Metal Cutting & Machine Tools

1. Metal Working Processes
2. What are Machine Tools ?
3. Principles of operations of Machine Tools
4. Metal cutting Tools: Properties
5. Metal cutting Tools: Materials
6. Lathe Machine & operations

Metal Working Processes

Metal forming or Chip less processes:

Required shape is obtained by pressing/pushing metal in a certain shape, without producing chips.

1) Rolling (Continuous contact)
2) Forging (Intermittent contact)

Metal cutting or Chip forming processes: Required shape is obtained by cutting metal i.e. by producing chips. Cutting is done by single point or multipoint tools.

1) Turning, Shaping (Single point cutting , Continuous contact, sizable chips)
2) Milling (Multipoint cutting, Intermittent contact, sizable chips)
3) Grinding ((Multipoint cutting, Intermittent contact, ground chips)

What are Machine Tools ?

1) Machine tools are power driven machines.
2) Required shape & size is obtained by removing the material in the form of chips, from a bigger size of raw material.
3) One or more cutting tools are used for the machining processes.

Principles of Operation of Machine Tools

1) All component shapes can be considered as made from regular geometric shapes like lines, planes, arcs, circles, cylinders, spheres etc.
2) Principle of generation of surface is used in machine tools.
3) Surface is generated by the combined effect of relative motion between two lines of action. (work piece and tool)
4) The accuracy of the component produced depends on the geometric relationship between two lines of action. (work piece and tool)

Tool Materials for Machine Tools

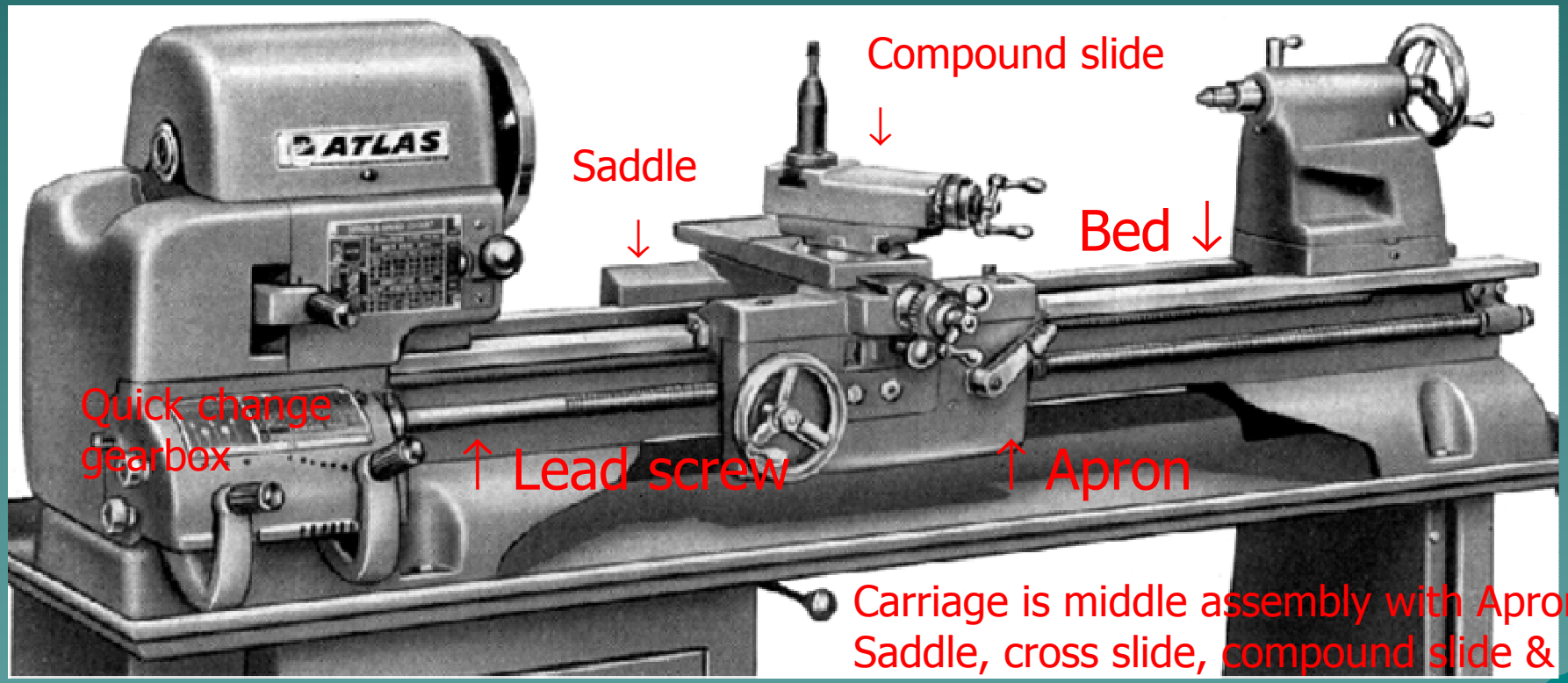
Properties essential for cutting Tools:

1) High Hot Hardness
2) High Wear resistance
3) Toughness
4) Ease of manufacturing
5) Low Coefficient of friction with the work piece material
6) Low cost

Tool Materials Used:

1) High carbon steel: Carbon 0.6 - 1.4%, Hot hardness limit up to 250^0C
2) High speed steel (H. S. S): 18% W, 4% Cr, 1% V, Hot hardness up to 900^0C
3) Cemented carbides: Carbides of W, Cr & Co, Hot hardness up to 1000^0C. Cutting speeds @ 6 times of H.S.S.
4) Ceramics: Aluminium oxides compacted under high pressure. Hot hardness up to 1200^0C. Cutting speeds @ 40 times of H.S.S.
5) Diamond: Basically Carbon. Hot hardness up to 1650^0C.
6) Abrasives: Aluminium Oxides or Silicon Carbides. For finishing operations like Grinding, Honing, Lapping etc.

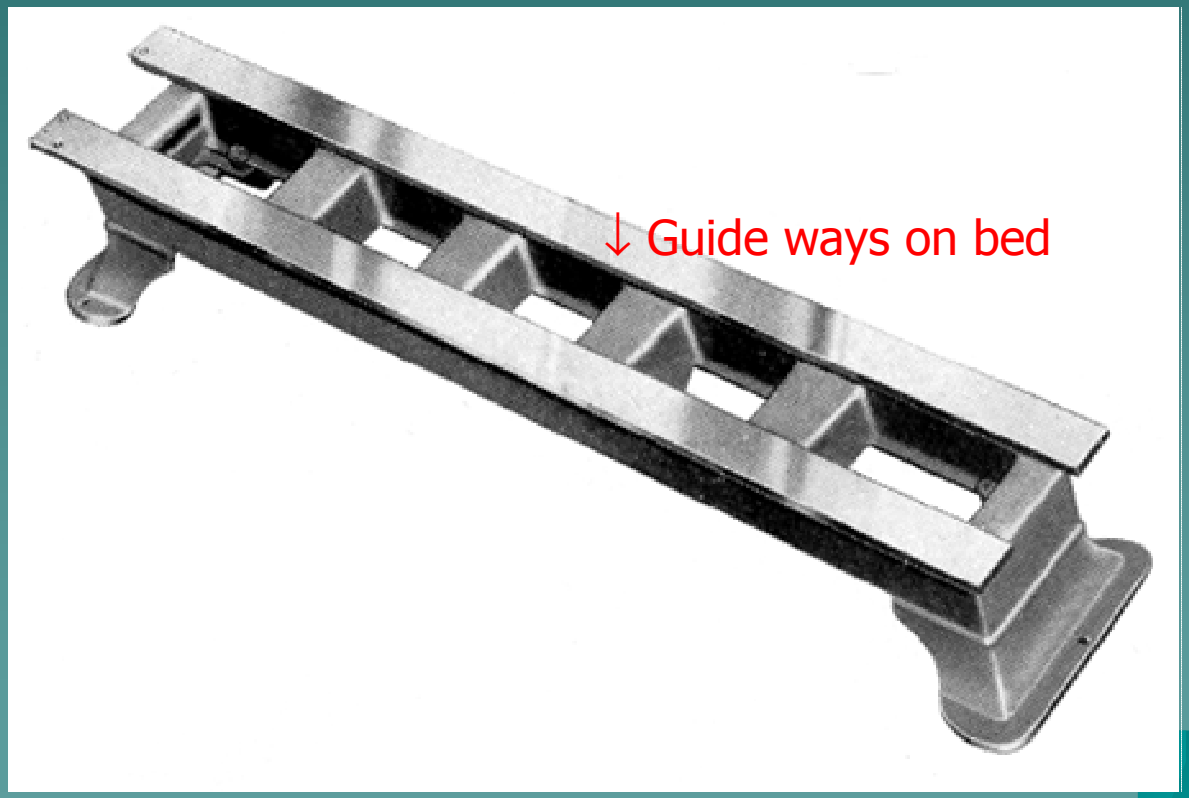
Lathe Machine:



Main Parts of Lathe Machine:

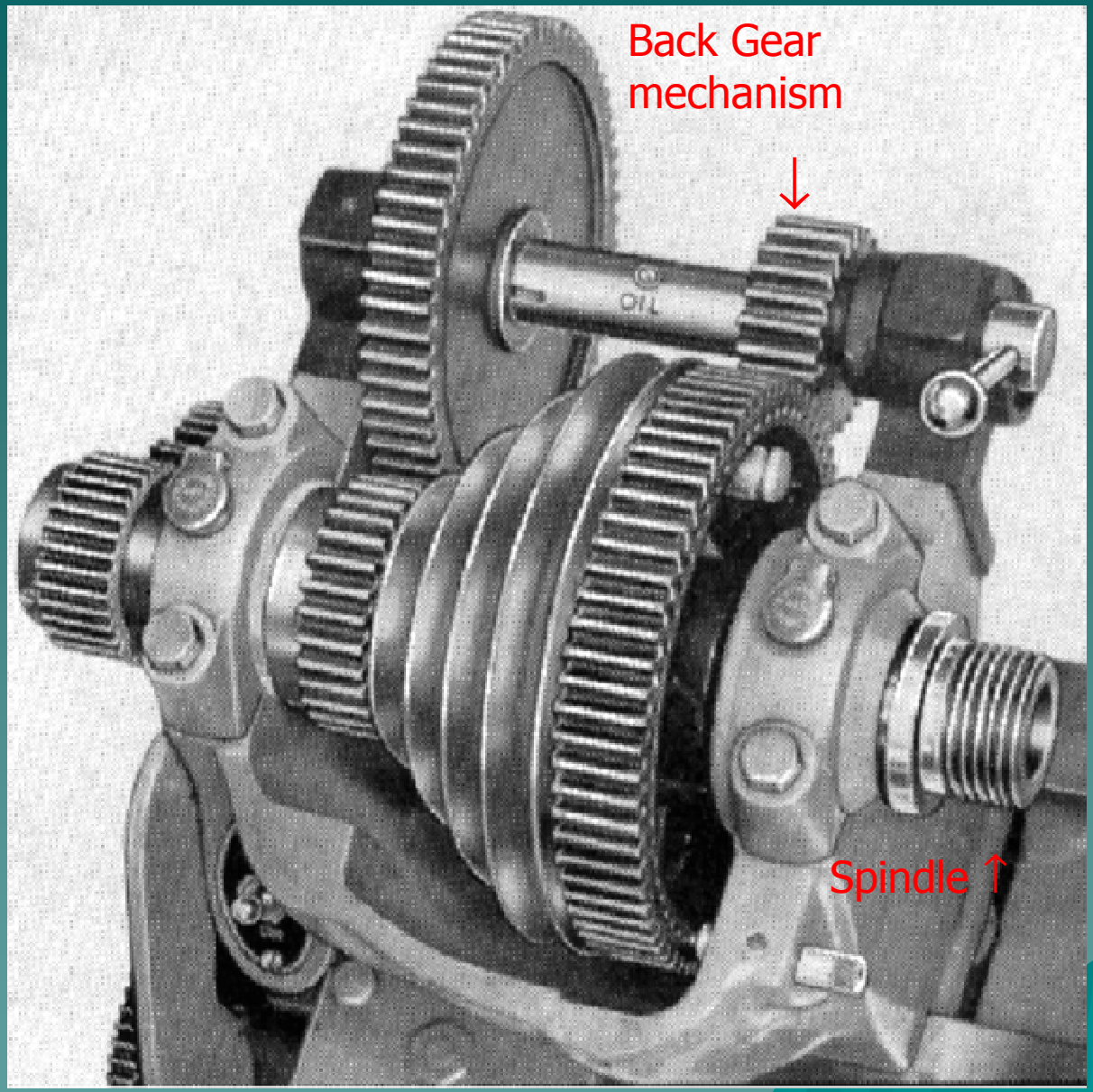
Bed: Made of C. I., Structural member on which all other parts are mounted. It has guide ways on it for moving carriage & tailstock.

Headstock, carriage and tailstock are held in alignment on the bed

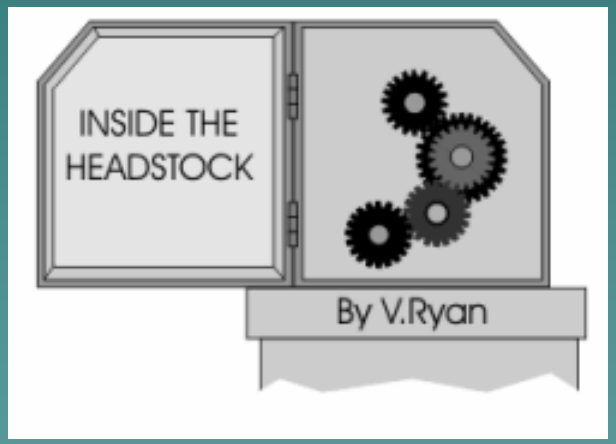


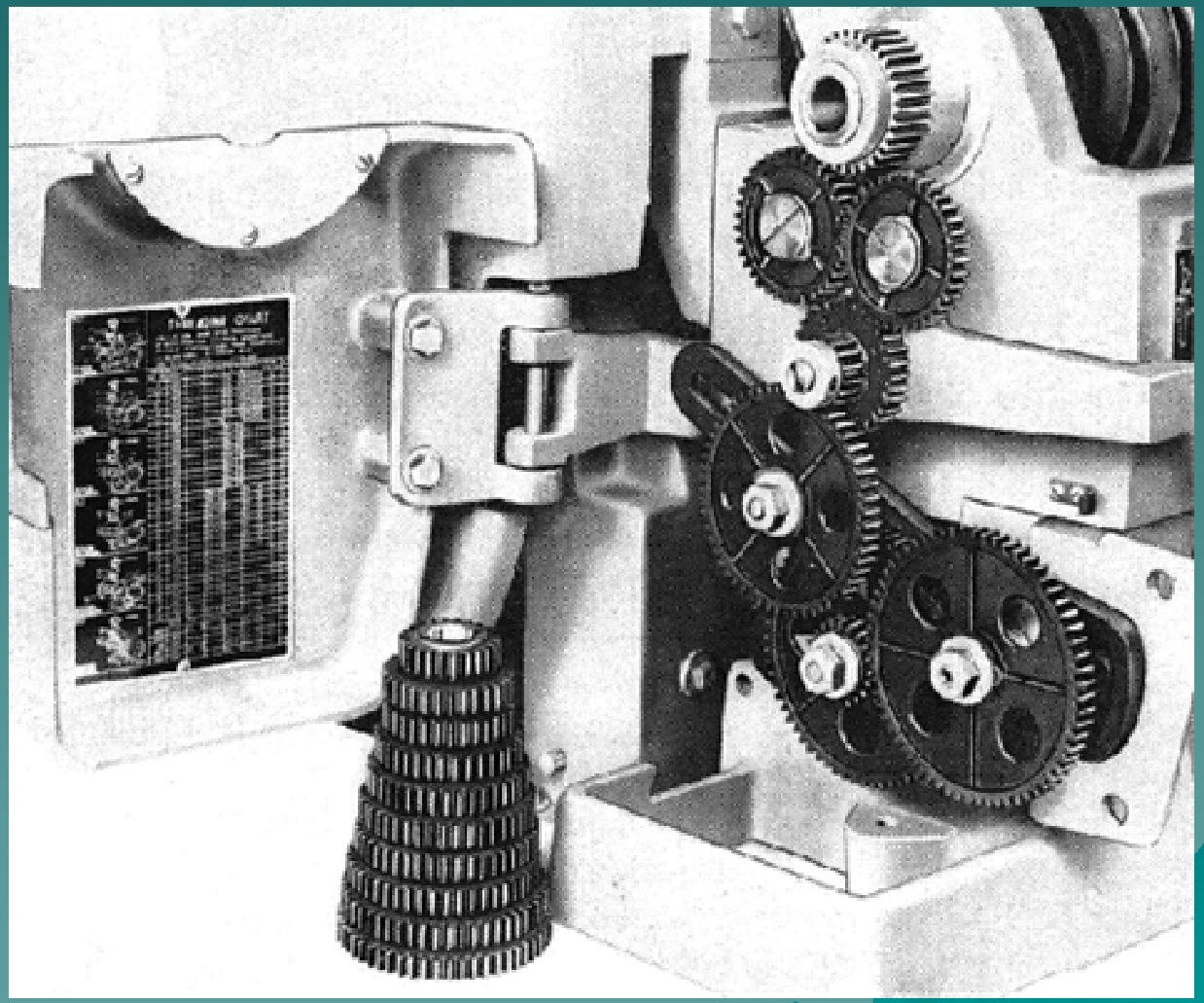
Headstock: Top view

It houses a spindle which can rotate at various speeds. Spindle holds the job by some holding device. Assembly containing some mechanism (belts/ gears) for changing speed of the spindle is housed inside the headstock



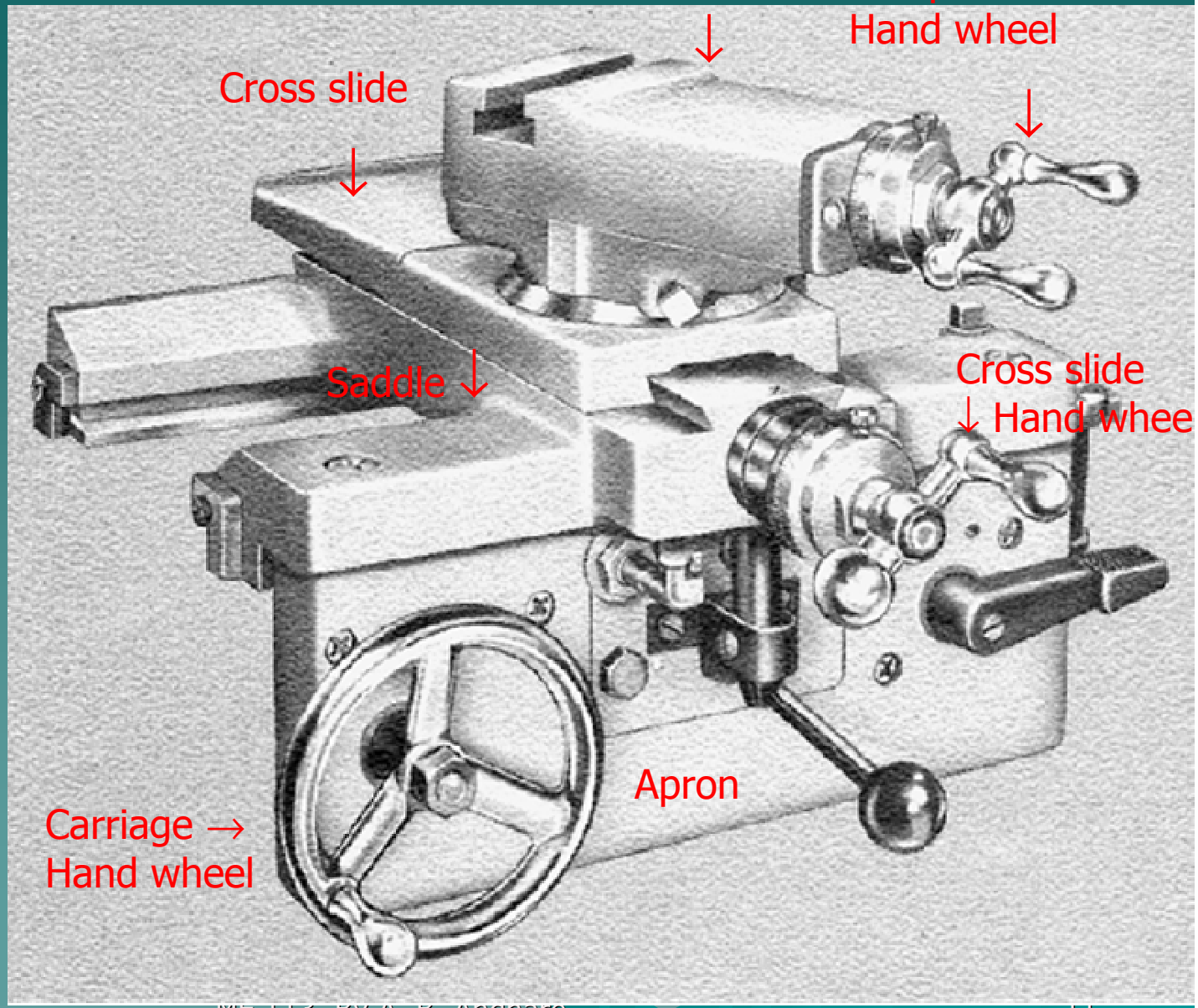
Headstock: End View





Carriage Assembly

Mounted on bed between the headstock & the tailstock. It finally carries the tool in a tool post. Carriage can slide along the bed. It carries a cross slide which moves across the lathe axis



Lathe accessories
1. Chucks 2. Steadies or rests 3. Centres 4. Face plate & Angle plate 5. Mandrels

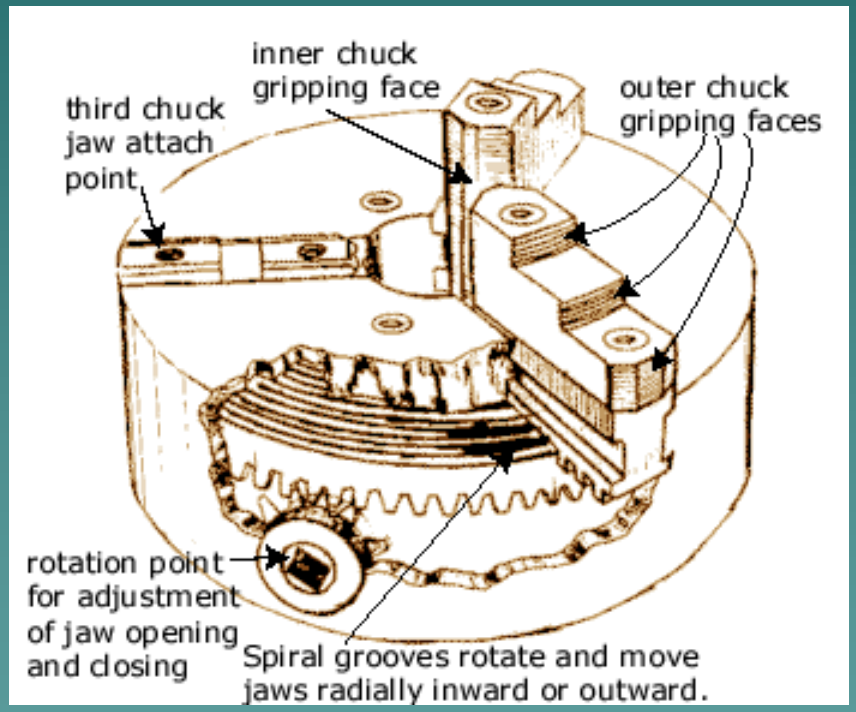
3 Jaw chuck:

All the three jaws move in or out simultaneously

Easy to locate the job.

Also called as self centering chuck

Suitable only to clamp round job.



1. Chucks

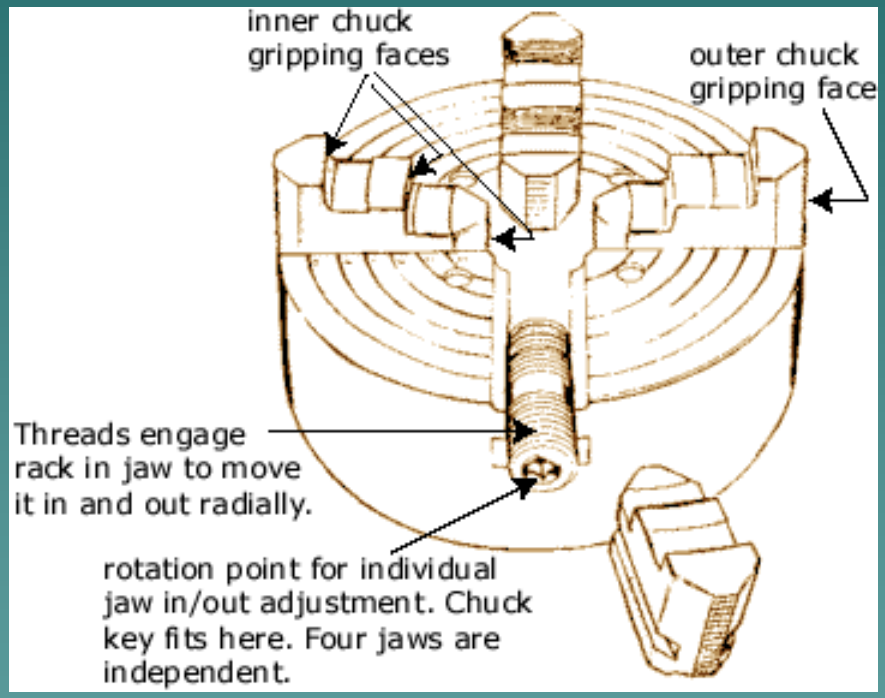
4 Jaw chuck:

All four jaws move independently.

Takes more time to locate the job.

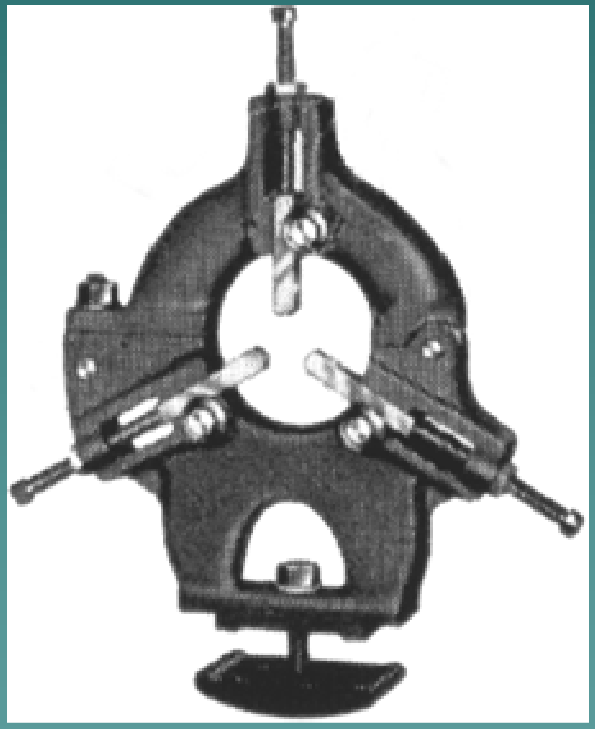
Rectangular shape job can also be clamped

Suitable for eccentric turning



2. Lathe steadies or rests

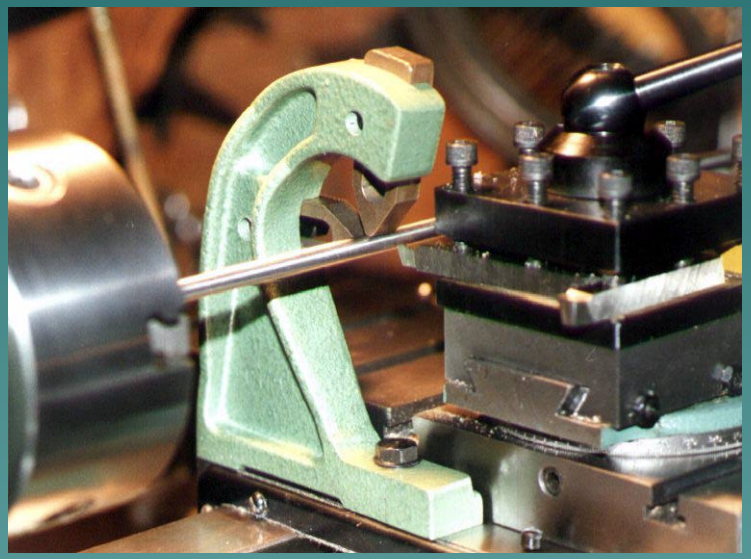
Steady Rest



Rests are used to support long jobs

Follower rest

Lathe steadies in use

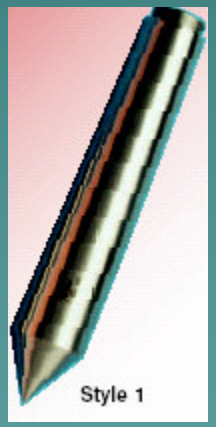


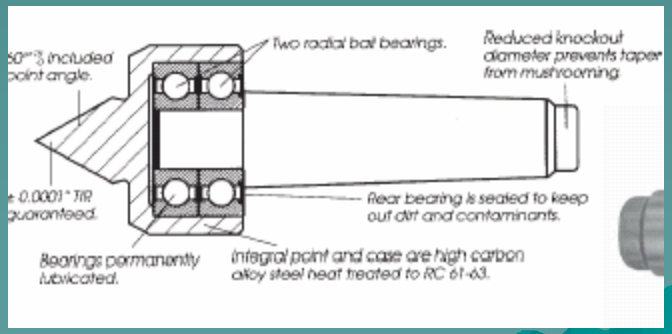
3. Lathe centres

Lathe centres are used to support the long length of jobs at the tailstock end. Centres are mounted in the tailstock.

Dead centre: Remains fixed

Revolving centre: Rotates with the job





Lathe specifications

A – Length of bed

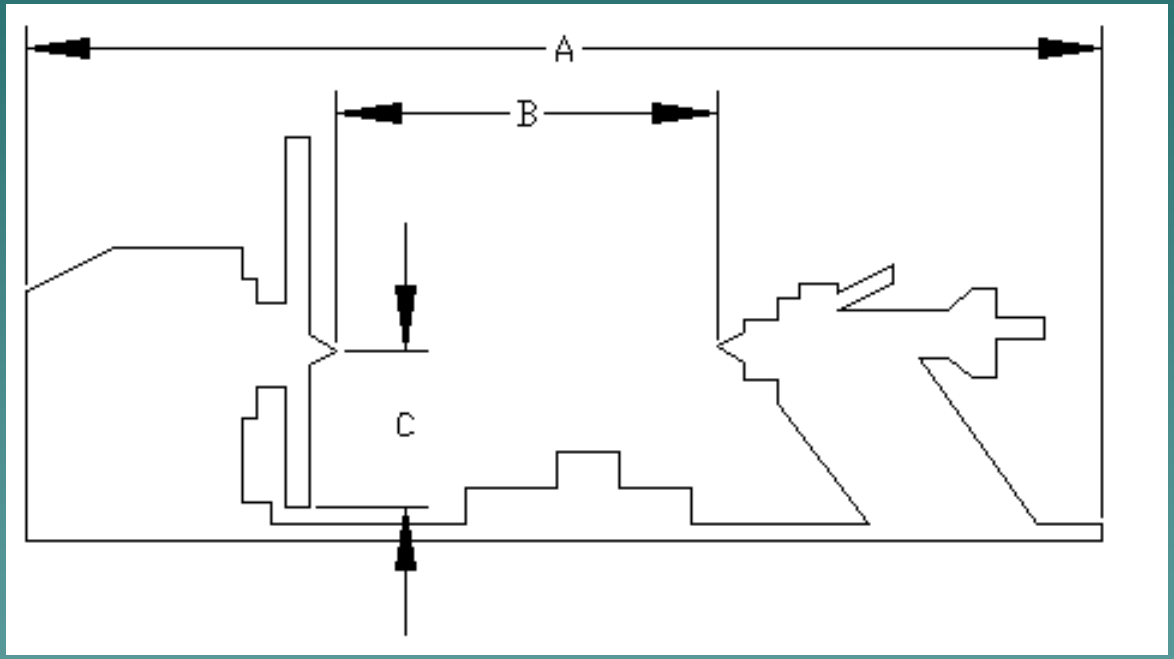
B – Admit between centres

C- Height of centres

Swing dia over bed

Swing dia over carriage

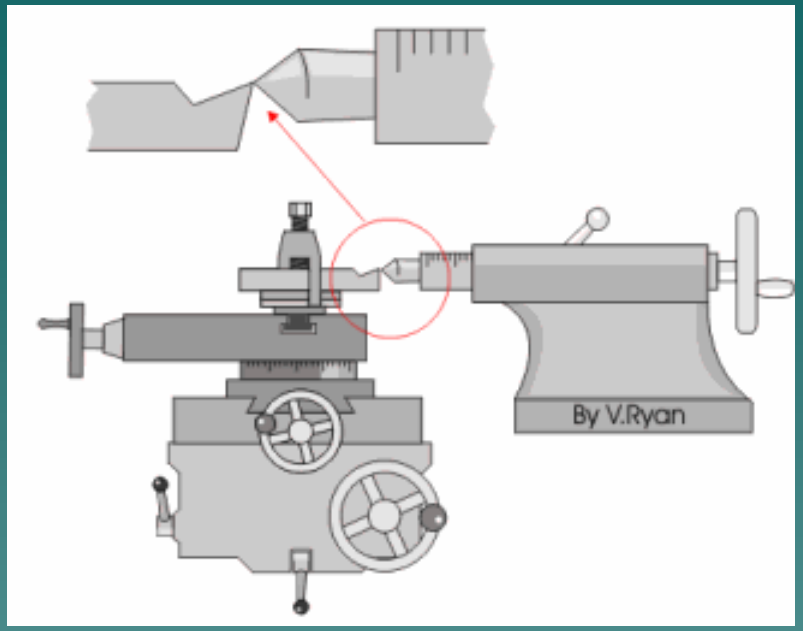
Max. bar diameter



Lathe Operations

1) Centering
2) Turning
3) Drilling
4) Boring
5) Facing
6) Chamfering
7) Taper Turning
8) Knurling
9) Threading
10) Grooving and Parting off

How to set tool height ?



1. Mount the tool in the tool post.
2. Move the carriage towards the tailstock.
3. Tool tip height is matched against the centre height in the tailstock.
4. Tool is clamped at the set height.

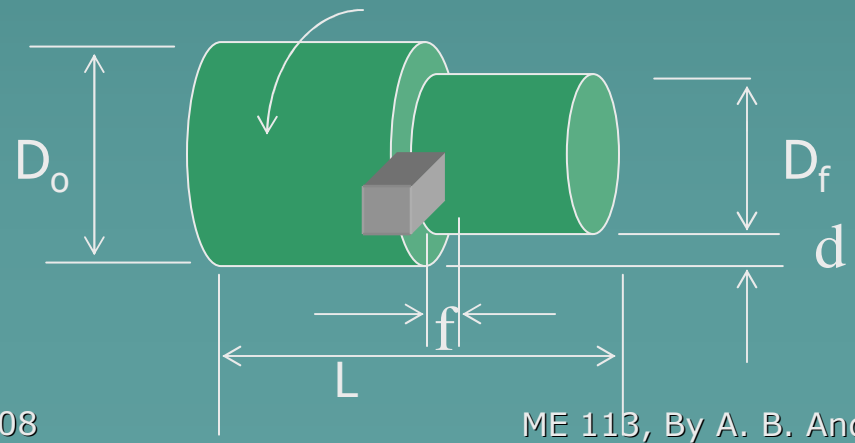
The operating parameters

1. **Rotational speed** (N): For the combination of tool material and work piece material, select the best cutting speed (v) for the operation.
2. **Cutting speed** (v): It is the linear speed (m/min) at the point of contact between the tool and the work piece.
3. Calculate the rpm (N) from the above information by using the following formulae.
4. The **feed** f, (mm/rev) is selected on the same lines as cutting speed.

e.g. for H.S.S. as tool material and Mild steel as work piece, v is 30 m/min for turning operation. For a 50 mm dia this gives N = 191 rpm. Select lathe spindle speed which is closer to the calculated value.

Cutting Speeds (m/min) for H.S.S Tool & M.S. Job

Turning: 25-31	Threading: 9-10
Drilling: 28-35	Knurling: 6-9



Rotational speed $$N = \frac{v}{\pi D_o}$$

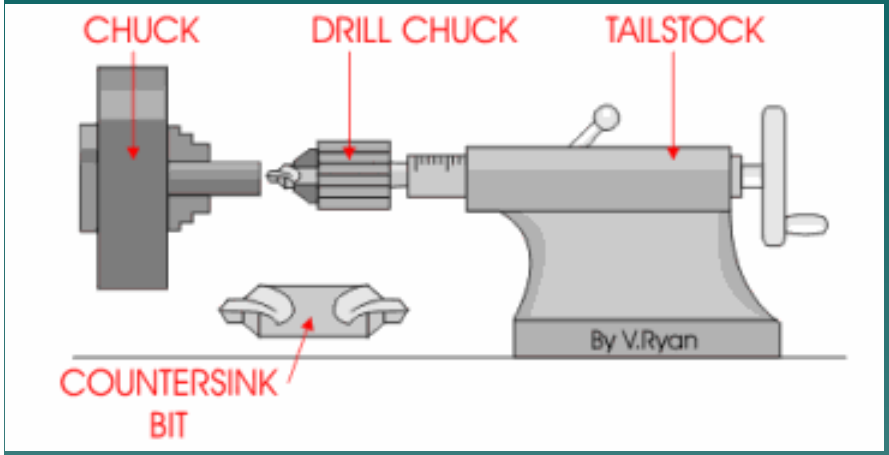
Depth of cut $$D_o - D_f = 2d$$

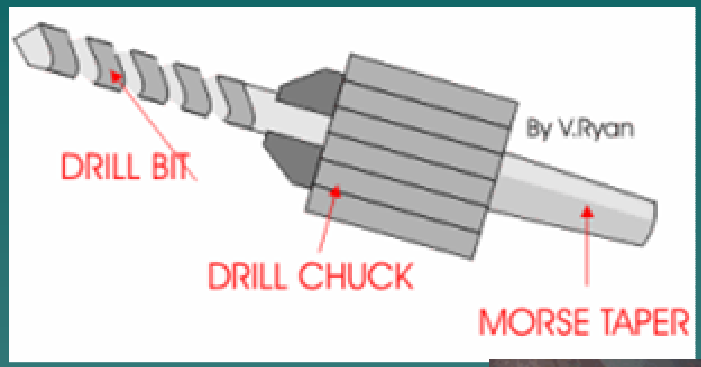
Feed rate mm/min $$f_r = Nf$$

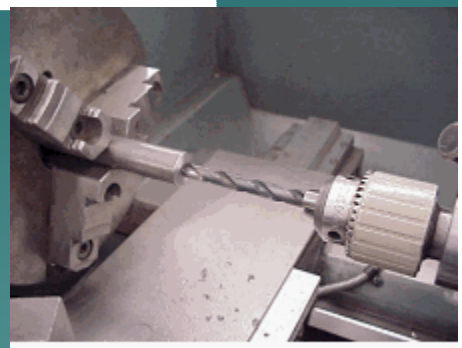
Machining time $$T_m = \frac{L}{f_r}$$

Material removal rate $$MRR = vfd$$

Centering / Drilling





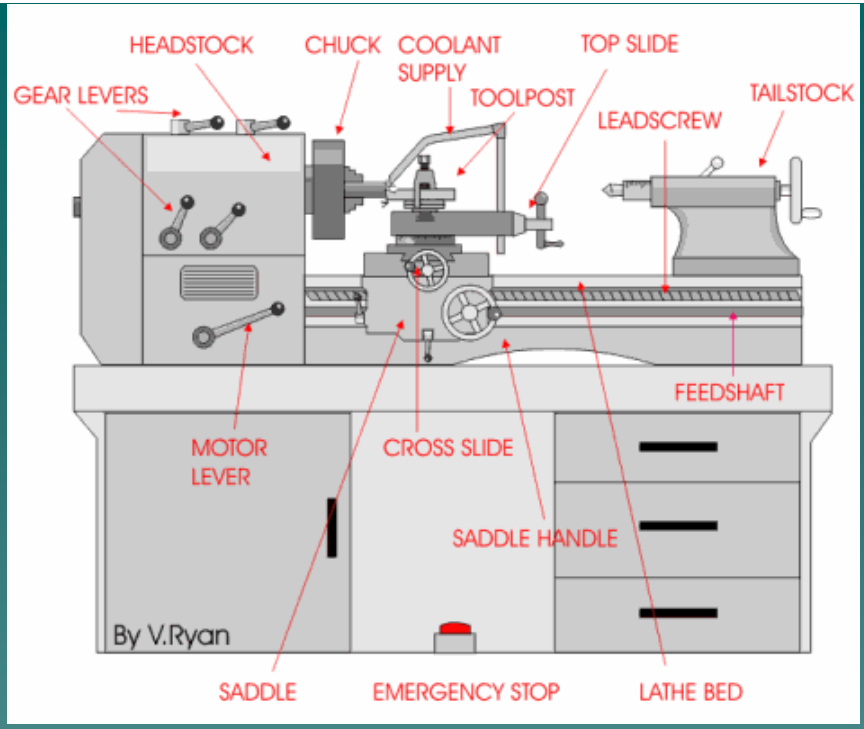


Drilling

1. Centering - Operation of making a small conical shaped hole at the end of job along the axis of job.
2. This hole is used for supporting the job at the tailstock end by centres.
3. Drilling - Operation of making a cylindrical hole along the axis of rotation, using a drill bit. Tool Feed is given by rotating the tail stock hand wheel.

Turning

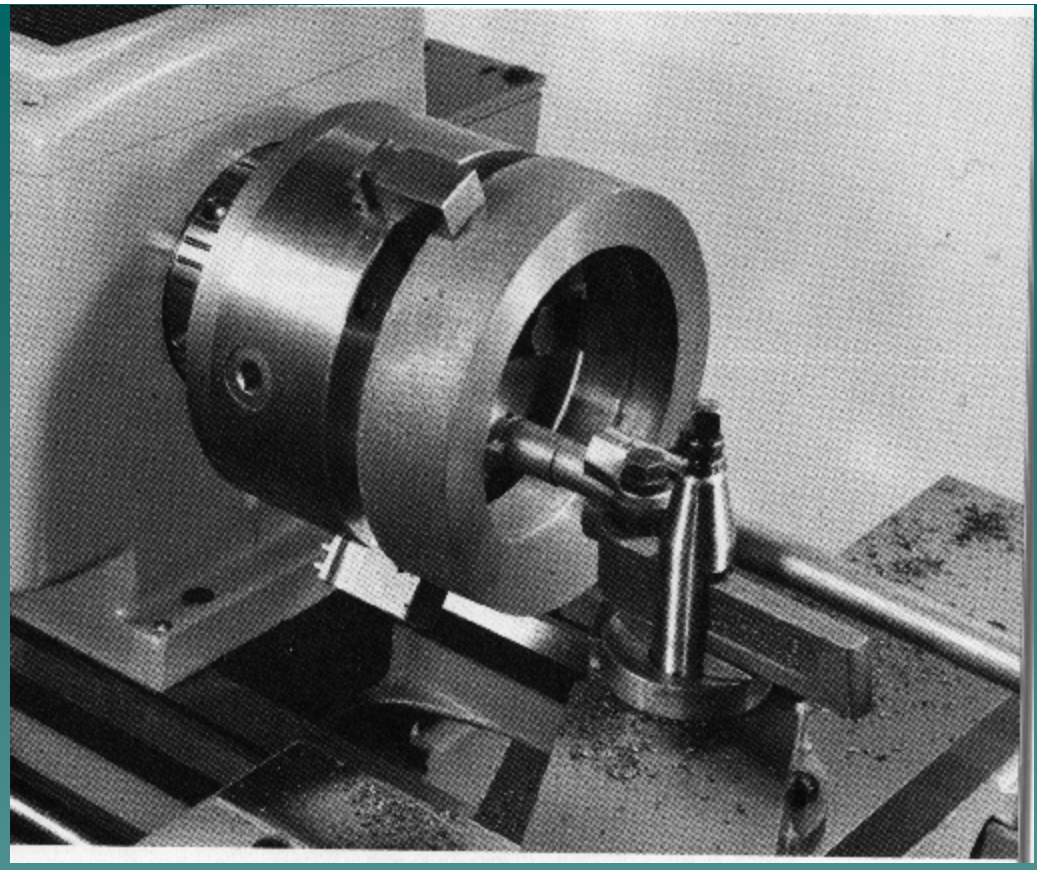
Turning



1. Job rotates. Tool moves parallel to the axis of rotation of job. Tool motion by carriage hand wheel.
2. First cut is light cut, then 2-3 rough cuts (feed 0.3-0.5 mm, lower speed & depth of cut 2-5 mm) and last cut is finish cut (feed 0.1-0.3 mm, higher speed & depth of cut 0.5-1 mm)
3. Rotational speed of the job depends on the job material, tool material, the operation and condition of the tool and the machine.

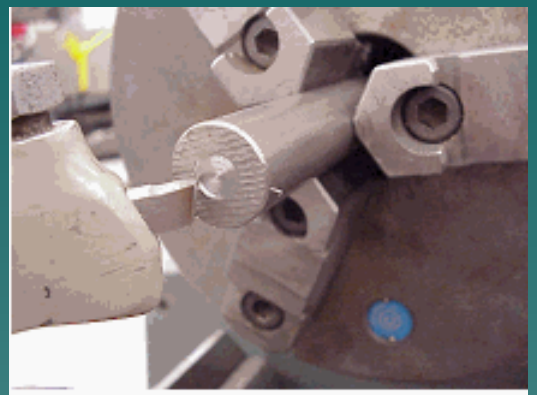
Boring

Boring

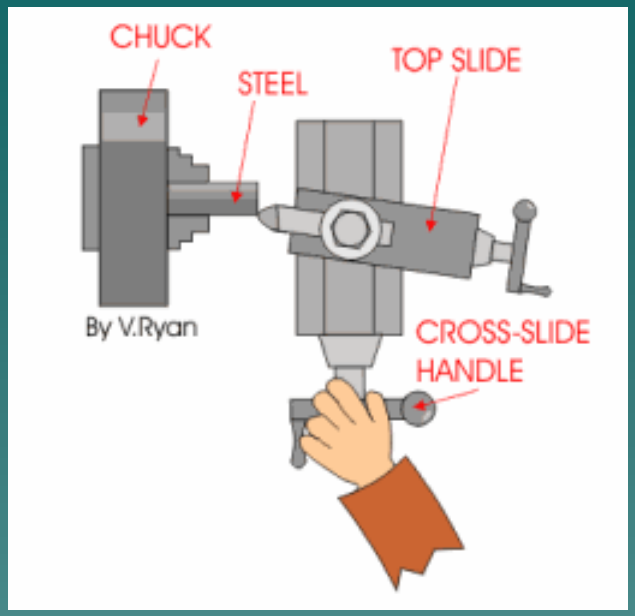


1. Operation of enlarging a hole.
2. Tool is moved by carriage hand wheel parallel to lathe axis.
3. It may be called as internal turning.
4. Geometric accuracy obtained is better than drilling.

Facing



Facing



1. Job rotates & tool is moved across the lathe or spindle axis by cross slide.
2. Facing creates a reference surface for measuring length.
3. Facing is also used for reducing the length of job.

Chamfering

1. Operation of producing beveled edge or small taper at the end of the job.
2. This may be done by a form tool fed parallel to the axis of rotation.
3. Also can be achieved by turning the compound slide.
4. Chamfer is required to avoid sharp corners/ burrs.
5. It helps in proper engagement of matching parts.

Taper Turning

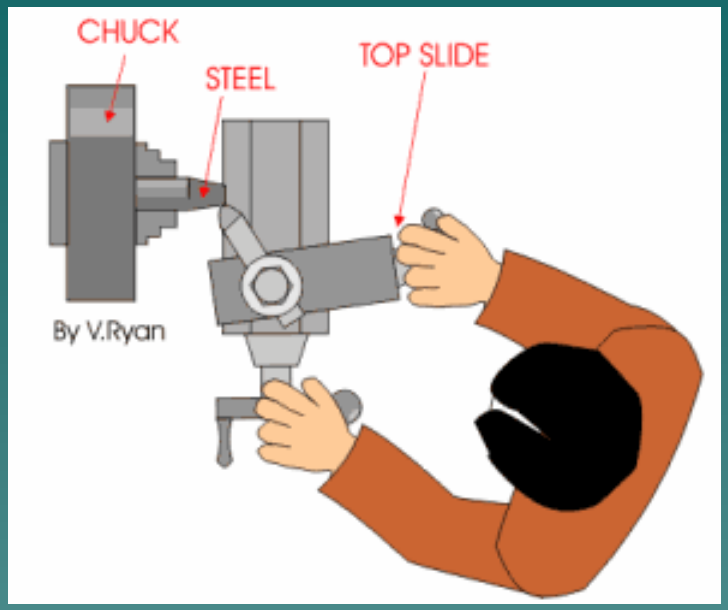
Taper is a constant change in diameter. Different methods are used.

1) By using a form tool.
2) By using the compound slide.
3) By setting over the tailstock
4) By using a taper turning attachment
5) By combining two feeds

By Form Tool: Method of using a form tool is similar to chamfering.

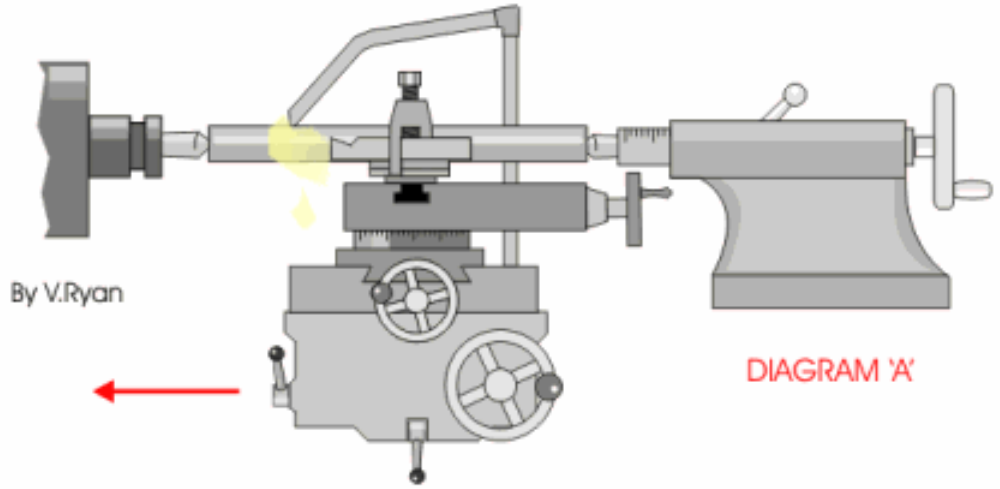
- Form tool is a tool having the required taper on it (in opposite sense).
- Entire width of tool acts as a cutting edge.
- Method is suitable only for very short length of taper.

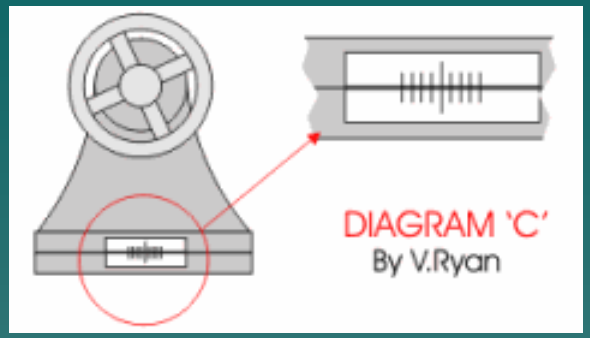
Taper turning by swiveling the compound slide

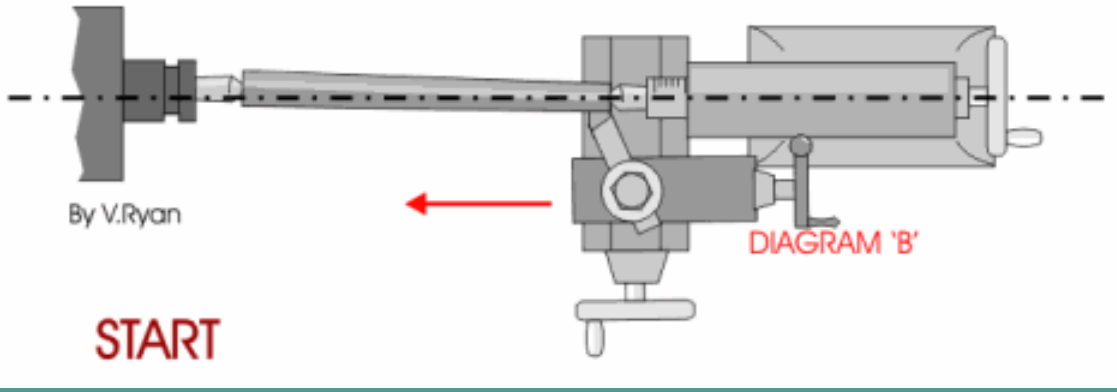


1. Compound slide is turned to the required angle of taper.
2. Any angle of taper can be obtained.
3. Suitable for small length of taper.
4. Tool moves at an angle to the axis of rotation of the job.
5. Tool is moved by the compound slide hand wheel.

Taper turning by the tailstock set over method

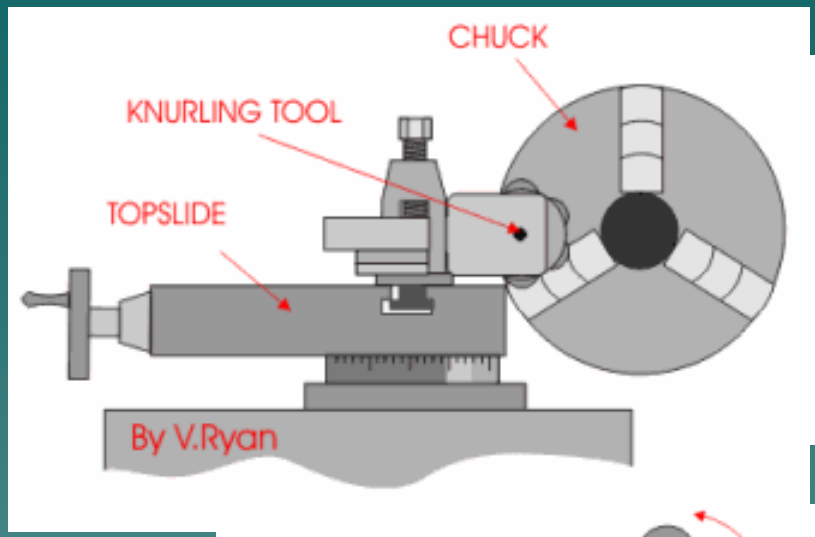


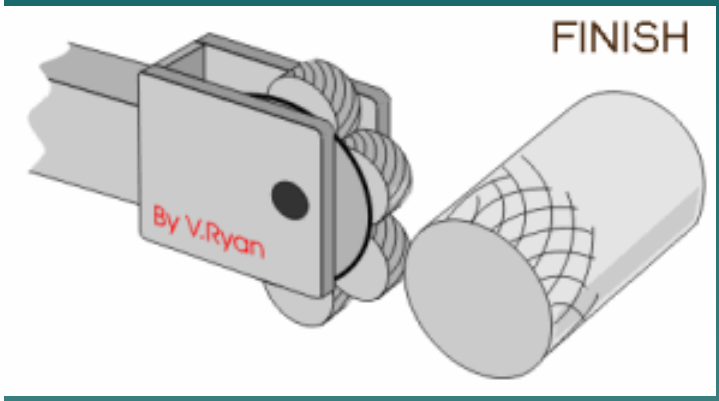


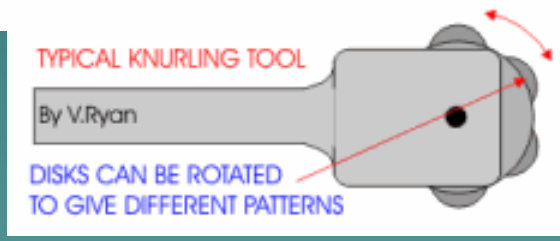


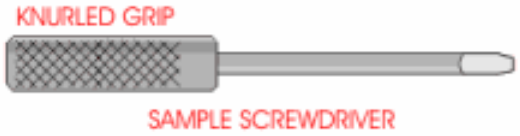
1. Job is supported between centres at the headstock & the tailstock end.
2. Axis of rotation of the job is shifted by shifting the tailstock.
3. Tool is moved parallel to the axis of the lathe.
4. Method is suitable for long length of jobs with less taper angles.

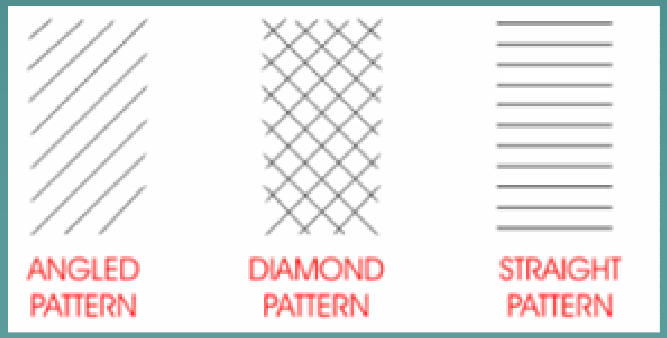
Knurling


CHUCK
KNURLING TOOL
TOPSLIDE
By V.Ryan

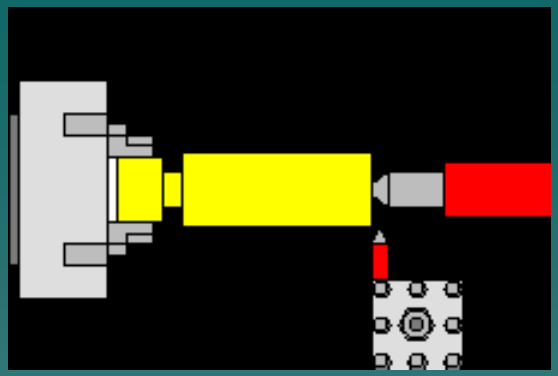

FINISH
By V.Ryan


TYPICAL KNURLING TOOL
By V.Ryan
DISKS CAN BE ROTATED
TO GIVE DIFFERENT PATTERNS


KNURLED GRIP
SAMPLE SCREWDRIVER


ANGLED
PATTERN
DIAMOND
PATTERN
STRAIGHT
PATTERN

Threading



An operation of producing threads (helical grooves) on a cylindrical surface.

Important parameters: Shape of thread, pitch and depth.

Shape – controlled by tool shape, Pitch – obtained by definite relation between the job rotation and tool feed. (What should be the feed per rotation?). Depth is controlled by the depth of cut.

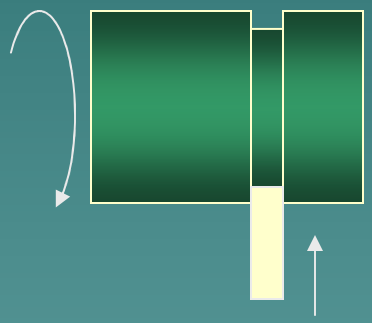
Operation is done in 4-5 steps.

Each time cut should start at the same point.

Threads are specified as M 12*1.75. What is the meaning?

Grooving and Parting off

1. Operation of making a groove (narrow cut deeper than adjacent diameters)
2. A grooving or parting tool is used.
3. Grooves can have different shapes.
4. Groove shapes are controlled by the shape of the tool.
5. Grooving is done at the ends of threads/ shoulders.



Grooving or parting off