Safety in the Machine Shop

Machine shop safety can be divided into two areas of concern:

1. Protection against personal injury
2. Prevention of damage to tools, machines, and equipment

Personal Safety

Hot, sharp metal chips produced in cutting operations can burn and cut the worker. Grinding wheels can throw abrasive particles into unprotected eyes. Rotating tools and workpieces can catch loose clothing and hair. Workers who think safety and work safety can avoid hazards. They must dress properly, follow correct work procedures, and work harmoniously with fellow workers, Figure 1.

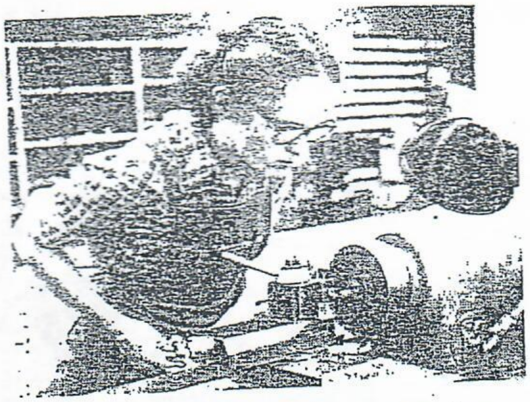


Figure 1: Worker in a machine shop

How to Dress Safely

1. For eye protection, wear clean proper goggles.
2. Wear close fitted clothing. Long sleeves should be close fitted. Wear a close fitting apron or shop coat to protect clothes.
3. Protect your feet by wearing proper shoes.
4. Always remove all jewelry before working with tools and equipment.
5. Confine long hair under a close fitting cap or tie it back securely.
6. Never wear gloves while operating machines.

Safe Work Practices

1. Before starting a machine, be sure that all its safety devices are in place.
2. Be sure that the workpiece and the cutting tool are mounted securely.
3. Keep your hands away from moving machinery and tools.
4. Handle materials carefully to avoid getting cut.
5. Avoid feeling the machined surface of the workpiece while the machine is running.
6. Never leave a machine while it is running.
7. Always stop the machine to perform an operation as measuring.
8. Never use your hand to stop a machine or a moving part.
9. If you want to change speed, wait until a complete stop of moving parts.

10. When working with another person on a machine, agree beforehand on who will operate the switches and controls.
11. Make it a habit to stop, look, and think in unfamiliar or possibly dangerous situations.
12. Always try to be alert, patient, and willing to help.
13. Ask for help in lifting and handling heavy weights. Remember to lift with your legs, not your back. (See Figure 2)

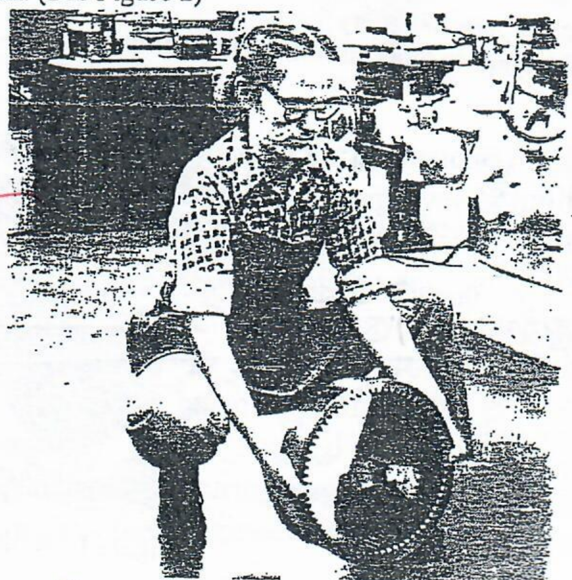


Figure 2: Lifting heavy objects

Safety with Hand Tools

1. Use the right tool for the job.
2. Keep hands and tools wiped clean and free of dirt, oil, and grease.
3. Keep tools sharp.
4. Carry sharp-edged tools with the edges or points down.
5. When handling a tool to another worker, be sure to offer its handle first.
6. The heads of chisels should be properly dressed.
7. Use the right wrench for the job.
8. Check for secure tool handle.
9. Do not use damaged tools

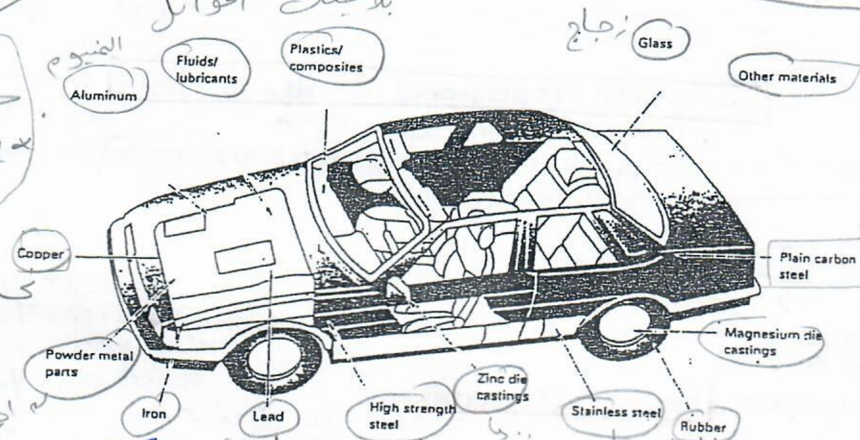
First Aid

1. Always notify the instructor immediately when injured.
2. Always get first aid treatment for cuts promptly.
3. Always treat burns promptly.
4. If you are concerned about either injury or an illness, get professional help as soon as possible.

Engineering Materials

The wealth of a community is measured by the variety and quantity of the articles it possesses for its use and consumption. All the material things we possess are made from substances, which in the first place are won from the earth, or from nature.

Engineers are concerned with the materials available to them. Consider the variety of materials used in the manufacturing of an automobile: Iron, steel, glass, plastics, rubber, and nickel.



The general classification of materials is shown below:

- Materials
  - Metals
    - Ferrous
      - steel
      - cast iron
    - Non ferrous
      - copper
      - aluminum
  - Non-metals
    - Natural Materials
      - glass
      - rubber
    - Synthetic Materials
      - thermoplastic
      - silicon

Pure metals: They are called elements, such as iron or copper. Pure state metals are not used very often.

Metal alloys: Combination of two or more metals or metals and nonmetals. Some of the common known alloys are:

- Bronze = Tin + Copper
- Steel or Cast iron = Iron + Carbon
- Steel: Up to 2% Carbon + Impurities (manganese, silicon, phosphorus).
- Cast iron: 2 to 2.5% Carbon + Impurities.
- Stainless steel: Iron + one or more of (chromium, nickel, tungsten, titanium)

Plastics: Hydrocarbons (paraffin's) linked together to form very large molecules.

Mechanical Properties of Metals and Alloys

When selecting a material, a primary concern of engineers is to assure that the *material properties* are consistent with the operating conditions of the component.

Material properties are classified as:

1. Mechanical properties
2. Physical properties (weight, density, electrical conductivity)

Some of the important **Mechanical Properties** are:

Strength: The ability to resist the application of force without rupture (N/m^2).

- Tension
- Compression
- Torsion
- Shear
- Bending

Elasticity: The power of returning to the original shape after deformation by force.

Ductility: The property of being deformed plastically under load without rupture.

Brittleness: The property of breaking without being plastically deformed.

Hardness: The resistance to indentation by harder bodies.

Toughness: The amount of energy a material can absorb before it fracture.

Production of Iron and Steel

Iron is the fourth most plentiful element in the earth and for centuries has been the most important of the basic engineering materials.

The raw materials required for the production of steel are:

- 2t Iron ore
- 1t Coke
- ½ t Limestone
- 3½ t Air

→ Blast Furnace → 1 t Pig iron

Iron Ores as: Fe_3O_4 (Magnetite), and Fe_2O_3 (Hematite)

Pig iron is converted to steel by taking out some of its impurities through one of the following processes:

1. Bessemer Process
2. Open Hearth Process
3. Electric Furnace Process
4. Basic Oxygen Process

Heat Treatment of Steel:

Heat treatment is a variety of heating and cooling operations by which the characteristics of metals are changed. Some of these operations are:

Annealing: To soften the steel for better machinability. To relieve internal stresses.

Normalizing: To refine the structure after forging, welding, casting, cold working.

Hardening: To harden the steel to resist wear. To enable the steel to cut other materials.

Tempering: To reduce brittleness and increase toughness.

Case hardening: To harden the outer surface.

Measurement

Measurement, the act of measuring or being measured, is the process of comparing the value to be measured with an accepted standard. Precision measurement is the key to producing interchangeable parts and mass production consumer goods

Basic Standard measurements:

- Length
- Angle
- Weight
- Time
- Temperature
- Optical or electrical standards

Commercial standards have the disadvantage that there is a limit to the accuracy with which the instrument can read. To insure accuracy, engineer must know the principles of measurement. They also must know how to use the common hand tools, measuring instruments, and gages.

Measuring instruments are *checked* and *calibrated* periodically to ensure their accuracy.

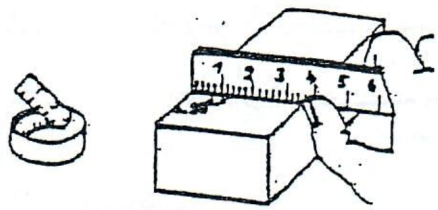
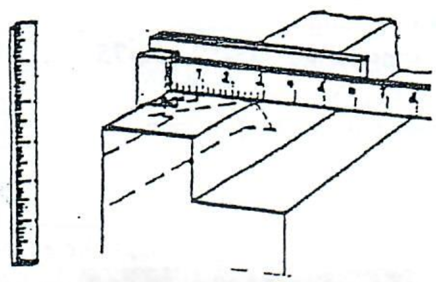
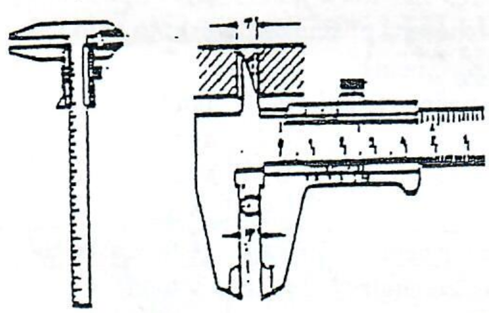
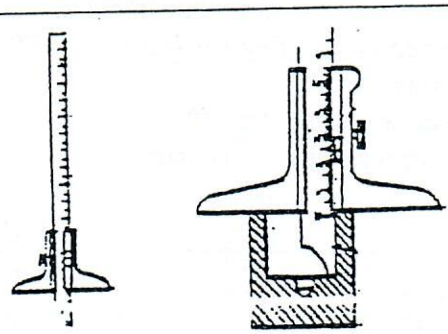
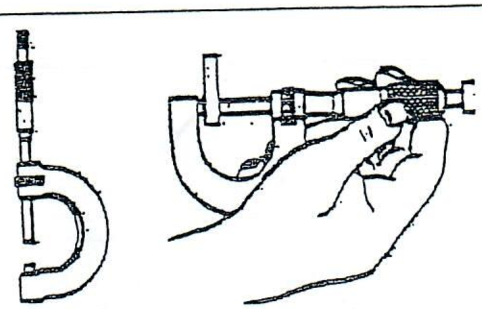
The accuracy of measurements depends on:

1. Least count of the subdivision on the instrument.
2. Line matching.
3. Parallax in reading the instrument.
4. Elastic deformation of the instrument and workpiece.
5. Temperature effect.
6. Operator skill

Types of Measuring Tools:

1. Gradual measuring tools (Figure 1).
2. Checking tools (Figure 2).

Figure 1: Graduated Measuring Tools

	Steel-tape rule. A flexible rule that when extended will support itself, but may also be used to measure curved or irregular surfaces. Measuring range: 2000 mm Reading accuracy: 1 mm
	Steel rule. A flexible rule used for taking linear measurements. Measuring range: 150, 300, 500, 1000 mm Reading accuracy: 0.5 mm
	Vernier caliper. A measuring tool for taking inside and outside measurements. The vernier caliper gives an end measurement. Measuring range: 100, 125, 150, 200, ... 2000 mm Reading accuracy: 0, 1, 0.05, 0.02 mm
	Vernier depth gauge. A tool used to measure the depth of blind holes, grooves, slots, and similar dimensions. Measuring range: 100, 125, 150, 200, ... 500 mm Reading accuracy: 0, 1, 0.05, 0.02 mm
	Micrometer caliper. A tool for taking outside measurements. The micrometer gives an end measurement. Measuring range: 0-25, 25-50, 50-75, ... 500-600 mm Reading accuracy: 0.01 mm

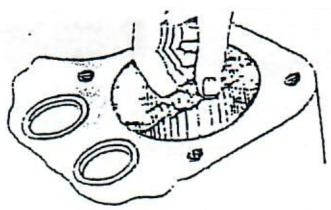
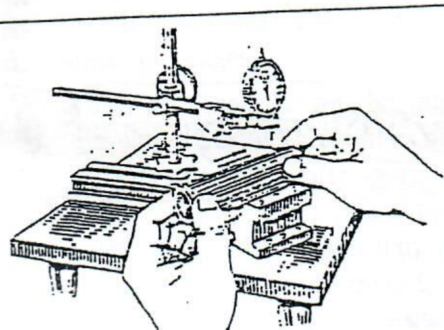
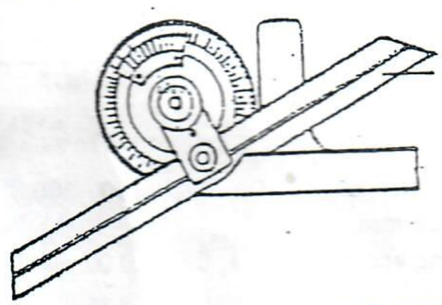
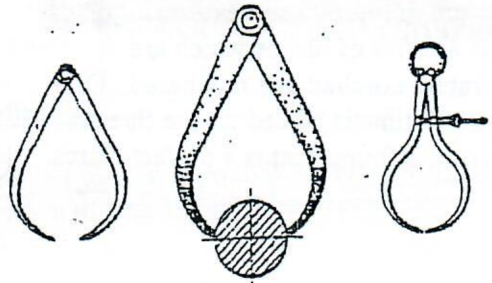
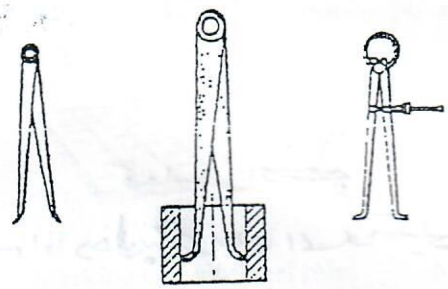
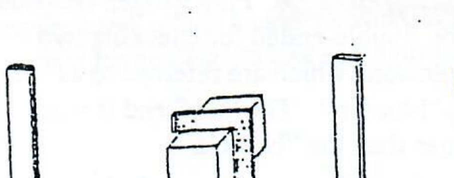
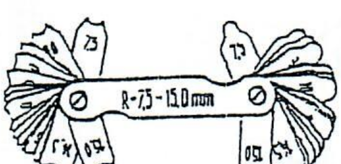
	Depth micrometer. A tool used to measure the depth of blind holes, grooves, slots, and similar dimensions. Measuring range: 0-75, 0-150, ... 0-300 mm Reading accuracy: 0.01 mm
	Inside micrometer. A tool used for taking internal measurements. A set of lengthening bars is used to increase the measuring range. Measuring range: 35-50, 50-75 ..... , 50-1450 mm Reading accuracy: 0.01 mm
	Dial indicator. A tool which is like a small clock, used to true and align machine tools, fixtures and work; to test and inspect size and trueness of finished work; to compare measurements. Measuring range: 0-50 mm to 0-2 mm Reading accuracy: 0.01 mm or 0.001 mm
	Vernier bevel protractor. A tool used to measure angles. The sliding blade is connected to a vernier scale, the main scale is divided up into degrees from 0 to 90 each way. Measuring range: 4x0-90 Reading accuracy: 5' (minutes)

Figure 2: Checking Tools:

	Outside caliper. A tool used in measuring outside diameters. When the tool has been adjusted properly, the diameter may be read from a rule or a vernier caliper.
	Inside caliper. A tool used in measuring inside diameters. The size of the opening is then read from a rule or a vernier caliper.
	Beveled straightedge. A tool used for testing the flatness of a surface. If the knife-edge is placed against a surface and then held up to the light, any small discrepancy can be detected by the appearance of light. A gap of 0,003 to 0,005 mm can be seen.
	Try square. A tool used for testing squareness. When using the square care should be taken to ensure that its blade is held perpendicular to the surface being tested.
	Radius gauge. A tool used for testing concave and convex corners. It consists of a set of steel blades that are shaped to curved surfaces of definite size. The size of the radius of the curve is stamped on each blade.

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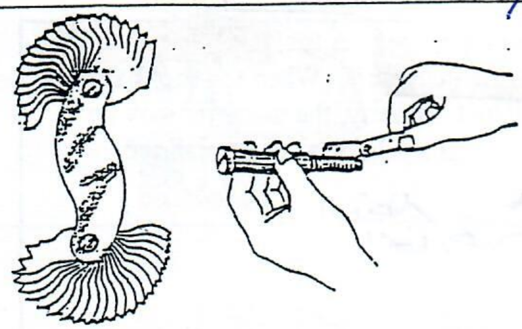
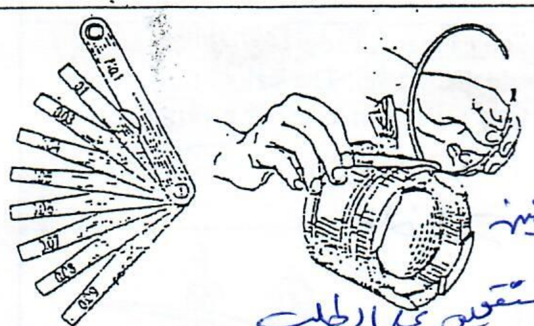
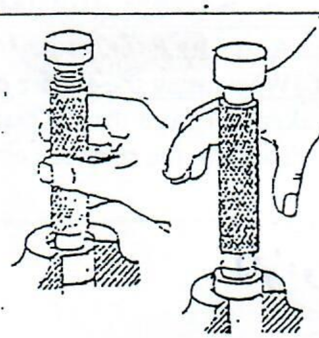
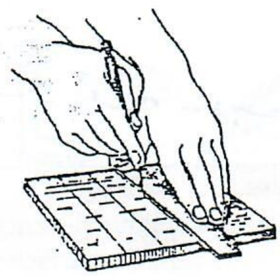
	Screw-pitch gauge. A tool used for testing the pitch of internal and external threads. It has a series of blades which are accurately notched and numbered. One blade at a time is placed on the threads until one is found that is a perfect match.
	Feeler gauge. A tool used for testing the space between two surfaces. It consists of a set of blades having thickness ranging from 0,05 to 1 mm. قياس المسافة بين سطحين
	Snap-gauge. A tool used for testing external dimensions. Snap gauges are usually made double-ended for checking two dimensions which are referred to as "Go" and "Not Go". قياس الابعاد
	Plug gauge. A tool used for testing the accuracy of holes. Plug gauges are usually made double-ended for checking two dimensions which are referred to as "Go" and "Not Go". The "Go" end is made longer than the "Not Go". للدقة للثقوب

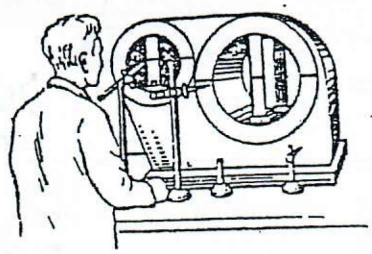
Marking Out

Definition:

Marking out (laying out) is the process of scribing lines on blanks which indicate the position of finished surfaces or center points.



Marking out with steel rule

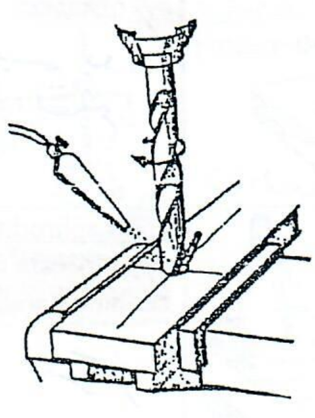


Marking out with surface gauge

Principles of Marking Out:

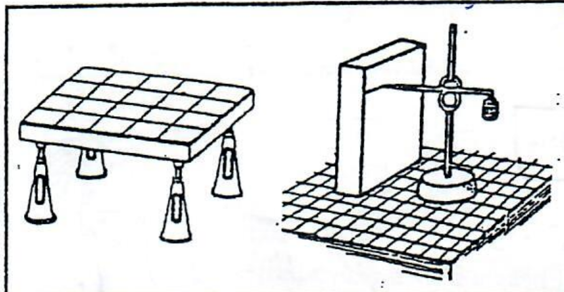
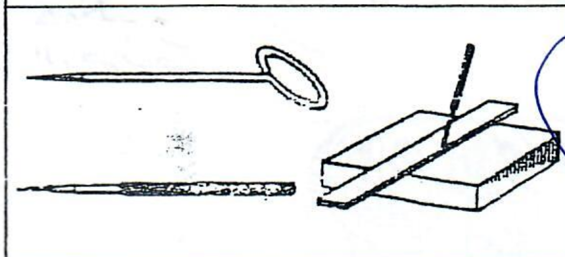
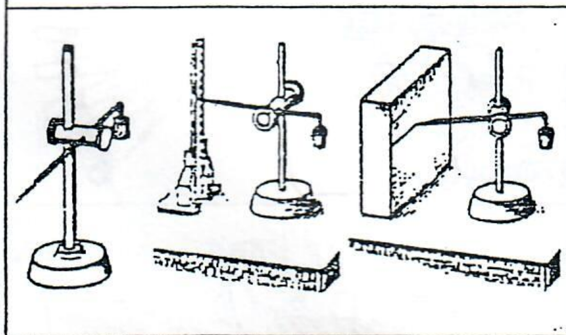
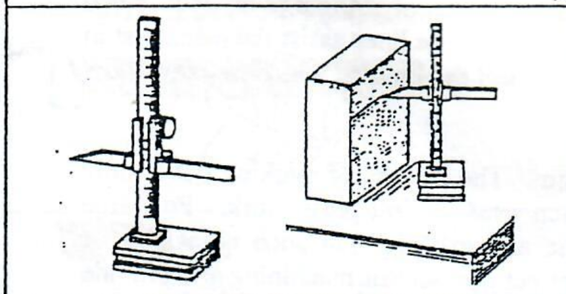
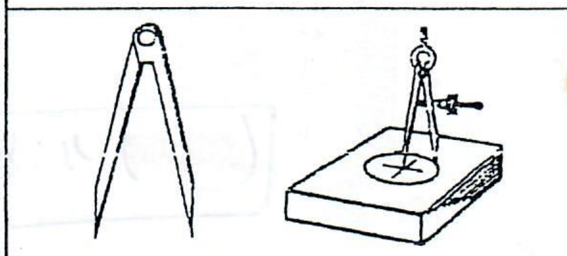
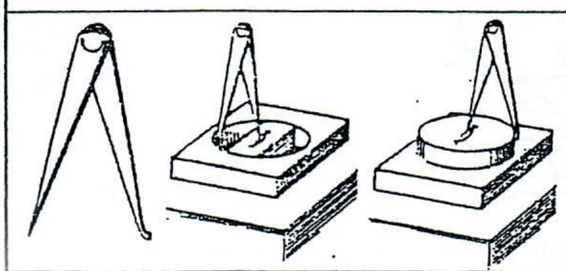
Marking out includes scribing of center points, circles, arcs or straight lines upon metal surfaces. The layout must be exactly like the drawing. These lines assist the machinist in setting up the work in his machine, and indicate to him the limit to which he may allow the cutting to proceed.

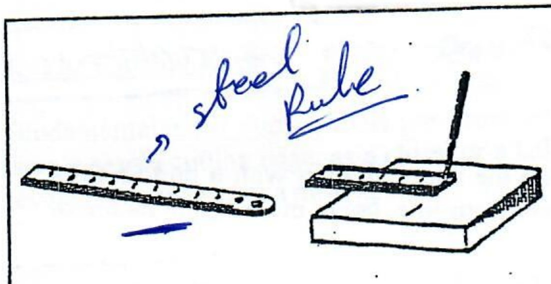
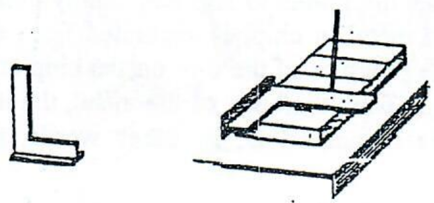
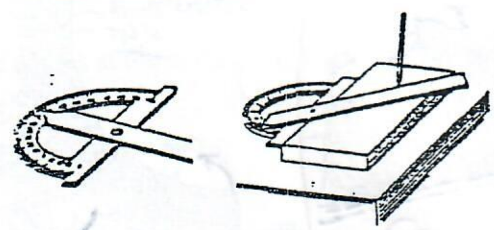
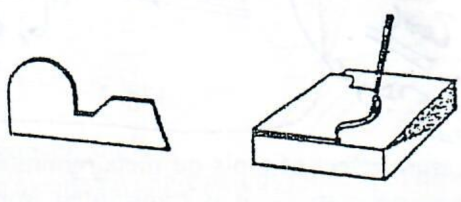
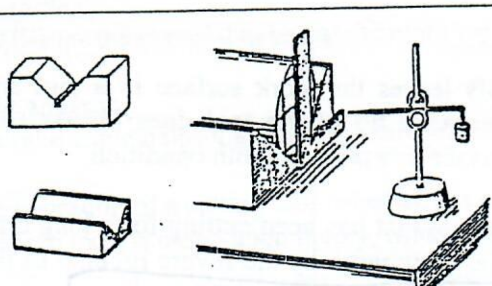
Marking out accuracy ranges from 0.25 to 0.5 mm. The process of marking out is only employed in single piece production. It is much used in drill-press work. For large quantities, marking out would be waste of time and expense. In such cases jigs or fixtures are used, which locate the work in the correct position for machining and provide some means for guiding the tool in the proper path.



Drilling according to layout

Equipment used for Marking Out:

	Surface Plate. A plate made of cast iron or granite, being considerably flat. Used as a base upon which to rest the work, gauges, and other tools when marking out.
	Scriber. A slender steel rod with hardened points, used to scribe lines on metal surfaces.
	Surface gauge. Used for scribing horizontal lines having a definite distance from the working surface of the surface plate.
	Height gauge. Used for scribing horizontal lines.
	Divider. Used for scribing circles or laying off distances.
	Hermaphrodite caliper. Used to locate approximate centers of work or for scribing parallel lines.

 	Steel rule. Used to take measurements and for scribing straight lines. مسطرة
	Try square. Used to test squareness and right angles and for scribing straight lines perpendicular to an edge of the work. للزاوية ٩٠
	Protractor. Used for laying out angles. منقلة
	Template. The template is pressed on the work and the outline is transferred to it by means of a scriber.
	V-Block. Used for supporting shafts and bushes. تحديد القطر وجعله بشكل (٧)

ممكن انك تحط الأداة على google حتى تفهمها

Forming of Metals by Removing Chips

1. The Cutting of Metal:

The usual conception of cutting suggests cleaving the material apart with a thin knife or wedge. When we cut metal, the action is different from this, being more in the nature of a tearing than a cutting process.

Metal is made up of many grains. Pressure of the wedging action of the cutting tool passes from grain to grain of the metal. This causes the grains to slip and finally break. When enough grains are thus fractured, a piece of metal, a chip, is separated from the workpiece and passes over the face of the tool. The pressure of the tool on the chip at A in the direction of the arrow (see Fig. 3) tears the chip from the body of the metal, the tear being continuous and taking place along the crack marked B. In other words, the compressed element of the chip is sheared.

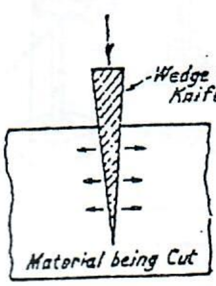


Fig. 1

Fig. 2

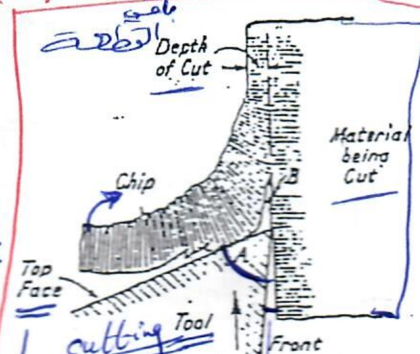


Fig. 3

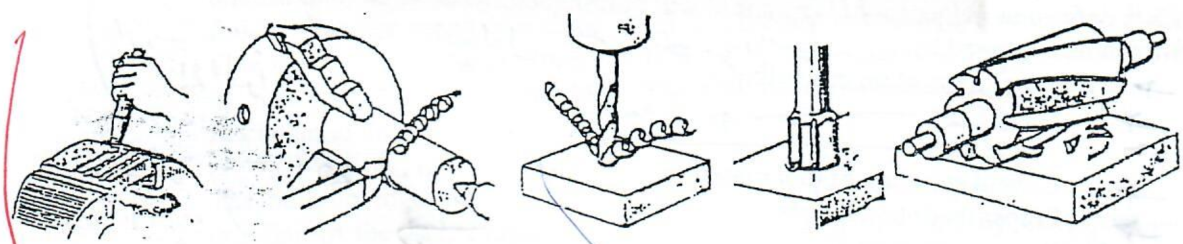
Fig. 1: cutting with a sharp edge, Fig. 2: the pressure effect of tools on metal grains is similar to that of pressure applied to one marble in a group - it is transmitted from marble to marble, Fig. 3 : cutting metal with a tool.

The tearing of the chip from the work naturally leaves the work surface in a torn and rough condition. It is at this point that the extreme tip of the tool does its work by trimming off the irregularities and leaving the surface in a fairly smooth condition.

A small cavity may be observed at point A of a tool that has been cutting for a long time without having been reground. The hard tool has been worn by the severe rubbing of the chip.

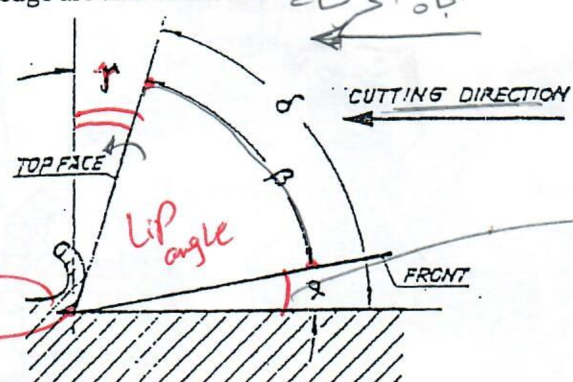
2. The Cutting Edge:

Fundamentally, all cutting tools are provided with a cutting edge. A cutting tool may have a single cutting edge, as a chisel or a lathe tool; two cutting edges as a twist drill; or several, as a reamer or a milling cutter.



Chisel Lathe tool Twist drill Reamer Milling cutter

The angles at the cutting edge are shown below.



Clearance angle α:
The clearance angle avoids rubbing of the tool on the work surface.

Lip angle β:
The harder the material to be cut the more the cutting edge must be supported.

Rake angle γ:
The rake angle helps that the tool peals off the chip instead of pushing it off.

The operation of a cutting tool, whether it is on a lathe, on a milling machine or any other machine tool, is based upon theory, which is the same for all processes.

Tool failure may result from the wearing away of the tool's cutting edge, which changes the geometry of the tool. This geometric change may be in the nature of a dull edge, roughness, or a shift in the clearance angles.

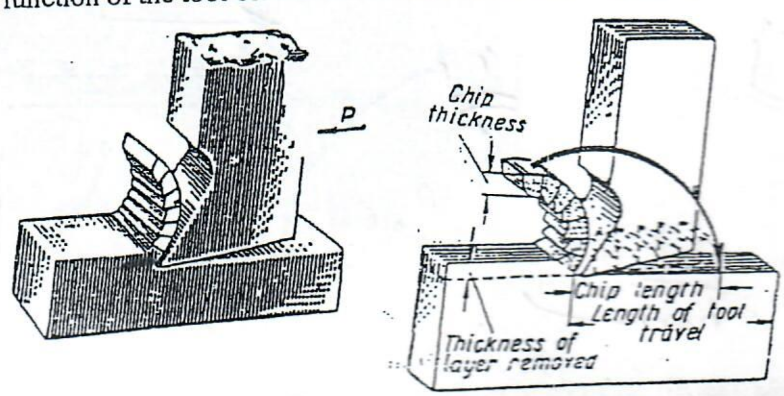
Changes in the tool geometry will generate heat, which may cause the tool to lose hardness and soften. If the relative motion of the tool to the work is too great, the rubbing action of the tool material against the work will create even higher temperatures. The process of softening and rubbing away continues until the tool fails. Another cause of tool failure results from the high stresses set up by the tool within the workpiece and within the resulting chip. The metal is said to work-harden, and as a result greater forces are needed to separate the chip from the parent metal.

Tool life is defined as the length of time a tool will operate before failure occurs.
Tool life can be increased by:

1) Proper lubrication or cooling
2) Sharp tools
3) Proper angles
4) Careful selection of tool materials
5) Proper feeds and speeds
6) Proper setting-up of the tool relative to the work

3. Chip formation:

Chip formation is a function of the tool bit and the nature of the material being cut.



Chip types:

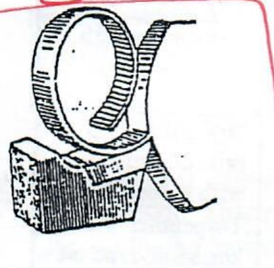
1. Continuous Chip: When ductile metals, such as lead, tin, copper, soft steel, aluminum, etc., are machined, the separate elements of the chip are bonded firmly together and form an uninterrupted chip that curls into a coil.

2. Sheared Chip: If less ductile metals such as hard steel are machined, the chip will consist of separate elements weakly bonded together.

3. Discontinuous Chip: If the metal to be machined is brittle such as cast iron or bronze, the elements of the chip will break off and will be separate from each other.

4. **Build-up Edge Chip:** The high heat generated during cutting welds a small chip to the tool. As the weld builds up, the welded chip grows and finally breaks away from the tool. A built-up edge is useful in roughing, as the cutting edge is heated less and its wear is reduced. For finishing operations a built-up edge is undesirable, since it distorts the shape of the cutting edge and effects poor surface finish. Another result of welded chips is cratering in the face of the tool. Each time the chip breaks away from the face of the tool, it takes a very small amount of material off the face of the tool. The accumulated effect of many such actions is a crater in the face of the tool.

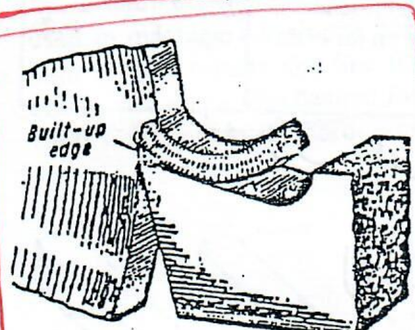
The built-up edge may be reduced by increasing the rake angle, by high quality grinding of the tool, by employing a suitable cutting fluid and by increasing the cutting-speed.



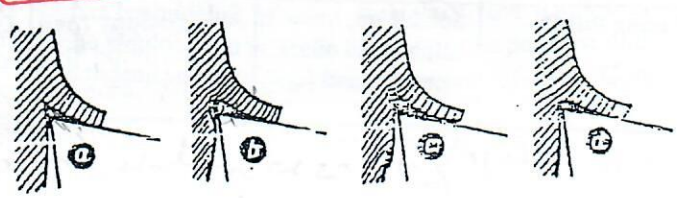
Continuous chip

Sheared chip

Discontinuous chip



Built-up edge



Built-up edge: a = material welded on tool, b = growing of welded material, c = breaking away of particles, welded on chip and work, d = growing of welded material.

4. Cutting Fluids and Coolants:

From the above discussion it can be seen that the friction must be kept as low as possible to reduce the heat generated. Using lubricants that form an oily film on the surface of the metal and thus make the shearing of the metal easier can reduce heat. This is the primary purpose of a lubricant. It may be a fatty oil, mineral oil, or sulfurized mineral.

Its secondary effect is to remove heat generated during the cutting operation.

Where the cutting operation is severe and the lubricant cannot remove the heat rapidly enough, there are water-soluble oils used. When mixed with a high concentration of water, the cooling effect is greatly increased with some lubricating properties retained. These mixtures do not corrode the steel parts with which they come into contact.

Thus, lubricating oils are used chiefly to reduce friction and water-soluble oils are used chiefly as coolants

Selection of Cutting Fluids for Various Types of Lathe Work

Type of lathe work	Material to be machined			
	carbon steel	alloy steel	grey cast iron and brass	aluminum and its alloys
Turning external surfaces	Soluble oil, sulphurised oil	Sulphurised soluble oil, sulphurised oil, mixed oils	Dry, soluble oil, kerosene	Dry, kerosene
Boring	Soluble oil, sulphurised oil, rape oil	Soluble oil, mixed oils, linseed oil	Dry, rape oil	Turpentine with kerosene (4:5)
Drilling and enlarging holes	Soluble oil	Soluble oil, mixed oils, linseed oil	Dry, soluble oil, kerosene	Dry, soluble oil, rape oil, mixed with kerosene
Reaming	Soluble oil, sulphurised oil, vegetable oils	Soluble oil; mixed oils, linseed oil	Dry, rape oil	Turpentine with kerosene, rape oil
Cutting thread	Soluble oil, sulphurised oil. vegetable and mixed oils	Sulphurised and plain soluble oil. rape or linseed oil	Dry, kerosene (rape on for brass)	Dry, kerosene, rape oil

5. Tool Bit Materials:

The materials used for tool bits must possess the following properties:
1) hardness, 2) strength, 3) toughness, 4) heat resistant.

High-carbon tool steel: tools are used for small-quantity production of wood parts or machining soft materials such as free cutting steels and brass. It is important that the operational temperatures be kept below 200° to 250°C. This type of material loses its hardness above this temperature. For this reason coolants should be used freely.

High-speed steel: contains tungsten, chromium and vanadium. The most common type has 18% tungsten, 4% chromium, and 1% vanadium. Other alloying elements are cobalt and molybdenum. The main property of high-speed steel is its "red hardness", i.e. its ability to retain its cutting properties without decreasing the tool life when heated even to 600°C as a result of high cutting speeds.

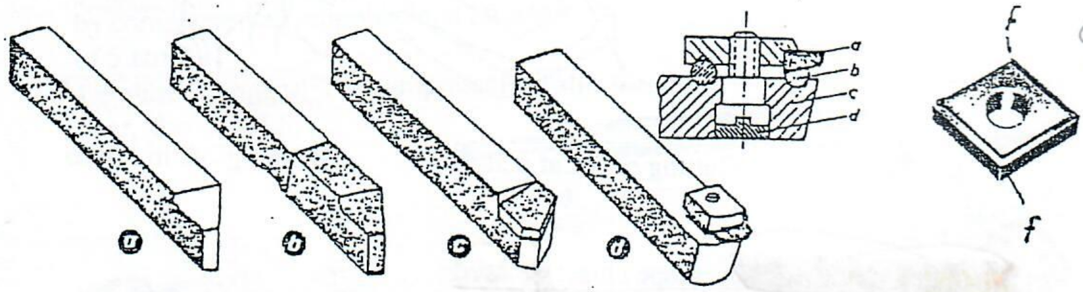
Cemented carbides: are manufactured in the form of tips from a mixture of tungsten and titanium carbides with cobalt. Tungsten and titanium carbides have a very high hardness and heat resistance.

Cemented-carbide tips are brazed to the tool shank and are the cutting element of the tool. The main advantages of cemented carbides are their excellent resistance to wear from the chip and the retention of their cutting qualities at temperatures of 900° to 1000°C. Due to these properties, tools tipped with cemented carbides are suitable for machining the very hardest metals and nonmetallic materials, such as glass, porcelain, and plastics, at speeds from 4 to 6 times higher than possible with high-speed steel tools.

The disadvantage of cemented carbides is their brittleness.

Ceramic tool materials: namely aluminum oxide or silicon carbide, are mixed with a glass binder. This mixture is hard and brittle and will withstand temperatures of 1200°C without losing hardness or strength.

Industrial diamonds: have limited use in present-day machining of metals. They may be used to machine aluminum, plastics, hard rubber, and, if used with very fine feeds and high spindle speeds, for fine finishing of bored holes in steel. They are expensive and difficult to shape into desired forms. Diamonds will withstand temperatures of 1600°C to 1800°C without losing hardness or strength.



a = cutting tool made entirely of tool steel or high-speed steel, b = high-speed cutting tool welded to a shaft of structural steel, c = tip made of high-speed steel, welded, or made of cemented carbide, brazed, d = diamond tip with holder (a = diamond, b = support, c = holder, d = seal), f = cutting edges of a tool tip made of ceramic tool material (these tips are clamped in holders similar to those used for diamonds).

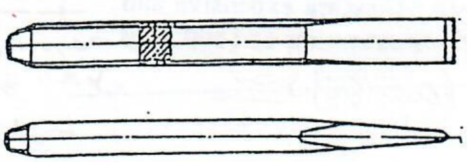
CHIPPING

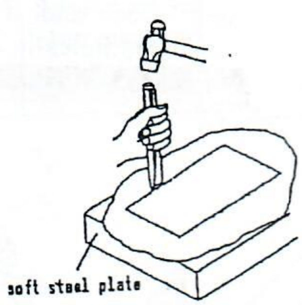
(CHISELING)

THE PURPOSE OF CHIPPING IS TO SHEAR OFF WORK PIECES OR TO ROUGHLY REMOVE EXCESSIVE MATERIAL

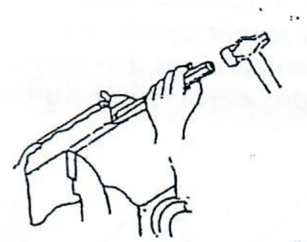
1. THE MAIN TYPES OF CHISELS

1. FLAT CHISEL is used for cutting sheet and plate material and for surfacing work.



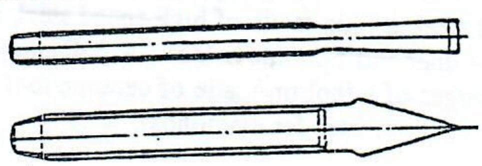


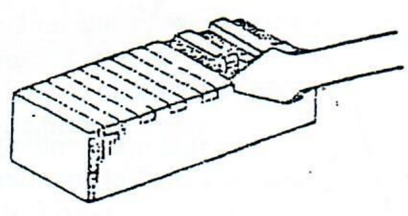
Cutting on a flat plate



Shearing-off in a vice

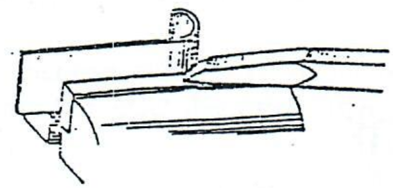
2. *CROSS-CUT CHISEL* (cape chisel) is used for cutting keyways, slots and grooves. The cutting edge is slightly wider than the body; this is to ensure that the chisel does not bind in the cut.





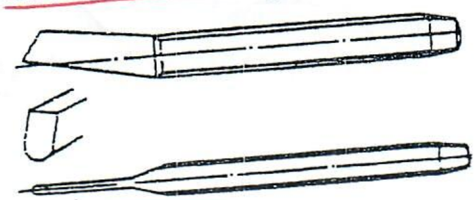
Chipping grooves

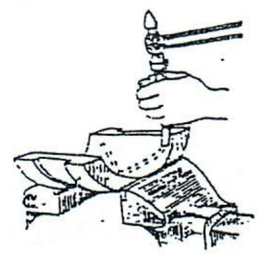
3. ***SHEAR CHISEL*** is used for shearing thin sheet metal.



Shearing-off a strip of sheet metal

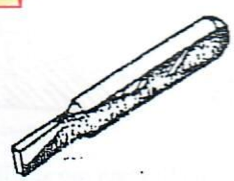
4. ***HALF-ROUND CHISEL*** is used for forming flutes and oil channels in bearings or pulley bushes. Also used for "drawing" a hole into correct position when it has been set out inaccurately in drilling.



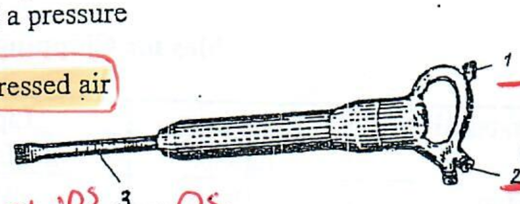


Chipping an oil groove

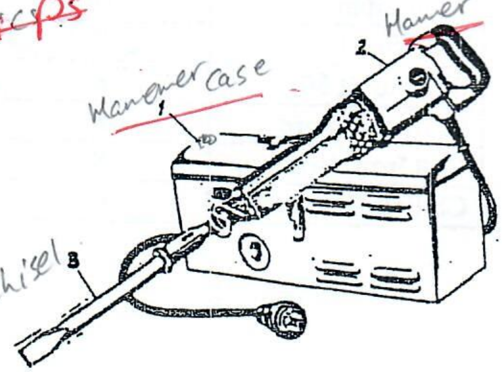
5. ***FILLET CHISEL*** (backing-out chisel) is used for cutting out predrilled slots.



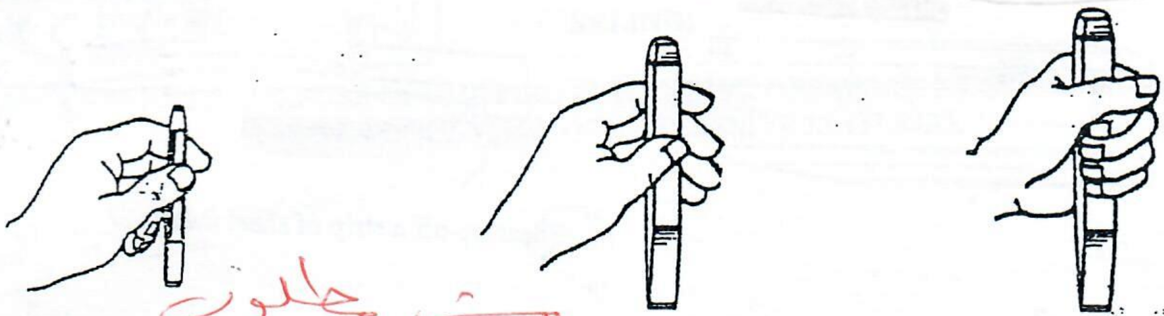
6. ***PNEUMATIC HAMMER*** is operated by compressed air, supplied at a pressure of 5 atm.
1 = starting trigger, 2 = compressed air inlet, 3 = chisel.



7. ***ELECTRIC HAMMER*** is operated by electric current.
1 = hammer case with switch box,
2 = hammer, 3 = chisel
1000 to 5000 blows per minute.

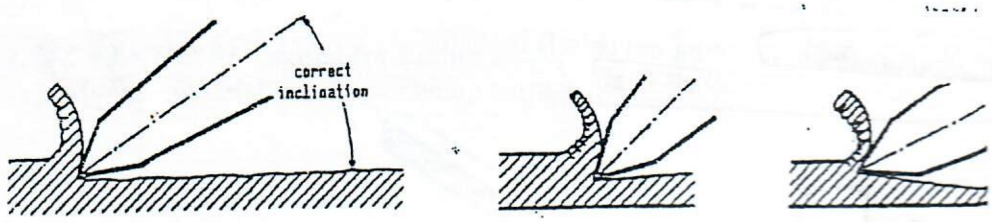


2. HOLDING THE CHISEL : Depending on its size the chisel is held with:



2 fingers small chisel	5 fingers medium chisel	whole hand large chisel

3. PROCESS OF CHIPPING



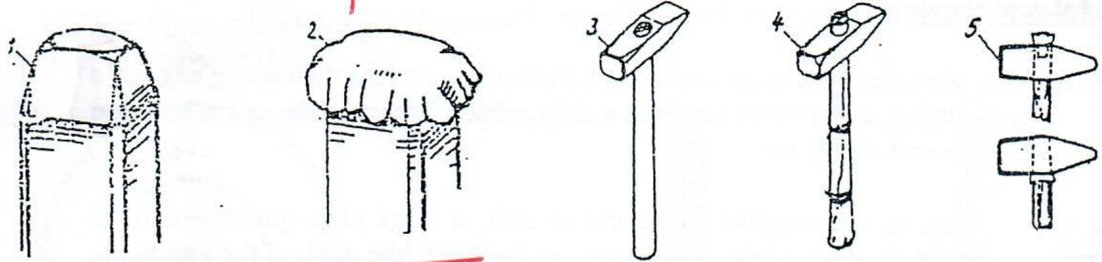
correct inclination of the chisel gives equal chip thickness.	inclination too small, the chisel penetrates too deep into the material.	inclination too great, the chisel will slide off the work piece.

Tables for Chipping

Material	Clearance angle α	Lip angle β	Rake angle γ
Aluminum	10	≈ 40	40
Mild Steel	8	≈ 55	27
St 33 to St 50	8	≈ 60	22
St 70 and more	8	≈ 70	12
Cast Iron, Brass	8	≈ 72	10
Chilled Cast Iron	6	≈ 80	4

Safety Rules in Chipping:

1) Never use a chisel with a "mushroom head". Always grind the end back of the head so that the mushroom disappears.
2) When chipping, always wear goggles. If there are other men close by see that they wear goggles or that a shield is attached to your vise to protect them from flying chips.
3) Use a hammer that is heavy enough for the job. Make sure that the hammer handle is tight. Keep the hammer and the head of the chisel clean and free from grease or oil to prevent the hammer from slipping.
4) If the work is held in a vise, always chip toward the solid jaw of the vise. Never chip toward the movable jaw. Where possible, avoid chipping parallel with the jaws.

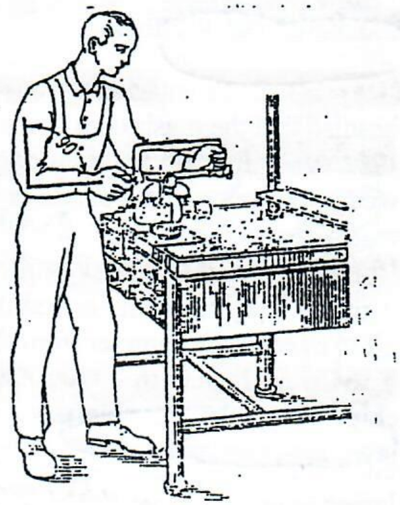


1 = correctly ground chisel head, 2 = mushroom head, 3 = hammer handle and hammer head in proper working condition, 4 = very dangerous hammer, 5 = poor practice of fastening hammer heads.

Sawing

Definition:

Sawing is a chip removing process used for separating materials by cutting a narrow groove by means of a saw.

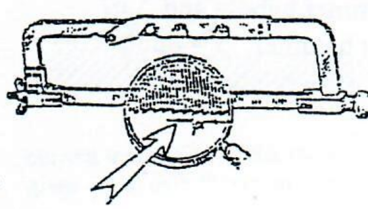


Sawing with hacksaw

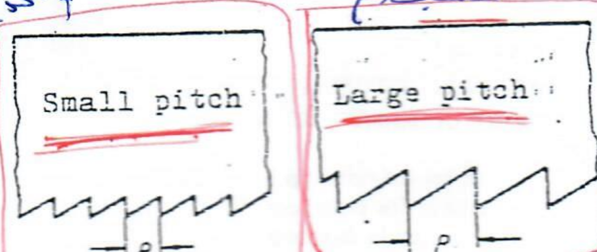
Principles of Sawing:

A saw blade is provided with many teeth, each of them being like the cutting edge of a chisel. When cutting, every tooth removes a chip, which is kept in the space between the teeth until the end of the cut.

If the cut is long, or the material to be cut is soft, a large chip quantity will be removed. To avoid clogging of the space between the teeth, the pitch of the saw blade must be large enough.

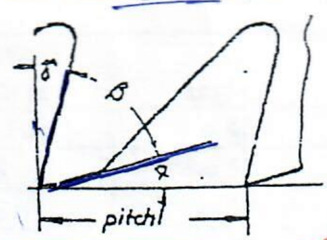


Hacksaw, p = pitch



The angles of a saw-blade tooth, used for cutting metals, are:

Clearance angle $\alpha = 30°$
Lip angle $\beta = 60°$
Cutting angle $\delta = 90°$
Rake angle $\gamma = 0°$

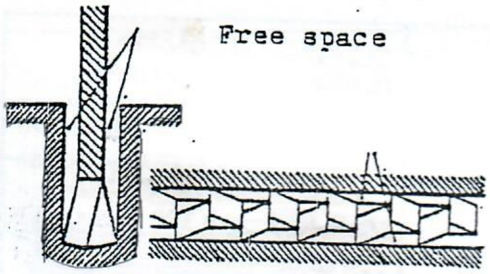


The comparatively large clearance angle α is necessary to make the space between the teeth large enough for the chips. By adding much rake the tooth would become too weak for cutting metals.

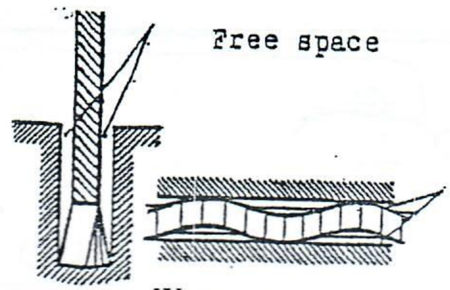
Saw blades used for cutting wood and circular saw blades are provided with a larger pitch. Clearance angles are from 5° to 15°, rake angles from 5° to 25°.

The teeth are "set" so as to make a cut wider than the saw blade and so prevent binding or sticking of the blade in the cut or kerf.

The set is obtained by having alternate teeth bent slightly outward, or by the blade being curved to a wavy form near the cutting edge.

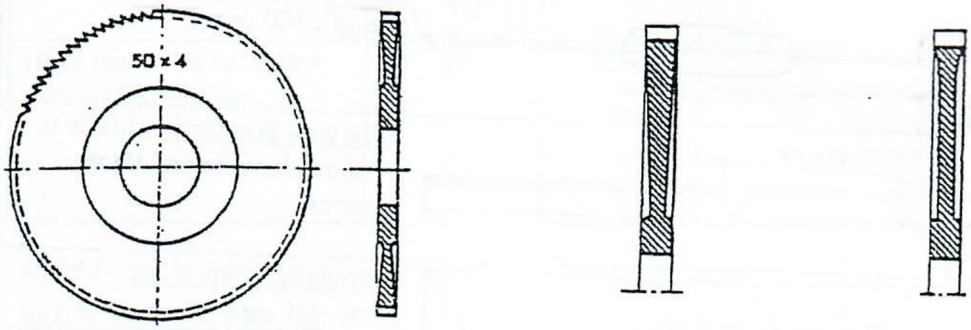


Alternate set



Wavy set

For circular saw blades a set is obtained either by alternate setting or by grinding the teeth to a tapered shape.



Circular saw blade

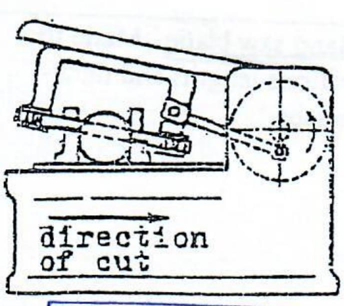
Tapered shape

Concave shape

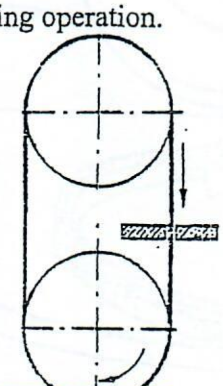
Sawing is used for cutting blanks to rough length, for making thin cuts preparatory to other chipping, filing or machining operations, and for cutting slots and grooves.

Sawing may be classified as hand sawing and power sawing. In hand sawing there is a reciprocating movement, the backward stroke being an idle stroke.

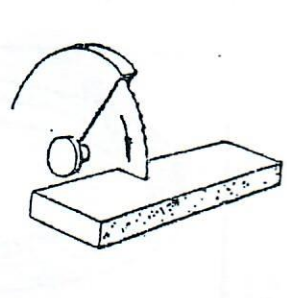
In power sawing, the power hacksaw is operated with a reciprocating movement too. A circular saw performs a circular motion and a band saw a straight lined motion, both of them yielding a continuous cutting operation.



Power hacksaw



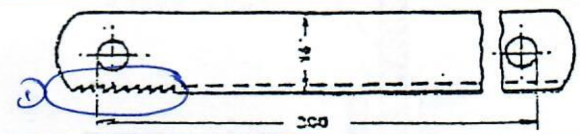
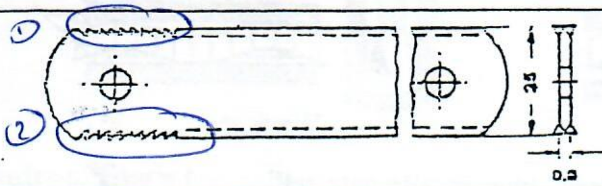
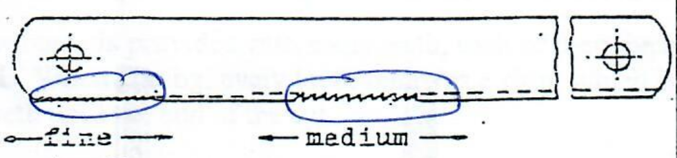
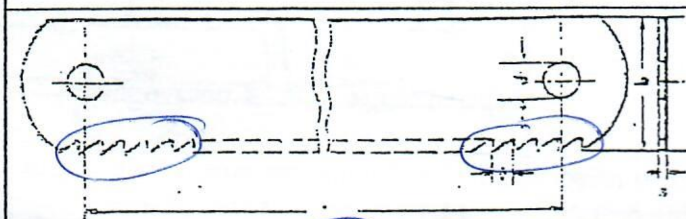
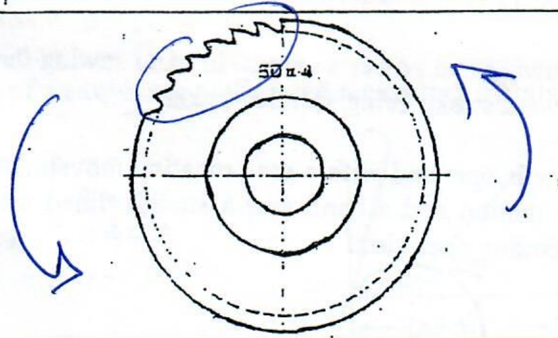
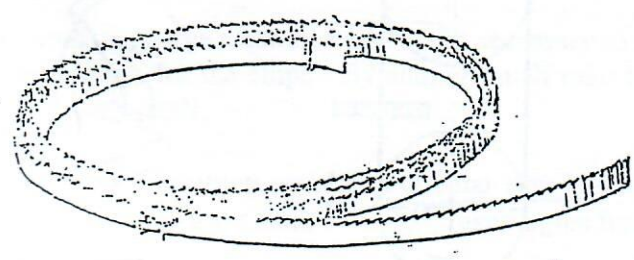
Band saw



Circular saw

Sawing Tools:

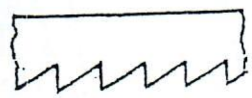
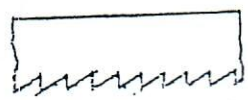
Saw blades are made of plain carbon tool steel or alloy tool steel. There are two types of saw blades, the all-hard and the flexible. All hard blades are hardened throughout, whereas only the teeth of the flexible blades are hardened.

	Hacksaw blade. One side toothed, length 300 mm.
	Hacksaw blade. Both sides toothed, length 300 mm and 350 mm.
	Hacksaw blade. With fine pitch at the starting end, length 300 mm.
	Piercing saw blade. Made to various lengths and thicknesses.
	Powerhacksaw blade. Length 300-710 mm. Thickness 0.8 - 2.5 mm.
	Circular saw blade. Diameter 20-315 mm. Thickness 2-6 mm.
	Band saw blade. Made to various lengths and thicknesses.

Tables for Sawing:

Hacksaw blades are made with a different number of teeth, from 14 to 32 teeth per 25 mm.

The harder the material, the finer the tooth-pitch.

	teeth/25 mm	pitch	
Soft materials aluminum, copper, plastics	16	coarse	
Medium hard materials steel	22	medium	
Hard materials tool steel, thin walled objects	32	fine	

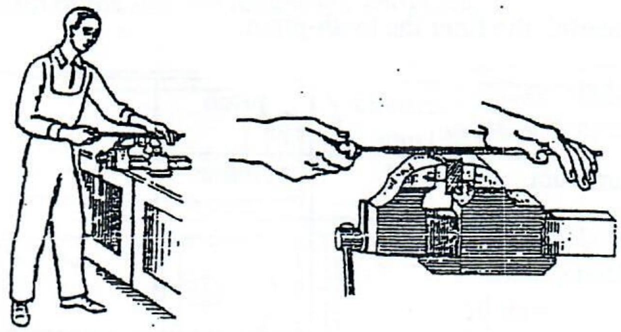
Safety Rules in Sawing:

1. Secure the saw blades firmly and properly.
2. Secure the work in a vice, or with clamps.
3. Never use a hacksaw with cracked handle or one without handle.
4. At the end of a cut reduce the pressure on the hacksaw and support the piece being cut off so as not to allow it to fall on your feet.
5. Don't blow out the chips of the cut. They may get into your eyes.

Filing

Definition:

Filing is the process of removing a layer of metal from the surface of a workpiece by means of a file.



Filing

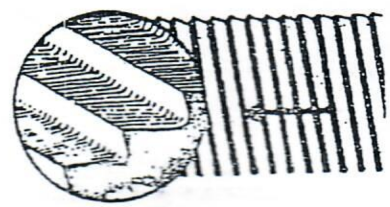
Principles of Filing:

A file is a piece of high-carbon tool steel having teeth cut upon its body.

A ***single-cut file*** has a single series of cuts across its face. Single-cut files can be used for taking cuts as wide as the length of the file cut.

Single-cut file

Angle of cut

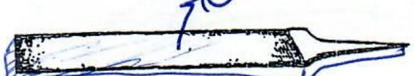


Enlarged view

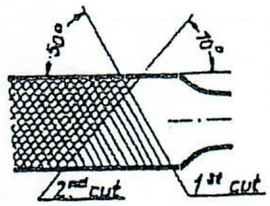
They are used in filing soft metals which offer little resistance to cutting (brass, zinc, babbitt, lead, aluminum, bronze, copper, etc.). These files are also used in sharpening of saws as well as in working on wood or cork.

Single-cut files have their cuts made at an angle of 70°-80° with respect to the file axis.

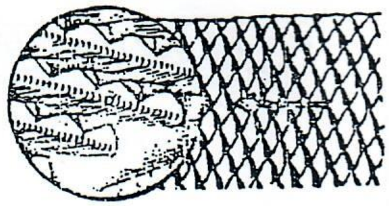
A ***double-cut file*** has two courses of cuts crossing each other. The second cut divides the long cutting edges made by the first cut into many small cutting edges, each of them removing only a small chip.



Double-cut file



Angle of cut

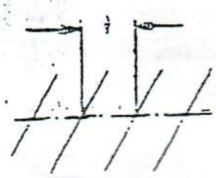


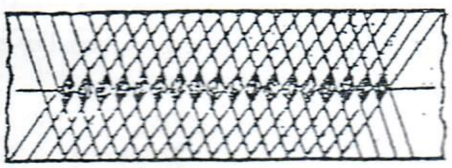
Enlarged view

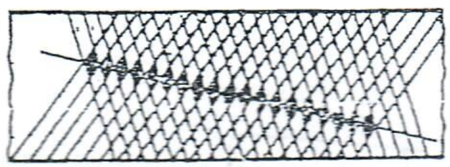
Double-cut files are used in filing of hard metals (steel, cast iron) which offer considerable resistance to cutting. To work these metals with single-cut files would require much force, therefore double-cut files are used which remove short chips.

Double-cut files have their first cut made at an angle of 50° and their second cut at an angle of 70°.

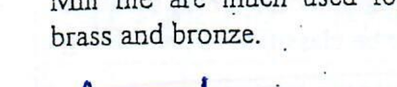
The spacing of the first cut and the second cut is made different to avoid having the file teeth one behind the other in direction of the file axis. Such a row of teeth would scratch deep grooves on the work surface.

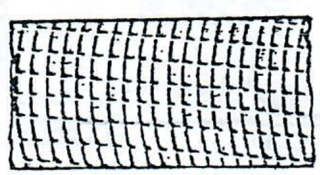

Spacing


Equal spacing


Different spacing

A *mill file* also called vixen file, has large cutting edges made by milling. The cutting edge is usually curved and is provided with a rake angle. Chip breaking flutes separate the cutting edge into smaller parts. The chisel teeth give a smoother finish than the pointed teeth of a double-cut file.


Mill file

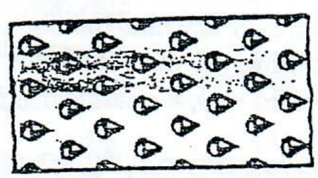

Chip breaking flutes

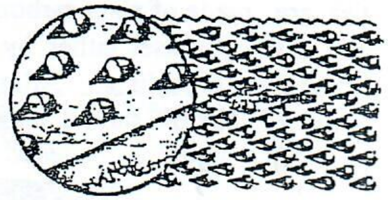

Enlarged view

Mill file are much used for drawfiling, and the bastard cut is fairly efficient for filing brass and bronze.

A *rasp file* has isolated projections and recesses which form relatively coarse and widely-spaced teeth shaped like pyramids.


Rasp file

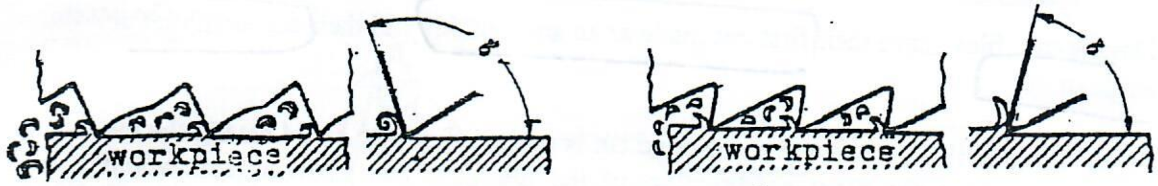

Rasp cut


Enlarged view

Such files are used in filing of babbitt, lead, zinc, leather, wood, rubber, etc. Soft materials would clog up the teeth of single cut files and stop further cutting action.

File geometry:

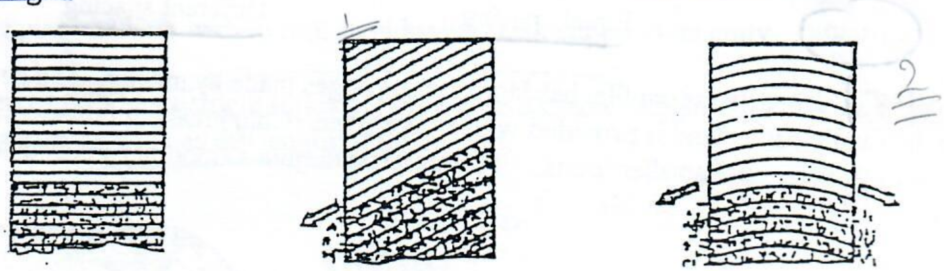
The geometry of file teeth depends on the method of production. File teeth cut with a chisel are different from those being milled by means of a milling cutter.



cut file scraping milled file cutting

A cut file tooth scrapes, the lip angle is large and cut files are therefore used for filing hard materials. A milled file tooth cuts, the lip angle is smaller and milled files are therefore used for filing soft materials or for finishing work

Chip escape is obtained either by inclining the cutting edge or by milling a curved cutting edge.



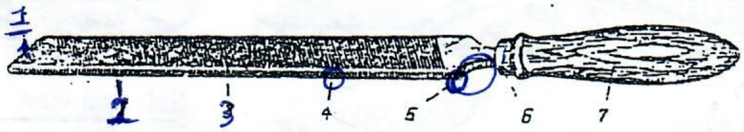
No chip escape Inclined cutting edge Curved cutting edge

Process Accuracy:

The accuracy of metal filing ranges from 0.1 mm to 0.01 mm. When fitting machine parts together there are occasions when a slight reduction in size is required, and the use of a machine tool is impracticable. In such cases the file is most useful. Further, in many classes of work such as diemaking, experimental work, and model work, surfaces must be finished and parts fashioned by filing. Filing may be classified as hand filing and machine filing.

Filing Tools:

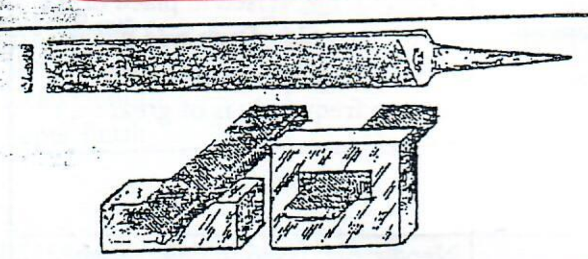
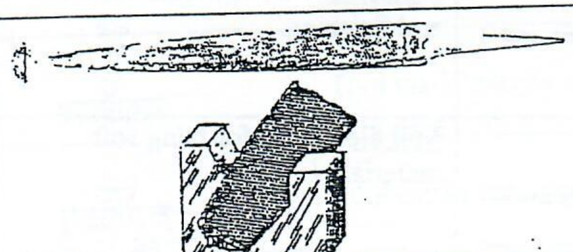
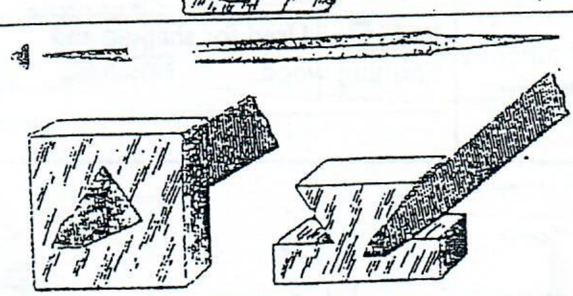
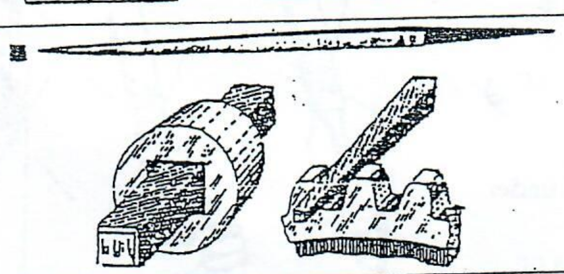
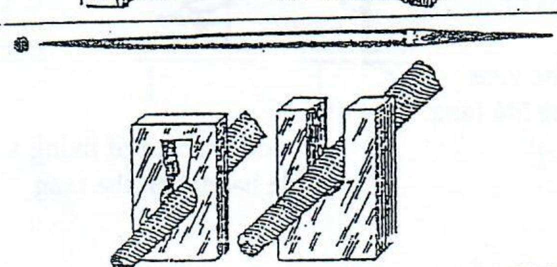
Files are made of plain carbon tool steel or alloy tool steel. The teeth on a file are cut with a sharp chisel either by hand or machine methods. Other methods are milling, grinding or broaching. After cutting of the teeth, the file is hardened and the tang tempered. The file should be provided with a suitable handle properly fitted.

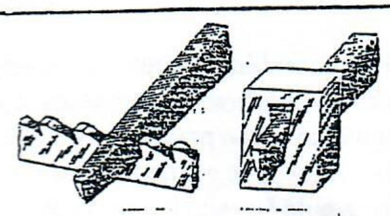
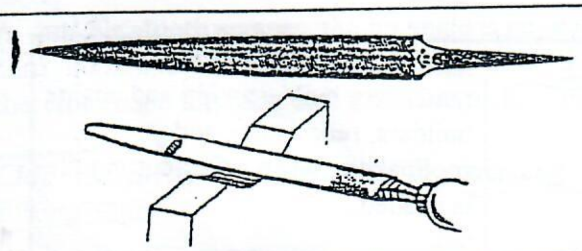


File: 1 = tip, 2 = edge, 3 = face, 4 = cutting edge, 5 = tang, 6 = ferrule, 7 = handle.

Most files are made with one or two faces slightly convex lengthwise. There are good reasons for this. If when filing a broad surface all the teeth were in contact, it would require too much pressure to make it cut; this would mean practically double work and also make it more difficult to control the file. If the face of the file were straight, to produce a flat surface every part of the stroke would have to be perfectly straight. This is impossible.

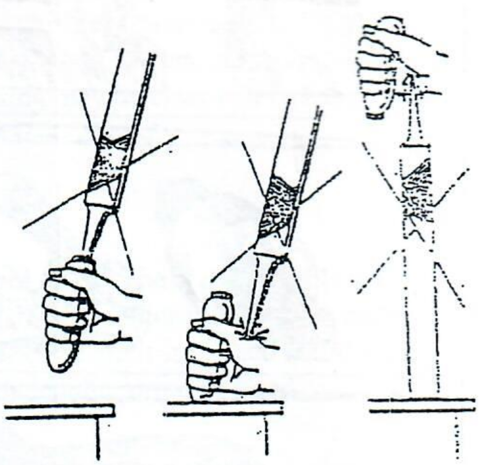
The safe edge of a flat file is the one on which no teeth have been cut (or where the teeth have been ground off). This edge keeps one side of a piece of work safe while filing an adjacent surface. As a matter of fact a sharper corner may be obtained with such a file.

	Flat file. Used by machinists, machinery builders, ship and engine builders, repair men, and toolmakers, when a fast-cutting file is needed.
	Half-round file. Used for filing concave surfaces as well as flat surfaces. The half-round file is one of the most useful files.
	Three-square file. Used for finishing surfaces that meet at less than a right angle, for clearing out square corners, for filing taps, cutters in backing off. Three-square files are also used for sharpening saws, either by hand or held in a machine.
	Square file. Used for filing small square or rectangular holes, for finishing the bottom of narrow slots. etc.
	Round file. Used for enlarging round holes, for rounding irregular holes, and for finishing fillets.

	Knife file. Used for finishing the sharp corners of many kinds of slots and grooves.
	Rhombic file. Used for filing the sharp corners of many kinds of slots and grooves. This file is also called "feather edge file".
	Crossing file. Used in place of the half-round file. Each side of the file has a different curve which feature frequently is of great convenience.
	Needle file. Used in fine die work and finishing.
	Mill file. Used for filing soft materials.
	Rasp file. Used for shaping and finishing wood.

Safety Rules in Filing:

1. Don't use a file with a broken handle or without any handle.
2. See that the bench is stable.
3. When filing objects with sharp edges, don't hold the fingers of the left hand under the file during the return stroke.
4. Never brush chips off with your hands or blow them off.
5. Always clamp the work securely in the vice.
6. Take care when fixing a handle on the file tang.



Poor practice of fixing a file handle on the tang

Tables for Filing:

The terms rough, coarse, bastard, second cut, smooth and dead smooth refer to the distance apart of the parallel cuts on files and the Nos. 00, 0, 1, 2, 3, 4, 5, 6, 7 and 8 refer to the same things, No. 00 being the coarsest. These terms are relative and depend on the length of the file.

Term	Number	Cuts per cm
Rough	00	4 - 5
Coarse	0	5 - 10
Bastard	1	12 - 18
Second cut	2	20 - 40
Smooth	3	42 - 60
Dead smooth	4	65 - 80
Super finish	5 - 10	100 - 120

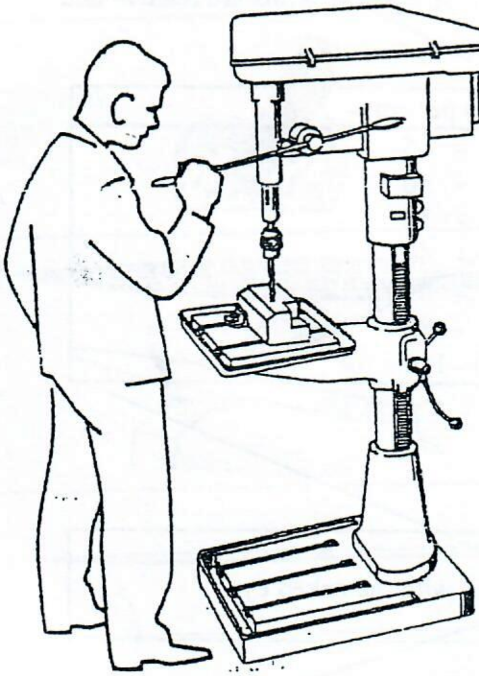
Surface Quality Finish Marks:

	Tool marks can be seen with the naked eye
	Tool marks can merely be seen with the naked eye
	Tool marks cannot be seen with the naked eye

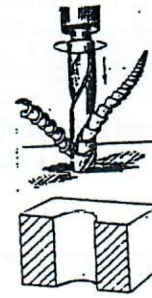
Drilling

Definition:

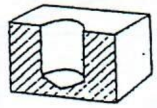
Drilling is the process of originating a circular hole by removing chips.



Drilling on the drill press



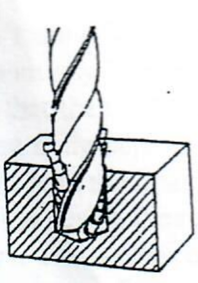
Through hole



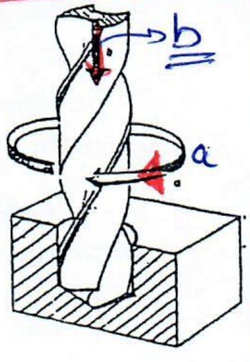
Blind hole

Principles of Drilling:

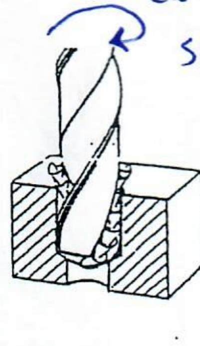
Drilling is the result of two motions, the rotary cutting motion and the **axial feed** motion of the drill. The **cutting speed** is the speed of a point on the drill's circumference and is measured in m/min. The feed is the distance that the drill enters the work at each revolution of the drill, measured in mm/rev.



Drilling into full material



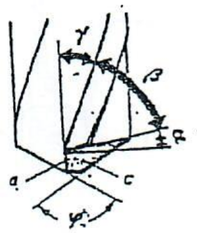
a = cutting motion
b = feed motion



Enlarging a predrilled hole

The drills most commonly used are twist drills. The two main cutting edges of a twist drill remove the chips, which are carried out of the hole by two flutes.

As on other cutting tools, there are clearance, rake and lip angles on twist drills.



α = Clearance angle
β = Lip angle
γ = Rake angle
ξ = Point angle
a = Cutting lip
c = Clearance surface

Drill holes are usually oversized. The enlargement depends on the drill diameter and is between 0.1 and 0.3 mm.

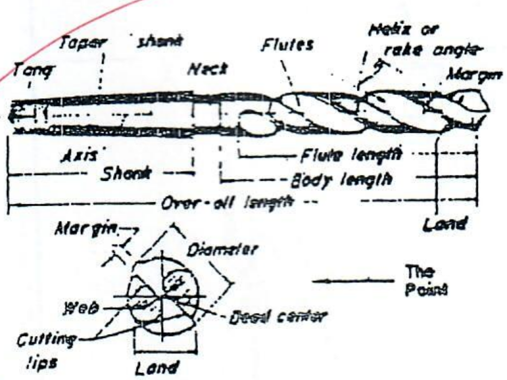
The surface quality of a drill hole is not very high. Drilling is a roughing process.

Drilling is used for originating holes in all types of work. Holes are drilled for joining parts by means of bolts, screws, rivets or other fasteners; for making holes which have to be threaded; for removing excess material in a more efficient way than by chipping or filing; for performing repair and assembly work.

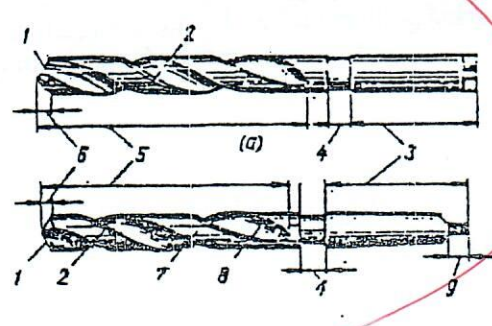
Drilling may be classified as drilling with hand tools and drilling with power tools (machine tools, drilling machines).

Drilling Tools:

Drilling tools are the drill and the drilling machine. The drills most commonly used are twist drills. Twist drills are made of plain carbon tool steel or alloy tool steel. (HSS = High Speed Steel). For drilling of very hard materials drills with cemented carbide tips are used. The shank of a drill may be either straight or tapered.

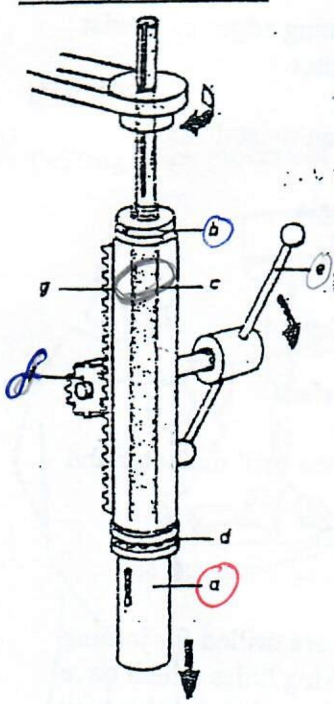


Parts of a twist drill



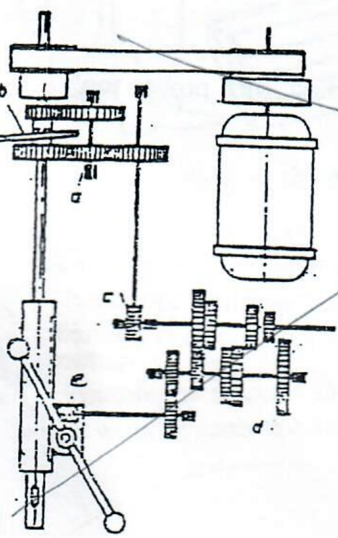
Straight shank and taper shank

Drilling Machines:



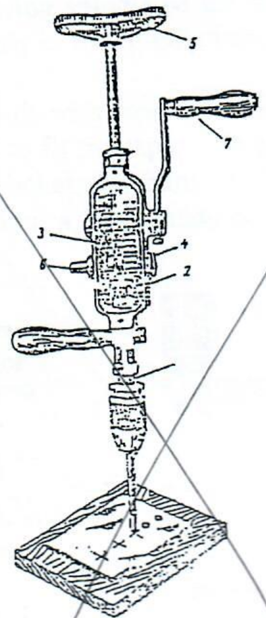
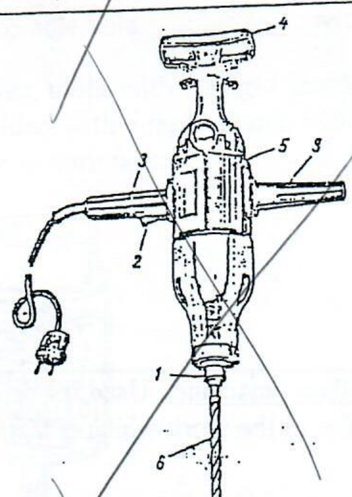
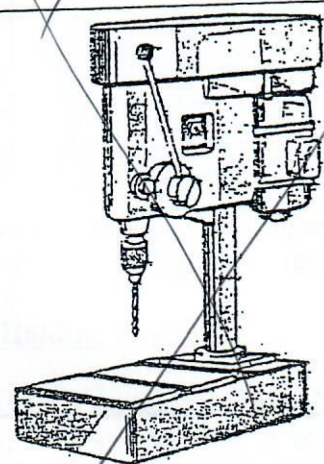
The common mechanical feature of all drilling machines consists of revolving spindle, which holds the drills and a non-revolving sleeve, which carries the spindle. The sleeve slides in its bearing in a direction parallel to its axis.

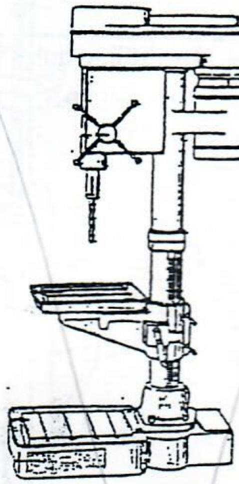
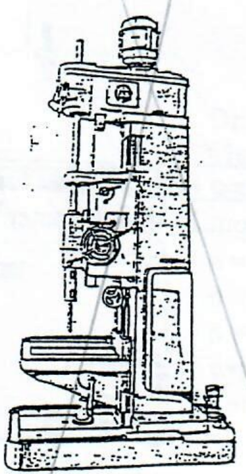
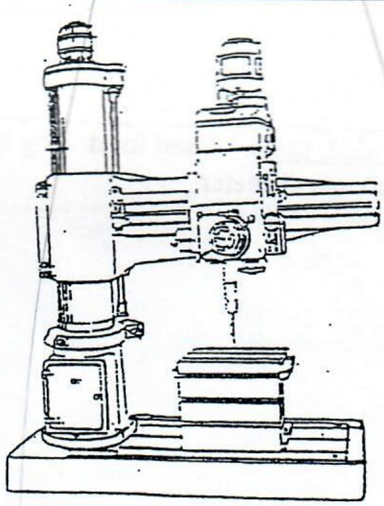
a = revolving spindle
b = ring nut
c = non-revolving sleeve
d = ball bearing
e = feed lever
f = gear
g = tooth rack



Drilling machines are usually driven by an electric motor. The various cutting speeds (or numbers of revolutions) and feeds may be obtained through cone pulleys or gears.

a = gears for main drive
b = control lever for main drive
c = main drive and feed drive connected by a worm and a worm gear
d = gear drive for various feeds
e = worm and worm gear for power feed

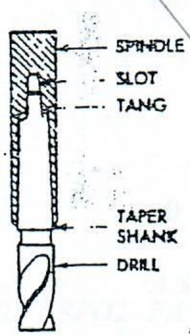
	Hand drill. Used for drilling holes up to 10 mm diameter. 1 = spindle 2 = bevel gear 3 = bevel gear 4 = gear 5 = breast plate 6 = shaft 7 = handle
	Portable electric drill. Used for drilling holes up to about 15 mm diameter. 1 = spindle 2 = switch 3 = handle 4 = breast plate 5 = aluminum housing 6 = drill
	Bench drill press. Used for drilling holes up to 10 mm diameter.

	Sensitive drill press. Used for drilling holes up to 25 mm diameter.
	Heavy-duty drilling machine. Used for drilling holes up to 40 mm diameter.
	Radial drilling machine. Used for drilling several holes in the work which is fastened securely.

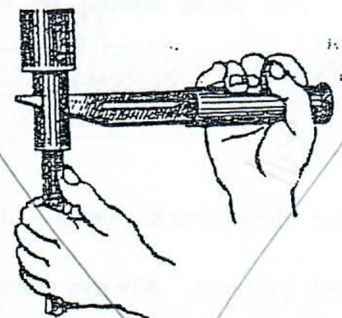
Tool Holding Devices:

The revolving spindle of the drill press carries the cutting tool. Some tools may be held directly in the spindle hole; others may be held in a taper socket, or a drill chuck.

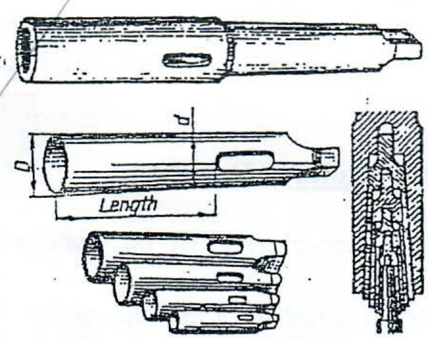
Cutting tools with taper shank are held in the taper hole of the spindle. Tools that are too small to fit the taper hole in the spindle of the machine are held in a small taper hole in a socket, the shank of which fits the spindle hole. If the socket makes too long an extension, a sleeve may be used. Sockets and sleeves are made in all necessary sizes.



Holding the drill in the spindle hole

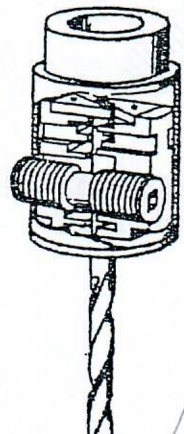


Removing a drill with a drill drift

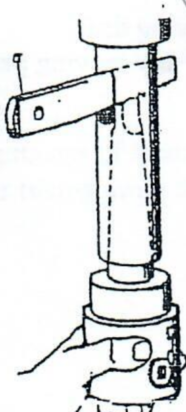


Socket (above) and a set of sleeves

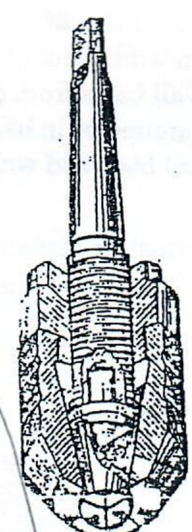
Cutting tools with straight shank are held in drill chucks. The drill chuck itself is provided with a taper shank, which fits the taper hole in the spindle. Drill chucks are made in various sizes.



Two-jaw chuck



Two-jaw chuck being removed by a drill drift



Three-jaw chuck in closed position

Work Holding Devices:

Work is held on the drill press by means of clamps, vises and jigs. Clamping with clamps, bolts and parallels is very slow and not very accurate. Also a vise does not accurately locate work under the drill.

General Rules for Drilling:

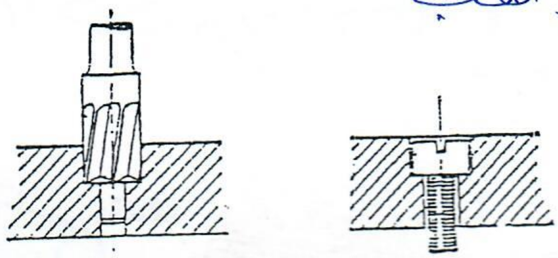
1. Always examine a drill for size and sharpness before using it.
2. Have the shank of the drill and socket, or of the chuck, clean, dry, and tight in the spindle.
3. Be sure the setup is arranged so that the drill will clear as it goes through the work, and not cut into the parallels table, or vice.
4. A drill will follow a hole already made. A pilot hole will keep a larger drill from running.
5. When the drill "breaks through" at the end of the cut, it has a tendency to "dig in". Especially when hand feed is used, care must be taken or a broken drill will result.
6. A squeak indicates undue friction. The cause should be looked for immediately and the fault corrected.

Safety Rules in Drilling:

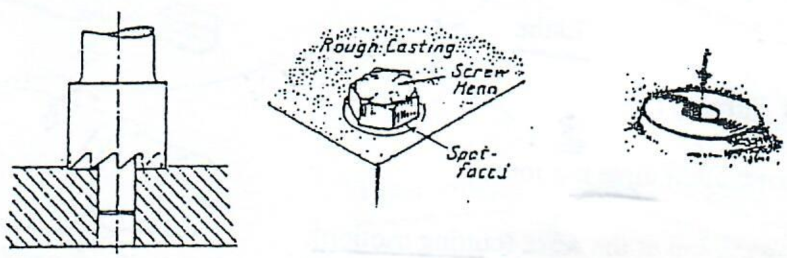
1. Chuck wrenches must be removed from drill chucks before starting the machine.
2. Never attempt to hold work under the drill by hand. Always clamp work to table.
3. Run drill at proper speed; forcing or feeding too fast may result in broken or splintered drills and serious injuries.
4. Change belt for speed regulation only when power is "Off" and the machine has come to a dead stop.
5. If work should slip from clamp, never attempt to stop it with your hands. Stop the machine and make adjustments.
6. If drill stops in work, shut off the motor and start drill by hand.
7. File or scrape all burrs from drilled holes.
8. Do not reach around or in back of a revolving drill.
9. Keep your head back and well away from any moving part of the drill press.

COUNTERBORING, SPORT FACING, COUNTERSINKING

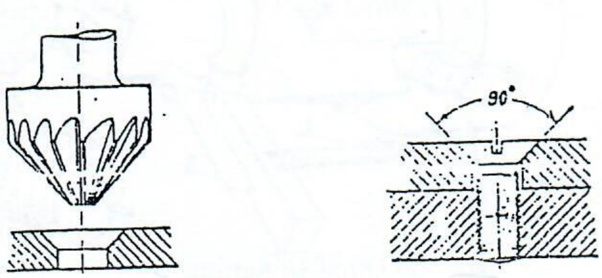
1. ***COUNTERBORING*** is the process of increasing the diameter of a hole for a certain distance down for the head of a screw or bolt, which should not project above the surface of the work.



2. ***SPOT FACING*** is the process of facing a rough surface around a hole, to provide a flat seating for a washer, bolt head, or nut.



3. ***COUNTERSINKING*** is the process of tapering a hole a certain distance for the head of screws or rivets and for taking away the burr of a hole.



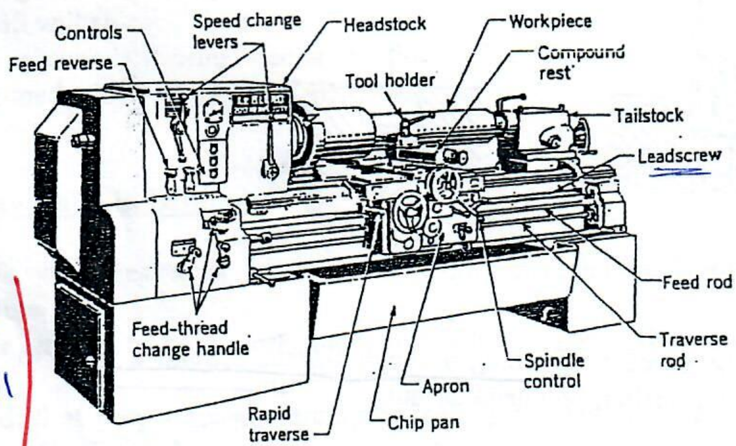
Tools:

The tools used in core drilling, boring, counterboring, countersinking and spot facing are made from alloy tool steel (HSS).

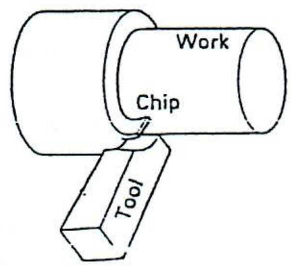
Turning

Definition:

Turning is a chip removing process performed on a machine tool called lathe. The function of the lathe is, primarily, the production of cylindrical surfaces.



Lathe

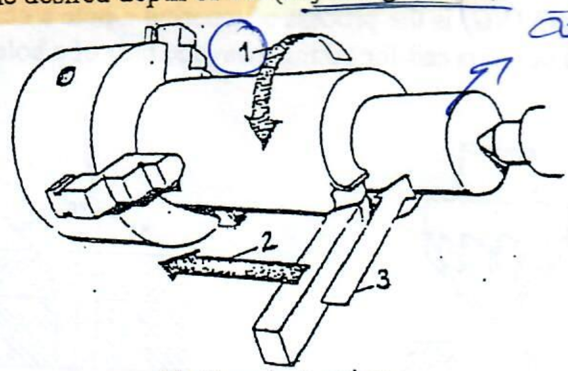


Turning

Principles of Turning:

Turning is the result of three motions:

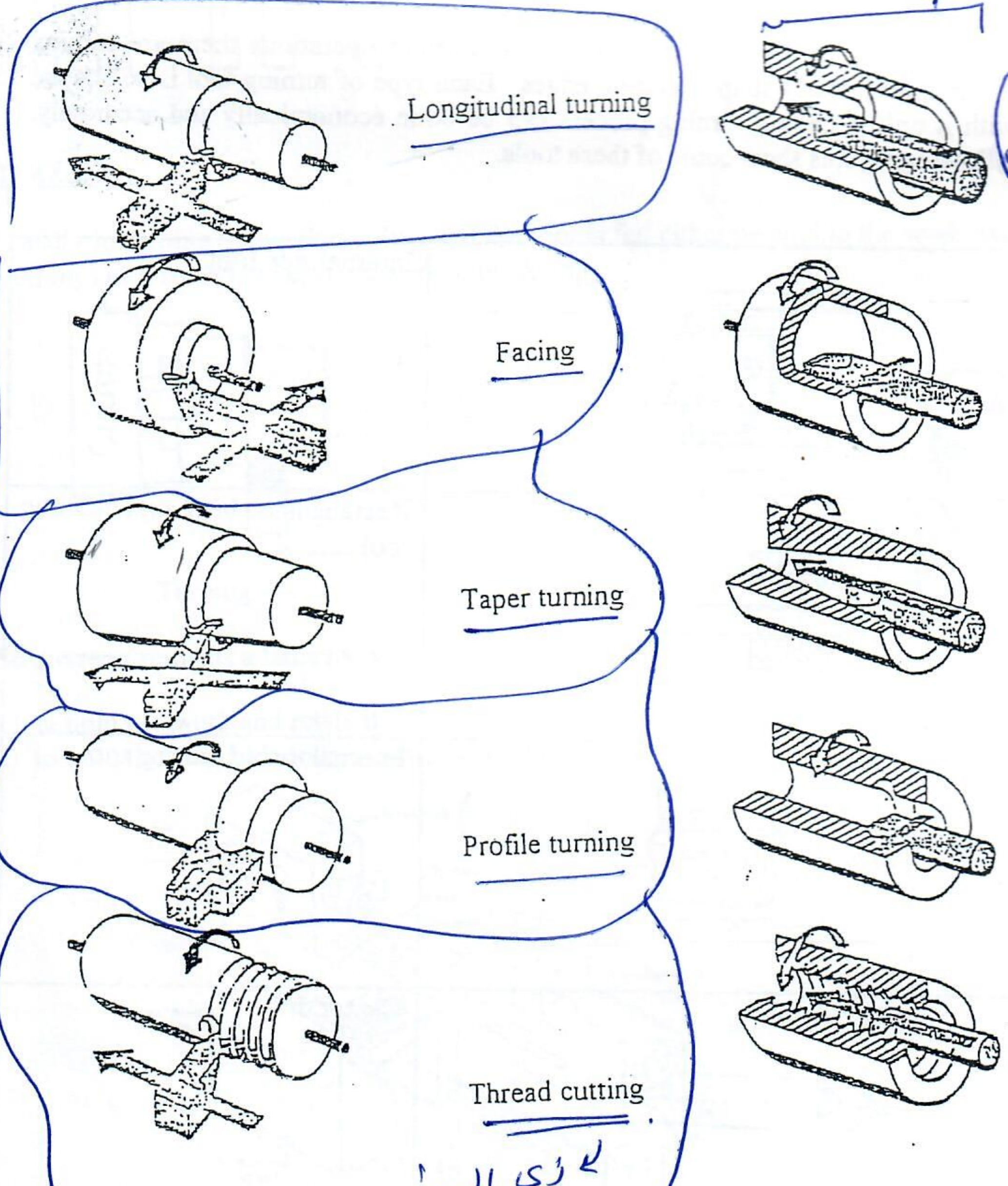
1. The rotating motion of the work (cutting motion).
2. The tool traveling either longitudinal or cross to the work-axis (feed motion).
3. The tool is set to the desired depth of cut (adjusting motion).



Motions in turning

The single-point tools used in turning are ground differently for the different cutting operations. But all of them are subject to the same geometry of cutting edges. The accuracy obtained in turning depends on the condition of the lathe as well as on the abilities of the lathe operator. In most cases an accuracy of 0.01 mm can be considered as a good result.

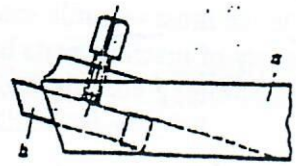
The lathe is the most versatile and useful of all machine tools and is used in producing a great variety of machine parts having circular cross-sections. The following figures show some turning processes.



Turning Tools:

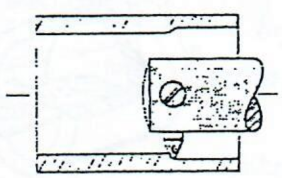
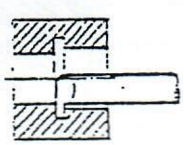
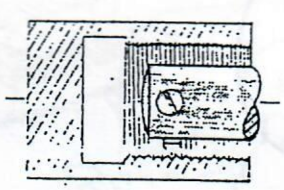
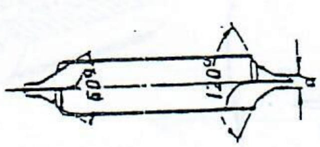
Carbon tool steels and high-speed steels, cemented carbides and ceramic materials are used in manufacturing single-point turning tools.

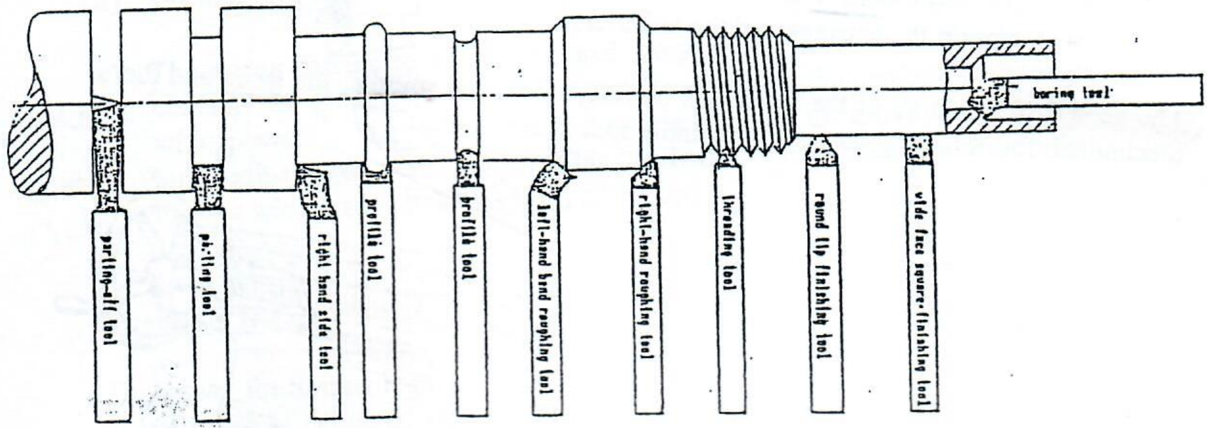
Tool holders are specially made for clamping of small tool bits. They are manufactured of cheap structural steel and save expenditure on tool steel.



Tool holder (a) with tool bit (b)

Various shapes of turning tools: For special turning operations there are turning tools with appropriately shaped cutting edges. Each type of turning tool is so shaped that with it only a certain turning process can be done economically and accurately. The following figures show some of these tools.

	Internal side tool.
	Rectangular bent undercutting tool.
	Internal thread cutting tool.
	Center drill.



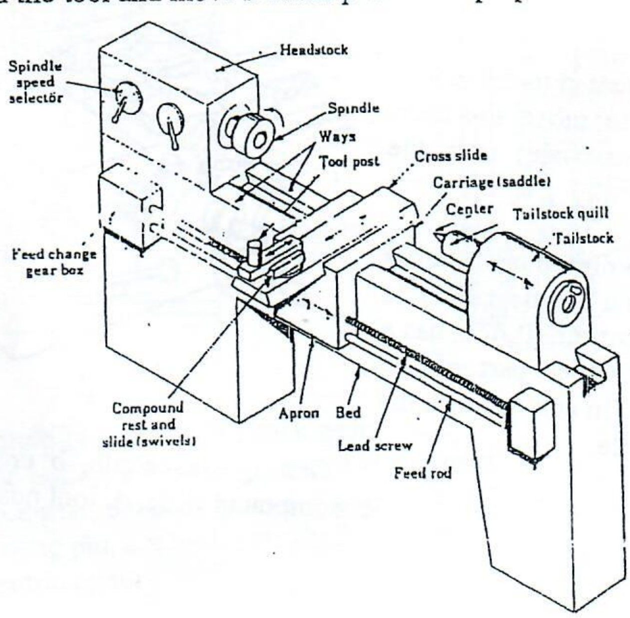
The Lathe:

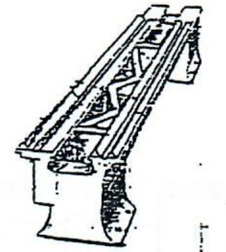
Usually in turning the work revolves and the tool is fed either parallel to the work axis (turning) or perpendicular to the work axis (facing).

Turning Facing

So the requirements a lathe has to meet are:

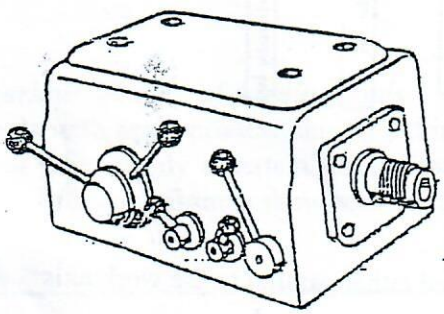
1) to hold the work and rotate it.
2) to hold the tool and move it either parallel or perpendicular to the work axis.



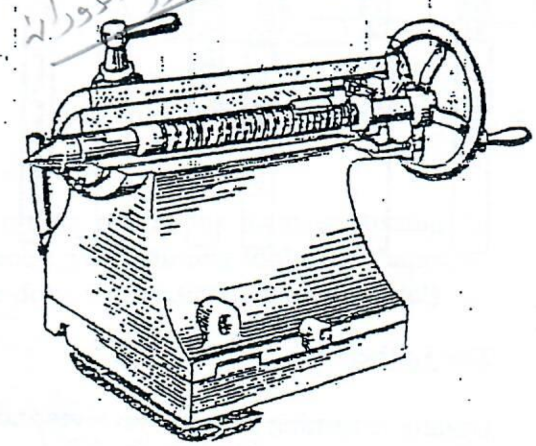


The lathe bed is the base, made of cast iron, on top of which are the ways, both V and flat. These ways are rails that support the carriage and the tailstock.

The headstock consists of the headstock casting, where the spindle, the gears and the mechanism for obtaining the various spindle speeds are located.



Headstock



Tailstock

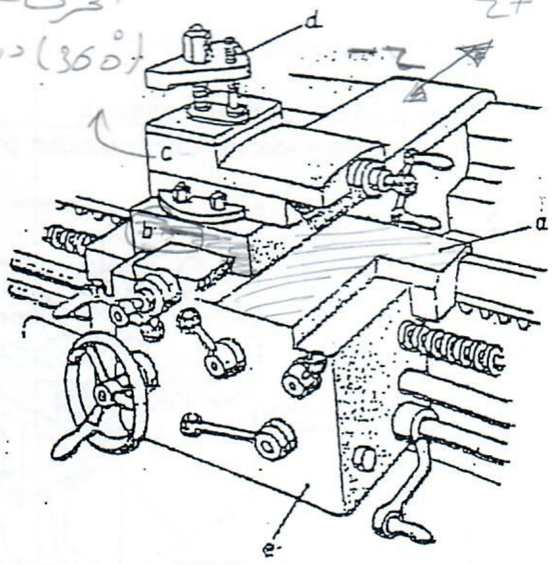
The tailstock can be moved along the bed and locked in any position. It has two castings (1) and (2). The lower one rests on the ways, and the upper one is fastened to it. The upper casting can be moved toward or away from the operator to offset the tailstock for taper turning. A hollow spindle (3) moves in and out of the upper casting by turning the tailstock wheel (9). This spindle has a taper on the inner end, in which the dead center (5) fits.

The carriage has five parts:

a) *The saddle* is an H-shaped casting that fits over the bed and slides along the ways.

b) *The cross slide* is mounted to the saddle. A handle is turned to move the cross slide transversely (crosswise) from the operator.

c) *The compound slide* on top of the cross slide can be turned in a 360-degree circle and locked in any position. It, too, has a slide in which the upper part of the casting can be moved in and out with the compound-slide handle.



Carriage: a: saddle, b: cross slid, c: compound slide, d: tool post, e: apron

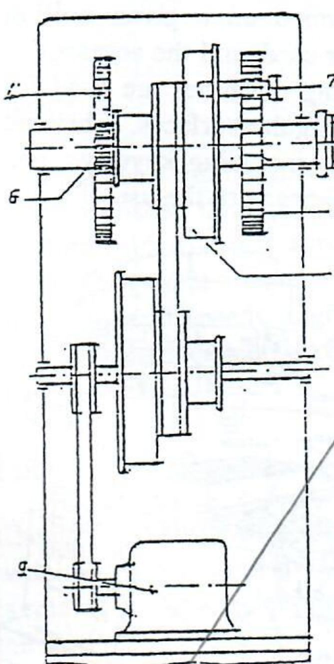
d) *The tool post* is fastened on top of the compound slide.

e) *The apron* fastens to the saddle and hangs over the front of the bed. It contains the gears, clutches, and levers for operating the carriage by hand or with power. The apron handwheel is rotated to move the carriage longitudinally (back and forth). This hand-wheel is attached to a pinion that meshes with a rack under the front of the bed.

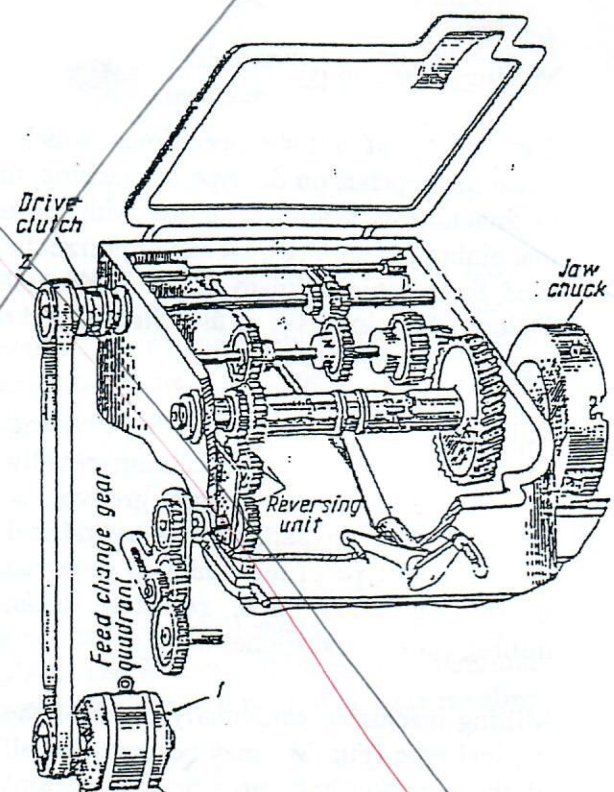
The Main Drive:

The power for turning is provided by an electric motor. On *belt-driven lathes*, direct-drive power is delivered through belts to a step pulley that turns the spindle. The spindle speed is changed by moving the belt to different positions.

In *modern lathes*, the functions are performed by the *speed gearbox*, which consists of gears, shafts and other parts arranged inside the cast-iron headstock housing. The rotation of motor (1) is transmitted by a belt to pulley (2). Pulley (2) gives power to the gearbox.

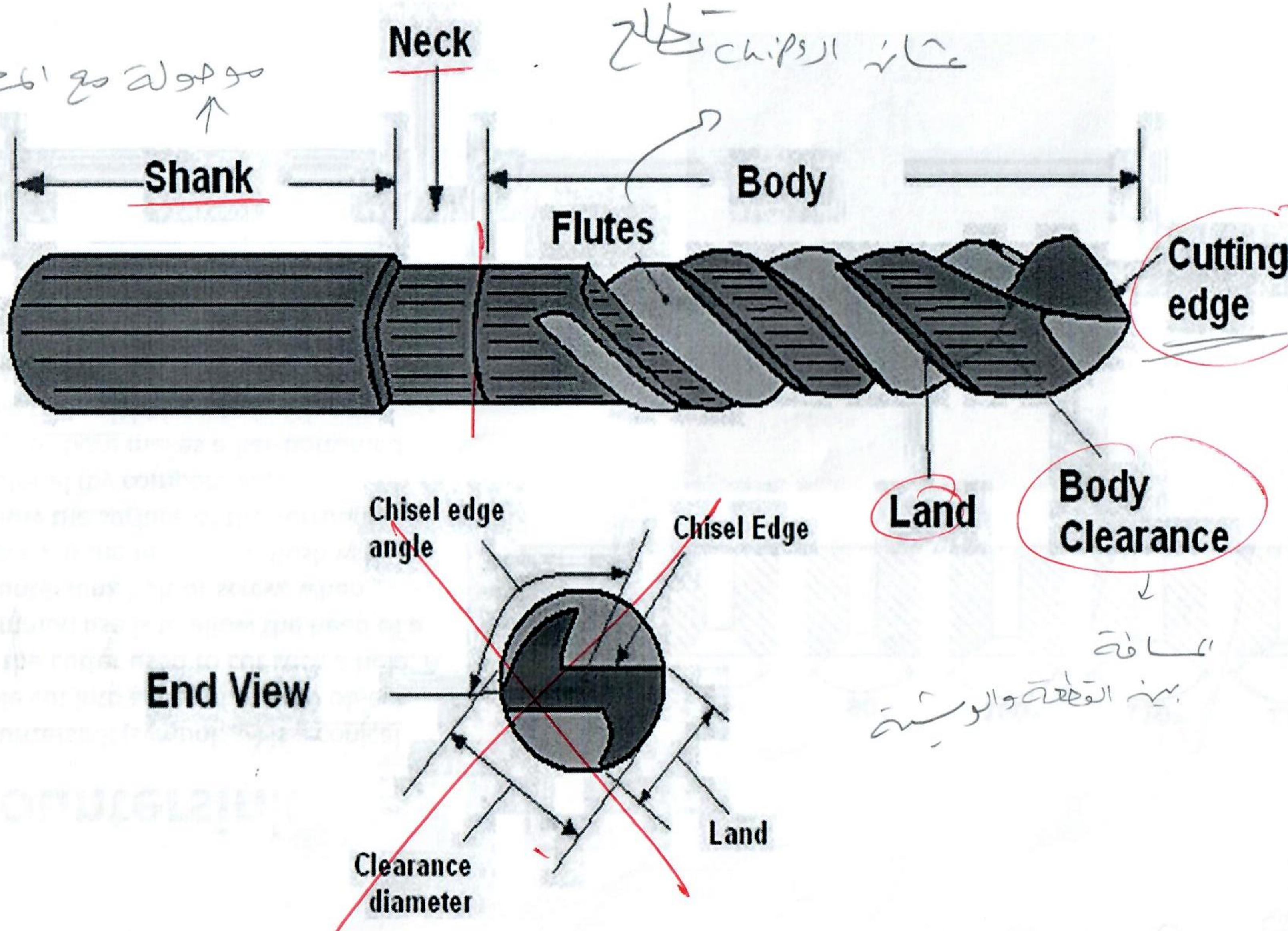


Belt-drive headstock with back gear
1 = step pulley, 2 = main spindle, 3 = face gear
4 = back gear, 5 = back gear, 6 = gear
7 = driving pin, 8 = back gear shaft
9 = electric motor



Speed gearbox of lathe

Parts of Twist Drill



Turning

السكك تاعت الالة (بتمشي عليها)