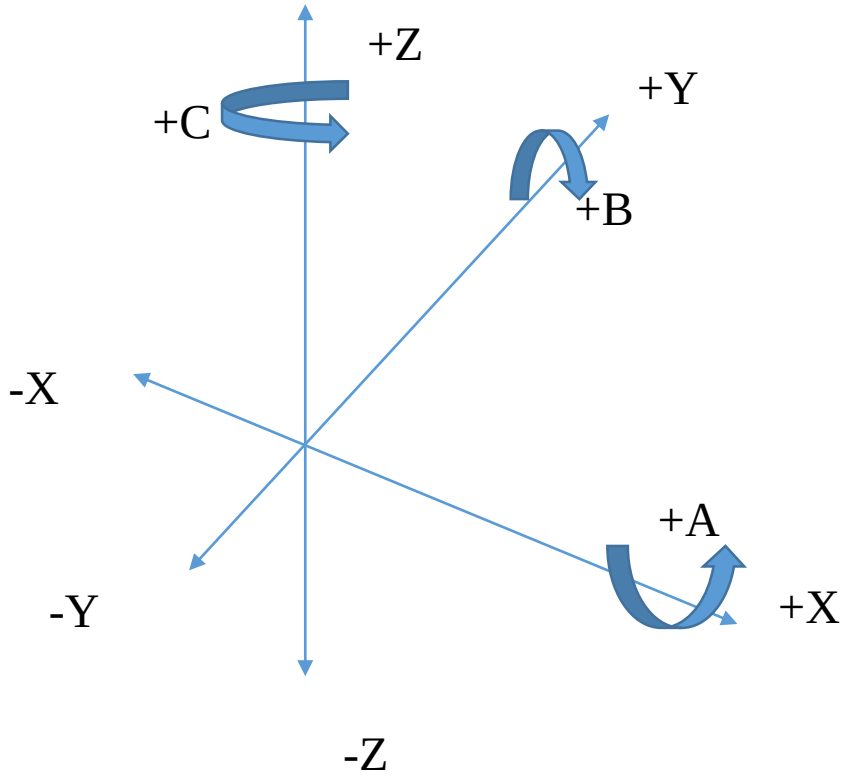
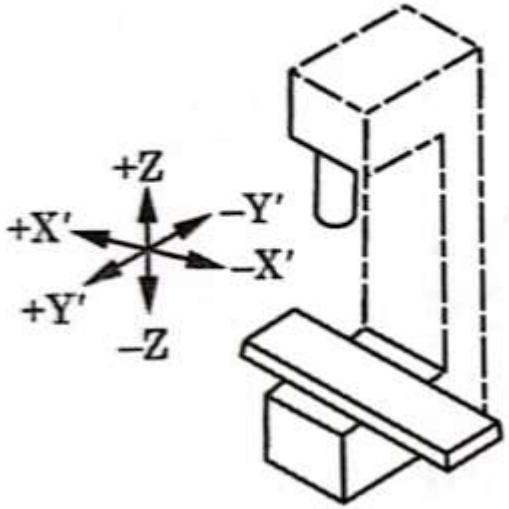
CNC MACHINES AND AUTOMATION

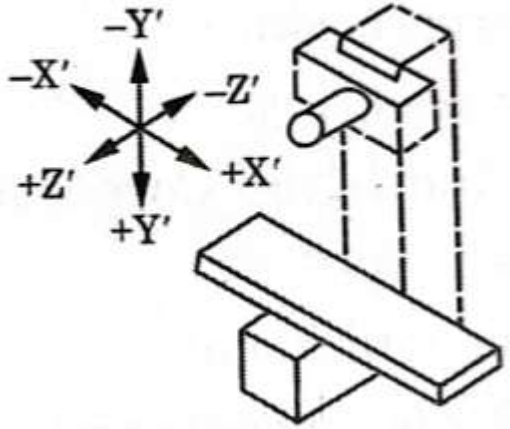
AMIT JANGRA
Lecturer
Mechanical Engineering Department
GP HISAR

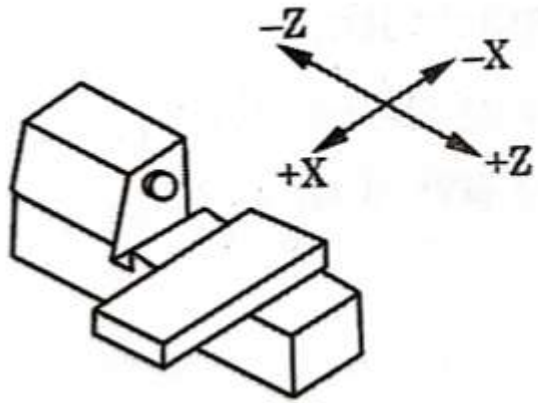
Axis Identification

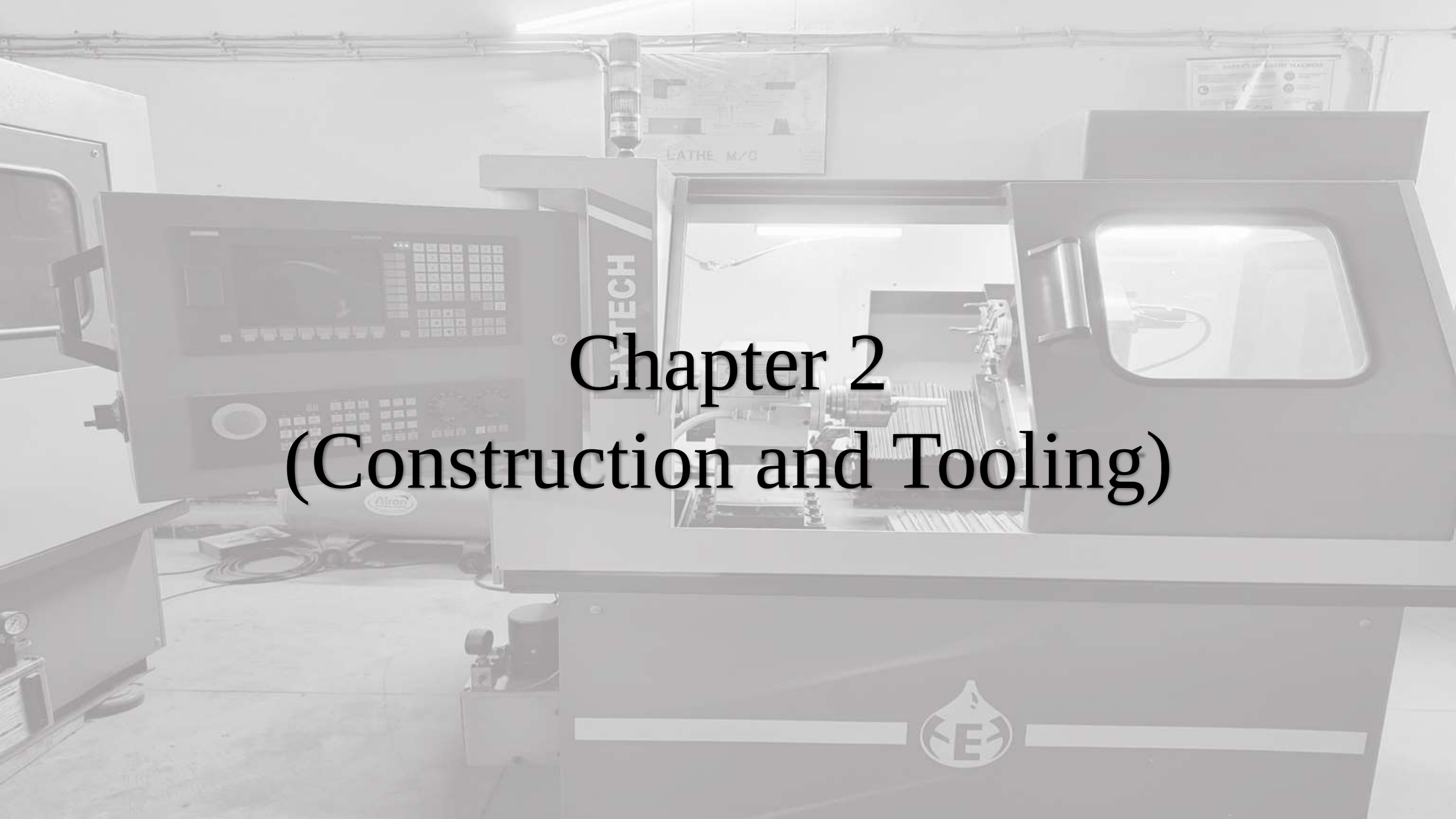
Most of machines have two or more slideways disposed at right angle to each other, along which slides are displaced.











Chapter 2
(Construction and Tooling)

Design Features

CNC machines need special design for its elements as these are high accuracy and productivity machines.

- Understand the development in design and construction of machine structure.
- Different type of elements of motion transmission.
- Contribution of slideways.
- Tool and work devices
- Swarf Removal.
- Feedback mechanism.
- Various types of drives

Machine Structure: **-** It should be able to meet the following main objectives:

i) High Precision and accuracy
ii) Reliability and repeatability
iii)Efficiency and performance

The basic design factors involved in the design of machine structure follows:

1. Static load
2. Dynamic load
3. Thermal load
4. Guideways
5. Feed Drive:

i) Servo Motor

ii) Mechanical Transmission system

6. Spindle bearing: i) Hydrodynamic ii) Hydrostatic iii) Antifriction
7. Measuring systems: i) Direct ii) Indirect
8. Controls, software and user interface
9. Gauging
10. Tool monitoring systems

Specifications chart of a CNC system

1. Number of controlled axis : Two/Four/Eight etc.
2. Interpolation : Linear/circular/parabolic or cubic/cylindrical
3. Resolution : Input resolution (feedback)
   : Programming resolution
4. Feed rate : Feed/Min
   : Feed/revolution
5. Rapid traverse rate : Feed rate override
   : Feed/Min
6. Operating modes : Manual/Automatic/MDI (editing)/Input/Output/Machine data set-up/Incremental etc.
7. Type of feedback : Digital (rotary encoders with train of pulsed)
   : Analog (transducers etc.)
   : Both

Specifications chart of a CNC system

8. Part program handling	: Number of character which can be stored
	: Part program input devices
	: Output Devices
9. Part programming	: Though MDI
	: Graphic simulation
	: Blue print programming
	: Background editing
10.Compensations	: Backlash
	: Lead screw with pitch error
	: Temperature
	: Cutter radius compensation
11.Thread cutting/Tapping	: Type of threads that can be cut

Specifications chart of a CNC system

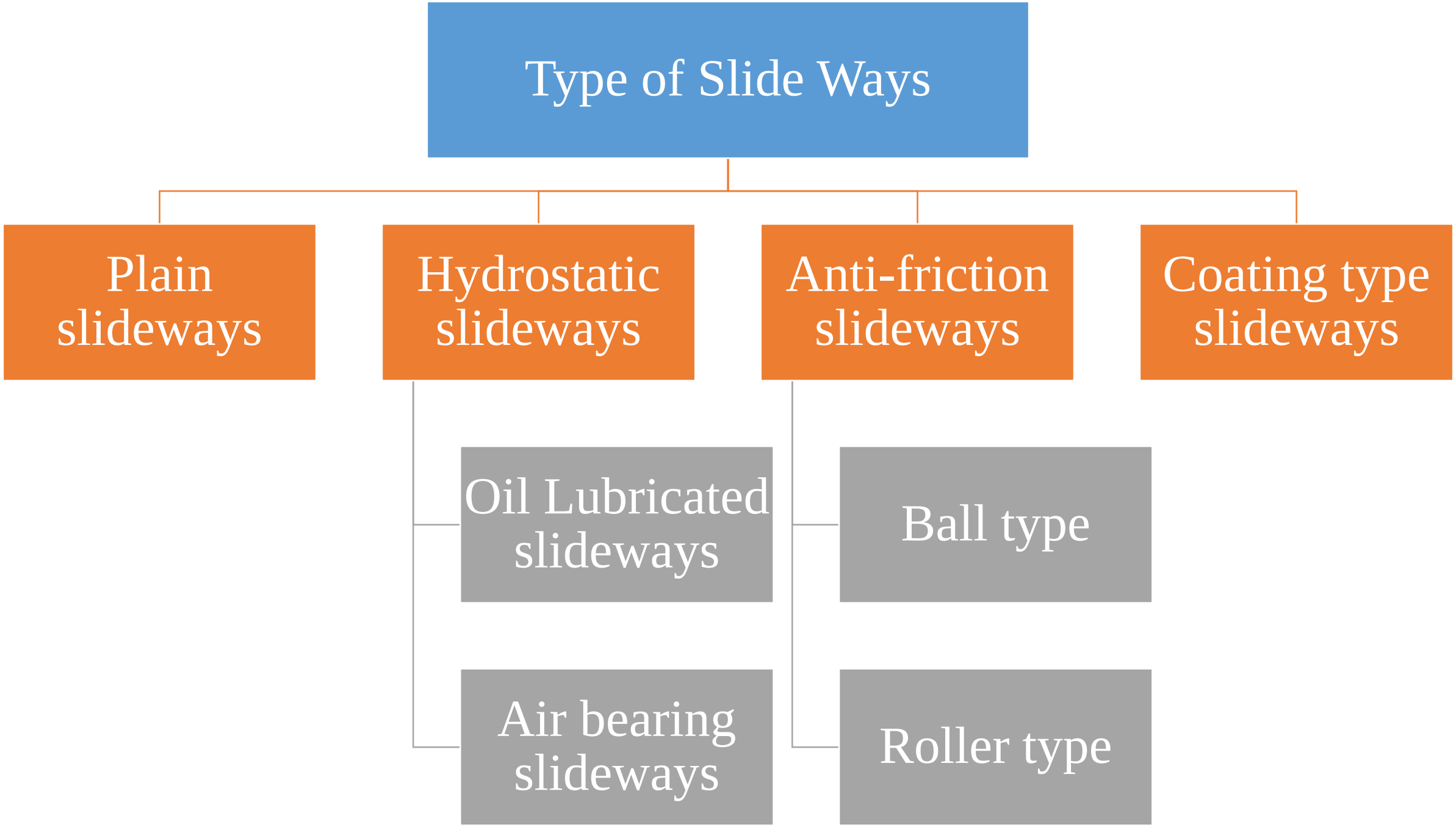
12. Programmable logic controller : Built in /External
: Type of communication with NC
: Number of inputs, outputs, timers, counters
: User memory
: Program organisation

13.Spindle control : Analog/Digital control
: Spindle orientation
: Spindle speed overrides

Slide and Slideways

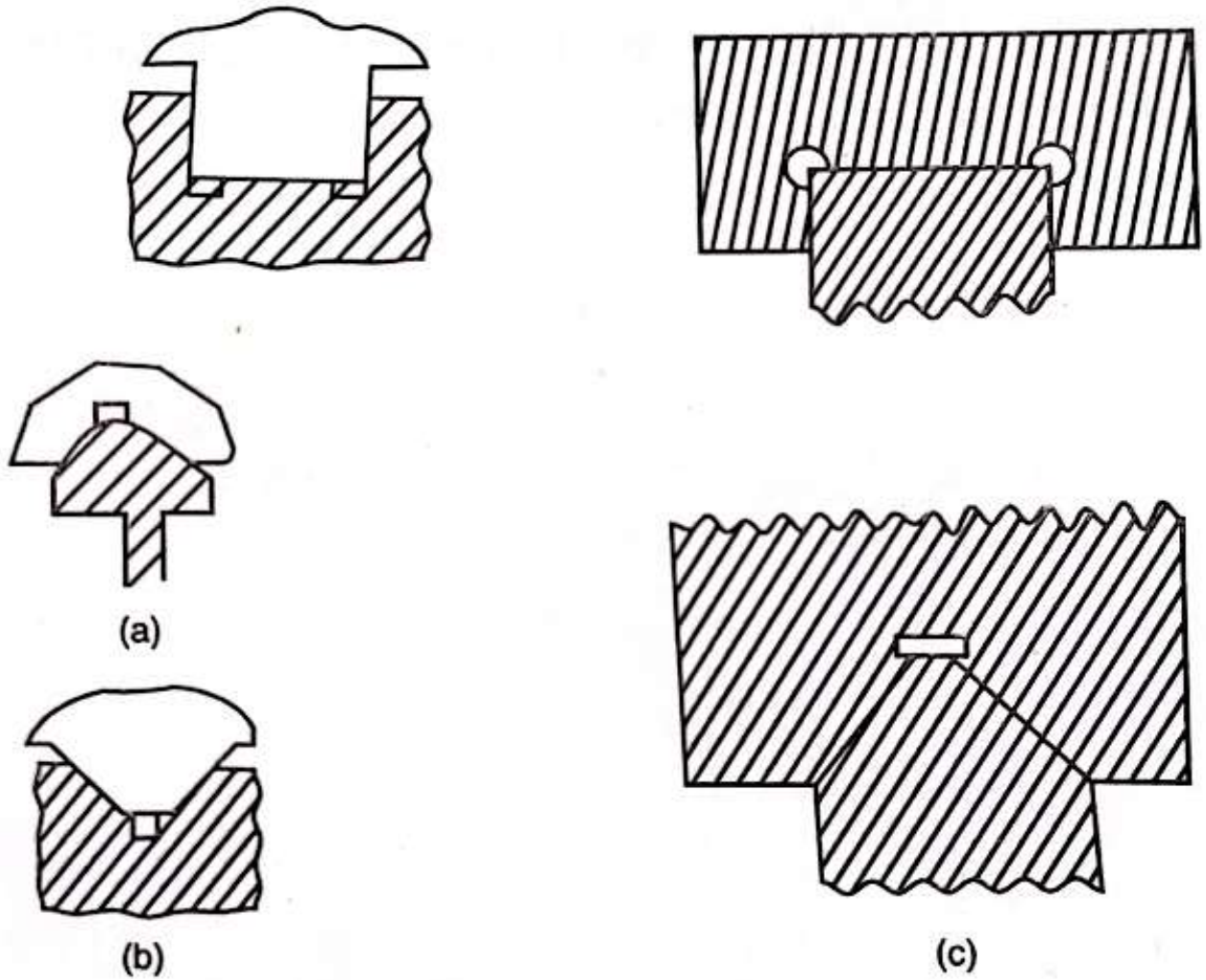
The old conventional machines has direct metal to metal contact between the slideways and the moving slides. But the design of slideways of CNC machine tool should have :

i) High accuracy
ii) Good surface finish
iii)Reduce friction
iv)Reduce wear
v) Smoothness of the drive.


Type of Slide Ways
Plain slideways
Hydrostatic slideways
Anti-friction slideways
Coating type slideways
Oil Lubricated slideways
Air bearing slideways
Ball type
Roller type

Type of Slideways

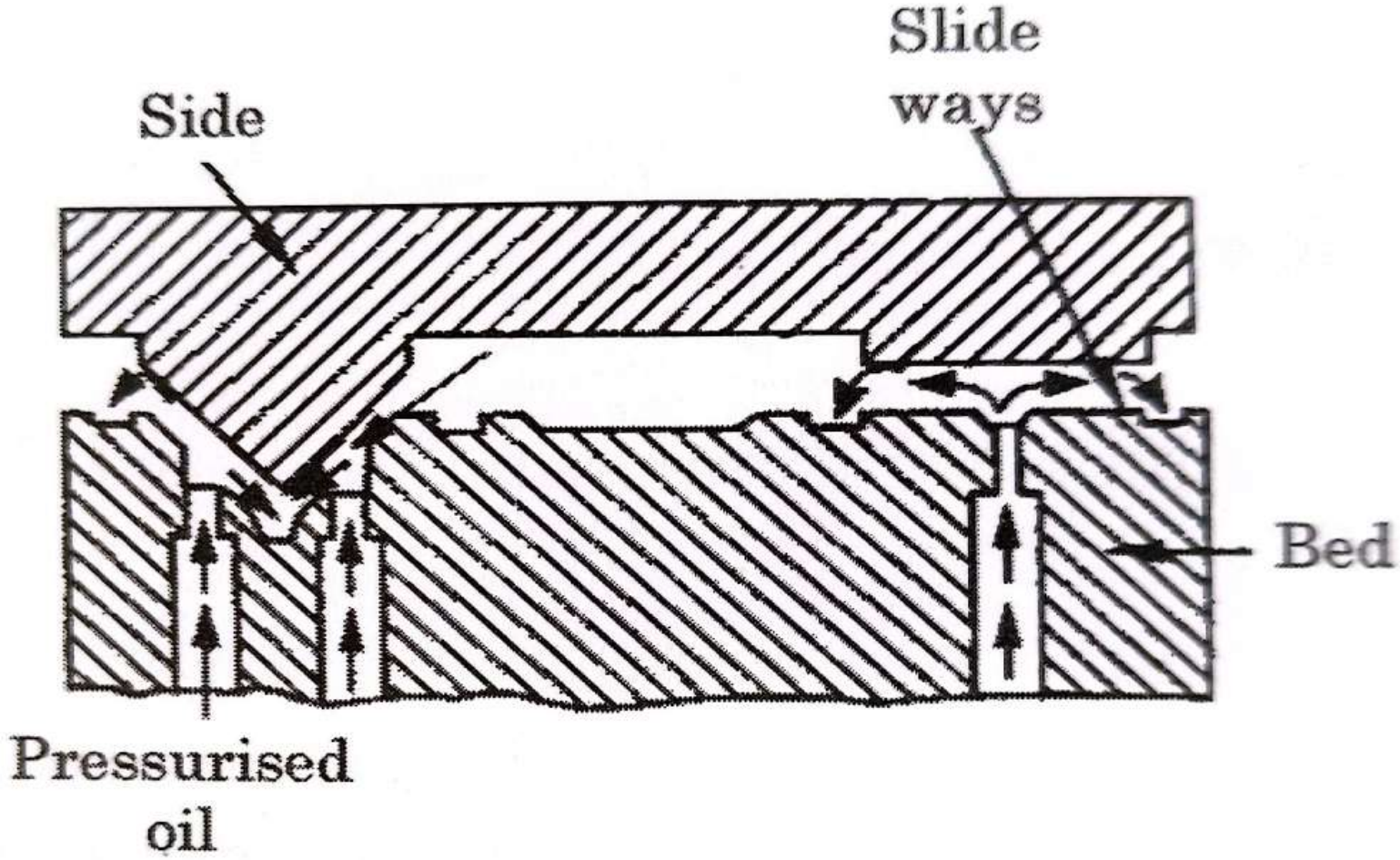
Plain Slideways: - These are also known as friction slide ways. They have good damping characteristics than anti-friction and pressurized slide ways.



Type of Slideways

Hydrostatic Slideways

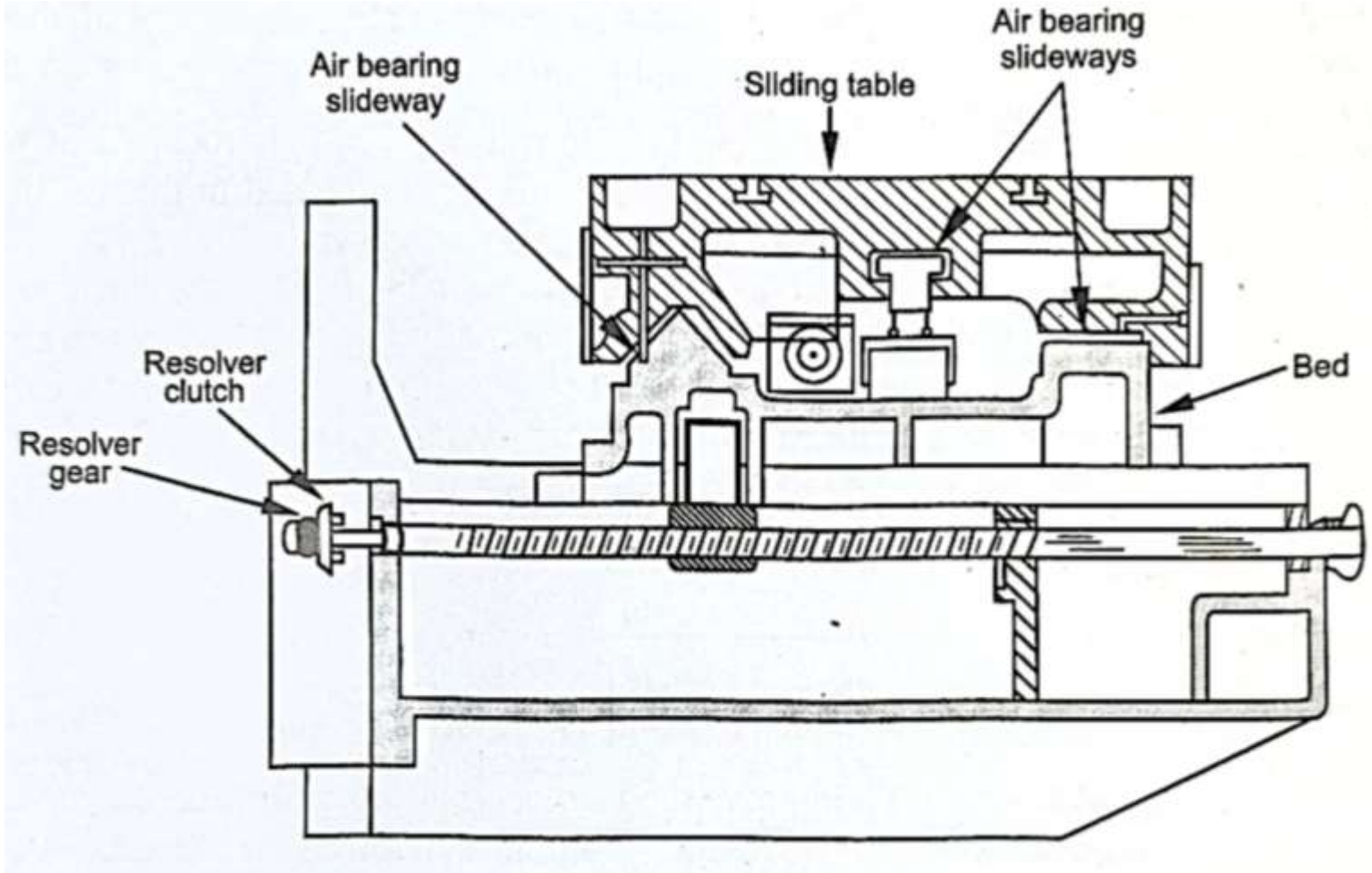
Oil Lubricated Slideways: - The friction is reduced by forcing oil under mating surfaces. These slides are best suitable for CNC milling machines



Type of Slideways

Hydrostatic Slideways

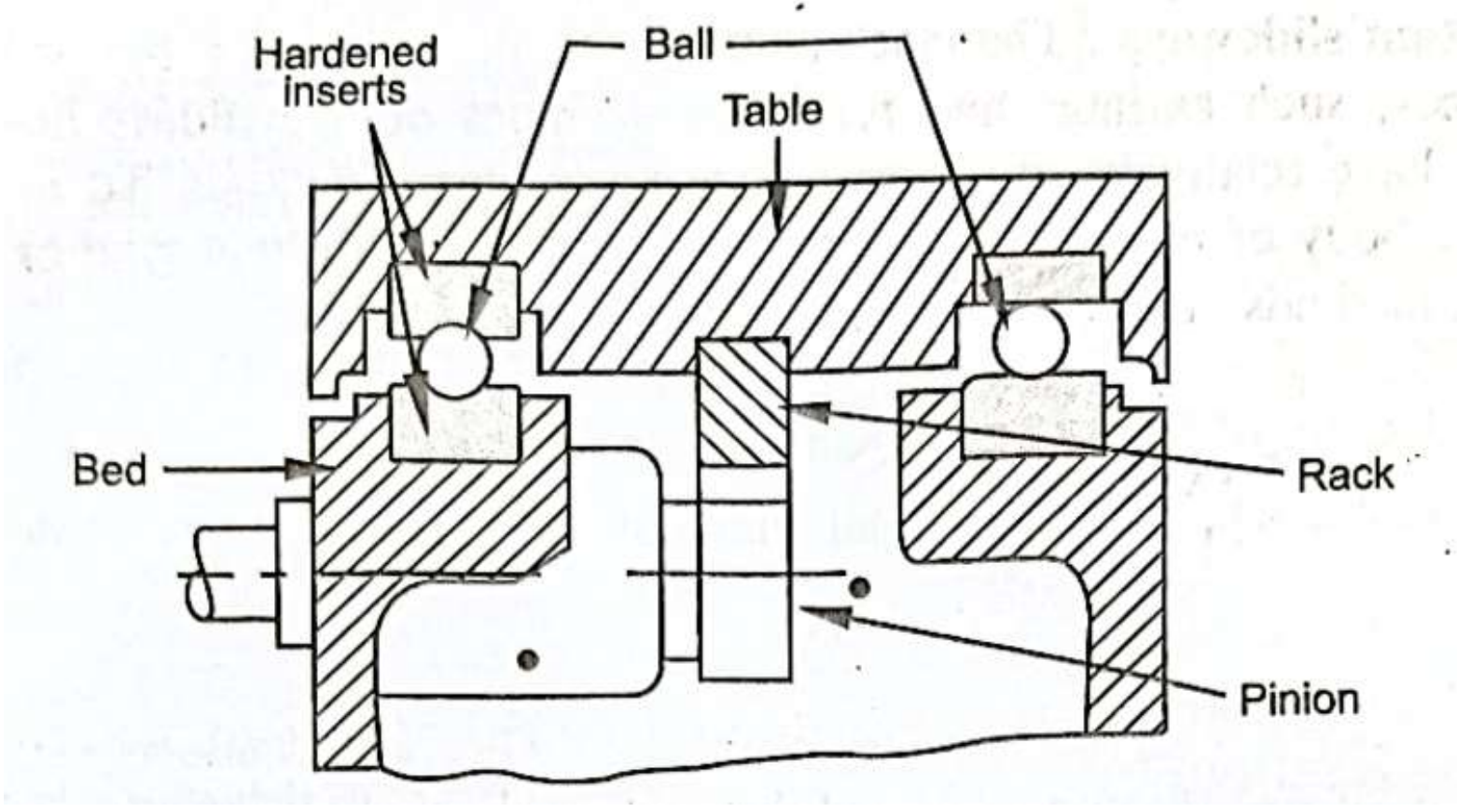
Air bearing Slideways: - The friction is reduced by using compressed air instead of oil. Mating surfaces are raised on the cushion of compressed air which separates the slide and slideways. It is most suitable for drilling machines.



Type of Slideways

Anti-friction Slideways

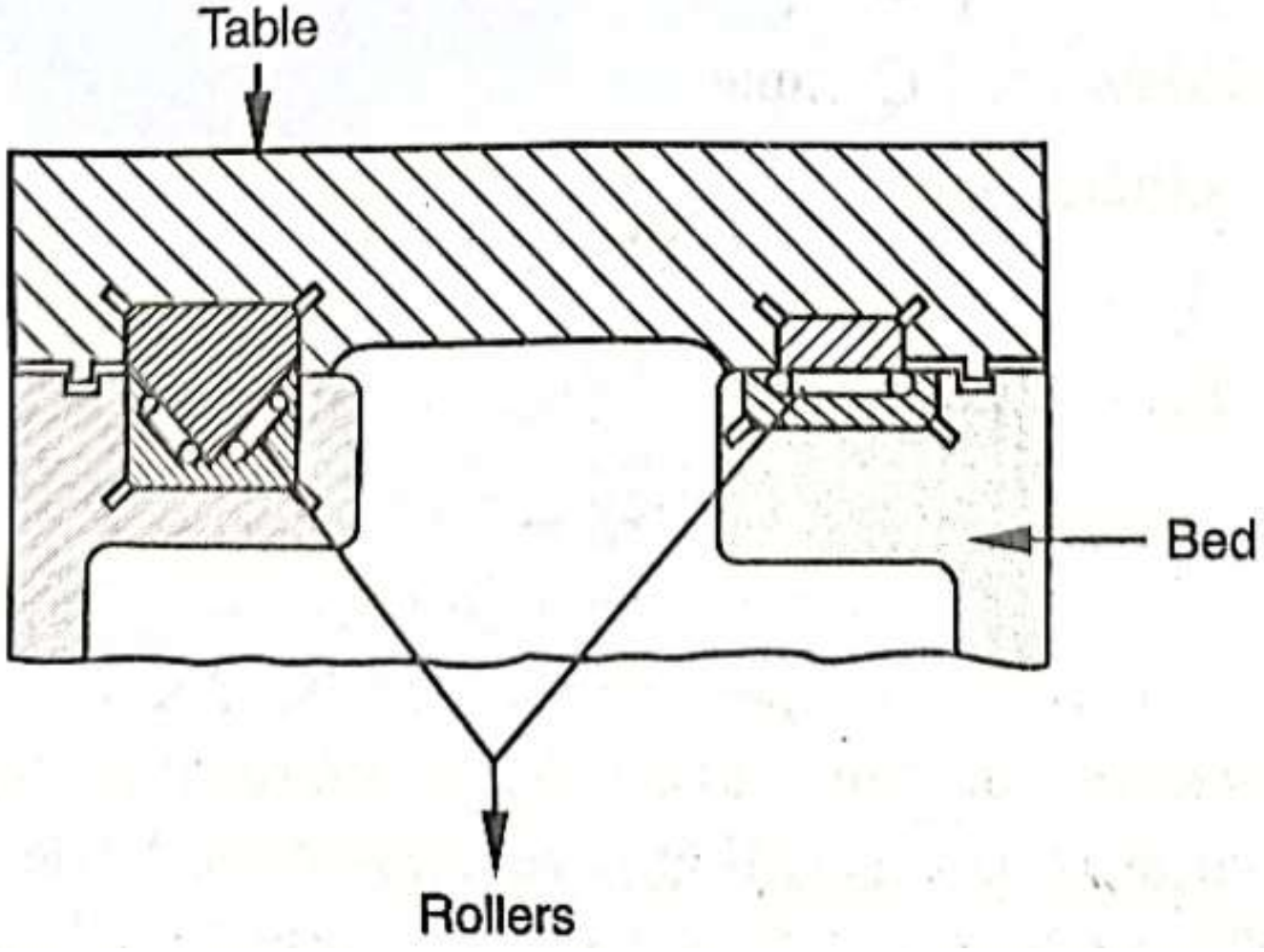
Ball bearing slideways: - The bed forms the guideways for the balls, which are carried in chain cages. Hardened inserts are fitted into the table which is located on the ball track with a single flat surface in contact with balls.



Type of Slideways

Anti-friction Slideways

Roller bearing slideways: - To improve the load bearing properties, hardened steel inserts known as rollers are used in slideways to reduce friction and lower the starting effort.



Elements of Motion Transmission: - The old conventional machines use lead screw for the motion transmission.

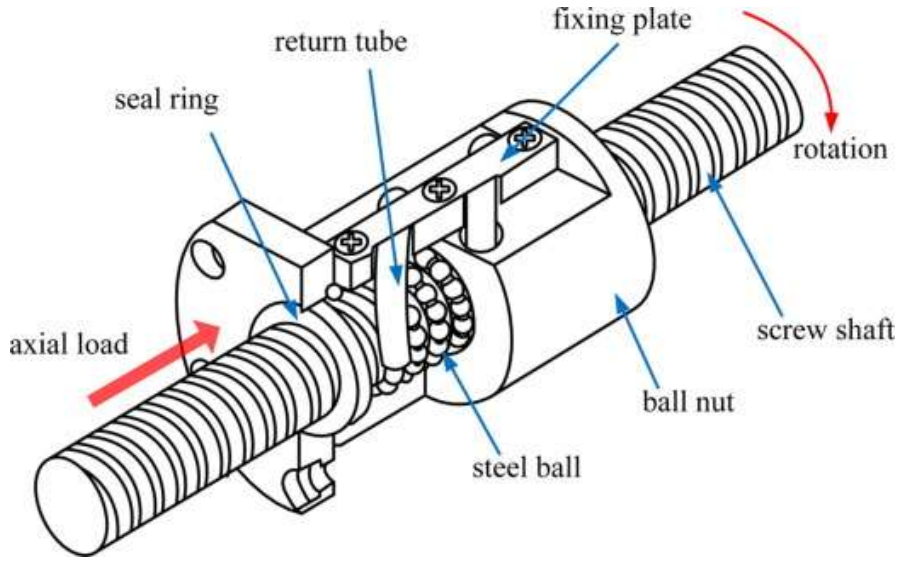
For CNC machines it is not suitable.

- High friction between lead screw and nut
- Poor power transmission efficiency
- Inaccuracy due to backlash

Alternative is recirculating ball screw and nut arrangement.

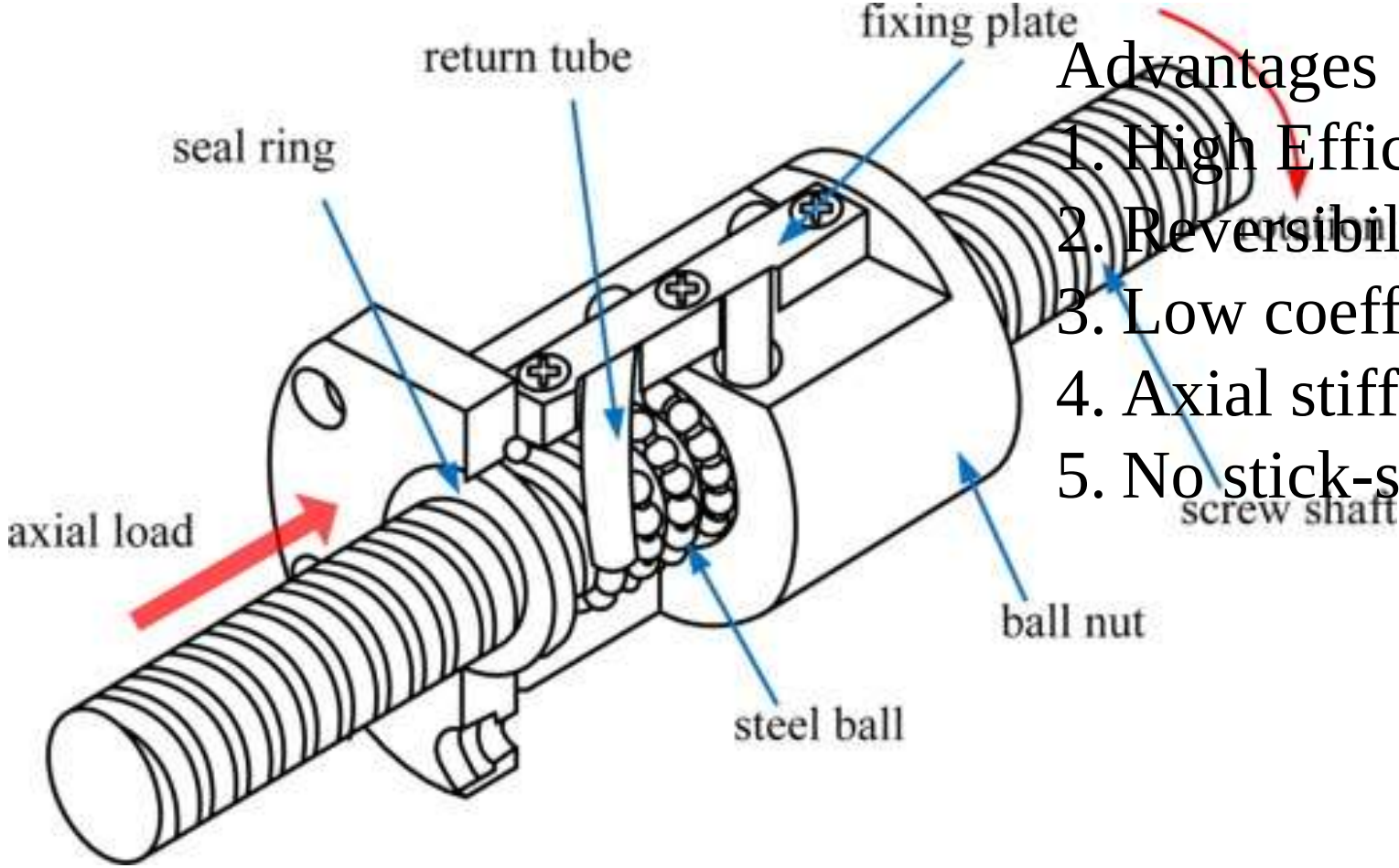
Advantages:

1. High efficiency: - Upto 90%
2. Reversibility: - Possible to back drive.
3. Wear and life
4. No stick slip



Source: - https://ars.els-cdn.com/content/image/1-s2.0-S0888327021000273-gr1.jpg

Recirculating ball screw and nut assembly



Advantages

1. High Efficiency
2. Reversibility
3. Low coefficient of friction
4. Axial stiffness
5. No stick-slip

Source: - https://ars.els-cdn.com/content/image/1-s2.0-S0888327021000273-gr1.jpg

Drives (Motor)

The main function of drive is to cause motion of the controlled machine tool member to confirm as closely as possible to the motion commands issued by the system. In order to achieve the a high degree of consistency in production, variable speed drives are necessary. The machine tool drives can be classified as

1. Spindle drives (constant power)
2. Feed drives (constant torque)

Drives (Motor)

A.C Motor: - A.C. induction motors are used to drive main spindle directly. Speed variation in A.C. motors can be achieved by the pole change method.

D.C. Motor: - D.C. motors are being extensively used for stepless speed variation of spindle. The stepless variation of speed is achieved by varying the D.C. voltage applied to the motor.

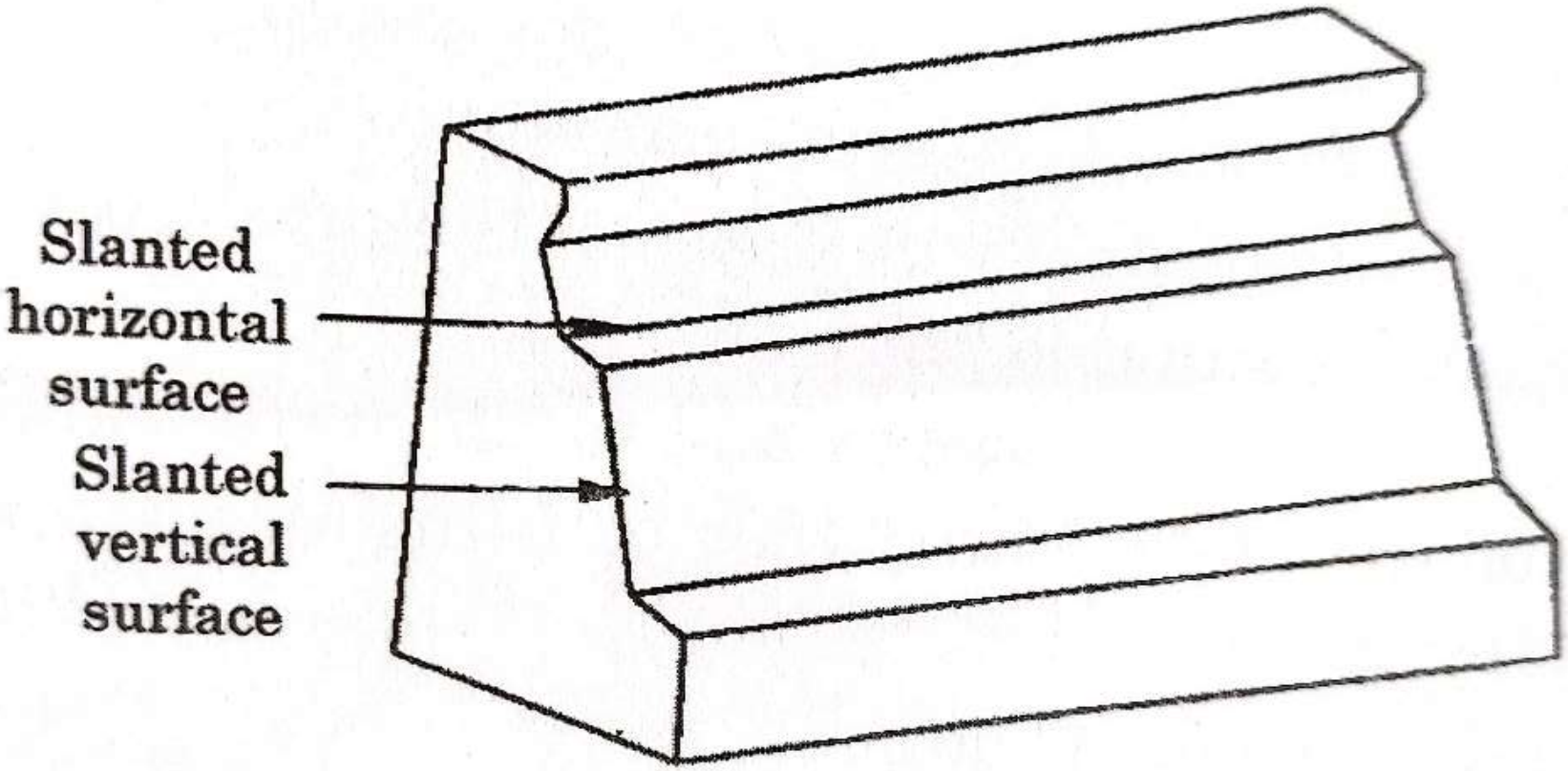
Swarf Removal: -CNC machines are designed to work at optimum cutting condition with the improved cutting tools on a continuous operation basis. Since the cutting time is much more in CNC machines, the volume of swarf generated is also more.

Method of swarf removal

1. Swarf removal from Cutting zone
2. Swarf disposal from machine tool

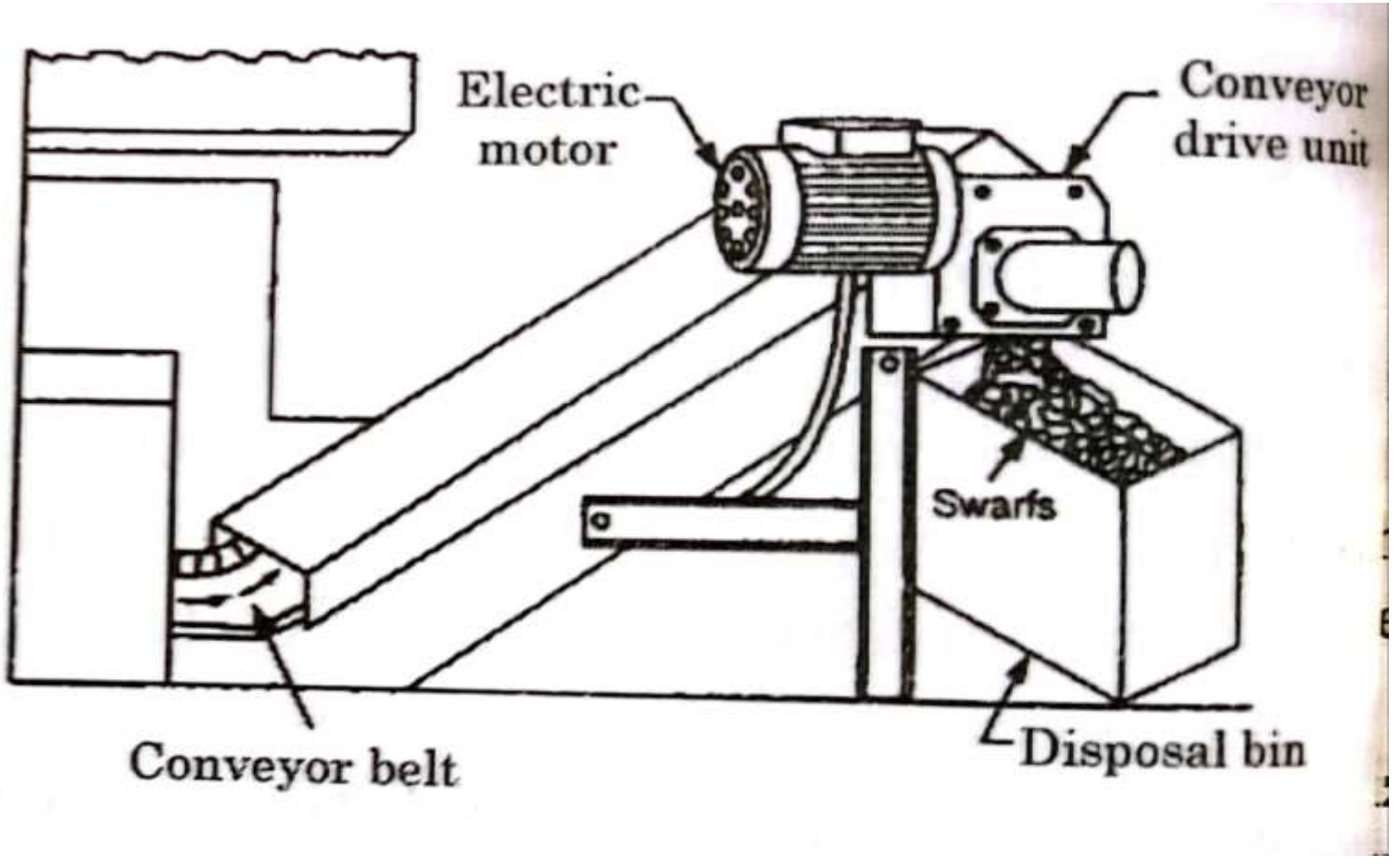
Swarf Removal

Swarf removal from cutting zone: - It is generally taken care of by the design configuration of the machine. Slant bed and vertical bed turning centers have the advantages over flat bed or horizontal configuration in that the swarf does not accumulate on the guide ways. Some time coolant wash is embedded in part programme.



Swarf Removal

Swarf disposal from machine tool: - Continuously operating linear or rotary conveyors are used for removing the swarf from machine tool. The system is such that the swarf from the cutting zone falls directly on the conveyer and immediately taken away.



Safety and Guarding: Since the CNC machine are under continuous automatic operation, there is a need to protect the machine guideways and to ensure the safety of the operator.

a) Safety of machine element and workpiece

b) Safety of operator

Safety and Guarding

a) Safety of machine element and workpiece

   i) Overload protection

   ii) Clamping sensors

   iii) Work-table control sensors

   iv) Measuring device safeguards

b) Safety of operator

   i) Perimeter guards

   ii) Pressure mats

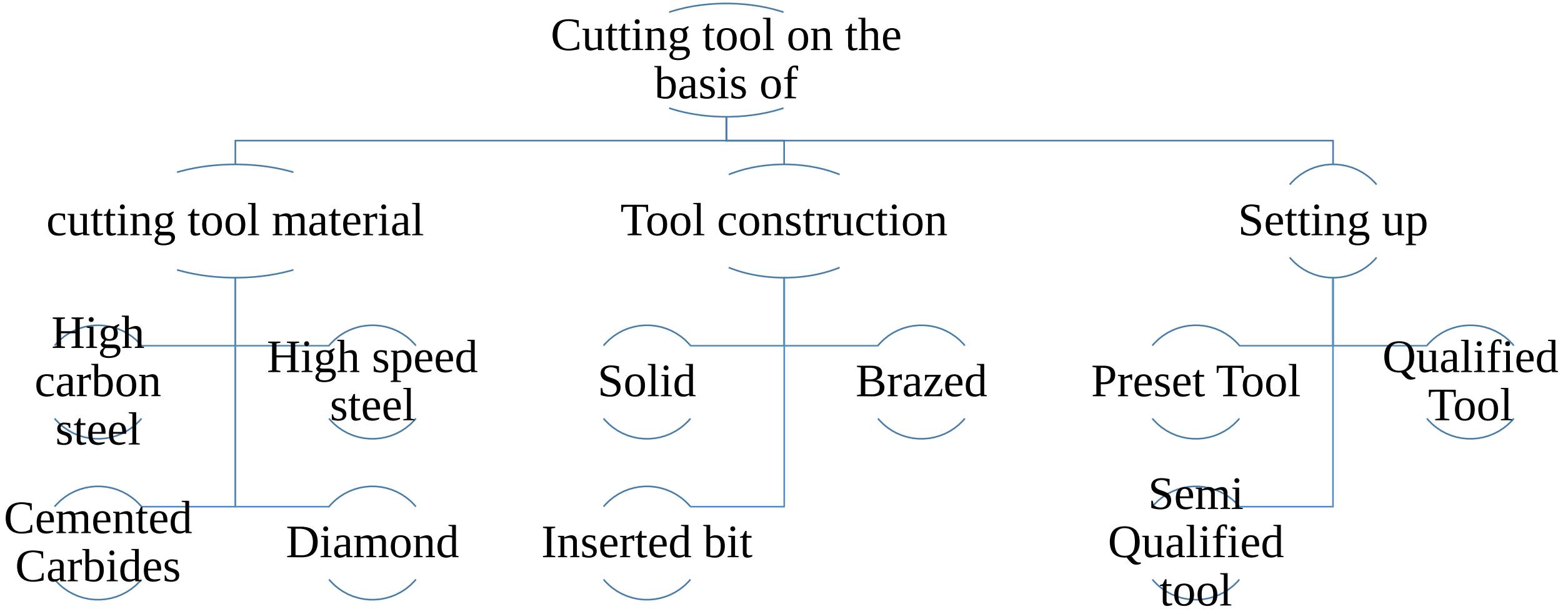
   iii) Light barriers

   iv) Safety clutches

Various cutting tool for CNC machines

The cutting tool can be divided into following type on the basis of cutting material, tool construction and setting up of tools.

Various cutting tool for CNC machines



Properties of Tool Materials

- ❖Toughness: - It enables the cutting tool to withstand various forces and to absorb shock during interrupted cutting.
- ❖Hot hardness: - Tool must retain its hardness at high temperature.
- ❖Wear resistance
- ❖Thermal conductivity
- ❖Harden ability
- ❖Recovery hardness

Concept of CNC tool holder

A tool holder consists of five basic components

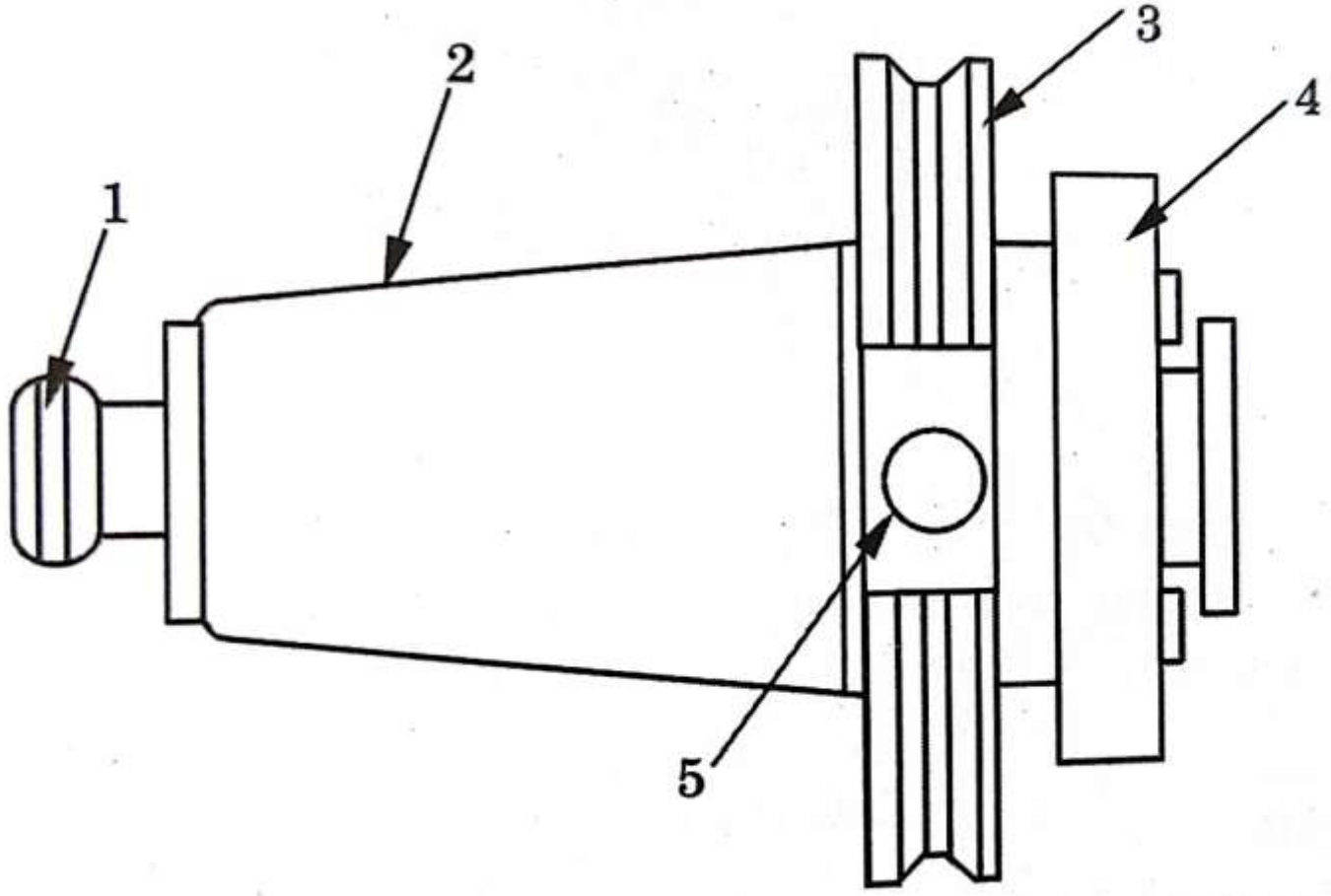
a) Pull stud

b) Tapered shank

c) Flange

d) Adapter

e) Oppose slot



Automatic Tool changer (ATC)

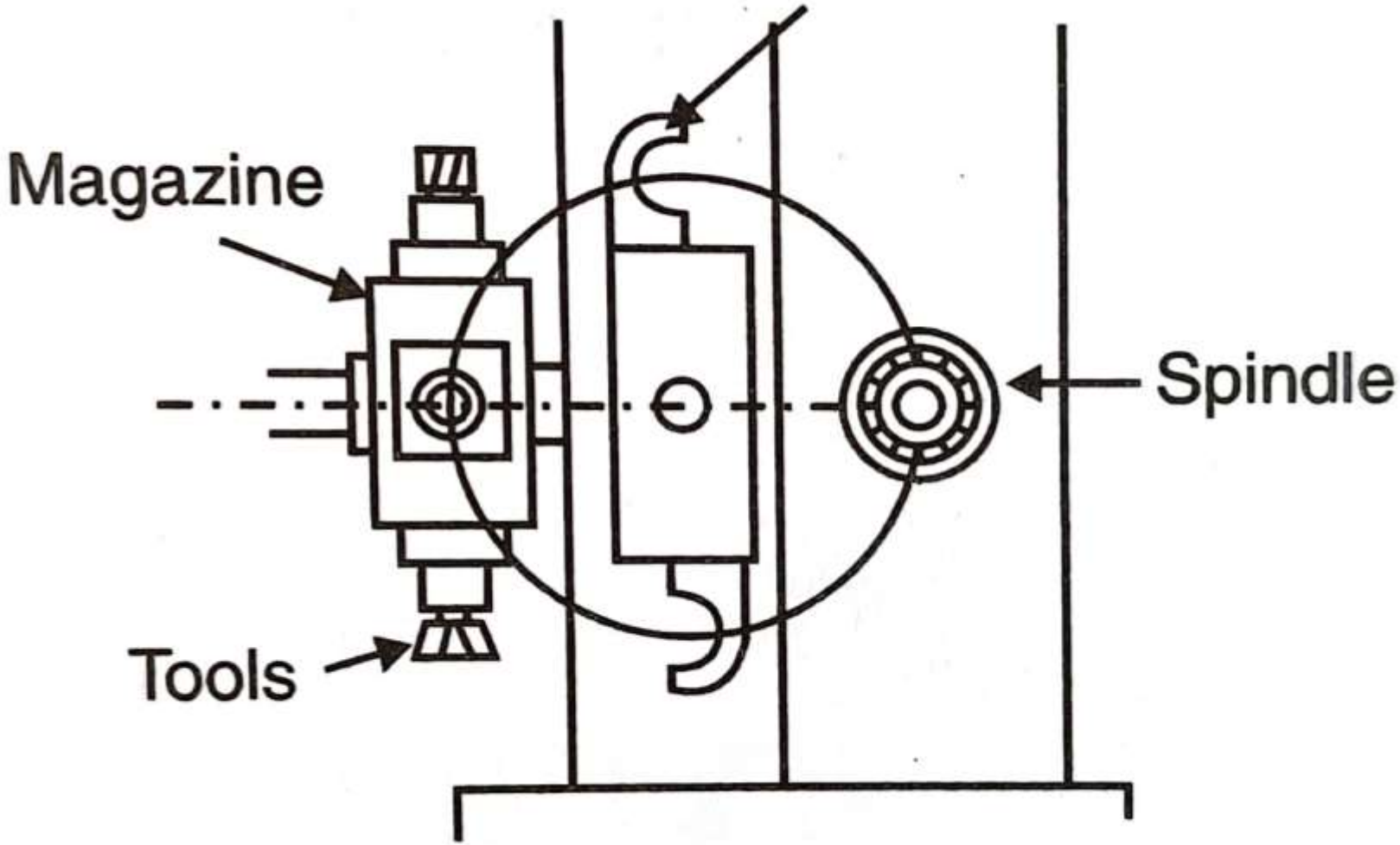
A number of machining operation may be performed for finishing a particular job. So, variety of tools are used to do the machining operations. To reduce idle time and improve the machine utilization, we used a device known as ATC. ATC take approximately 3 to 7 seconds.

ATC advantages

a) Lines changed in second instead of hours.
b) Increase operator safety by changing tools automatically.
c) Change tools in seconds for maintenance and repair.
d) Increase flexibility.
e) Heavy and large multi-tools that are automatically exchanged.

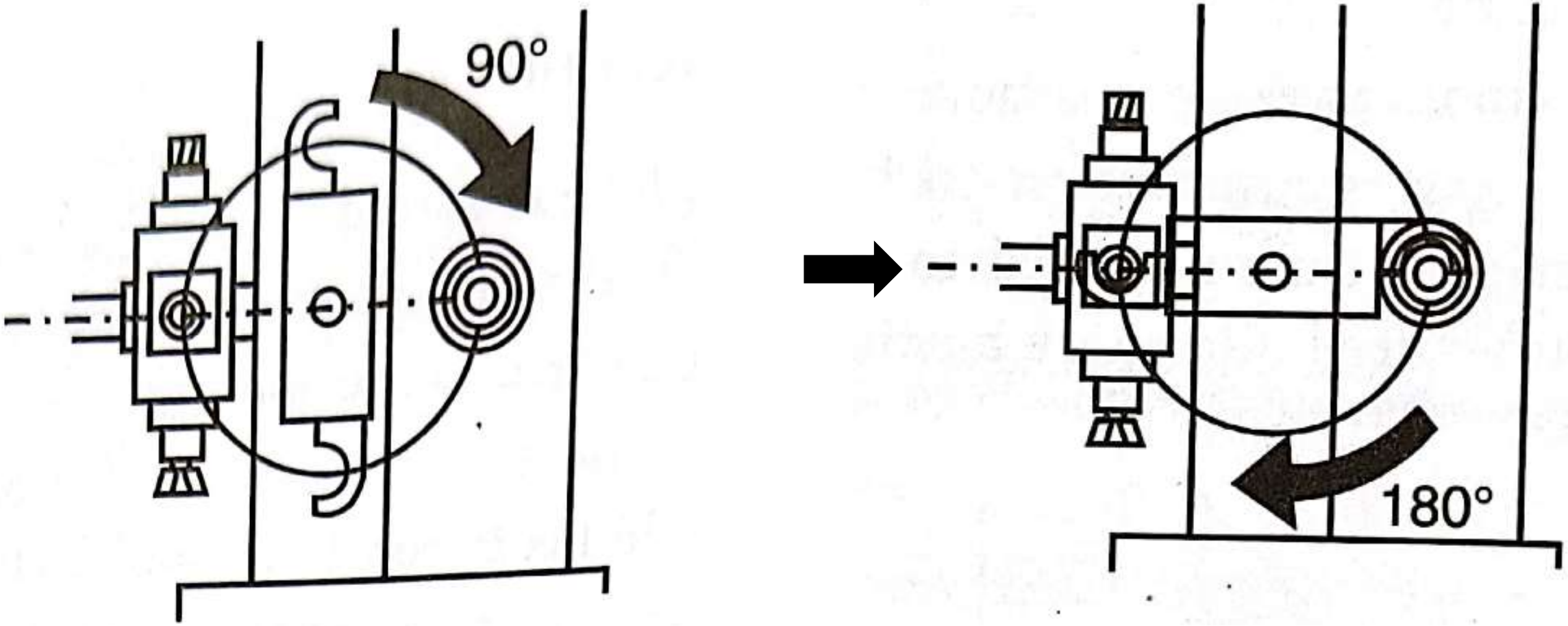
Working principle of ATC

- Tool magazine to index into the right position where the tool is placed from the spindle.
- Stop the spindle at right orientation.



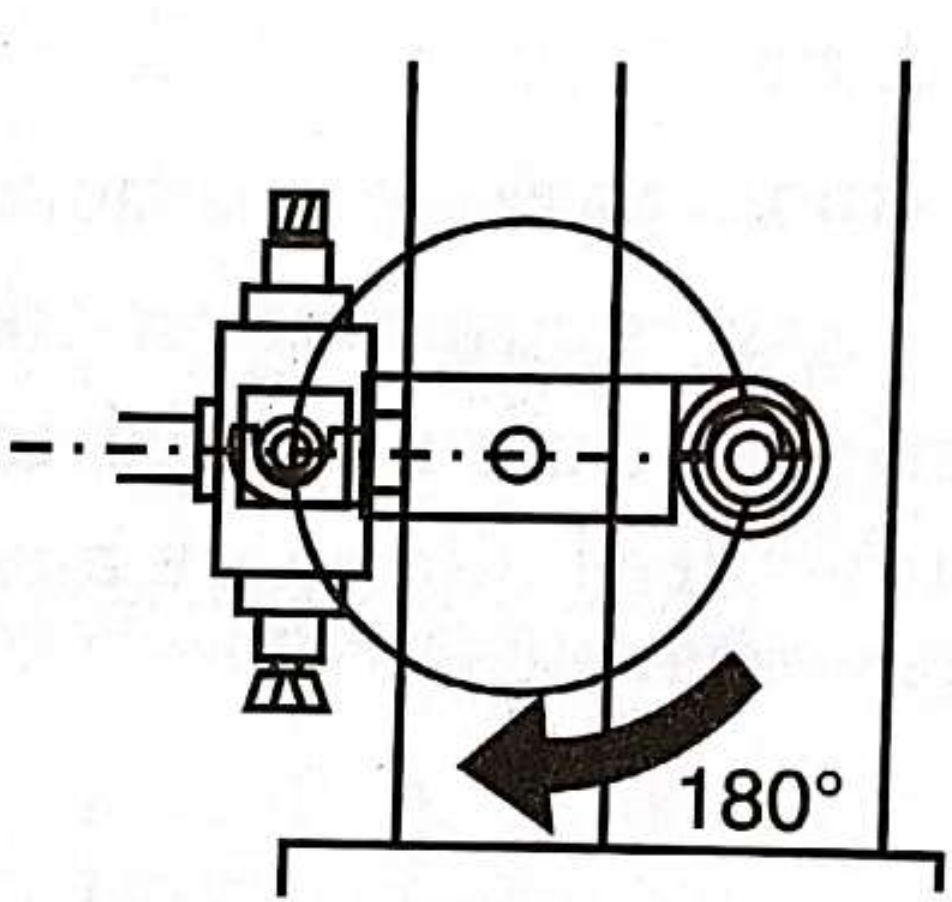
Working principle of ATC

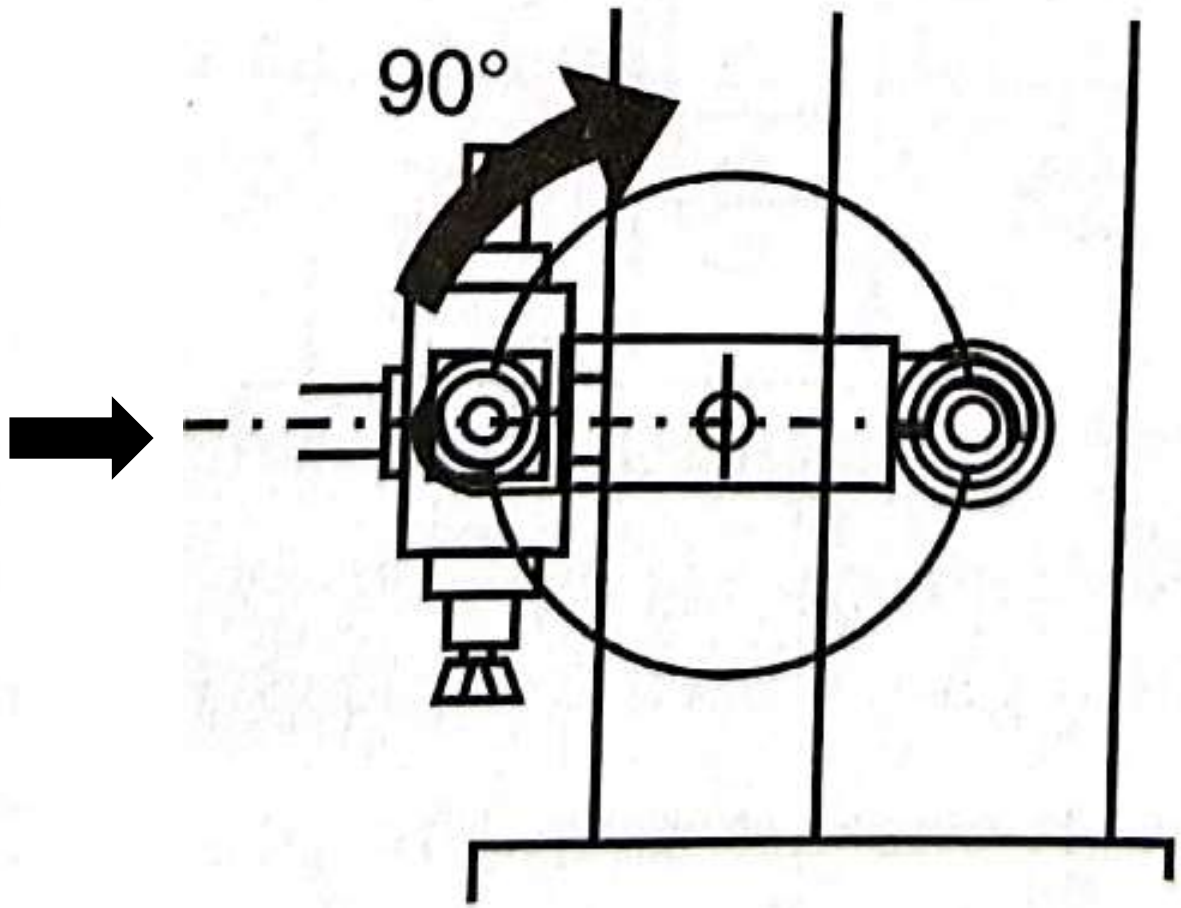
- Tool change arm to index to reach the tool magazine.



Working principle of ATC

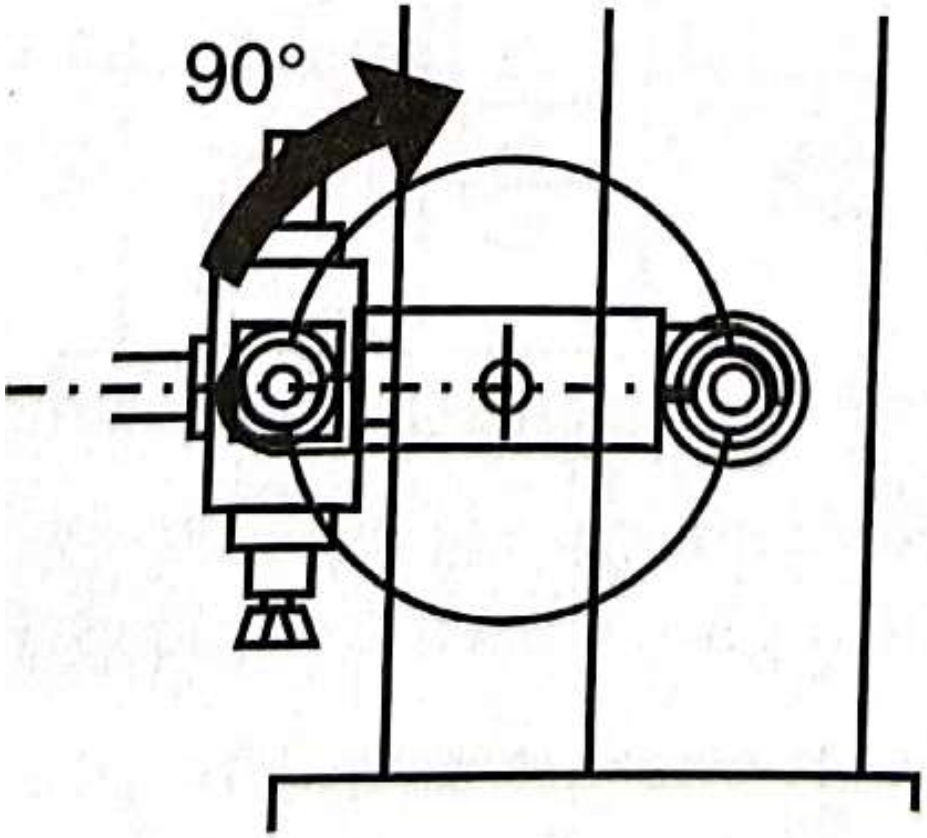
- Tool change arm to pick the tool from magazine and spindle simultaneously.
- Arm to index to reach the spindle.

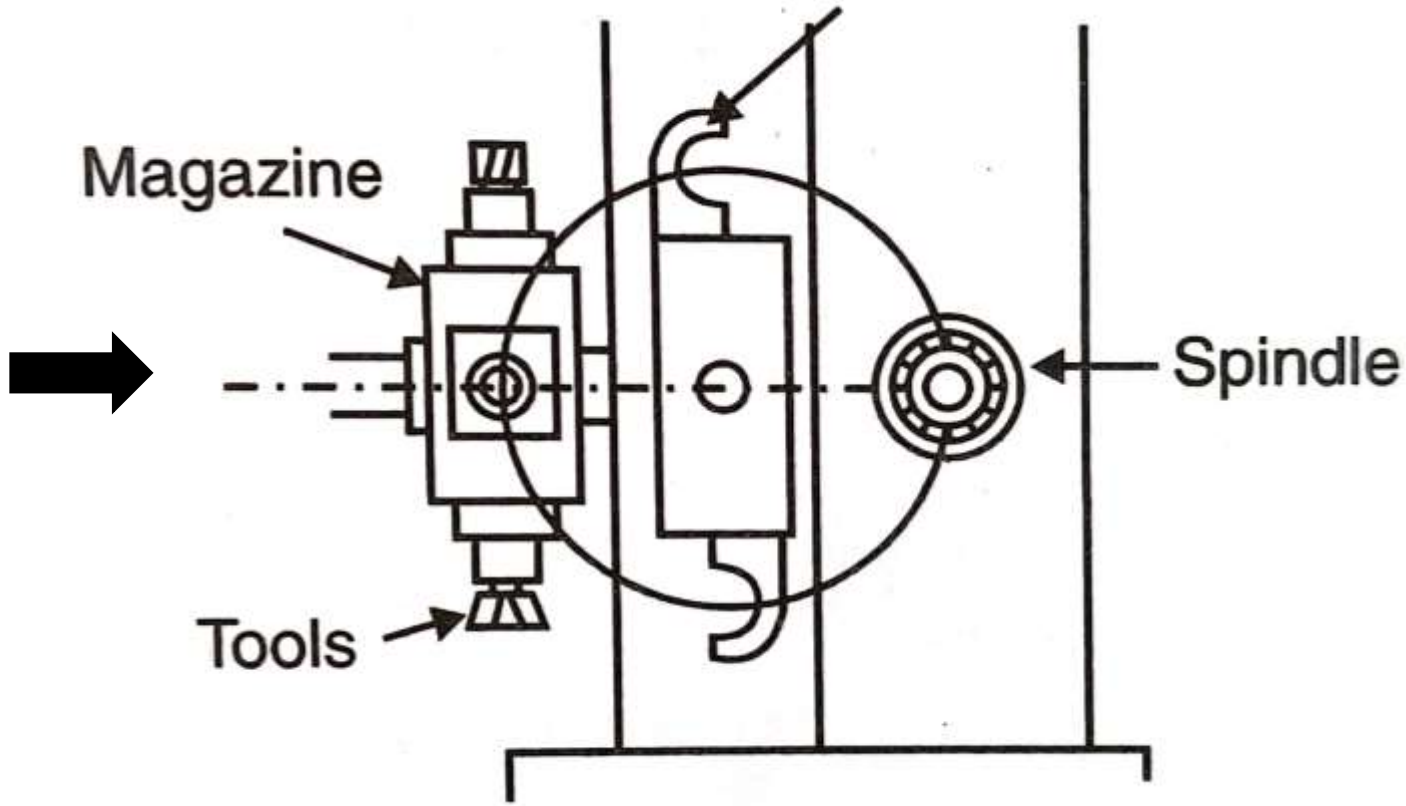




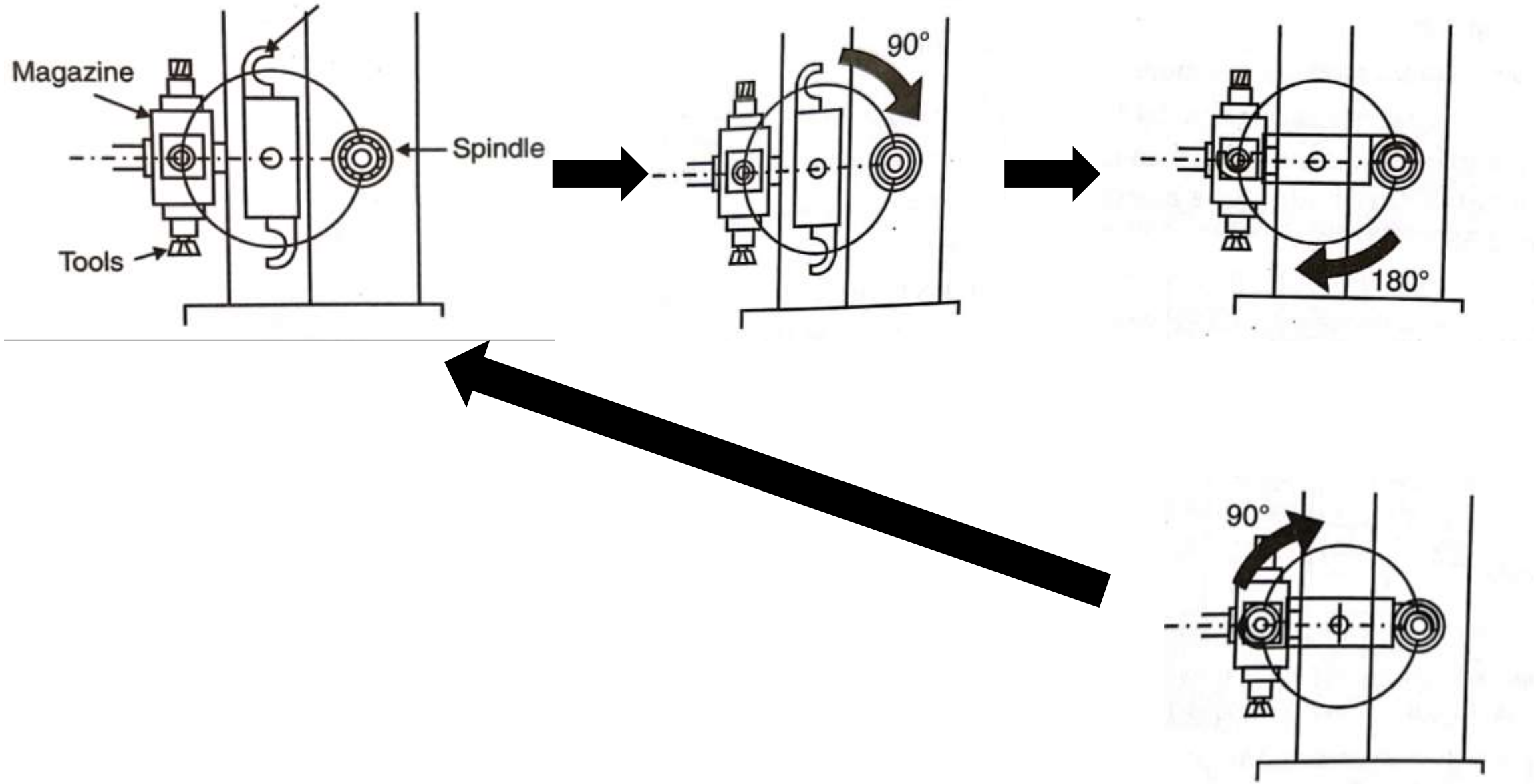
Working principle of ATC

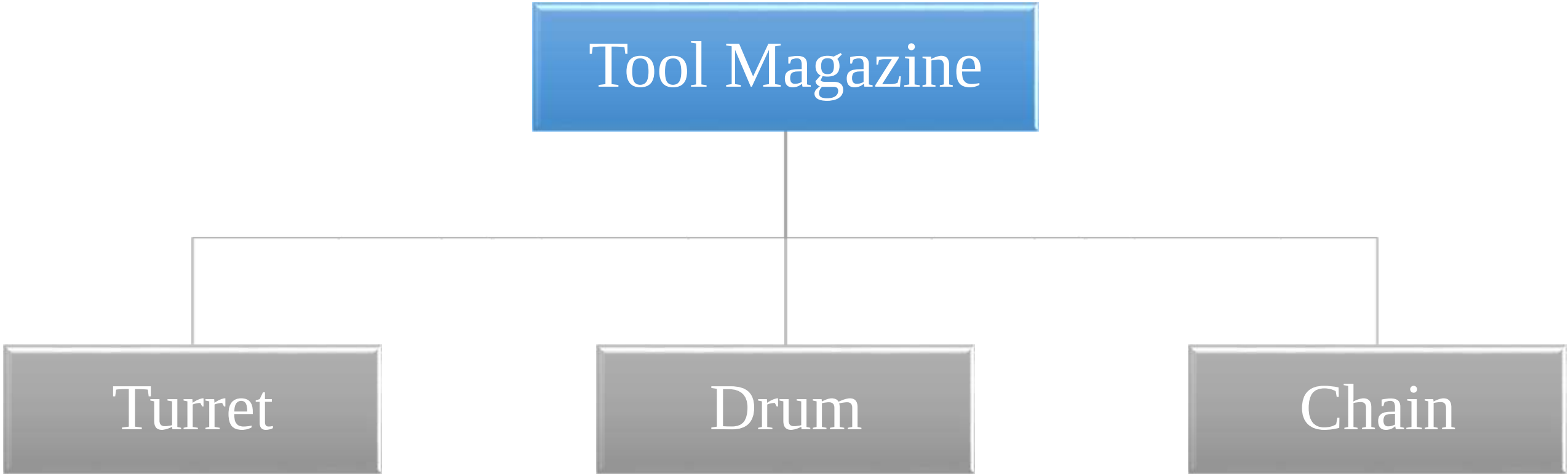
- New tool is placed in spindle and old one in tool magazine.
- Tool change arm moves into its parking position.





Working principle of ATC

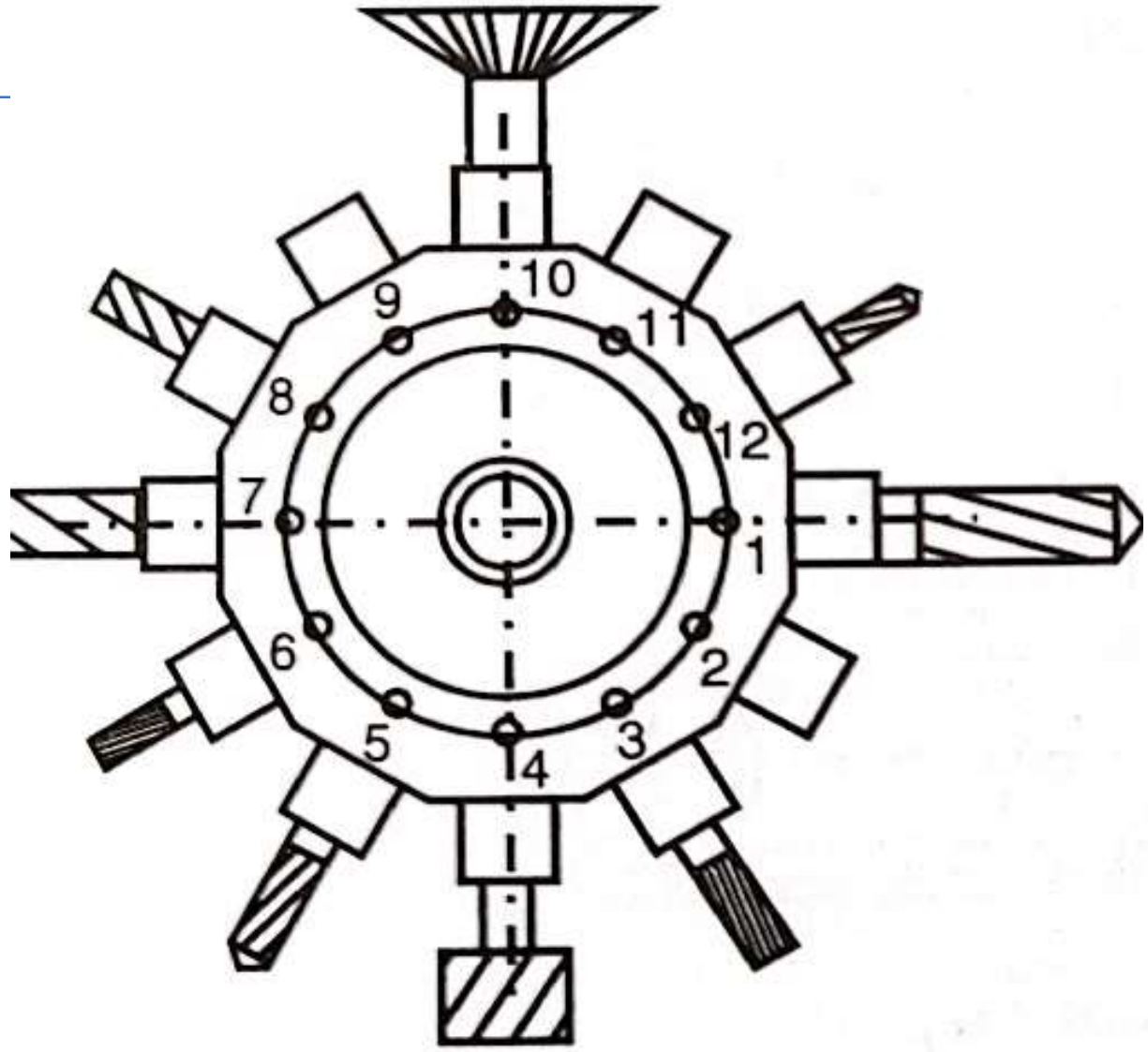



Tool Magazine
Turret
Drum
Chain

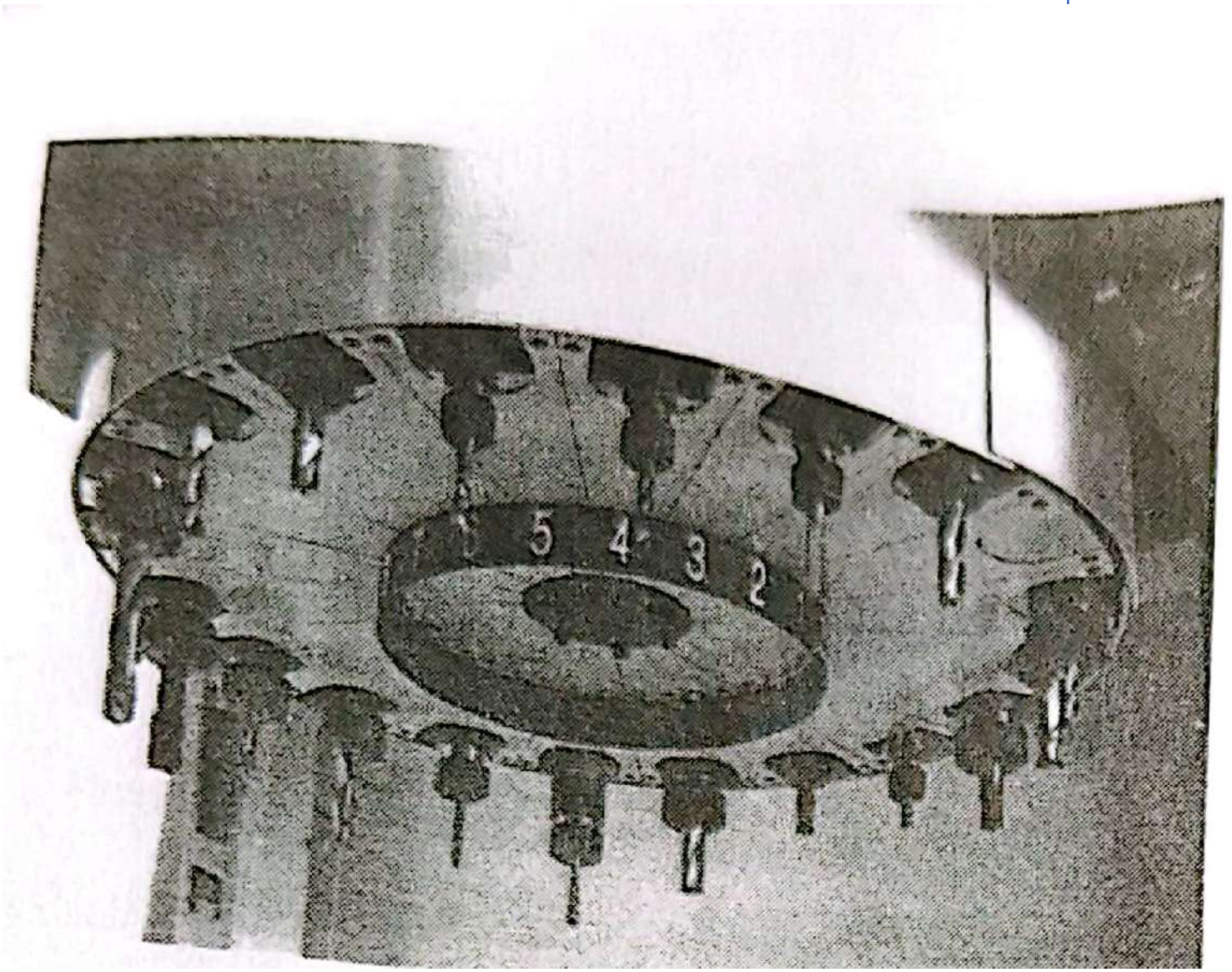
Tool Magazine

Turret

- Simplest type



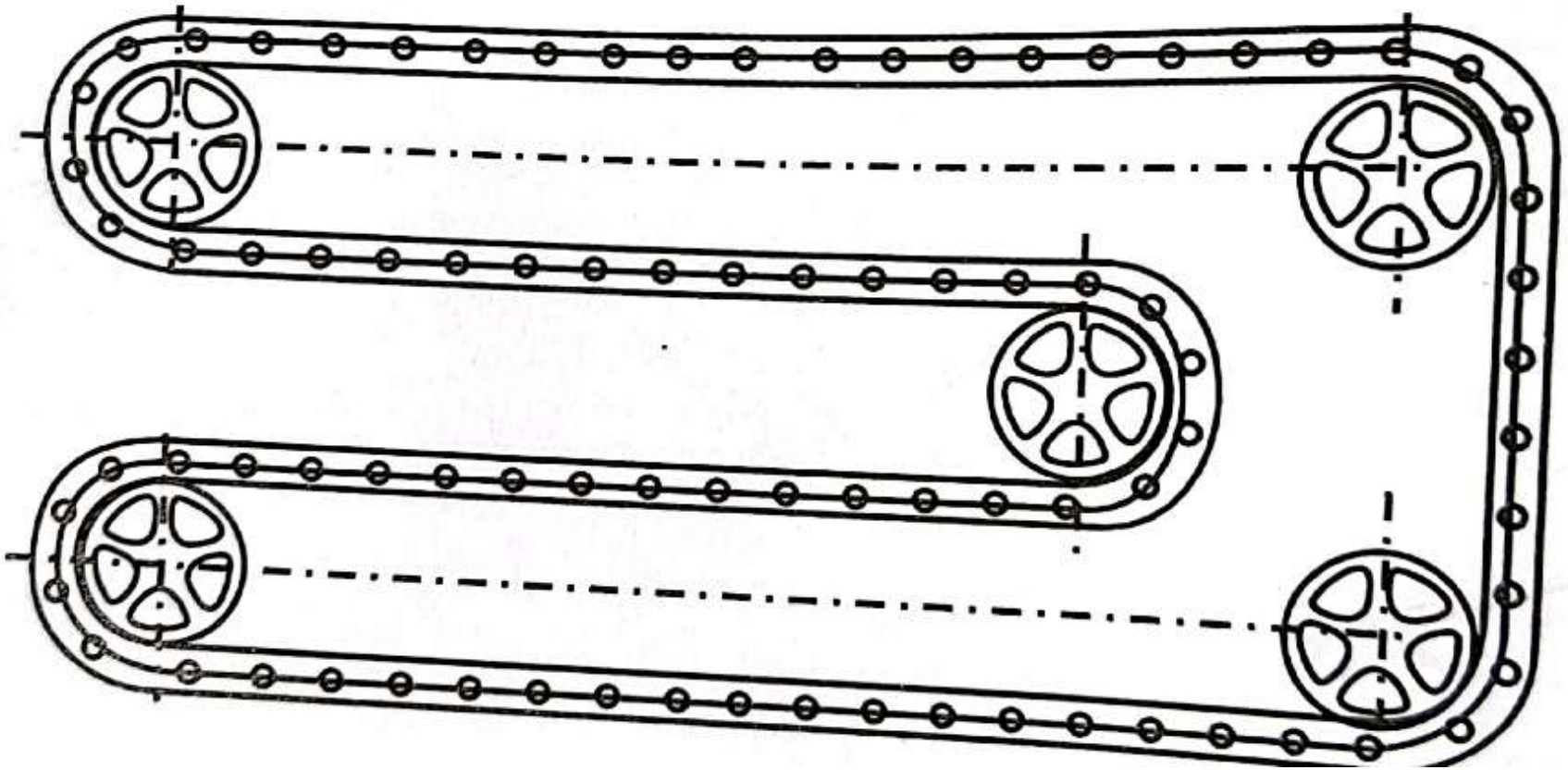
Tool Magazine



Drum

- Diameter of tool indicated the number of tool it can hold

Tool Magazine



Chain

- Can carry 30-200 tools
- Tool search time is more

Management of A Tool Room

A tool room is a place in the industry where the different type of tools are stored or placed. Here management of a tool room means how they are managed.

Thank You