.

- While carrying out knurling operation the back gear is engaged and the tool is held rigidly on the tool post and the rollers are pressed against the revolving work piece to squeeze the metal against the multiple cutting edges thereby producing depressions in a regular pattern on the surface of the workpiece.

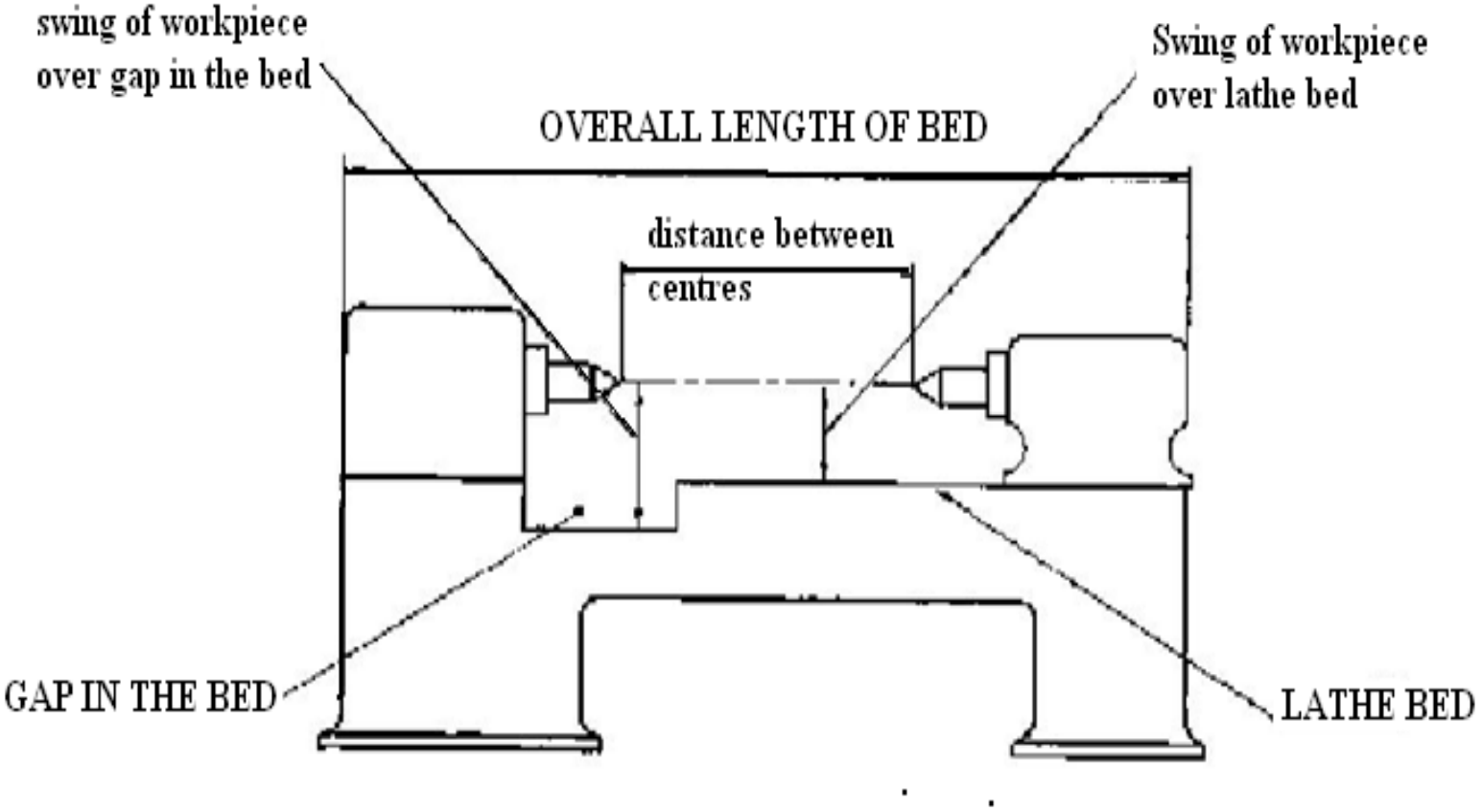
7. Chamfering Operation





- Chamfering is an operation of bevelling the extreme ends of a workpiece. This is done to remove the burrs, to protect the ends of the workpiece from getting damaged and to have a better look.
- The operation may be performed after knurling, turning, thread cutting etc. It is an essential operation after thread cutting so that the nut may pass freely on the threaded workpiece.

Specification of a lathe.



Specification of a lathe

1. **Distance between centers:**
   - Maximum distance that can be obtained between the lathe centers
   - Represents the maximum length of the work piece that can be held between centers.
2. **Overall length of the bed:**
   - Maximum length of the bed starting from the head stock end to tailstock end.
3. **Swing of workpiece over lathe bed:**
   - Largest diameter of the work piece that can be rotated without touching the bed.
4. **Swing of workpiece over gap in the bed:**
   - It is the maximum diameter and the width of a work piece that can swing when the lathe has gap in the bed.

Machining time Calculation

Cutting Speed

$$V = \frac{\pi D N}{1000}$$

where V = Cutting speed (surface) in m/min

D = Diameter of the workpiece in mm

N = Rotational speed of the workpiece in rpm

Time for a single pass

$$t = \frac{L + L_O}{f N}$$

where t = Time required for single pass in min

L = Length of the job in mm

L_O = Over travel of the tool beyond the length of the job in mm

f = Feed rate in mm/rev

Machining time Calculation

Number of roughing passes

$$P_r = \frac{A - A_f}{d_r}$$

where P_r = Number of passes for roughing operation

A = Total machining allowance in mm

A_f = Finish machining allowance in mm

d_r = Depth of cut in roughing in mm

Number of finishing passes

$$P_f = \frac{A_f}{d_f}$$

where P_f = Number of passes for finishing operation

A_f = Finish machining allowance in mm

d_f = Depth of cut in finishing in mm

DRILLING MACHINE

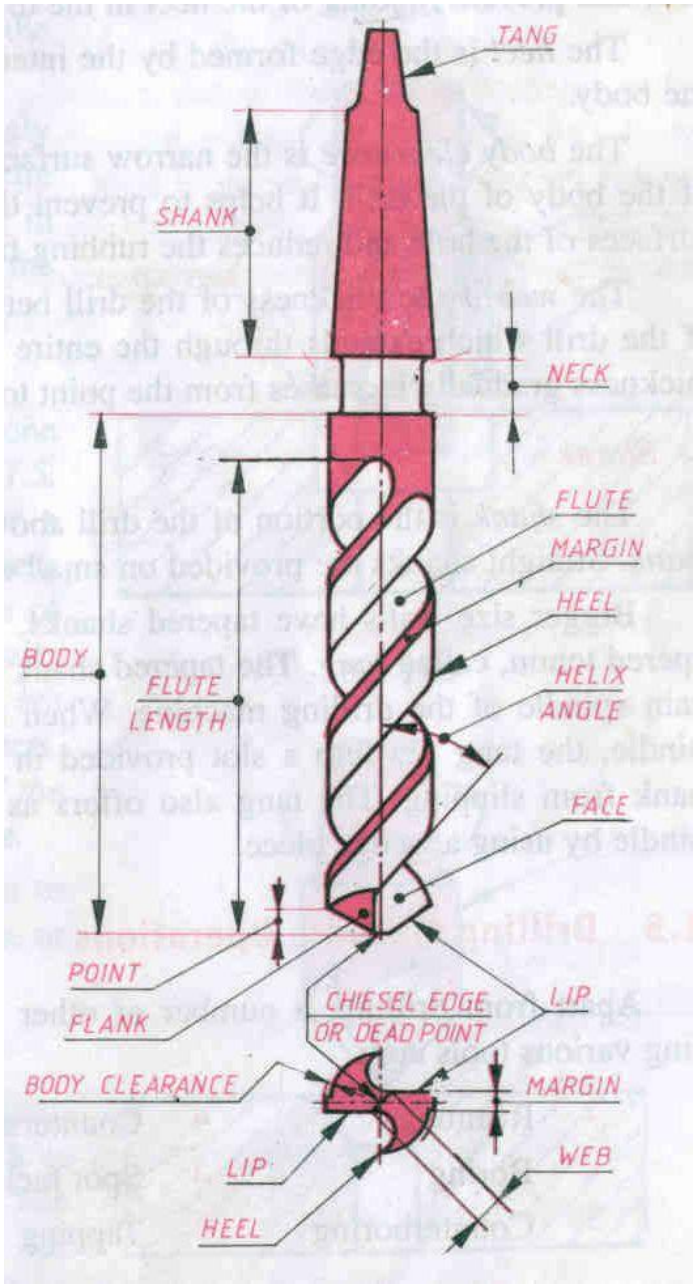
DRILLING

Drilling is a metal cutting process carried out by a rotating cutting tool (twist drill) to make circular holes in solid materials.

Drilling Machine

A power operated machine tool, which holds the drill in its rotating spindle and produces a hole when moved linearly against the work piece.

Twist Drill


TANG
SHANK
NECK
FLUTE
MARGIN
HEEL
BODY
FLUTE LENGTH
HELIX ANGLE
FACE
POINT
FLANK
CHIESEL EDGE OR DEAD POINT
LIP
BODY CLEARANCE
MARGIN
LIP
WEB
HEEL

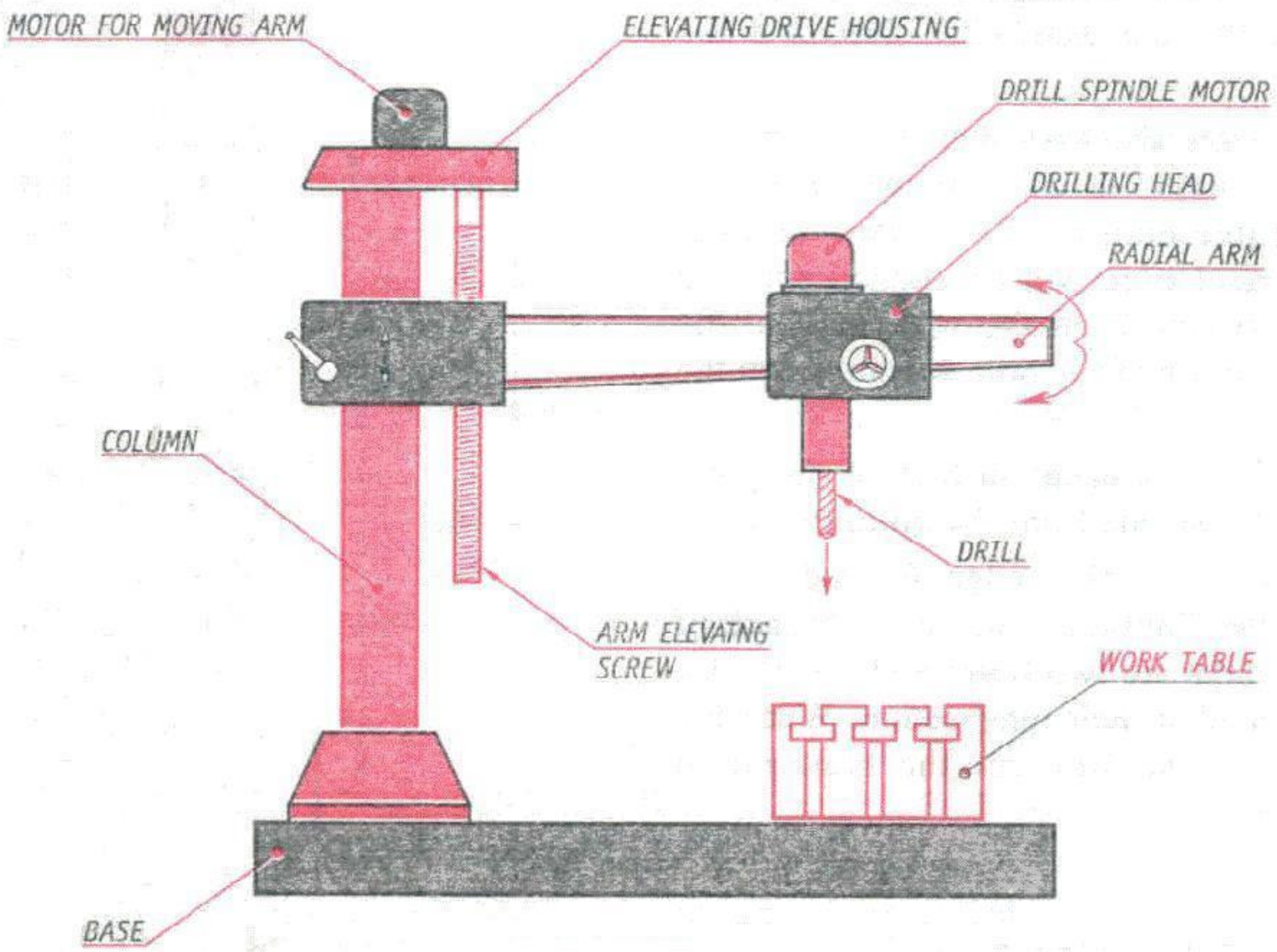
Types of Drilling Machines

Drilling machines may be classified as

1. **Portable Drilling Mchine.**
2. **Bench or Sensitive Drilling Machine.**
3. **Pillar or Upright Drilling Machine.**
4. **Gang Drilling Machine.**
5. **Multiple Spindle Drilling Machine.**
6. **Radial Drilling Machine.**

Radial Drilling Machine

Radial Drilling Machine



Radial Drilling Machine

- Radial drilling machine is used for medium and heavy duty applications
- Consists of a heavy, circular column mounted on a very strong base
- Radial arm can be swung around to any position and can be raised and lowered
- Drill head with drive and feed mechanism is fitted on to the radial arm

Radial Drilling Machine

Drill head can move horizontally along the guides of the arm and can be locked at any desired position.

These three movements of the machine permit the drill to be located at any desired position for carrying out the drilling operation.

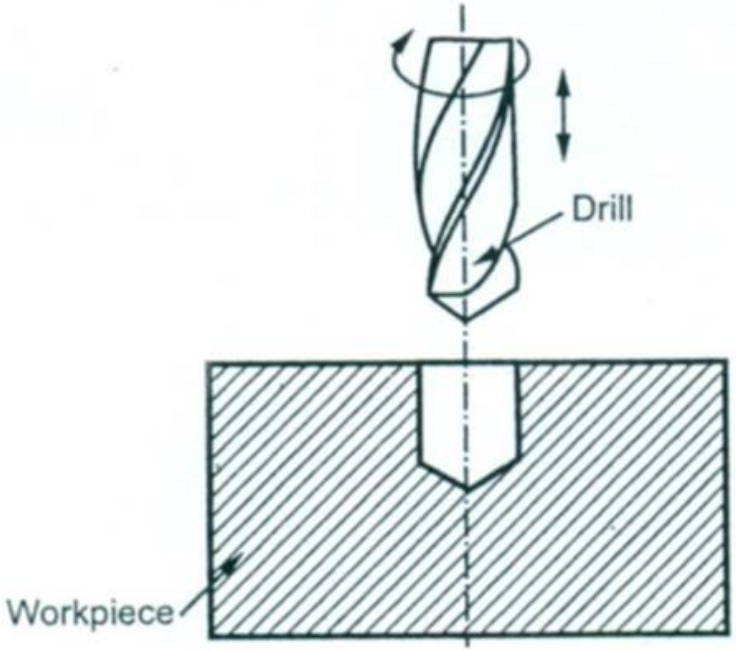
When several holes are to be drilled on a larger workpiece the arm and the drill head may be adjusted so that the drill spindle may be moved from one position to the other without altering the setting of the work.

Drilling Operations

The different operations that can be performed by a drilling machine are as follows.

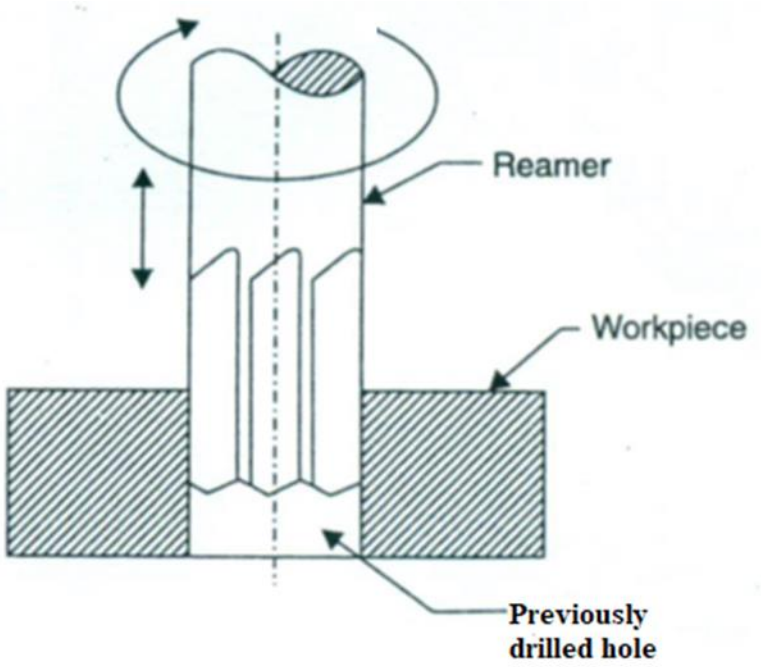
1. **Drilling**
2. **Reaming**
3. **Boring.**
4. **Counter Boring**
5. **Counter sinking**
6. **Spot facing**
7. **Tapping.**

1. DRILLING



- Drilling is an operation of producing cylindrical holes in a workpiece by removing the metal by the rotating edge of the cutting tool known as the drill.
- The centre of the hole is located on the workpiece and a indentation is made using the centre punch. The drill bit is then fed at this centre point to produce the required hole.

2. REAMING

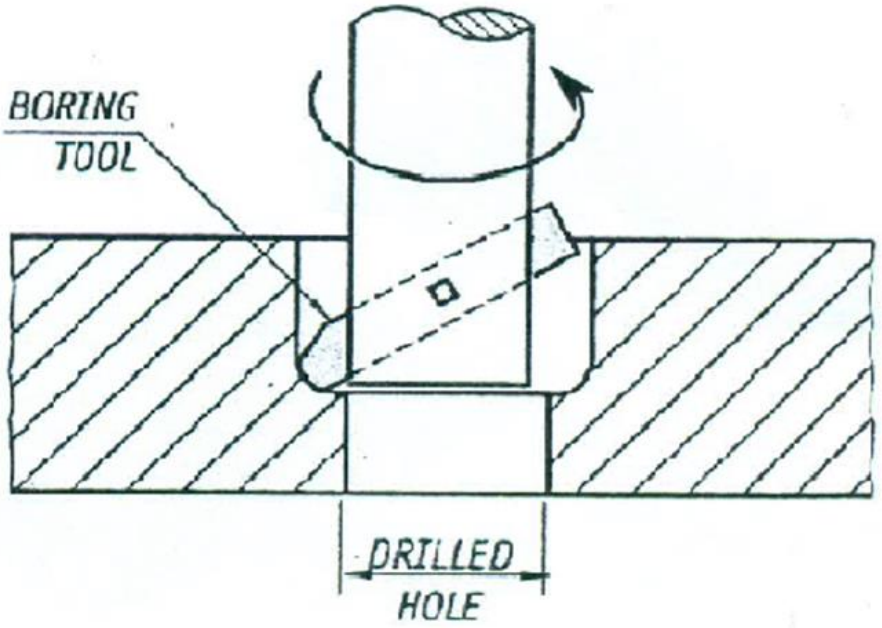


- Reaming is an operation of rightsizing and finishing the previously drilled hole using a tool called reamer.
- In drilling operation the drilled hole is slightly undersize and has a rough surface. Hence a tool called reamer which has straight multiple cutting edges is mounted in place of the twist drill and reaming is done in the same way as drilling.

2. REAMING

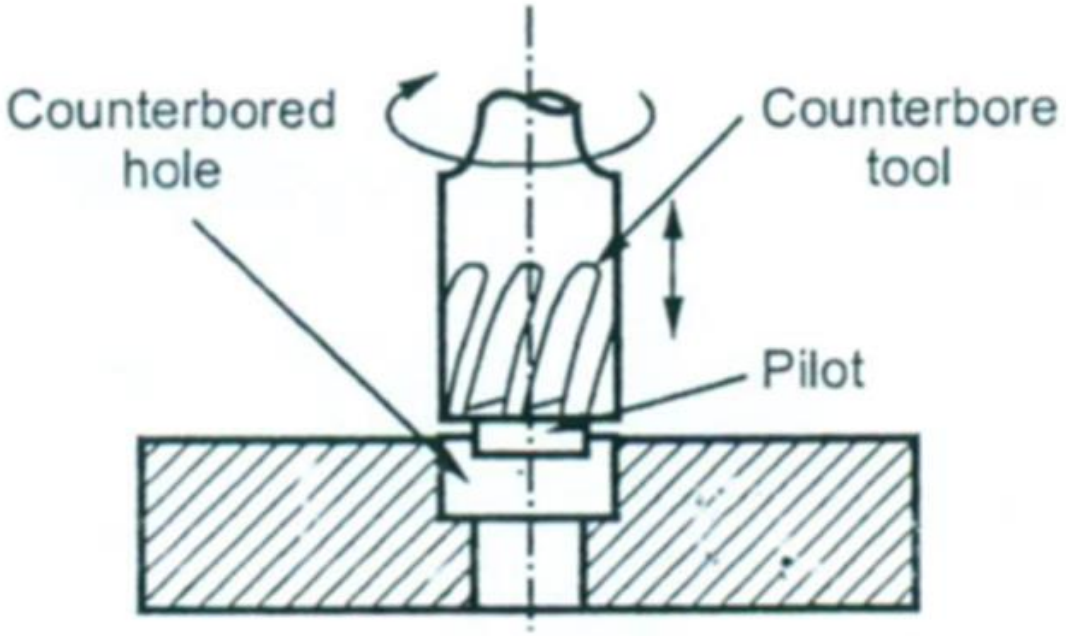
- Reaming removes only a small amount of material and produces a smooth finish on the drilled surfaces. Reamer simply follows the path which has been previously drilled and cannot correct the hole location.

3. BORING



- Boring is an operation of increasing the size of the already drilled hole.
- When a suitable size drill is not available, initially a hole is drilled to the nearest size and using a single point cutting tool, the size of the hole is increased to the required size as shown in the figure. By lowering the tool while it is continuously rotating, the size of the hole is increased over its entire depth.

4. COUNTERBORING



- Counterboring is an operation of increasing the size of a hole only at one end through a small depth as shown in the figure.

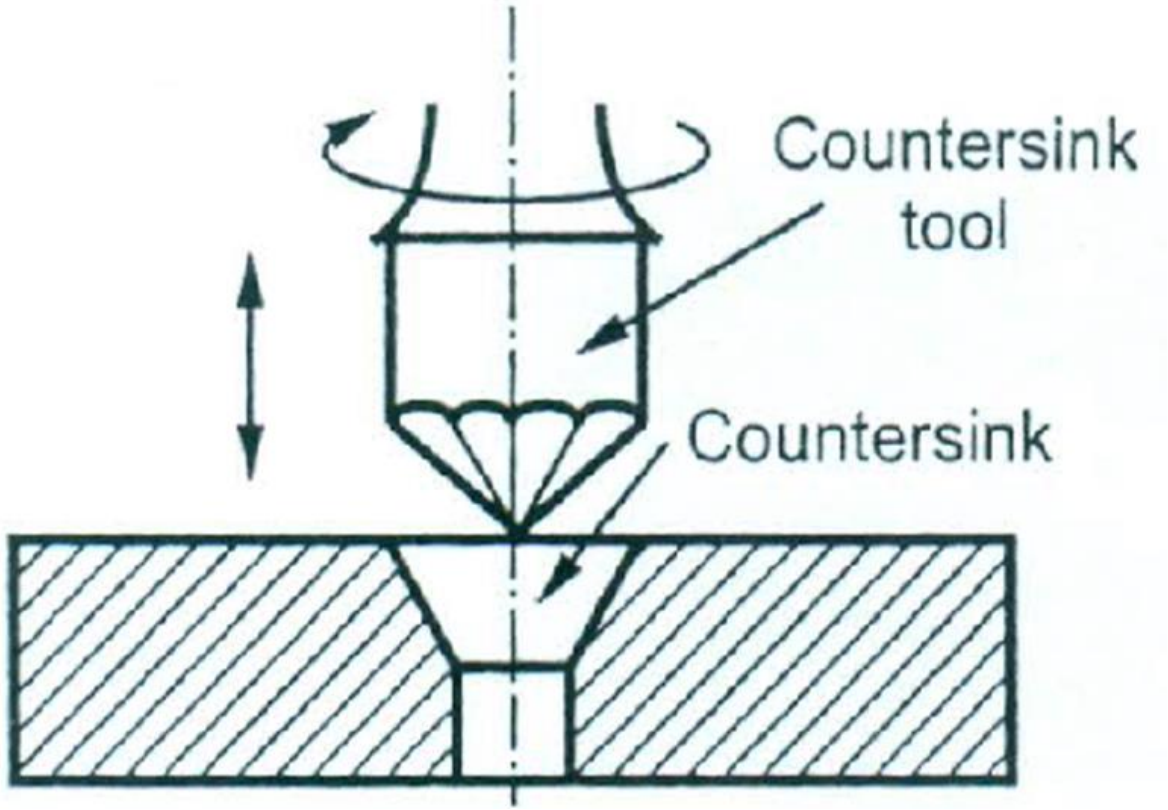
4. COUNTERBORING

- Counterboring operation forms a larger sized recess or a shoulder at one end of the existing hole.

- The cutting tool will have a small cylindrical projection known as pilot to guide the tool while counterboring. The diameter of the pilot will always be equal to the diameter of the previously drilled hole.

- Counterboring is done on the holes to accommodate the socket head screws, or grooved nuts, or round head bolts.

5. COUNTERSINKING



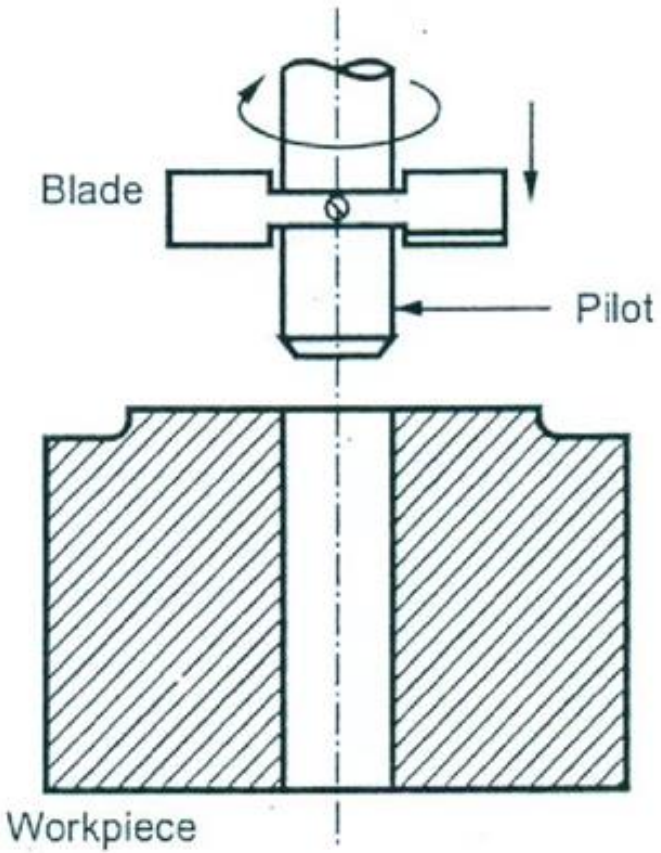
- Countersinking is an operation of making the end of the hole into a conical shape.

5. COUNTERSINKING

- It is done using a countersinking tool as shown in the figure.

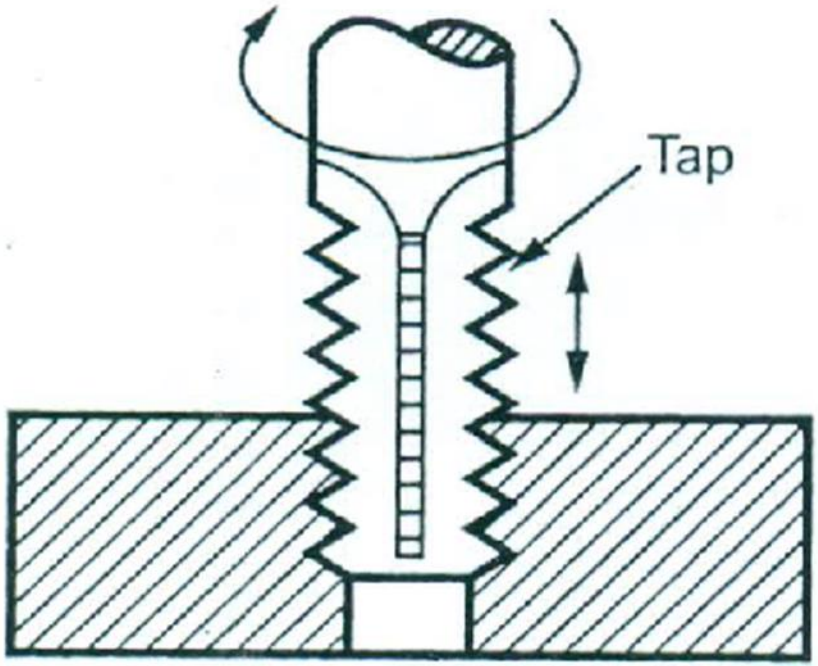
- The countersunk holes are used when the countersunk screws are to be screwed into the holes so that their top faces have to be in flush with the top surface of the work piece.

6. SPOTFACING



- Spot facing is an operation of producing a flat round surface around a drilled hole to so as to provide a good bearing surface for the proper seating of a bolt head or a nut. This is carried out using a spot facing tool as shown in the figure.

7. TAPPING



- Tapping is an operation of cutting internal threads using a cutting tool called tap.
- Initially a hole is drilled which must be smaller than the tap size by twice the depth of the thread.
- The drill spindle is then fitted with the tap and the feeding is done by operating the feed lever similar to the conventional drilling operation.