TURNING MACHINES

LATHE

Introduction

Lathe is a machine, which removes the metal from a piece of work to the required shape & size

HENRY MAUDSLAY - 1797

Types of Lathe

Engine Lathe

The most common form of lathe, motor driven and comes in large variety of sizes and shapes.

Bench Lathe

A bench top model usually of low power used to make precision machine small work pieces.

Tracer Lathe

a lathe that has the ability to follow a template to copy a shape or contour.

Automatic Lathe

A lathe in which the work piece is automatically fed and removed without use of an operator. Cutting operations are automatically controlled by a
sequencer of some form

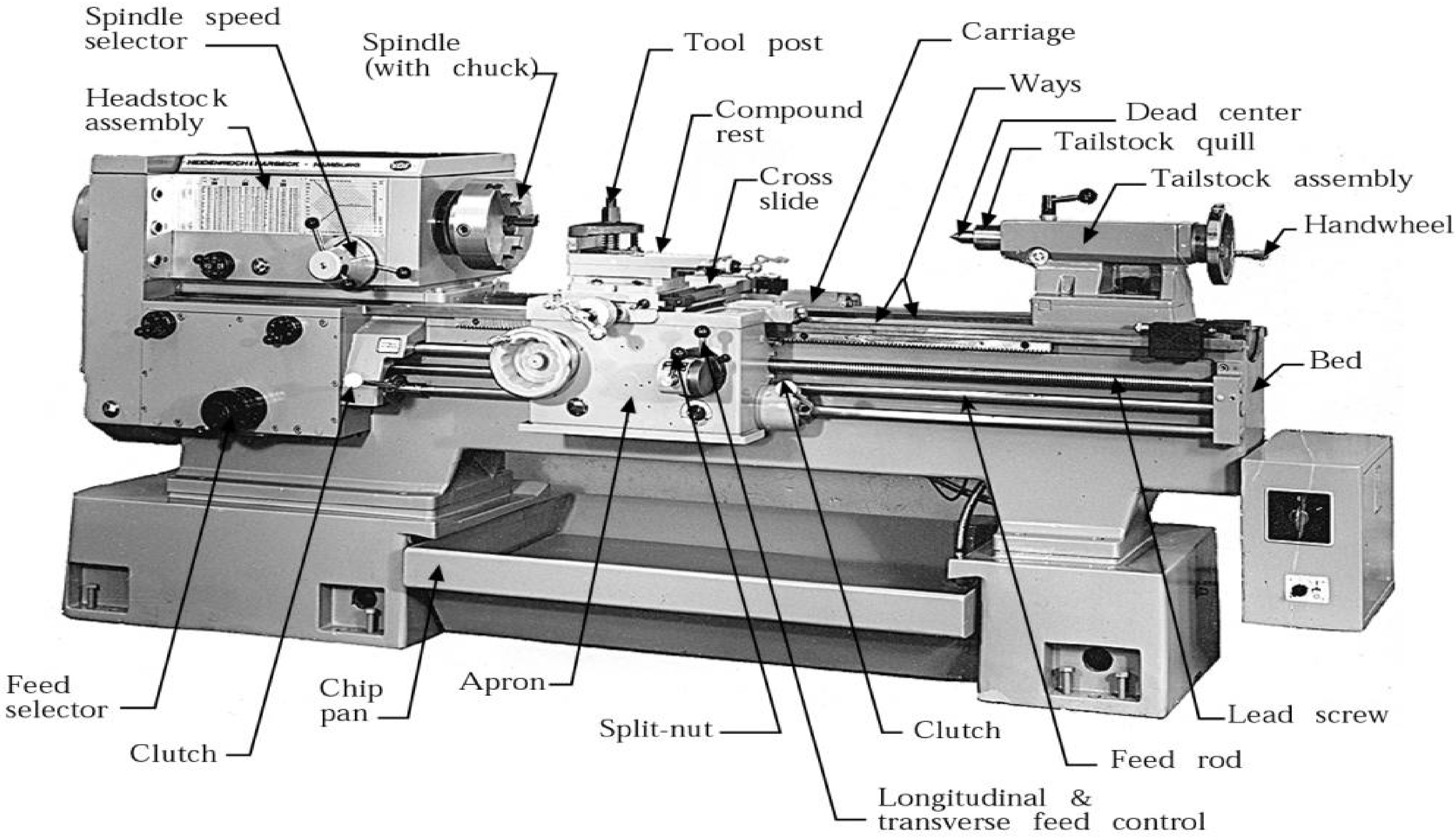
Turret Lathe

lathe which have multiple tools mounted on turret either attached to the tailstock or the cross-slide, which allows for quick changes in tooling and cutting operations.

Computer Controlled Lathe

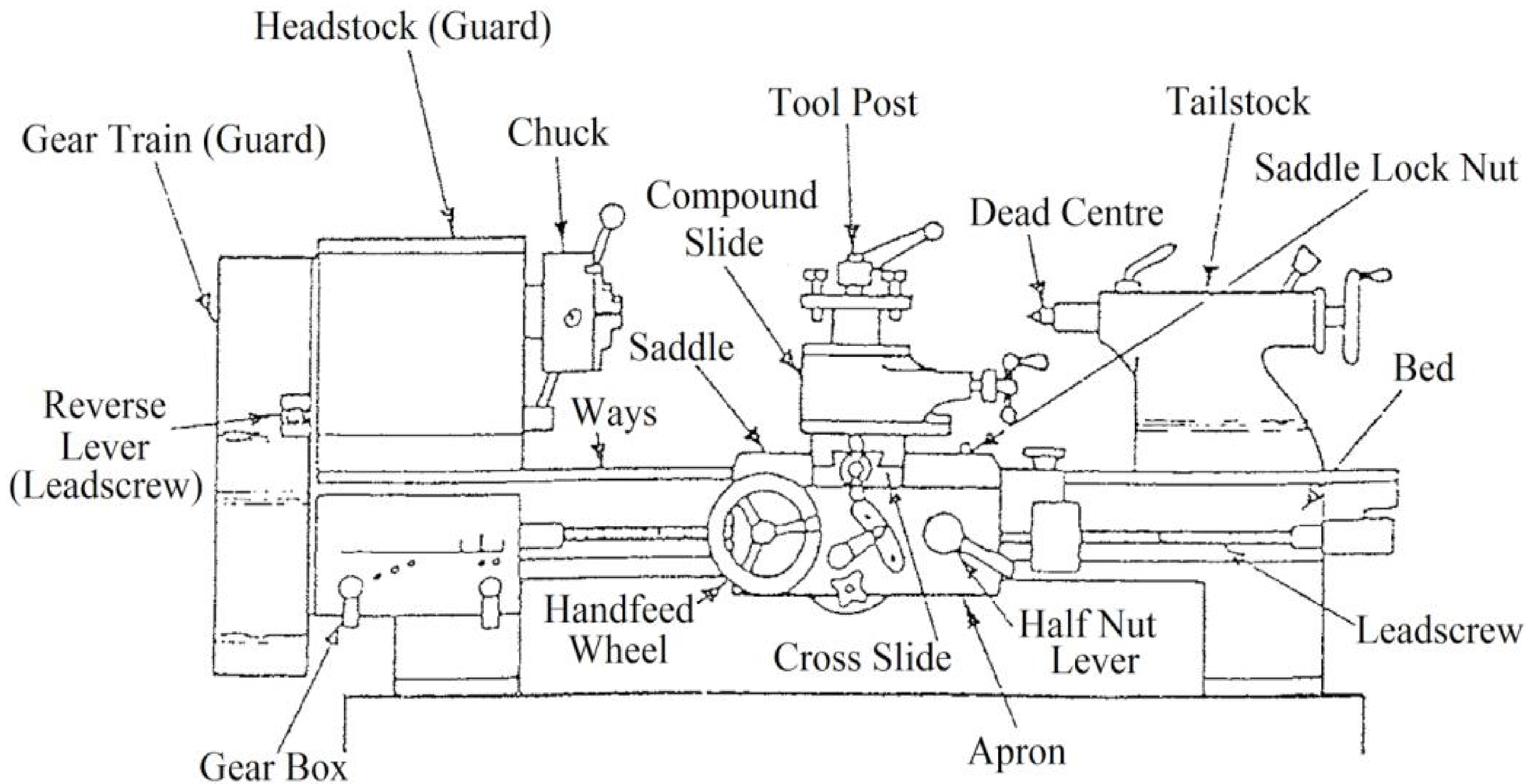
A highly automated lathe, where both cutting, loading, tool changing, and part unloading are automatically controlled by computer coding.

Components

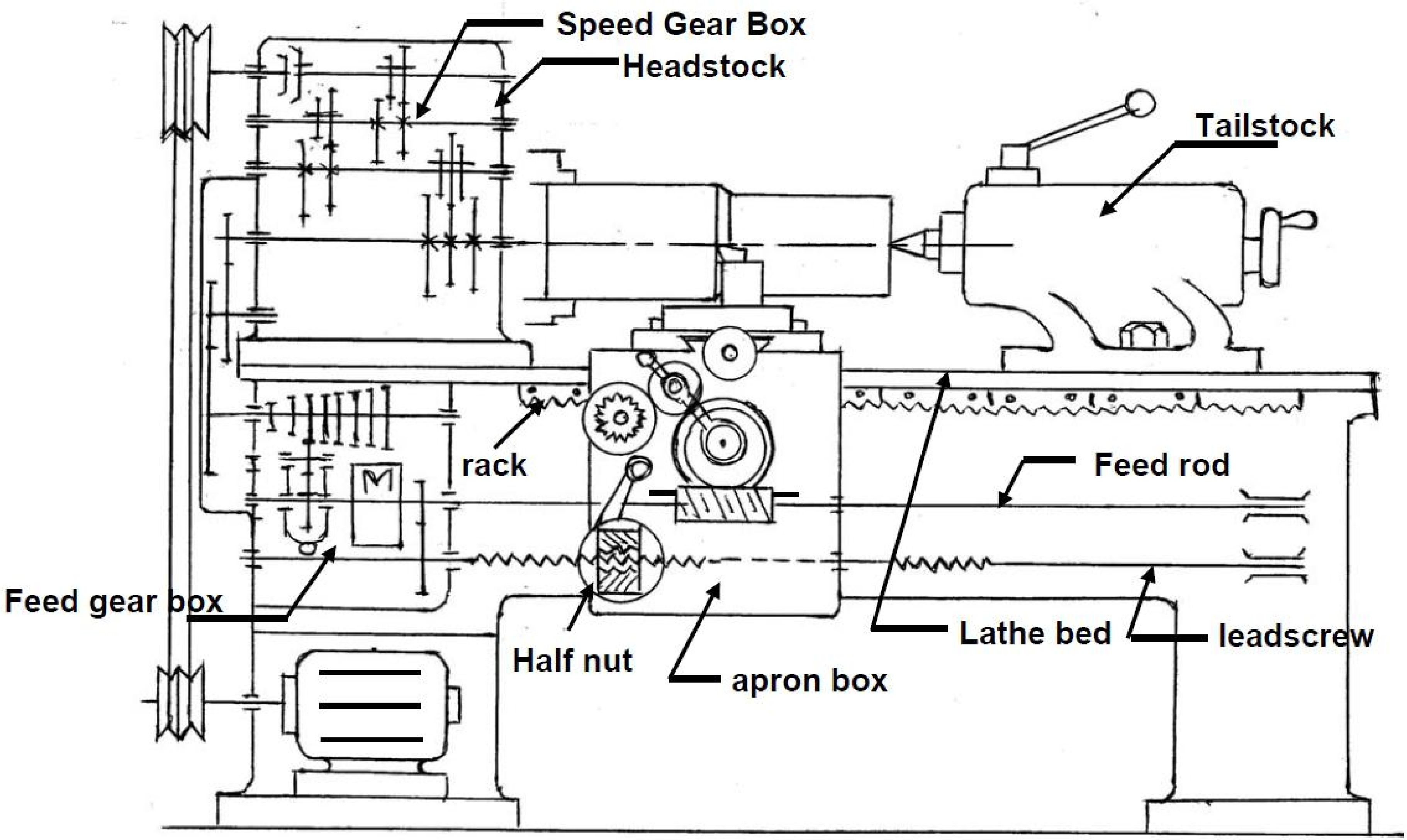


Spindle speed selector
Spindle (with chuck)
Tool post
Carriage
Headstock assembly
Compound rest
Ways
Dead center
Tailstock quill
Cross slide
Tailstock assembly
Handwheel
Bed
Feed selector
Chip pan
Apron
Clutch
Split-nut
Clutch
Lead screw
Feed rod
Longitudinal & transverse feed control

Schematic view of Lathe



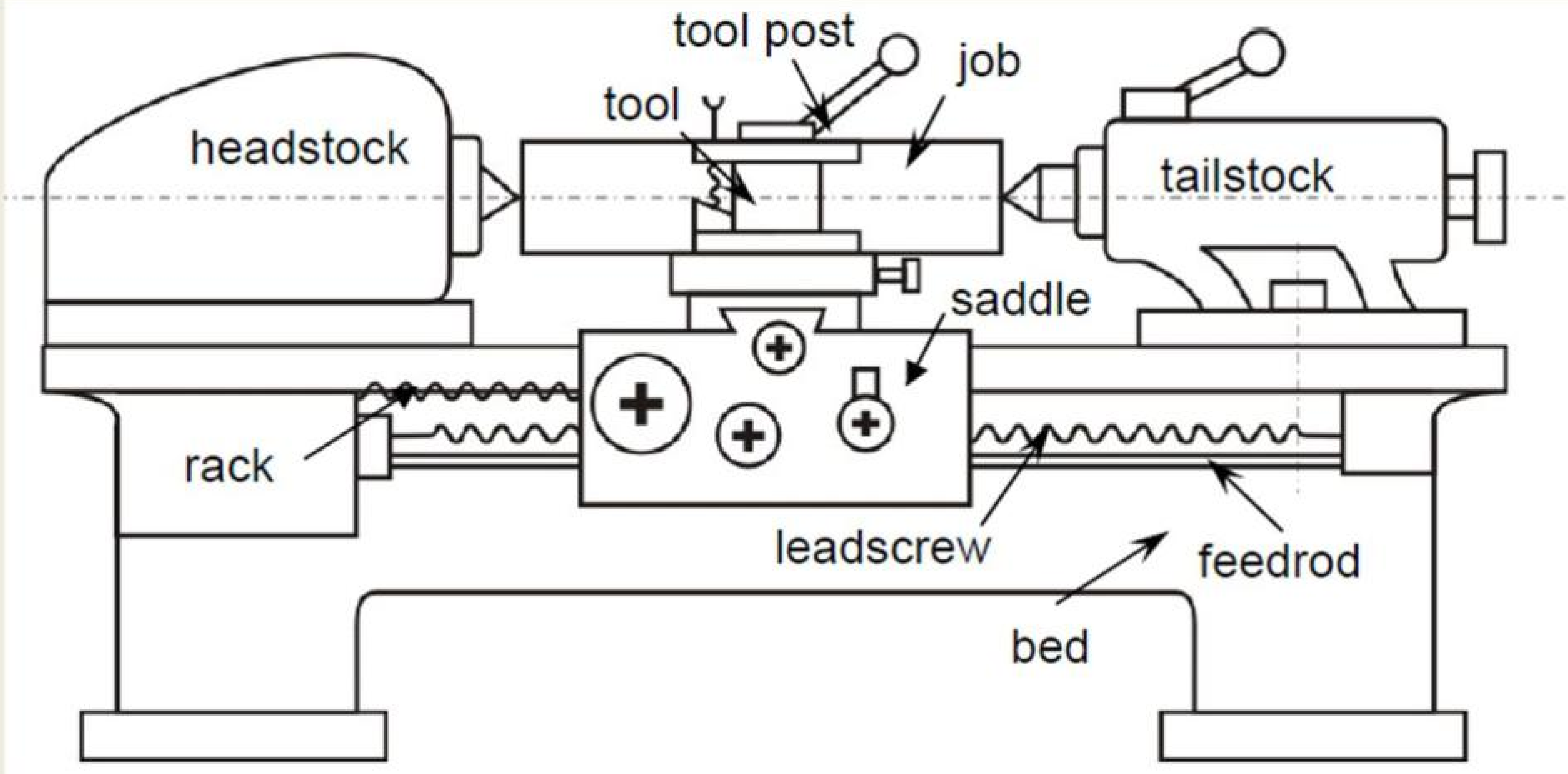
Metal Lathe



Speed Gear Box
Headstock
Tailstock
rack
Feed rod
Feed gear box
Half nut
apron box
Lathe bed
leadscrew

PRESIDENT UNIVERSITY

Schematic Lathe



Schematic diagram of a centre lathe. .

Operations on Lathe

Turning: produce straight, conical, curved, or grooved work pieces

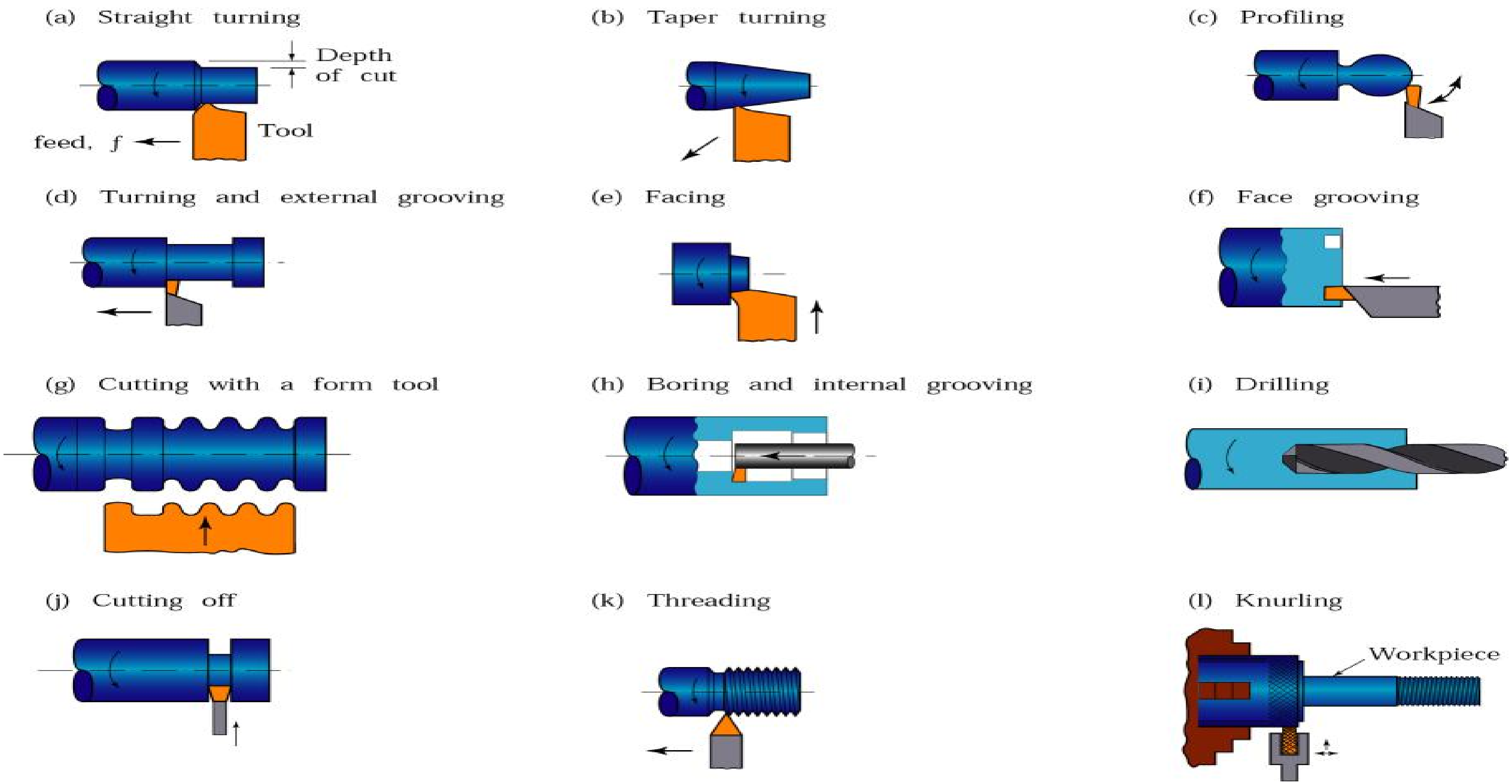
Facing: to produce a flat surface at the end of the part or for making face grooves.

Boring: to enlarge a hole or cylindrical cavity made by a previous process or to produce circular internal grooves.

Drilling: to produce a hole by fixing a drill in the tailstock

Threading: to produce external or internal threads

Knurling: to produce a regularly shaped roughness on cylindrical surfaces


(a) Straight turning
Depth of cut
Tool
feed, f
(b) Taper turning
(c) Profiling
(d) Turning and external grooving
(e) Facing
(f) Face grooving
(g) Cutting with a form tool
(h) Boring and internal grooving
(i) Drilling
(j) Cutting off
(k) Threading
(l) Knurling
Workpiece

Operations performed either by holding w/p b/w centers or by chuck

1. Straight turning
2. Shoulder turning
3. Chamfering
4. Thread cutting
5. Facing
6. Knurling
7. Filing
8. Taper turning
9. Eccentric turning
10. Polishing
11. Grooving
12. Spinning
13. Spring winding
14. Forming

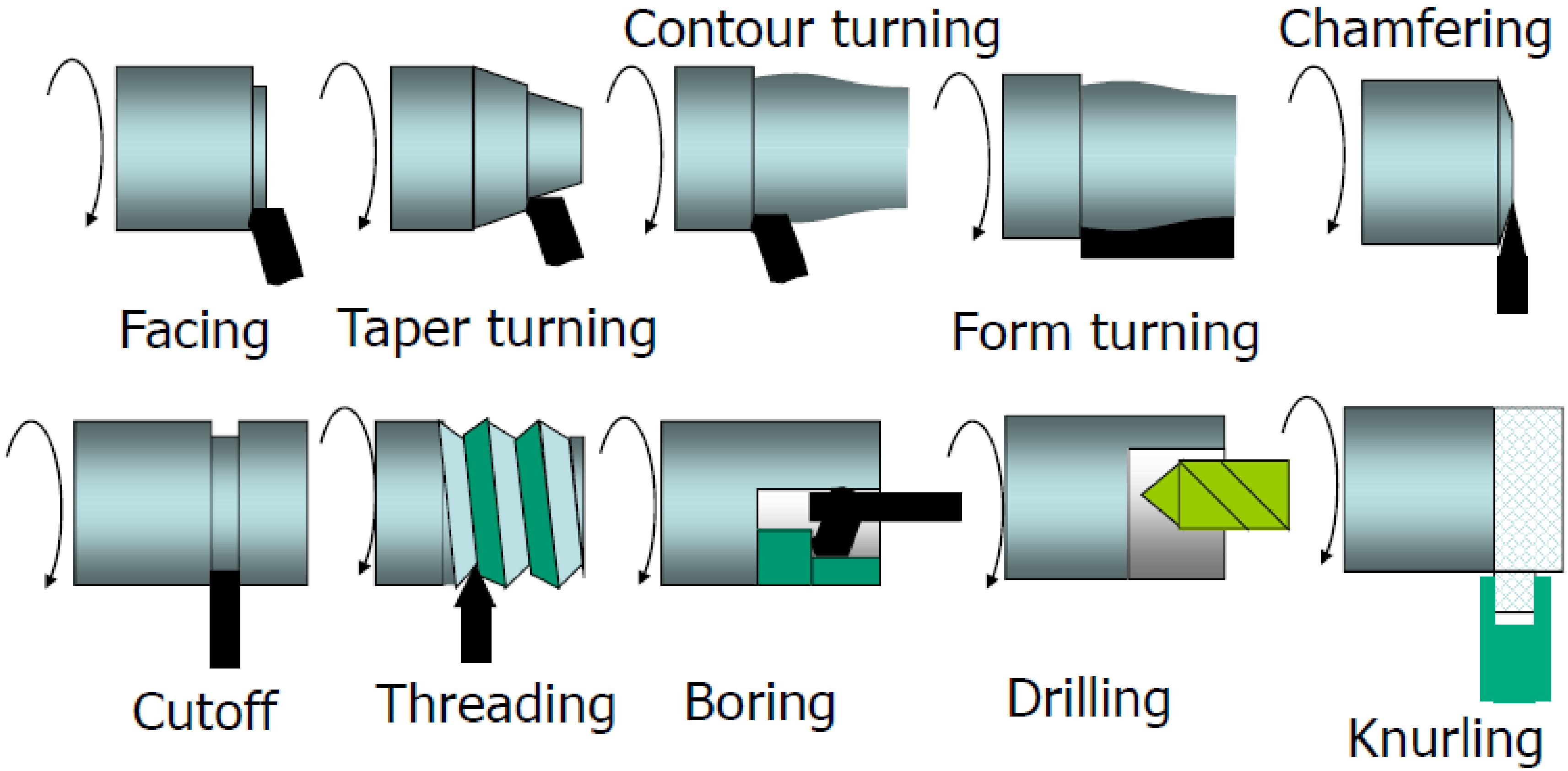
Operations performed either by holding w/p by chuck or faceplate or angleplate

1. Drilling
2. Reaming
3. Boring
4. Counterboring
5. Taperboring
6. Internal thread cutting
7. Tapping
8. Under cutting
9. Parting off

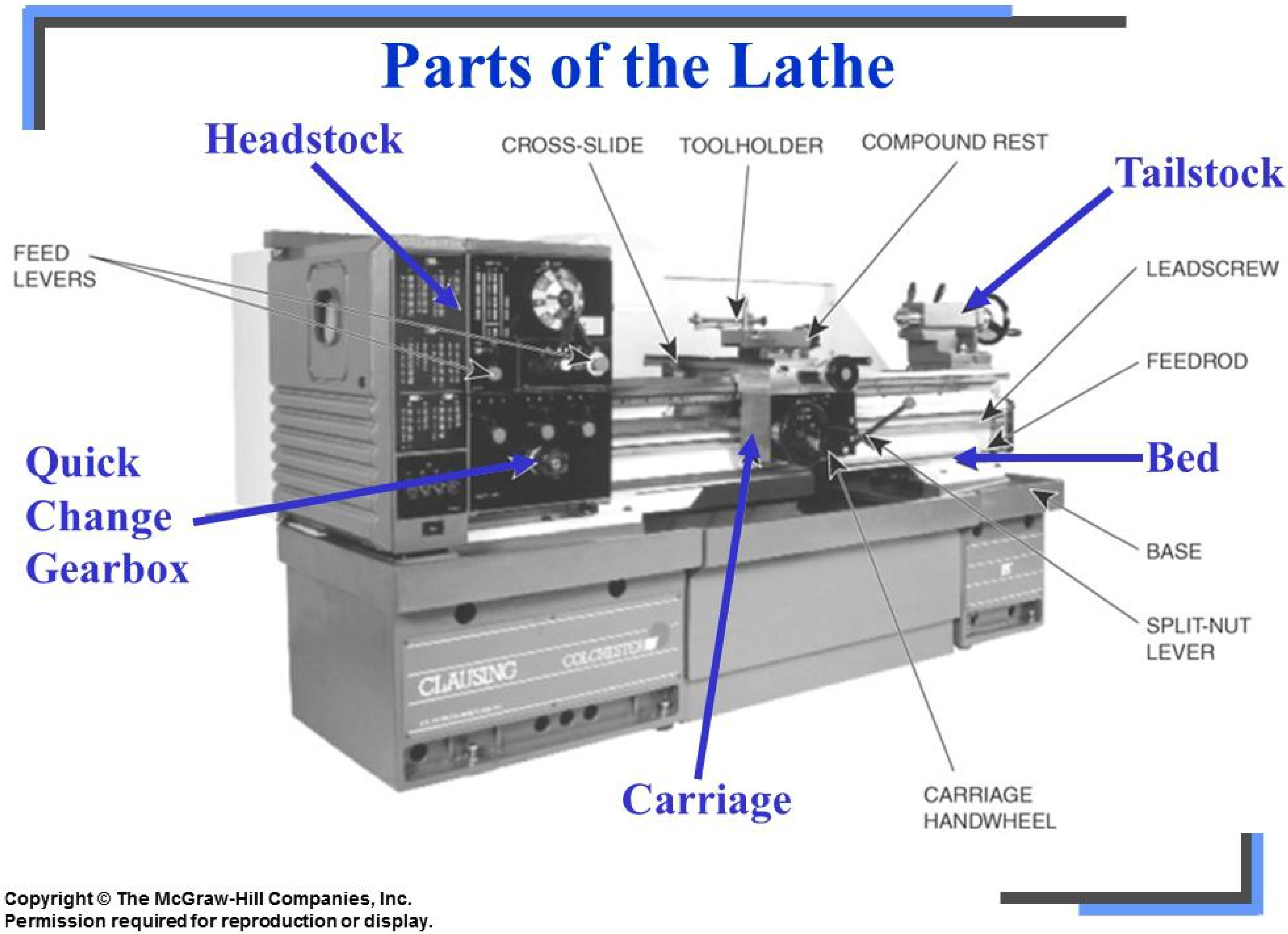
Operations performed by using special attachments

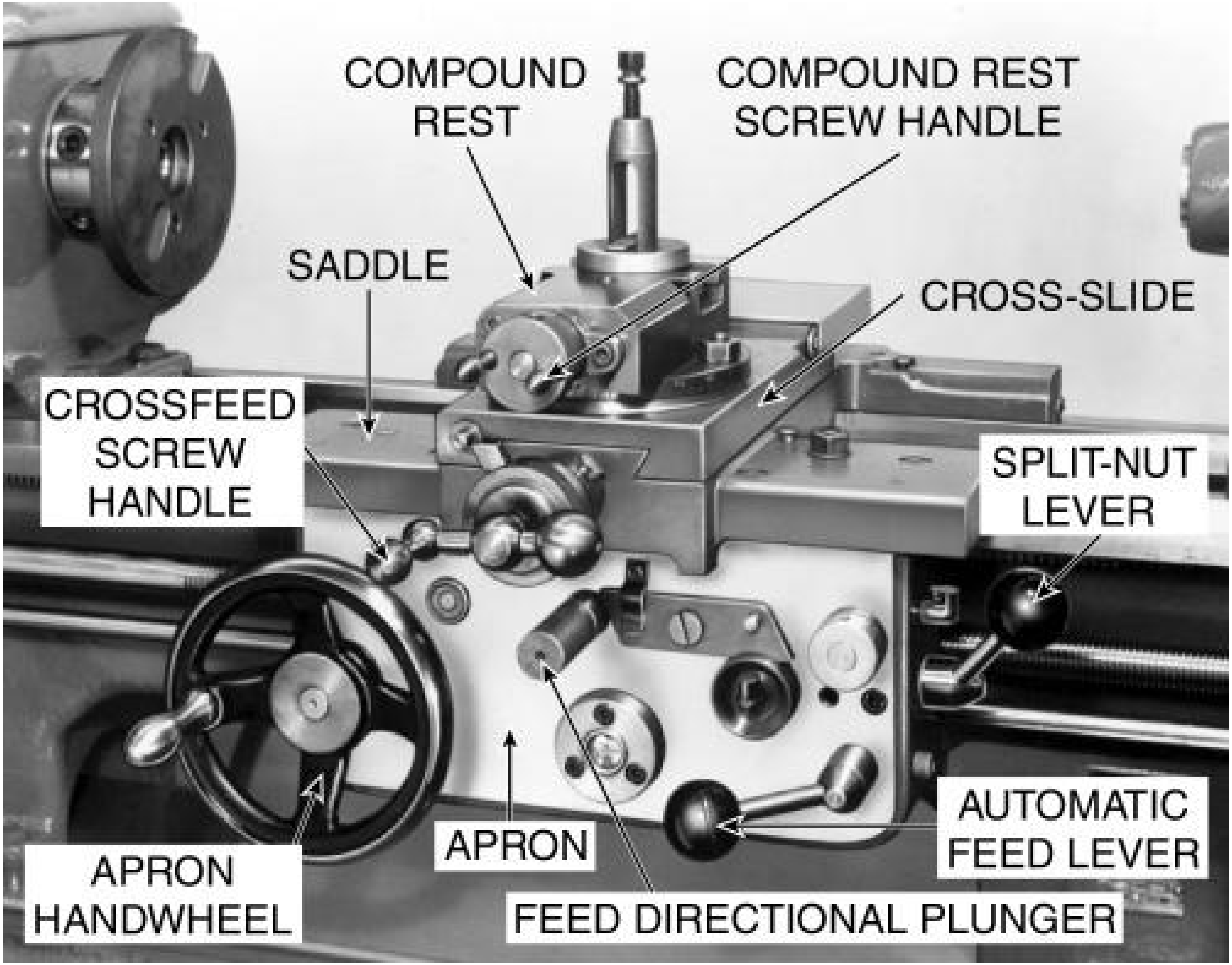
1. Grinding
2. Milling

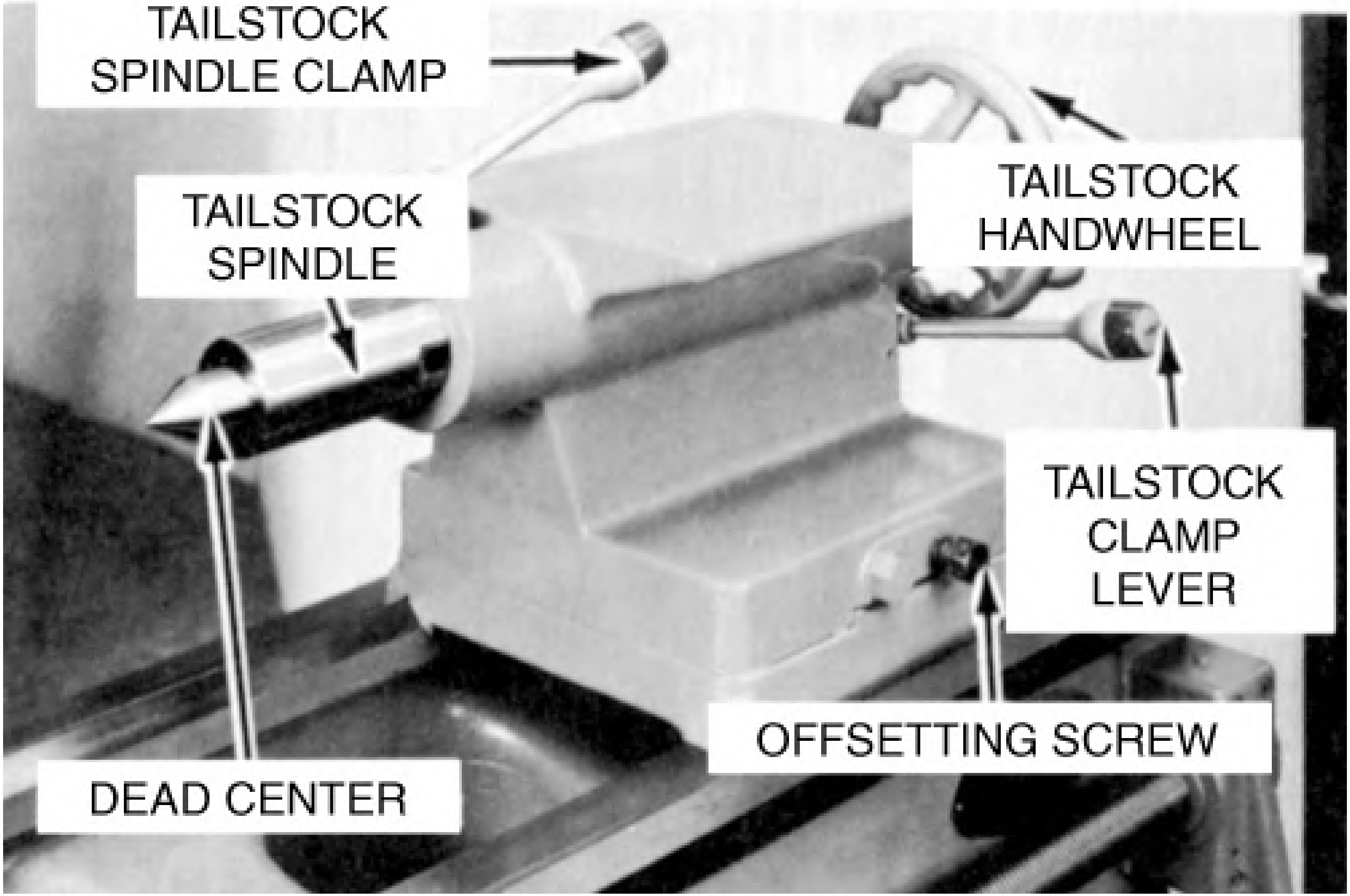
Operations related to Turning



Constructional Features of Lathe




COMPOUND REST
COMPOUND REST SCREW HANDLE
SADDLE
CROSS-SLIDE
CROSSFEED SCREW HANDLE
SPLIT-NUT LEVER
AUTOMATIC FEED LEVER
APRON
APRON HANDWHEEL
FEED DIRECTIONAL PLUNGER


TAILSTOCK SPINDLE CLAMP
TAILSTOCK SPINDLE
TAILSTOCK HANDWHEEL
TAILSTOCK CLAMP LEVER
DEAD CENTER
OFFSETTING SCREW

Constructional features & functions

Lathe Machine consists of

- bed
- headstock
- tailstock
- carriage assembly
- quick change gearbox

Bed

Bed made out of gray or ductile cast iron or fabricated from steel by welding. Bed is divided to 2 types, first is the outer way and another one is the inner way.

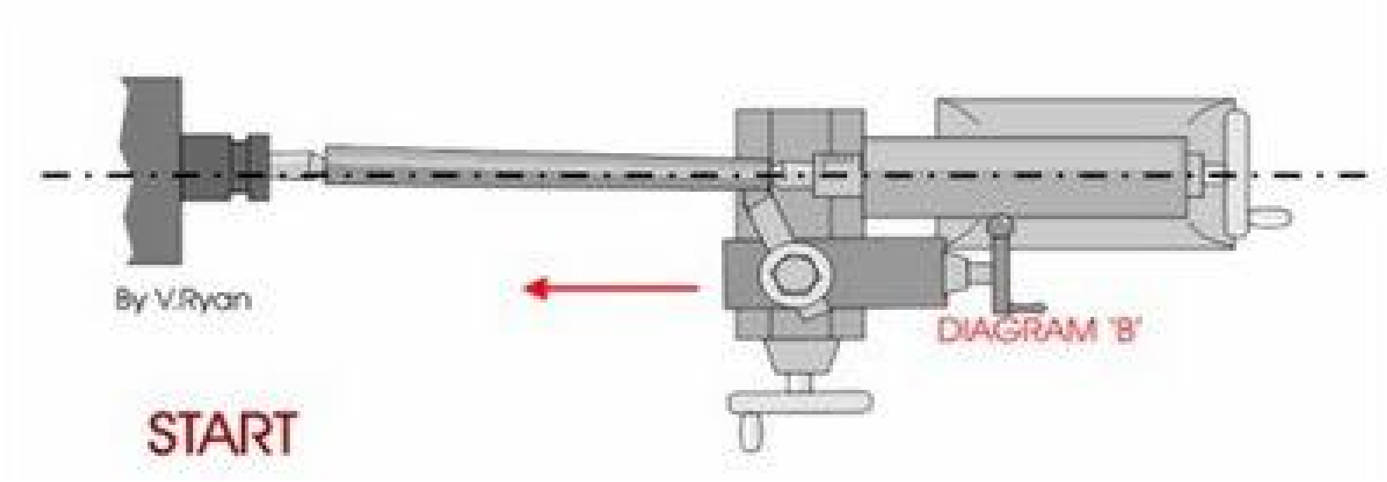
In the Inner way, headstock and tailstock located in it. By the longitudinal movement for the carriage assembly and towards the centerline of the lather. The bed is needed to clean to avoid damaging to the machine

Headstock

- Headstock mounted on the left side of the lathe machine.
- the function of the headstock is to turn the work piece and where it is support to hold the attachments mount.
- the spindle is mounted on the bearings on the headstock and it is hardened and specially ground to fit different type of devices. Spindle speed is controlled by varying the geometry of the drive train
- 3 jaw chucks, collets and centers can be held in the spindle
- To reverse the headstock movement, the lead screw and feed rod will change the direction of the movement of the carriage

Tailstock

- support the end of the longer work piece
- holds cutting tools for internal machining operations
- spindle is graduated to control the depth of the drilling operations.
- fastened into the position by tailstock clamp
- the spindle in the tailstock can be adjusted longfitudinally by rotating hand wheel and locked by tailstock spindle lock



It allow the top part to move toward or backward from the operator
- For turning tapered parts or aligning the tailstock spindle true with headstock spindle.
- Must be realigned exactly on center when turning a cylindrical part

Carriage Assembly

- move along longitudinally
- H- shaped casting fitted on the outer set of ways
- cross slide mounted on the top of the saddle and moves the cutting tool laterally across the bed by cross feed hand wheel that has a micrometer collar that allows the cutting tools to remove metal.
- Compound Resta mounted on the cross slide and support the tool post and able to swiveled to any angle for taper turning or cross - feed hand wheel.
- Aprona mounted beneath the front of saddle and houses the carriage and cross - slide control mechanisms. The apron hand wheel is used to move the carriage assembly by rack and gears.

Gearbox

- Gearbox - Mounted on the left side of bed and below the headstock
- Houses gears and other mechanisms that transmit various feed rates from the headstock spindle to either of lead screw or feed rod
- Lead screw advances the carriage during threading operations, feed rod moves the carriage during turning, boring and facing operations.

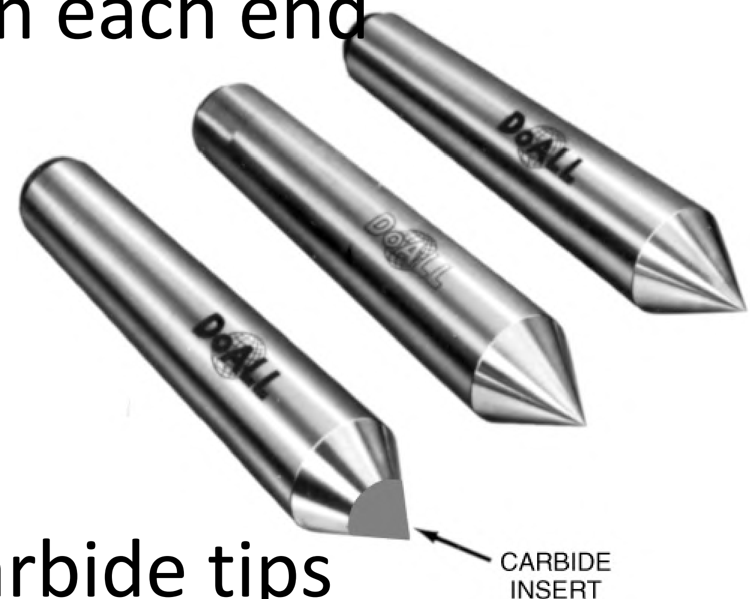
Lathe Accessories

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 tool holders
    - Threading tool holders, boring bars
    - Turret-type tool posts

Lathe Centers

- Work to be turned between centers must have center hole drilled in each end
  - Provides bearing surface
- Support during cutting
- Most common have solid Morse taper shank 60º centers, steel with carbide tips
- Care to adjust and lubricate occasionally



Chucks

- Used extensively for holding work for machining operations
  - Work large or unusual shape
- Most commonly used lathe chucks
  - Three-jaw universal
  - Four-jaw independent
  - Collet chuck

Three-jaw Universal Chuck

- Holds round and hexagonal work
- Grasps work quickly and accurate within few thousandths/inch
- Three jaws move simultaneously when adjusted by chuck wrench
  - Caused by scroll plate into which all three jaws fit
- Two sets of jaw: outside chucking and inside chucking

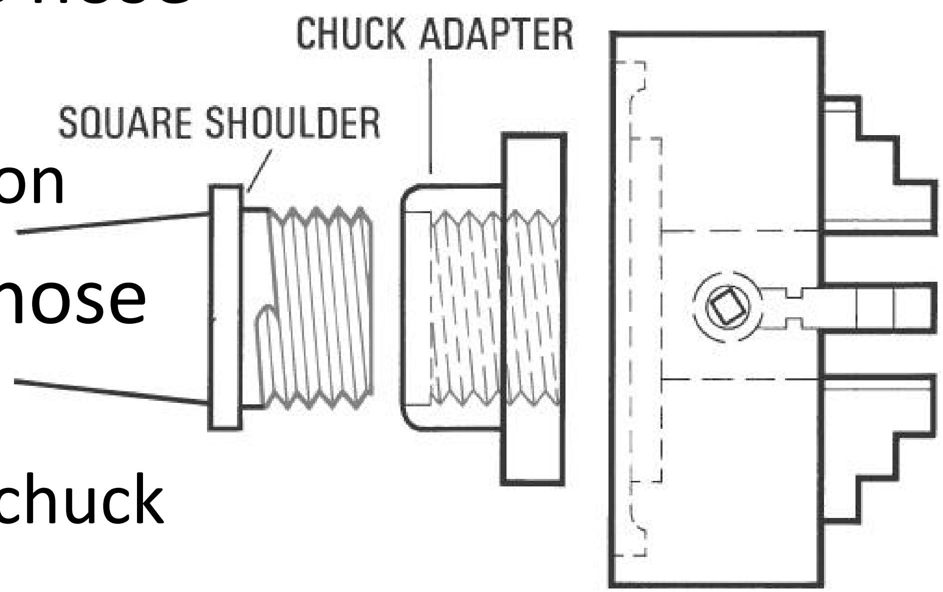
Four-Jaw Independent Chuck

- Used to hold round, square, hexagonal, and irregularly shaped workpieces
- Has four jaws
  - Each can be adjusted independently by chuck wrench
- Jaws can be reversed to hold work by inside diameter

Headstock Spindles

Universal and independent chuck fitted to three types of headstock spindles

1. Threaded spindle nose
   - Screws on in a clockwise direction
2. Tapered spindle nose
   - Held by lock nut that tightens on chuck



Headstock Spindles

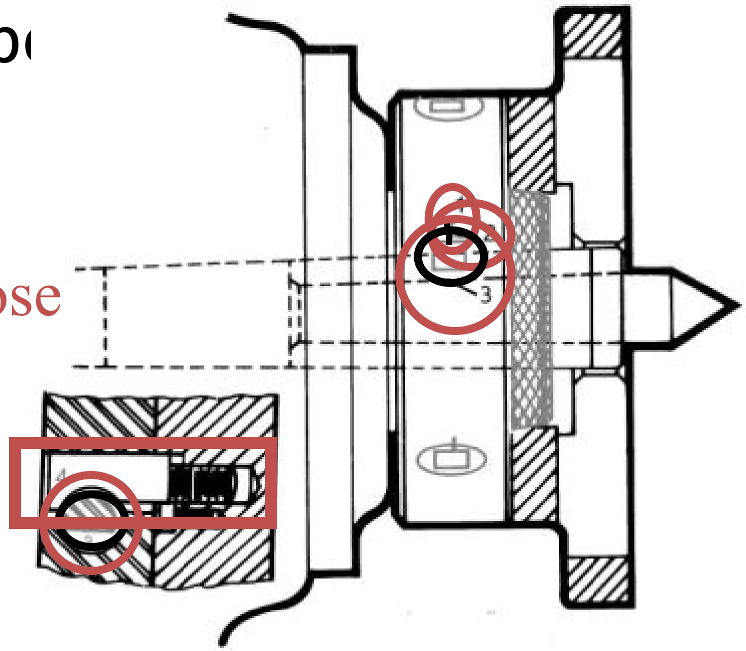
3. Cam-lock spindle nose
   - Held by tightening cam-locks using T-wrench
   - Chuck aligned by tap
     on spindle nose

Registration lines on spindle nose

Registration lines on cam-lock

Cam-locks

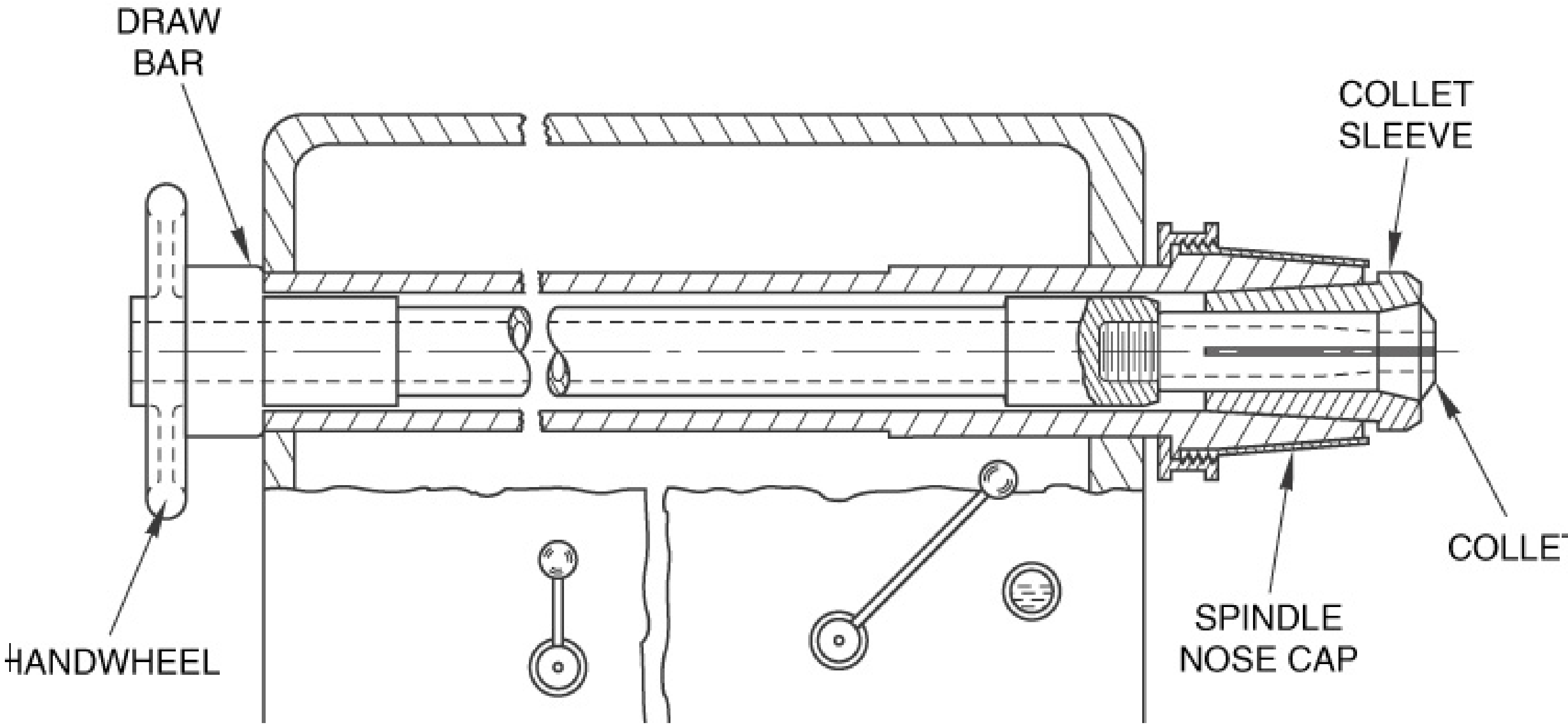
Cam-lock mating stud on chuck or faceplate



Collet Chuck

- Most accurate chuck
- Used for high-precision work
- Spring collets available to hold round, square, or hexagon-shaped workpieces
- Each collet has range of only few thousandths of an inch over or under size stamped on collet

Collet Chuck



Special adapter fitted into taper of headstock spindle, and hollow draw bar having internal thread inserted in opposite end of headstock spindle. It draws collet into tapered adapter causing collet to tighten on workpiece.

Types of Lathe Dogs

- Standard bent-tail lathe dog
  - Most commonly used for round workpieces
  - Available with square-head setscrews of headless setscrews
- Straight-tail lathe dog
  - Driven by stud in driveplate
  - Used in precision turning

Types of Lathe Dogs

- Safety clamp lathe dog
  - Used to hold variety of work
  - Wide range of adjustment

- Clamp lathe dog
  - Wider range than others
  - Used on all shapes

Left-Hand Offset Toolholder

- Offset to the right
- Designed for machining work close to chuck or faceplate and cutting right to left
- Designated by letter L

Right-Hand Offset Toolholder

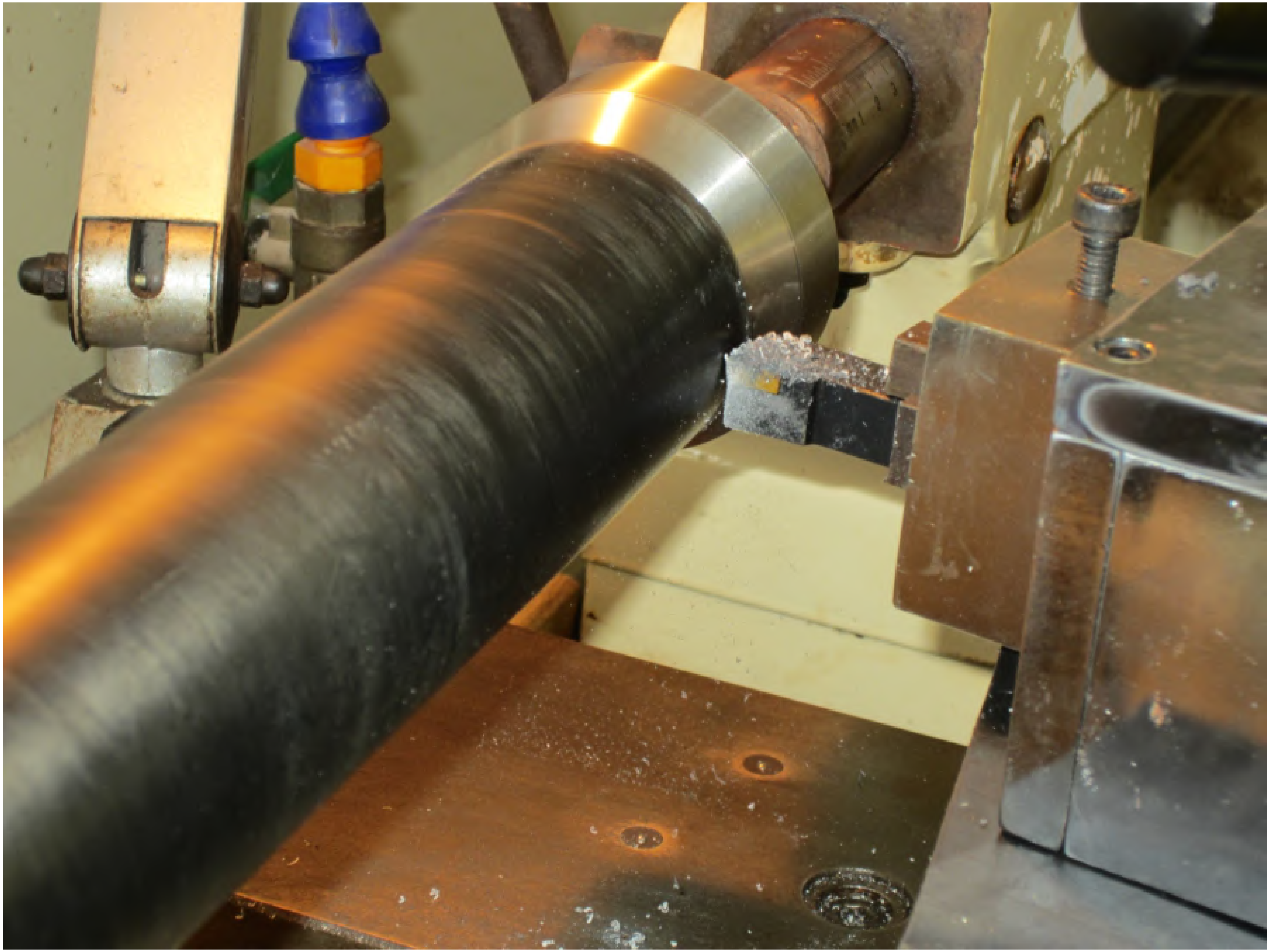
- Offset to the left
- Designed for machining work close to the tailstock and cutting left to right
  - Also for facing operations
- Designated by letter R

Straight Toolholder

- General-purpose type
- Used for taking cuts in either direction and for general machining operations
- Designated by letter S

Toolholders for Indexable Carbide Inserts

- Held in holder by cam action or clamps
- Types available
  - Conventional
  - Turret-type
  - Heavy-duty toolposts



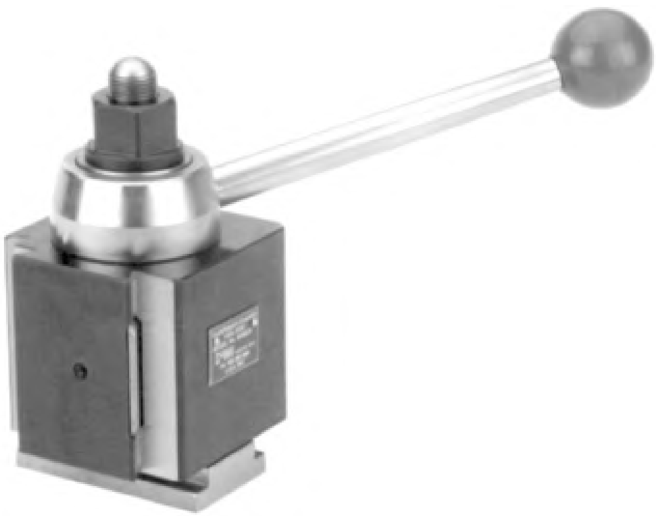
Cutting-Off (Parting) Tools

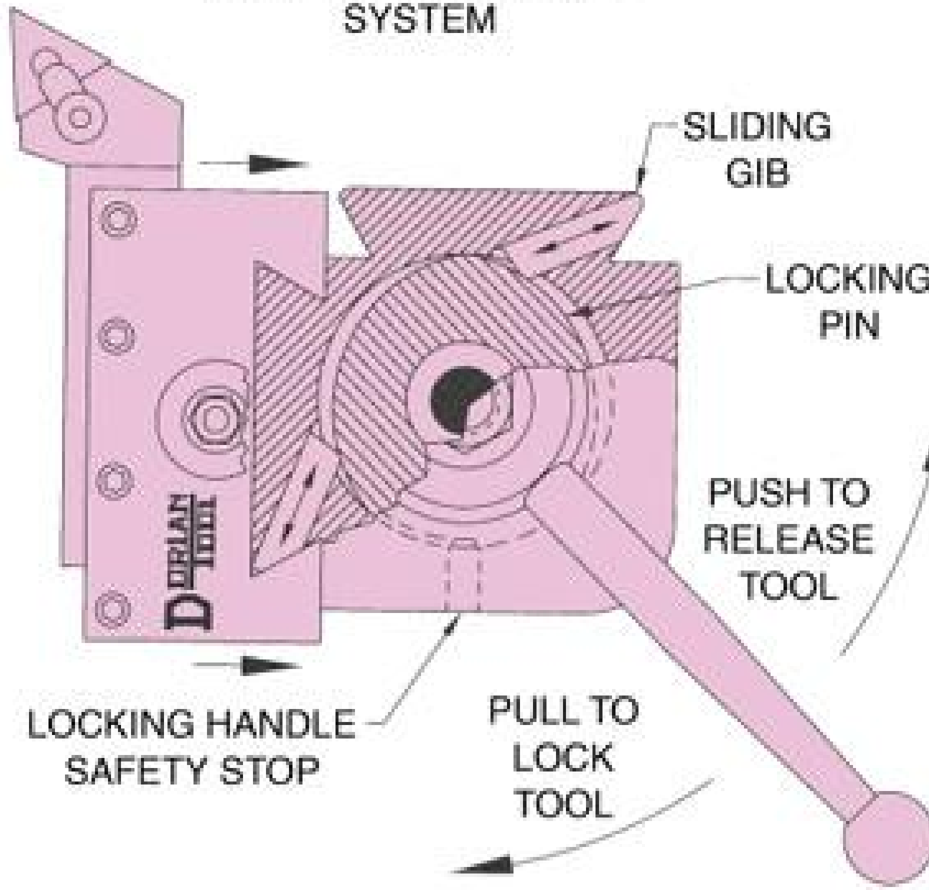
- Used when work must be grooved or parted off
- Long, thin cutting-off blade locked securely in toolholder by either cam lock or locking nut
- Three types of parting toolholders
  - Left-hand
  - Right-hand
  - Straight

Threading Toolholder

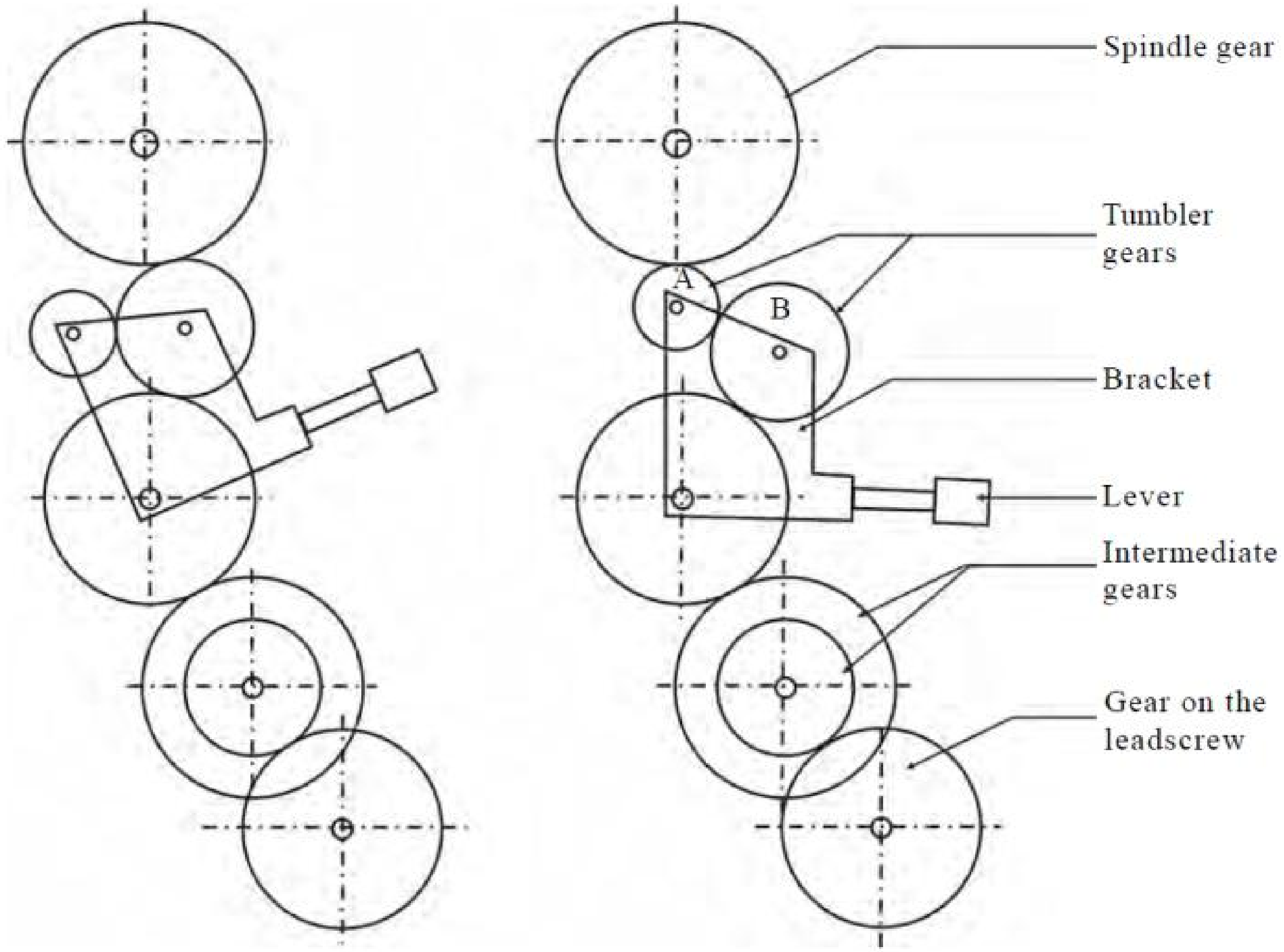
- Designed to hold special form-relieved thread-cutting tool
- Has accurately ground 60º angle
  - Maintained throughout life of tool
    - Only top of cutting surface sharpened when becomes dull

Super Quick-Change Toolpost



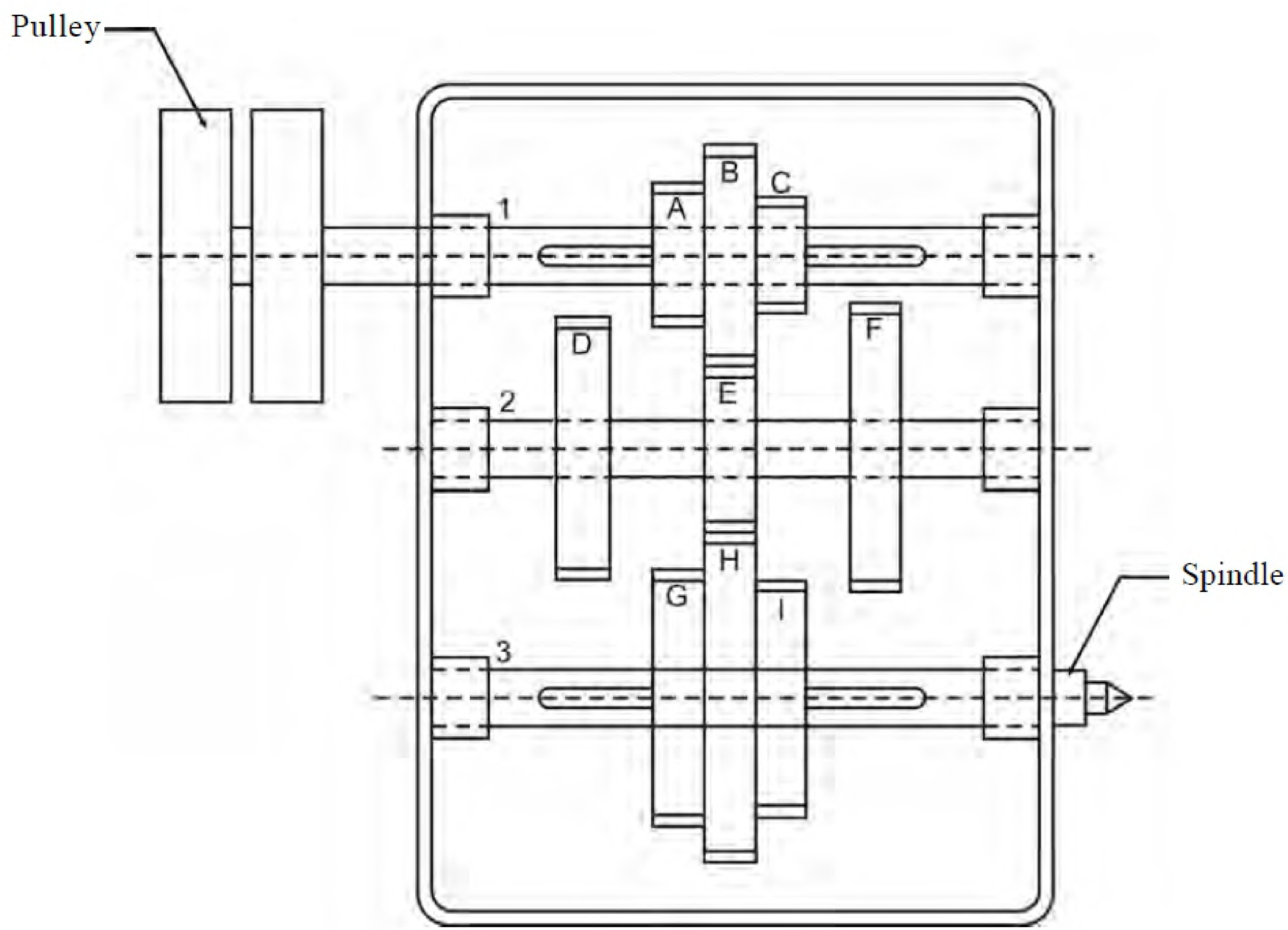


Tumbler Gear Mechanism



Forward position **Reverse position**

Quick Change Gear Mechanism



Taper Turning Methods

Taper turning is the operation by which the tapered surface is produced on the workpiece. A taper is defined as the uniform change in the diameter of workpiece measured along its length.

Taper Turning Method

Taper turning can be performed by any of the following methods:

1. By using a form tool.
2. By tailstock set over
3. By swiveling the compound rest
4. By taper turning attachment
5. By combination longitudinal and cross feeds.

Semi automatic and Automatic Lathe

General purpose machine tools may have both fixed automation or flexible automation where the latter one is characterized by computer Numerical Control (CNC).

The conventional general purpose automated lathes can be classified as,

(a)Semiautomatic :

- capstan lathe (ram type turret lathe)
- turret lathe
- multiple spindle turret lathe
- copying (hydraulic) lathe

(b) Automatic :

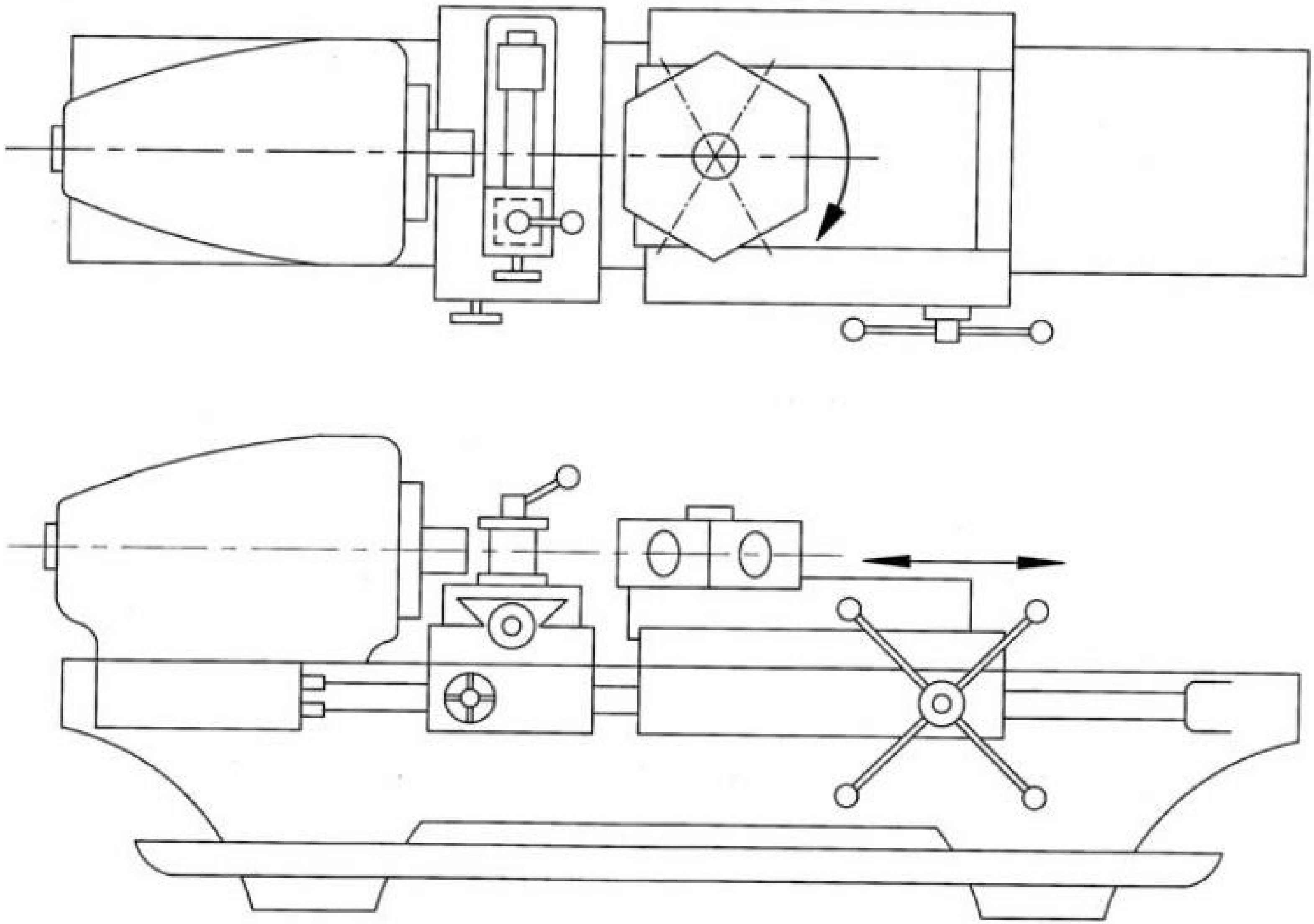
- Automatic cutting off lathe
- Single spindle automatic lathe
- Swiss type automatic lathe
- multiple spindle automatic lathes Version

Capstan & Turret Lathe

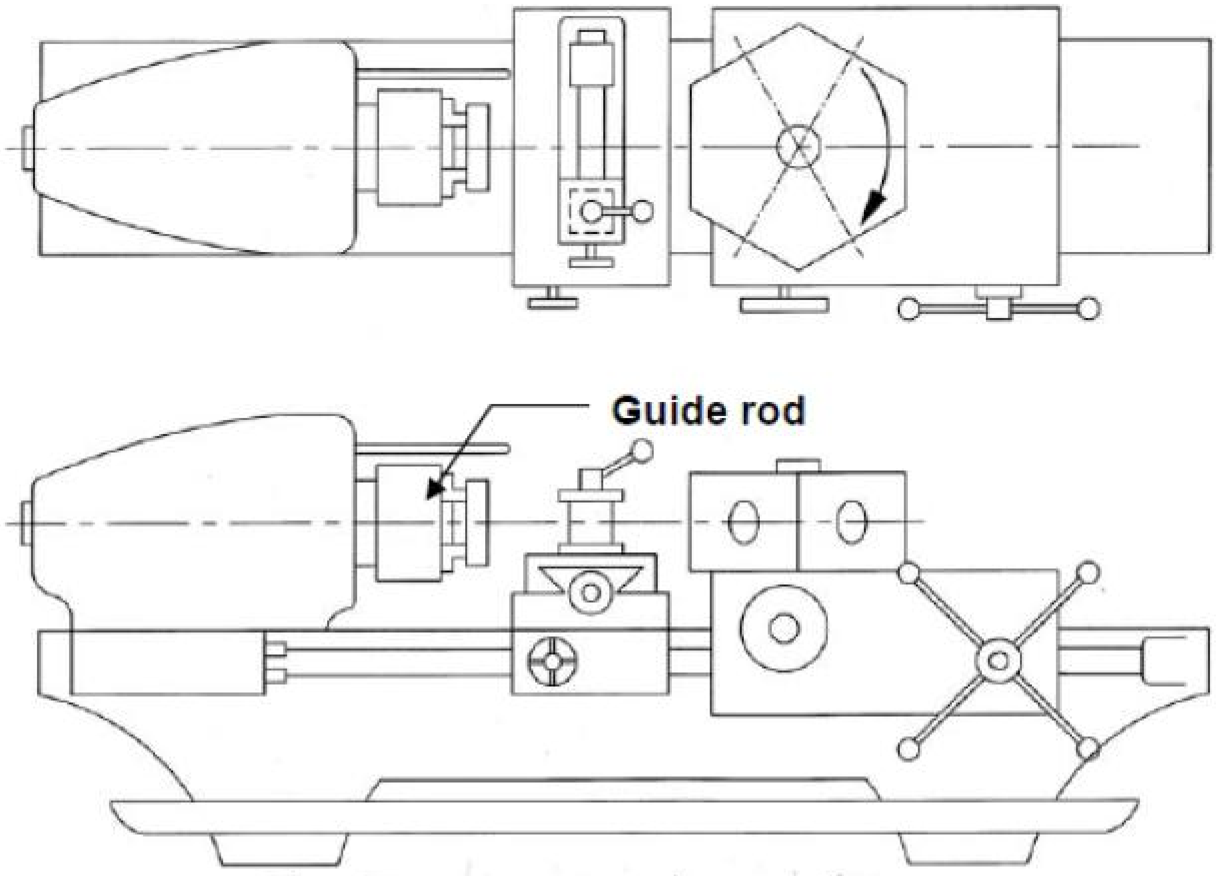
In contrast to centre lathes, capstan and turret lathes

- are semiautomatic
- 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 slide, one in the rear slide and upto six in the turret (if hexagonal) as indicated in the schematic diagrams.
- 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 tools
- are relatively costlier
- are suitable and economically viable for batch production or small lot production.

capstan lathe



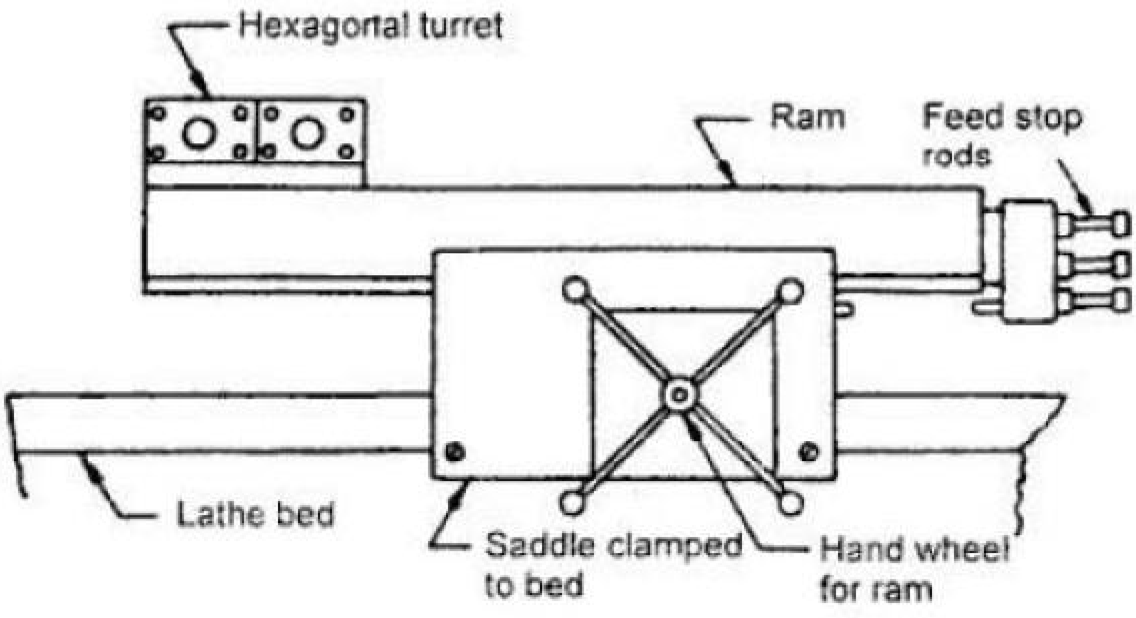
Turret lathe



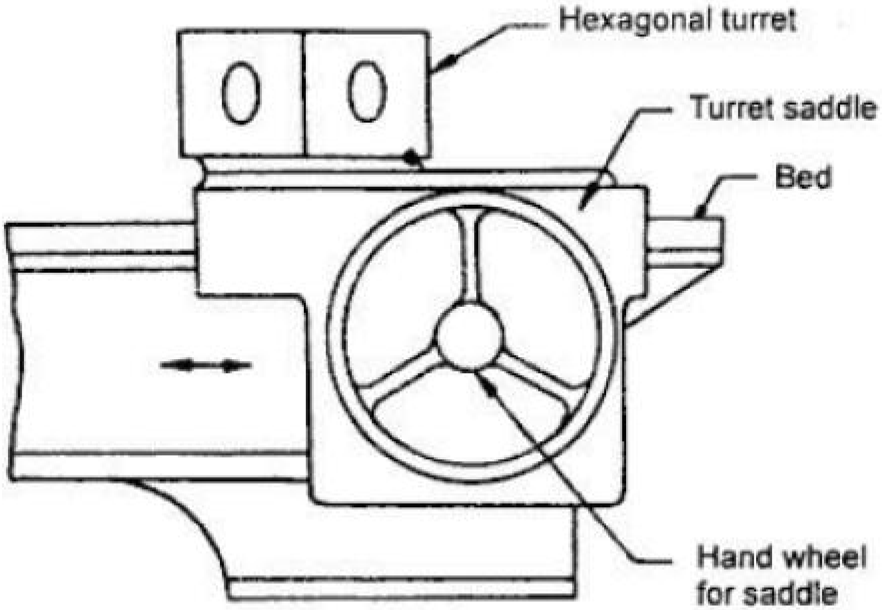
There are some differences in between capstan and turret lathes such as,

- Turret lathes are relatively more robust and heavy duty machines
- Capstan lathes generally deal with short or long rod type blanks held in collet, whereas turret lathes mostly work on chucking type jobs held in the quick acting chucks
- In capstan lathe, the turret travels with limited stroke length within a saddle type guide block, called auxiliary bed, which is clamped on the main bed as indicated in Fig. 4.7.1, whereas in turret lathe, the heavy turret being mounted on the saddle which directly slides with larger stroke length on the main bed as indicated in Fig. 4.7.2
- One additional guide rod or pilot bar is provided on the headstock of the turret lathes as shown in Fig. 4.7.2, to ensure rigid axial travel of the turret head
- External screw threads are cut in capstan lathe, if required, using a self opening die being mounted in one face of the turret, whereas in turret lathes external threads are generally cut, if required, by a single point or multipoint chasing tool being mounted on the front slide and moved by a short leadscrew and a swing type half nut.

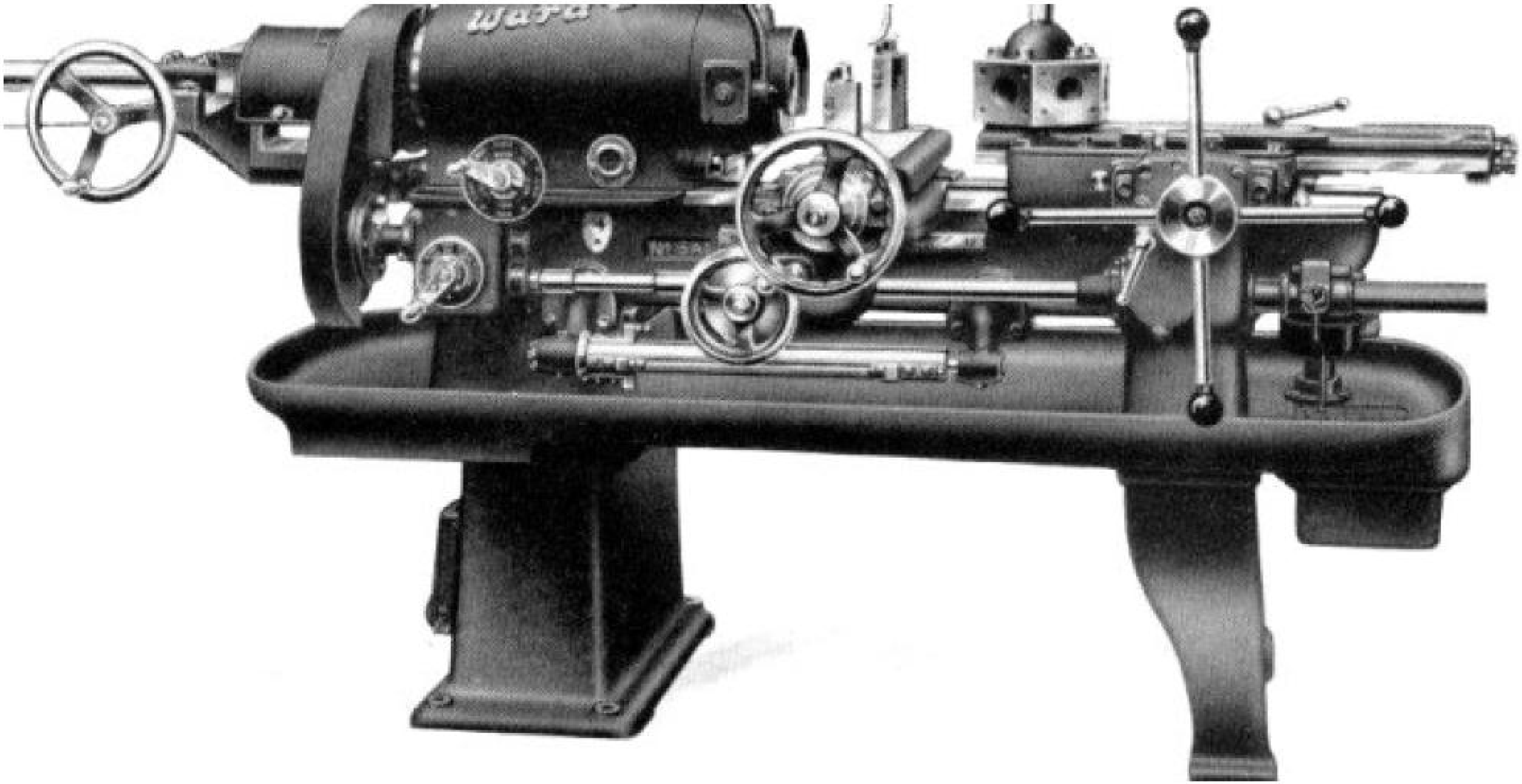
Ram of capstan lathe



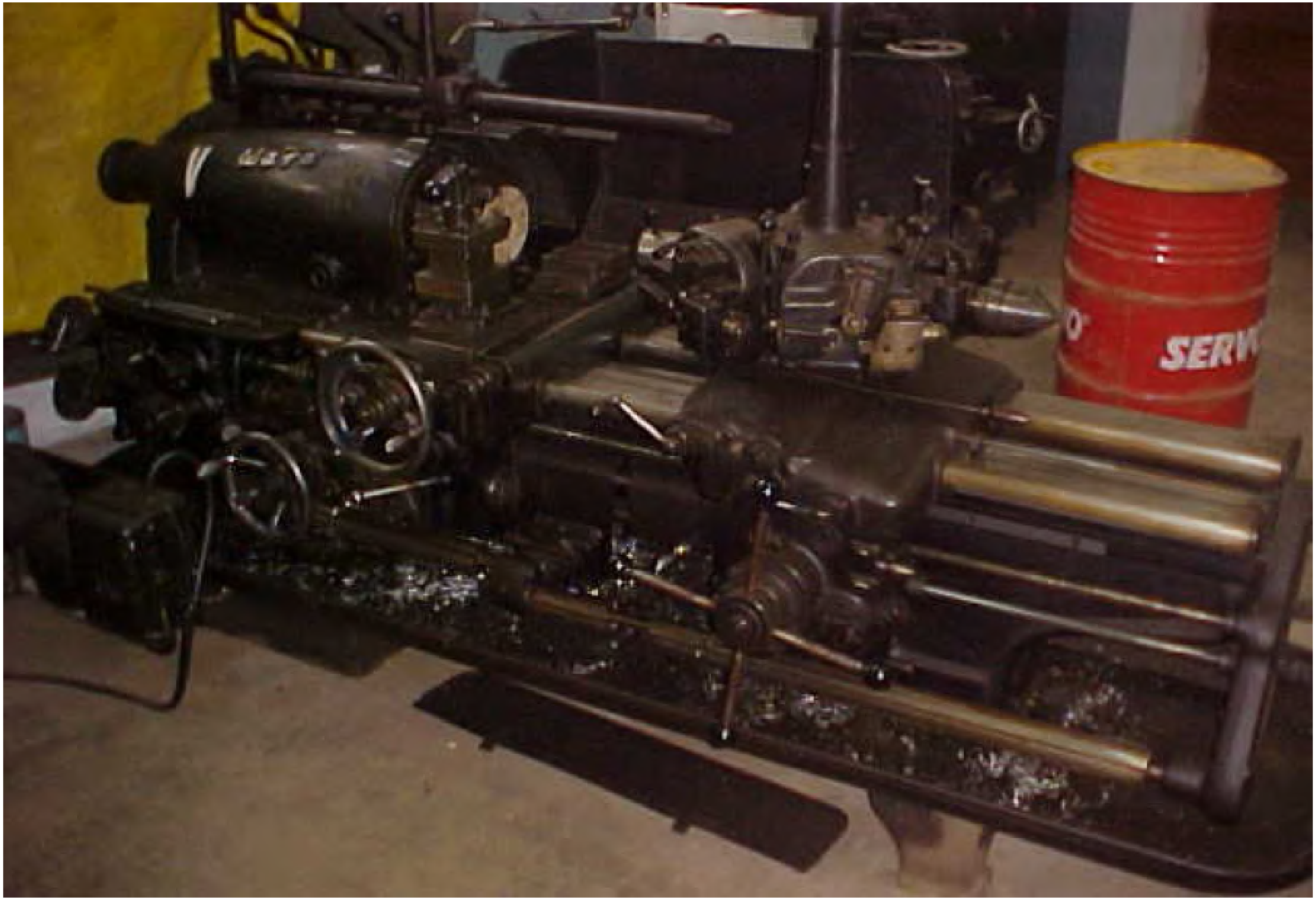
Saddle of turret lathe



Pictorial view of Capstan Lathe



Pictorial view of Turret Lathe



Multi spindle Turret Lathe

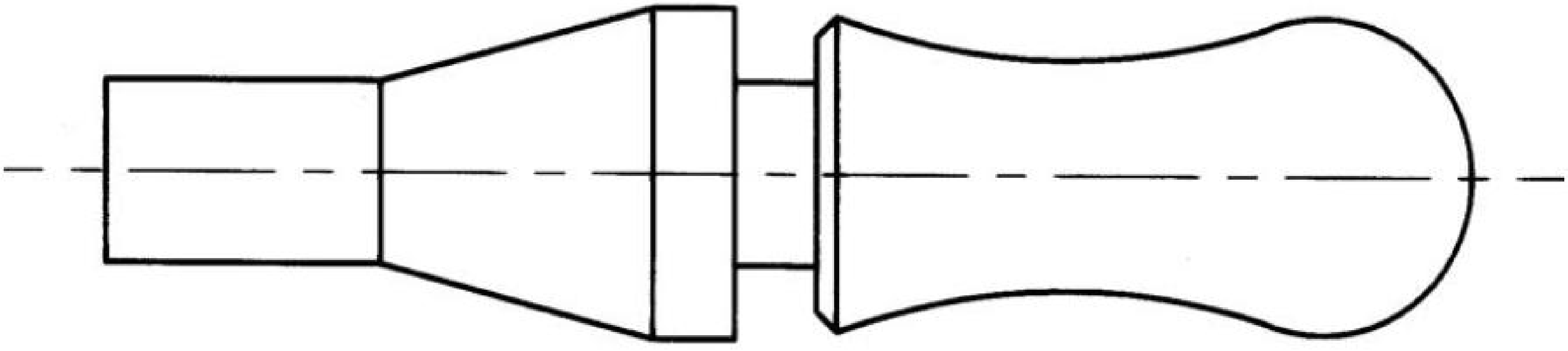
Turret lathes are mostly horizontal axis single spindle type. The multiple spindle vertical turret lathes are characterised by :

- Suitably used for large lot or mass production of jobs of generally ;
  - Δ chucking type
  - Δ relatively large size
  - Δ requiring limited number of machining operations
- Machine axis – vertical for
  - Δ lesser floor space occupied
  - Δ easy loading and unloading of blanks and finished jobs
  - Δ relieving the spindles of bending loads due to job – weight.
- Number of spindle – four to eight.

Hydraulic Copying Lathe

- **Hydraulic copying (tracer controlled) lathes**

Jobs having steps, tapers and / or curved profiles, as typically shown in Fig. 4.7.6, are conveniently and economically produced in batch or lot in semiautomatically operated tracer controlled hydraulic copying lathe. The movement of the stylus along the template provided with the same desired job-profile) is hydraulically transmitted to the cutting tool tip which replicates the template profile.



Automatic Lathe

Automatic Lathe

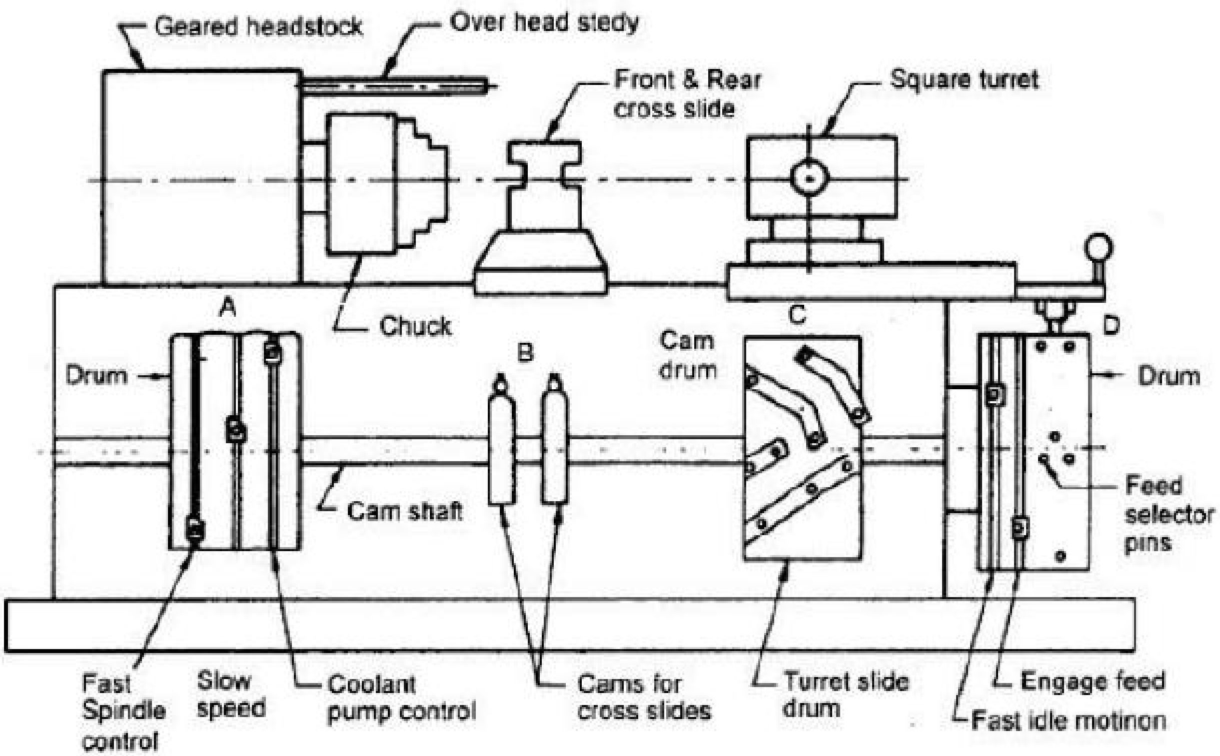
Automatic lathes are essentially used for large lot or mass production of small rod type of jobs. Automatic lathes are also classified into some distinguished categories based on constructional features, operational characteristics, number of spindles and applications as follows

- Single spindle
  - Δ Automatic cutting off lathes
  - Δ Automatic (screw cutting) lathe
  - Δ Swiss type automatic lathe
- Multispindle automatic lathe

Automatic cutting off lathe

These simple but automatic lathes are used for producing short work pieces of simple form by using few cross feeding tools. In addition to parting some simple operations like short turning, facing, chamfering etc. are also done.

Automatic Cutting Off Machine



Single Spindle Automatic Lathe

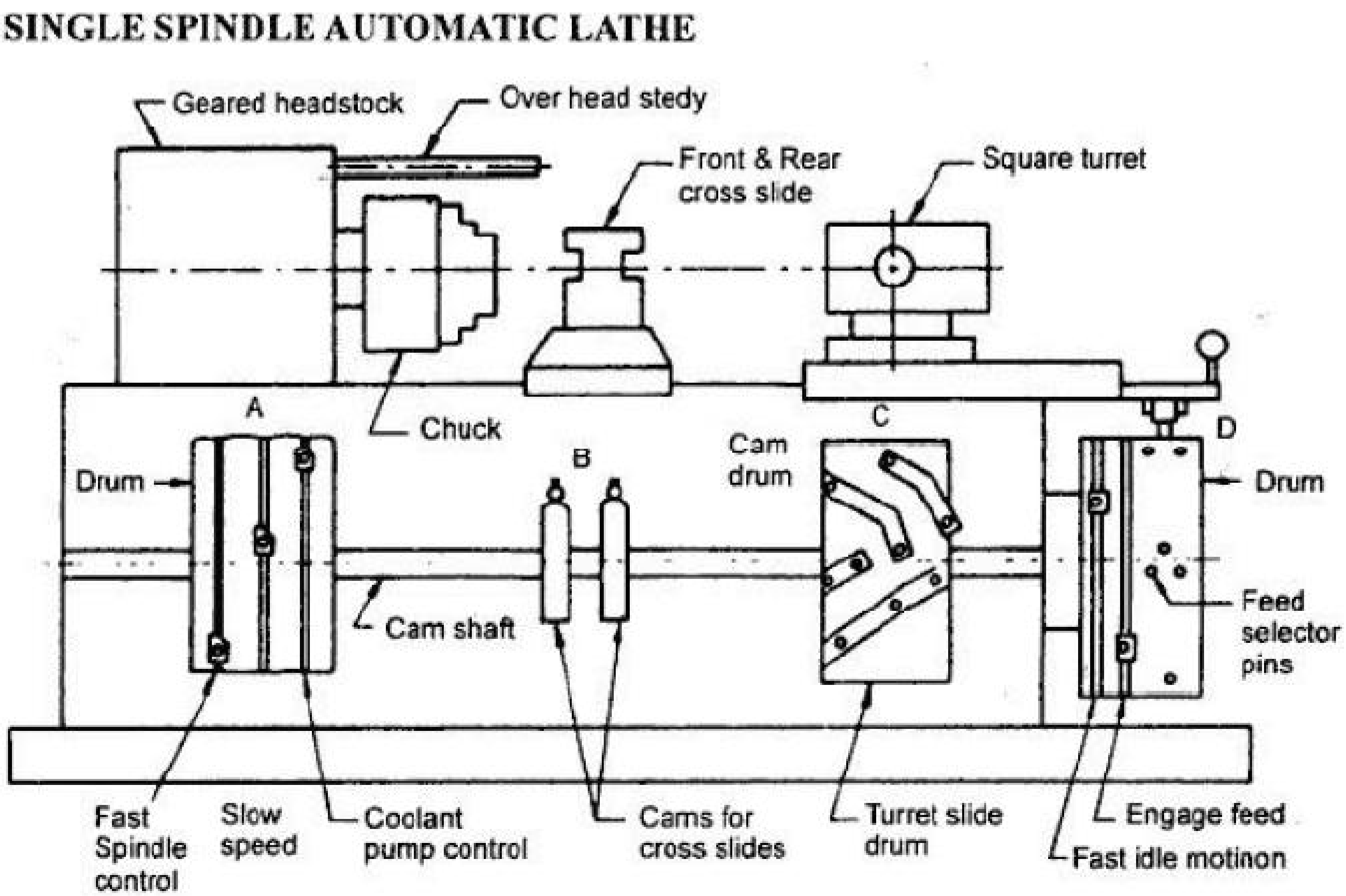
The general purpose single spindle automatic lathes are widely used for quantity or mass production (by machining) of high quality fasteners; bolts, screws, studs etc., bushings, pins, shafts, rollers, handles and similar small metallic parts from long bars or tubes of regular section and also often from separate small blanks.

Fig. 4.7.7 shows a typical single spindle automatic lathe.

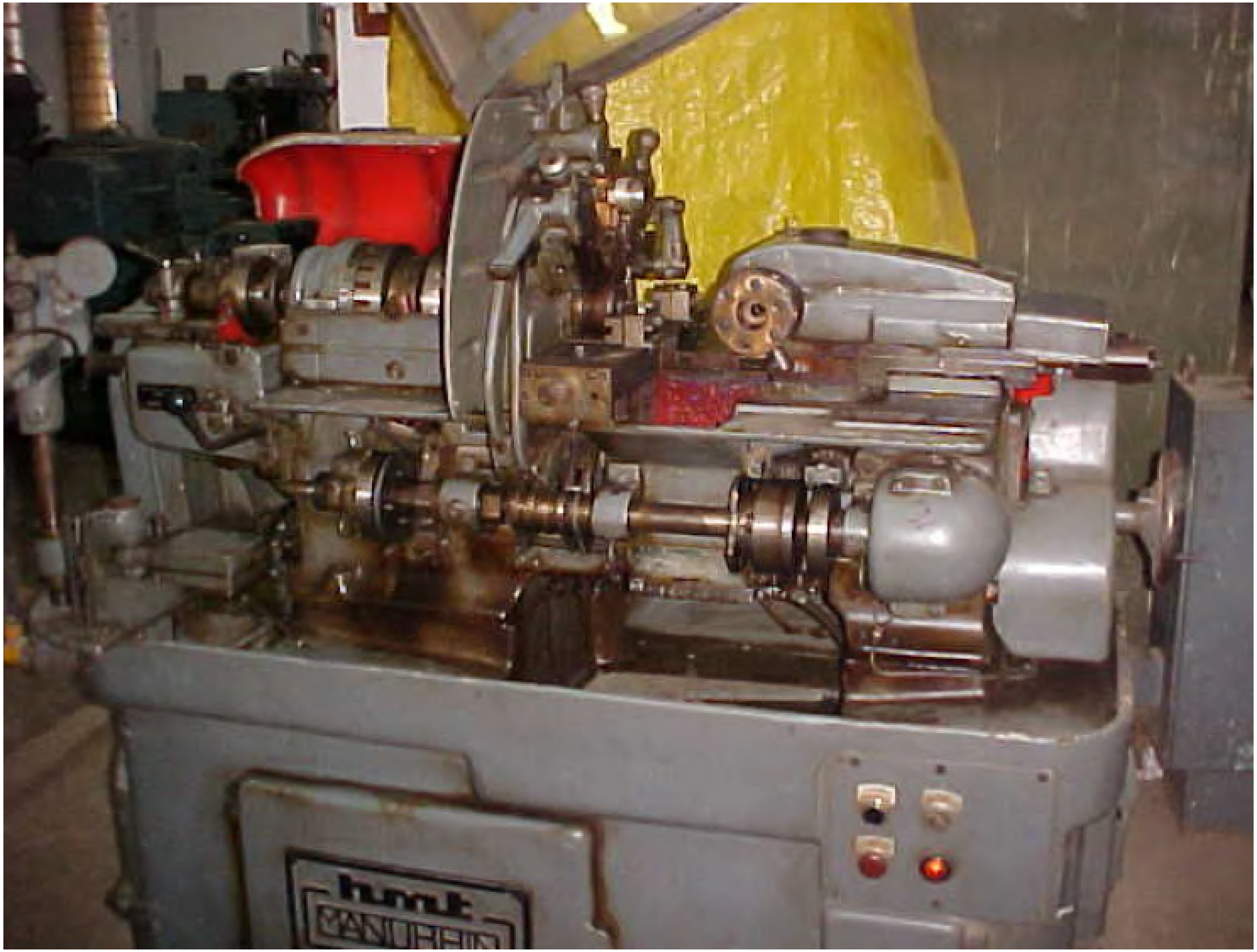
Unlike the semiautomatic lathes, single spindle automats are :

- preferably and essentially used for larger volume of production i.e., large lot production and mass production
- used always for producing jobs of rod, tubular or ring type and of relatively smaller size.
- run fully automatically, including bar feeding and tool indexing, and continuously over a long duration repeating the same machining cycle for each product
- provided with upto five radial tool slides which are moved by cams mounted on a cam shaft
- of relatively smaller size and power but have higher spindle speeds

Single Spindle Automatic Lathe

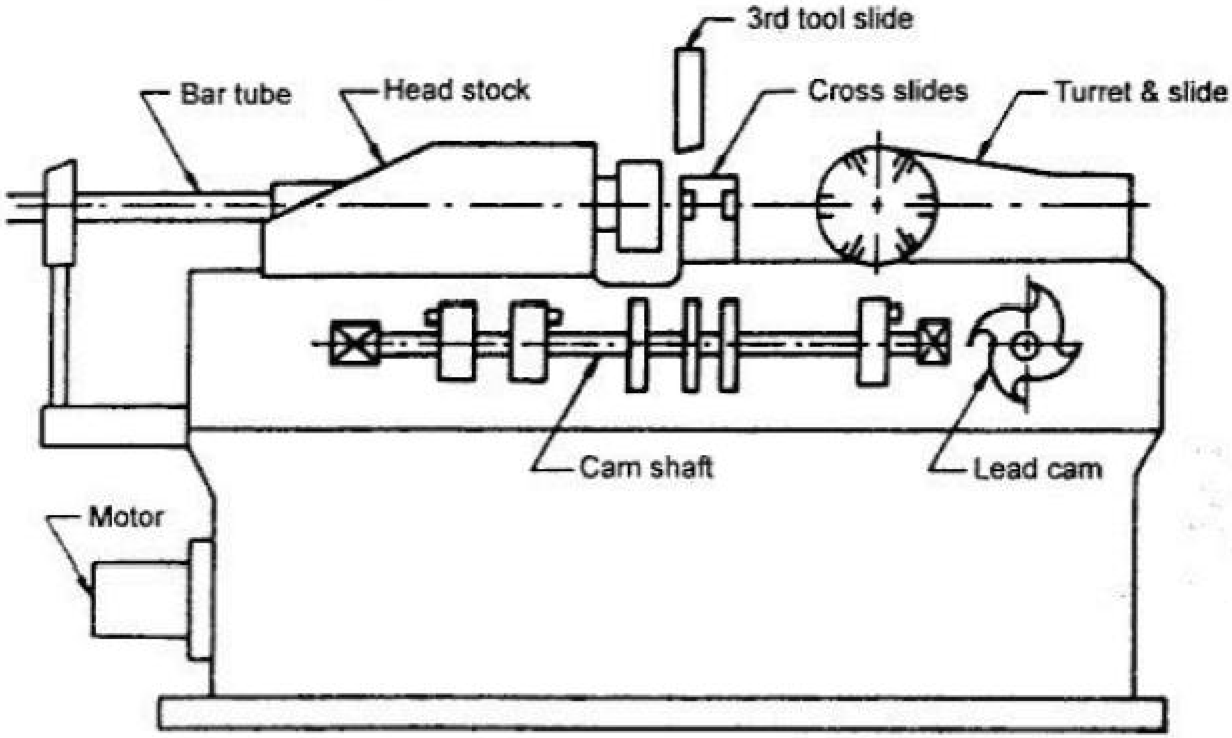


Pictorial view of Single Spindle Automatic Lathe



Automatic Screw Cutting Machine

Automatic screw cutting machine



Swiss Type Automatic Lathe

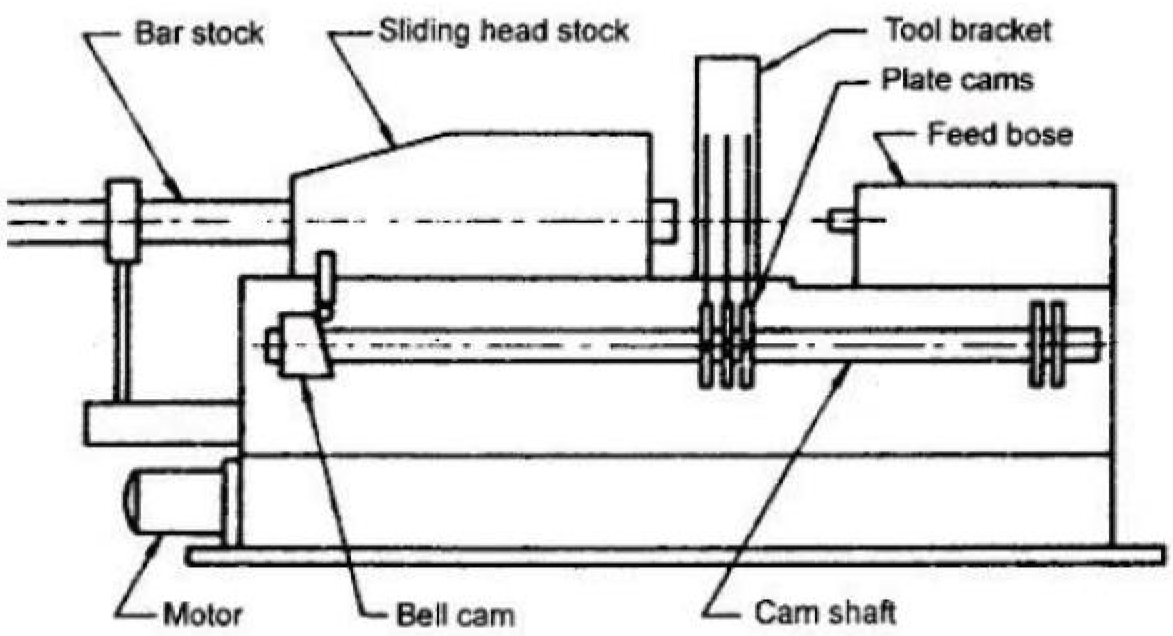
The characteristics and applications of these single spindle automatic lathes are :

- In respect of application :
  Used for lot or mass production of thin slender rod or tubular jobs, like components of small clocks and wrist watches, by precision machining;
  - Job size (approximately)
    - Diameter range – 2 to 12 mm
    - Length range – 3 to 30 mm

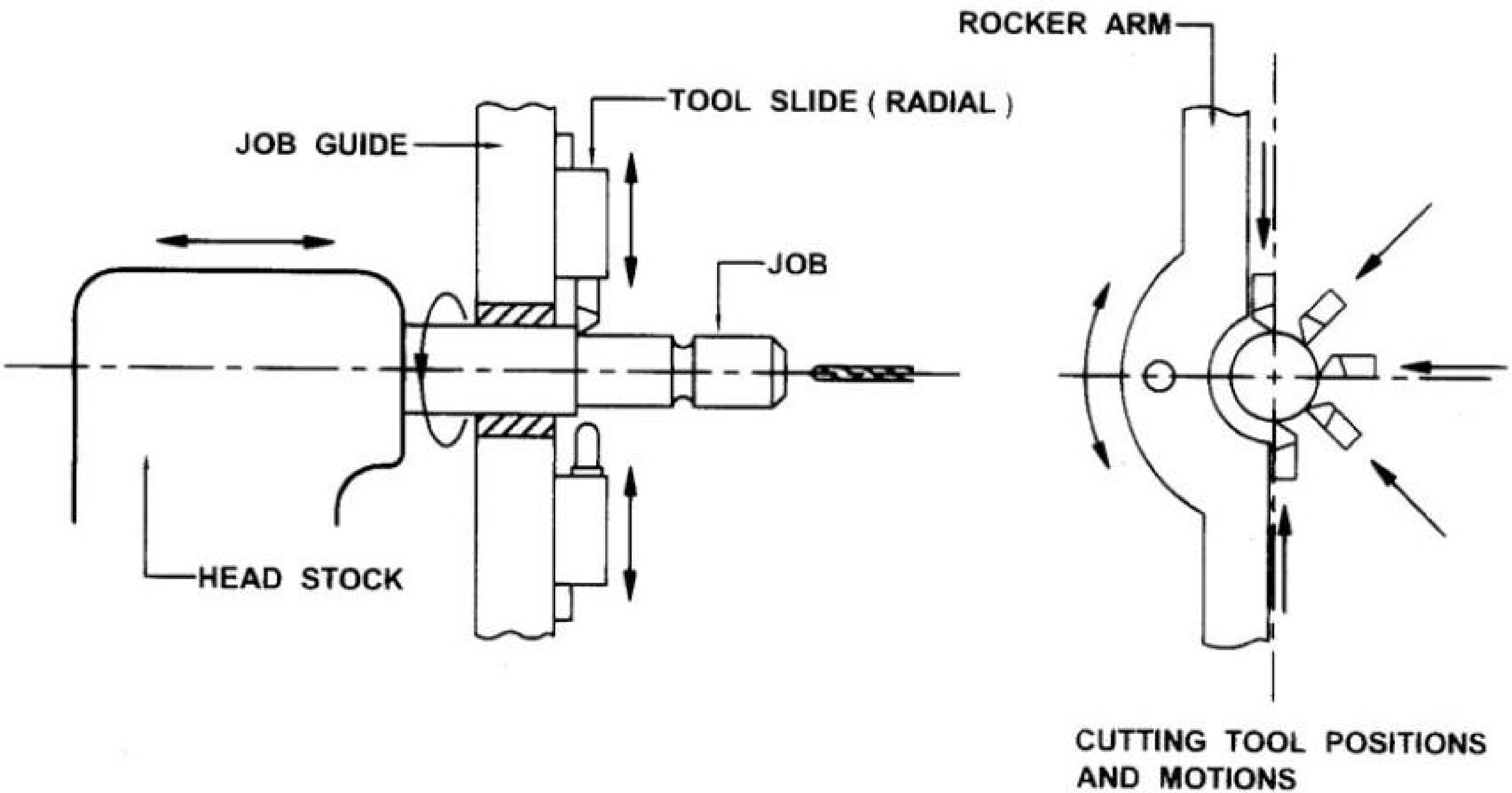
  Dimensional accuracy and surface finish – almost as good as provided by grinding
- In respect of configuration and operation
  - The headstock travels enabling axial feed of the bar stock against the cutting tools as indicated in Fig. 4.7.8
  - There is no tailstock or turret
  - High spindle speed (2000 – 10,000 rpm) for small job diameter
  - The cutting tools (upto five in number including two on the rocker arm) are fed radially
  - Drilling and threading tools, if required, are moved axially using swivelling device(s)
  - The cylindrical blanks are prefinished by grinding and are moved through a carbide guide bush as shown.

Swiss Type Automatic Lathe

Swiss type automatic screw machine



Basic principle of Swiss Type Automatic Lathe



Multi Spindle Automatic Lathe

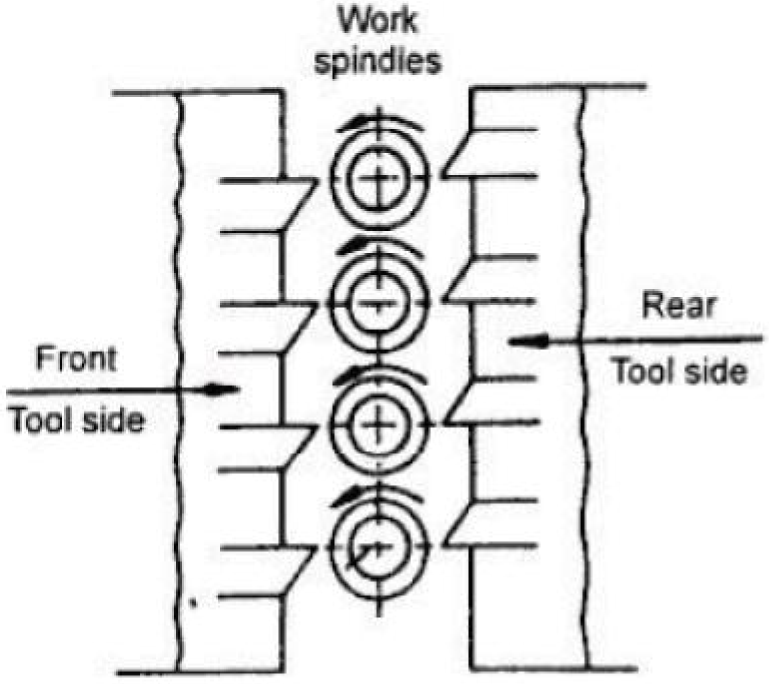
For further increase in rate of production of jobs usually of smaller size and simpler geometry. Multispindle automatic lathes having four to eight parallel spindles are preferably used. Unlike multispindle turret lathes, multispindle automatic lathes ;

- are horizontal (for working on long bar stocks)
- work mostly on long bar type or tubular blanks

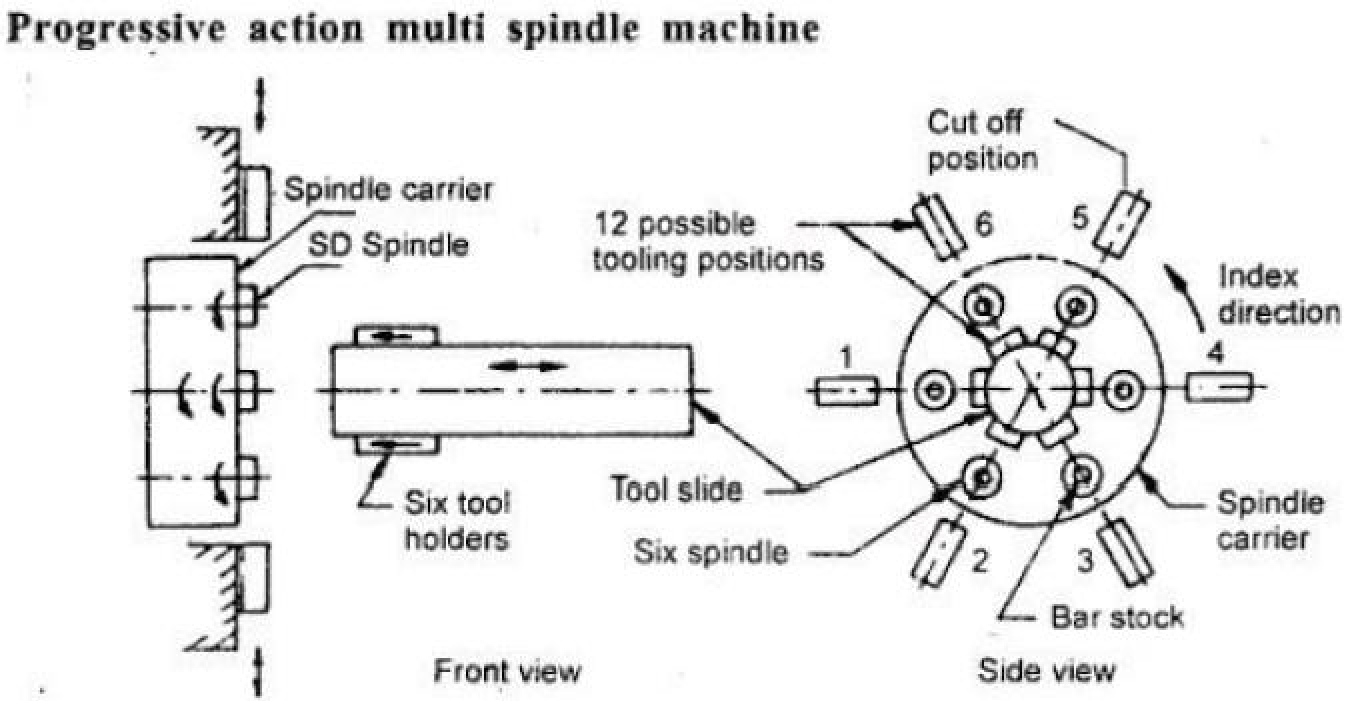
Multiple spindle automats also may be parallel action or progressively working type. Machining of the inner and outer races in mass production of ball bearings are, for instance, machined in multispindle automatic lathes.

Parallel action multi spindle automatic lathe

Parallel action multi spindle automatic machine



Progressive action multi spindle machine



Progressively processing type

The spindle carrier with the blanks fitted in the chucks on the rotating spindle is indexed at regular interval by a Geneva mechanism. At each station the job undergoes a few preset machining work by the axially and / or radially fed cutting tools. The blank getting all the different machining operations progressively at the different work stations is unloaded at a particular station where the finished job is replaced by another fresh blank. This type of lathes are suitable for jobs requiring large number of operations.

Machining Time - Estimation

Here,
$$T_C = \frac{L_C}{N s_o} x n_p$$

where, L_C = actual length of cut

= L + A + O

A, O = approach and over run as shown

N = spindle speed, rpm

s_o = feed (tool), mm/rev

n_p = number of passes required

Speed, N, is determined from cutting velocity, V_C

$$V_C = \frac{\pi D N}{1000} m/\min$$

where, D = diameter of the job before cut

Therefore,
$$N = \frac{1000 V_C}{\pi D}$$

The number of passes, n_p is mathematically determined from,

$$n_p = \frac{D_1 - D_2}{2t}$$

Problem 1

How much machining time will be required to reduce the diameter of a cast iron rod from 120 mm to 116 mm over a length of 100 mm by turning using a carbide insert. Reasonably select values of V_C and s_o.

For turning C.I. by carbide insert, V_C is taken as 100 m/min and s_o = 0.2 mm/rev

$$T_C = \frac{L_C}{Ns_o} \text{ for single pass}$$

L_C = 100 + 5 + 5 = 110 mm

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

For turning C.I. by carbide insert, V_C is taken as 100 m/min and s_o = 0.2 mm/rev

$$\therefore \quad N = \frac{1000 x 100}{\pi.120} \cong 250 \; rpm$$

Nearest standard speed, N = 225

$$\therefore \quad T_c = \frac{110}{225 x 0.2} = 2.5 \min \quad \textbf{Ans.}$$

Problem 2

Determine T_C for plain milling a rectangular surface of length 100 mm and width 50 mm by a helical fluted plain HSS milling cutter of diameter 60 mm, length 75 mm and 6 teeth. Assume A = O = 5 mm, V_C = 40 m/min and s_o = 0.1 mm/tooth

Determine T_C for plain milling a rectangular surface of length 100 mm and width 50 mm by a helical fluted plain HSS milling cutter of diameter 60 mm, length 75 mm and 6 teeth. Assume A = O = 5 mm, V_C = 40 m/min and s_o = 0.1 mm/tooth

Solution:

$$T_C = \frac{L_C}{s_m} \text{ min}$$

$$L_C = L_w + A + O + \frac{D_C}{2} = 100 + 5 + 5 + 30 = 140\, mm$$

$$s_m = s_o Z_C N = 0.1 x 6 x N$$

where, $$N = \frac{1000 V_C}{\pi D_C} = \frac{1000 x 40}{\pi x 60} \cong 200\, rpm$$

$$s_m = 0.2 x 6 x 200 = 120\, mm/\text{min}$$

So, $$T_C = \frac{L_C}{s_m}$$

$$= \frac{140}{120} = 1.17 \text{ min.}$$

Power Estimation - Turning

- What is the cutting power required for machining mild steel at cutting speed 120m/min with depth of cut 3mm and feed 0.2mm/rev (Machine coefficient 80%), where specific cutting force Kc=3100MPa?

$$Pc = \frac{ap \cdot f \cdot vc \cdot Kc}{60 \times 10^3 \times \eta} \text{(kW)}$$

- ap (mm)Depth of Cut
- f (mm/rev)Feed per Revolution
- vc (m/min)Cutting Speed
- Kc (MPa)Specific Cutting Force
- η(Machine Coefficient)

What is the cutting power required for machining mild steel at cutting speed 120m/min with depth of cut 3mm and feed 0.2mm/rev (Machine coefficient 80%), where specific cutting force Kc=3100MPa?

$$Pc = \frac{ap \cdot f \cdot vc \cdot Kc}{60 \times 10^3 \times \eta} \text{ (kW)}$$

$Pc=(3 \times 0.2 \times 120 \times 3100) \div (60 \times 10^3 \times 0.8)$

$=4.65$(kw)

Power Estimation - Milling

- What is the cutting power required for milling tool steel at cutting speed 80m/min. With depth of cut 2mm, cutting width 80mm, and table feed 280mm/min by ø250 cutter with 12 insert. Machine coefficient 80%.

$$Pc = \frac{ap \cdot ae \cdot vf \cdot Kc}{60 \times 10^6 \times \eta}$$

ap (mm) Depth of Cut
ae (mm) Cutting Width
vf (mm/min) Table Feed per Min.
Kc (MPa) Specific Cutting Force
η (Machine Coefficient)

What is the cutting power required for milling tool steel at cutting speed 80m/min. With depth of cut 2mm, cutting width 80mm, and table feed 280mm/min by ø250 cutter with 12 insert. Machine coefficient 80%.

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

N = (1000×80)÷(3.14×250)
=101.91 rpm

Feed per tooth

fz = vf÷(z×n) = 280 ÷ (12×101.9)
= 0.228mm/tooth

Pc=(2×80×280×1800)÷(60×10^{6}×0.8)
=1.68kw