General Purpose Machine Tools

"LATHE OPERATIONS"

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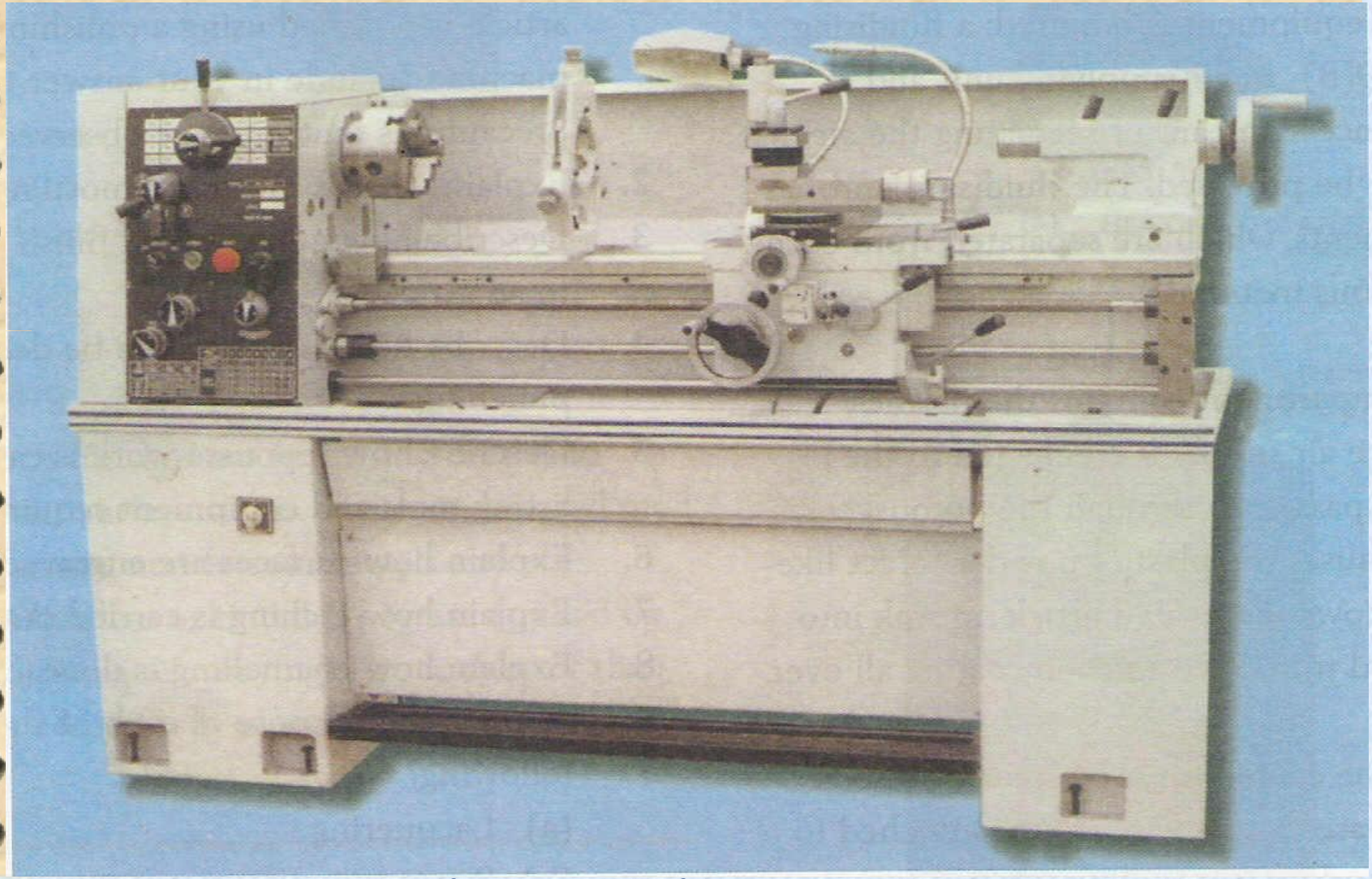
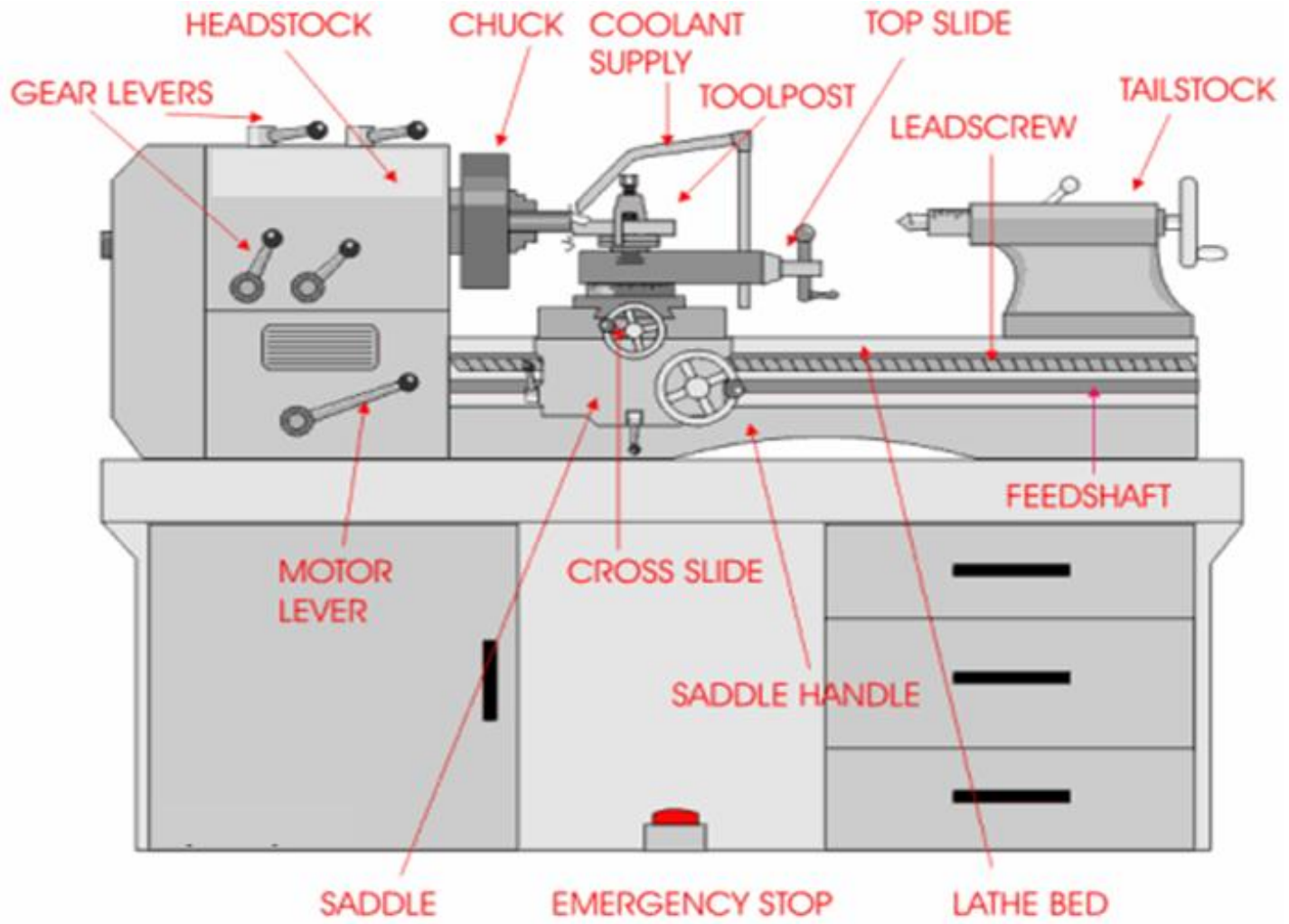
Introduction

- ✓ Lathe is a machine, which removes the metal from a piece of work to the required shape & size
- ✓ Used to manufacture cylindrical shapes from a range of materials including; steels and plastics
- ✓ The Lathe may be operated by
  - Manual lathes
  - Computer controlled lathes (CNC machines)

Photograph of lathe



Principal parts



Types of Lathe

- ✓ According to the configuration
  - Vertical
  - Horizontal
    - Centre lathe, Engine lathe, bench lathe
- ✓ According to the Purpose or use
  - General purpose
  - Single purpose
  - Special purpose
    - Tool room lathe, tracer / copying lathe

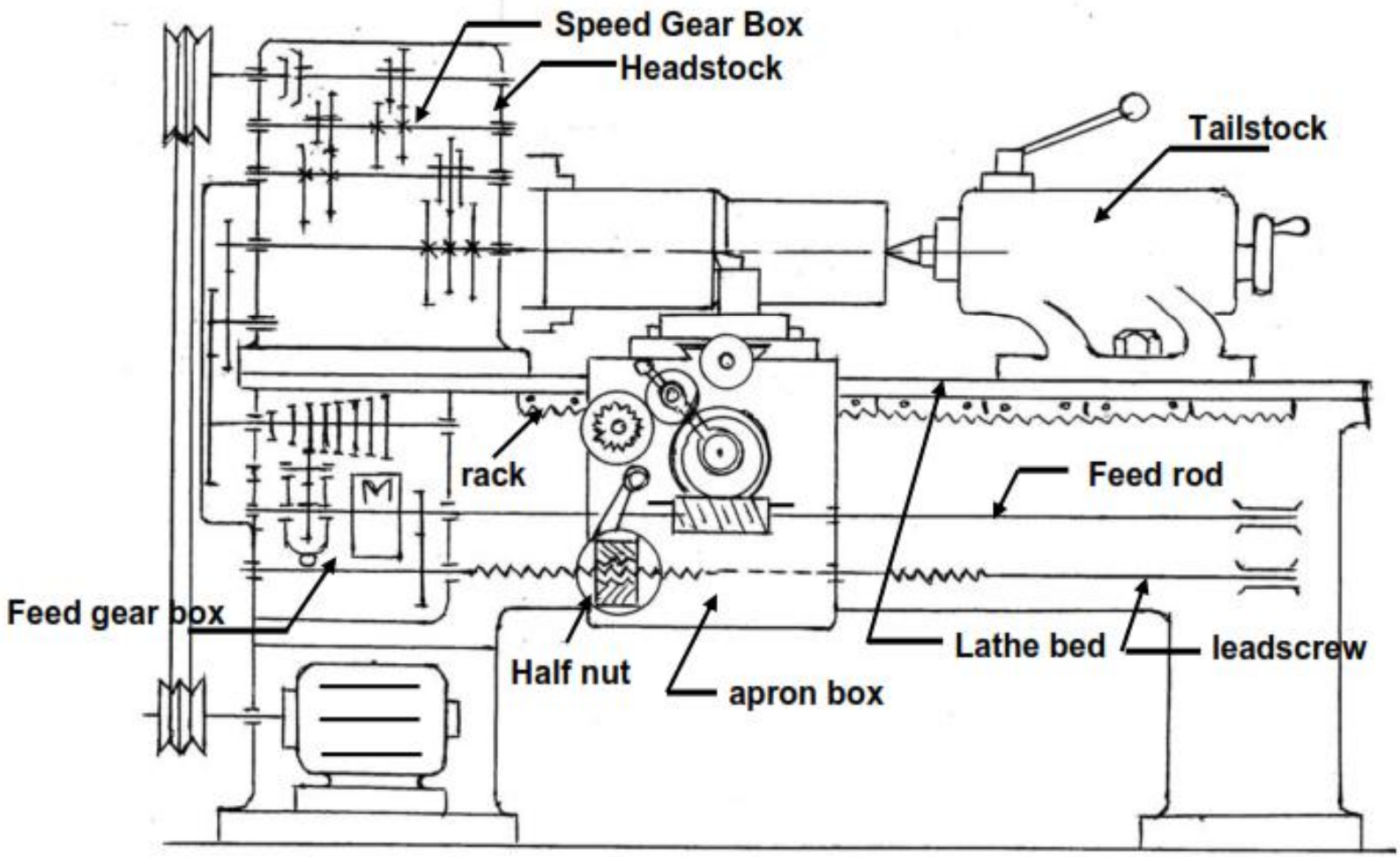
Contd.,

- ✓ According to the size and capacity
  - Small (low duty)
  - Medium (medium duty)
  - Large (heavy duty)
  - Mini or micro
    - Table top lathe
- ✓ According to the degree of automation
  - Non-automatic
  - Semi-automatic
  - Automatic

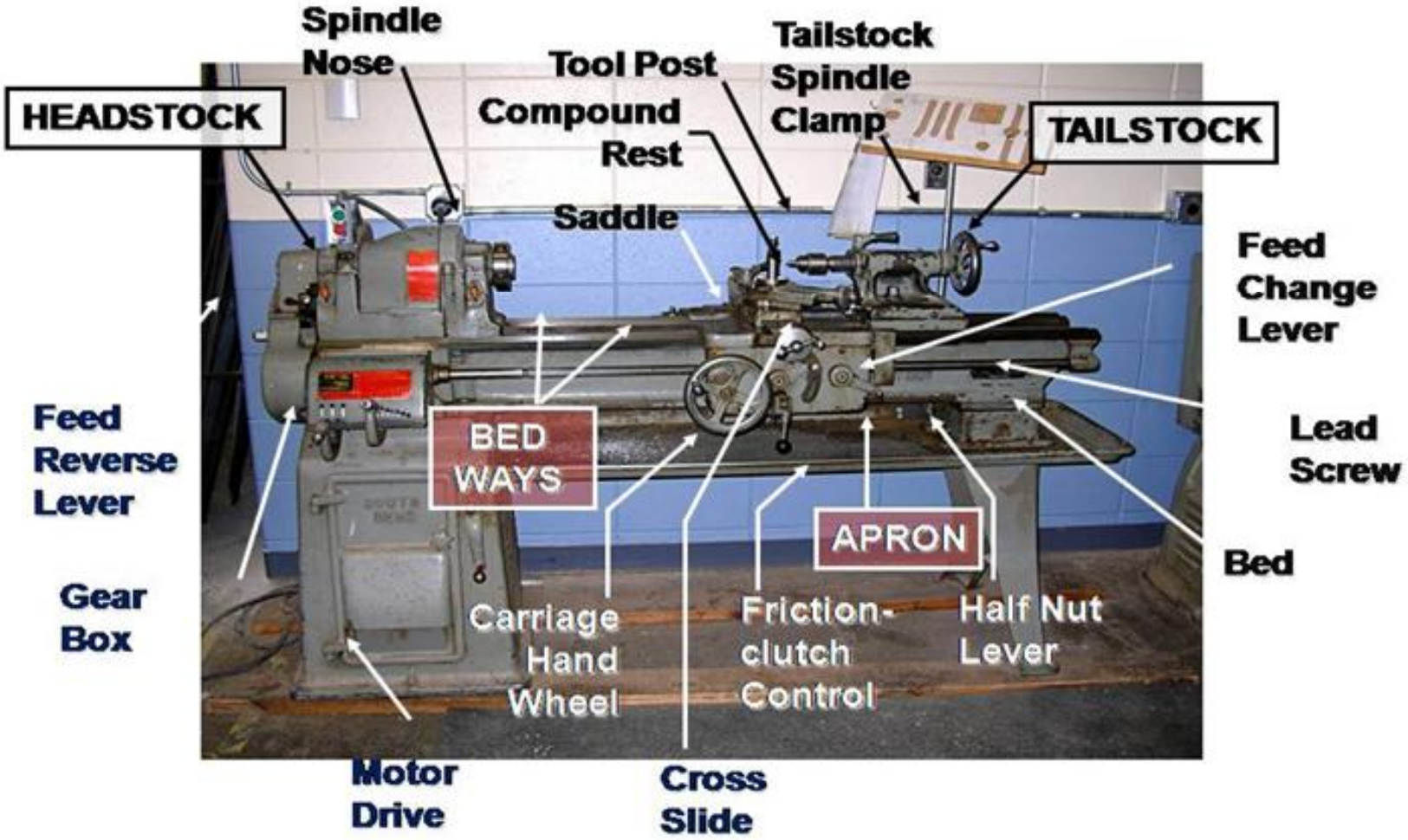
Contd.,

- ✓ According to types of automation
  - Fixed automation
  - Flexible automation
- ✓ According to no. of spindle
  - Single spindle
  - Multi spindle

Kinematic System and Working Principle

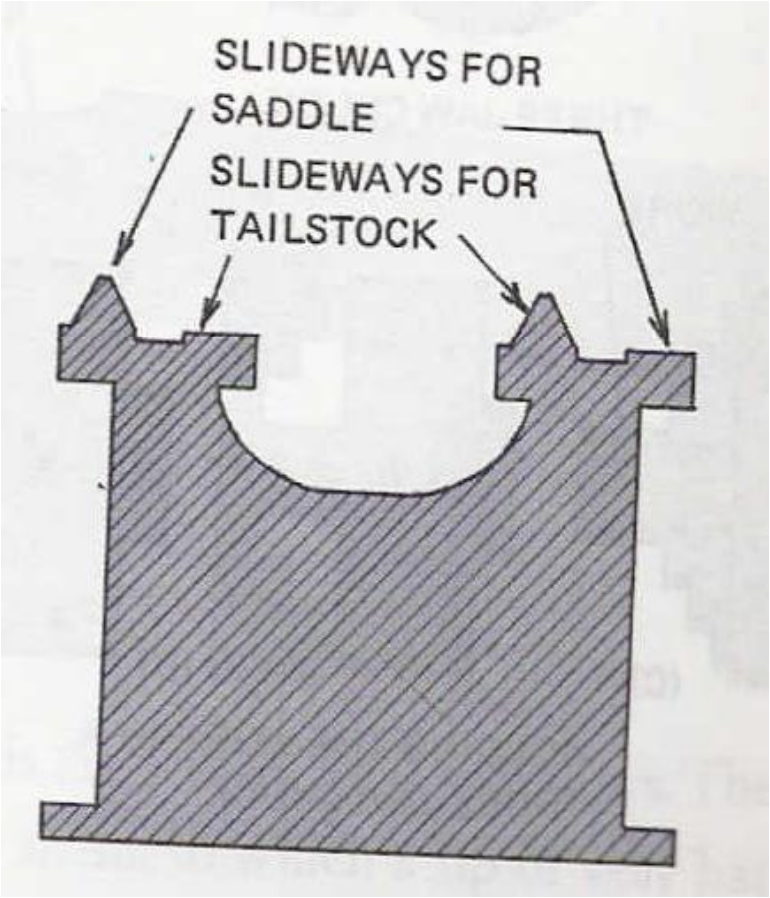


Part descriptions

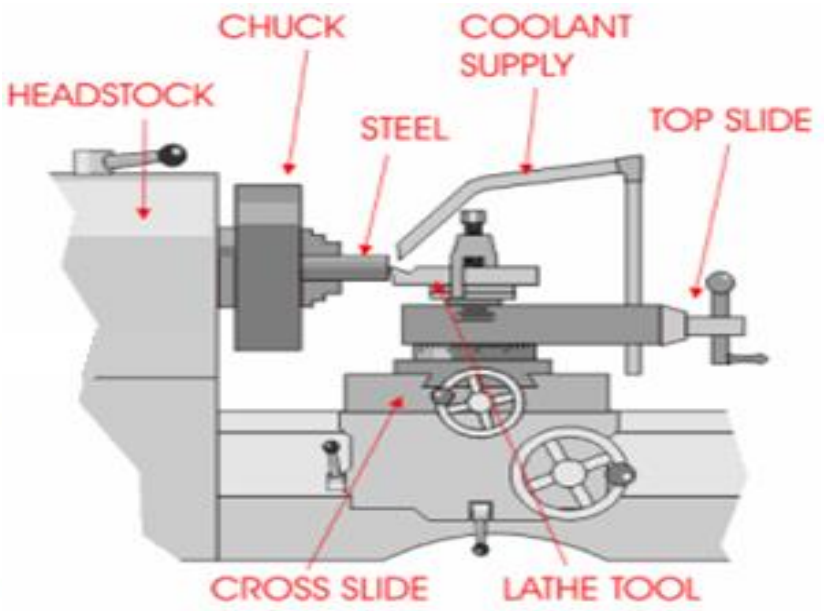


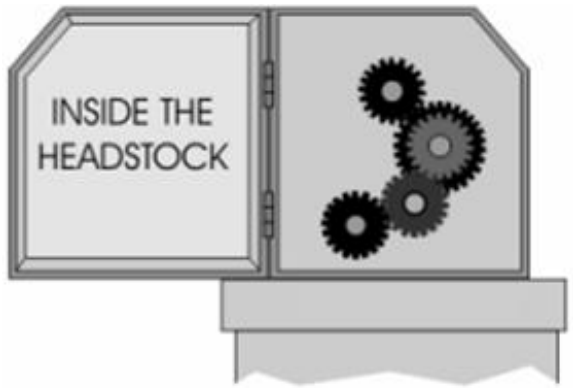
Lathe parts

- ✓ Lathe bed
  - Made from rigid cast iron
  - Accurately machined slideways
  - Slideways guide carriage & tailstock
  - Headstock on upper end of the lathe bed



Lathe parts-Contd.,

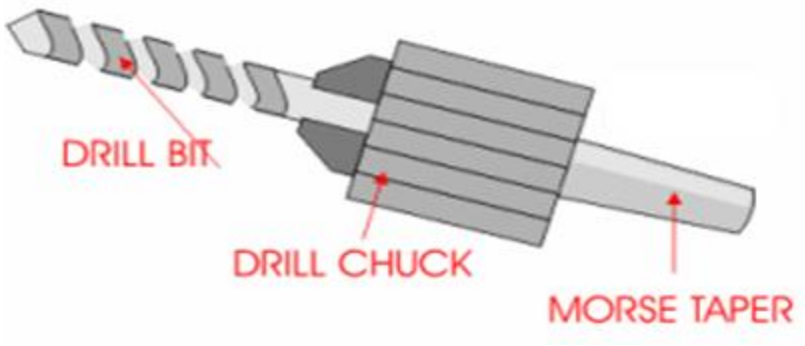


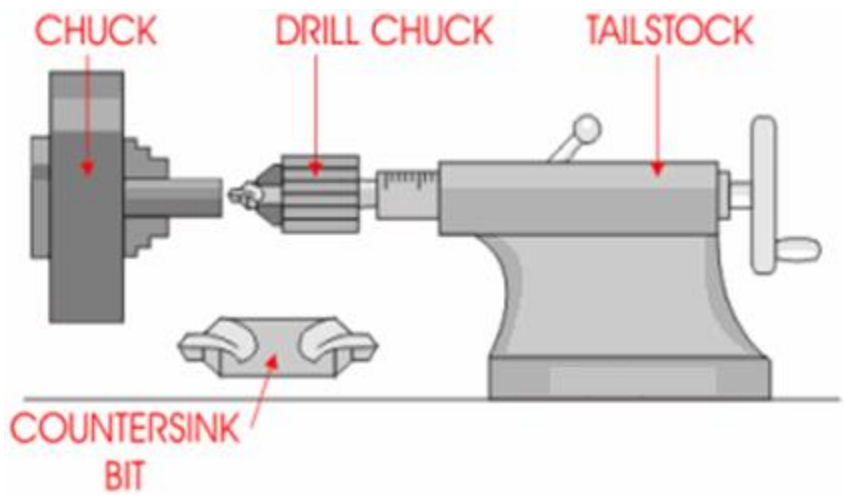


- ✓ Headstock
  - Holds lathe spindle and gears
  - Chuck is fitted to spindle
  - Spindle is hollow for long bars

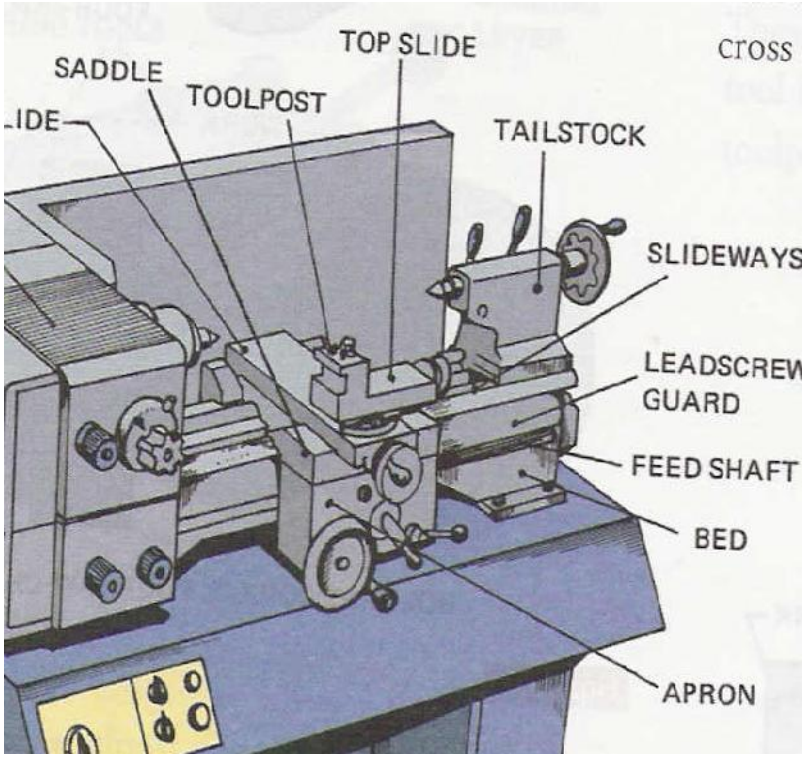
Lathe parts-Contd.,

- ✓ Tailstock
  - Can be moved along slideways
  - Can be clamped in any location
  - Inside tapered to hold drill chuck





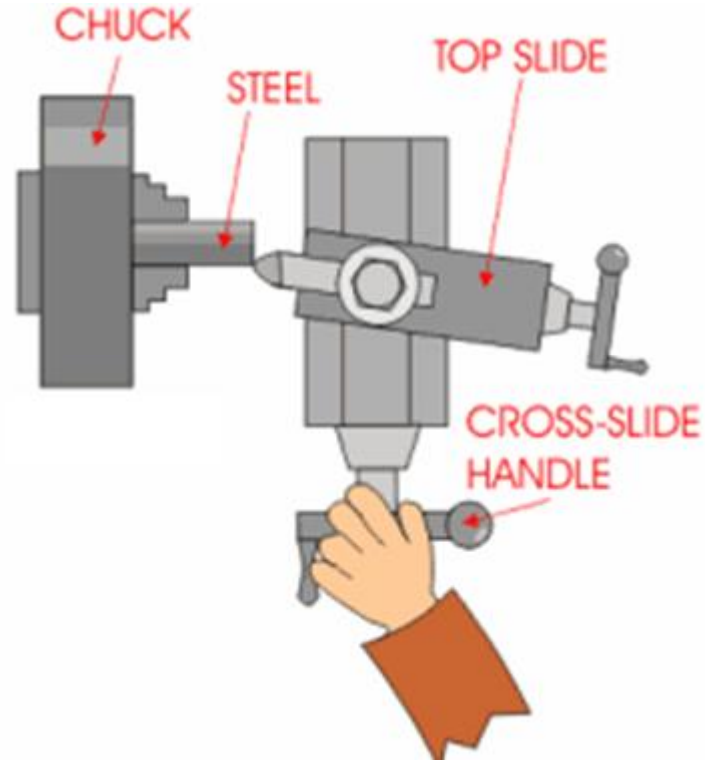
Lathe parts-Contd.,



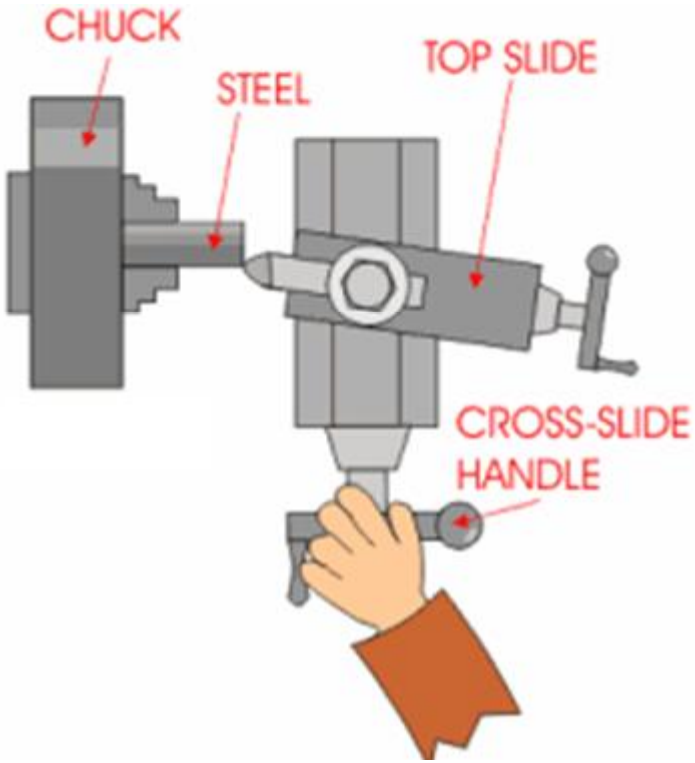
- ✓ Carriage
  - Moves along bed between tailstock and headstock
  - Saddle – across the lathe
  - Apron – hangs down in front

Lathe parts-Contd.,

- ✓ Cross Slide
  - Fitted on the Saddle
  - Moves cutting tool at right angles to lathe bed



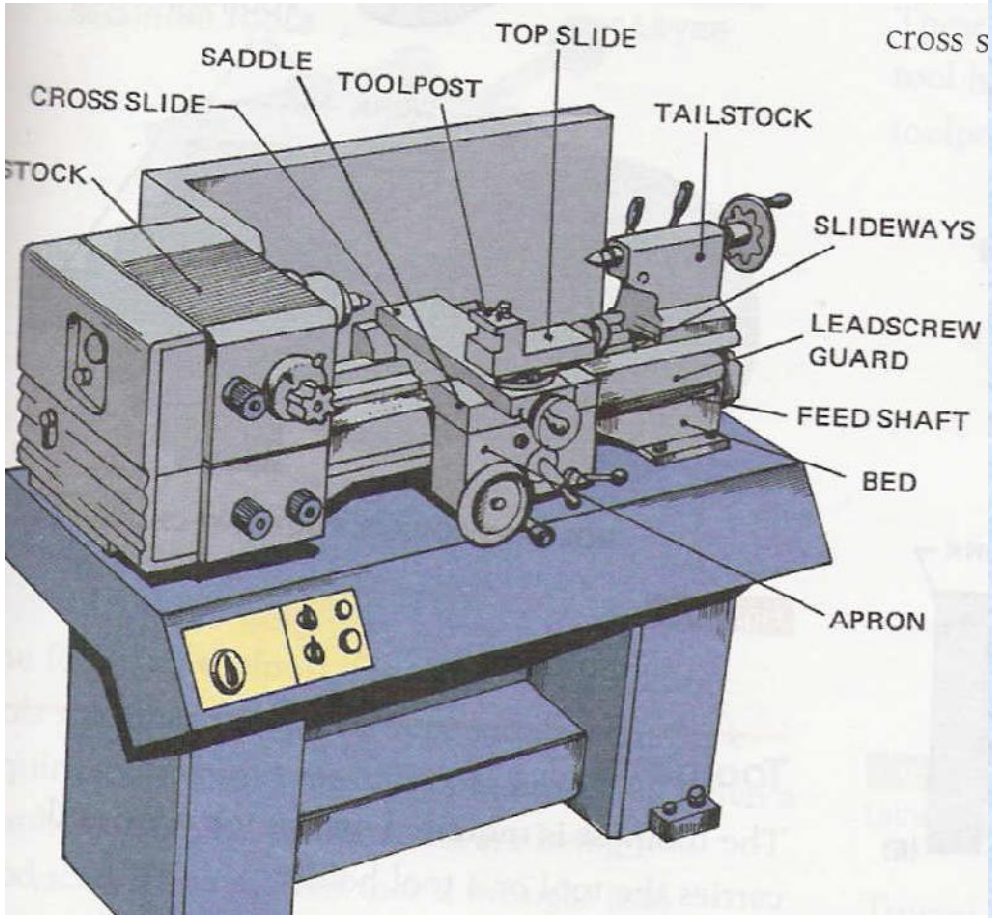
Lathe parts-Contd.,



- ✓ Top Slide (Compound rest)
  - Fitted to top of Cross slide
  - Carries toolpost and cutting tool
  - Can rotate to any angle
  - used to turn tapers

Lathe parts-Contd.,

- ✓ Feed shaft
  - Used to move the Carriage automatically
- ✓ Lead screw
  - Used when screw cutting on the lathe



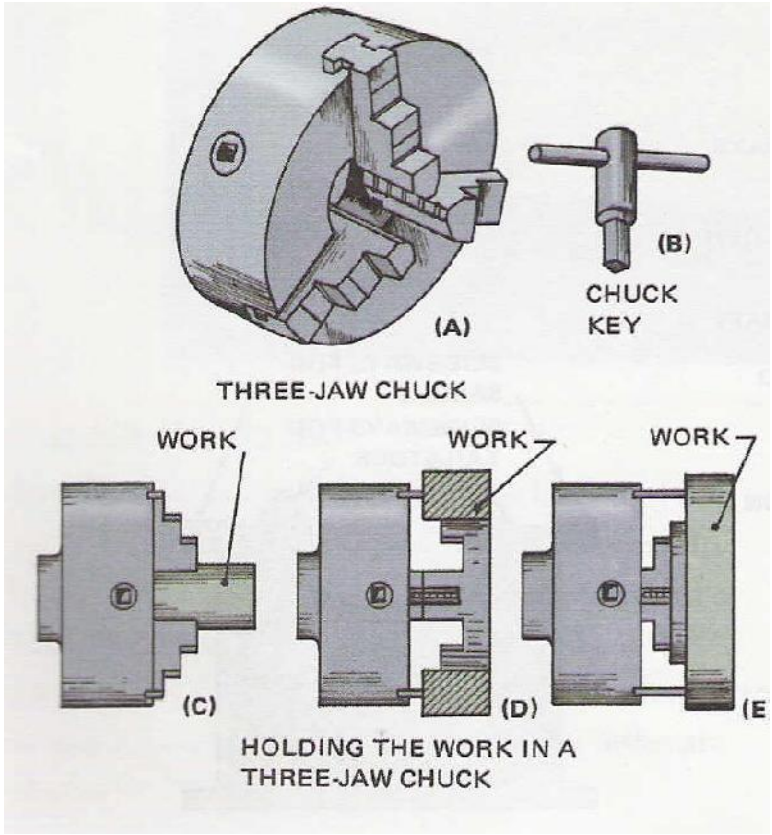
Lathe Specifications

- ✓ Distance Between the centres
- ✓ Swing over the bed
- ✓ Swing over the cross slide
- ✓ Horse power of the motor
- ✓ Cutting speed range
- ✓ Screw cutting capacity
- ✓ Accuracy achievable
- ✓ Spindle nose diameter

Lathe Accessories

- Divided into two categories
  - Work-holding, -supporting, and –driving devices
    - Lathe centers, chucks, faceplates
    - Mandrels, steady and follower rests
    - Lathe dogs, drive plates
  - Cutting-tool-holding devices
    - Straight and offset toolholders
    - Threading toolholders, boring bars
    - Turret-type toolposts

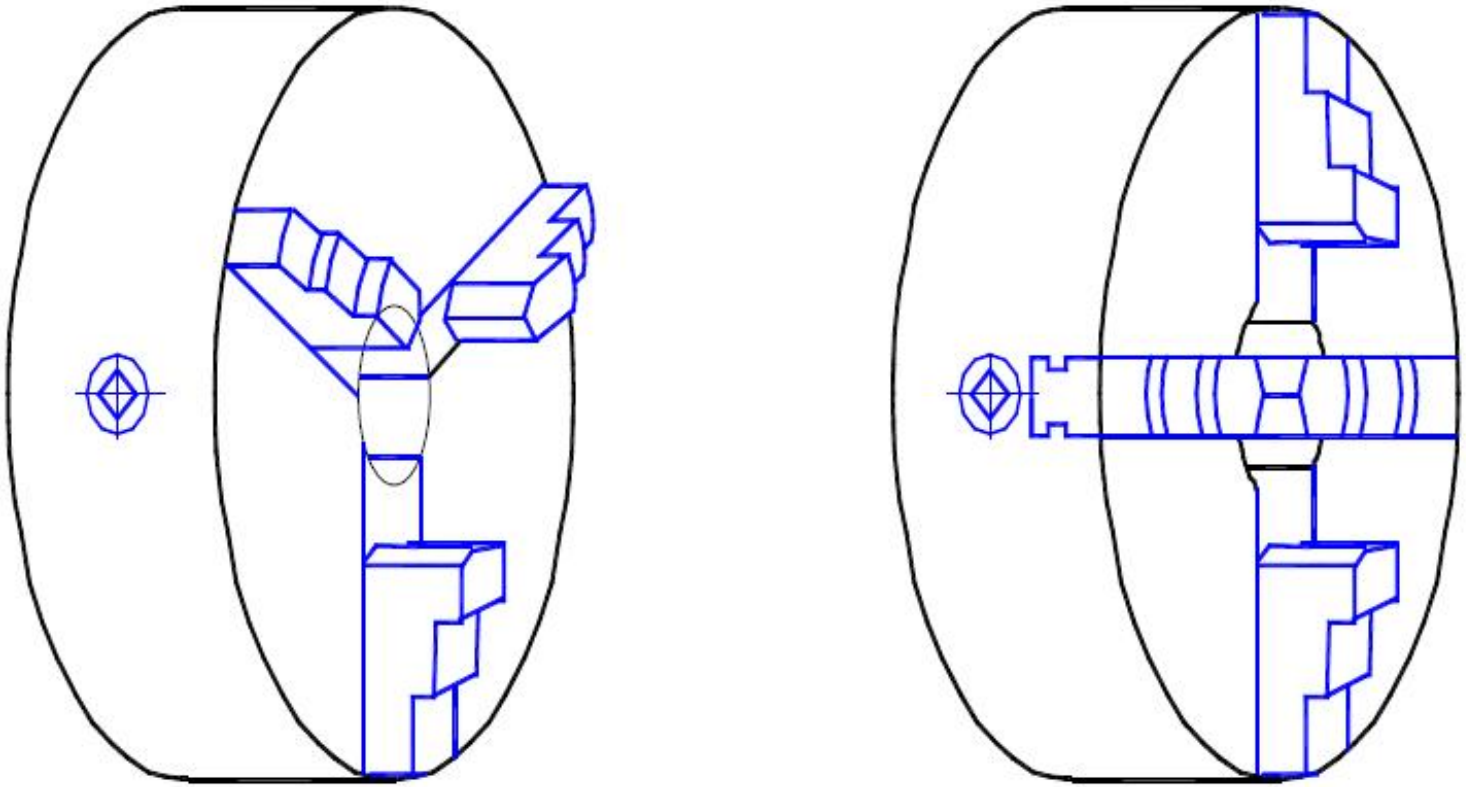
Work holding devices



- ✓ Three Jaw Chuck
  - Self centring
  - Holds round and hexagonal work
  - 3 jaws are connected
  - Jaws are stamped 1,2 & 3 and fitted in order
  - Chuck key used to open

Contd.,

Three jaw	Four Jaw



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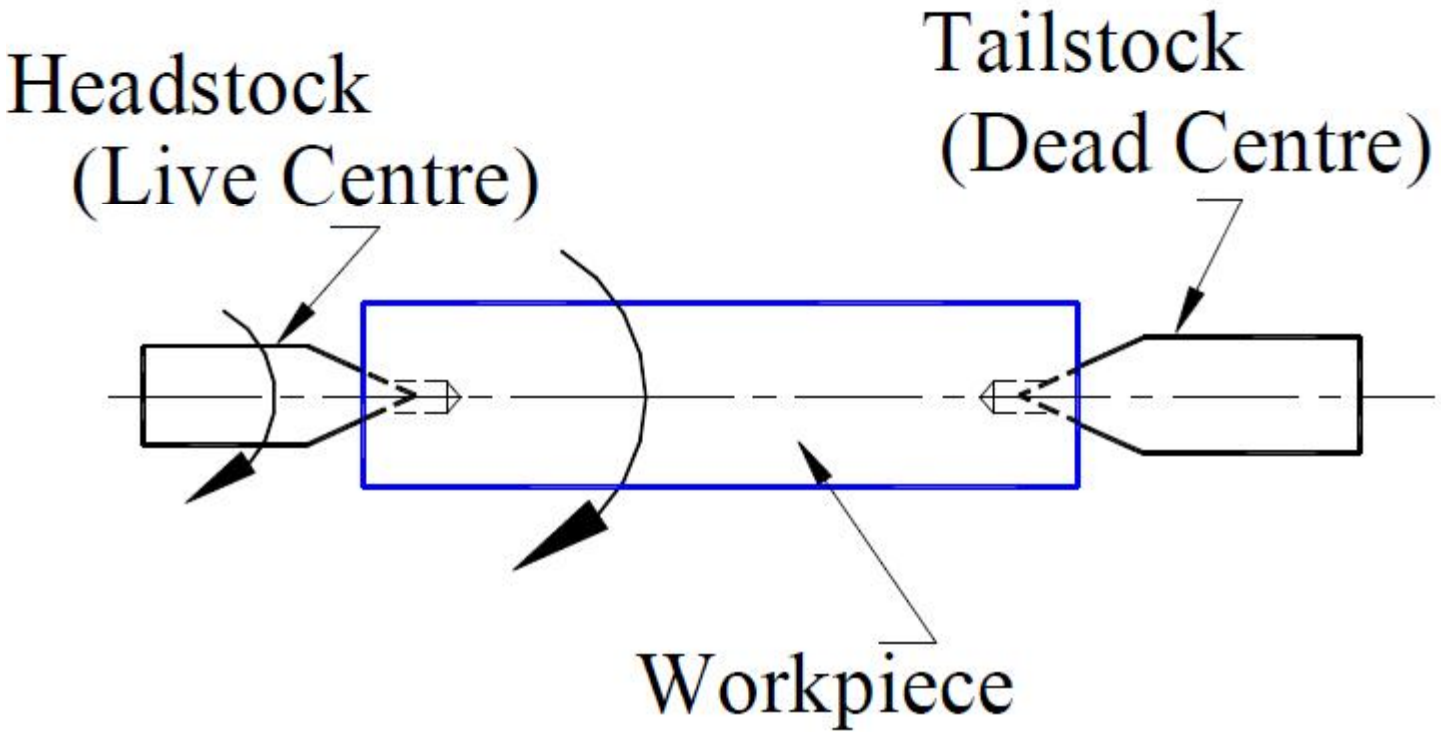
Centres



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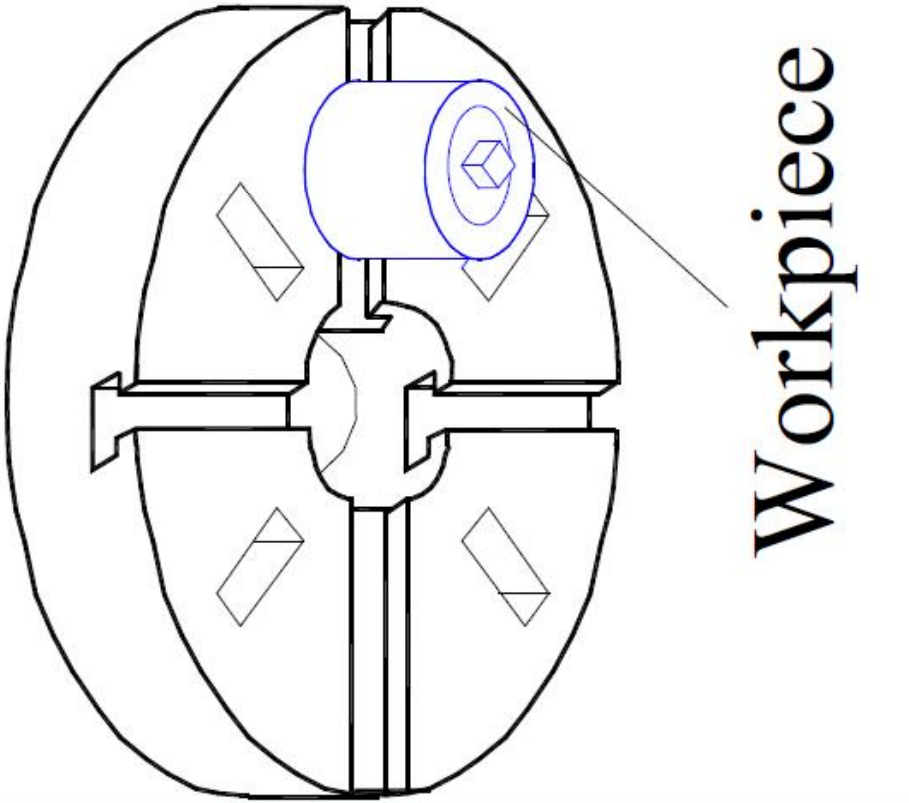
Face Plate



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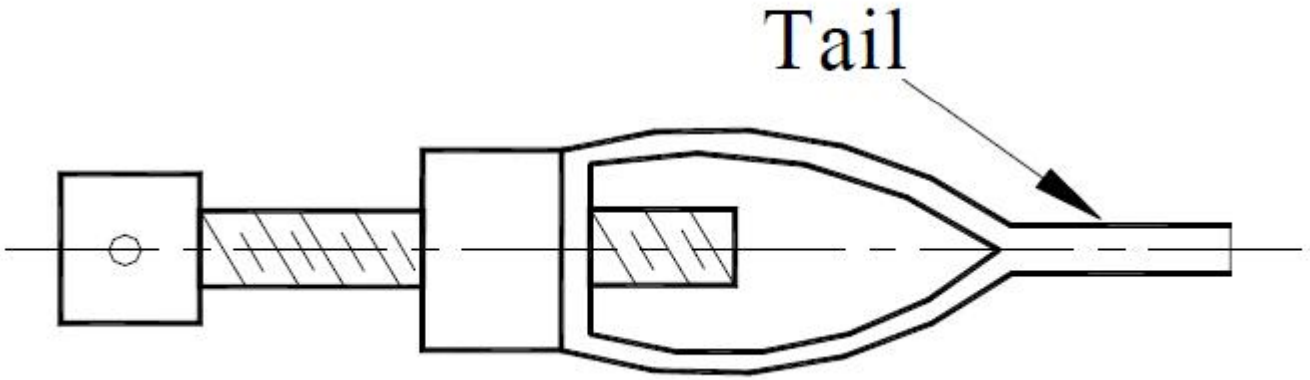
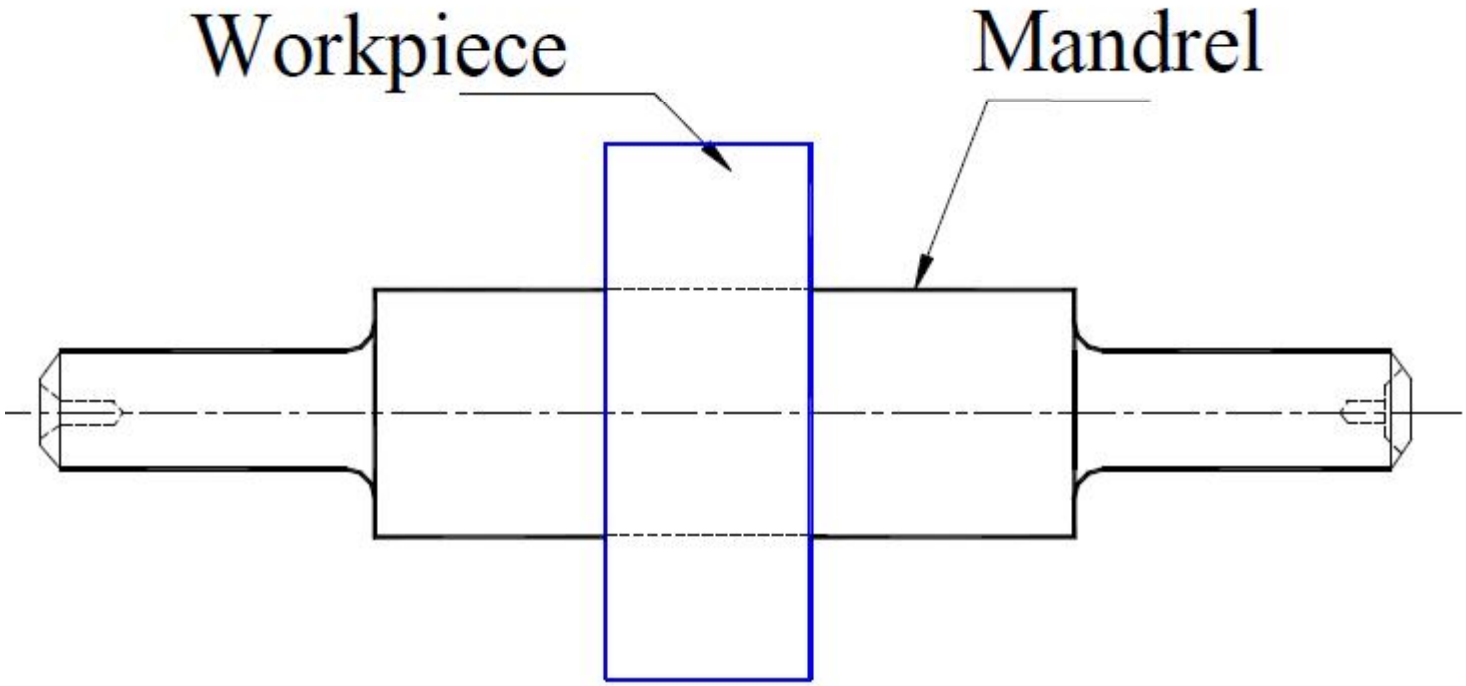
Dogs



Contd.,

Mandrel



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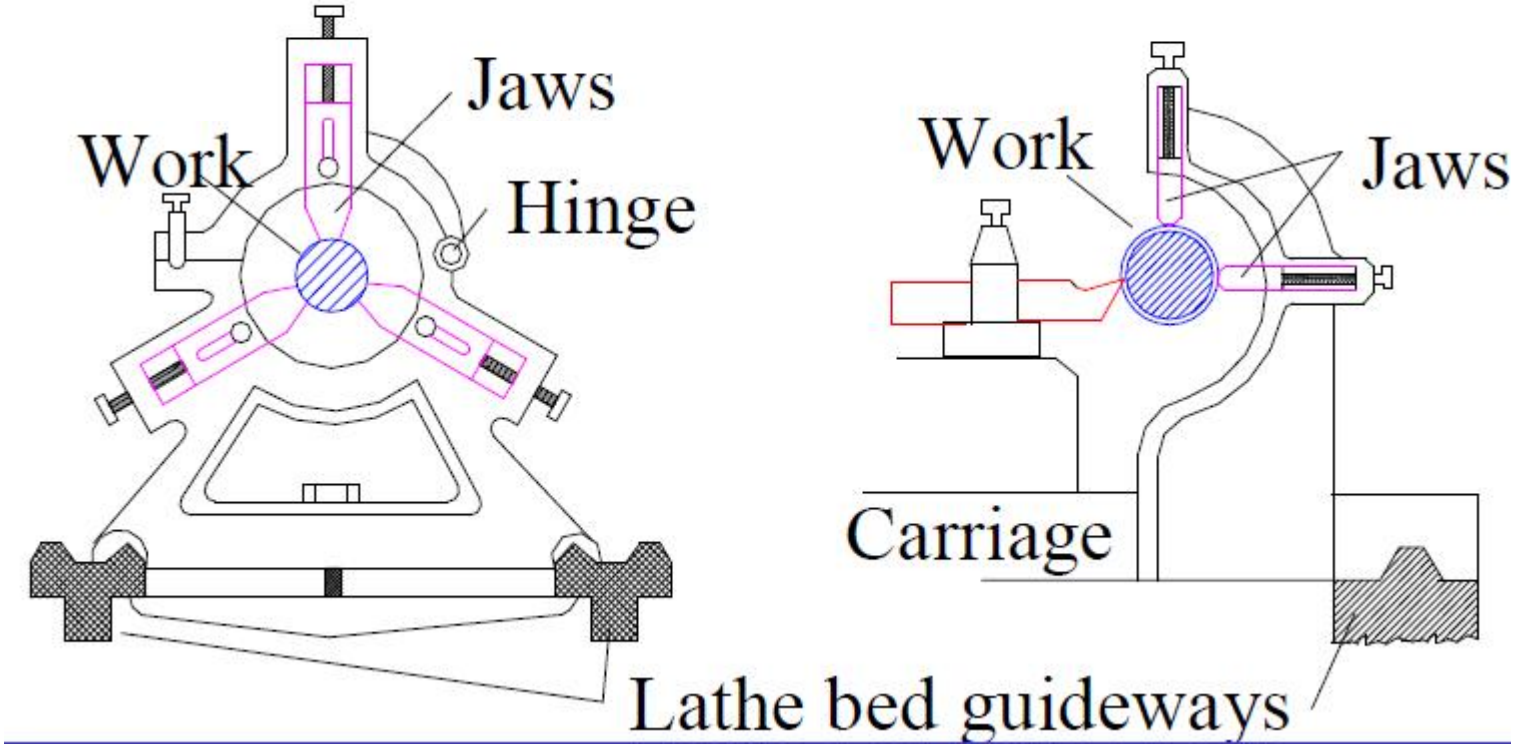
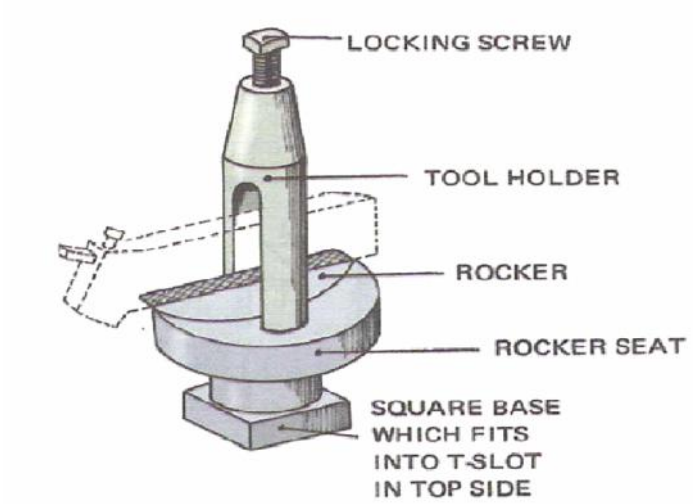
Steady Rest and Follower Rest

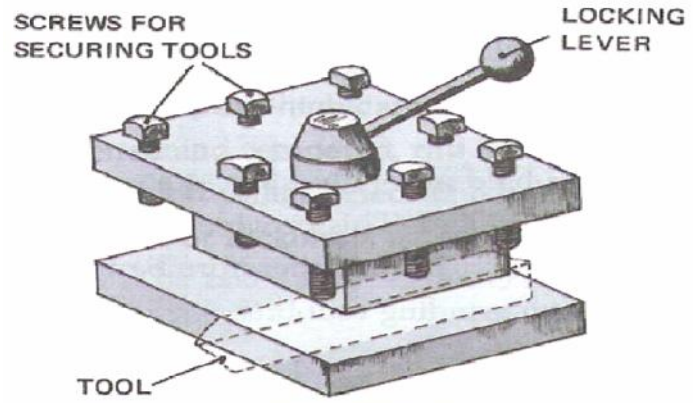


Tool holding devices

- ✓ Toolpost
  - Fitted on top slide and carries the cutting tool or the cutting tool holder
  - Can adjust the height on some types
  - Can carry 4 different tool holders



13.5
ican type toolpost



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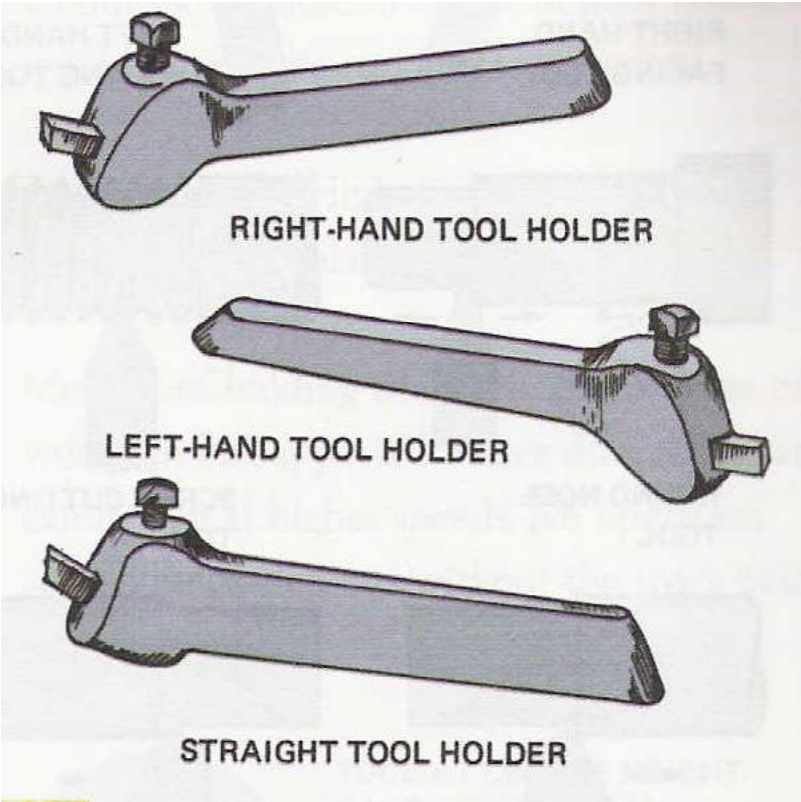
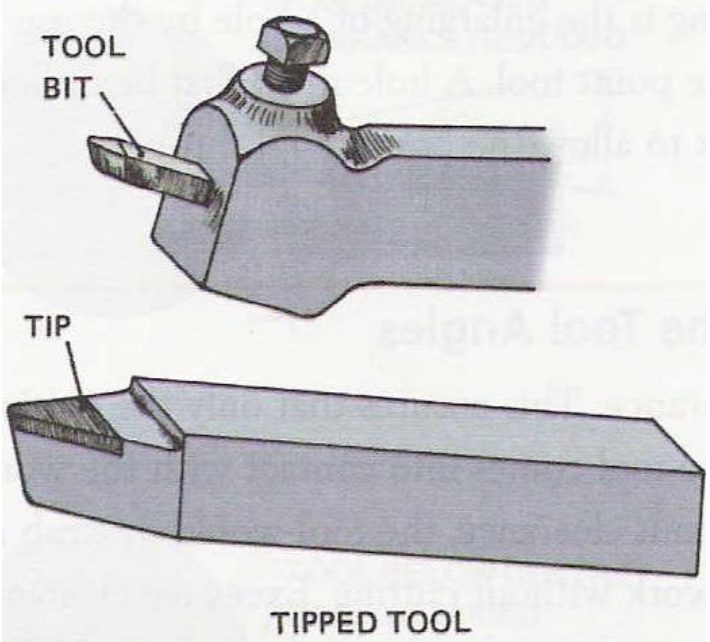


- ✓ Tool holders
  - Used for holding cutting tool bits
  - Available in Right hand, left hand and straight

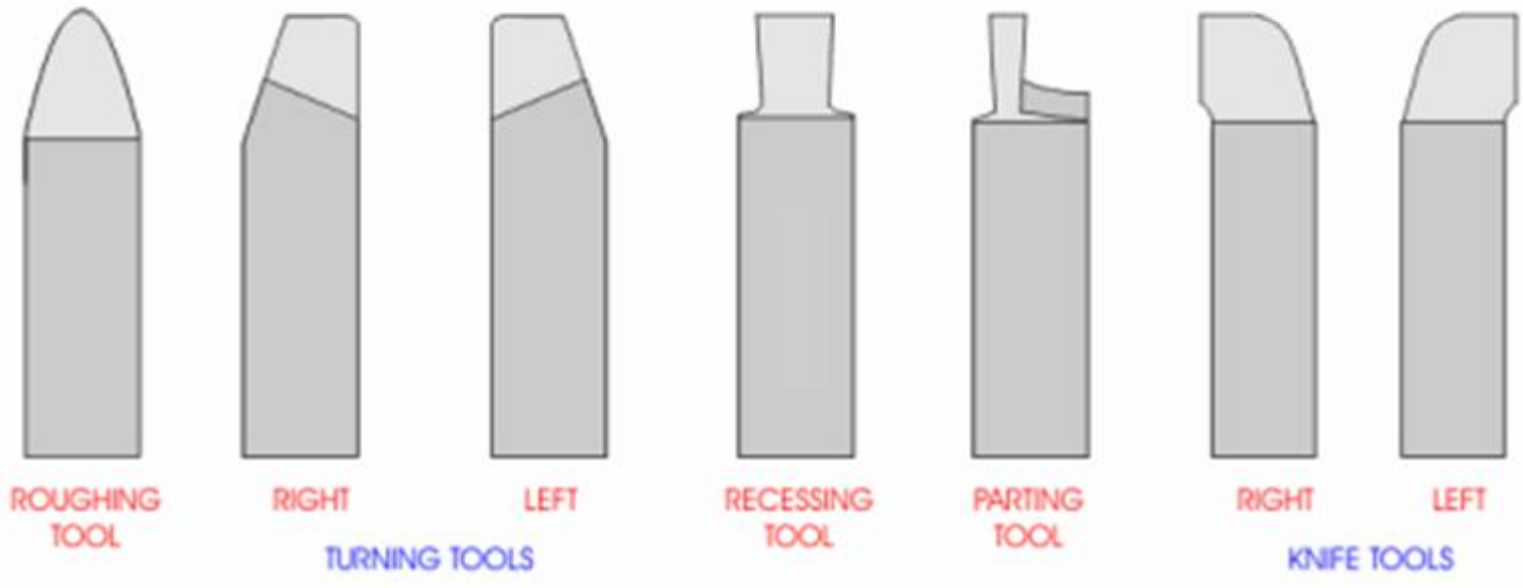
Cutting Tools

- ✓ Can be High Speed Steel held in tool holders
- ✓ Can be also Ceramic (Tungsten carbide) bits held directly in toolpost

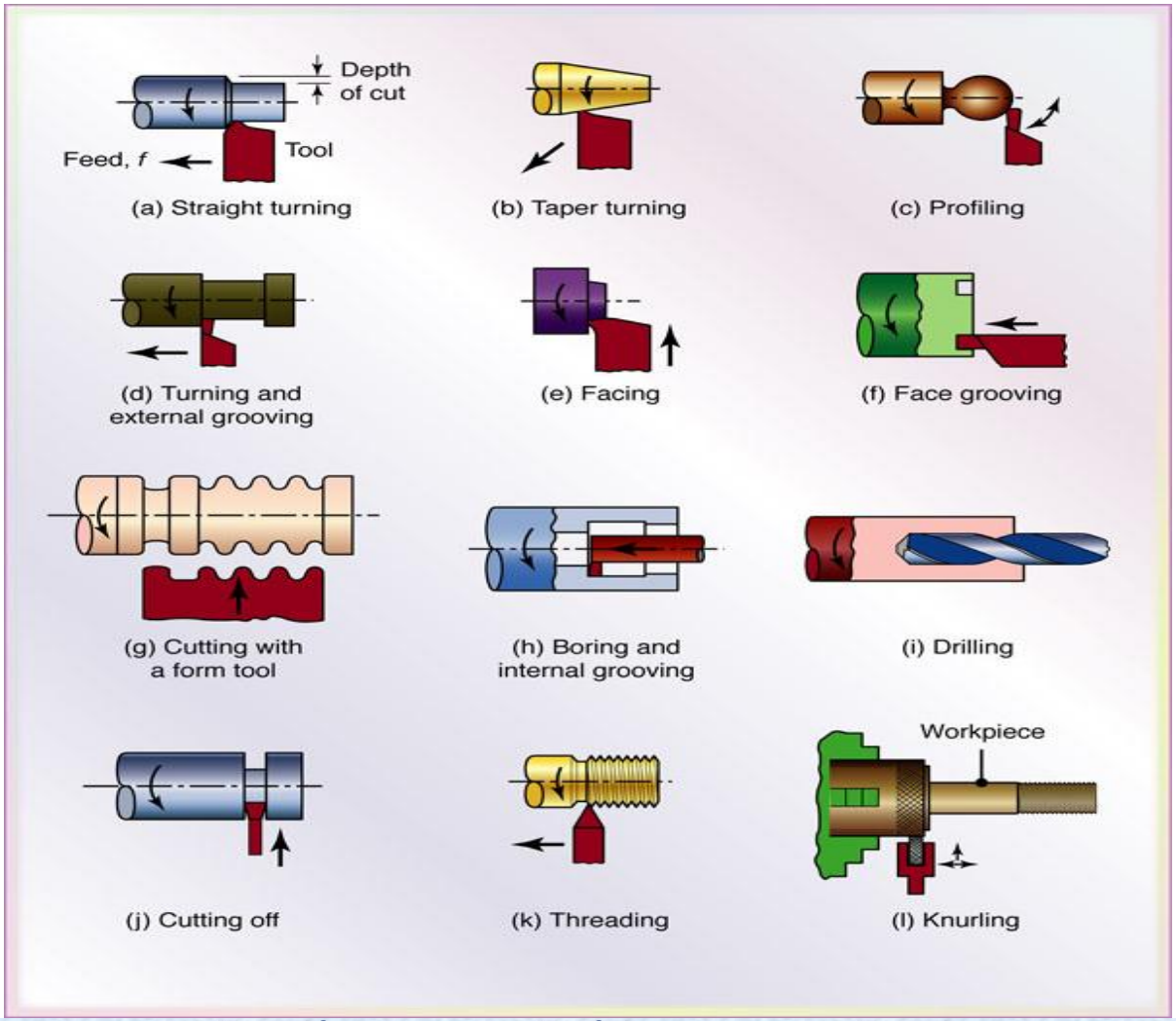


Contd.,

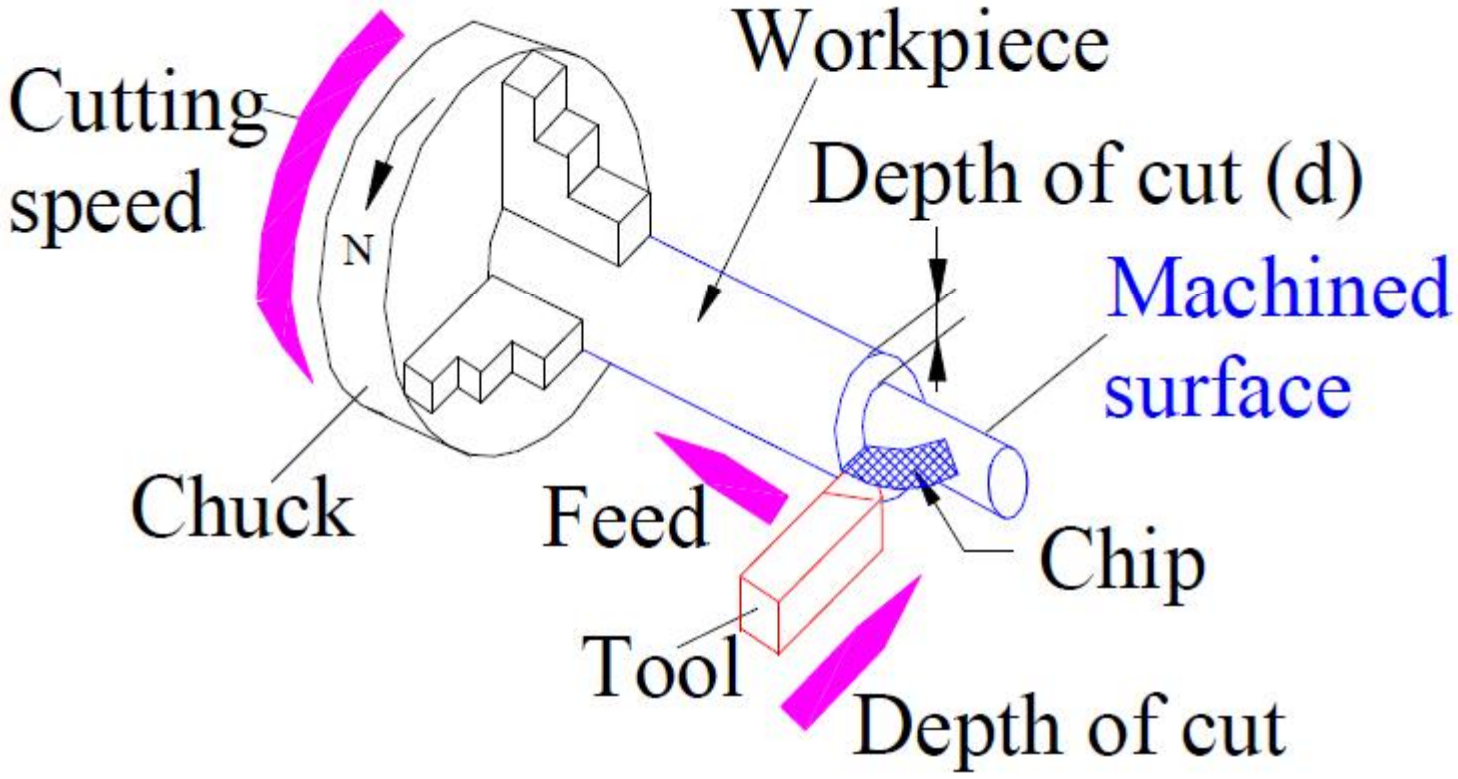
- ✓ We can put different shapes on the High speed tool bits to cut different shapes on the workpiece



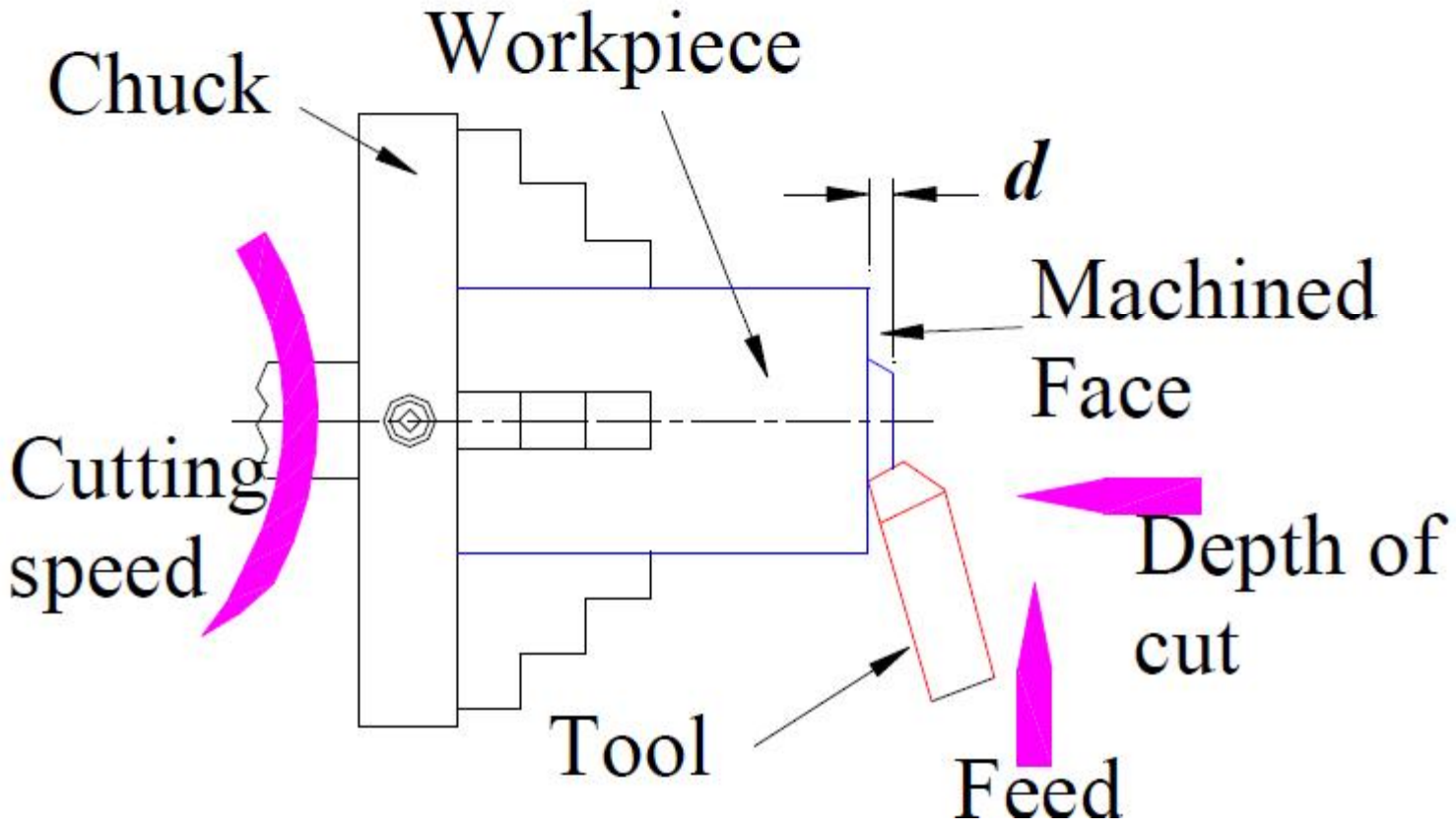
Lathe Cutting Operations



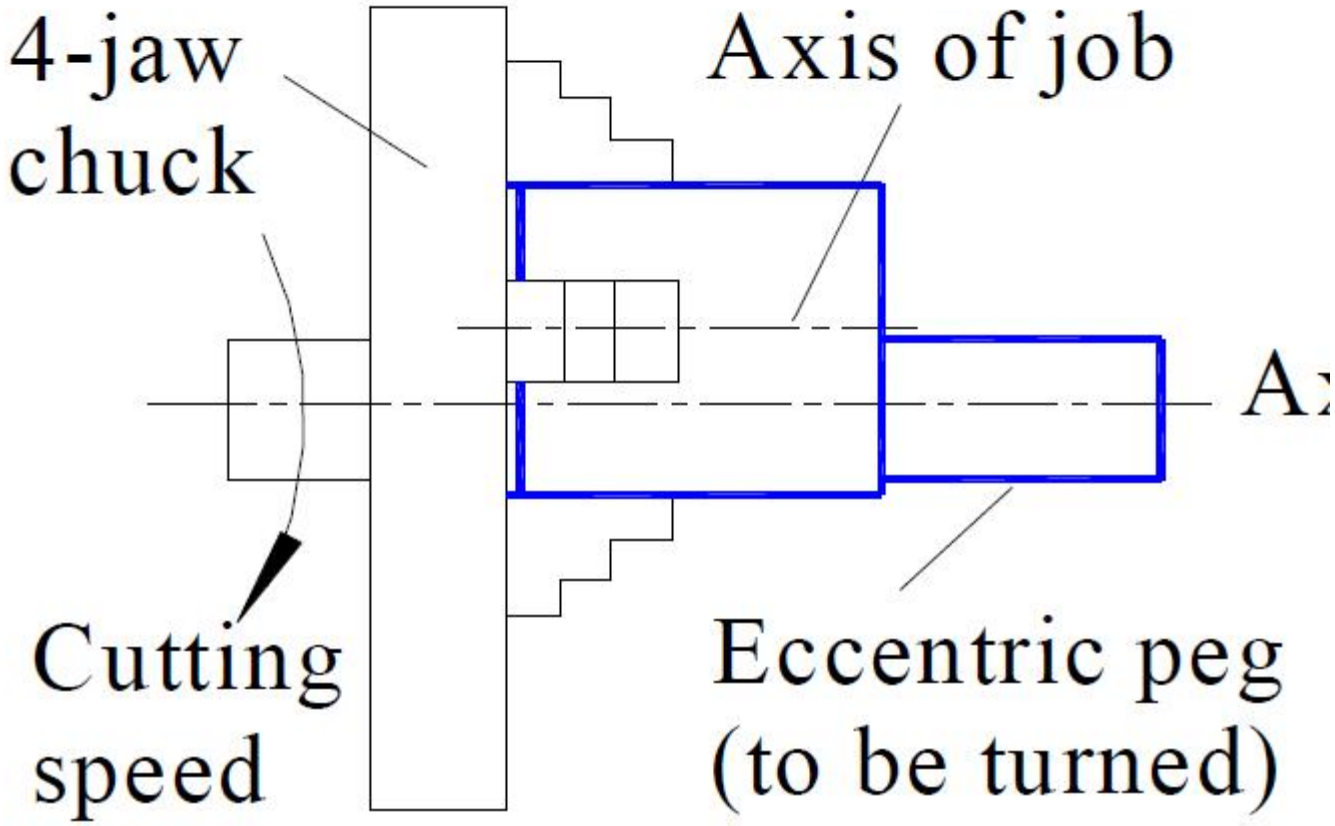
Turning


Workpiece
Cutting speed
N
Depth of cut (d)
Machined surface
Chuck
Feed
Chip
Tool
Depth of cut

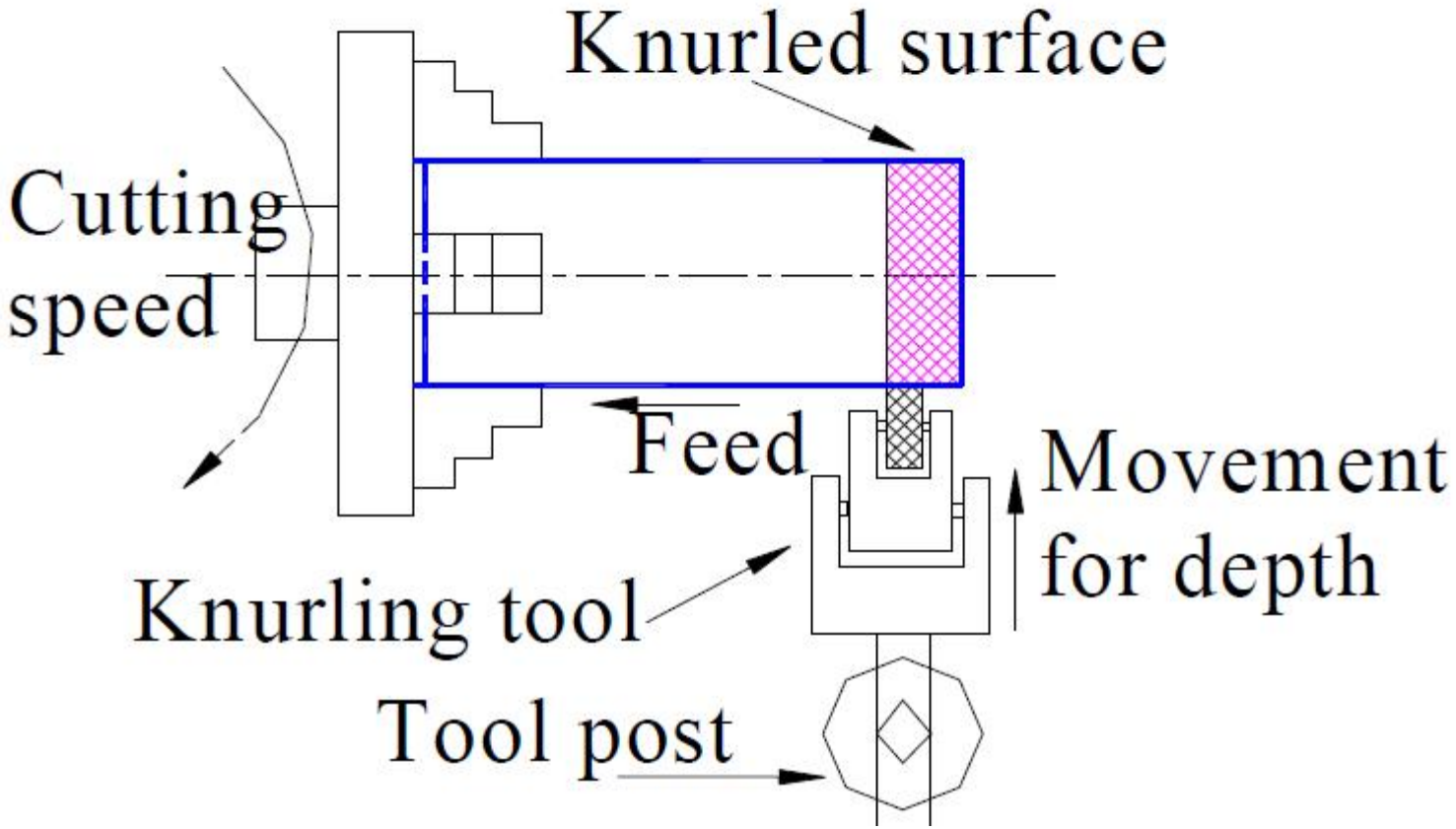
Facing


Chuck
Workpiece
d
Machined
Face
Cutting
speed
Depth of
cut
Tool
Feed

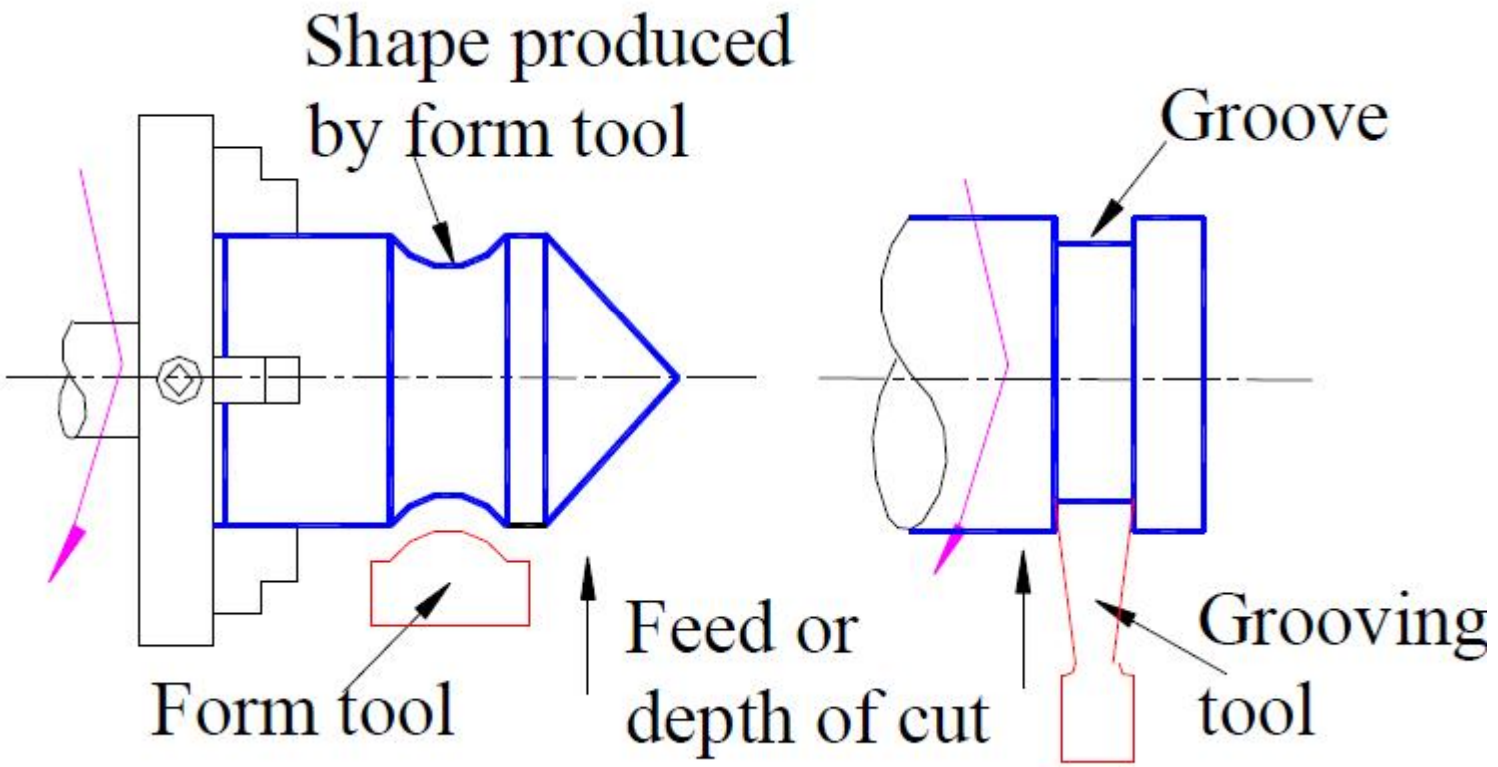
Eccentric Turning



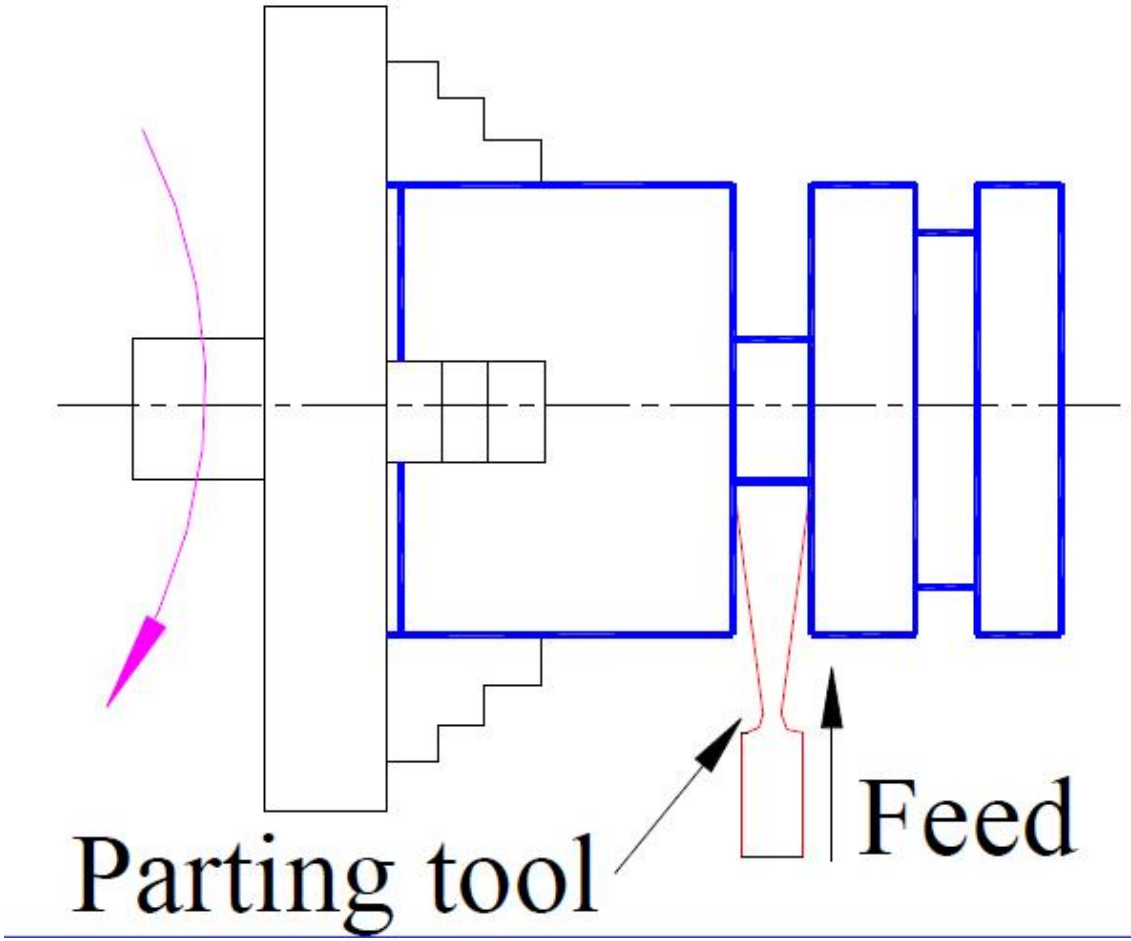
Knurling


Knurled surface
Cutting speed
Feed
Movement for depth
Knurling tool
Tool post

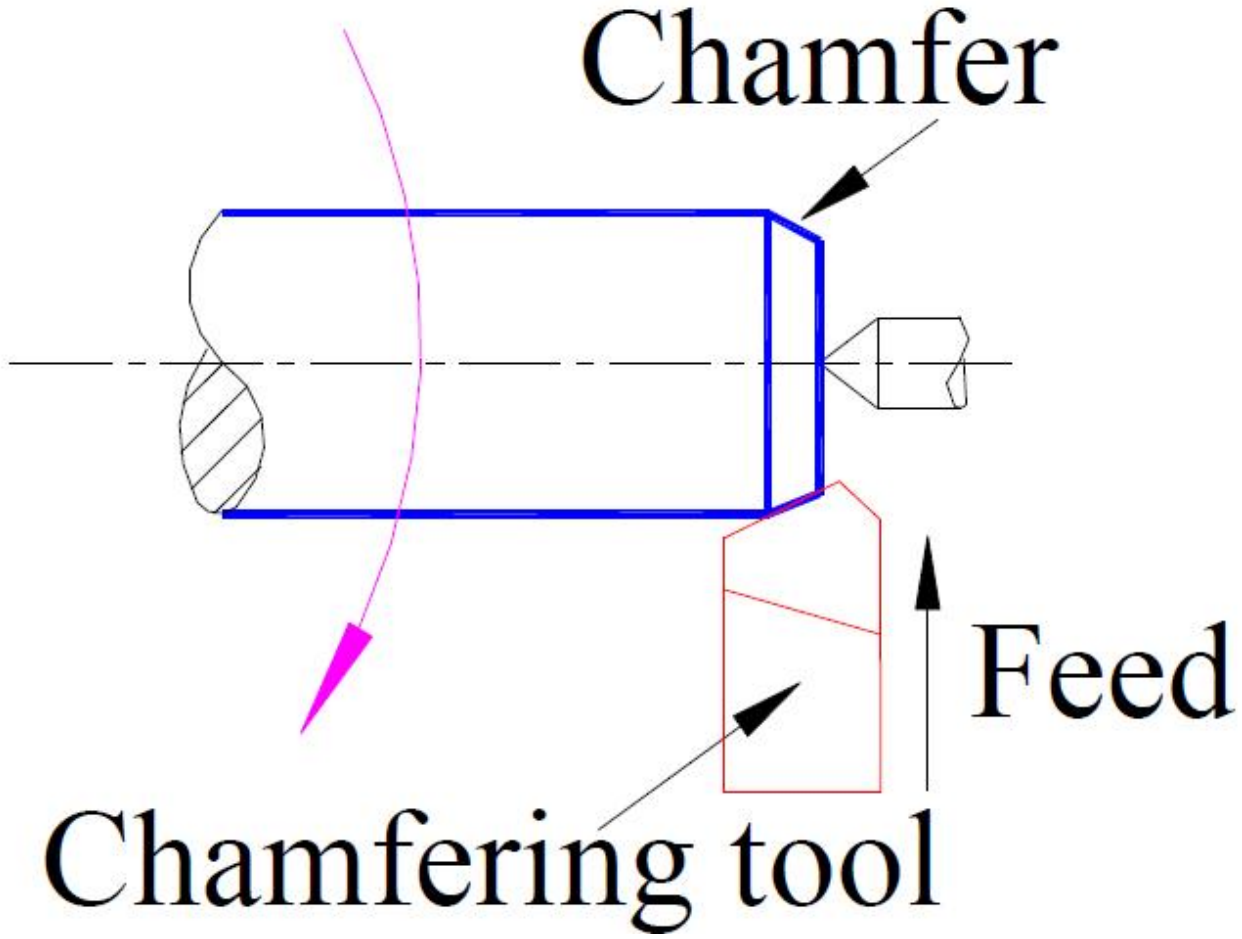
Grooving


Shape produced
by form tool
Groove
Form tool
Feed or
depth of cut
Grooving
tool

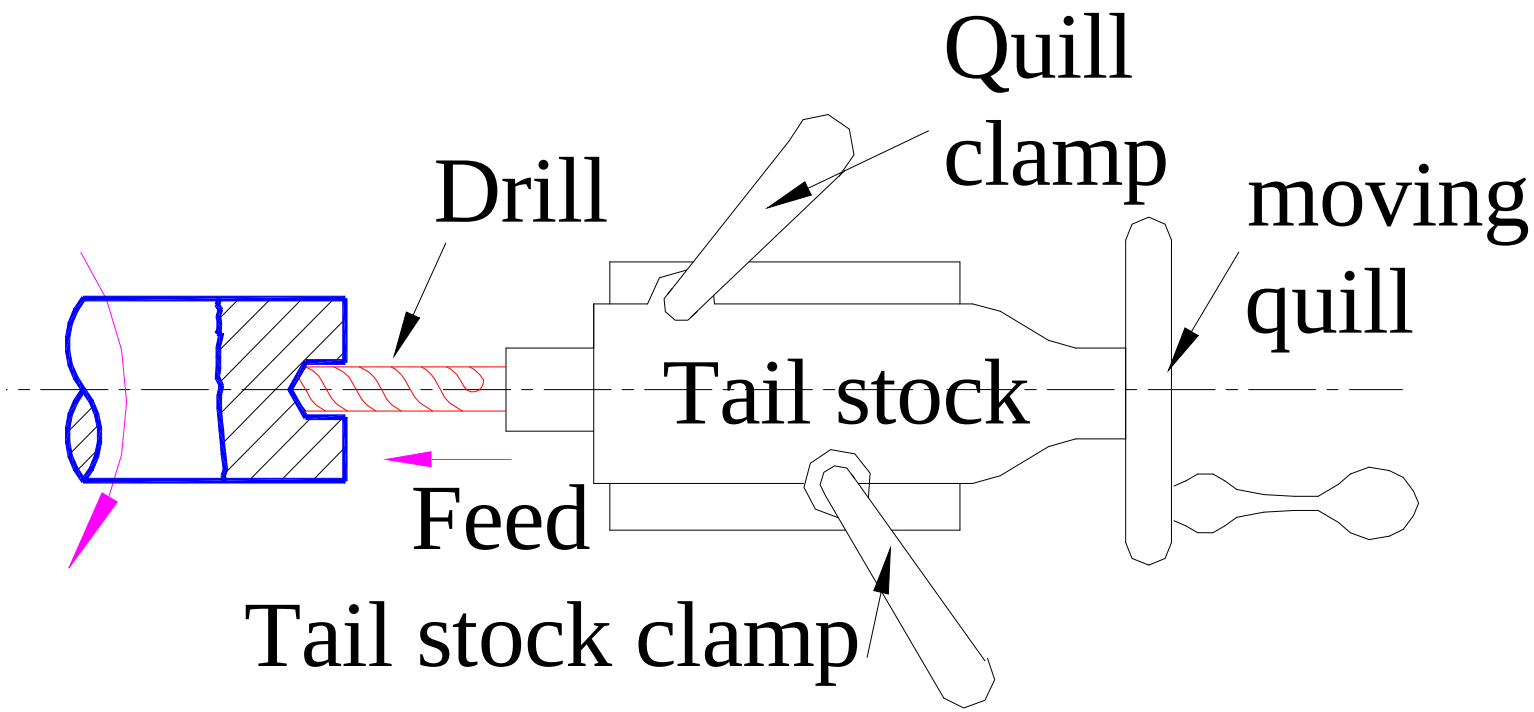
Parting



Chamfering



Drilling


Quill
clamp
Drill
moving
quill
Tail stock
Feed
Tail stock clamp

Boring

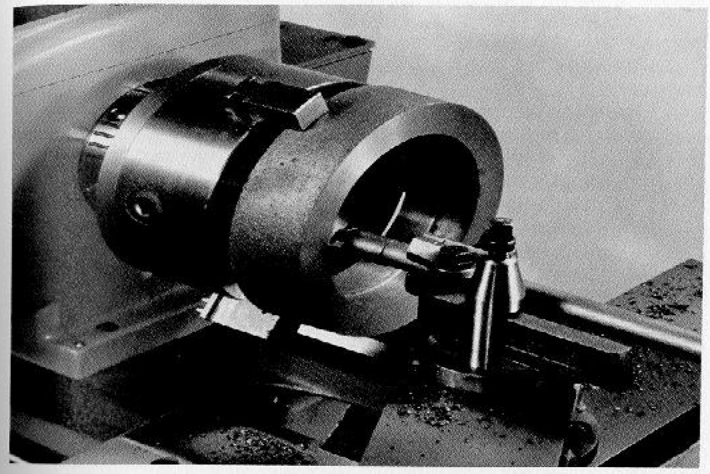


Fig. 10-188. Boring or machining internal surfaces is sometimes done on lathe.

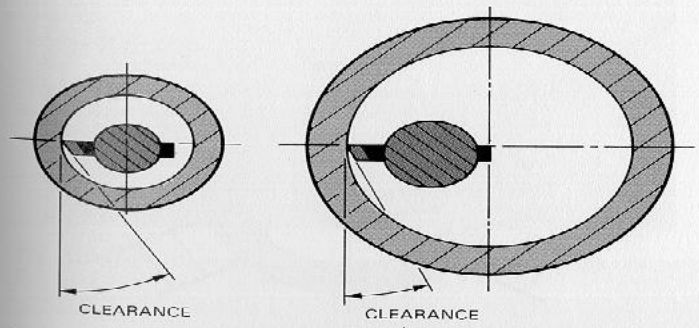
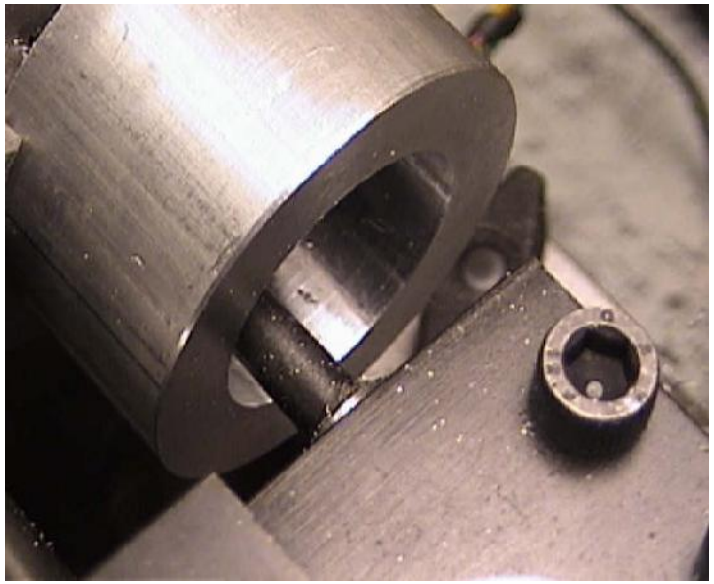


Fig. 10-189. Tool used to bore small diameters requires more front clearance to prevent rubbing.



Internal Operations

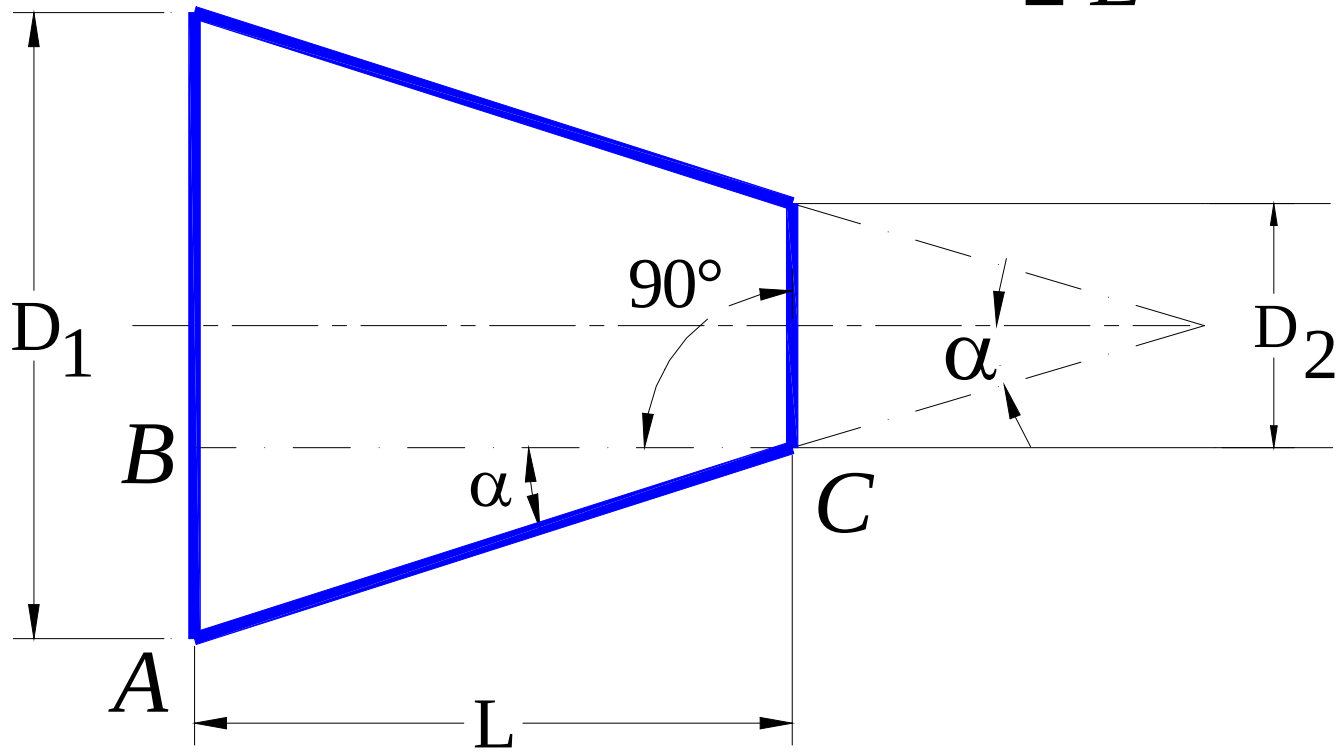
1) Internal facing and turning
2) Internal Reaming and Boring
3) Internal recess or grooving
4) Internal threading

Taper Turning - Methods

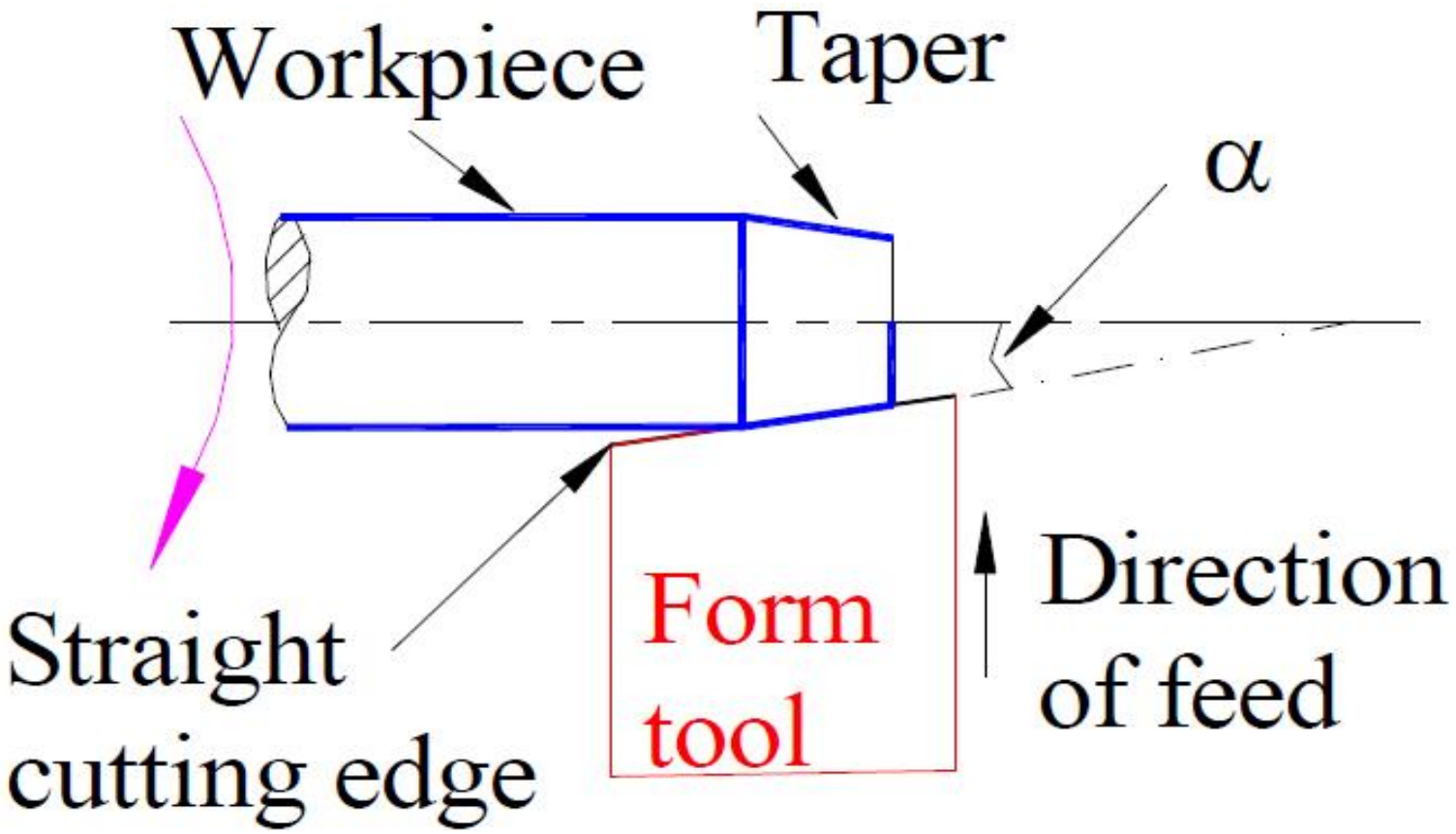
1) Form Tool Method
2) Swiveling Compound Rest
3) Taper Turning Attachment
4) Tail Stock Offset Method
5) Manual method

To find Taper angle

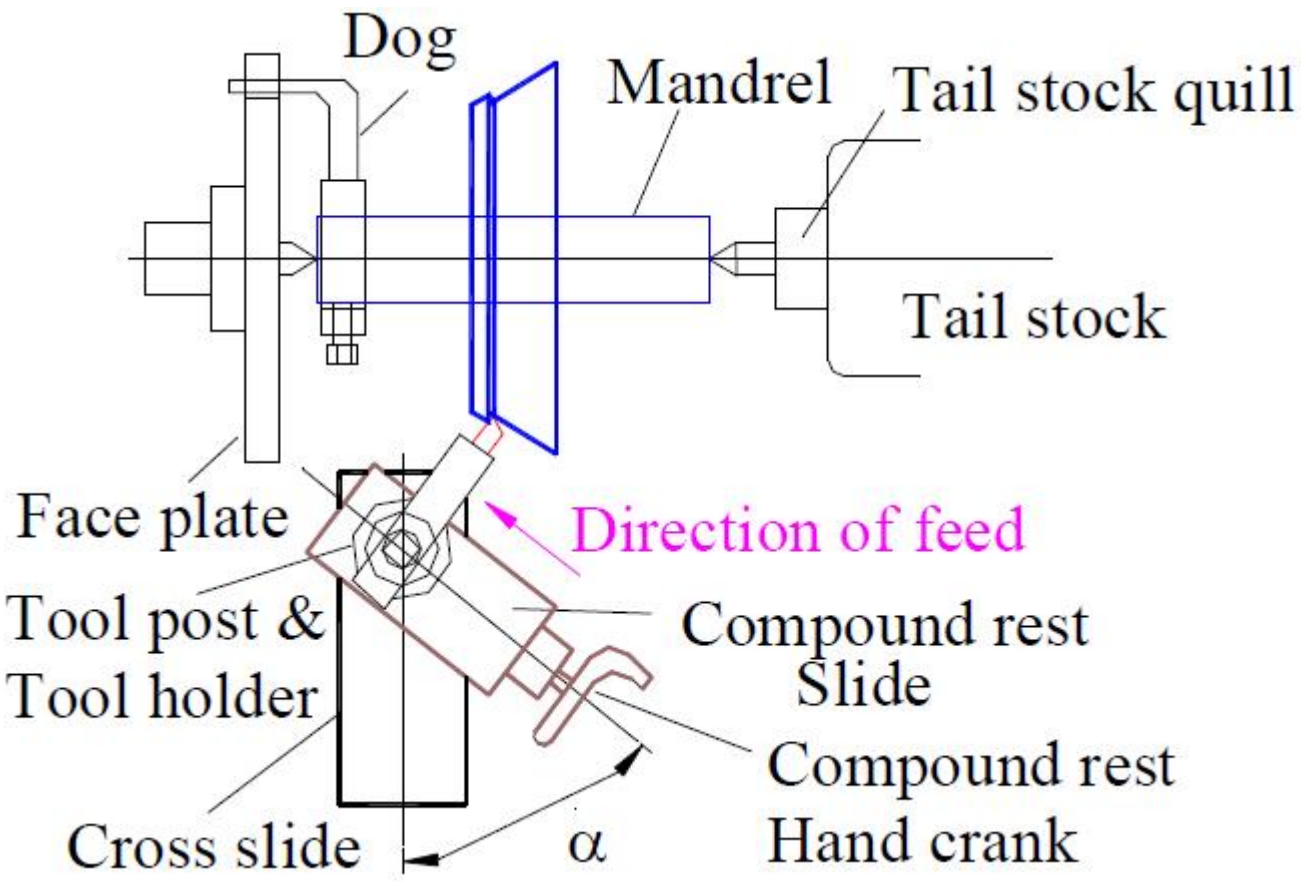
$$\tan \sim = \frac{D_1 - D_2}{2\,L}$$



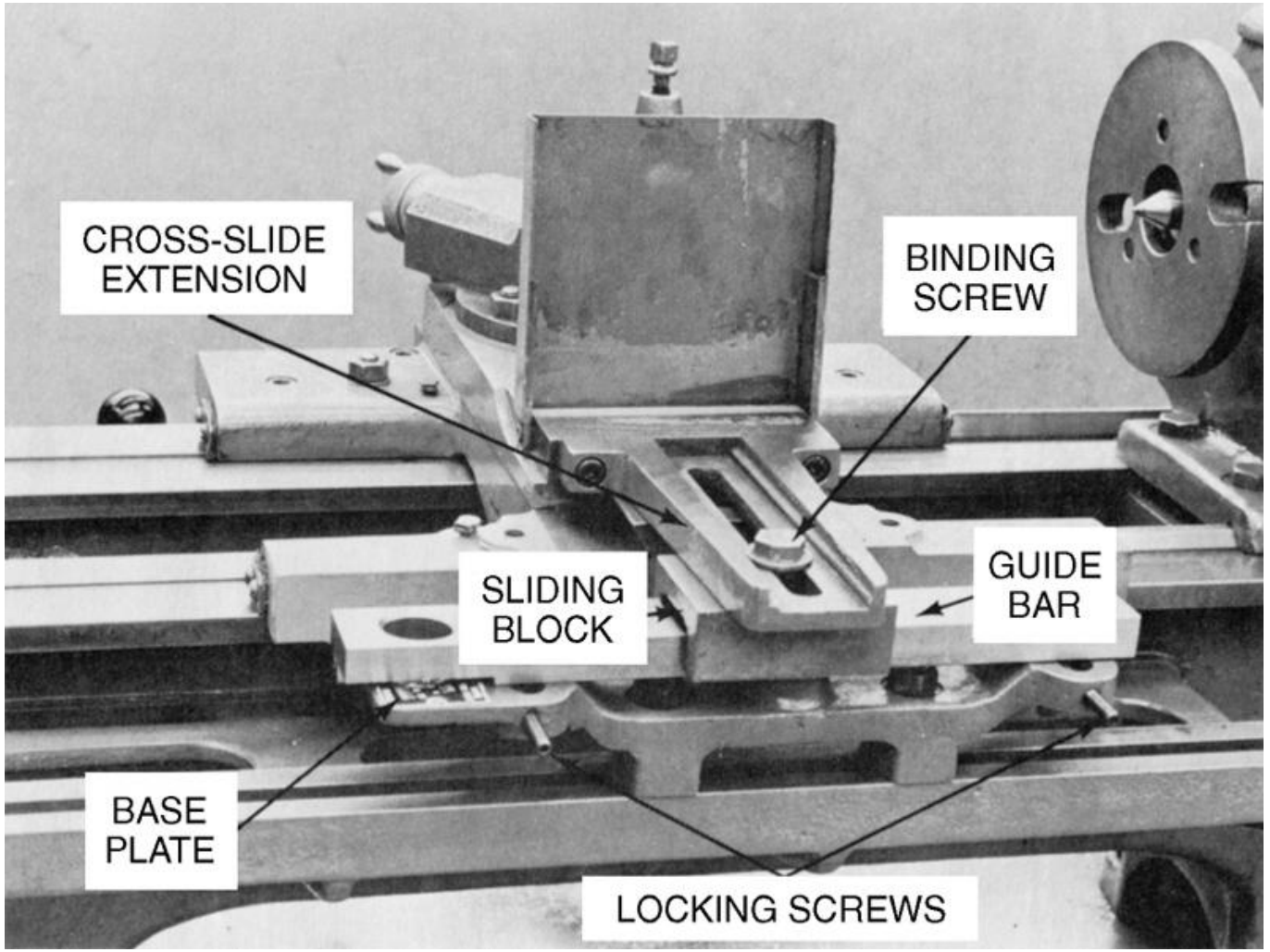
Form Tool Method



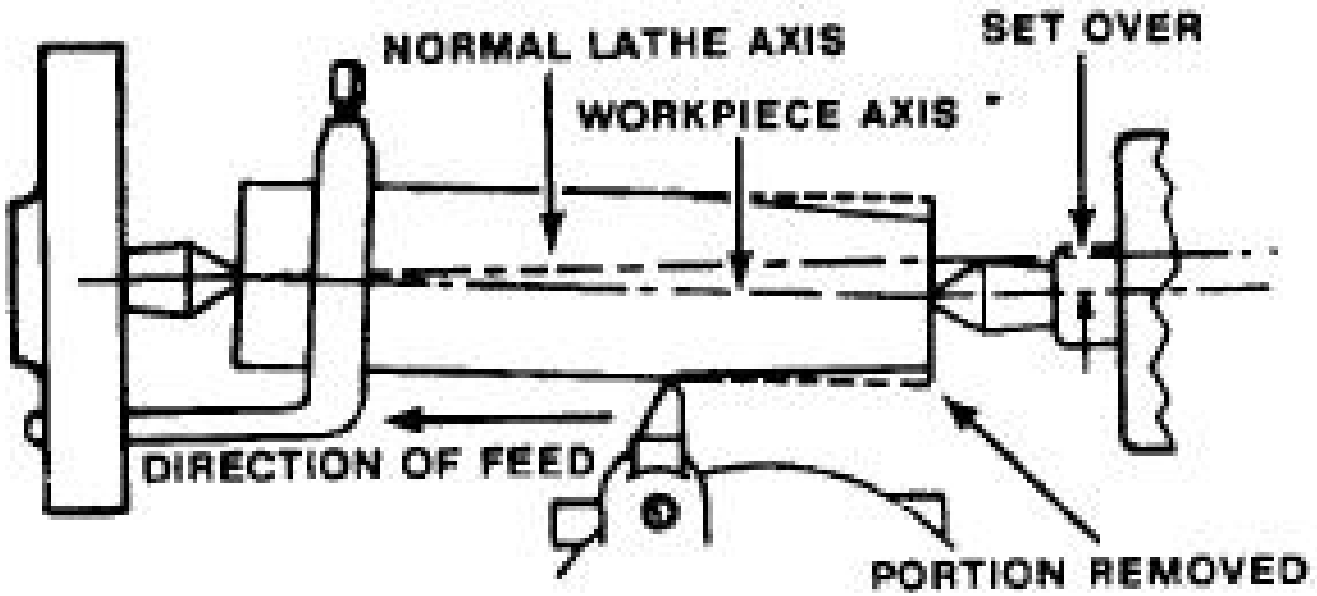
Compound Rest Method



Taper Turning Attachment

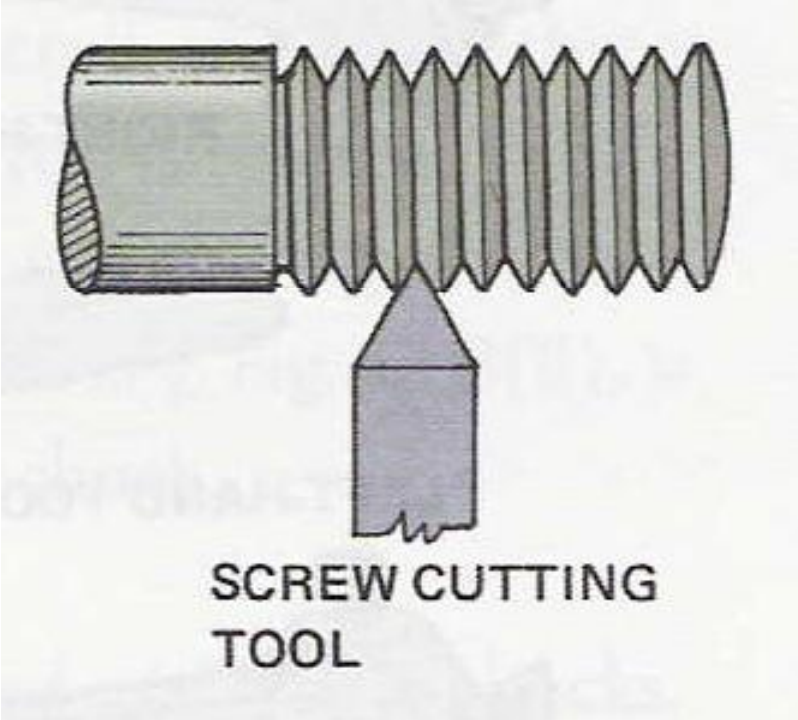


Tailstock Off set Method



Thread Cutting

- ✓ Lathes are also used to cut threads in round bars
- ✓ These threads take up different profiles e.g ISO (60°) ACME etc.,
- ✓ These threads can be seen on bench vices, lathes etc.



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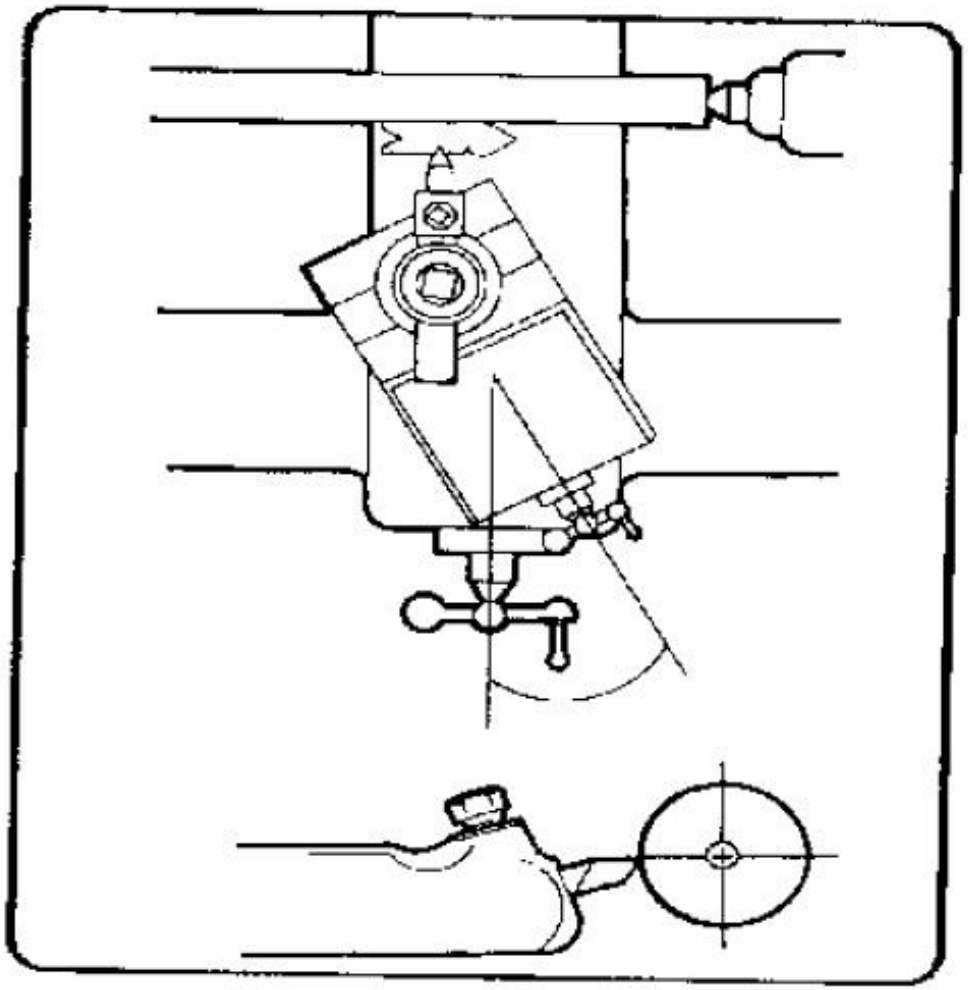
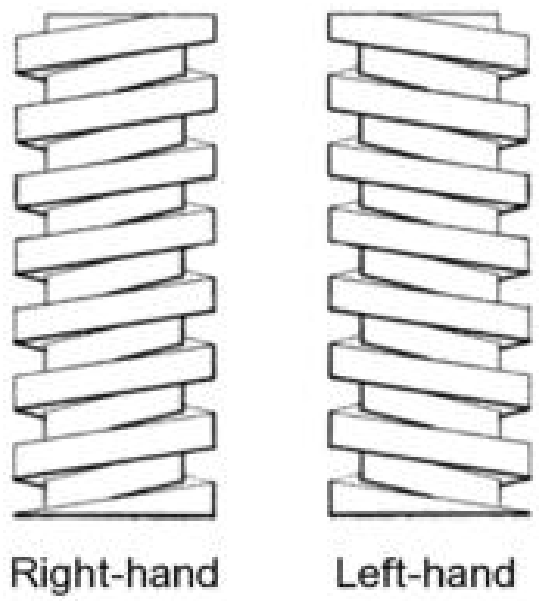
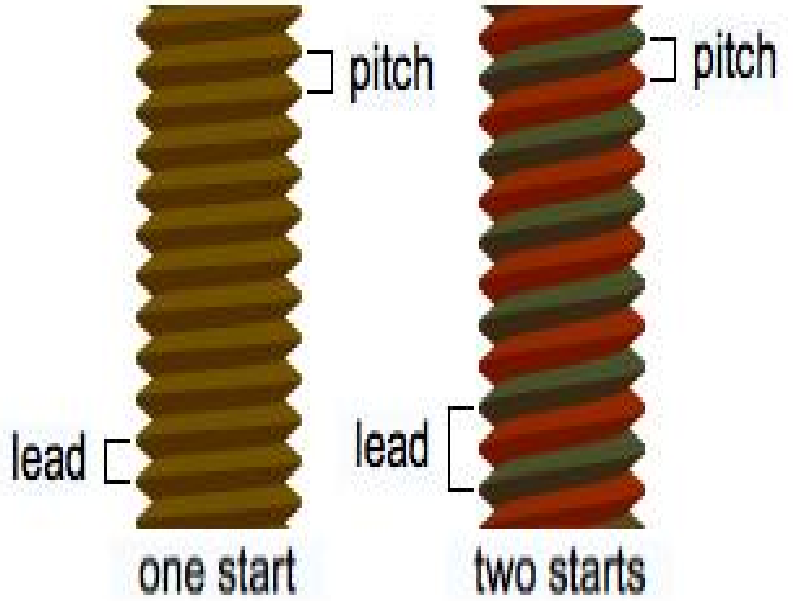


Types of Threads



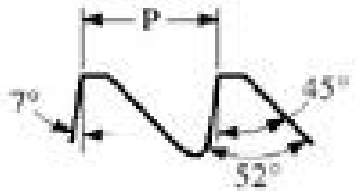


Types of Threads

Unified

American National

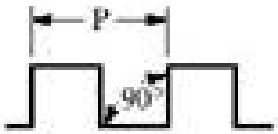
Buttress



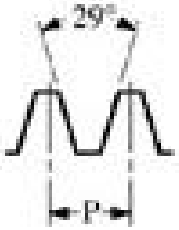
Isometric

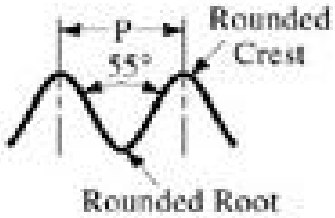
Sharp "V"

Square



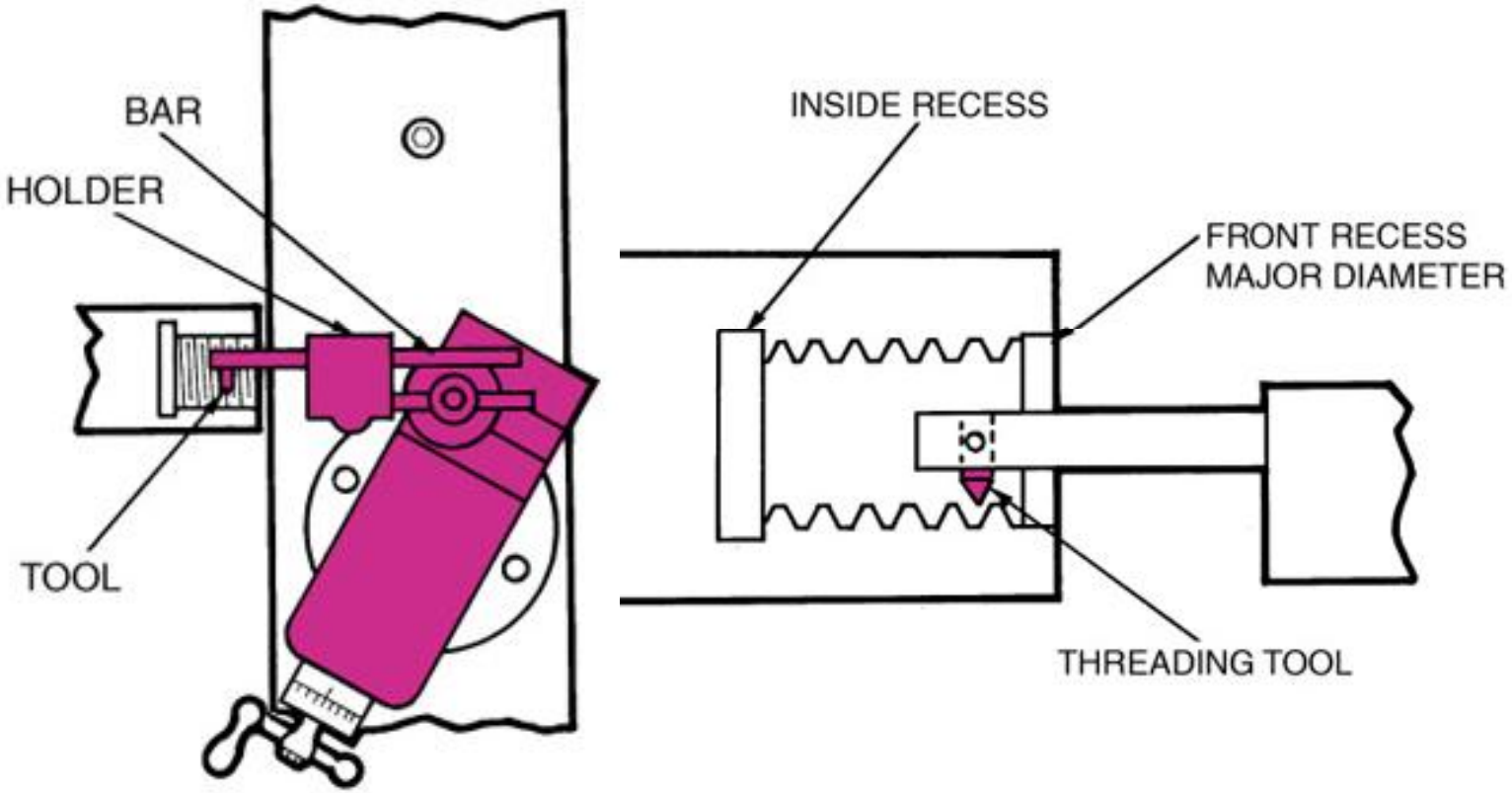
Acme





P = Pitch

Internal Threads



Operating Cutting Conditions

- ✓ Feed (f)
- ✓ Depth of cut (d)
- ✓ Cutting Speed (v)

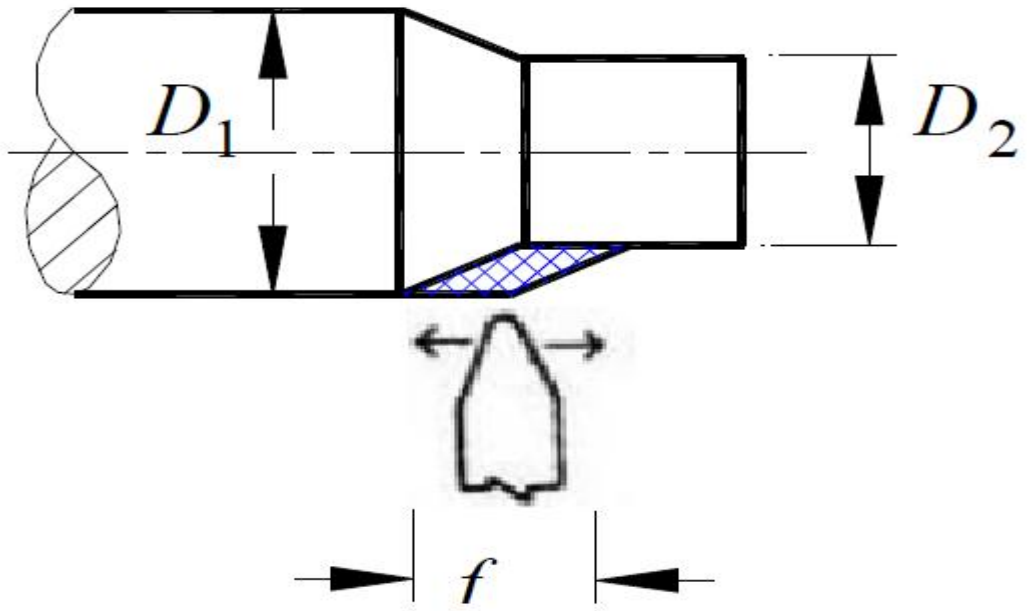
Cutting Speed

- ✓ D - Diameter (mm)
- ✓ N – Spindle speed (rpm)
- ✓ V - Cutting Speed (m/min)
  - Peripheral speed of workpiece past the cutting tool

$$v = \frac{\pi D N}{1000} \quad \text{m/min}$$

Feed

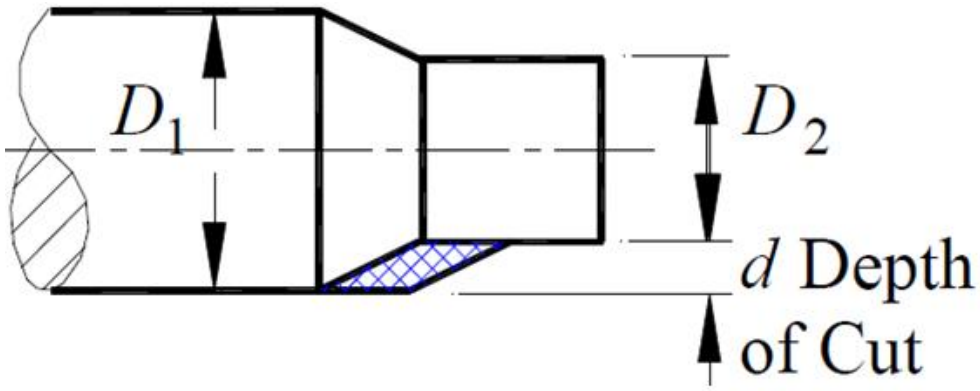
- ✓ The linear distance of tool advances for every rotation of workpiece



Depth of Cut

- d – depth of cut
  - Perpendicular distance between machined surface and uncut surface of the workpiece

$$d = \frac{D_1 - D_2}{2}$$



MRR

- ✓ Volume of material removed in one revolution

  $MRR = \pi D d f \ mm^3$

- ✓ Job makes in ‘N’ revolutions / min

  $MRR = \pi D d f N \ mm^3 / min$

- ✓ With respect to cutting velocity (v)

  $MRR = 1000 v d f \ mm^3 / min$

Machining time

- Cutting speed, $v = \frac{\pi D N}{1000}$ m/min

- The time (t) for single pass,

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

- Where,

L – Length of the work piece (mm).

L_o – Over travel of the tool (mm).

f – Feed rate (mm / rev).

Contd.,

The number of roughing passes (P_r) is given by

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

where, A – Total machining allowance (mm).

A_f – Finish machining allowance (mm).

D_r – Depth of cut in roughing (mm).

The number of finishing passes (P_f) is given by

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

where, d_f – depth of cut in finishing (mm).

Power

- ✓ Machining operation requires power
- ✓ The power to perform machining can be computed from force and velocity
- ✓ Power is the product of cutting force and velocity.

$$\text{Power required, } P_c = F_c\, v$$

where,

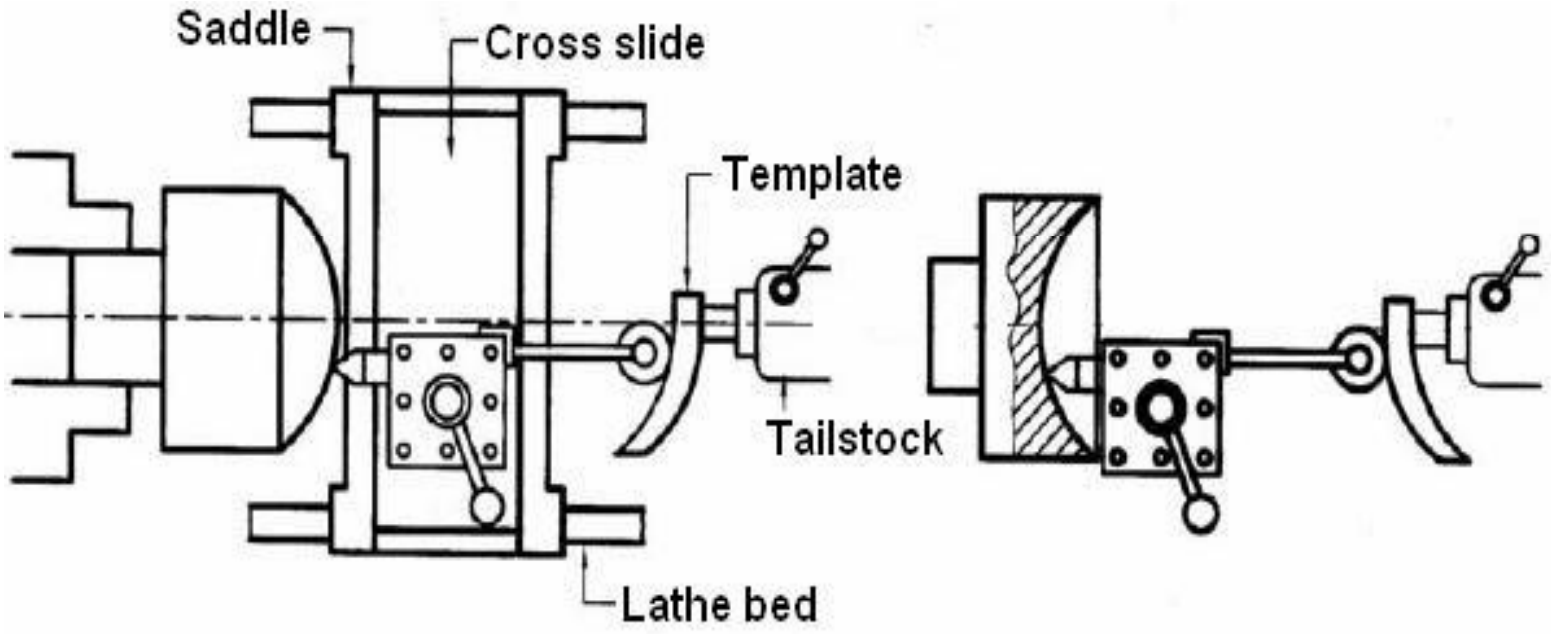
P_c = cutting power
F_c = cutting force
v = cutting speed

Special Attachments

Special attachments

- ✓ Each general purpose conventional machine tool is designed and used for a set of specific machining work on jobs of limited range of shape and size.
- ✓ Some unusual work also need to be done in a same ordinary machine tools
  - **e.g. milling in a lathe, tapping in a drilling machine, gear teeth cutting in shaping machine and so on.**
- ✓ Under such conditions, some special devices are additionally used being mounted in the ordinary machine tools which augment the processing capability are known as attachments.
- ✓ Unlike accessories, attachments are not that inevitable and procured separately as and when required

Spherical turning attachment



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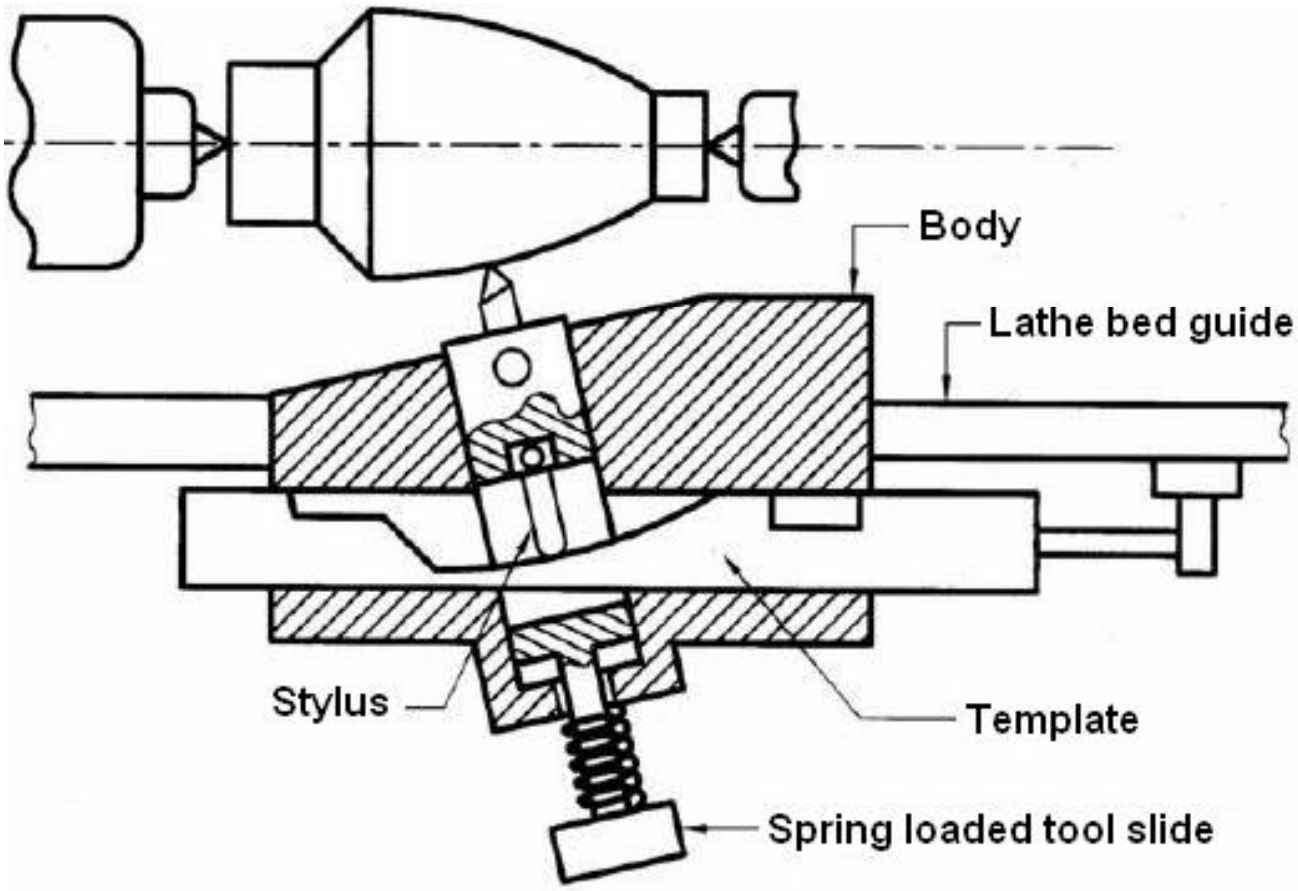
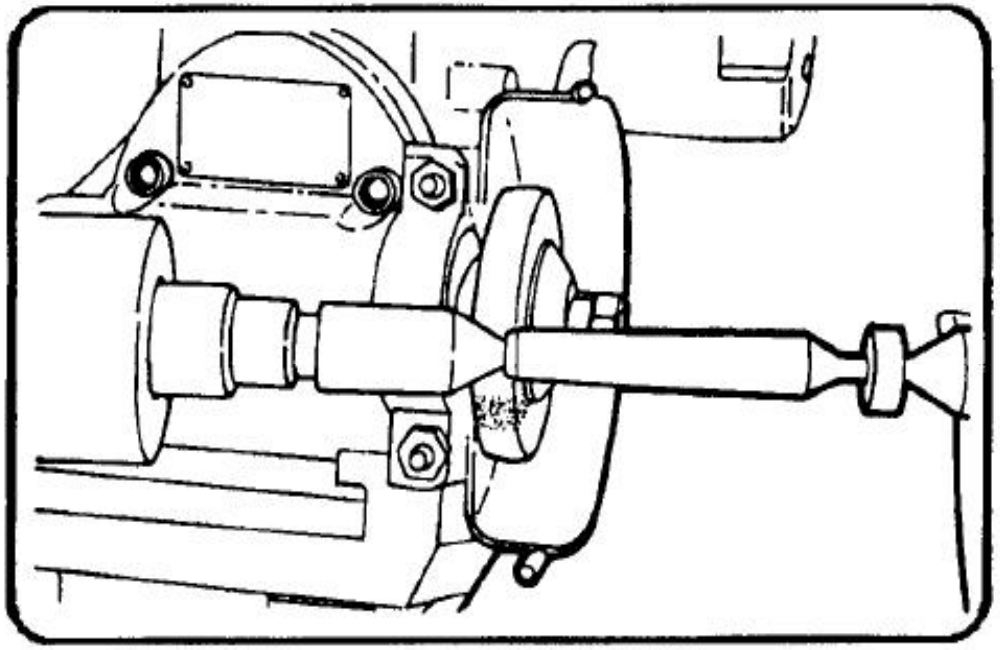
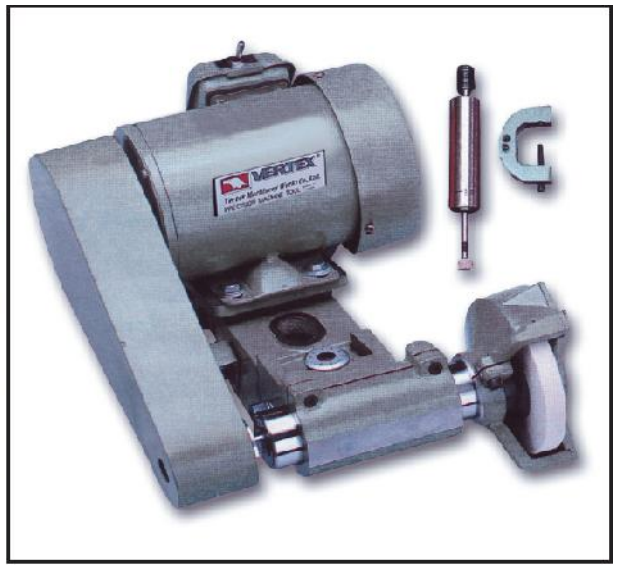
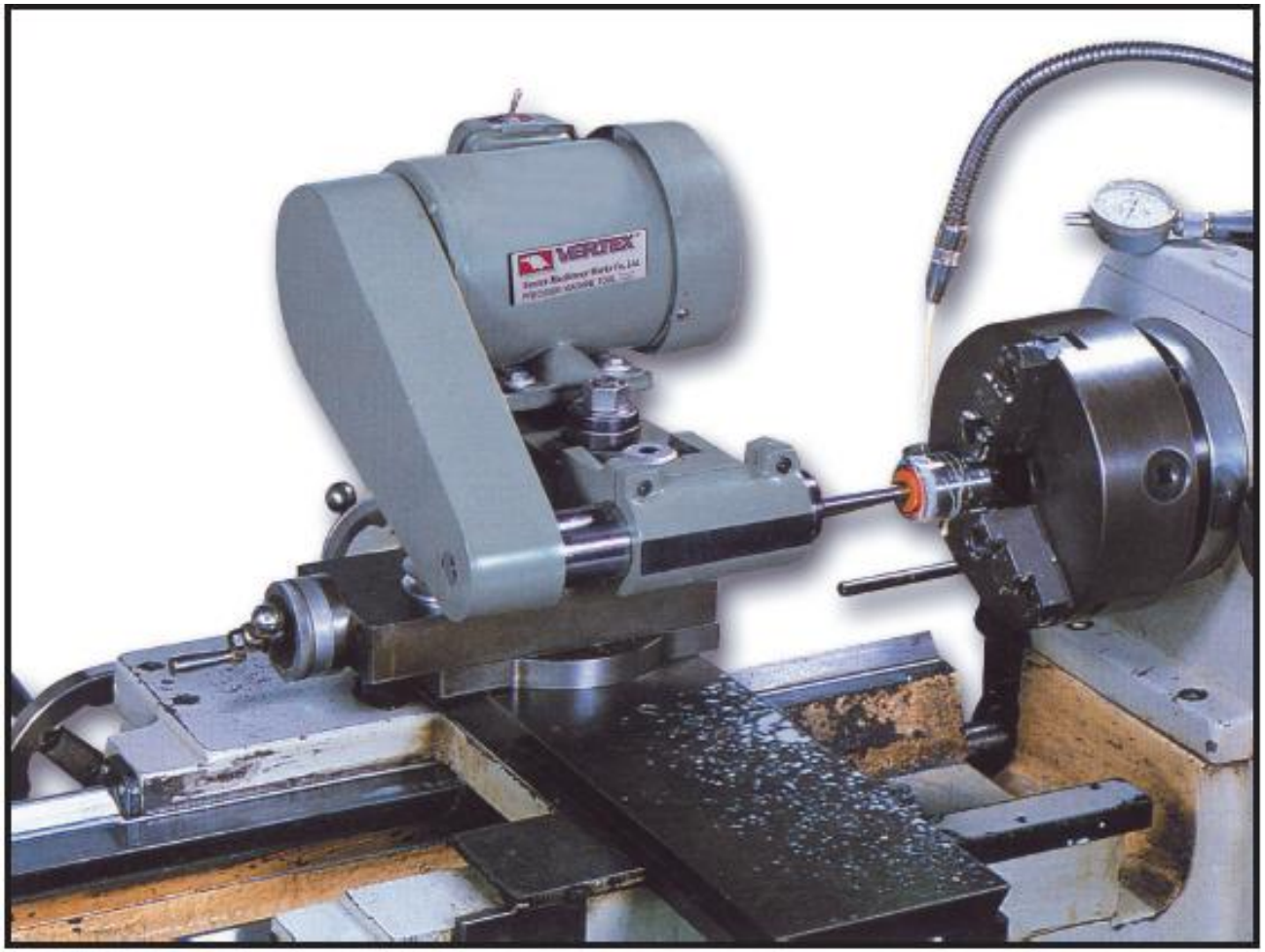


External grinding attachment

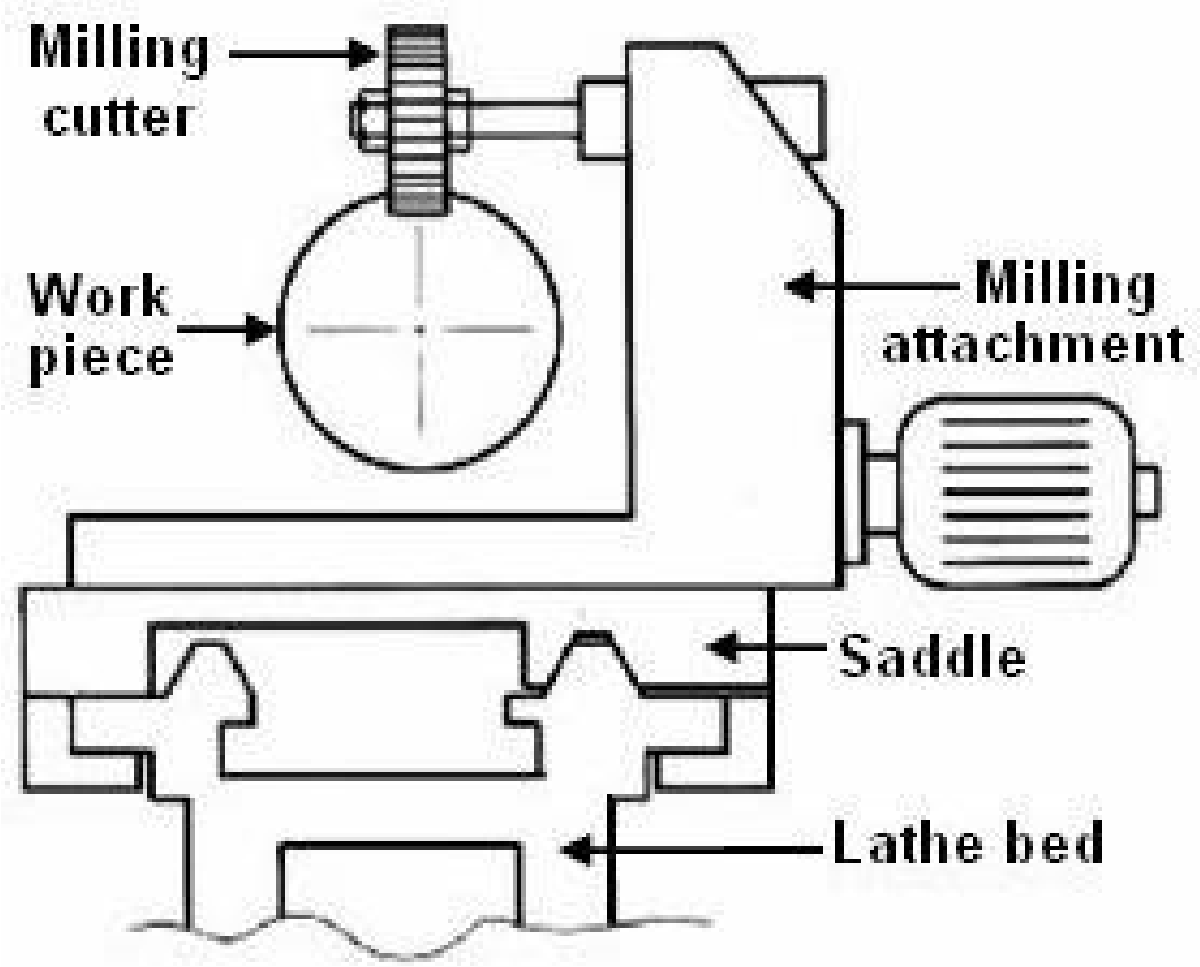




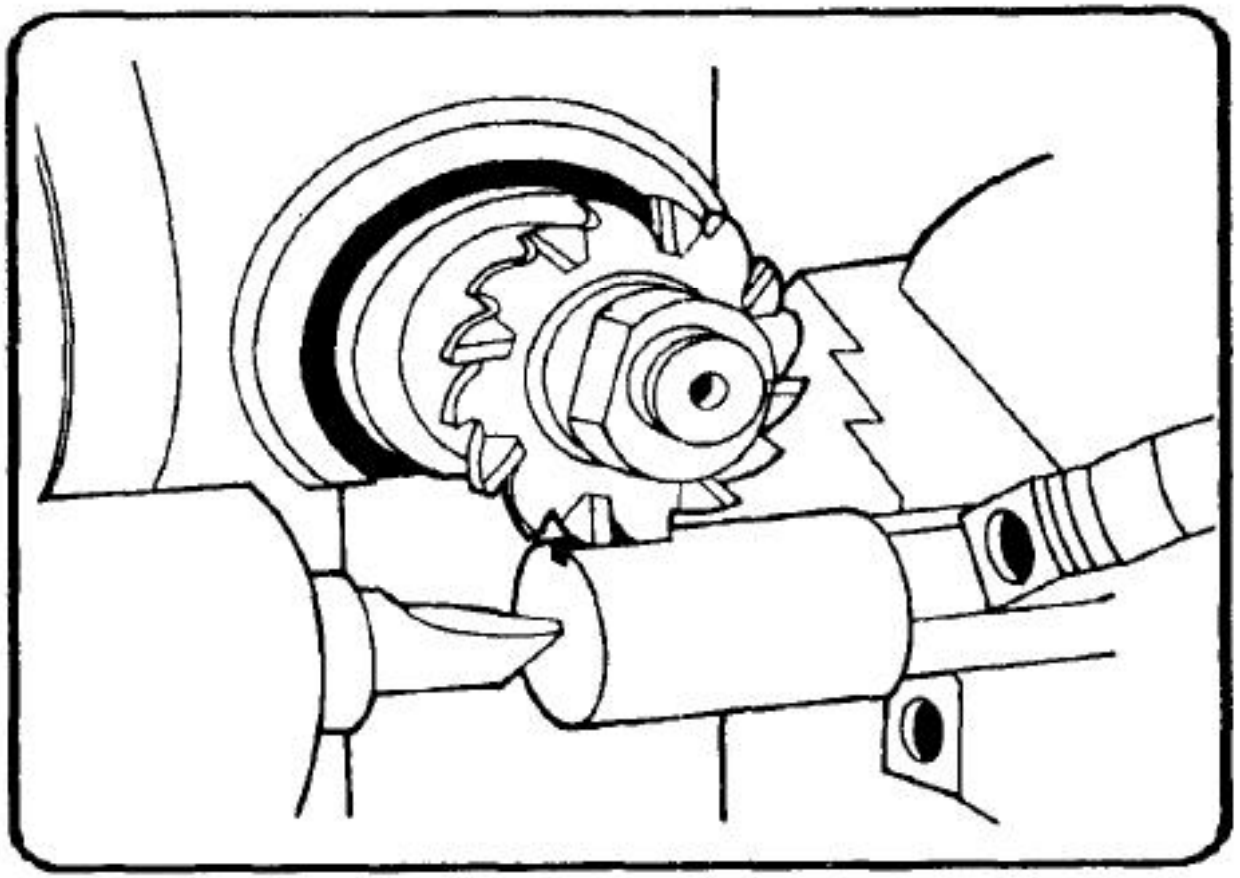
Internal grinding attachment



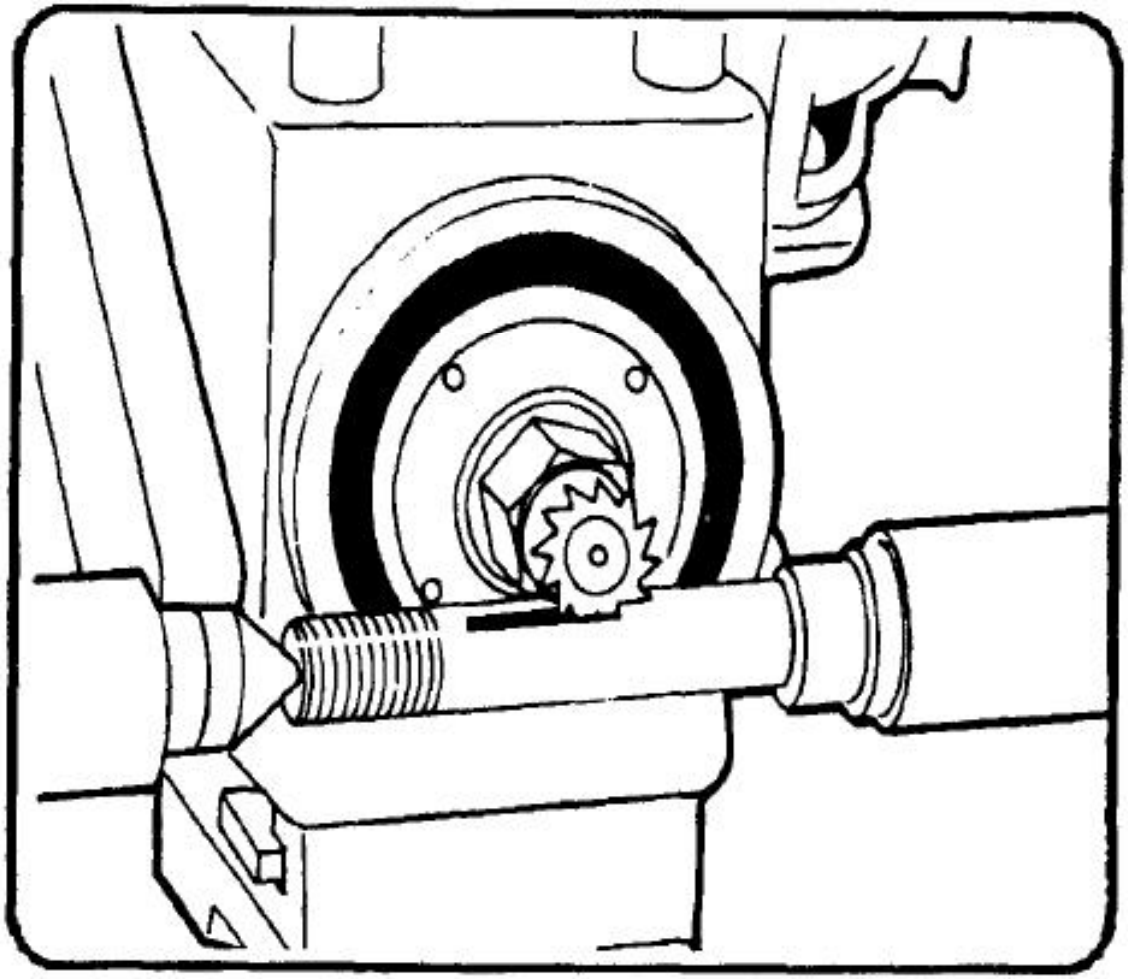
Milling attachments



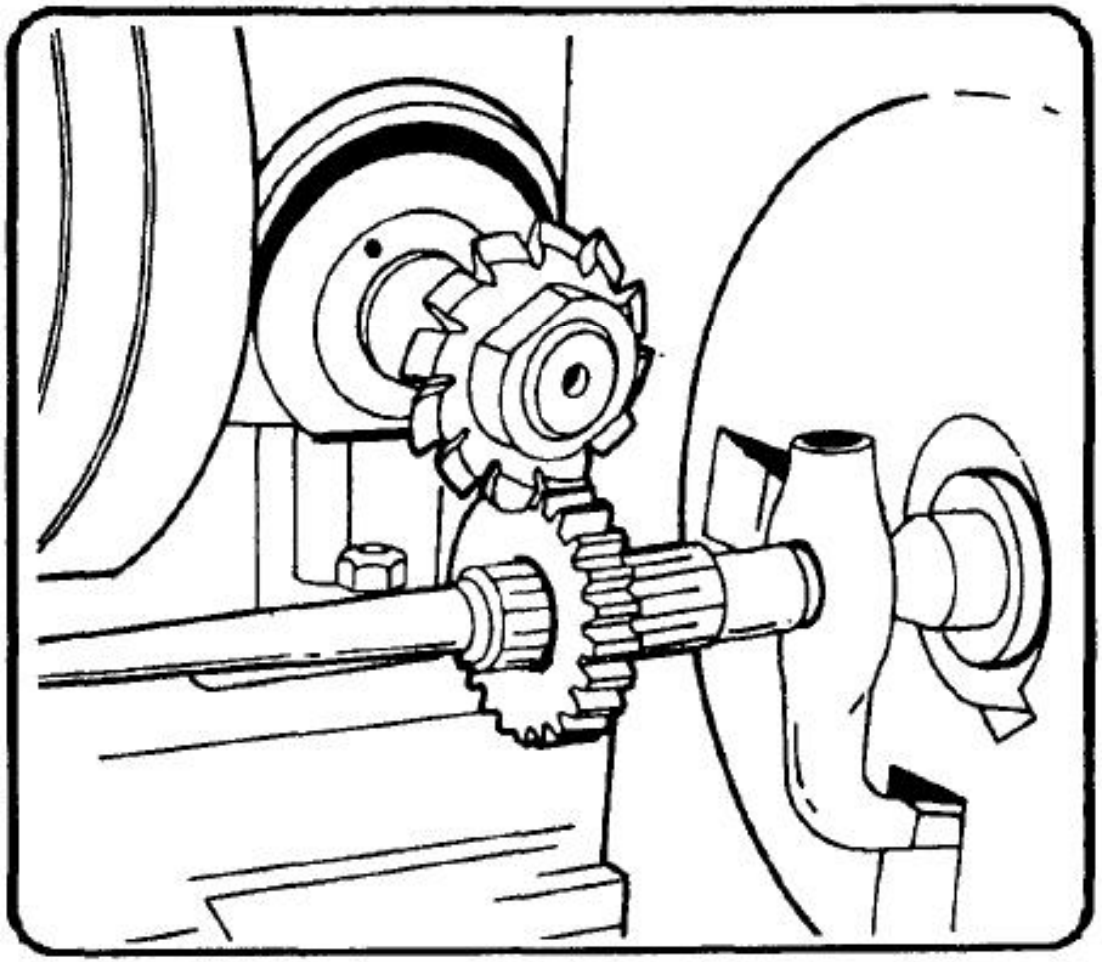
Keyway milling



Woodruff key slot milling



Gear cutting



Semiautomatic and Automatic Lathes

Introduction

- ✓ Automation is incorporated in a machine tool or machining system as a whole for higher productivity with consistent quality aiming at meeting the large requirements and overall economy.
- ✓ Such automation enables quick and accurate auxiliary motions, (i.e., handling operations like tool – work mounting, bar feeding, tool indexing etc.).
- ✓ With the help of special or additional mechanism and control systems, It can be achieved with the minimum human intervention.
- ✓ These systems may be of mechanical, electro-mechanical, hydraulic or electronic or their combination.

Contd.,

- ✓ **It is already mentioned that according to degree of automation machine tools are classified as,**
  - Non automatic
  - Semiautomatic
  - Automatic

(a) Semiautomatic :

- Capstan lathe (ram type turret lathe)
- Turret lathe
- Multiple spindle turret lathe
- Copying (hydraulic) lathe

(b) Automatic :

- Automatic cutting off lathe
- Single spindle automatic lathe
- Swiss type automatic lathe
- Multiple spindle automatic lathes

Difference b/w automates and semi automatics

Automats	Semi automatics
Loading and unloading of work piece are done automatically by the machine.	Loading and unloading are done manually.
Feeding of bar stock and bringing the tools to correct machining positions are done automatically.	These are done manually.
A single operator can attend a number of machines when they are arranged together as a group.	An operator can attend to only one or two machines at a line.
Production time and cost less.	Not so less.
Best suitable for production of small size components.	Suitable for large size components.
Initial cost of machine is high.	Initial cost is lower than that of automatic lathe.

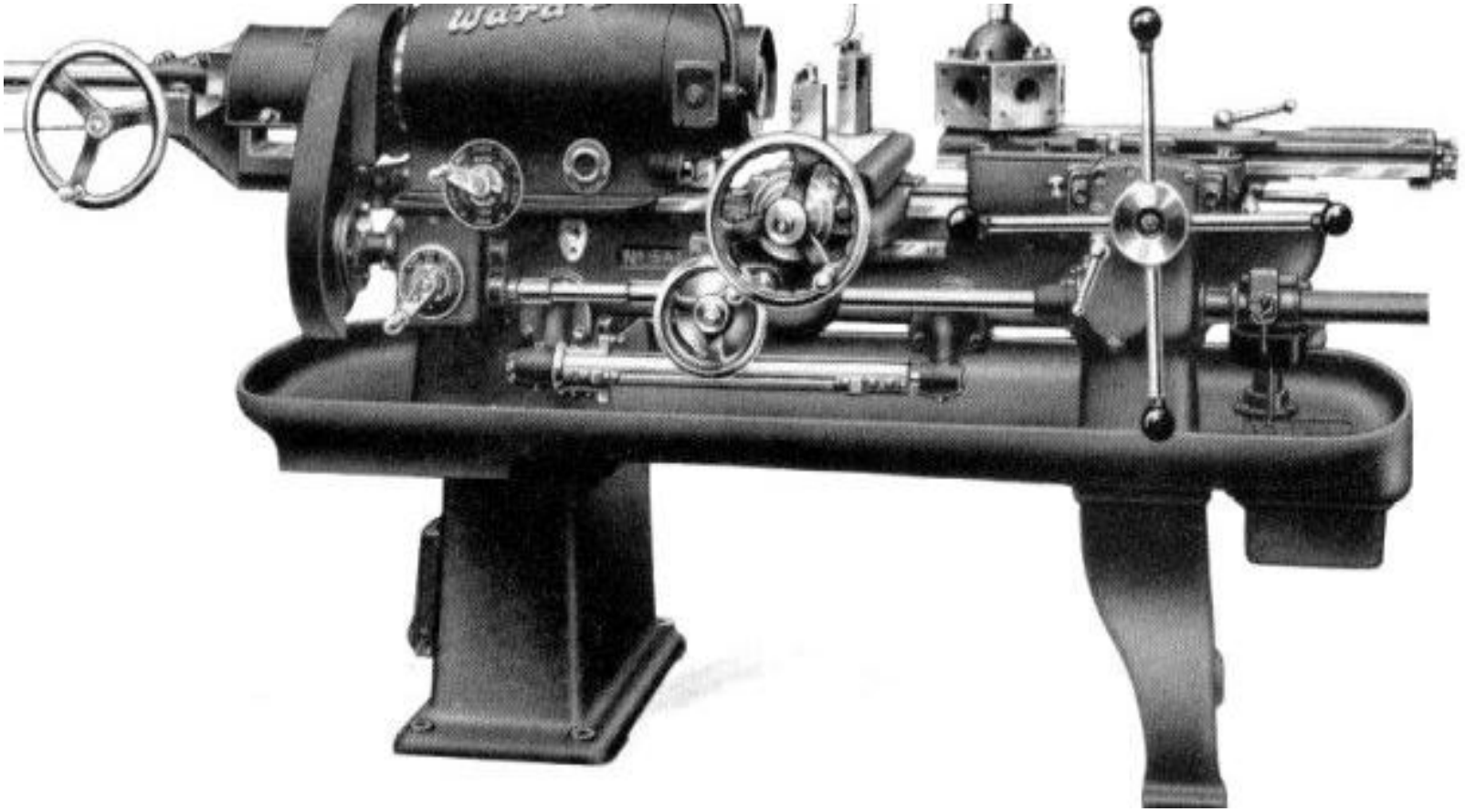
Capstan and Turret Lathe

- ✓ In contrast to centre lathes, capstan and turret lathes are semiautomatic machine tool.
- ✓ lathe are very similar in construction, operation and application.
- ✓ Possess an axially movable indexable turret (mostly hexagonal) in place of tailstock.
- ✓ Holds large number of cutting tools;
  - upto four in indexable tool post on the front & rear
  - upto six in the turret (if hexagonal) as indicated in the schematic diagrams

Contd.,

- ✓ These are more productive for quick engagement and overlapped functioning of the tools in addition to faster mounting and feeding of the job and rapid speed change.
- ✓ Enable repetitive production of same job requiring less involvement, effort and attention of the operator for pre-setting of work–speed and feed rate and length of travel of the cutting tool.
- ✓ Semiautomatic lathes are relatively costlier.
- ✓ But it is suitable and economically viable for batch production or small lot production.

Photo view of Capstan



Capstan Lathe

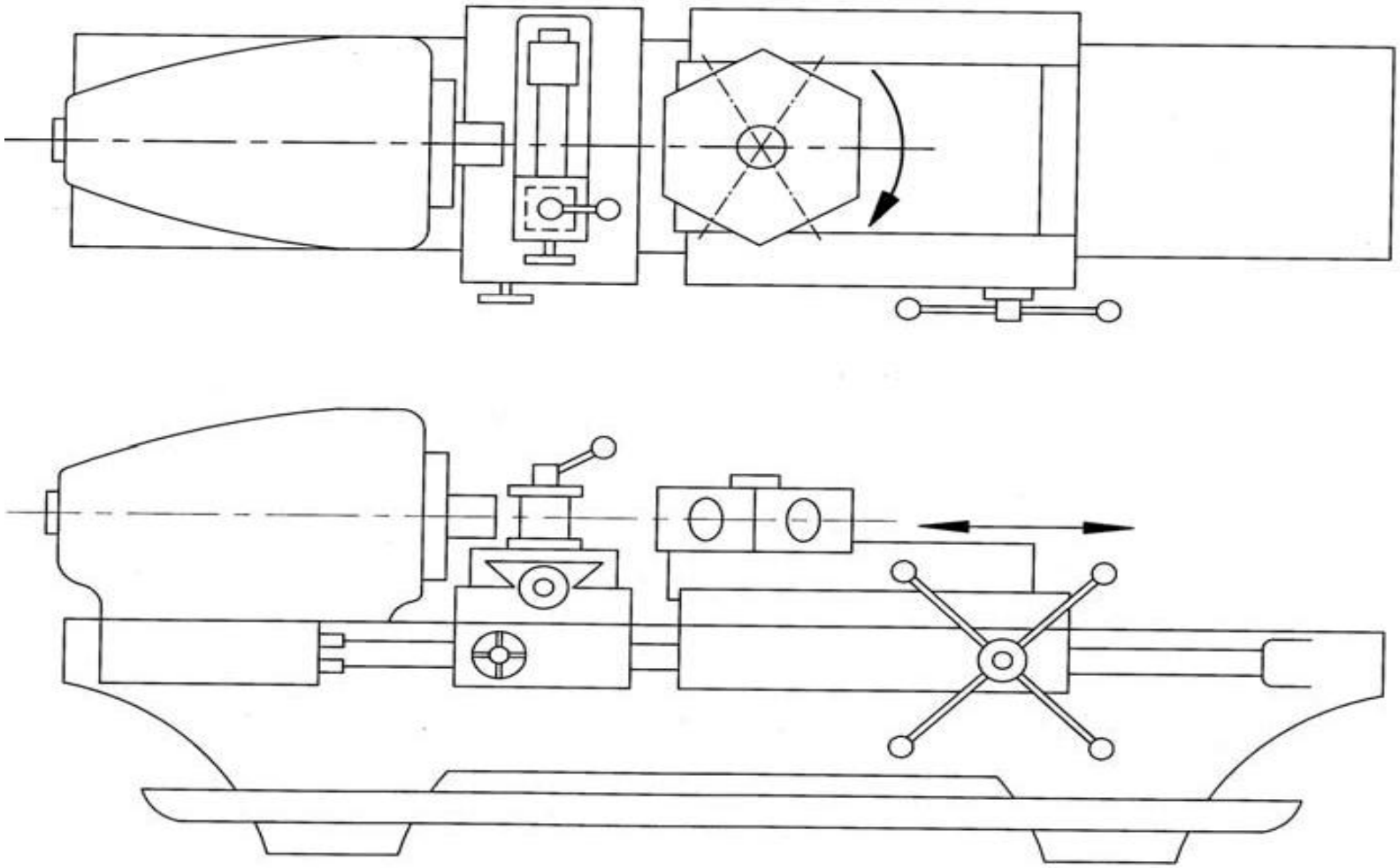
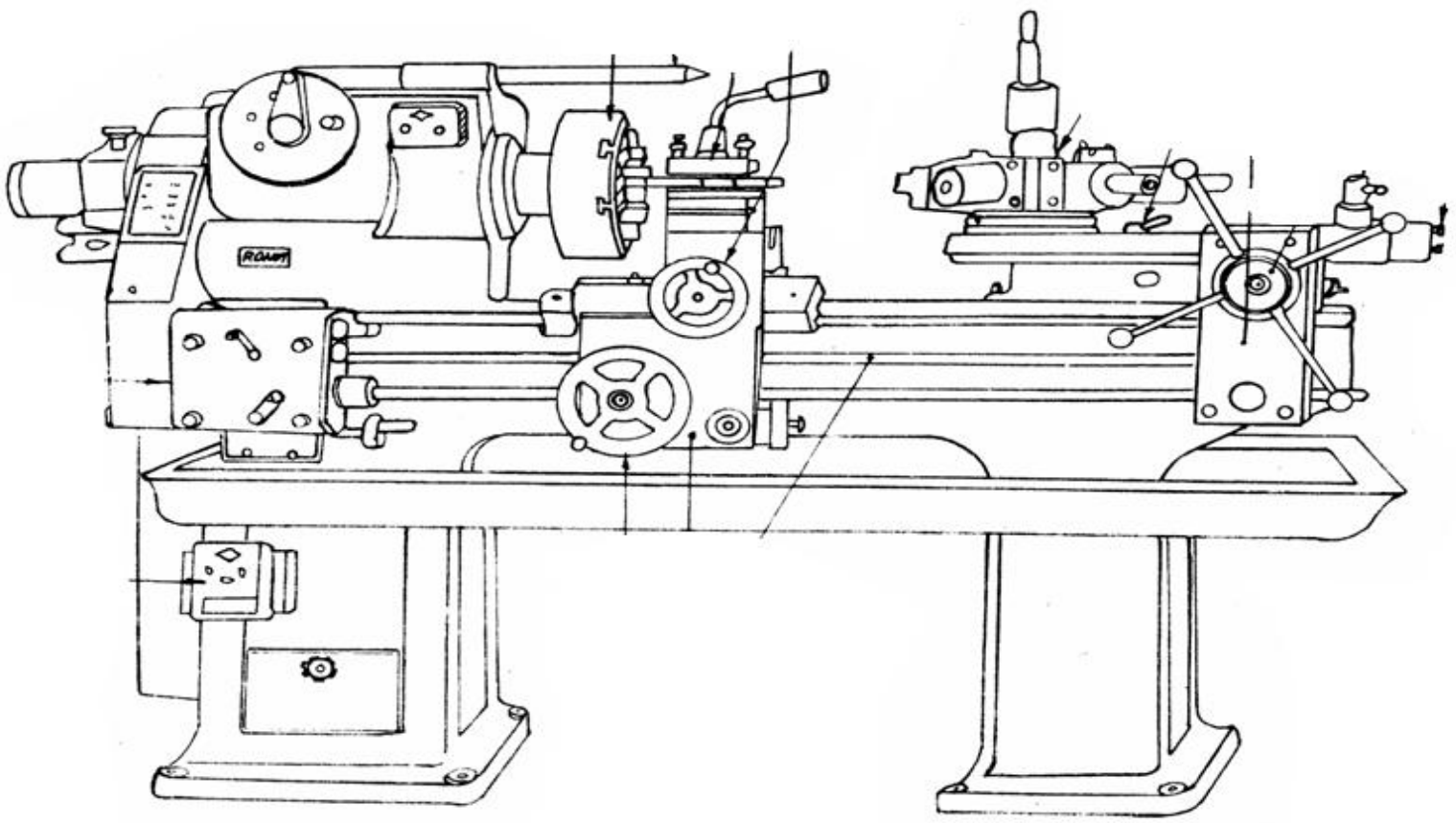


Photo view of Turret

Turret Lathe



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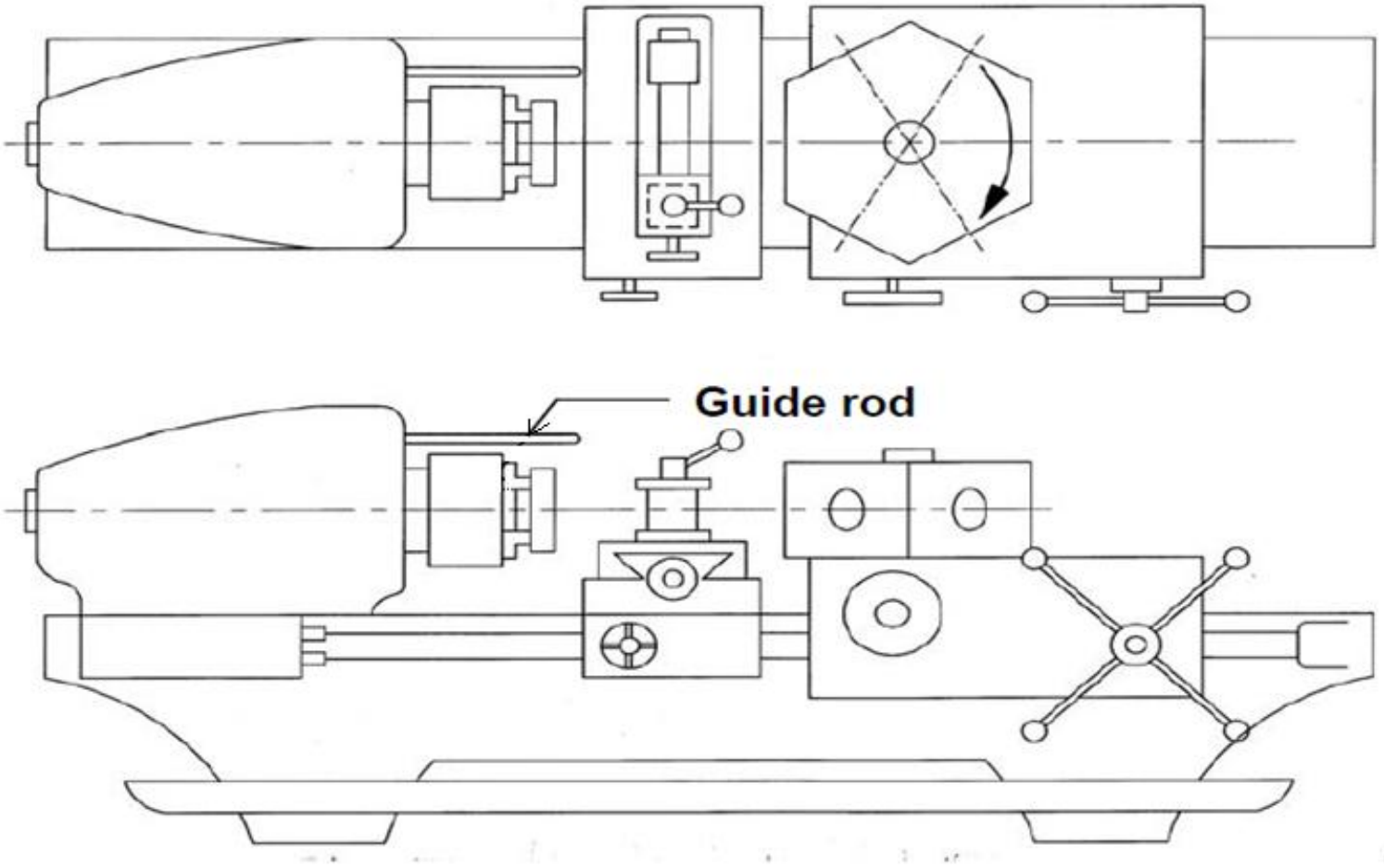


Differences between capstan and turret lathes

Capstan lathe	Turret lathe
Turret head is mounted on a ram which slides over the saddle.	Turret head is directly mounted on saddle. But it slides on the bed.
The turret movement is limited.	The turret moves on the entire length of the bed without any restriction.
Hence shorter work piece can be machined.	Longer work piece can be machined.
Its construction does not provide rigidity due to overhanging of ram beyond the bed.	It provides rigidity and strong.
It is suitable for light duty applications.	It is suitable for heavy duty applications.
Turret head can be moved manually.	Turret head cannot be moved manually.
The maximum size of 60 mm diameter work can be accommodated.	It can accommodate only from 125 to 200mm.
No cross-wise movement to turret.	Facing and turning are usually done by cross-wise movement of turret.
Overhung type of cross-slide is not used.	Overhung type of cross-slide is provided for some specific operations.

Automatic Lathes (Automates)

Introduction

- ✓ These are machine tools in which components are machined automatically
- ✓ The working cycle is fully automatic that is repeated to produce duplicate parts with out participation of operator
- ✓ All movements of cutting tools, their sequence of operations, applications, feeding of raw material, parting off, un loading of finished parts all are done on machine
- ✓ All working & idle operations are performed in definite sequence by control system adopted in automatic which is set up to suit a given work

Advantages

- ✓ Greater production over a given period
- ✓ More economy in floor space
- ✓ More consistently accurate work than turrets
- ✓ More constant flow of production
- ✓ Scrap loss is reduced by reducing operator error
- ✓ During machine operation operator is free to operate another machine/ can inspect completed parts

Application / Operations

- ✓ Automates designed to perform, centering, cylindrical turning, tapered, formed surfaces, drilling, boring, reaming, facing, knurling, thread cutting, facing, milling, grinding, cut off.
- ✓ Also with help of special attachments, additional operations like slotting & key way cutting can be done.

Machine selection

- ✓ Quantity of production required
- ✓ Number of machining operations to be done on job
- ✓ Number of tools required to employed
- ✓ Over all dimensions of that portion of job which is to be machined

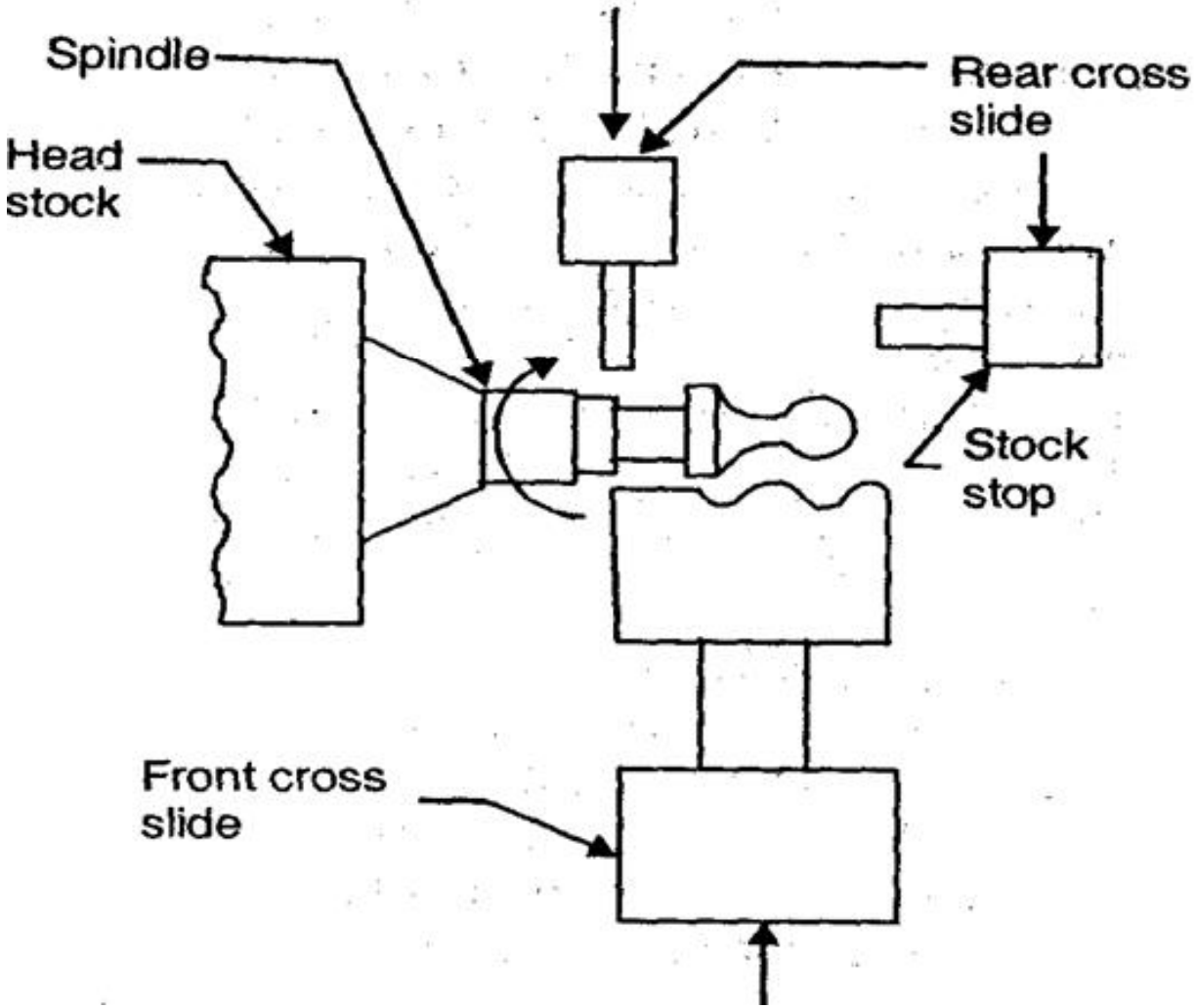
Classification

- ✓ The automates can be classified as follows:
- ✓ Single spindle machine
  - Automatic cutting off
  - Swiss type automatic screw
  - Automatic screw cutting
- ✓ Multi spindle machine
  - Parallel action
  - Progressive action

Single spindle vs Multi spindle

Single spindle automat	Multi spindle automat
There is only one spindle.	There are 2,4,5,6 or 8 spindles.
Only one work piece can be machined at a time.	More number of work pieces can be machined at a time.
The rate of production is low.	The rate of production is high.
Machining accuracy is higher.	Machining accuracy is lower.
Tool setting time is less.	Tool setting time is more.
Tooling cost is less.	Tooling cost is more.
Economical for shorter as well as longer runs.	Economical for longer runs only.
The time required to produce one job is the sum of all turret operation times.	The time required to produce one job is the time of the longest cut in any one spindle.
Tools in turret are indexed.	Work pieces held in spindles are indexed (Progressive action machine)

Single spindle automatic cutting off machine



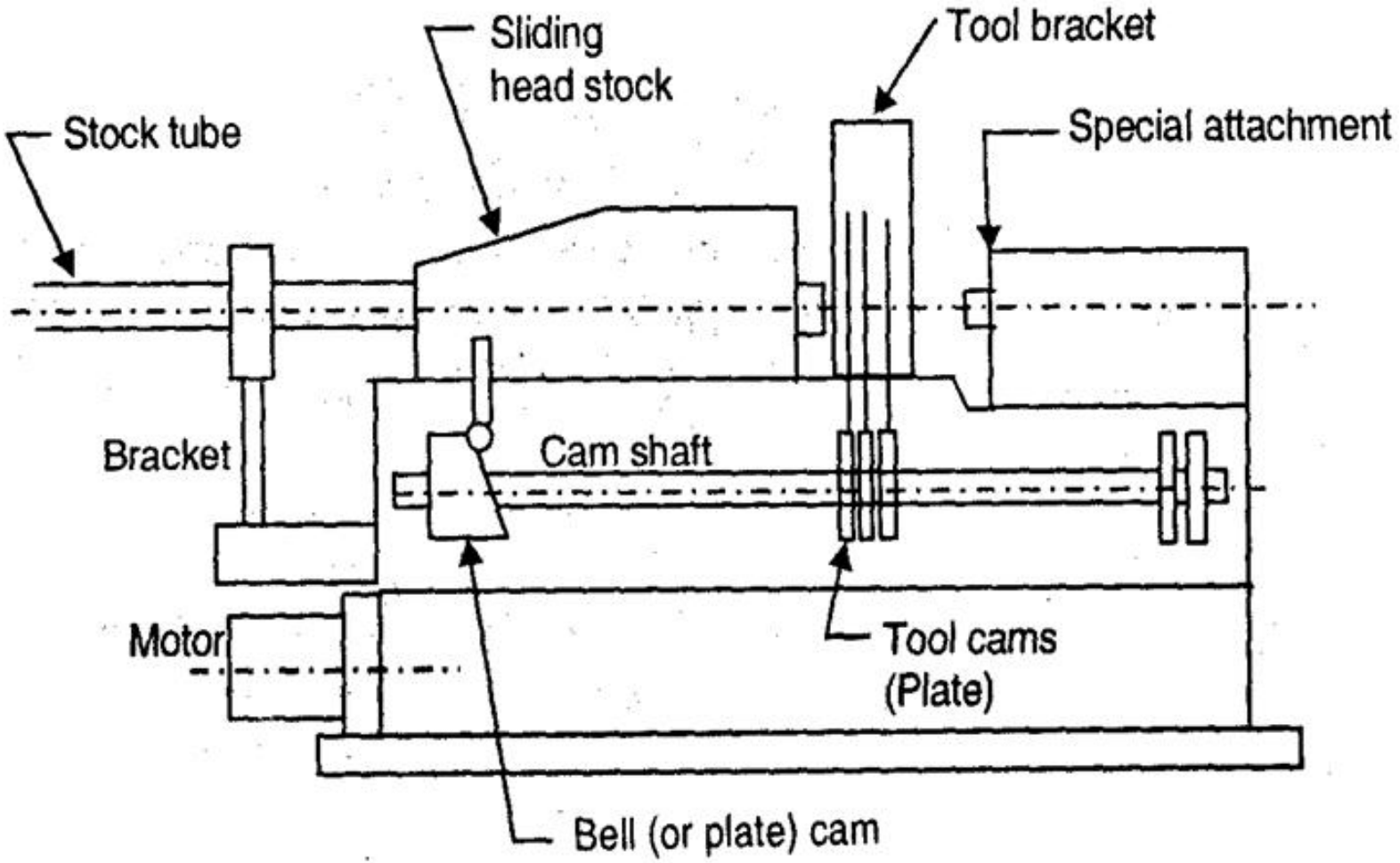
Contd.,

- ✓ These machines produce short w/p's of simple form by means of cross sliding tools.
- ✓ Machines are simple in design.
- ✓ Head stock with spindle is mounted on bed.
- ✓ 2 cross slides are located on bed at front end of spindle.
- ✓ CAMS on cam shaft actuate movements of cross slide through system of levers

Contd.,

- ✓ The required length of work(stock) is fed out with a cam mechanism, up to stock stop which is automatically advanced in line with spindle axis at each end of cycle.
- ✓ Stock is held in collet chuck of rotating spindle.
- ✓ Machining is done by tolls that are held in slides operating only in cross wise direction.
- ✓ Typical simple parts (3 to 20 mm dia) can be machined on this machine

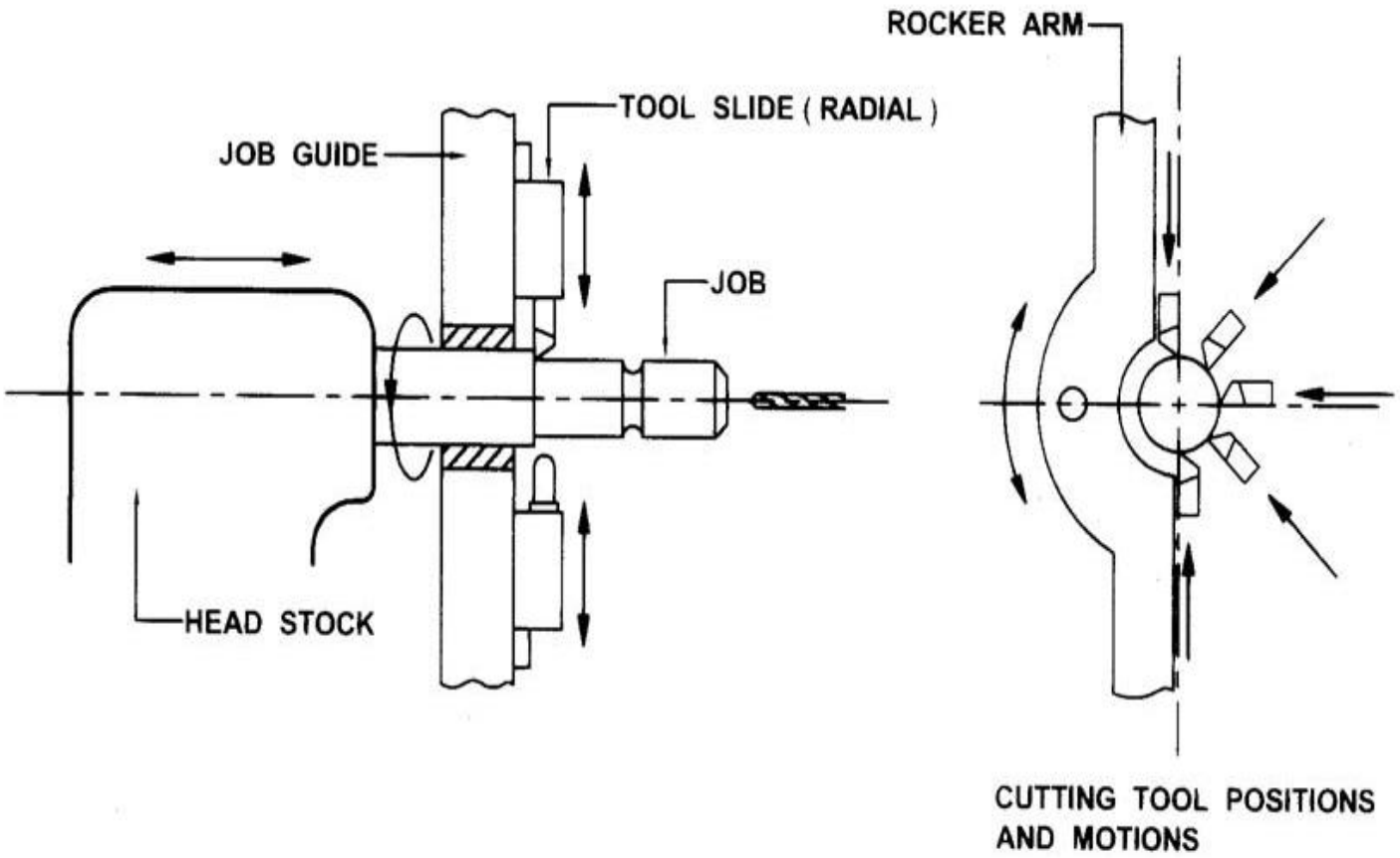
Swiss type automatic screw / sliding head screw



Contd.,

- ✓ As name implies in this m/c head stock is movable & tools are fixed.
- ✓ These machines are used for machining long accurate parts of small diameter. (2 to 25mm).
- ✓ Bar stock is held in rotating collet in head stock & all longitudinal feeds are obtained by cam which moves entire head stock as unit.
- ✓ Rotating bar stock is fed through hard bushing in centre of tool head.

Contd.,

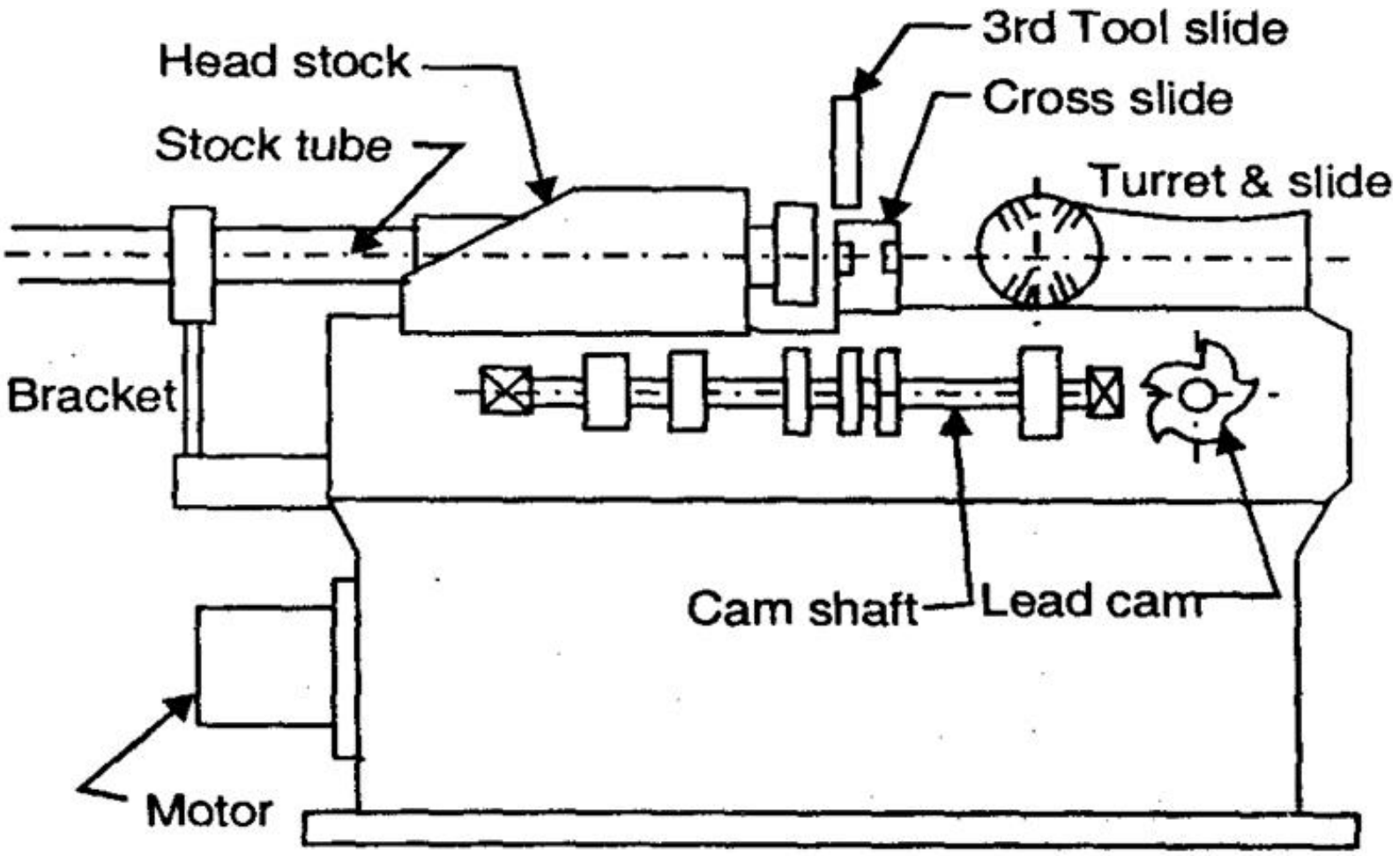


CUTTING TOOL POSITIONS AND MOTIONS

Contd.,

- ✓ Tool head consists of 5 single point tools is placed radially around bushing.
- ✓ Mostly diameter turning is done by 2 horizontal slides, other 3 slides used for operations such as knurling, chamfering, cutoff.
- ✓ Tools are controlled & positioned by cams that bring tool in as needed to turn, face, form, cutoff w/p from bar as it emerges from bushing. Close tolerances 0.005 to 0.00125 mm are obtained.

Single spindle automatic Screw m/c



Contd.,

- ✓ Generally used for producing small screws(12 to 60 mm dia), but also in production of all sorts of small turned parts.
- ✓ These are completely automatic bar type turret lathes, designed for machining complex internal & external surfaces on parts made of bar stock / separate blanks.
- ✓ Up to 10 different cutting tools can be employed at one time in tooling of this kind of screw machine.
- ✓ 2 cross slides (front & rear) are employed for cross feeding tools.
- ✓ Vertical tool slides for parting off operation may also be provided.

Contd.,

- ✓ Head stock is stationary and houses the spindle.
- ✓ Bar stock is held in collet chuck & advanced after each piece is finished & cut off.
- ✓ All movements of machine units are actuated by cams mounted on cam shaft.
- ✓ Bar stock is pushed through stock tube in a bracket & its leading end is clamped in rotating spindle by means of collet chuck.

Contd.,

- ✓ By stock feeding mechanism bar is fed out for next part.
- ✓ Machining of screw & central hole is done by tools that are mounted on turret slide.
- ✓ Parting off form tool is mounted on cross slide is cut the finished part.
- ✓ At end of each cut, turret slide is with drawn automatically & indexed to bring next tool to position.

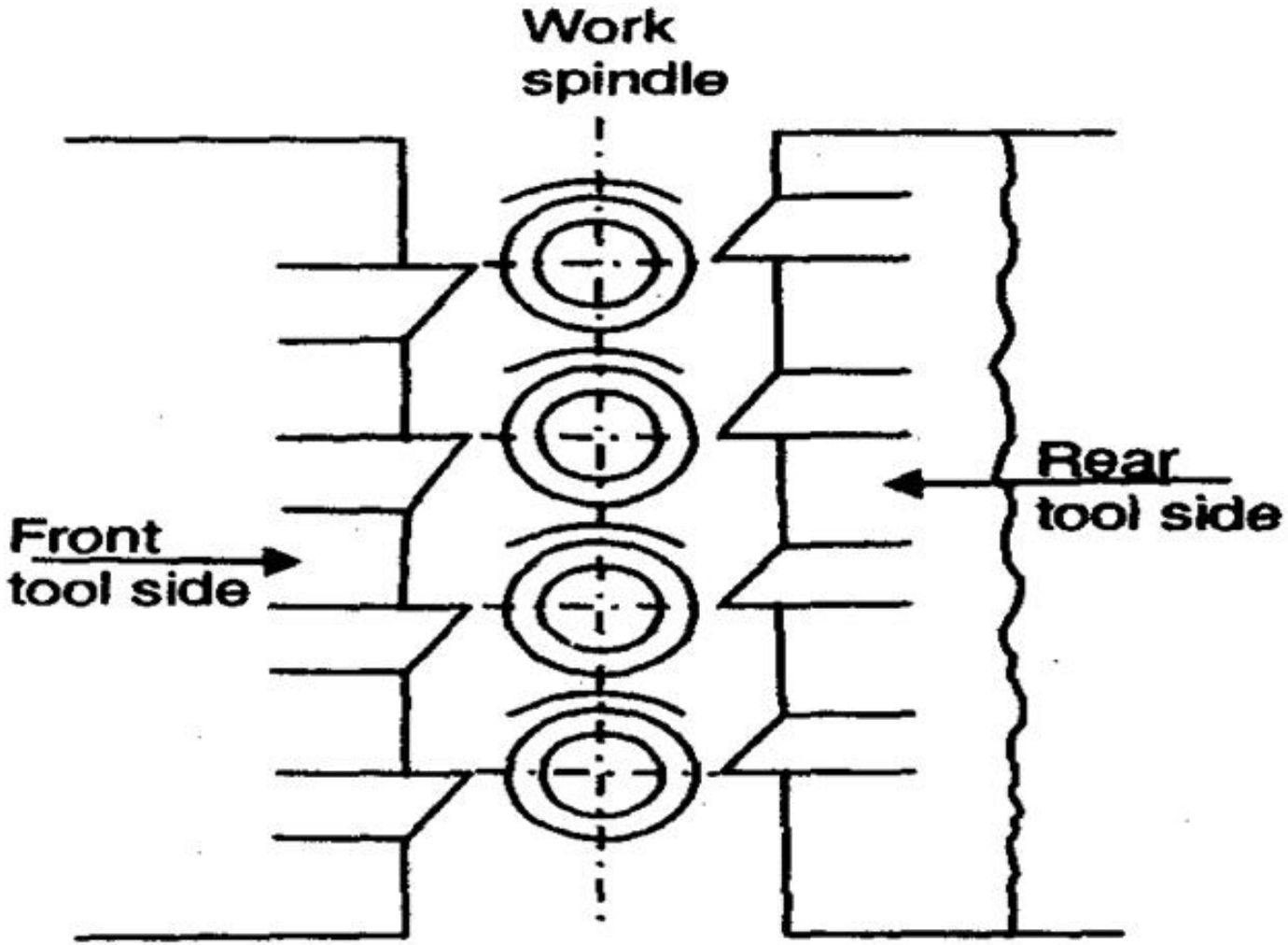
Multi spindle automates

- These are fastest type of production machines and are made in a variety of models with 2,4,5,6,8 spindles.
- In contrast with single spindle m/c where one turret face at a time is working on one spindle.
- In multi spindle m/c all turret faces works on all spindles at same time.

Contd.,

- ✓ Production capacity is higher.
- ✓ Machining accuracy is lower compared to single spindle.
- ✓ Because of longer set up time, increased tooling cost
- ✓ This machines are less economical for short runs and more economical for longer runs.

Parallel action multi spindle automat / multiple flow m/c



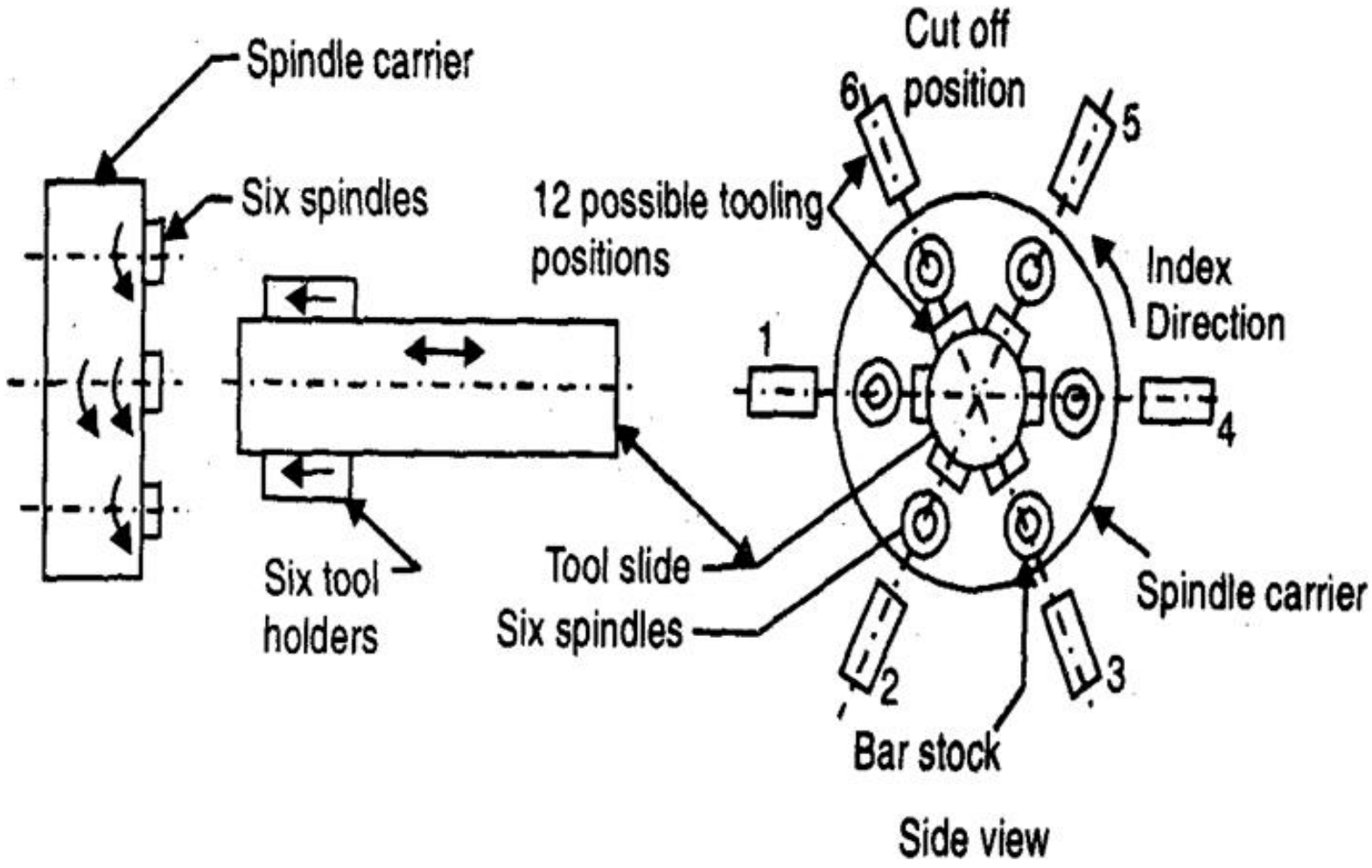
Contd.,

- In this type of machine same operation is performed on each spindle, w/p is finished in each spindle in one working cycle.
- No. of components being machined = No. of spindles in machine.
- Rate of production is high & machine can be used to machine simple parts only, since all the machining processes are done at one position.
- These machines are generally used to perform same work as single spindle automatic cut off machines.

Contd.,

- ✓ Machine consists of frame with head stock at right end.
- ✓ Horizontal work spindles that are arranged one above the another are housed in this head stock.
- ✓ Cross slides are located at right & left hand sides of spindles & carry cross feeding tools.
- ✓ All working & auxiliary motions of machine unit are obtained from CAM mounted on cam shaft.

Progressive action multi spindle automat



Contd.,

- ✓ In this machine, the w/p is machined in states & progressively in station after station.
- ✓ Head stock is mounted on left end of base of machine.
- ✓ It carries spindle carrier which rotates about a horizontal axis through centre of machine.
- ✓ Working spindles are mounted on this spindle carrier.
- ✓ Spindles carry collets & bars from which w/p's are machined.
- ✓ Bar stock is fed through each spindle from rear side.
- ✓ On face of spindle carrier support are mounted cross slides which carry tools for operations such as cutoff, turning, facing, forming, chamfering.

Contd.,

- ✓ No. of slides = No. of spindles.
- ✓ Main tool slide (end tool slide) extends from middle of this support.
- ✓ Fed of each tool, both cross slide & end tool slides is controlled by its own individual cams.
- ✓ In this diagram spindle carrier indexes on its own axis by 60° at each cutting tool retraction.
- ✓ As spindle carrier indexes, it carries work from one station to another station where different tolls operate on work.
- ✓ Stock moves round the circle in counter clock wise direction & returns to station no. 6 for cutting off.

Parallel vs Progressive

Parallel action multi spindle automat	Progressive action multi spindle automat
Same operation is done on all jobs in all the spindles.	Different operations are done on jobs at each station one after another.
In one cycle the number of components produced simultaneously is equal to the number of spindles.	It is not so. (i.e.) The number of components produced in one cycle is not equal to the number of spindles. For every indexing of component (spindle) one component is produced.
Rate of production is very high.	Rate of production is moderate.
If anything goes wrong in one station, the production in that particular station only is affected.	If anything goes wrong in one station, the production is completely affected in all the stations.
Small parts of simple shapes are produced.	Parts of complicate shapes can be produced.