**Multispindle automatic lathes**

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.

**Working Principles of Semi Automatic and Automatic Lathes**

The kinematic systems and basic principles of working of the following general purpose semi-automatic and automatic lathes of common use have been visualised and briefly discussed here :

(a) Semi-automatic lathes :

- Capstan and single spindle turret lathe
- Hydraulic copying lathe

(b) Automatic lathes

- Single spindle automatic (screw cutting) lathe
- Swiss type automatic lathe

**Kinematic system and working principle of capstan lathe**

Like general configurations and applications, the basic kinematic systems are also very similar in capstan lathes and turret lathes (particularly single spindle bar and horizontal types) in respect of their major functions, i.e.,

- bar feeding mechanism
- turret moving and indexing
- speed and feed drives

**Bar feeding mechanism of capstan lathe**

The bar stock is held and tightly clamped in the push type spring collet which is pushed by a push tube with the help of a pair of bell-crank levers actuated by a taper ring. Bar feeding is accomplished by four elementary operations;

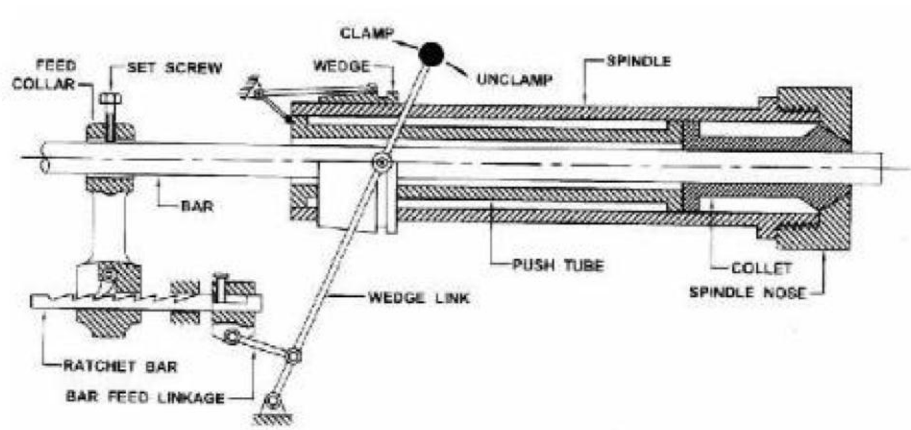
- unclamping of the job – by opening the collet
- bar feed by pushing it forward
- clamping of the bar by closing the collet
- free return of the bar-pushing element

After a job is complete and part off, the collet is opened by moving the lever manually rightward to withdraw the push force on the collet. Further moving of the lever in the same direction causes forward push of the bar with the help of the ratchet – paul system shown. After the projection of the bar from the collet face to the desired length controlled by a pre-set stop – stock generally held in one face of the turret or in a separate swing stop, the lever is moved leftward resulting closing of the collet by clamping of the barstock. Just before clamping of the collet, the leftward movement of the lever pushes the bar feeder (ratchet) back freely against the paul.

**Turret indexing mechanism in capstan and turret lathes**

The turret (generally hexagonal) holding the axially moving cutting tools have the following motions to be controlled mechanically and manually ;

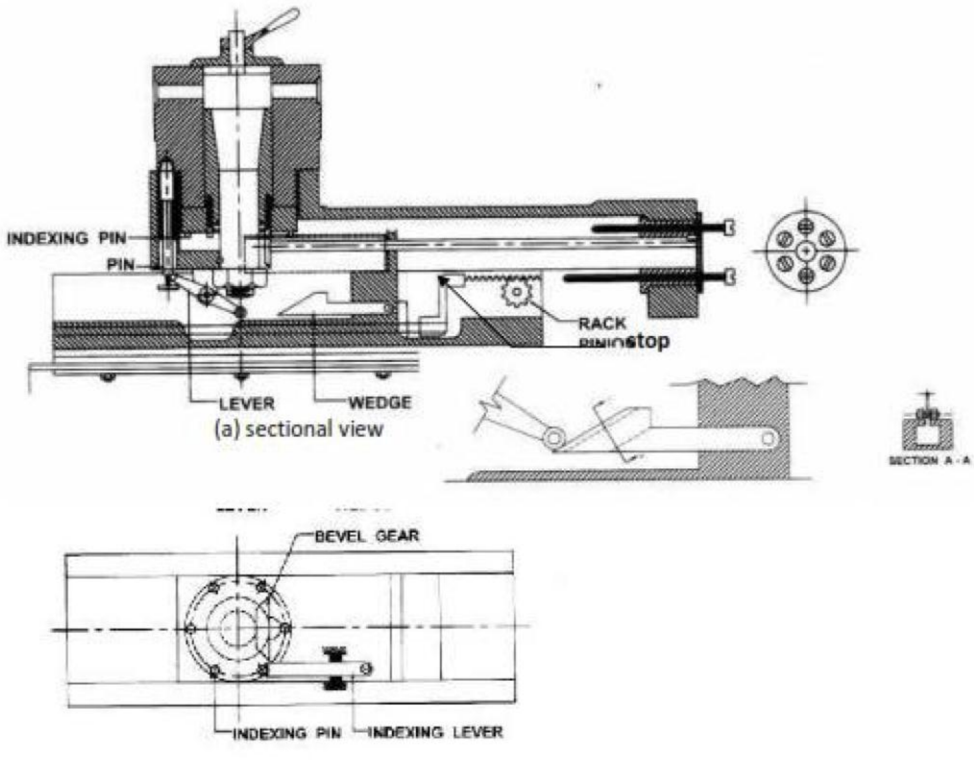
- forward axial traverse comprising;
  - quick approach – manually done by rotating the pinion
  - slow working feed – automatically by engaging the clutch
  - stop at preset position depending upon the desired length of travel of the individual tools
- quick return – manually done by disengaging the clutch and moving the turret back
- indexing of the turret by $60^\circ$ (or multiple of it) – done manually by further moving the turret slide back.




**Typical bar feeding mechanism in capstan lathe.**

Just before indexing at the end of the return stroke, the locking pin is withdrawn by the lever which is lifted at its other end by gradually riding against the hinged wedge. Further backward travel of the turret slide causes rotation of the free head by the indexing pin and lever. Rotation of the turret head by exact angle is accomplished by insertion of the locking pin in the next hole of the six equispaced holes. After indexing and locking, the turret head is moved forward with the next cutting tool at its front face when the roller of the lever returns through the wider slot of the wedge without disturbing the locking pin as indicated in the figure. The forward motion of the turret head is automatically stopped when the set- screw corresponding to the working tool is arrested by the mechanical stop. The end position and hence length of travel of the tool is governed by presetting the screw. There are six such screws, each one corresponds with particular face or tool of the turret. The drum holding those equispaced six screw with different projection length is rotated along with the indexing (rotation) of the turret head by a pair of bevel gears (1:1) .

The bottom most screw, which corresponds with the tool on the front face of the turret, when hits or touches the stop, the turret movement is stopped either manually by feeling or automatically by disengaging the clutch between the feed rod and the turret slide.

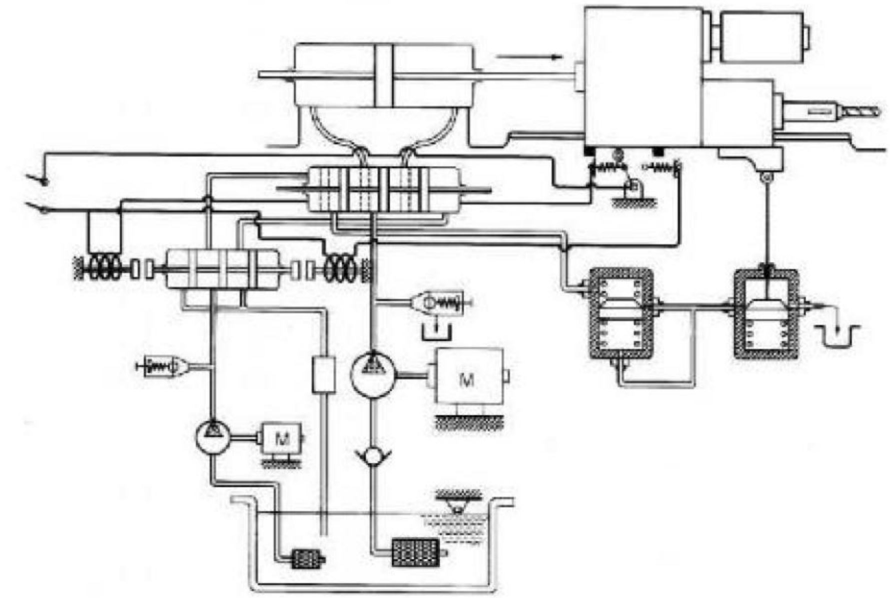



**Turret indexing in capstan and turret lathe.**

**Kinematics and working principle of hydraulic copying lathe**

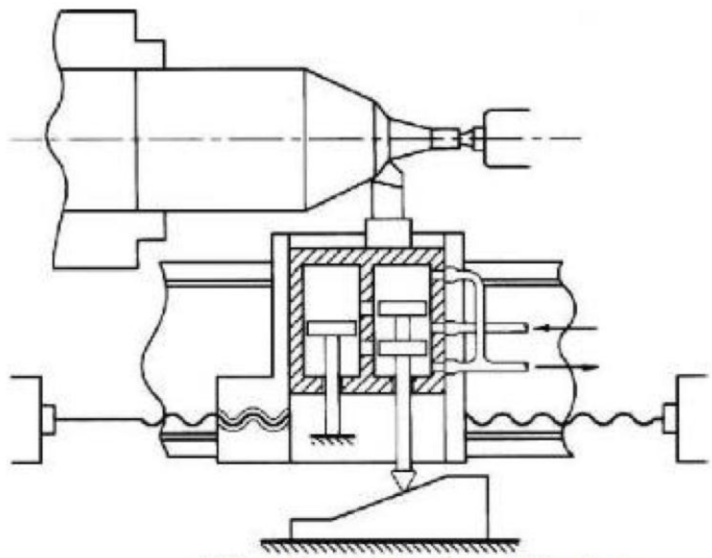
Hydraulic drive is often preferably used in some machine tools for smooth motions without jerk and noise, self lubrication, flexible transmission system and stepless variation in speed and feed despite the limitations like larger space requirement, oil leakage, difficult maintenance etc.

The circuitry of a hydraulically driven (tool travel) drilling machine. The direction and length of travel of the drilling head fitted on the moving piston are controlled by movement of the spool of the direction control valve which is actuated by the pilot valve and governed by the electromechanical stop as indicated in the figure. The rate of travel of the drill head i.e., the feed rate is governed by the throttle or metre controlling valve which is again controlled by a template like cam and a follower coupled with the spool of the throttle valve. To keep feed rate constant irrespective of the working force on the piston, a pressure reducing valve is provided prior to the throttle valve. The pressure reducing valve helps keep its exit pressure i.e., input pressure of the throttle valve fixed to a preset value irrespective of the input pressure of the pressure reducing valve which varies with the working load on the drill piston. Constant pressure difference keeps constant fluid flow rate through the throttle valve resulting constant feed rate irrespective of the cutting force.




**Circuitry and kinematic system of hydraulically driven machine tool**

The cross feed is controlled, under fixed longitudinal feed, hydraulically. When the stylus moves in the transverse direction slightly (by say $\Delta x$) due to the or profile in the fixed template, the ports open enabling the high pressure fluid enter in the lower chamber. Since the piston is fixed, the sliding cylinder holding the cutting tool will start moving down. When the tool also retracts by $\Delta x$ the ports get closed. This way the incremental or discrete motion of the stylus is replicated by the tool tip resulting true copying of the profile from the template to the job.



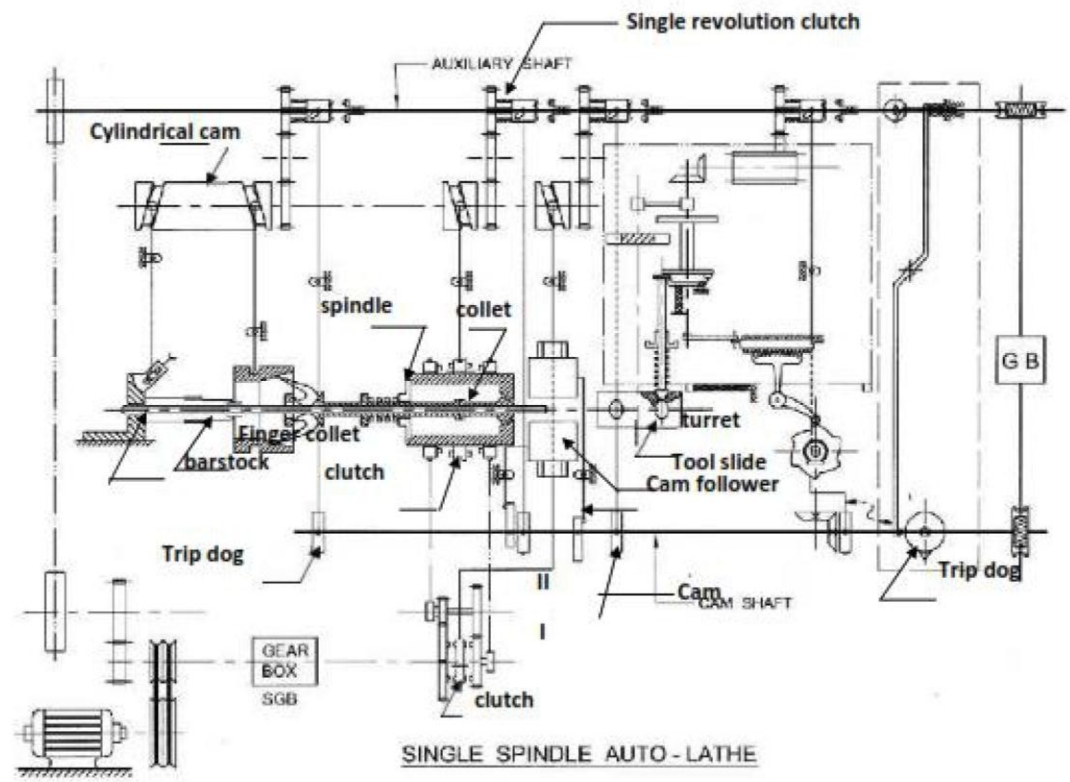
**Principle of hydraulic copy turning.**

- **Kinematic system and working principle of automatic lathes of common use.**

  - **Single spindle automatic lathe**

This general purpose and widely used automatic lathe is also known as single spindle automatic screw cutting lathe (ssASCL) because such lathes were introduced aiming mainly mass production of fasteners having screw threads. The major characteristic functions that are automatically accomplished in sequence and proper synchrony in such lathes are :

- Spindle speed change – magnitude and direction of rotation
- Bar feeding
- Transverse tools – feeding
- Turret indexing and travelling




**Typical kinematic system of single spindle automatic lathe.**

**Change of spindle speed**

Repetitive production in large volume and limted ranges of job – tool materials and job – diameter necessitate a small number of spindle speeds in automatic lathes unlike centre lathes. However, at least two speeds, high and low (for threading etc.) and provision of reversal of those speeds need to be provided in automatic lathes. Power and speed are transmitted from the motor to shaft. The two gear loosely mounted on shaft I are in mesh with two gears fixed on shaft II. Rotations are transmitted from shaft II to the spindle by two pairs of chain and sprockets as indicated in the kinematic diagram.The two sprockets are loosely mounted on the spindle and simultaneously rotate at the same speed, low or high, but in opposite directions. The spindle is made to rotate at high or low speed and clockwise or anticlockwise by engaging the clutches on shaft I and the spindle respectively. The clutch is shifted by a lever and cylindrical cam which is rotated at the desired moment by one revolution only with the help of a single revolution clutch which is again triggered by a trip dog controlled by the camshaft as shown in the figure.

**Bar feeding mechanism**

For feeding the bar stock to a desired projection length after completing machining and parting a job, first the collet is opened by withdrawing the push force by moving the taper ring outward by a lever automatically with the help of the cylindrical cam. Then the cam at the other end of the cylinder pushes the rod forward using the lever, a slide and finger collet. Next half of the rotation of that cylindrical cam accomplishes clamping collet and return of the finger collet by moving the levers in opposite direction.

Here again, the cylindrical cam is rotated by only one revolution by actuating another single revolution clutch at the proper moment by a trip dog as indicated in the figure.

**Transverse tool feeds**

The radially moving cutting tools (upto five) are fed sequentially at preset timings and desired length and rate of travel by individual cams mounted on the cam shaft which rotates slowly with one rotation for one machining cycle i.e., one product.

All the single revolution clutches are mounted on the auxiliary shaft which positively roates at a constant speed of 120 rpm. Rotation is transmitted from that to the cam shaft through speed reduction and a feed gear box (FGB) to vary the cam-shaft speed depending upon the cycle time for each job.

**Feed motions of the axially fed cutting tools mounted on the turret**

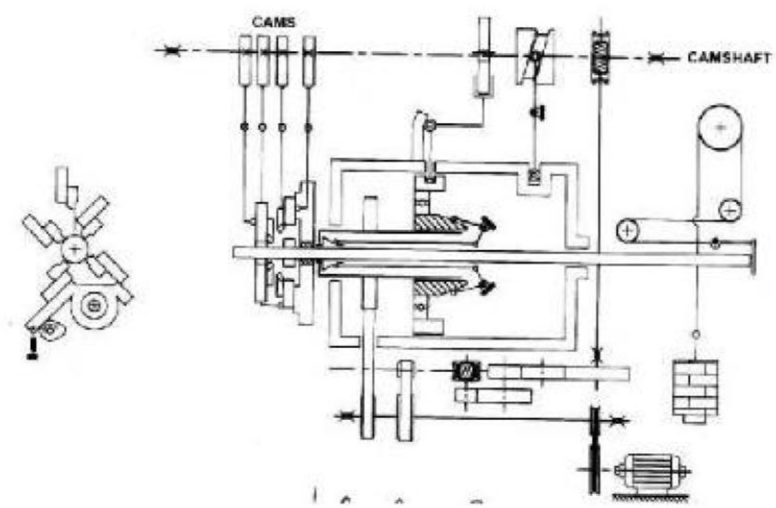
The end points, length and rate of travel of the six tools on the turret are governed by a single plate cam having six lobes corresponding to the tools in the turret as shown in the figure. The rotational speed of that cam is kept same as that of the cam shaft.

**Turret indexing mechanism**

The hexagonal turret is rotated (for indexing) by a Geneva mechanism where a Geneva disc having six radial slots is driven by a revolving pin. Before starting rotation, the locking pin is withdrawn by a cam lever mechanism shown in the diagram. The single rotation of the disc holding the indexing pin is derived from the auxiliary shaft with the help of another single revolution clutch as indicated

- **Kinematic system and operating principle of Swiss type automatic lathe**

Both the high speed of the spindle and the low speed of the cam shaft are derived from the motor as indicated in the diagram. All the cutting tools mounted on the transverse slides are travelled to desired depth and at desired feed rate by a set of plate cams mounted on the cam shaft. The headstock with the spindle having the barstock clamped in it is moved forward and returned at desired feed rate by a set of plate cams mounted on the camshaft as shown.



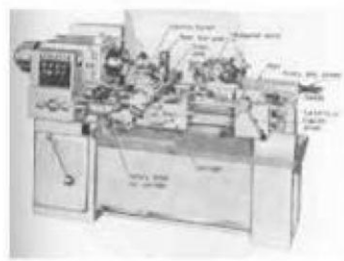

**Kinematic system of Swiss type automatic lathe.**

Feeding of the bar, after completion and parting of a job is done sequentially by

- Opening the collet by shifting the taper ring by a cam as shown
- Pushing the bar, against the last working tool, by a gravitational force
- Collet clamping by return of the ring

**Capstan and Turret lathes**

Capstan Lathe



Turret Lathe

The term "capstan lathe" overlaps in sense with the term "turret lathe" to a large extent. In many times and places, it has been understood to be synonymous with "turret lathe". In other times and places it has been held in technical contradistinction to "turret lathe", with the difference being in whether the turret's slide is fixed to the bed (ram-type turret) or slides on the bed's ways (saddle-type turret). The difference in terminology is mostly a matter of United Kingdom and Common wealth usage versus United States usage. American usage tends to call them all "turret lathes".

The word "capstan" could logically seem to refer to the turret itself, and to have been inspired by the nautical capstan. A lathe turret with tools mounted in it can very much resemble a nautical capstan full of handspikes. This interpretation would lead Americans to treat "capstan" as a synonym of "turret" and "capstan lathe" as a synonym of "turret lathe". However, the multi-spoked handles that the operator uses to advance the slide are also called capstans, and they themselves also resemble the nautical capstan.

No distinction between "turret lathe" and "capstan lathe" persists upon translation from English into other languages. Most translations involve the term "revolver", and serve to translate either of the English terms.

The words "turret" and "tower", the former being a diminutive of the latter, come ultimately from the Latin "turris", which means "tower", and the use of "turret" both to refer to lathe turrets and to refer to gun turrets seems certainly to have been inspired by its earlier connection to the turrets of fortified buildings and to siege towers. The history of the rook in chess is connected to the same history, with the French word for rook, tour, meaning "tower".

It is an interesting coincidence that the word "tour" in French can mean both "lathe" and "tower", with the first sense coming ultimately from Latin "tornus", "lathe", and the second sense coming ultimately from Latin "turris", "tower". "Tour revolver", "tour tourelle", and "tour tourelle revolver" are various ways to say "turret lathe" in French.

**Automatic**

During the 1870s through 1890s, the mechanically automated "automatic" turret lathe was developed and disseminated. These machines can execute many part-cutting cycles without human intervention. Thus the duties of the operator, which were already greatly reduced by the manual turret lathe, were even further reduced, and productivity increased. These machines use cams to automate the sliding and indexing of the turret and the opening and closing of the chuck. Thus, they execute the part-cutting cycle somewhat analogously to the way in which an elaborate cuckoo clock performs an automated theater show. Small- to medium-sized automatic turret lathes are usually called "screw machines" or "automatic screw machines", while larger ones are usually called "automatic chucking lathes", "automatic chuckers", or "chuckers".

**Semi-automatic**

Sometimes machines similar to those above, but with power feeds and automatic turret-indexing at the end of the return stroke, are called "semi-automatic turret lathes". This nomenclature distinction is blurry and not consistently observed. The term "turret lathe" encompasses them all. During the 1860s, when semi-automatic turret lathes were developed, they were sometimes called "automatic". What we today would call "automatics", that is, fully automatic machines, had not been developed yet. During that era both manual and semi-automatic turret lathes were sometimes called "screw machines", although we today reserve that term for fully automatic machines.