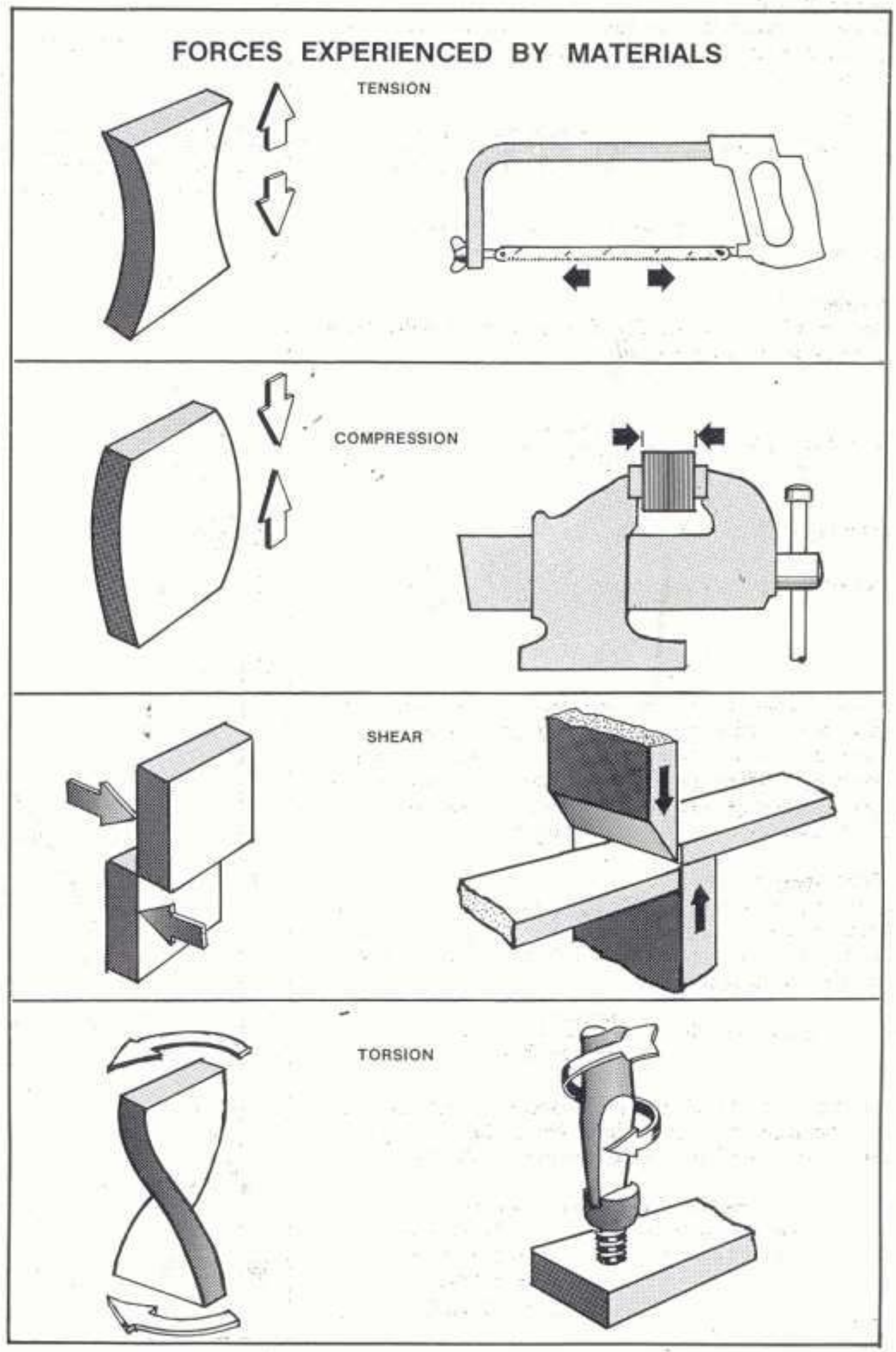
Q2 Materials Testing

Destructive Testing

- **Tensile Testing – tests *Ductility* of a material**
- **Hardness Testing – Tests ability to withstand indentation of a material**
- **Toughness Testing**

Non-Destructive Testing

- **X-ray Test**
- **Ultrasonic Test**
- **Eddy Current Testing**


FORCES EXPERIENCED BY MATERIALS
TENSION
COMPRESSION
SHEAR
TORSION

Tensile Testing

- Also known as *ductility* testing
- Tests the ability of a material to be drawn into a wire

Test Procedure :

- Specimen is placed into a machine called an *extensometer*
- Piece is clamped and a load is applied
- Initially the piece will return to its original position – due to *elasticity* - within its *elastic limit* range
- When a certain load is applied the piece will reach its *yield point* and no longer return to its original position
- With more load applied piece will eventually *fracture – cup and cone* shape formed
- Amount of stretch, proportional to the load, is measured and graphed

Copper = Very ductile
Cast Iron = Not ductile

Test Specimen:

What can be learned from the test results :

Strain = Extension / Original Length
Stress = Load / C.S.A
Modulus of Elasticity = Stress / Strain

Example 1

The folowing results were obtained from a tensile test on a material of diameter 10mm and gauge length 50mm.

Stress(N/mm2)	68	135	200	275	308	325	338	350
Strain (x 1000)	0.75	1.5	2.25	3.25	4	4.8	5.5	7.25

Plot the Stress-Strain Graph and determine

1. 0.2% proof stress
2. Youngs Modulus

1. Proof Stress of 0.2 %

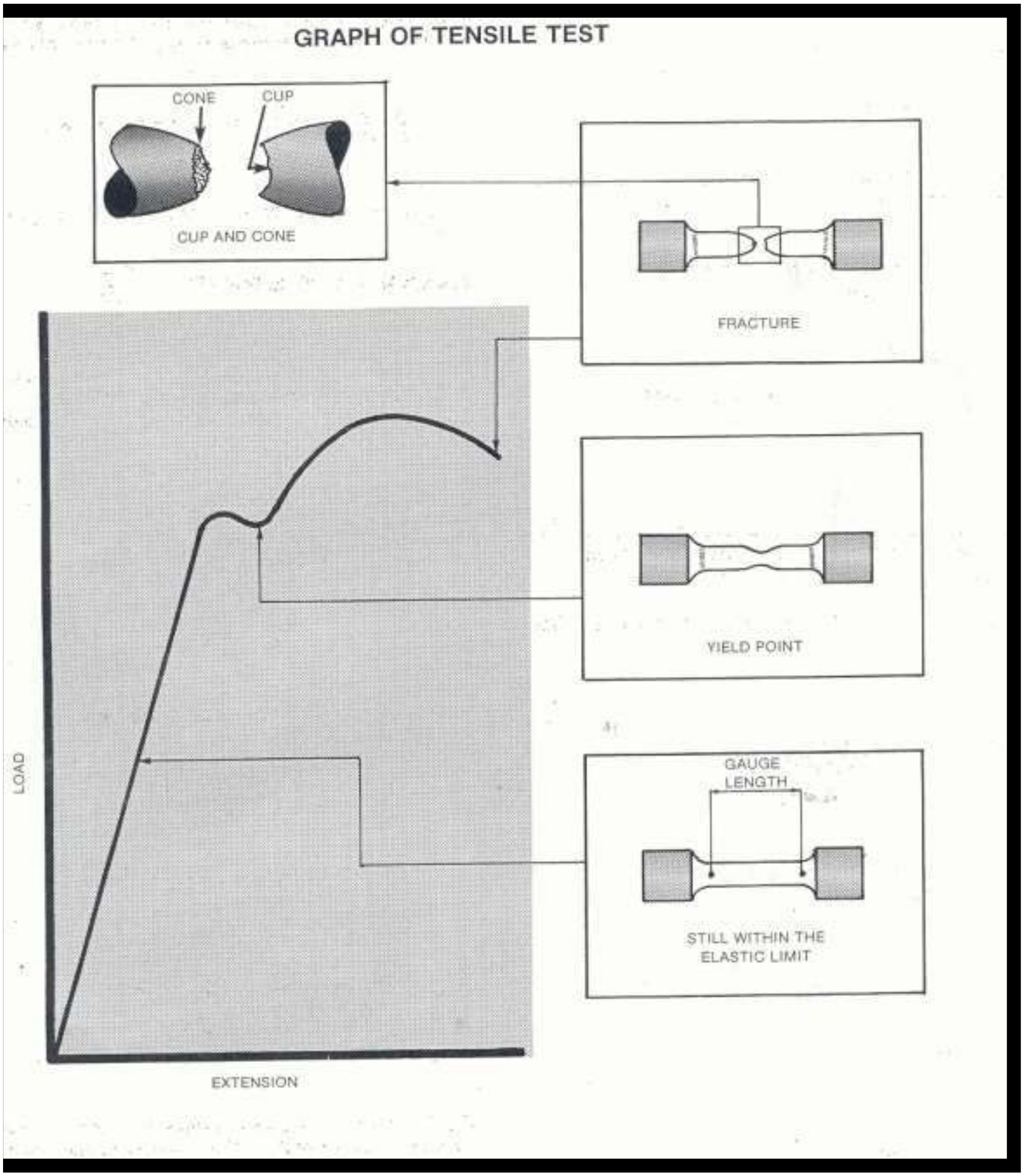
Draw line from 0.002mm parallel to the straight line portion where intersects with curve project across to load/force axis. From graph **proof force = 340 kN**

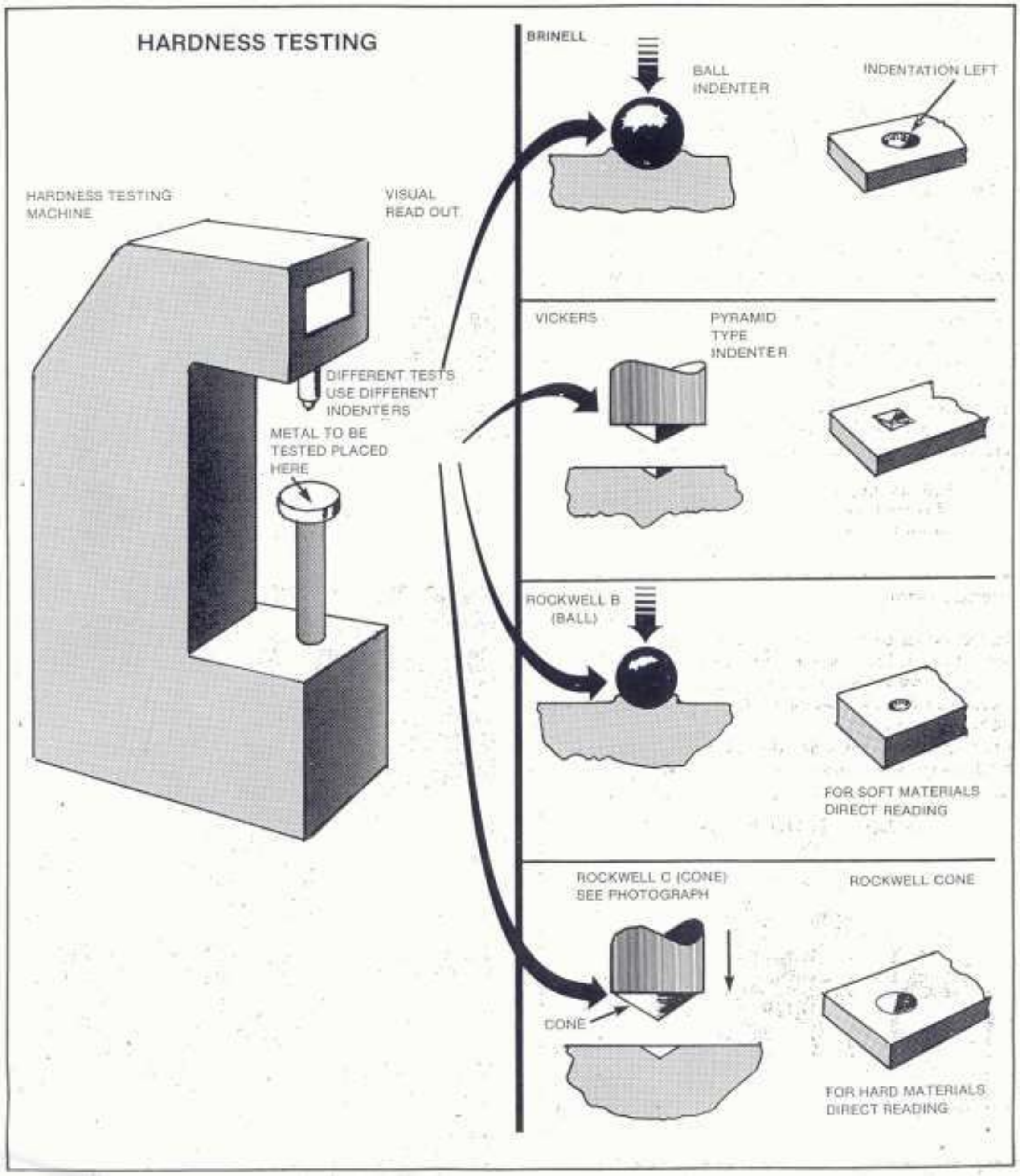
2. Youngs Modulus $= \dfrac{\textbf{Stress}}{\textbf{Strain}}$

Choose a point in the **elastic region** of curve

At point **X**

Youngs Modulus $= \dfrac{200 \text{ N/mm}^2}{0.0025} = 88.89 \text{ N/mm}^2$


GRAPH OF TENSILE TEST
CONE
CUP
CUP AND CONE
FRACTURE
YIELD POINT
GAUGE LENGTH
STILL WITHIN THE ELASTIC LIMIT
LOAD
EXTENSION



- **Brinell** – Hardened steel or tungsten ball used - *surface depth* is measured

- **Vickers** - Diamond shape indenter is used. *Diagonal length* is measured. Point angle of 136°
- **Rockwell B/C** – Direct digital readings

Impact Testing

- Tests for the *toughness* of a material
- Also known as the *notched bar* test

Testing procedure :

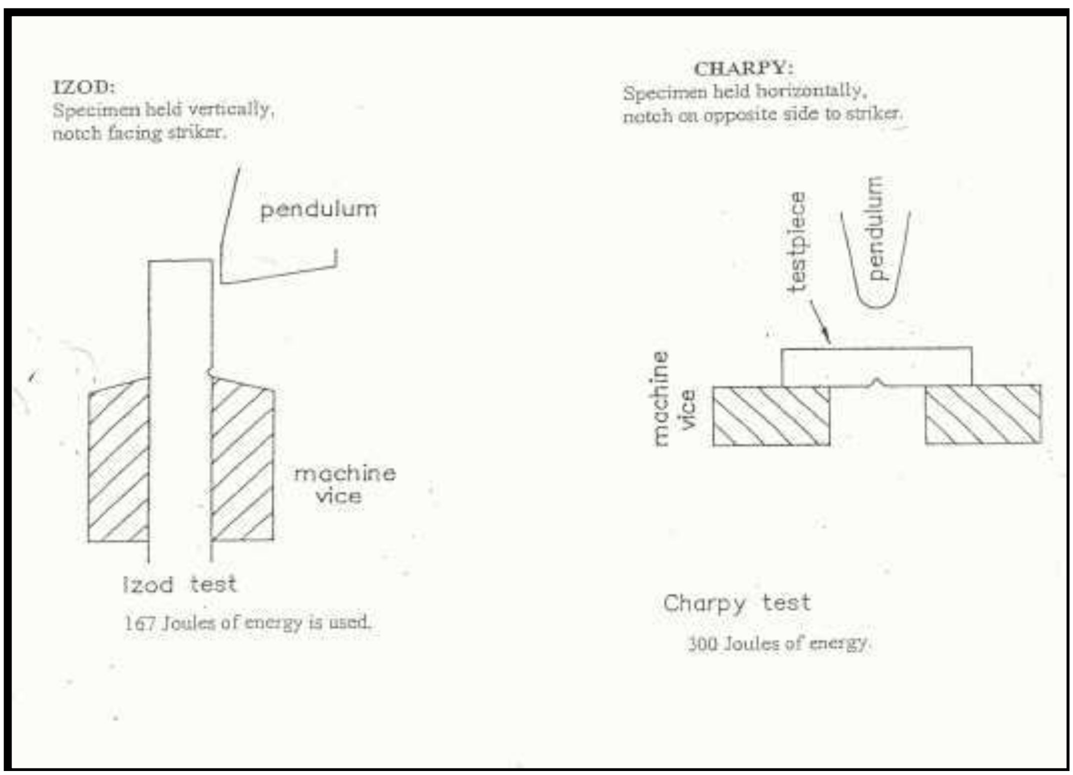
A striker / pendulum is released from a pre-determined height. It strikes and breaks the specimen. A pointer indicates the height of the follow through after breaking, thus determining the energy absorbed in breaking the specimen. Two main types of tests

Izod

- The specimen is held vertically, clamped at one end
- The notch is facing the pendulum
- The striking energy is 167 joules

Charpy

- The specimen is held horizontally, clamped at both ends
- The notch is on the opposite side to the pendulum
- The striking energy is 300 joules



Physical Failures in Materials

Creep

- Slow deformation of a material *over time* resulting from a steady force acting on a piece
- Occurs more often in materials subjected to high temperatures
- Higher the melting point of the metal – greater resistance to creep

Fatigue

- Failure due to on/off loading or cyclic stressing. Failure begins as a minute crack and grows under stress until un-cracked part is not strong enough to support load
- Vibration in another cause of fatigue

How to prevent fatigue :

1. Smooth surfaces
2. No sharp corners
3. Avoid corrosion

Non-Destructive Testing

- Test piece remains unharmed
- Each piece can be tested
- Used extensively in aeronautical industry and in welding

    - Two main categories of testing :

1. Surface flaws

2. Internal flaws

Surface Flaws Testing

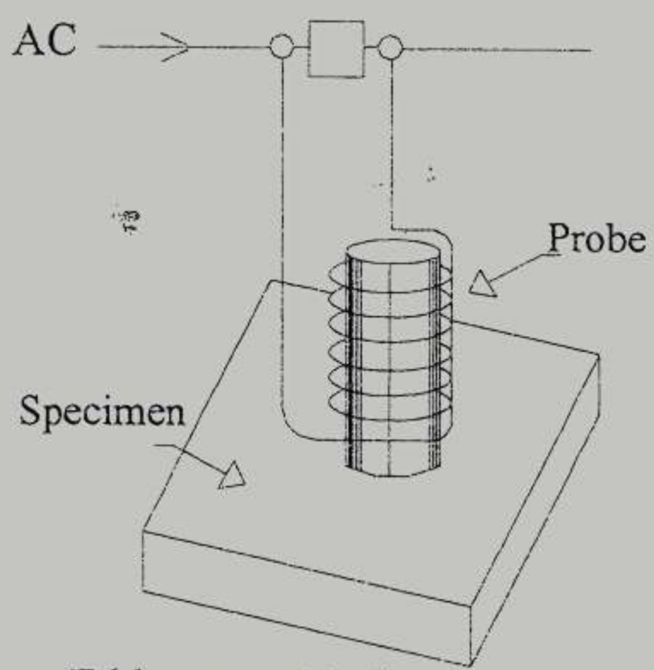
- **Visual** – Requires good light and magnification

- **Penetrants** – Fluorescent oils are used to flow into the gaps which will be viewed under UV lights

- **Magnetic particles Testing** – Particles (i.e. iron filings) applied to the surface of test piece – piece is magnetised – If any flaw is present filings will arrange around this flaw. Test can detect flaws up to 18mm in depth.

Eddy Current Testing

- Suited to both *surface* and *internal* defect for non-ferrous metals
- An induction current using AC current sets up an Eddy current in the specimen being tested — any flaws present will change the flow of current
- Image will be displayed on as oscilloscope (screen)
- Applications include detection of surface or subsurface flaws in metals of uniform section.

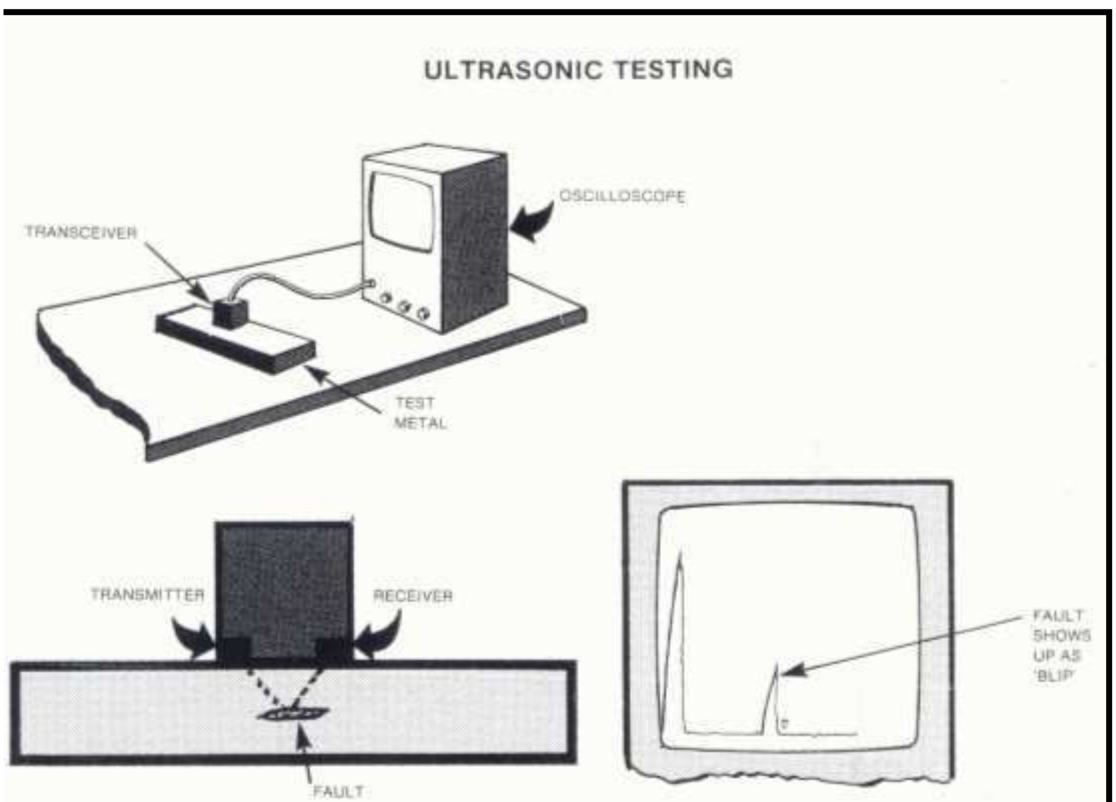


Eddy current testing

Ultrasonic Testing

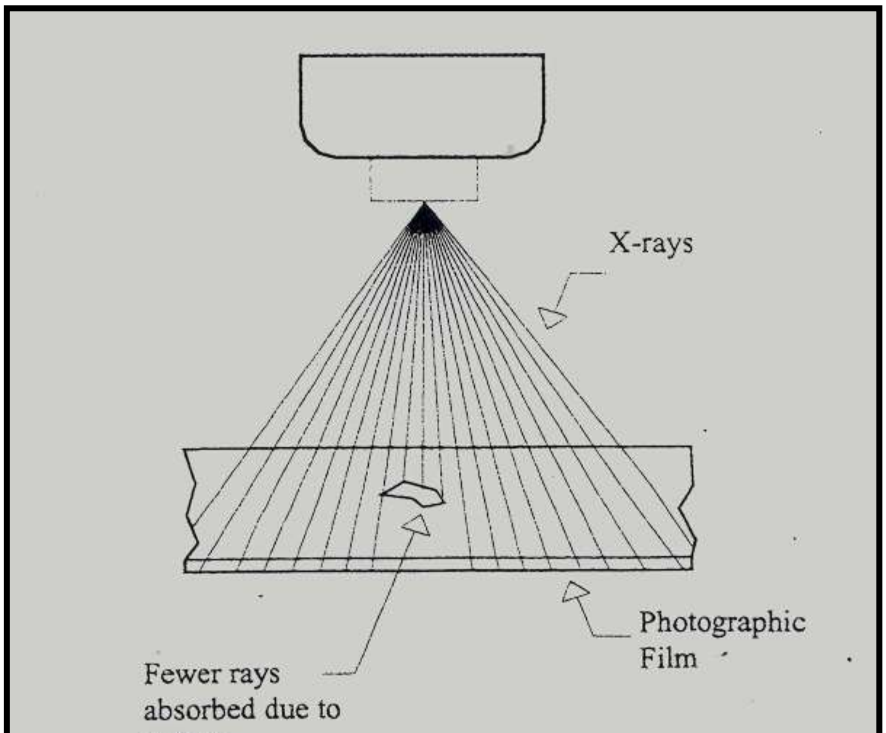
- High frequency sound waves are passed through the test piece - any voids will reflect back as an *echo* and be recorded on a cathode ray tube as a smaller peak than the signal emitted

- Used for checking internal faults in welds.



X-ray Testing

- Radiation from an x-ray tube is passed through the specimen and this develops a photographic image of the specimen
- Defects present will show up as a darker image on the photographic film
- Used extensively in Welding testing

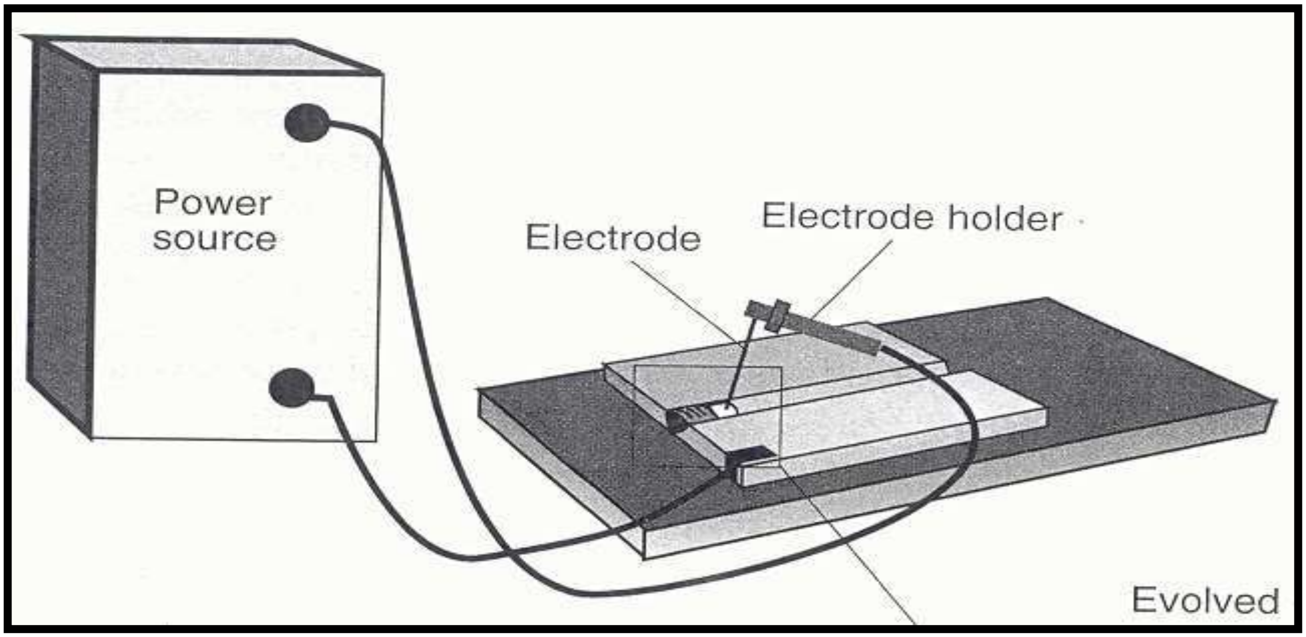


X-ray testing

Q5 Welding

1. **Manual Arc Welding**
2. **M.A.G.S. Welding**
3. **T.A.G.S. Welding**
4. **Oxy-Acetylene**
5. **Resistance Spot Welding**
6. **Seam Welding**
7. **Welding Safety**
8. **Rectifier**

Manual Metal Arc Welding

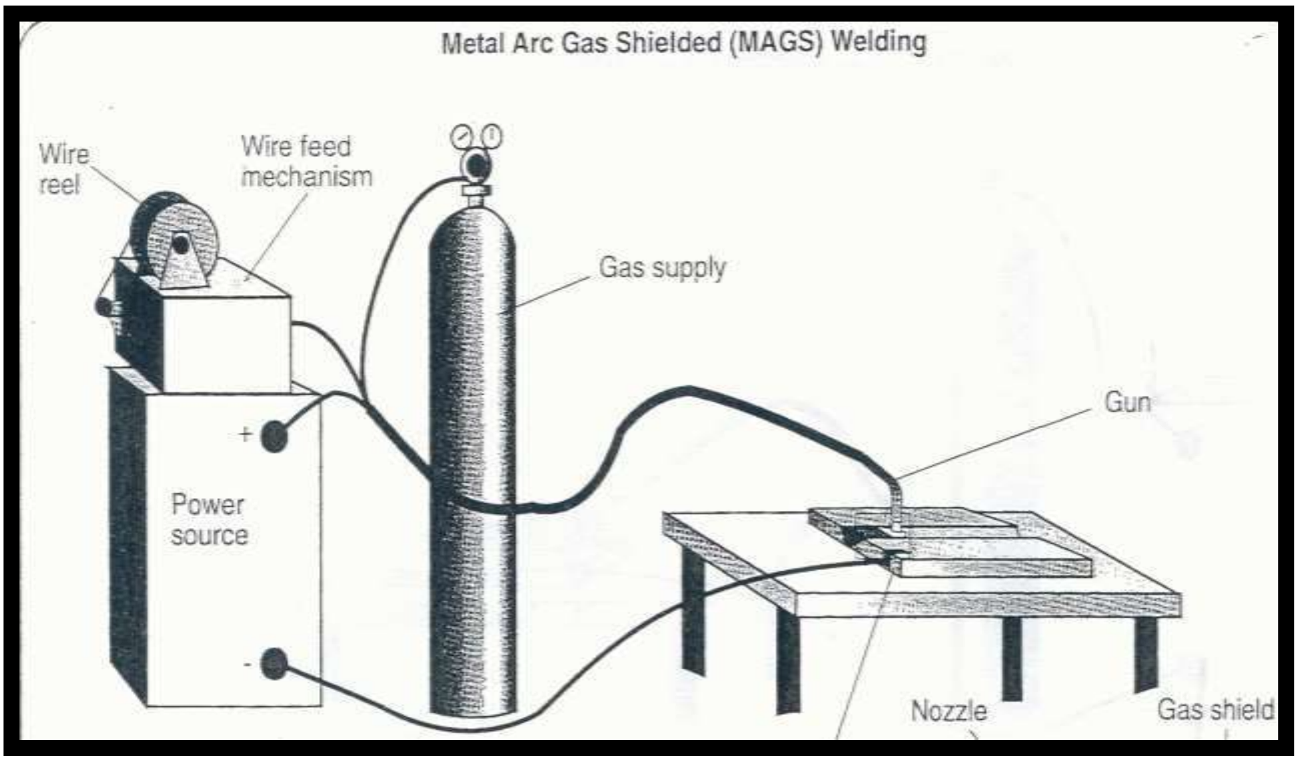


- Arc formed and maintained between work + electrode
- Intense heat generated melts metal edges
- Molten metal combined with the electrode make up the weld
- Once solidified a permanent joint is formed
- Fluxing elements of the electrode coating give off a gas which protects from contamination
- Slag formed protects during cooling - chipped off later

Applications : Wide range of applications including constructional steel work, agricultural maintenance.

Metal Arc Gas Shielded Welding (M.A.G.S)

- Previously known as M.I.G Welding
- Semi-Automatic process
- A consumable bare wire electrode fed continuously through a torch into weld pool
- Fluxing achieved through Inert Gas, (argon) which provides a protective shield around weld pool – Gas exits from torch/gun
- Operator controls feed rate of the electrode/ flow rate of gas



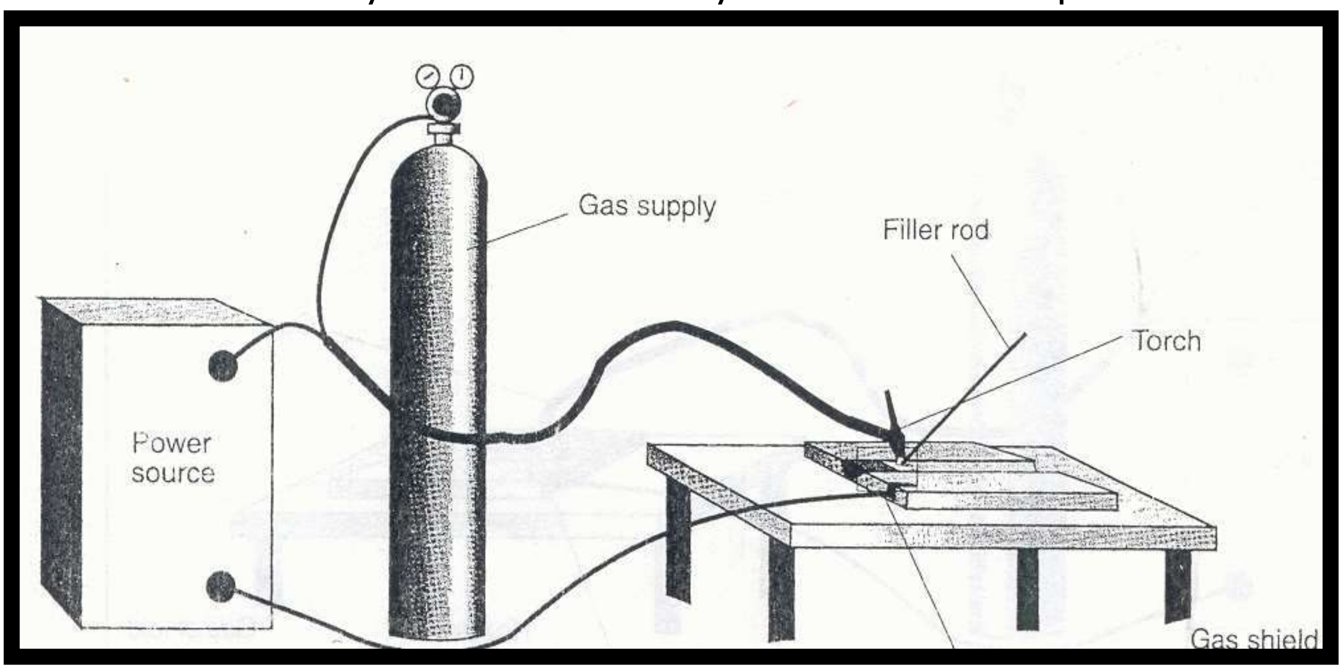
Applications :

- Light sheet metal / heavy plate steel.
- Commonly used in automotive industry – robotic assemblies.

Tungsten Arc Gas Shielded Welding (T.A.G.S)

- Previously known as T.I.G Welding
- High quality precision welding
- Arc is formed between non-consumed tungsten electrode and the metal being welded
- Fluxing is achieved through the inert gas (argon) which shields the weld (similar to MAGS welding) from impurities

Filler rod is held by hand and manually fed into the weld pool

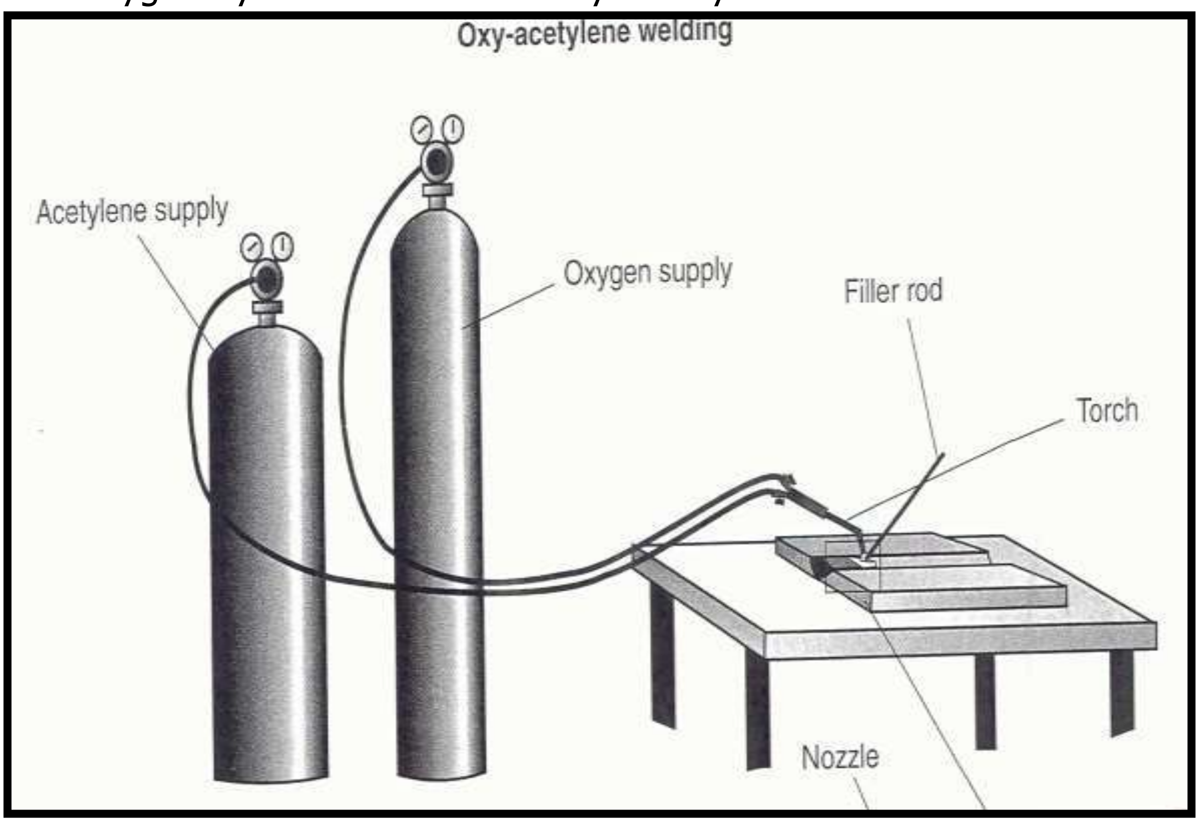


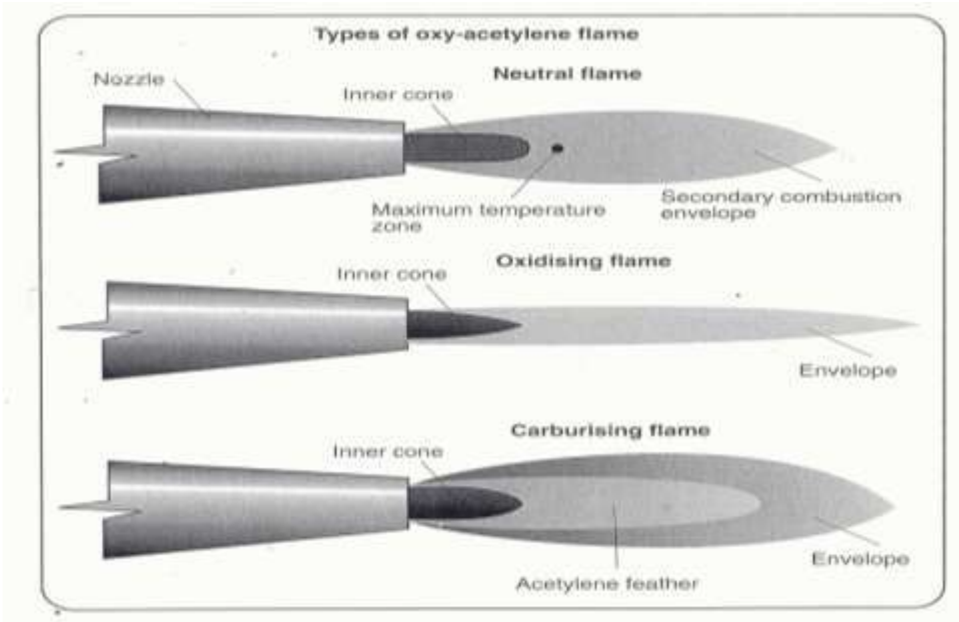
Applications : High quality welds in stainless steel/aluminium

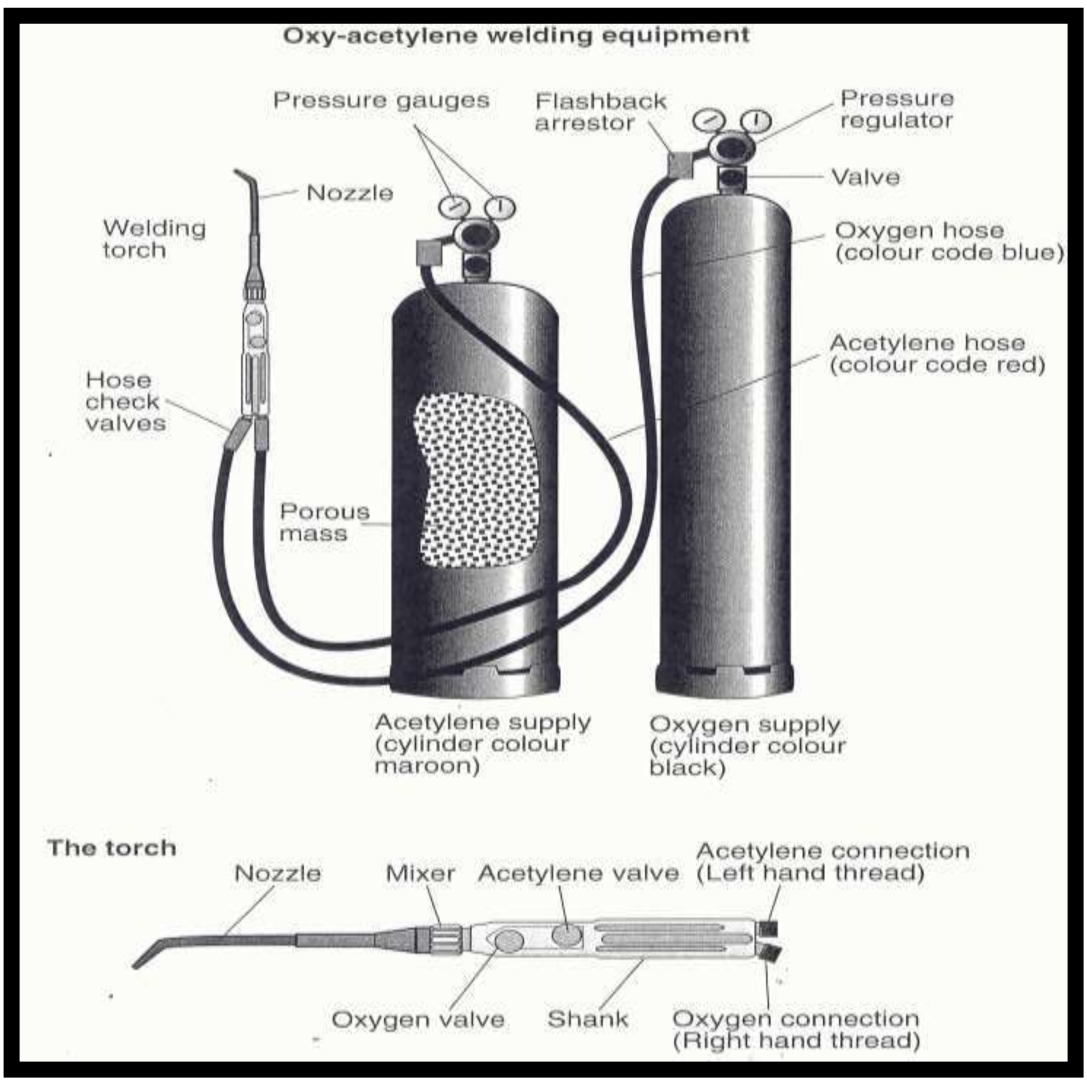
e.g. Air craft construction

Oxy-Acetylene Welding

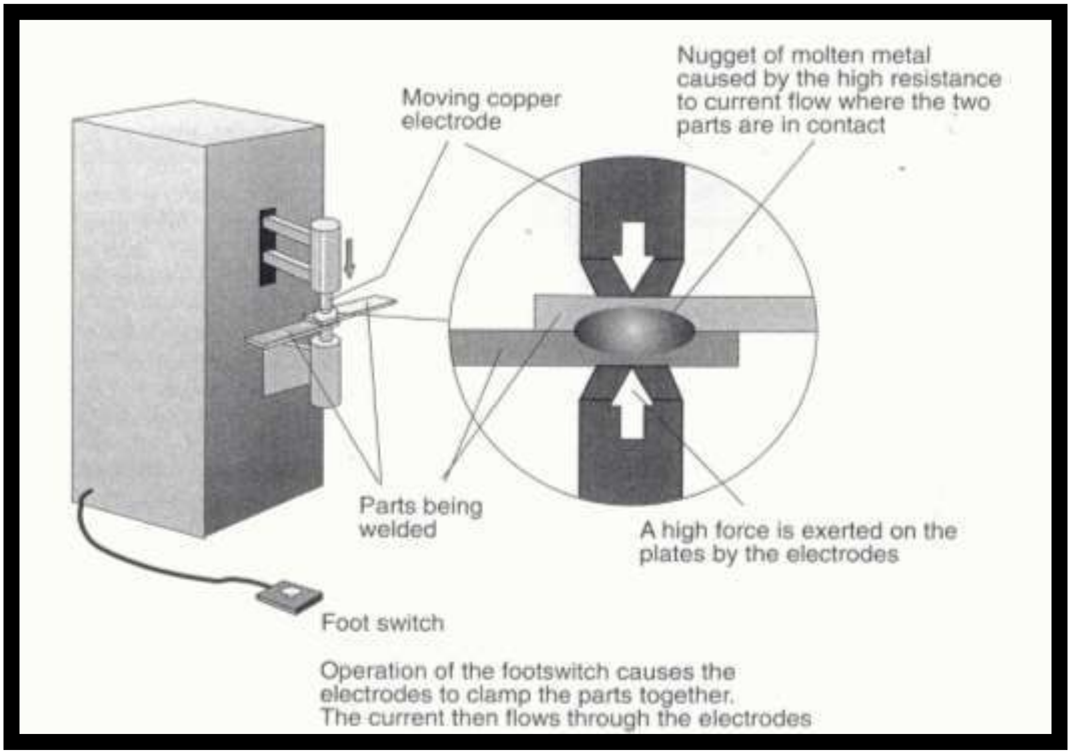
- Fusion welding process
- Oxygen + Acetylene gases are burned at the tip of the nozzle on the welding torch
- Mix is ignited to produce a flame of approx. 3100°C
- Heat concentrated on joint edges. Molten metal melts and flows between the two jointing metals for a permanent joint
- Oxidation is prevented by combusted gas envelop
- Filler metal can be added in rod / wire form
- Oxygen Cylinder = *Black* : Acetylene Cylinder = *Maroon*




Types of oxy-acetylene flame
Neutral flame
Nozzle
Inner cone
Maximum temperature zone
Secondary combustion envelope
Oxidising flame
Inner cone
Envelope
Carburising flame
Inner cone
Envelope
Acetylene feather


Oxy-acetylene welding equipment
Pressure gauges
Flashback arrestor
Pressure regulator
Valve
Nozzle
Welding torch
Oxygen hose (colour code blue)
Acetylene hose (colour code red)
Hose check valves
Porous mass
Acetylene supply (cylinder colour maroon)
Oxygen supply (cylinder colour black)
The torch
Nozzle
Mixer
Acetylene valve
Acetylene connection (Left hand thread)
Oxygen valve
Shank
Oxygen connection (Right hand thread)

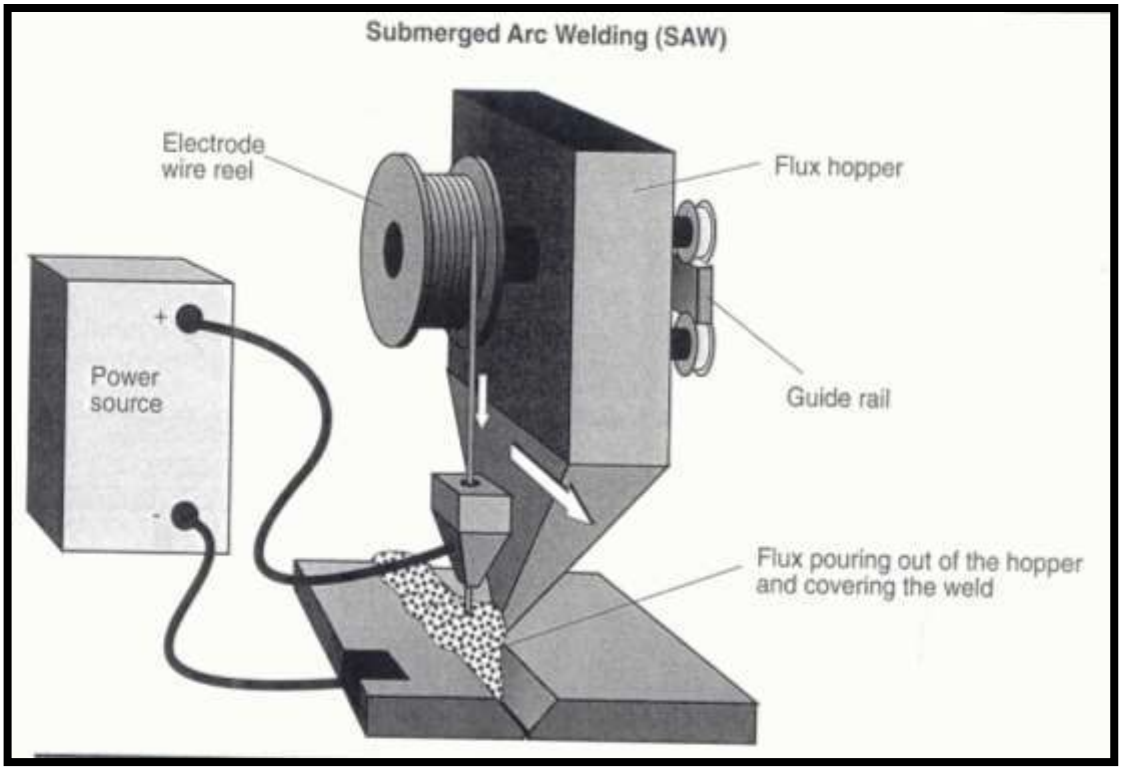
Resistance Spot Welding



- Copper electrodes used (conducts current easily)
- Clamping pressure is applied and a current is passed through piece between two electrodes
- Greatest resistance occurs at the interface and rapid heating occurs
- A nugget of molten metal forms and once cooled makes a permanent joint

Applications : Light sheet metal automotive industry

Submerged Arc Welding



- Copper coated bare wire electrode

- Arc is produced under a blanket of granulated flux
  - flux is fed from a hopper
  - flux floats on top of the joint and acts as a protective slag

- Welding electrode fed into welding area by a guide nozzle fed by two drive rolls

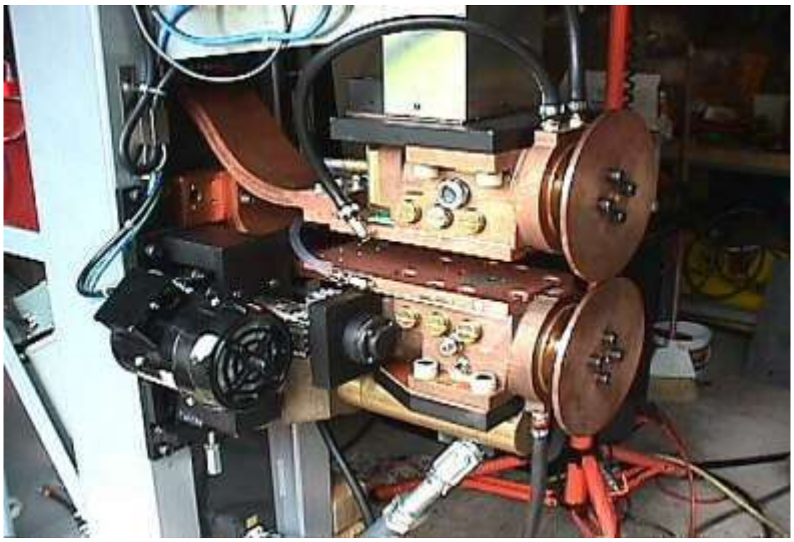
- Fully automated process

Applications :

Large scale - straight-line welds e.g. shipbuilding/bridges/beams

Seam Welding

Resembles spot welding in principle, but produces long seams of weld by using wheels as electrodes. The work pieces are passed between rotating electrodes and are heated to a plastic state by the flow of current. The electrodes are usually made from copper. Used in sheet metal applications.

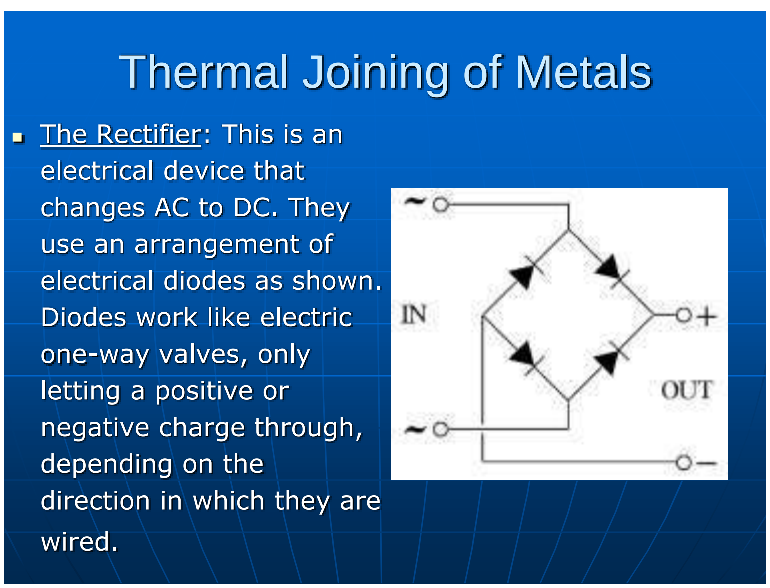


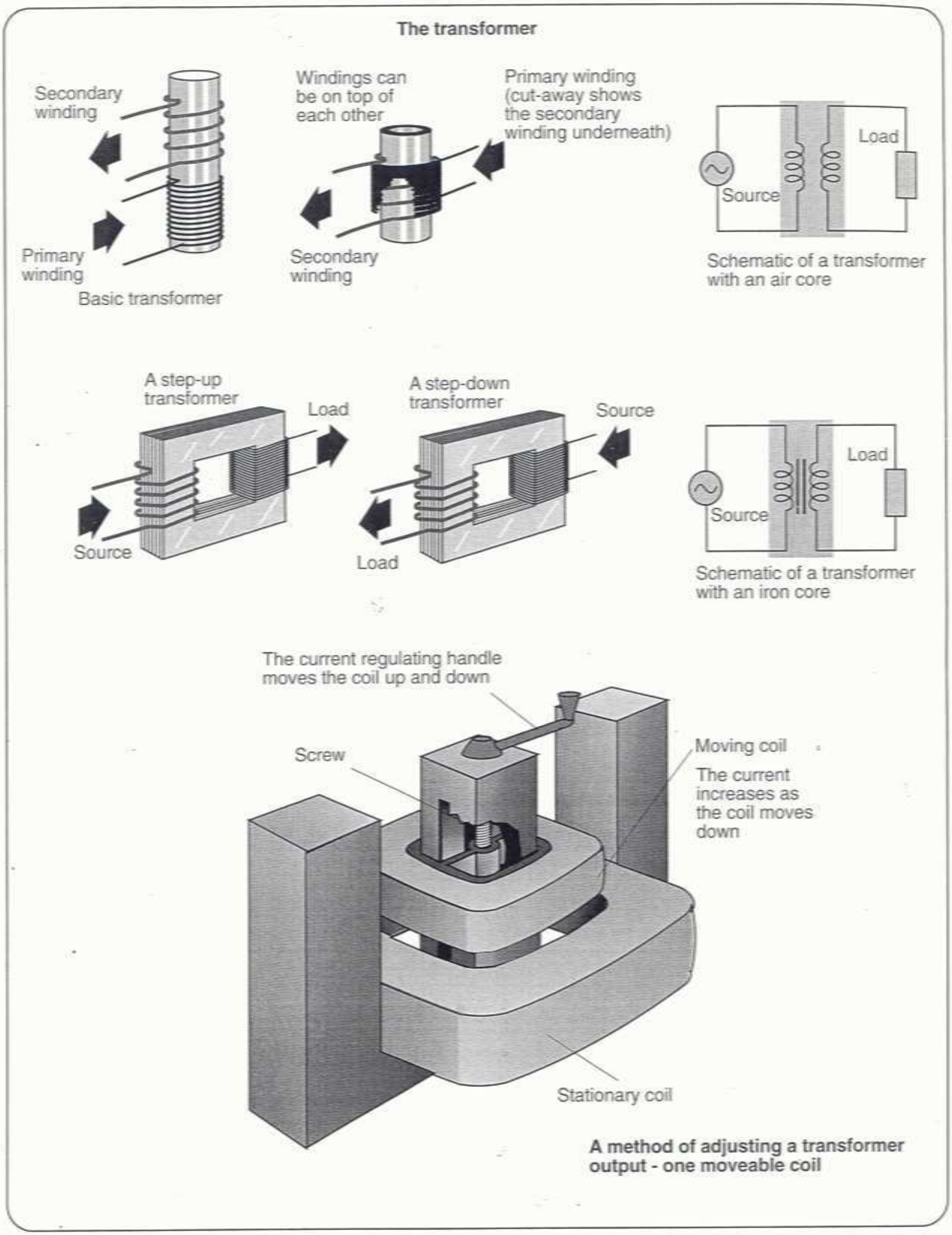
Welding Safety

- **Ensure all equipment is properly installed**
- **Ensure all terminals and wires are secure and properly insulated**
- **Never weld in damp conditions**
- **Make sure all equipment is earthed**
- **Always use protective equipment :**

➢ **gloves / goggles / face mask**

The Rectifier




The transformer
Secondary winding
Primary winding
Basic transformer
Windings can be on top of each other
Primary winding (cut-away shows the secondary winding underneath)
Secondary winding
Load
Source
Schematic of a transformer with an air core
A step-up transformer
Load
Source
A step-down transformer
Source
Load
Load
Source
Schematic of a transformer with an iron core
The current regulating handle moves the coil up and down
Screw
Moving coil
The current increases as the coil moves down
Stationary coil
A method of adjusting a transformer output - one moveable coil

Q7. Machining

1. **Drill**
2. **Lathe**
3. **Milling**
4. **Grinding**

Cutting Fluids

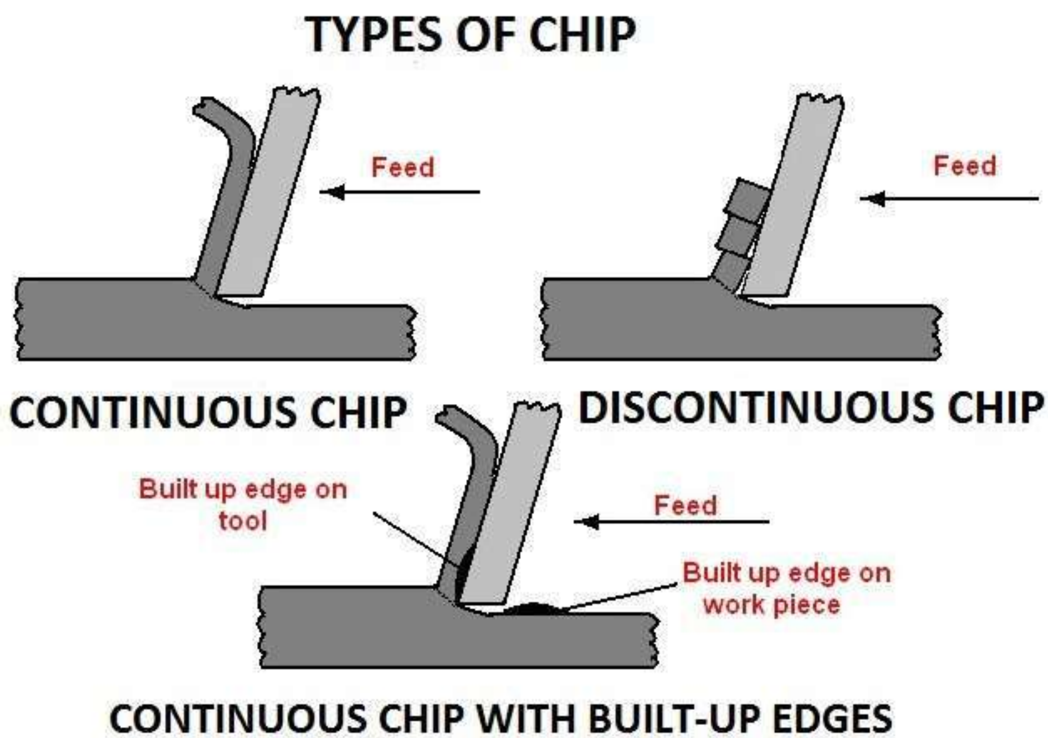
Although not used in schools cutting fluids are vital in any engineering production facility. They have several purposes during machining. Firstly they keep the cutting tool cool; this prevents wear to the cutting tool caused by heat due to the friction of cutting. They lubricate and aid the cutting action. Cutting fluids also wash away the swarf which causes difficulty if it builds up around the cutting tool.

Chip Formation

Three types of chip formed in metal cutting:

- **Continuous chip : Soft, ductile material such as aluminium.**
- **Discontinuous chip : Brittle materials with brass as an example.**

• **Chip with built-up edge : In single point cutting of metals, a built up edge is an accumulation of material against the rake face which adheres to the tool tip. The cutting tool is separated from the chip by the built-up edge.**



Preventing a built-up edge:

• **Use cutting fluids when machining.**

• **Choose suitable cutting tools for each machining process.**

• **Run the machine at the correct speed to prevent heat build-up.**

• **Ensure that the machine is in good condition and not prone to excessive vibration.**

Types of Milling Cutters

Chuck-mounted cutters are found on the Vertical Milling Machine and amongst others include;

End Mills: Used for general milling on top and side surfaces. These cutters have 4,6,8 or more cutting edges. They may also be used to make slots but only open ended slots.

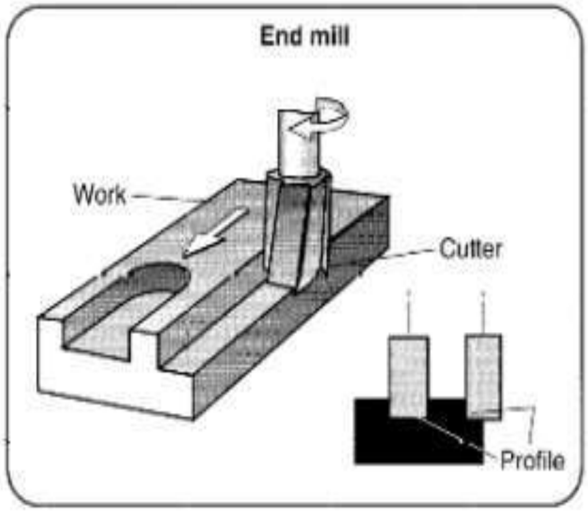
Slot Drills: Used for milling of internal slots. These cutters have only two cutting edges and will not cut as efficiently as an end mill because of this.

Angle Cutters: Used to create chamfers along edges.

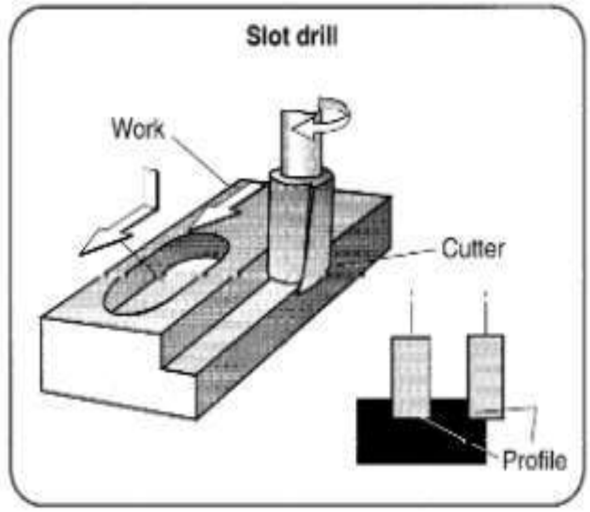
Ball-nosed Slot Drill: Used for cutting channels into material. Works similar to the standard slot drill.

Corner-rounding Cutter: Used to mill fillets along edges.

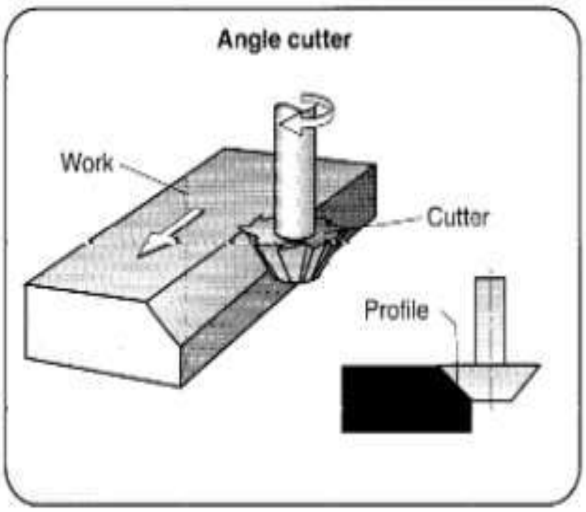
Dovetail Cutter: Used for the machining of dovetails. Machined dovetails can be found on the lathe topslide.



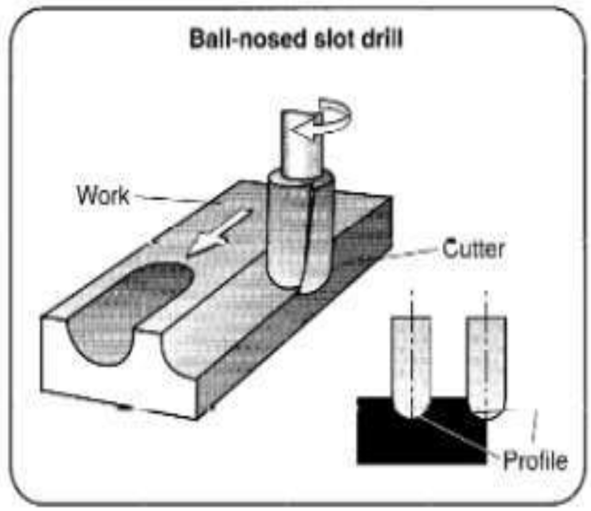
End mill



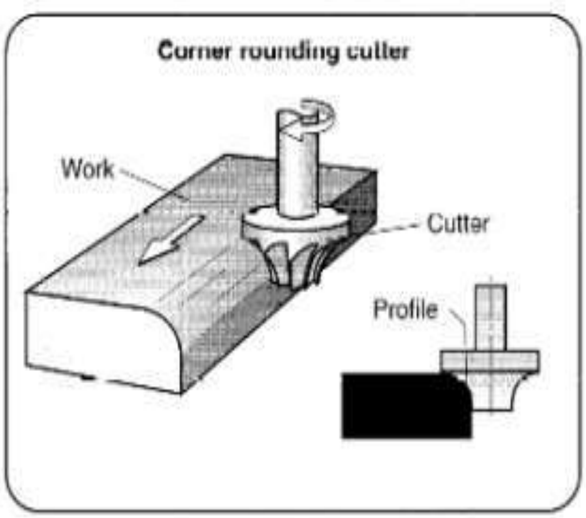
Slot drill



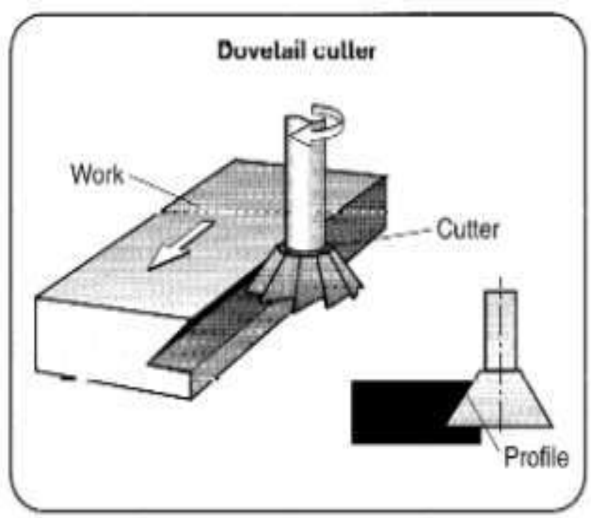
Angle cutter



Ball-nosed slot drill



Corner rounding cutter



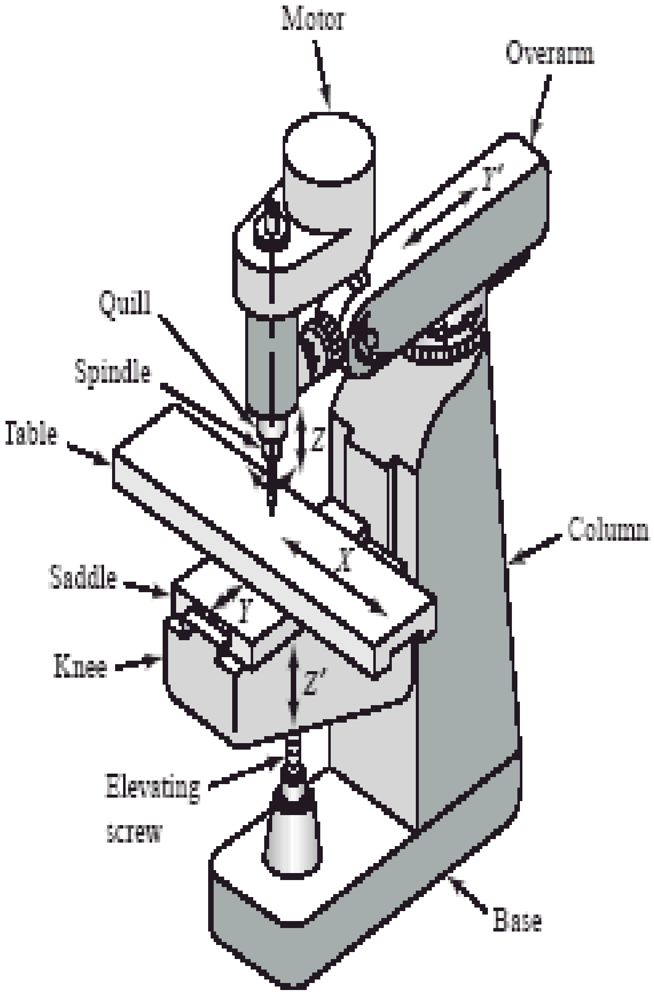
Dovetail cutter

Up-cut milling:

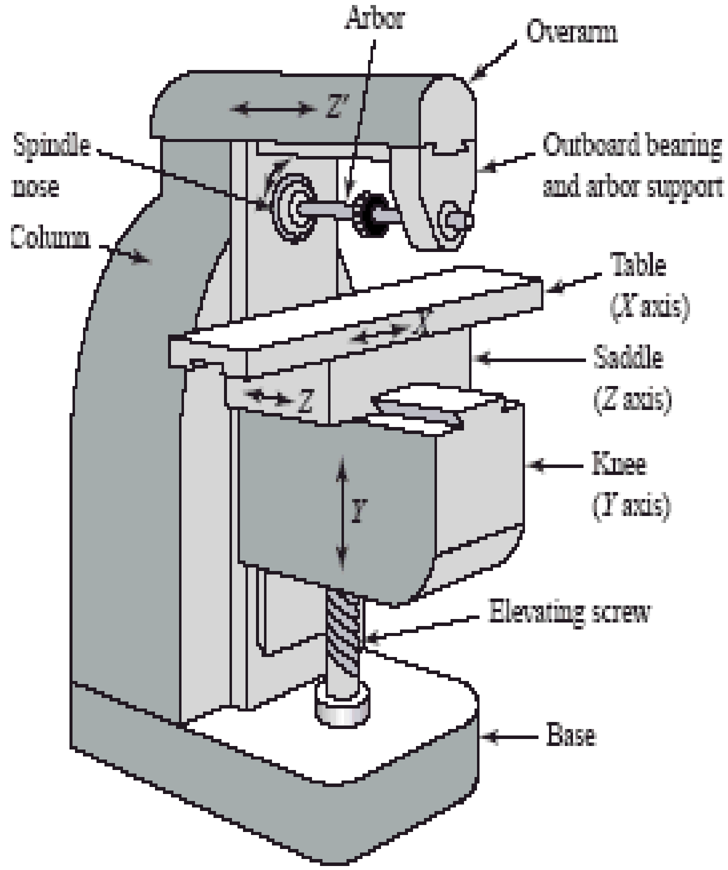
The conventional milling method. In this process the milling cutter is rotating against the direction of the workpiece. There is a danger of the workpiece lifting out of the vice, therefore effective clamping is necessary. A smoother cutting action is achieved.

Down-cut milling:

The milling cutter rotates in the same direction as the workpiece movement, it is also known as 'climb milling'. A backlash eliminator should be fitted to the machine for this type of milling to allow heavier cuts to be taken without the tendency to lift. It produces a finish with less defined cuter marks. Up-cut milling Down-cut milling.



Vertical Milling



Horizontal Milling

Grinding Wheel Flaws

Loading: a grinding wheel becomes loaded with small particles when grinding debris becomes trapped in the space between the abrasive grains and the wheel. This will cause overheating of the work piece

Glazing: the grinding wheel has a shiny appearance as the abrasive particles have lost their edge and failed to break away from the wheel. The grinding wheel not cut effectively. These faults are caused by inappropriate choice of grinding wheel for the material being ground.

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Morse taper sleeve:

Morse taper shanks are used to fix components such as drills and centres in to machines, they come in a variety of sizes. To increase a morse taper size, a sleeve can be used.


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Reamers:

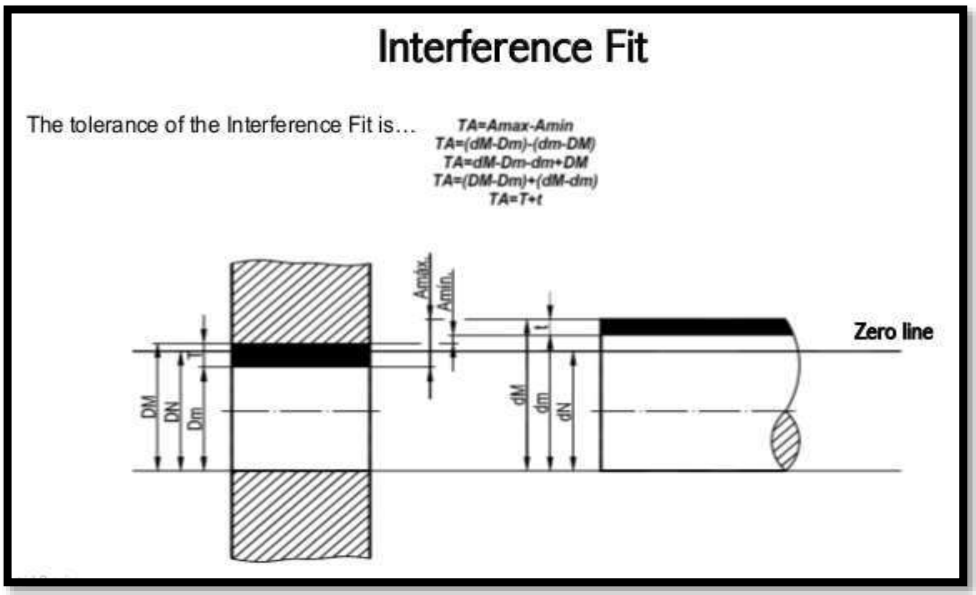
A reamer is a type of rotary cutting tool used in metalworking. Precision reamers are designed to enlarge the size of a previously formed hole by a small amount but with a high degree of accuracy to leave smooth sides. The process of enlarging the hole is called reaming.

Tolerance:

A tolerance is the extent by which a dimension is allowed to deviate from the nominal or basic size. If a nominal size of an object is 20.00mm with a tolerance of ±0.15 then the upper limit is 20.15mm and the lower limit is 19.85mm.

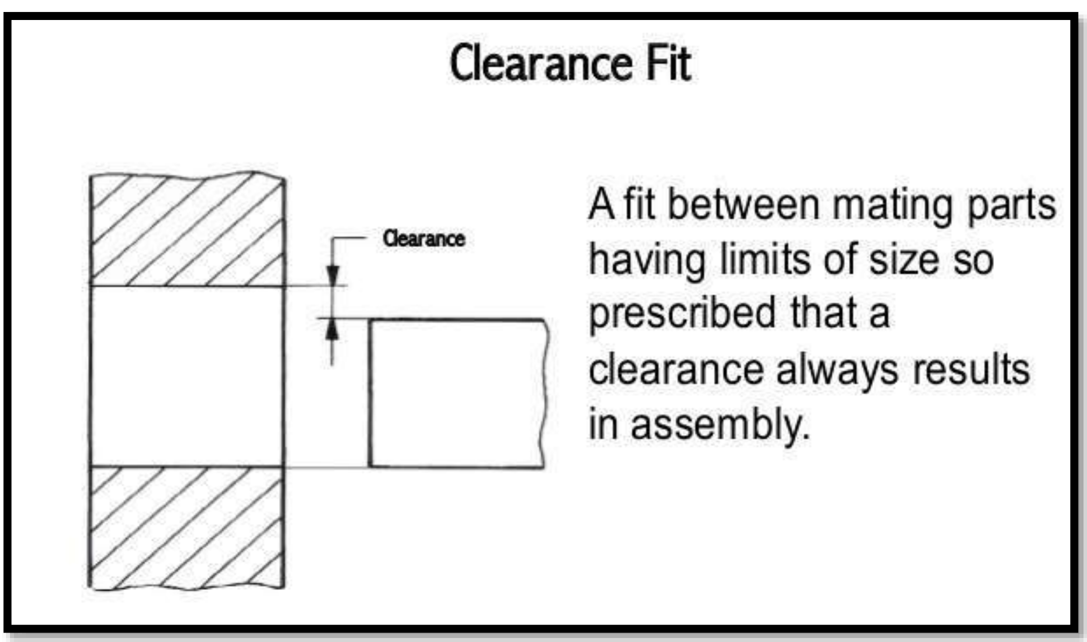
Interference Fit:

Interference fit has the shaft made larger than the part it is intended to fit. The parts will have to be forced together.



Clearance Fit:

Clearance fit has the shaft is smaller than the part it fits into, there is a space to allow the parts to fit together easily.



Q8 Mechanisms

- **Bevel Gears :**

These are used to transmit power at right angles from one rotating shaft to another shaft.

EXAMPLE :

***Woodwork hand drill*, hand whisk.**

- **Worm and Worm-wheel mechanism :**

The worm has one tooth in the form of a screw thread or spiral. When the worm makes one complete revolution, the worm wheel moves one tooth. For example, if there are 40 teeth on the worm wheel and to make the worm wheel complete one revolution, the worm would have to rotate 40 times.

EXAMPLE :

Lifts, cranes etc.

- **Ratchet :**

A ratchet is a wheel with specifically cut teeth. Ratchets are used in conjunction with a pawl. The mechanism only allows rotation in one direction unless the pawl is released.

EXAMPLE :

Seat belt, socket sets, fishing rod etc.

- **Vee Pulley and Vee Belt :**

This mechanism is used to transmit power from a motor to a spindle. It is very smooth running and slippage is prevented by the vee groove machined in the pulley.

EXAMPLE :

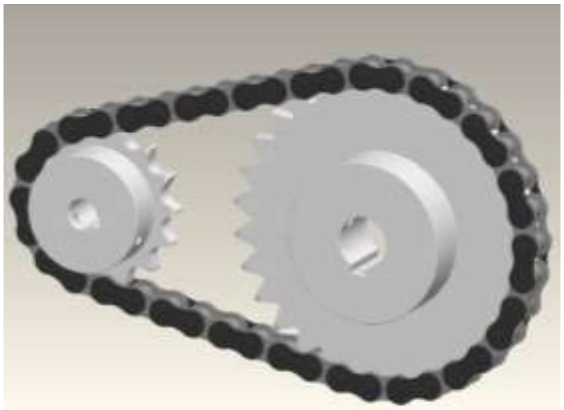
Cars belts, pillar drilling machines.

- **Chain and Sprocket :**

A *sprocket* (or *sprocket*-wheel) is a profiled wheel with teeth, or cogs, that mesh with a *chain*, track or other perforated or indented material. Slippage is prevented. This mechanism transmits rotary power.

EXAMPLE :

Bicycles / motorbikes



- **Toggle Mechanism :**

Used to create large clamping forces. Consists of two links joined to a common pivot point.

EXAMPLE :

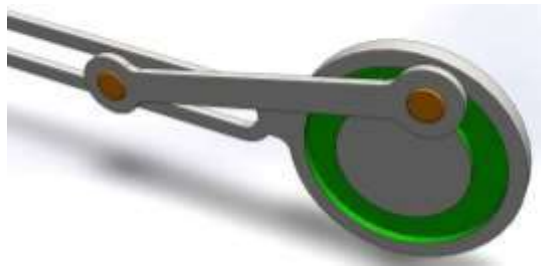
Locking systems in prams, vacuum forming machines, woodwork clamps etc.

- **Crank and Slider :**

These are used to convert rotary motion into reciprocating motion and vice versa. The connecting rod is used to convert these motions.

EXAMPLE :

Engine piston, power saw, etc.



- **Universal Joint :**

The universal joint allows one shaft to drive another shaft at various angles to each other.

EXAMPLE :

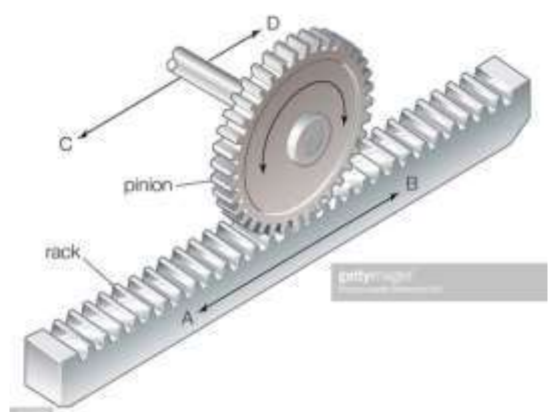
Driveshaft's, sockets, etc.

- **Rack and Pinion :**

A *rack and pinion* is a type of linear actuator that comprises a pair of gears which convert rotational motion into linear motion. When the pinion is attached to the feed lever is rotated the rack moves up and down lowering the spindle.

EXAMPLE :

Pillar drill, steering mechanism, etc.



- **Throttle Valve :**

These valves are used in pneumatic circuits. They restrict the flow of air.

- **Solenoid :**

These are electronic devices where a coil of wire is wound on a soft iron core. When the coil is energised a magnet force is induced by the current. This force will pull the iron core in towards the centre. A spring is used to return the iron core when it is switched off.

- **Clutch :**

A clutch is a mechanical device which engages and disengages power transmission especially from driving shaft to driven shaft.