Utilization of Electrical Energy

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Electric Welding

Welding

- Welding is a **process of joining two similar metals** by using heat

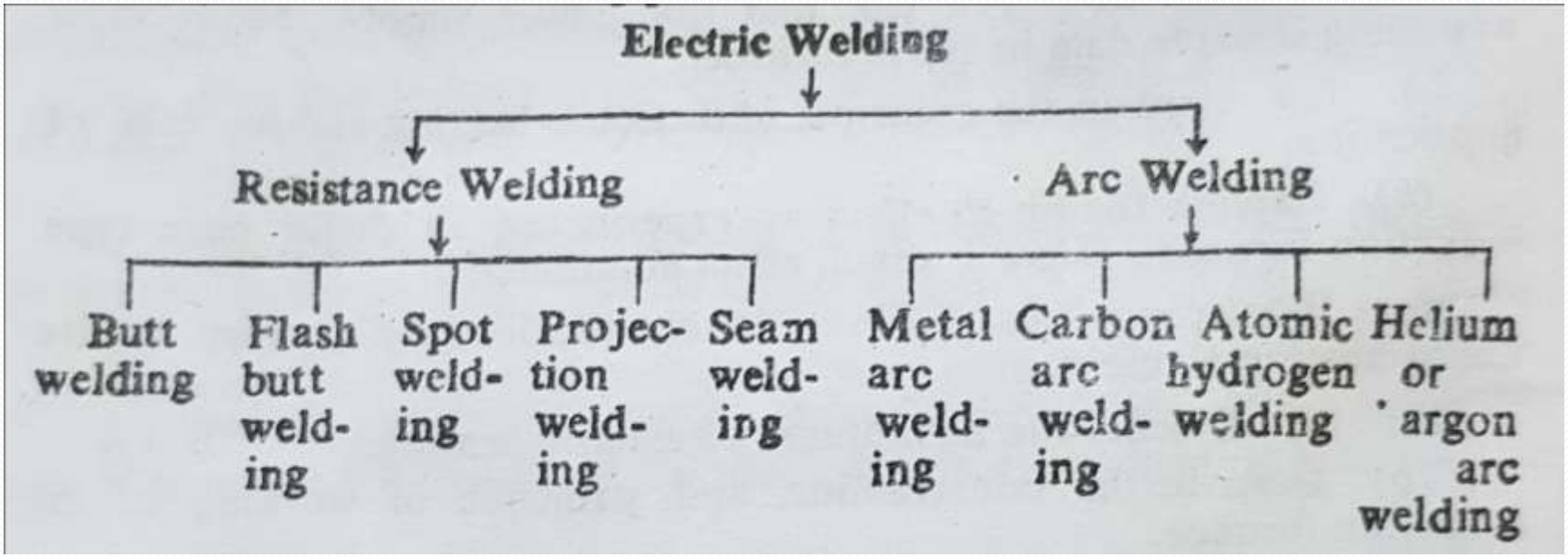
Advantages

- **Uniform weld** is obtained
- Greater mechanical **strength**
- Flexibility for doing welding work as welding equipment can be carried to remote place
- Electric weld does not produce smoke, ash, toxic gasses etc. So it **clean** from the welding
- **Efficient** and **economic** form of welding
- **Quick Operation**-Welding work can be started immediately when needed

Advantages

- **Ease of Control** –The welding current and hence temperature can be controlled easily

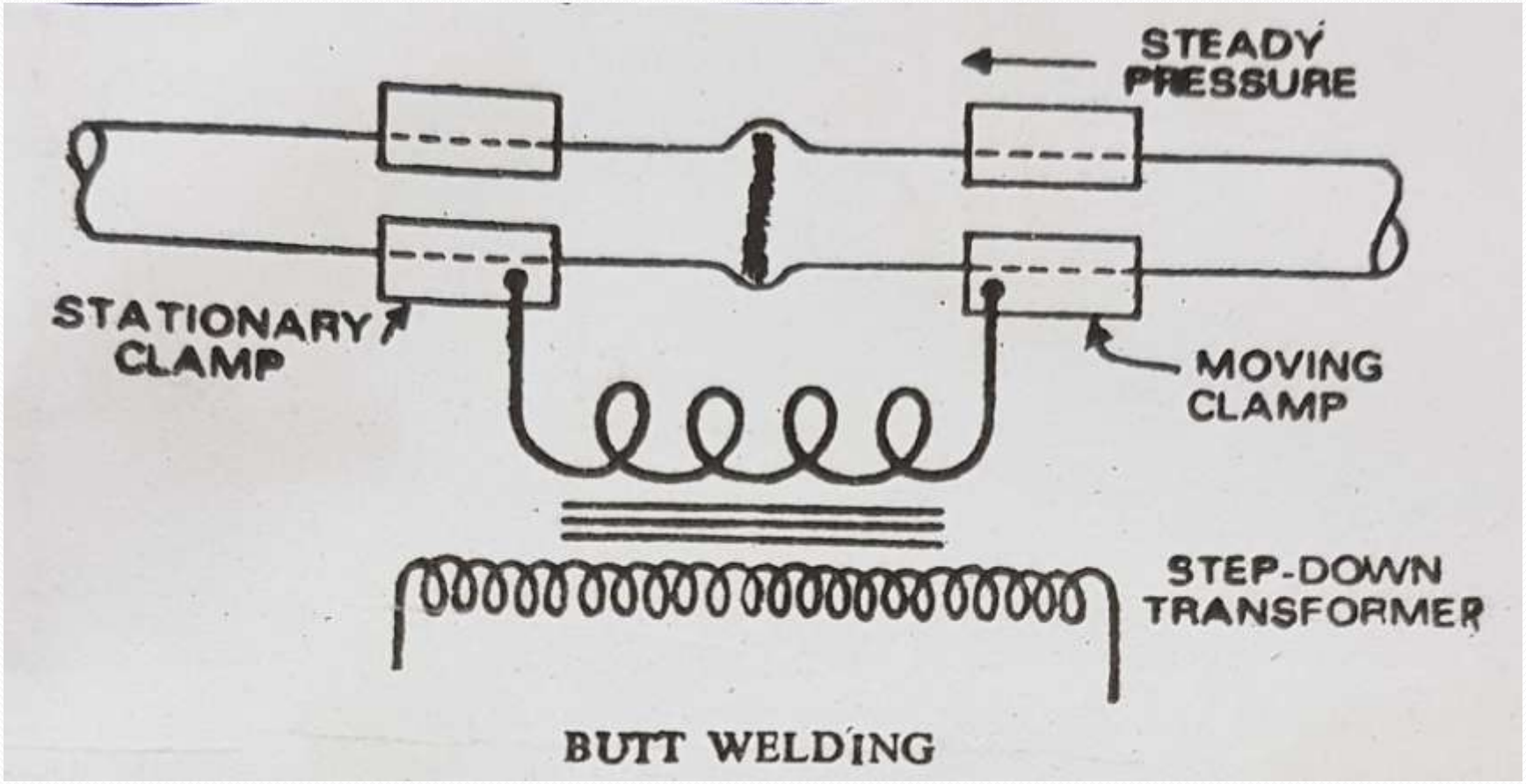
Electric Welding



Resistance Welding

- **Heavy current is passed** through the joint
- **Heat is produced** due to flow of current through joint
- **Metal is melted** due to heat and welding is performed

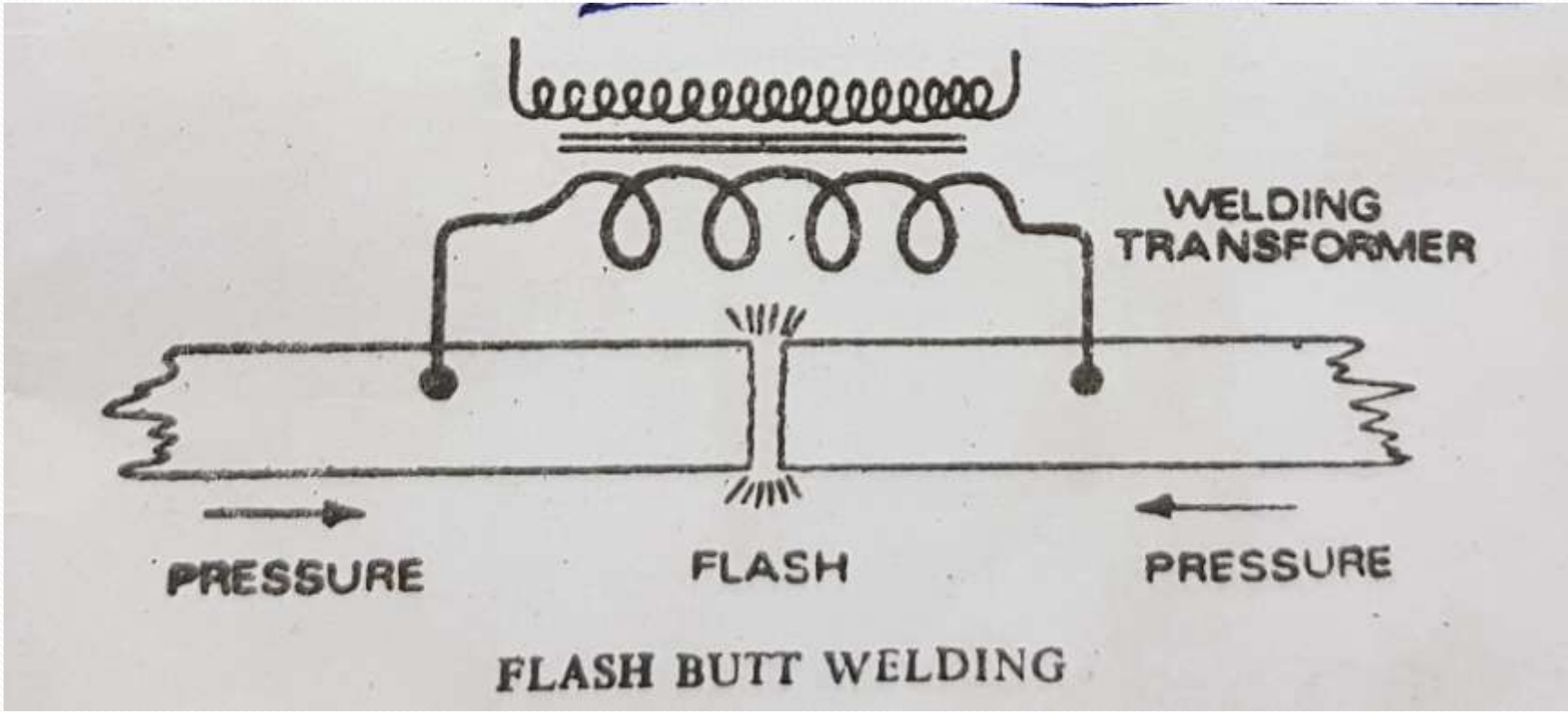
Butt Welding



Butt Welding

- The two **parts are brought together** and **pressure is applied** by using spring
- Voltage required is **2-10 volts**
- Current varies from **50 A to several 100 Amperes**

Flash Butt Welding

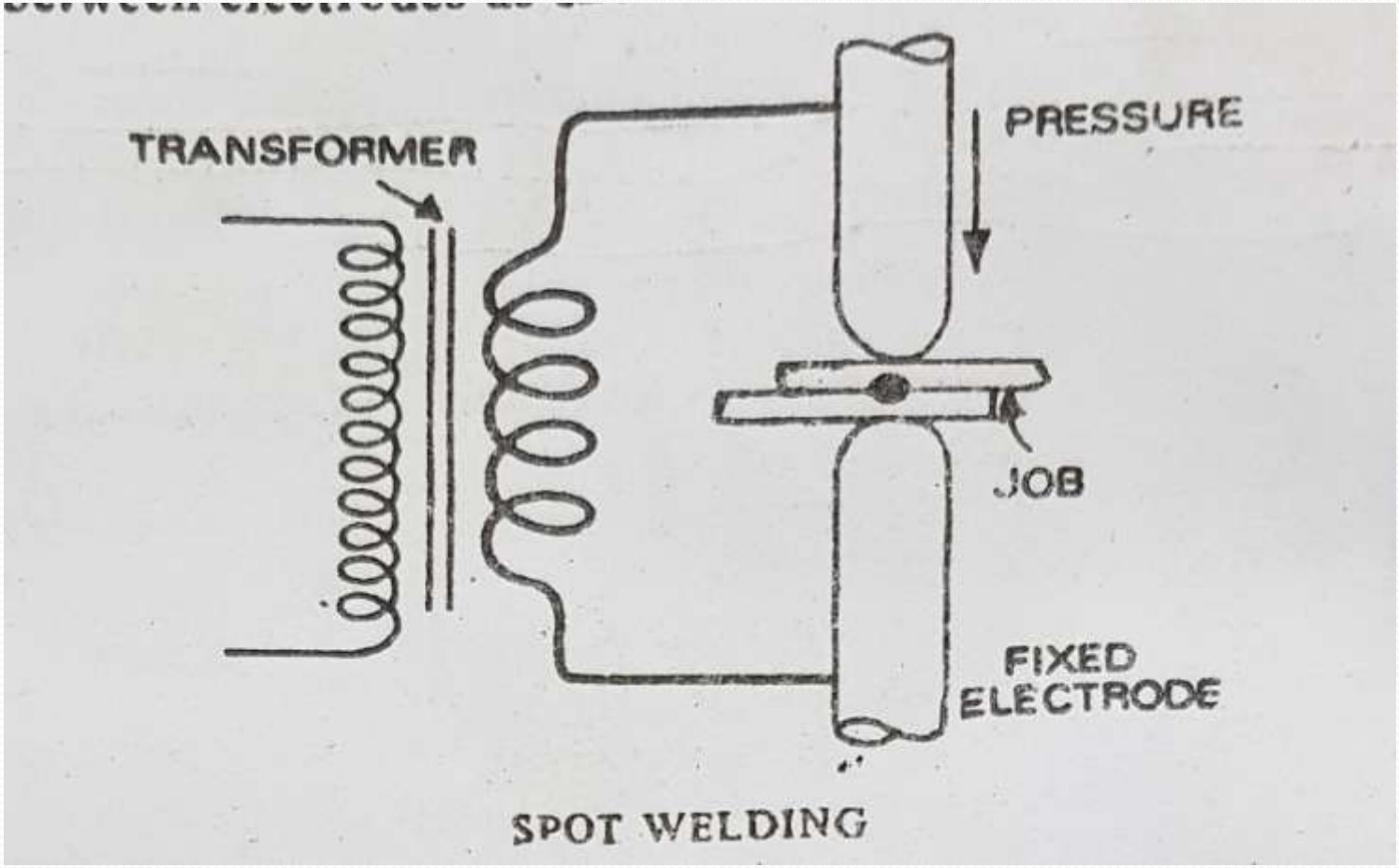


FLASH BUTT WELDING

Flash Butt Welding

- Two parts are **put together under light pressure**
- Due to heavy current, **arcing at joint takes place**
- After attaining desired temperature, **more pressure is applied**

Spot Welding

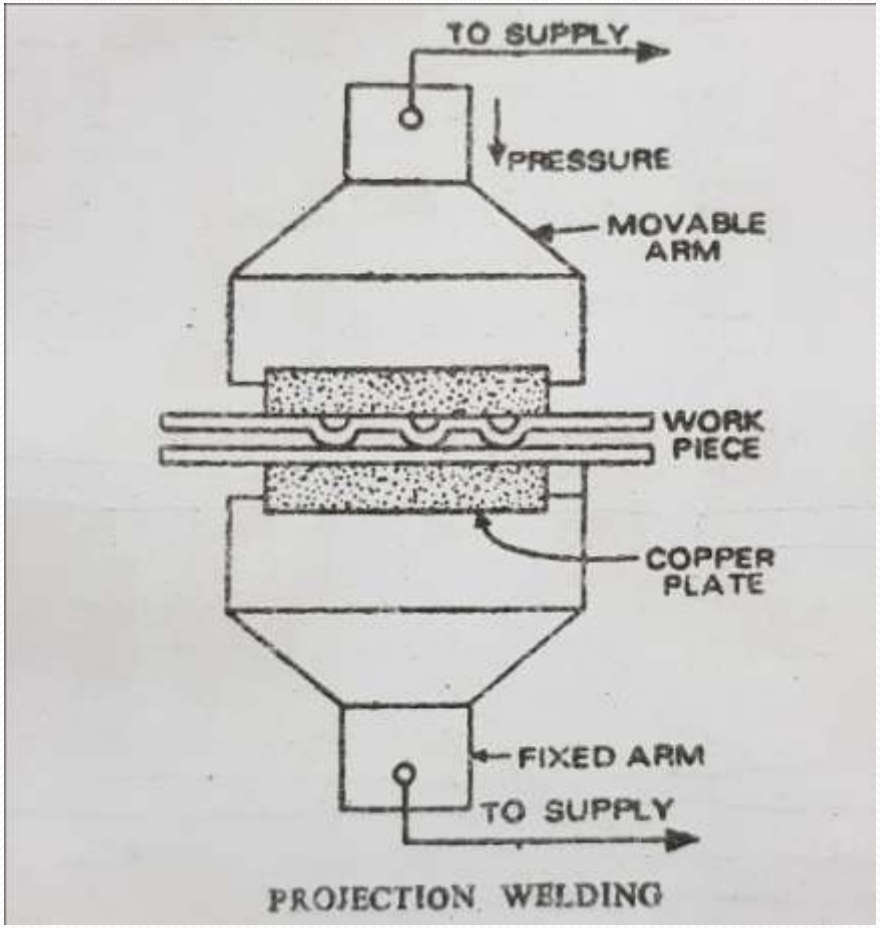


SPOT WELDING

Spot Welding

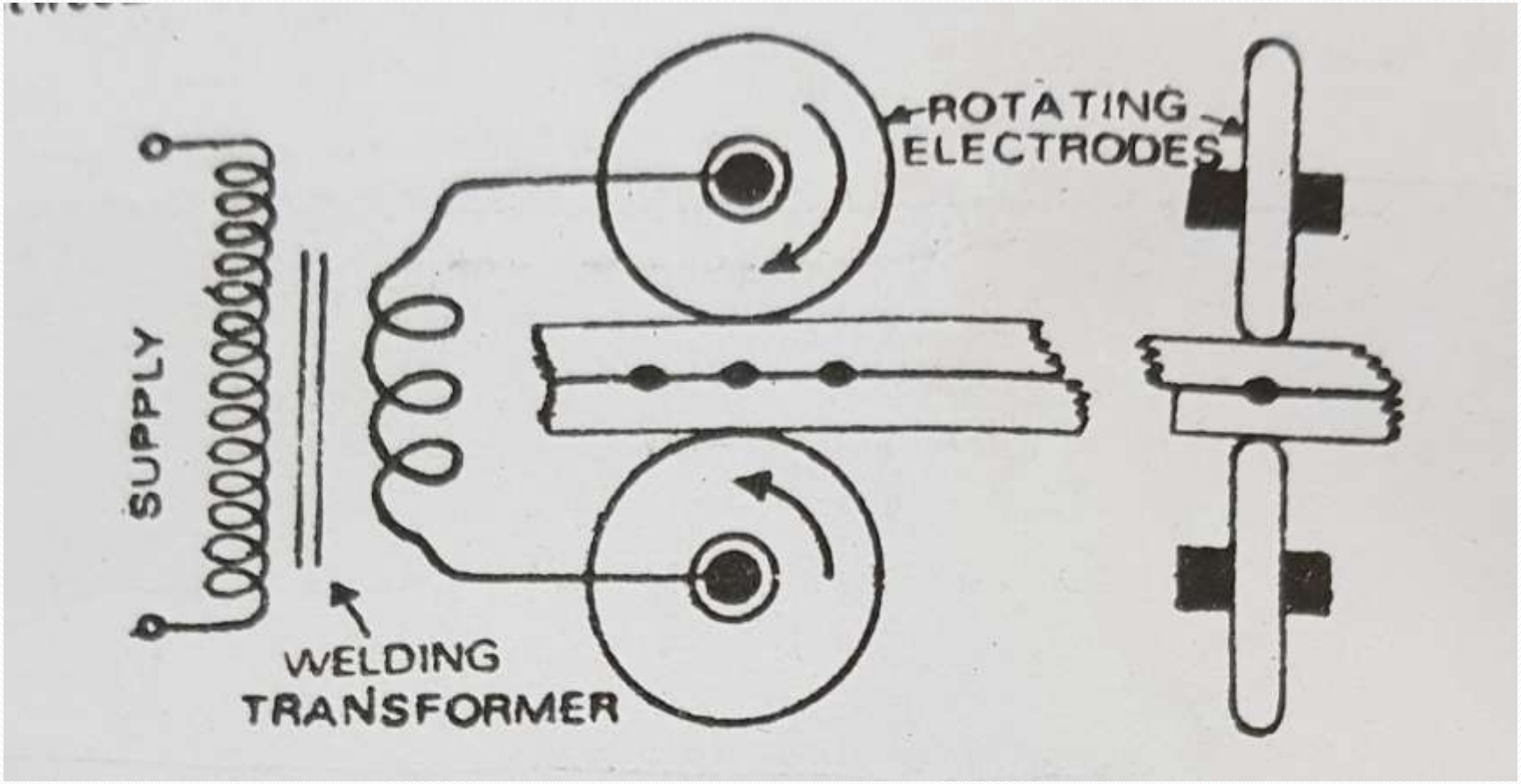
- Magnitude of **current depends upon the thickness and composition** of plates
- The current for spot welding may be from **1000 to 10000 Amp**
- The current may **flow for a fraction of second**
- Used for manufacture of **Automobiles, Refrigerators and other metal stamping** assemblies

Projection Welding

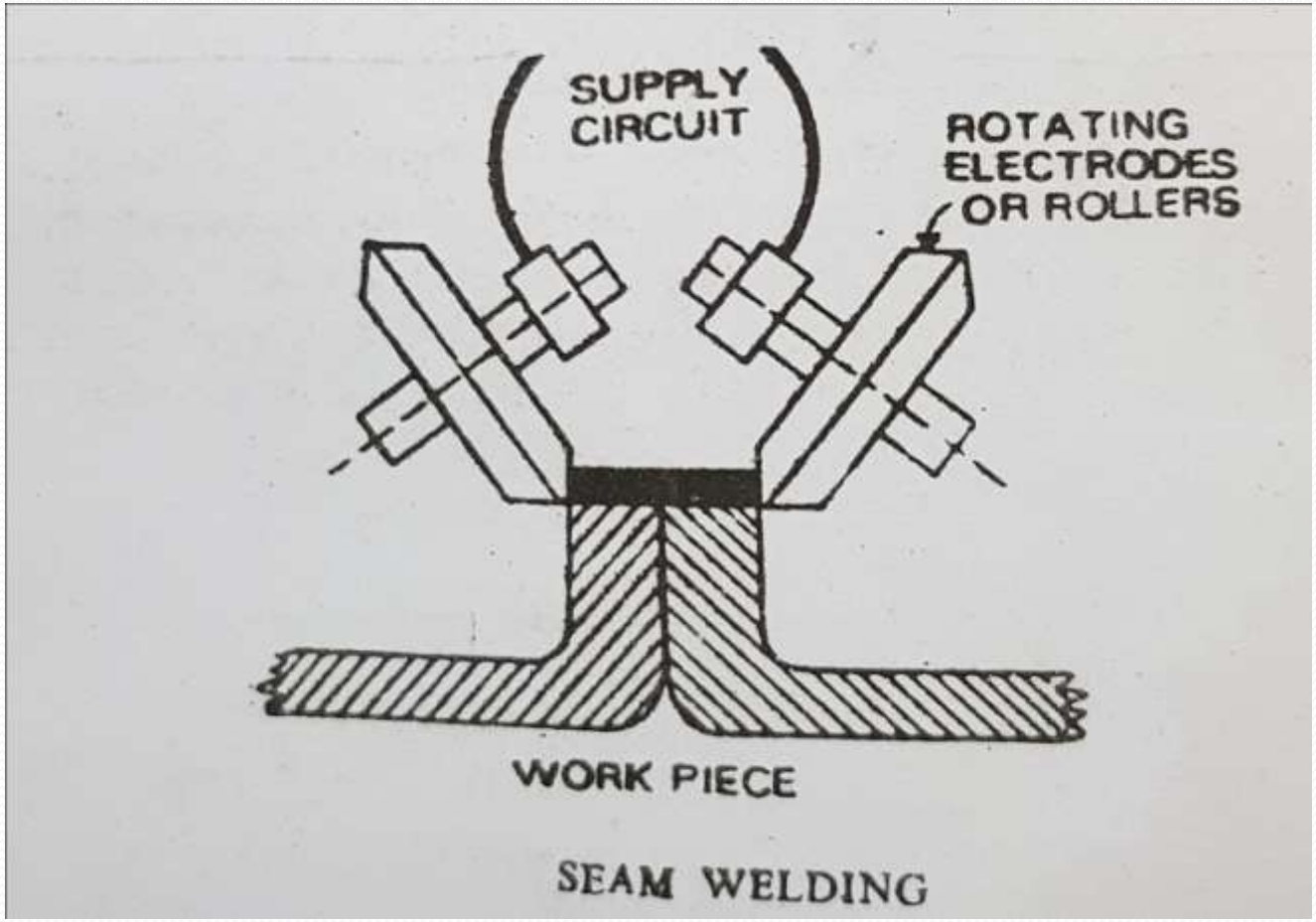


PROJECTION WELDING

Seam Welding



Seam Welding



Seam Welding

- Principle is **similar to spot welding**
- Difference is that **Wheels or Roller types electrodes are used**
- Speed of roller is **4-5 m per min**

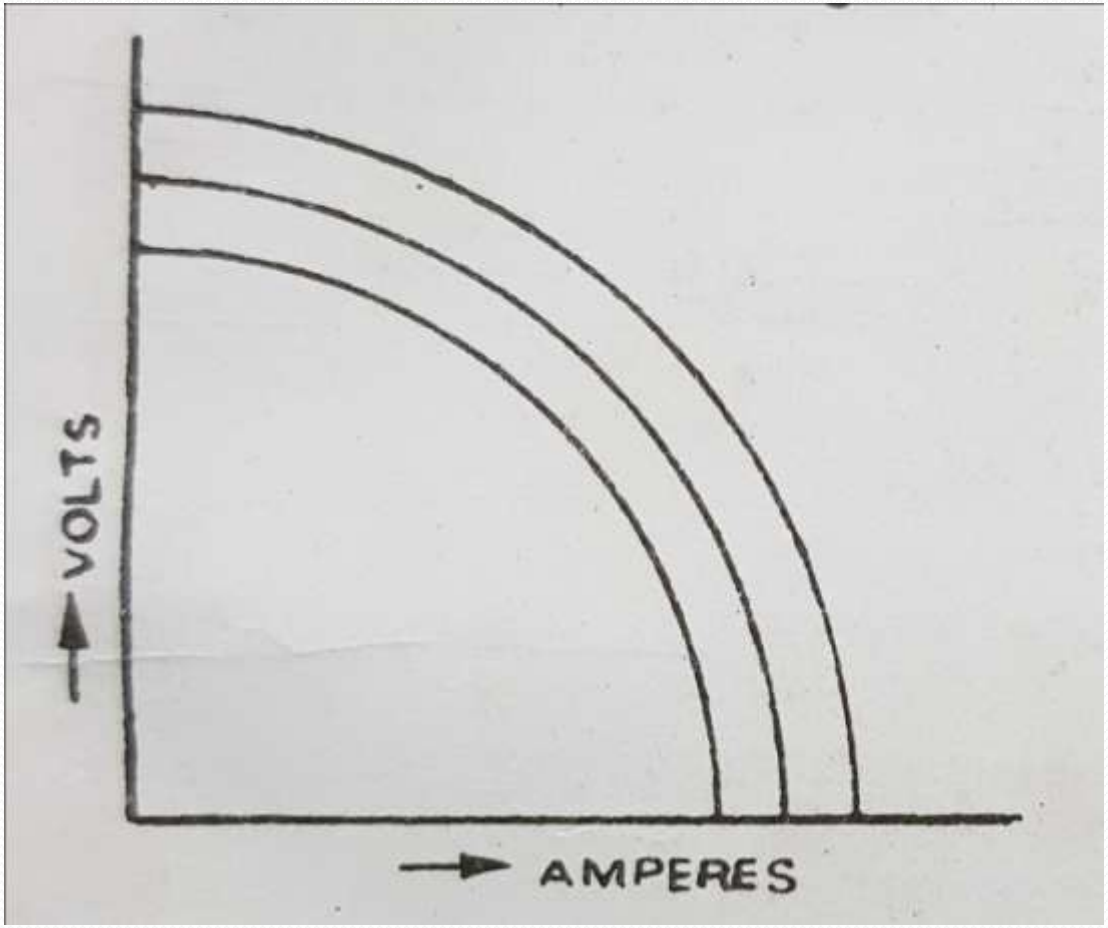
Arc Welding

- Arc welding is done by using heat of the **arc produced between an electrode and work piece** or **between two electrodes**
- The arc is struck by **ionizing the air between the electrodes**
- Due to resistance of ionized air and heavy current, **high temperatures are obtained**
- The arc has **negative temperature coefficient** of resistance

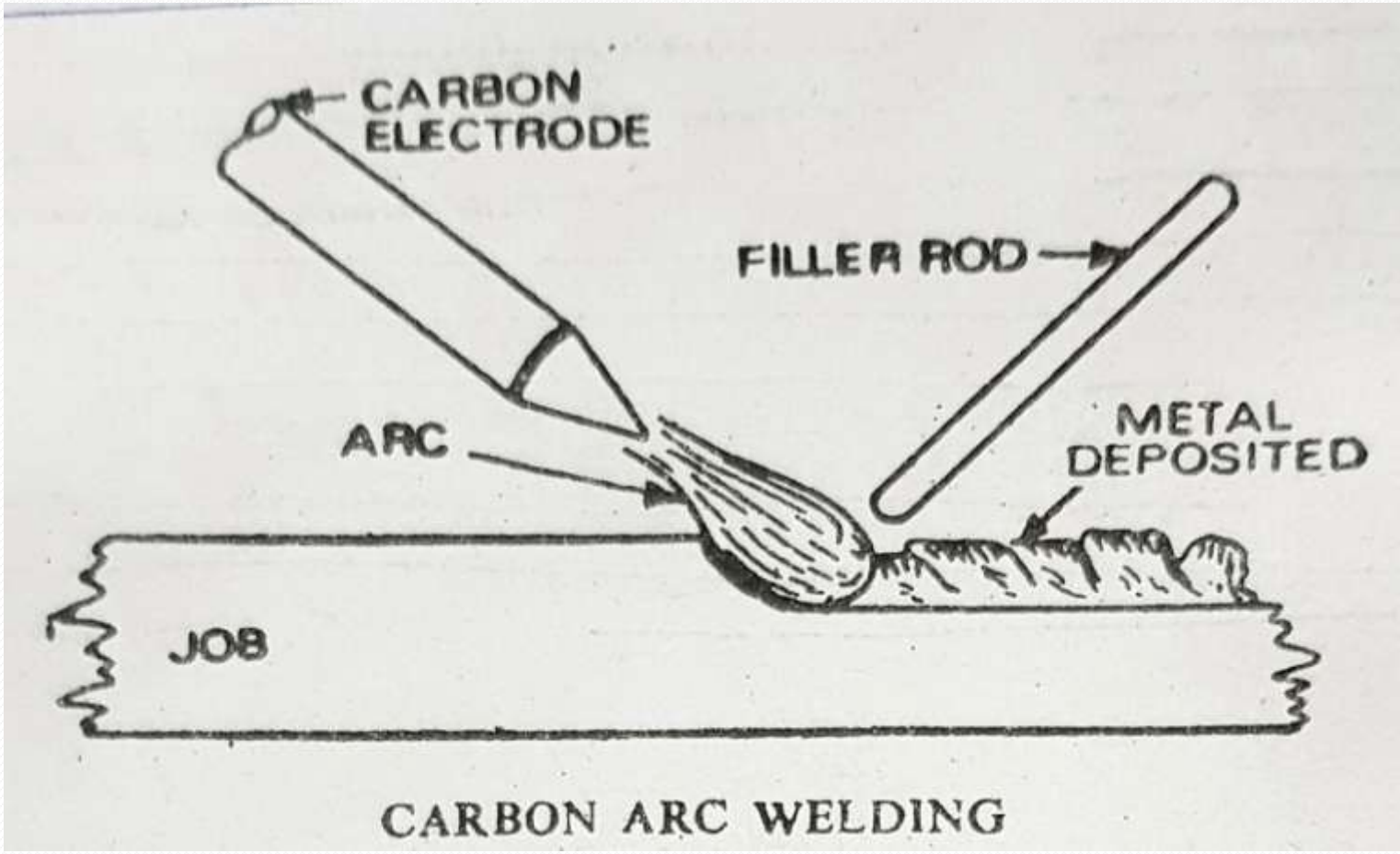
Arc Welding

- To stabilize the arc, either **stabilizing resistance or reactance** is used or **high leakage reactance transformer** is used
- The open circuit voltage supplied to the arc should not exceed about **60V for DC and 100V for AC** otherwise there will be danger of shock to the operator
- Widely used for **joining the metal parts, repair of fractured casting** etc.

Source Characteristics for Arc Welding



Carbon Arc Welding

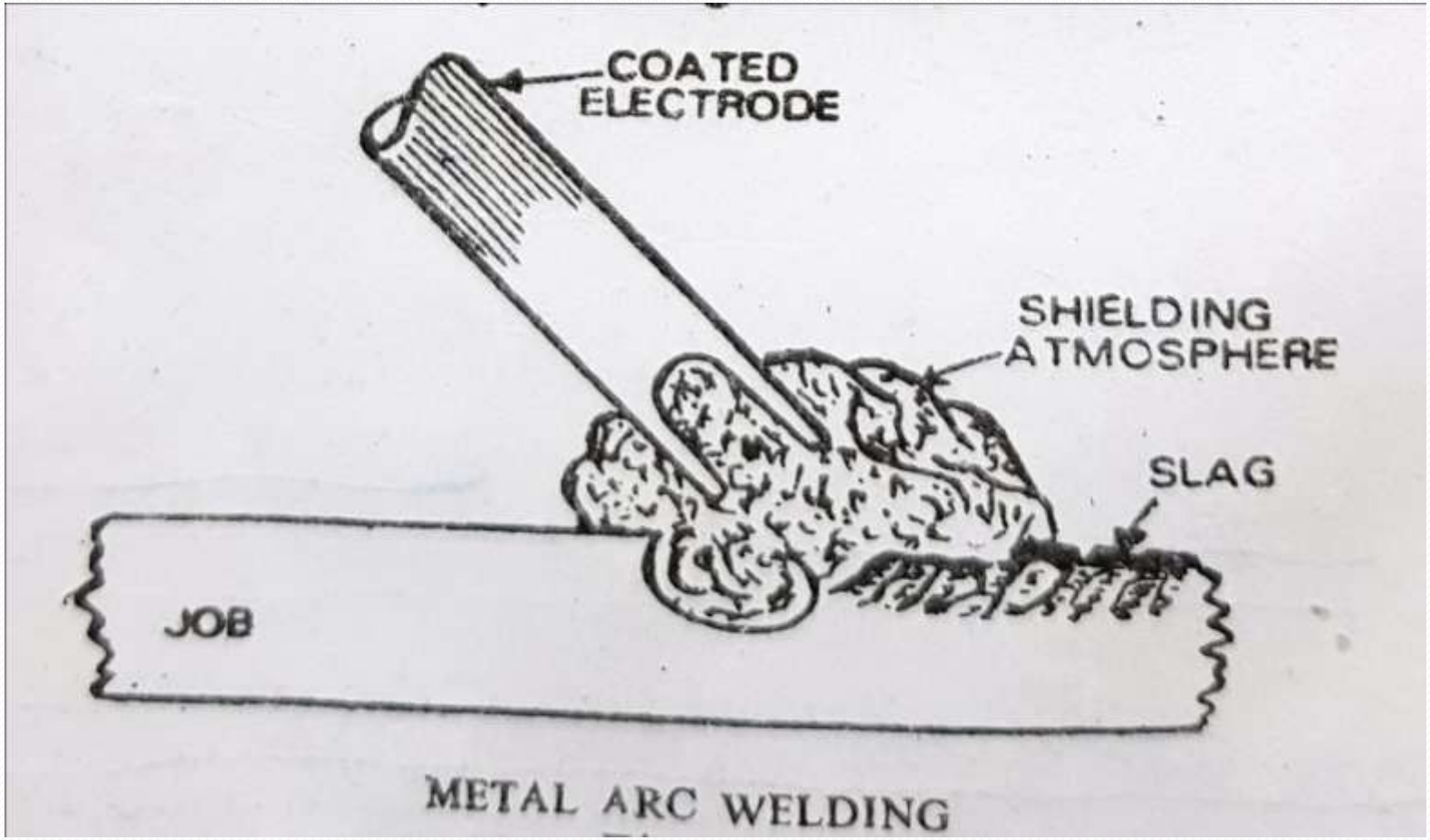


CARBON ARC WELDING

Carbon Arc Welding

- Arc is struck between **carbon electrode** & job
- When additional metal is required, a **filler rod** is used
- **Filler rod melts** in the joint
- **Carbon particles** from the electrodes **reduce the oxidation** effect of atmospheric oxygen
- **Used for** welding of **non ferrous metals** such as brass, copper and their alloys

Metal Arc Welding



METAL ARC WELDING

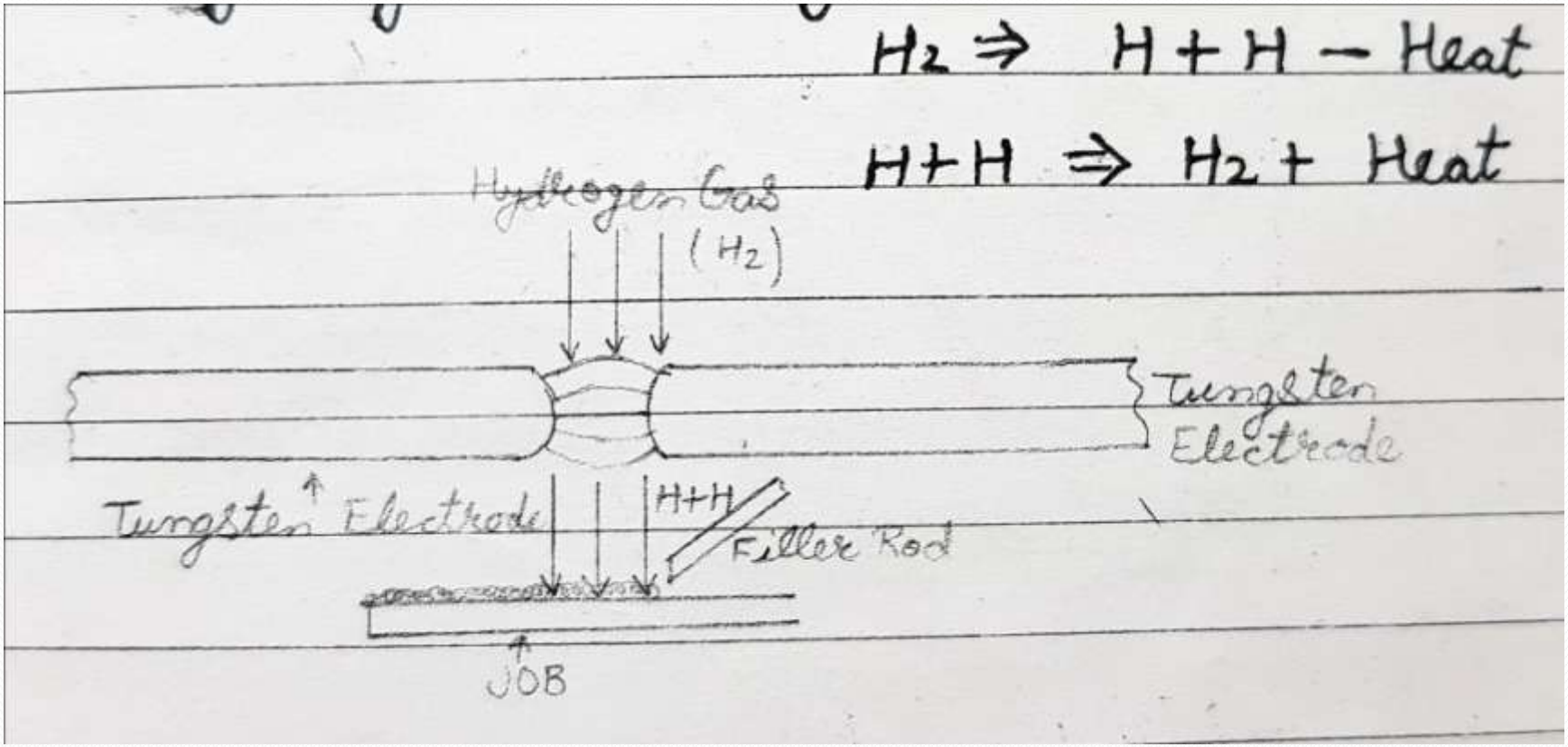
Metal Arc Welding

- **Metal electrodes** are used
- Electrodes may be **bare or coated** with flux
- **Coated electrodes** are used for **better quality & good strength**
- **Shielding** of joint from atmosphere is achieved from the gas which is produced a result of **decomposition of the flux** coated on electrode
- **Slag** left behind the electrode covers the weld and is allowed to remain for sometime in order that the joint **cool down gradually**

Atomic Hydrogen Welding

- Arc is struck between two **tungsten electrodes & hydrogen gas is passed** through the arc
- Due to high temperature, **hydrogen breaks up** in to atomic form
- In this process, it **takes up a lot of heat** from the arc
- **H_2 => H + H – Heat**
- The atoms of hydrogen have a great tendency to **recombine** to form hydrogen molecules
- Sufficient **heat is liberated** which welds the job
- **H = H => H_2 + Heat**

Atomic Hydrogen Welding



Gas Shielded Arc Welding

- Arc is struck between a **consumable or non consumable electrode** and job in an atmosphere of some inert gas like organ or helium
- The inert **gas shields the weld pool** and the electrode from the atmosphere
- When electrode is non consumable, the process is known as **TIG Welding** i.e. Tungsten arc Inert gas Welding
- The non consumable electrode is of **Tungsten**

Gas Shielded Arc Welding

- The other process is known as **MIG Welding** i.e. Metal arc Inert Gas welding
- In this the electrode is in the form of a **wire fed from a coil**

Electric Welding Equipment

- Basic requirement of welding equipment is that the **voltage of source should be high in open circuit** to struck the arc
- This voltage is around **50 to 60 volts in case of D.C.** and between **70 to 100 volts in case of A.C**.
- A voltage of **20 to 30V** is needed to **maintain** the arc

D.C. Welding Equipment

- Generally **motor generator set** is used
- The motor is **squirrel cage I.M.** and generator is **differential compound**, which gives dropping characteristics

A.C Welding Equipment

- This uses a **transformer** which reduces the voltage from that of supply mains to about **100 volts**
- To get **dropping** characteristics, a series **resistance** or **reactance** may be used
- The **resistance** reduces the **efficiency** of system
- The **reactance** reduce the **power factor**
- **Reactance** is preferred
- The open circuit voltage of welding T/F ranges from **80 to 100 volts** at nearly **0.35 lagging P.F.**

Advantages of Coated Electrodes

- When metals come in molten state, these have a tendency to **absorb oxygen and nitrogen** to form oxides and nitrites
- This makes the weld **brittle**
- This difficulty is overcome by using the **flux coated electrodes**
- The flux has certain compound which break up in the arc and gives a harmless **atmosphere of carbon monoxide**
- It **keeps away the oxygen and nitrogen** from the arc

Advantages of Coated Electrodes

- The flux melts with the metal and provides a protective coating of **slag**
- Being lighter, it **floats on the molten metal**
- It serves as a **cover** for solidifying weld metal
- It cools down uniformly thus **avoiding** any tendency of **cracking**
- Flux also **stabilizes** the arc

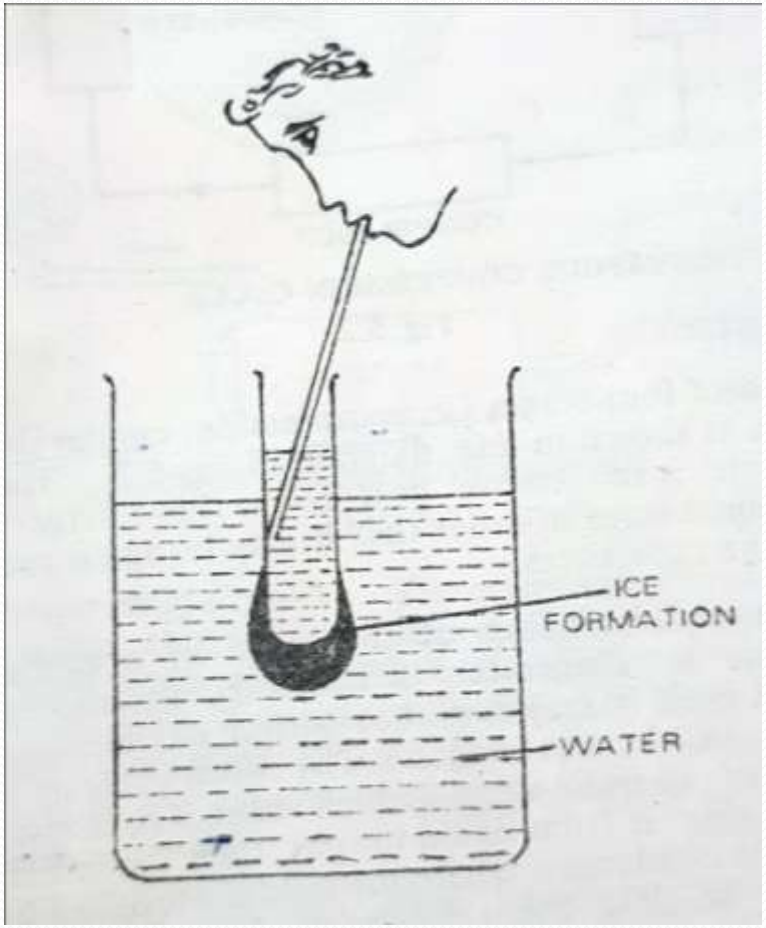
Welding Of Cu and Al

- Generally **TIG** welding is used
- Copper and aluminium are very **good conductors**
- The current **rating** of equipment should be **high** enough so that the required temperature is obtained for welding

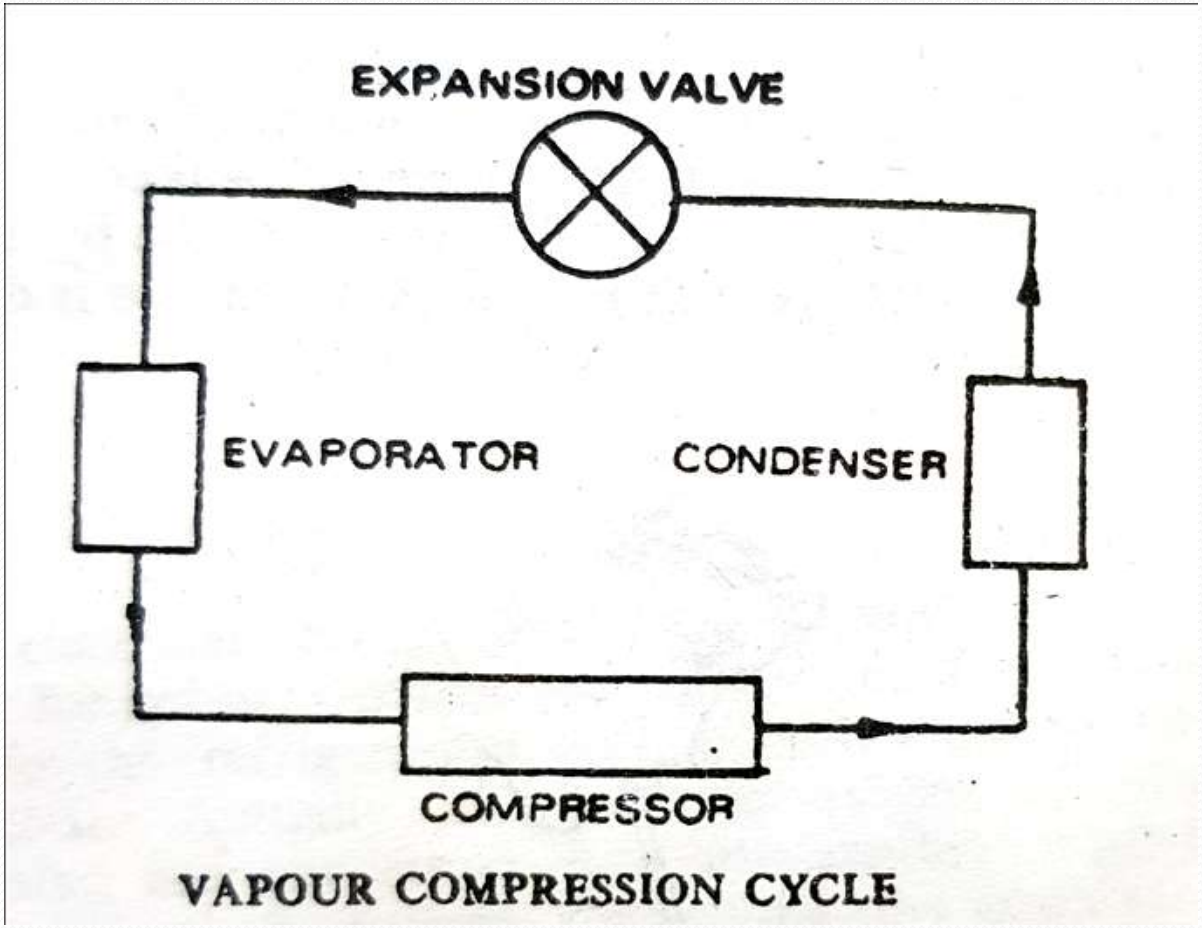
Electrical Circuits of Refrigerator, Air Conditioner and Water Cooler

- The process of reducing the temperature of a body from the general level of temperature of the surroundings is called refrigeration
- Works on the principle of cooling caused by evaporation

Refrigeration

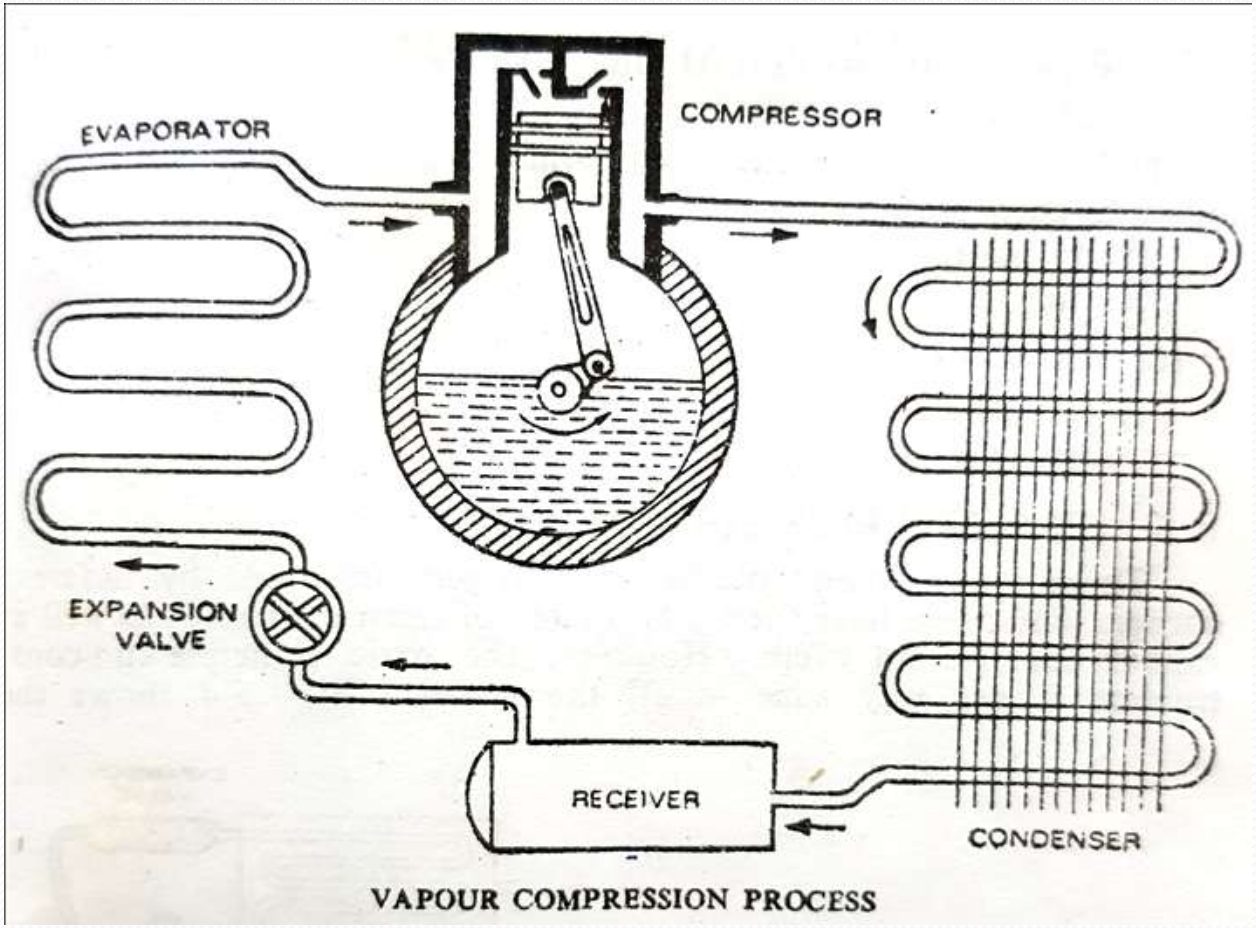


Vapour Compression Cycle



VAPOUR COMPRESSION CYCLE

Vapour Compression Cycle



VAPOUR COMPRESSION PROCESS

Vapourising Process

- Before entering the evaporator, the refrigerant is in liquid state
- It absorbs heat from the material to be refrigerated
- It is transformed from liquid to vapour state
- The process is called **Evaporation**

Compression Process

- Compressor draws the vapours from the evaporator
- It compresses the vapours until their temperature is raised above that of condensing medium
- The process is called **Compression**

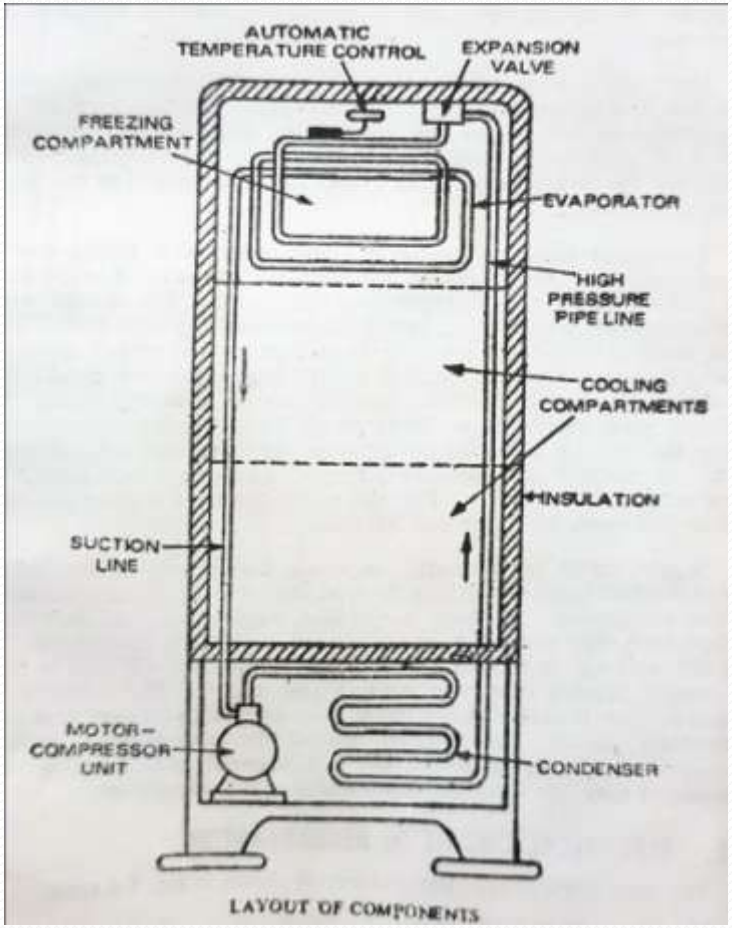
Condensing Process

- As the temperature is raised, the heat of vapourisation will flow from vapours to condensing medium
- It condenses the refrigerant to high pressure liquid
- This high pressure liquid flows to receiver, where it is stored until it is supplied to cooling unit through the expansion valve
- This process is completed in condenser

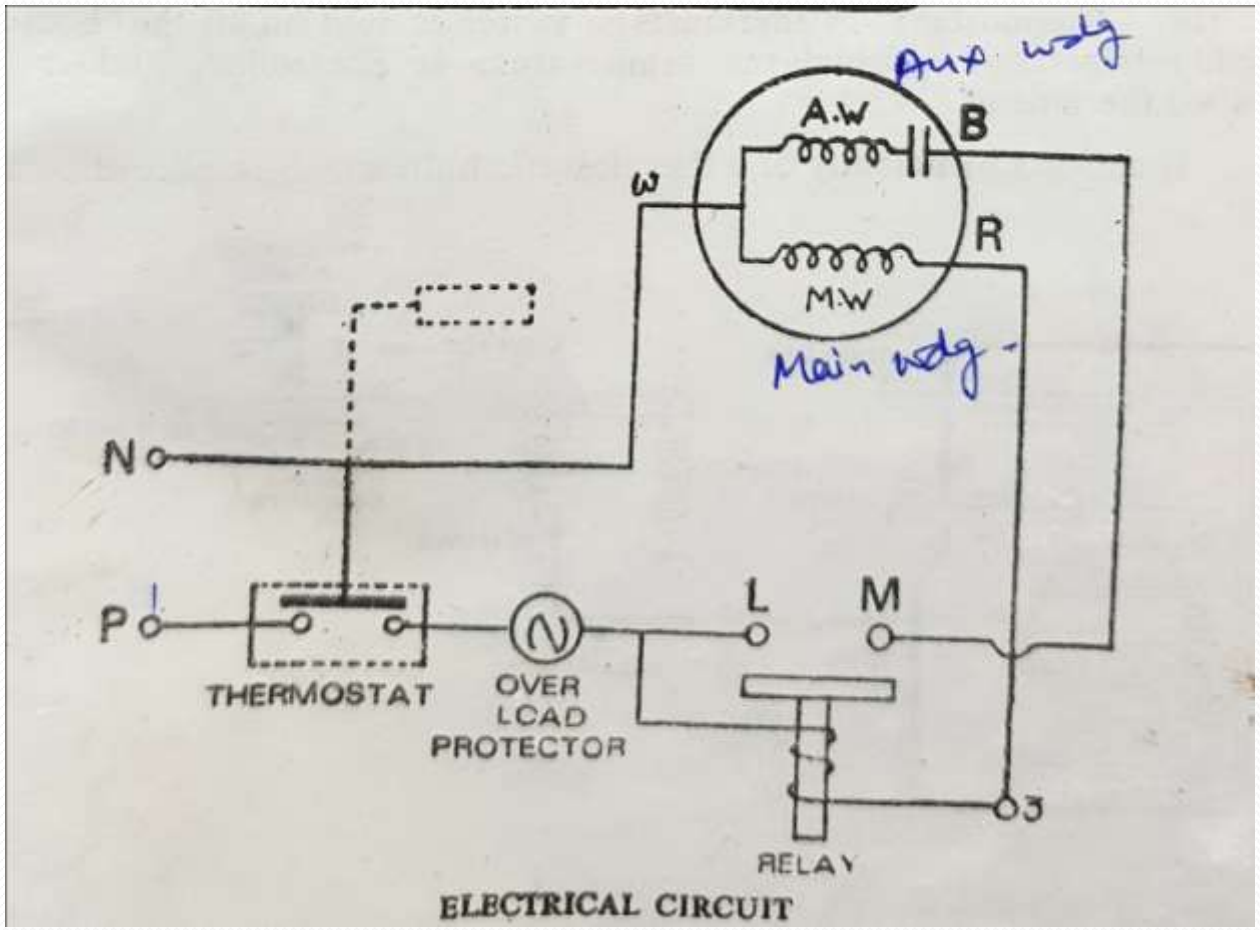
Pressure reducing process

- The expansion valve reduces the pressure of high pressure liquid from the receiver to a low pressure liquid capable of absorbing heat
- The process is called expansion

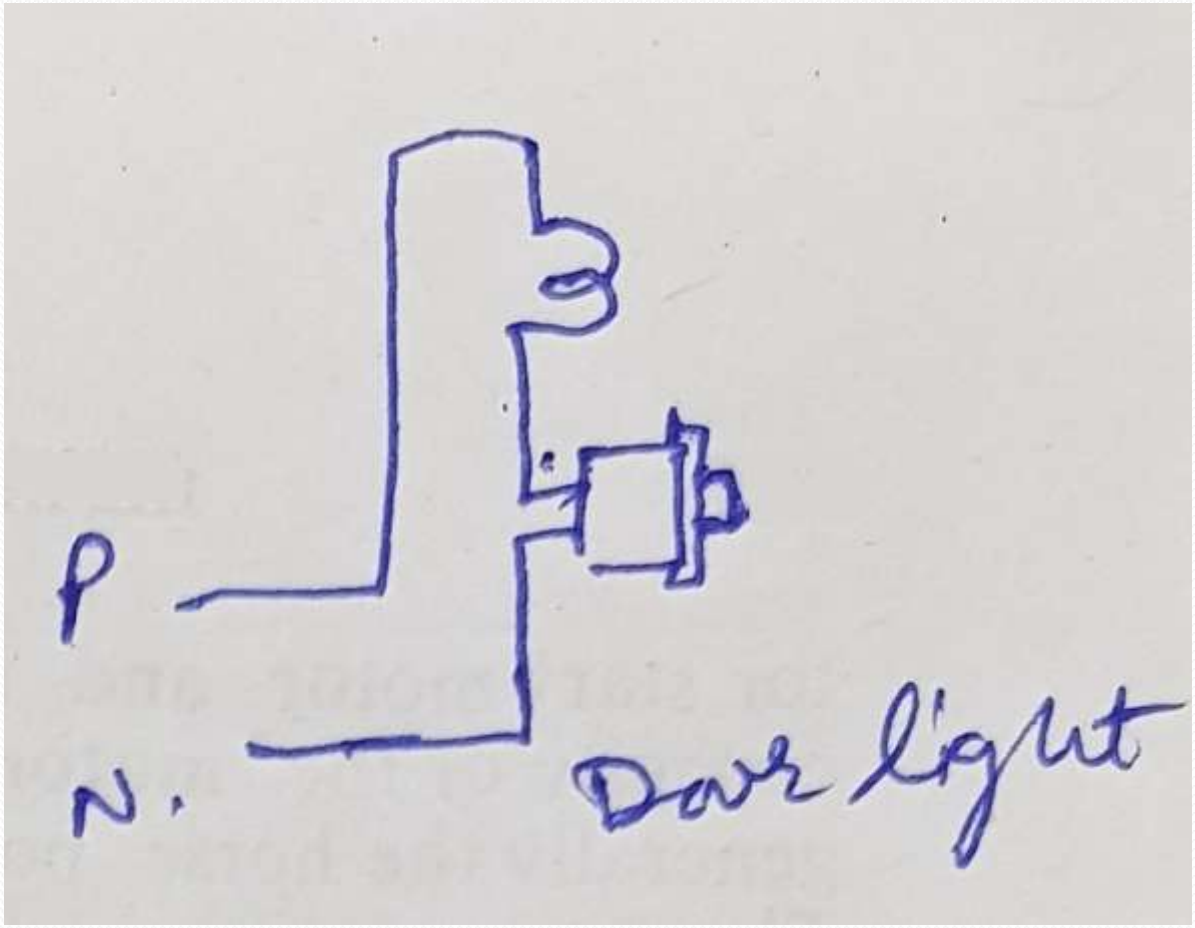
Refrigerator



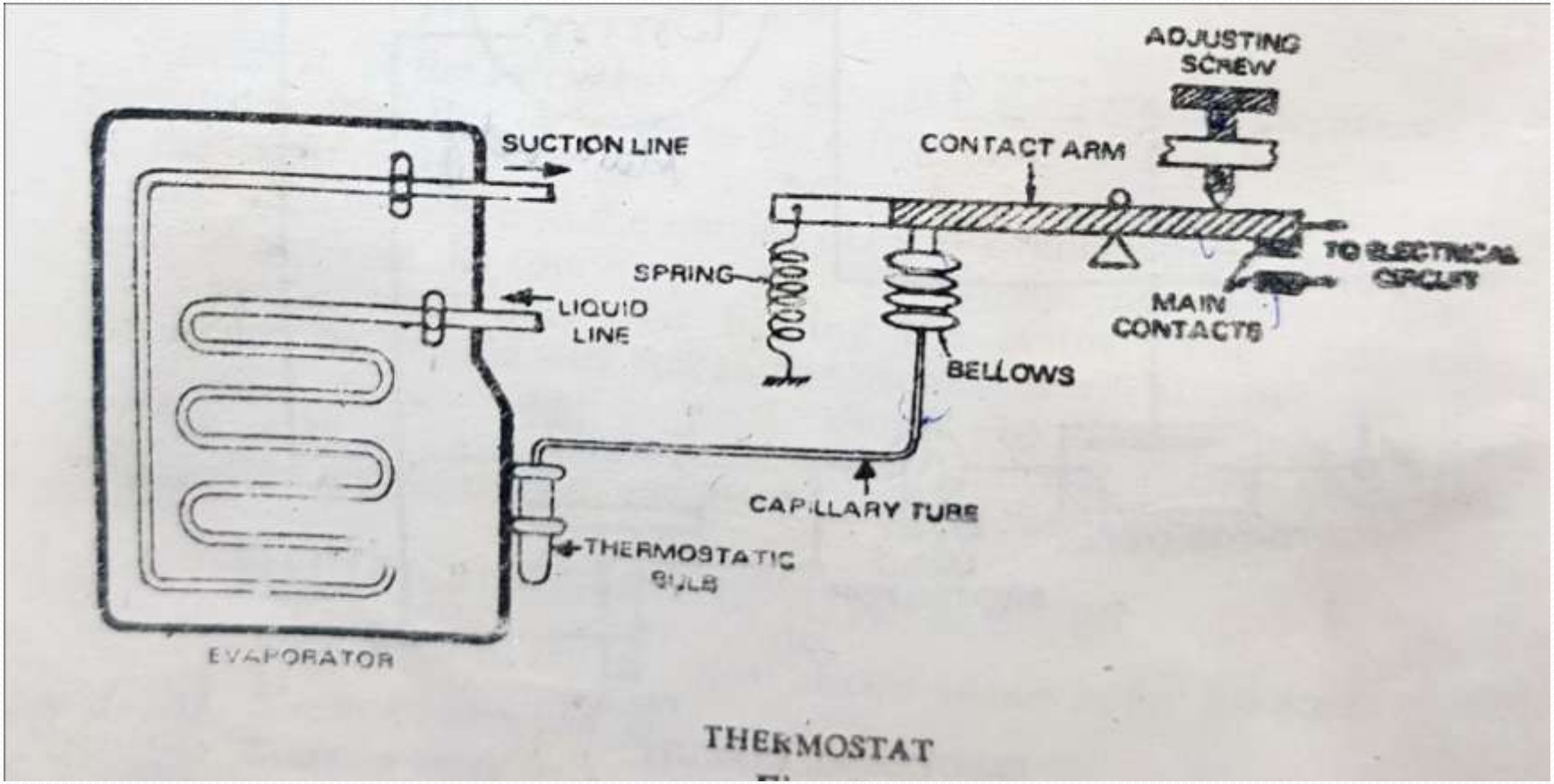
Electrical Circuit of Refrigerator



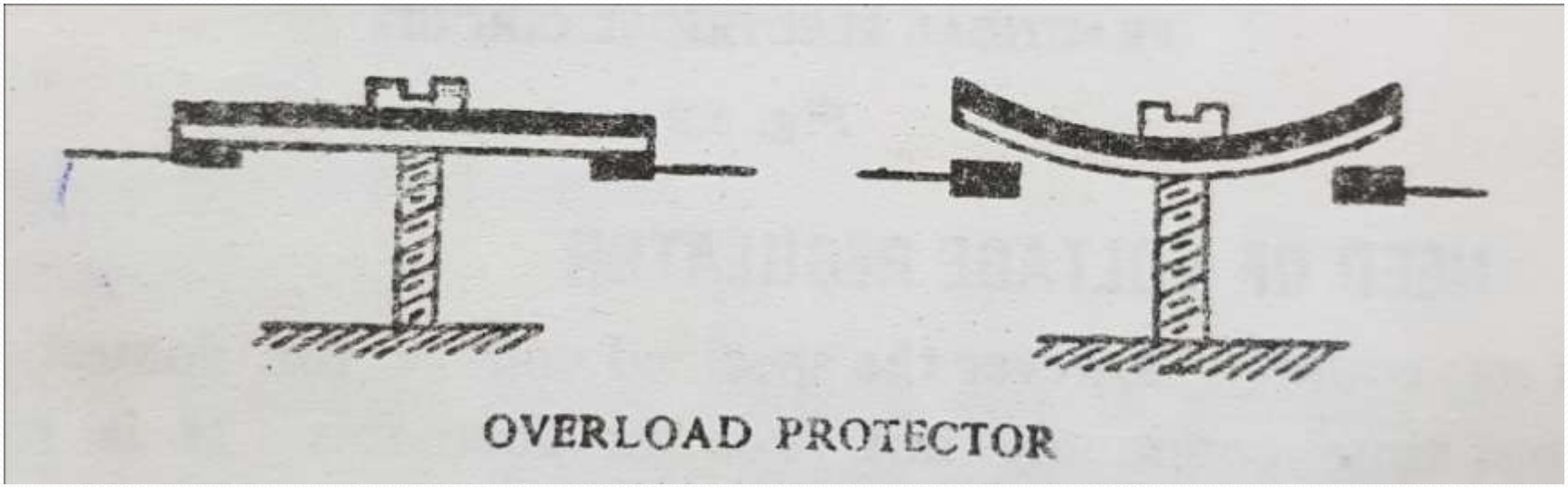
Electrical Circuit of Refrigerator



Thermostat


ADJUSTING SCREW
SUCTION LINE
CONTACT ARM
SPRING
LIQUID LINE
TO ELECTRICAL CIRCUIT
MAIN CONTACTS
BELLOWS
CAPILLARY TUBE
THERMOSTATIC BULB
EVAPORATOR
THERMOSTAT

Overload Protector

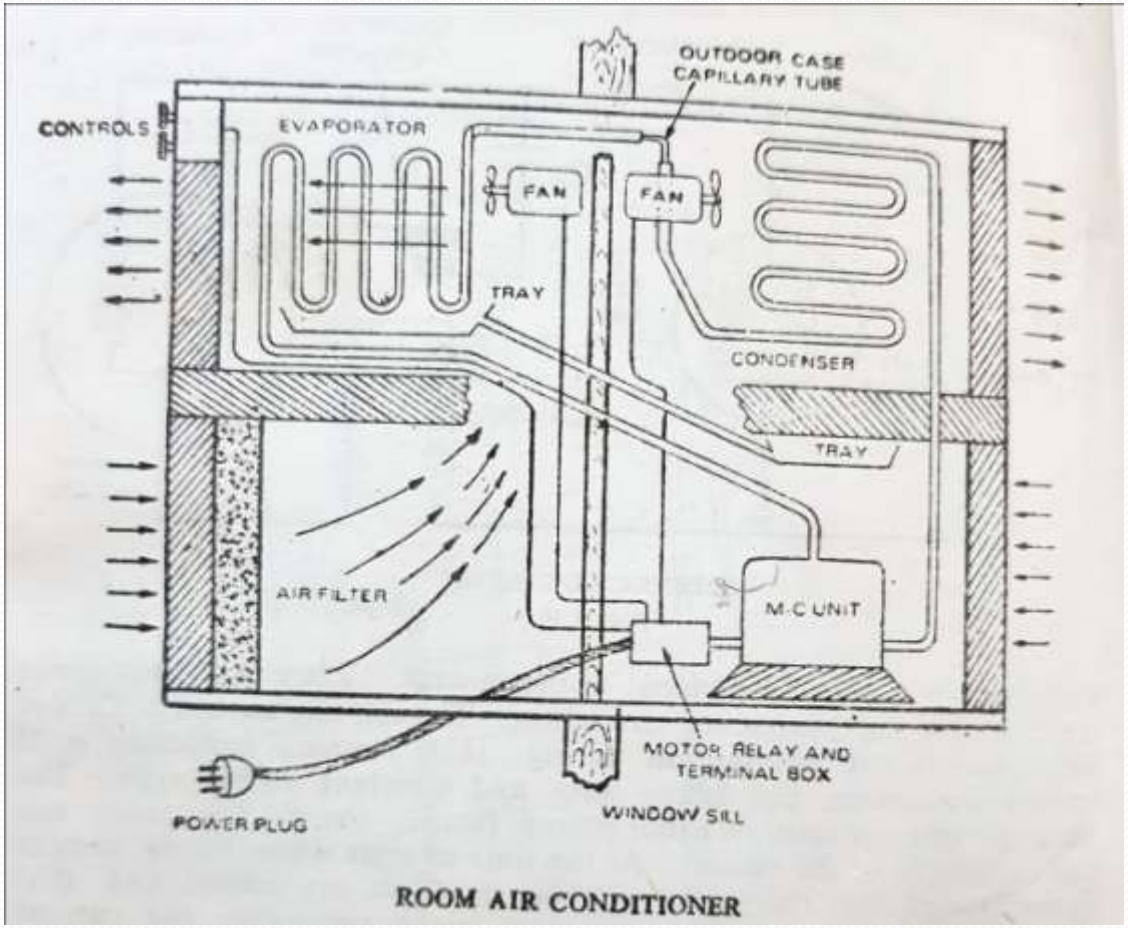


OVERLOAD PROTECTOR

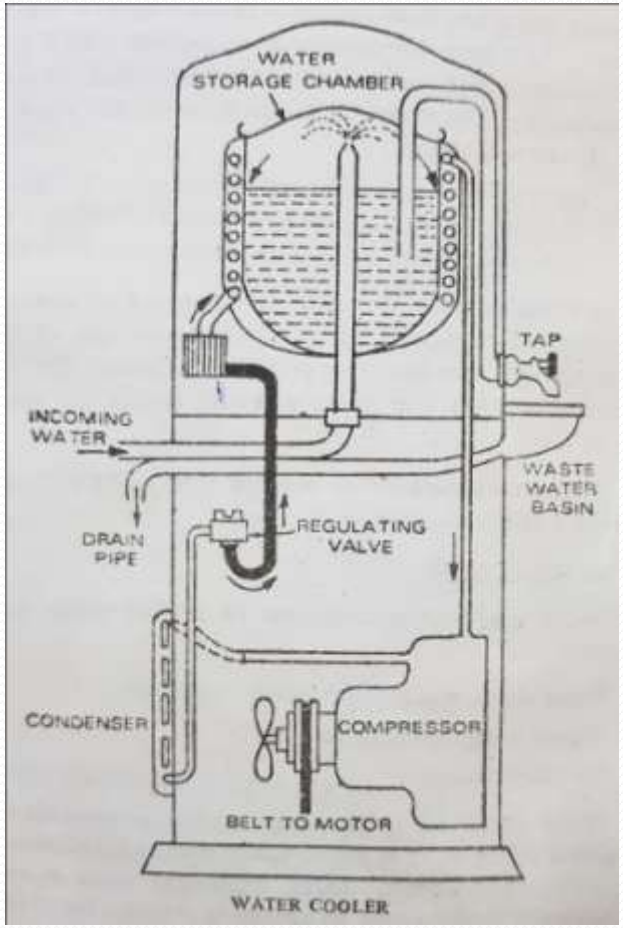
Air Conditioner

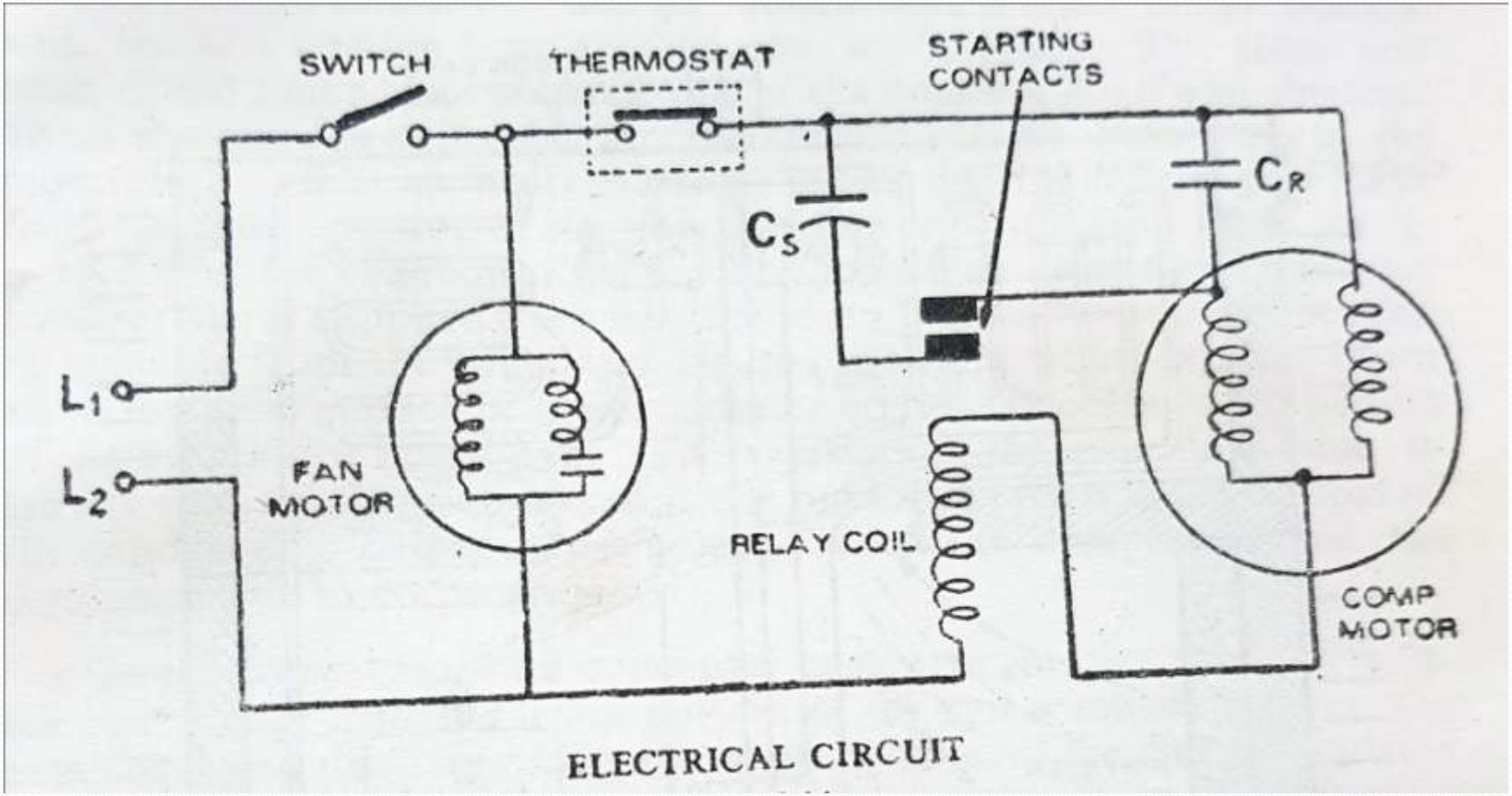
- It involves control of **Temperature, Humidity, Purity and movement of Air**
- Working conditions and comfort for human being is improved
- Air, after necessary control and adjustment is circulated throughout the building
- Humidity is maintained at about 60%, being most suitable for human beings

Air Conditioner



Water Cooler





ELECTRICAL CIRCUIT

Electric Traction

Advantages

- **Cleanest** System
- Only **suitable method for underground system**
- **Higher Acceleration** and **quick breaking**
- Electric Locomotive require **less maintenance**
- Electric Locomotive **can be put into service immediately**
- Electric **motors provide continuos torque**, so less vibrations
- **Electric breaking** is **superior** than mechanical breaking

Advantages

- **Speed control** is better
- **Separate generator not required** for lighting and fans
- Most **economical** in high traffic density areas

Systems of Electric Traction

- **DC System**
  - DC **Series motors** are used
  - Voltage rating is **600V for sub urban** railway
  - Voltage rating is **1500V – 3000V for main line** railway
  - Motor receive power from overhead line through **pentograph**
  - **Steel track** is used as **return conductor**

Systems of Electric Traction

- **3Ø AC System**
  - **3Ø slip ring induction** motors are used
  - **Rotor resistance and pole changing** methods are used for speed control
  - **Regenerative breaking** is immediately obtained as speed exceeds the synchronous speed
  - Operating voltage is about **3600V at** $16\,^{2}/_{3}$ **Hz**
  - **Two overhead conductors** are required, **third being rail** itself. Therefore rarely used.

Systems of Electric Traction

- **1Ø standard frequency system**
  - Single overhead wire at **25 KV, 50Hz** is used
  - A **transformer** is mounted on locomotive
  - The supply is **stepped down, rectified**, and supplied to traction motors

Systems of Electric Traction

- **1Ø low frequency system**
  - **1Ø ac series motors** are used
  - Due to **commutation problems**, **low frequency** is used
  - **15KV at** $16\,^{2}/_{3}$ **Hz, 11KV at 25 Hz** supply is used
  - Transformer is used to **step down voltage to 400V**

Systems of Electric Traction

- **1Ø to 3Ø system**
  - Locomotive carries a **phase converter**
  - It converts **1Ø to 3Ø AC**
  - 3Ø AC is supplied to **3Ø Induction Motors**
  - **16000V at 50Hz** is used

Categories of Railway Service

- **City Service**
  - **Distance of stops** is of the **order of a kilometre**
  - **High rate of acceleration** and **breaking** is required to maintain the **scheduled speed**

Categories of Railway Service

- **Suburban Service**
  - Distance between **stops** is about **5-6 kilometre**
  - **High rate of acceleration** and **breaking** is required

Categories of Railway Service

- **Main line service**
  - Distance between **stops** is about **20 to 40Km**
  - Operating **speeds are high**
  - **Acceleration and breaking are not much important**

Speed-Time Curve for Main Line Service

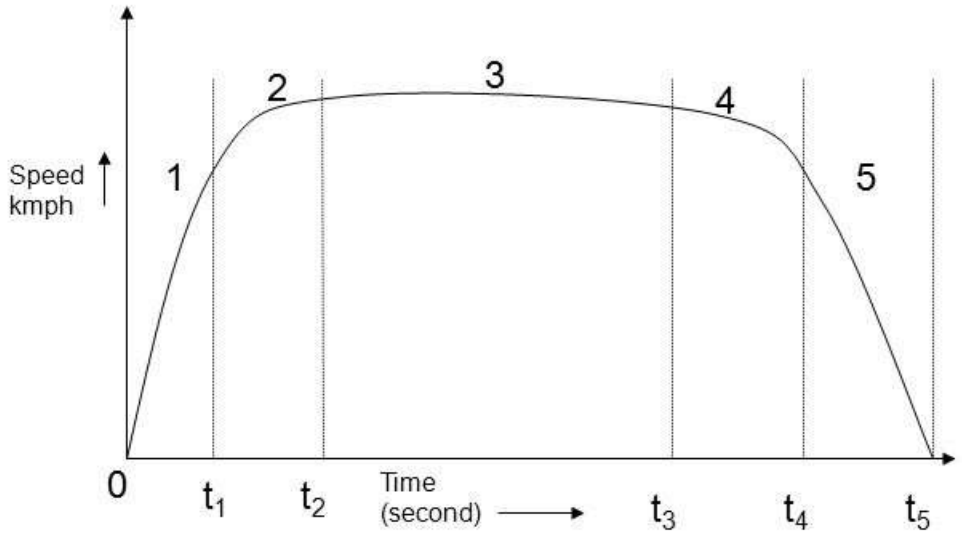


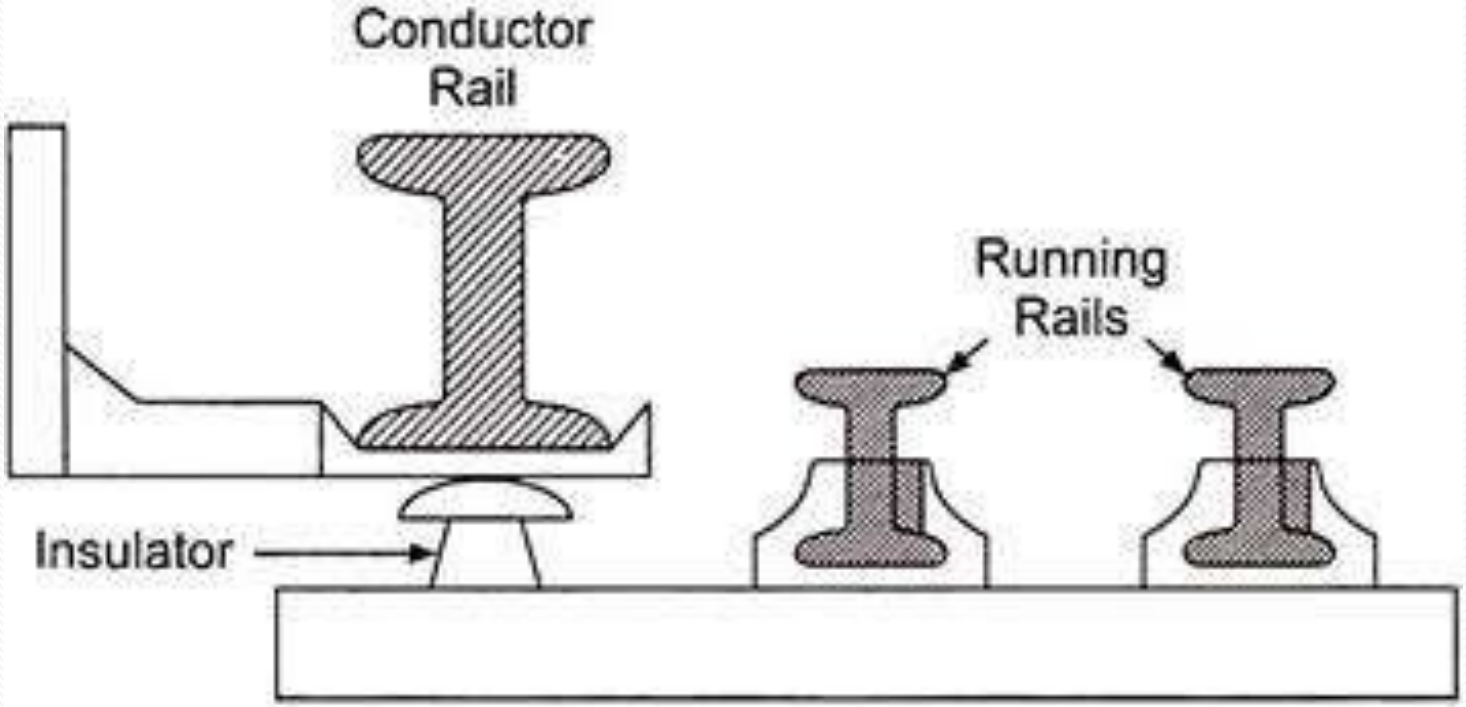
Fig.1

1. Notching up or Rheostatic acceleration.
2. Acceleration on speed curve.
3. Free running curve
4. Coasting or coasting retardation curve.
5. Braking curve.

Accessories for Track Electrification

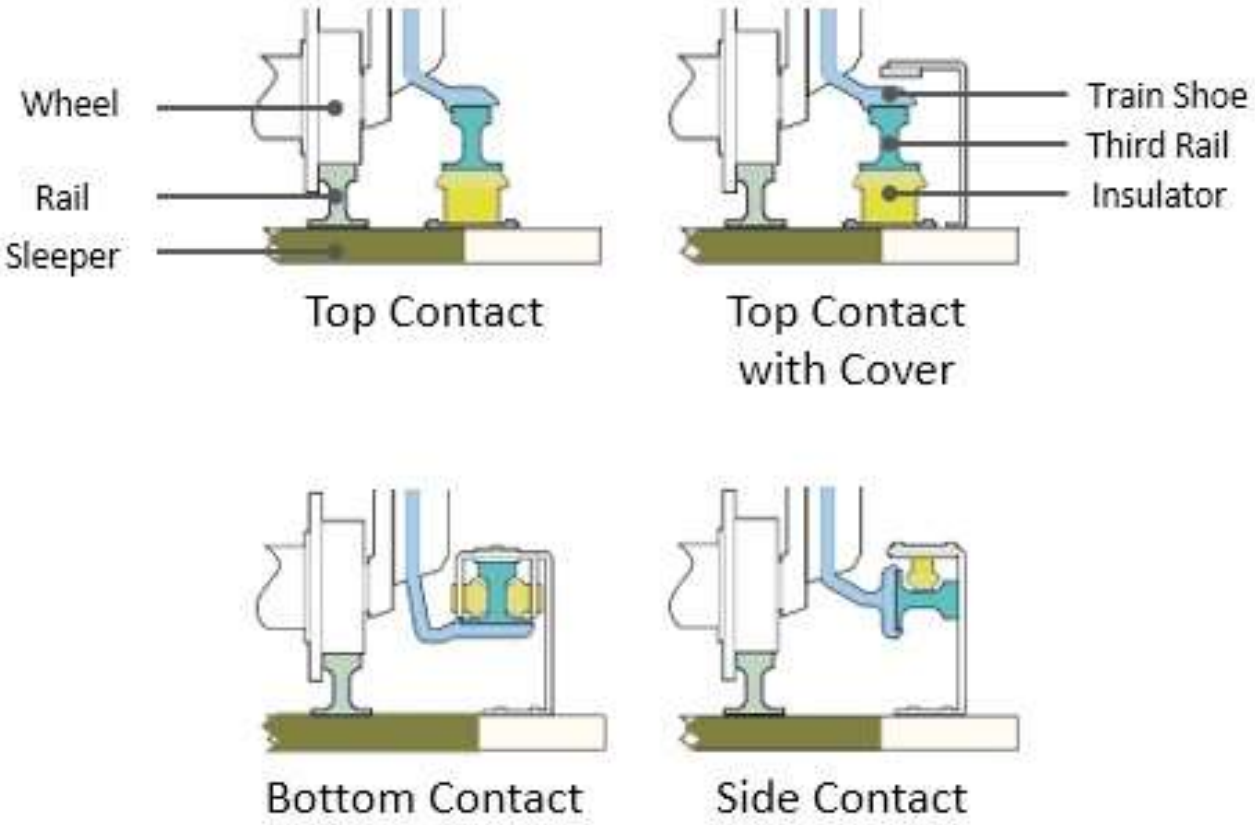
- **Power Supply**
  - Power is supplied to locomotives using different methods:

Conductor Rails



Conductor Rail System

Conductor Rails



Conductor Rails

Conductor Rails

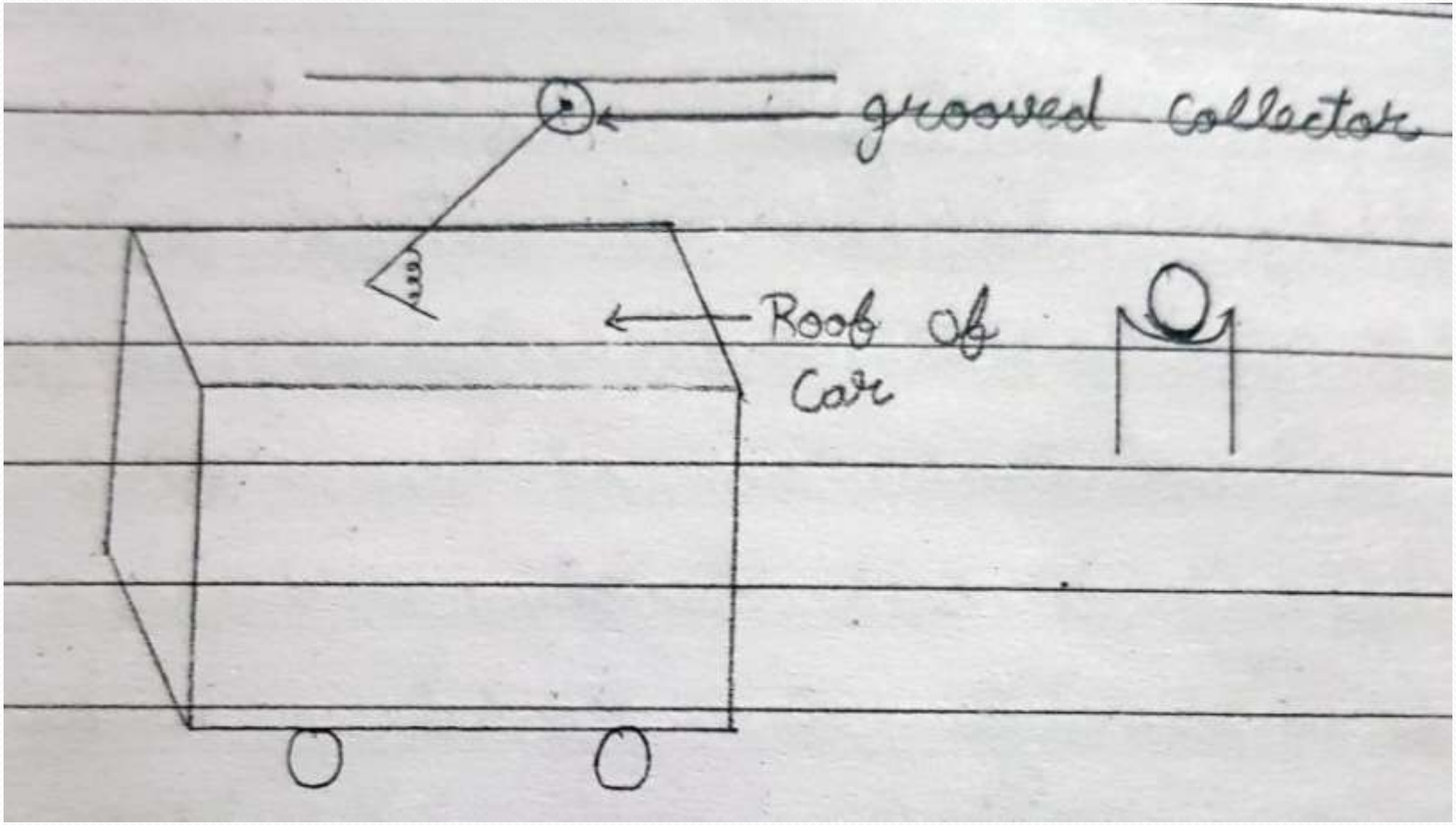
Conductor Rails

Conductor Rails

Overhead Systems

- **Trolley Collector**
  - Used in **Trams** and **Trolley Buses**
  - Uses **grooved gun metal wheel** or **grooved slider shoe** with carbon insert, carried at the **end of a long pole**
  - The other end of pole is **hinged to a base** fixed to the roof of the vehicle
  - Disadvantage is that **it has to be rotated through 180° for reversing** the direction of motion of vehicle
  - Drawback is that there is **poor contact** between wheel and trolley wire

Trolley Collector



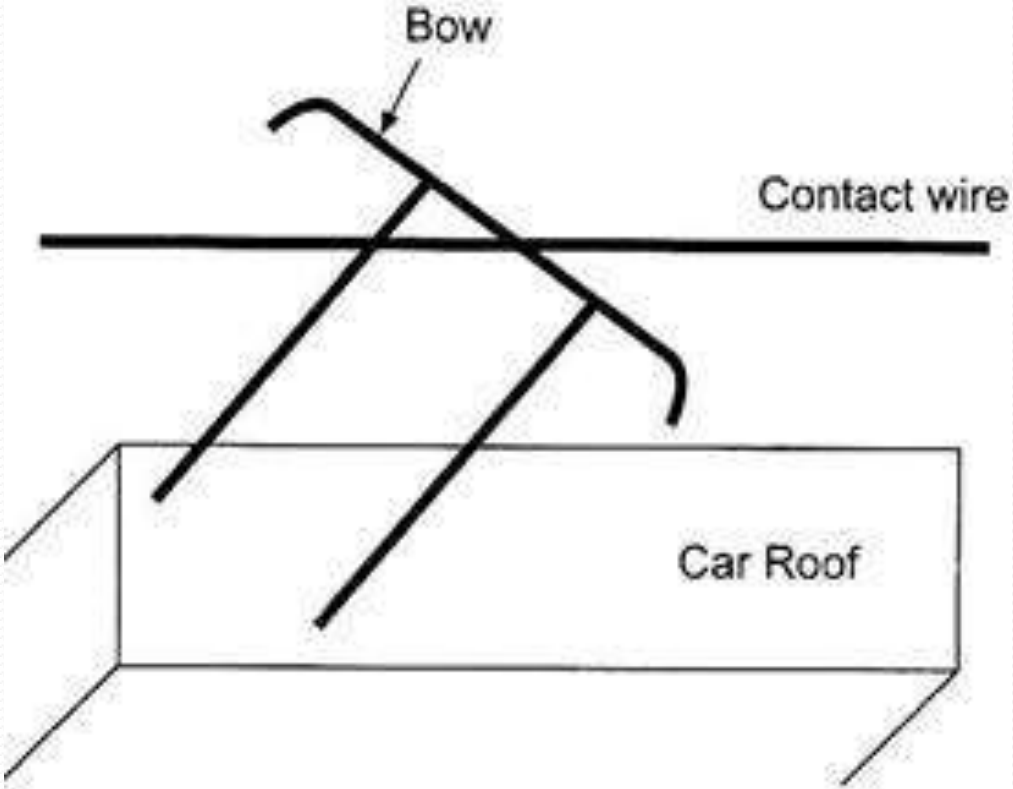
Trolley Collector

Trolley Collector

Overhead Systems

- **Bow Collector**
  - Used in **Tramways**
  - Consists of a **metal bow 0.6 to 0.9m wide**
  - Mounted on the **roof of the vehicle**
  - Presses against the trolley wire
  - **At high speed** there is possibility of **leaving the contact**
  - **Not suitable for trolley buses**
  - Upward pressure is obtained by using **spring**

Bow Collector



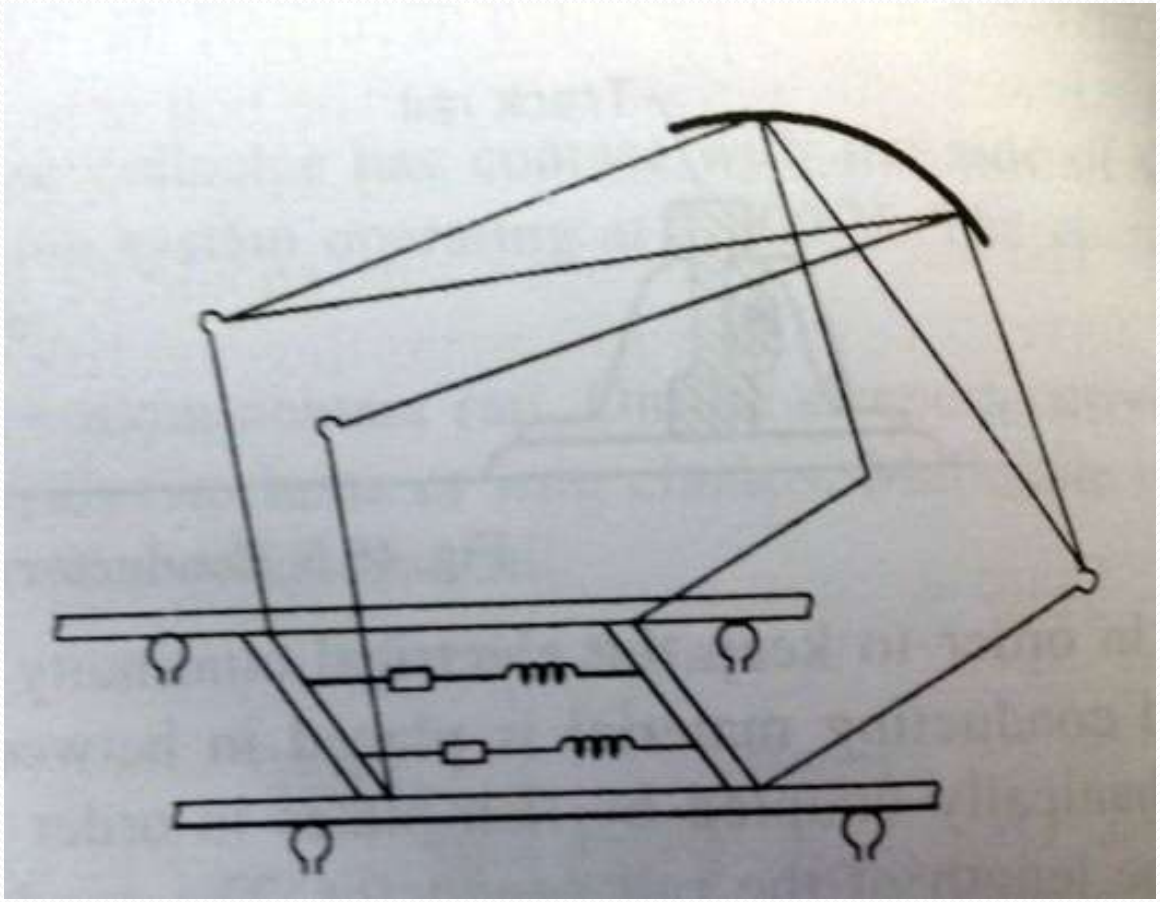
Bow Collector

Bow Collector

Overhead Systems

- **Pantograph Collector**
  - Employed in **Railways** to collect current
  - Operating speed is as high as **100 to 130Km/Hr**
  - Current to be collected is as large as **2000 to 3000A**
  - **Mounted on roof** of the vehicle
  - Carries a **sliding shoe** for contact with trolley wire
  - **Advantages**:
    - Can operate in **either direction**
    - **No risk of leaving the contact**
    - **Height can be varied** from driver's cabin

Pantograph Collector

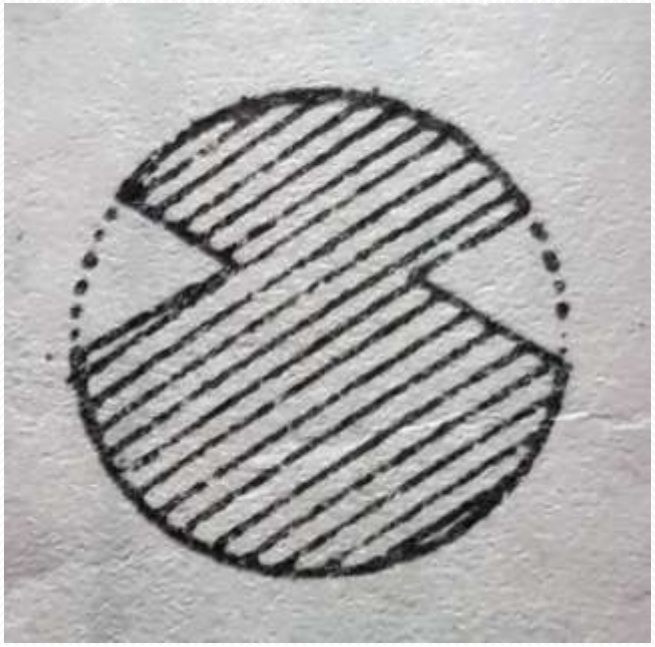


Pantograph Collector

Pantograph Collector

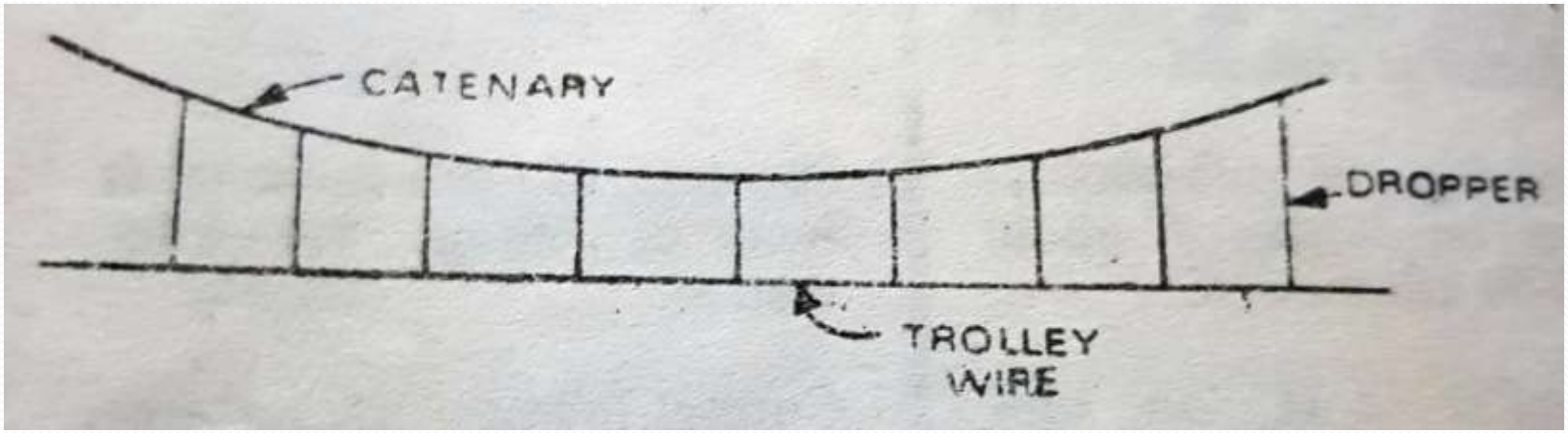
Overhead Conductor

- For **Tramways** and **Trolley Buses**
  - **Hard drawn copper** and alloys of copper are used
  - Cross section area of standard trolley wire is **80mm²**



Overhead Conductor

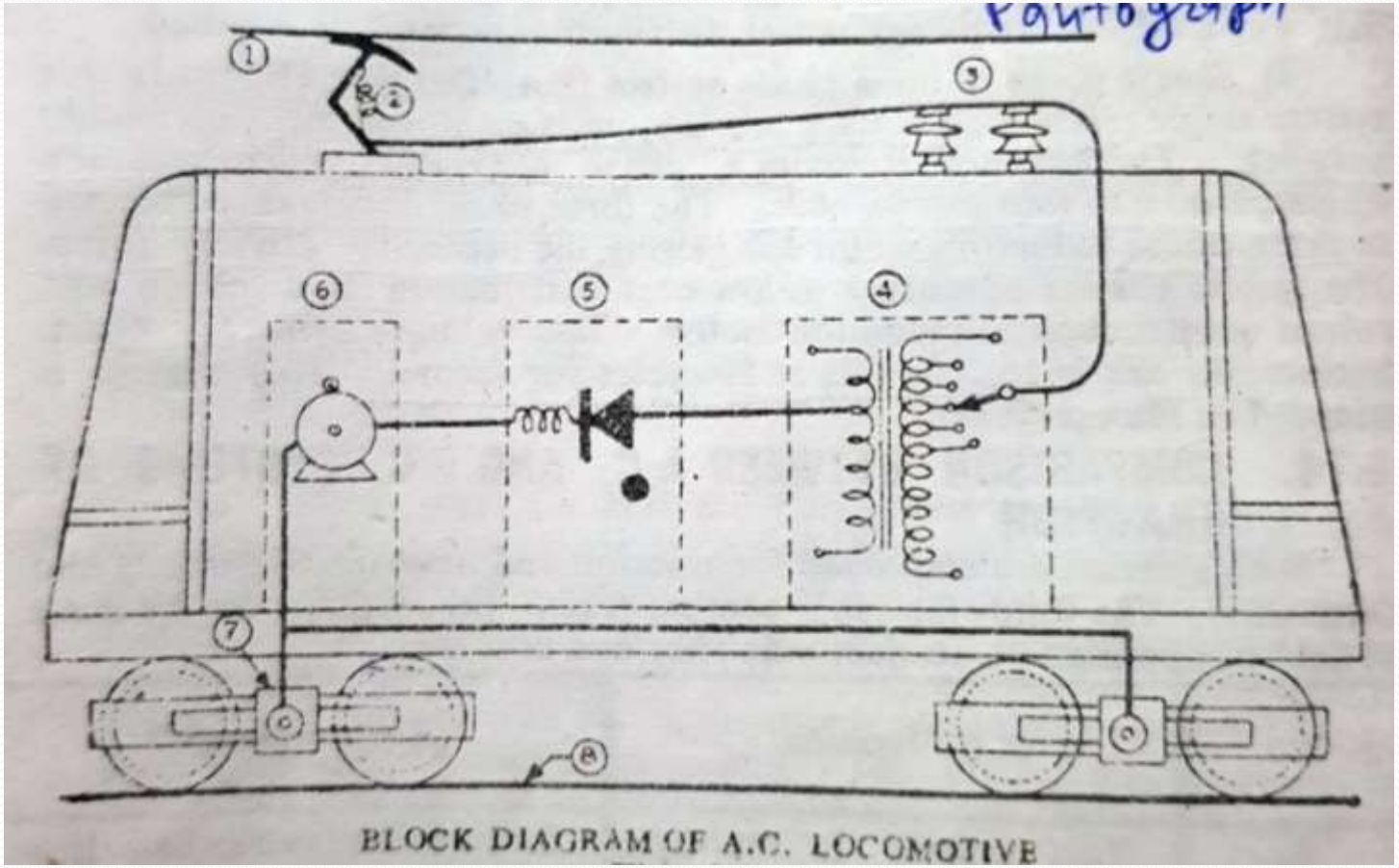
- **Railways**
  - **Good contact is required** at high speeds
  - **Sag should remain small** to maintain good contact
  - **Short spans** are created by suspending trolley wire with support of other wire known as **Catenary**



Factors Affecting Scheduled Speed

- **Average Speed** = $\frac{Distance\ between\ the\ stops}{Actual\ time\ of\ run}$
- **Scheduled Speed** = $\frac{Distance\ between\ the\ stops}{Actual\ time\ of\ run + Stop\ time}$
- **Crust Speed** (Maximum speed of vehicle during run)
- **Acceleration**
- **Braking** Retardation
- **Duration** of Stoppage

Electric Locomotive



BLOCK DIAGRAM OF A.C. LOCOMOTIVE

Motors Used in Traction

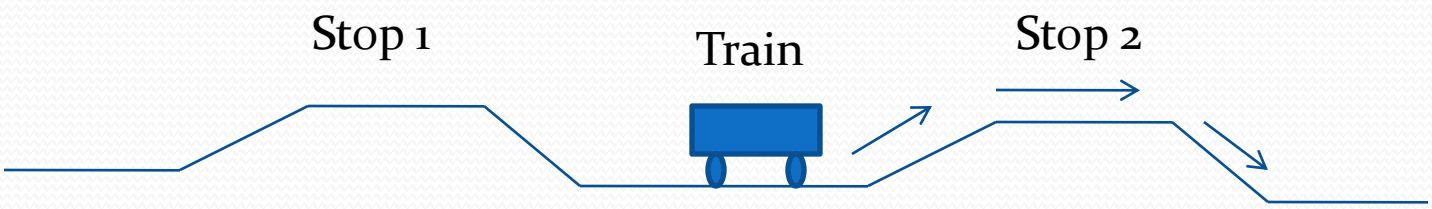
- **DC Traction**
  - DC **Series** and **Compound** Motors
- **AC Traction**
  - **AC series** motors and **3Ø Slip Ring Induction motors**
- The motors **should be robust** and **totally enclosed** type for protection against **water** etc
- The motors should have **speed control mechanism**

Braking

- Electric Braking
  - **Plugging**
  - **Rheostatic** Braking
  - **Regenerative** Braking

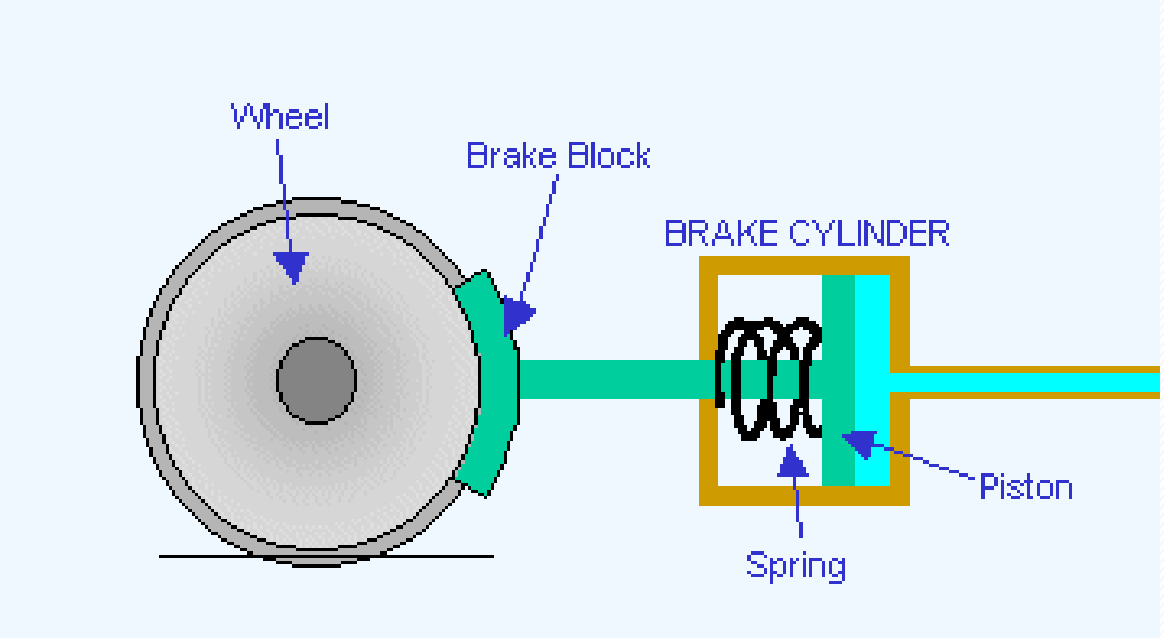
Braking

- Mechanical Braking
  - **Mechanical Regenerative Braking**

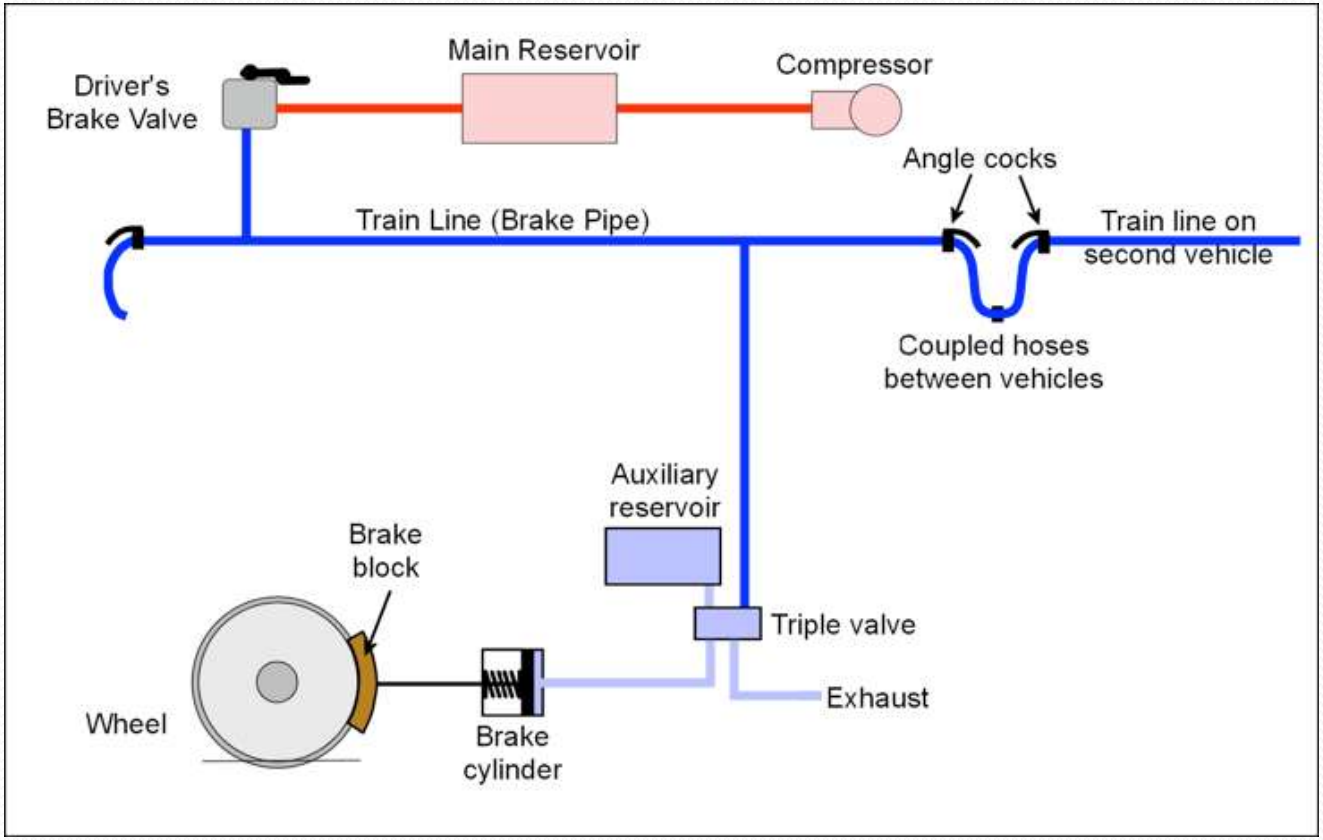


Braking

- Mechanical Braking
  - **Compressed Air Brake**

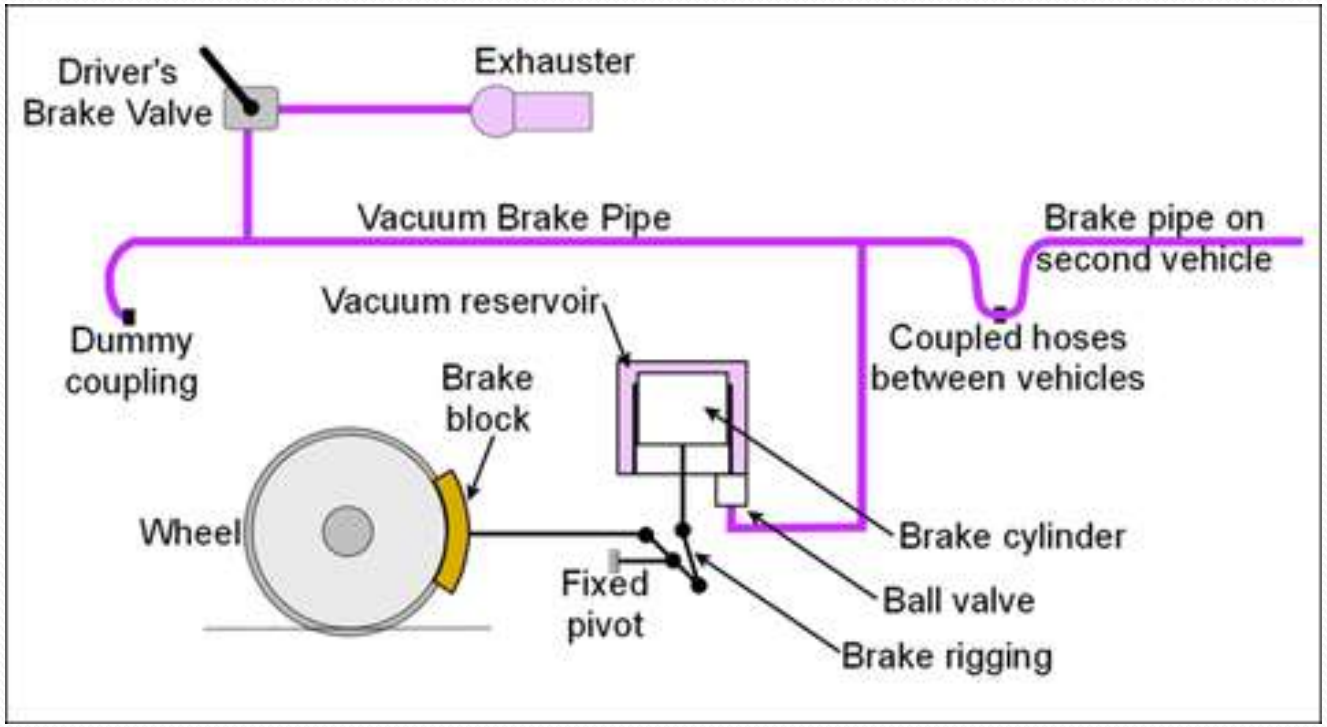


Compressed Air Brake



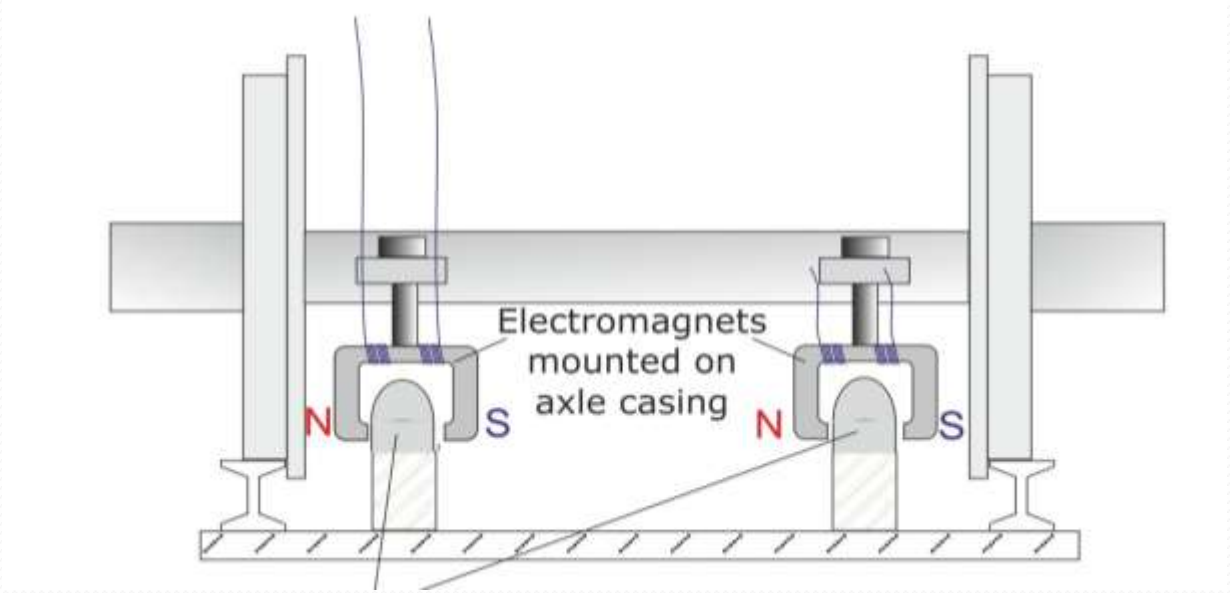
Braking

- Mechanical Braking
  - **Vacuum Brakes**



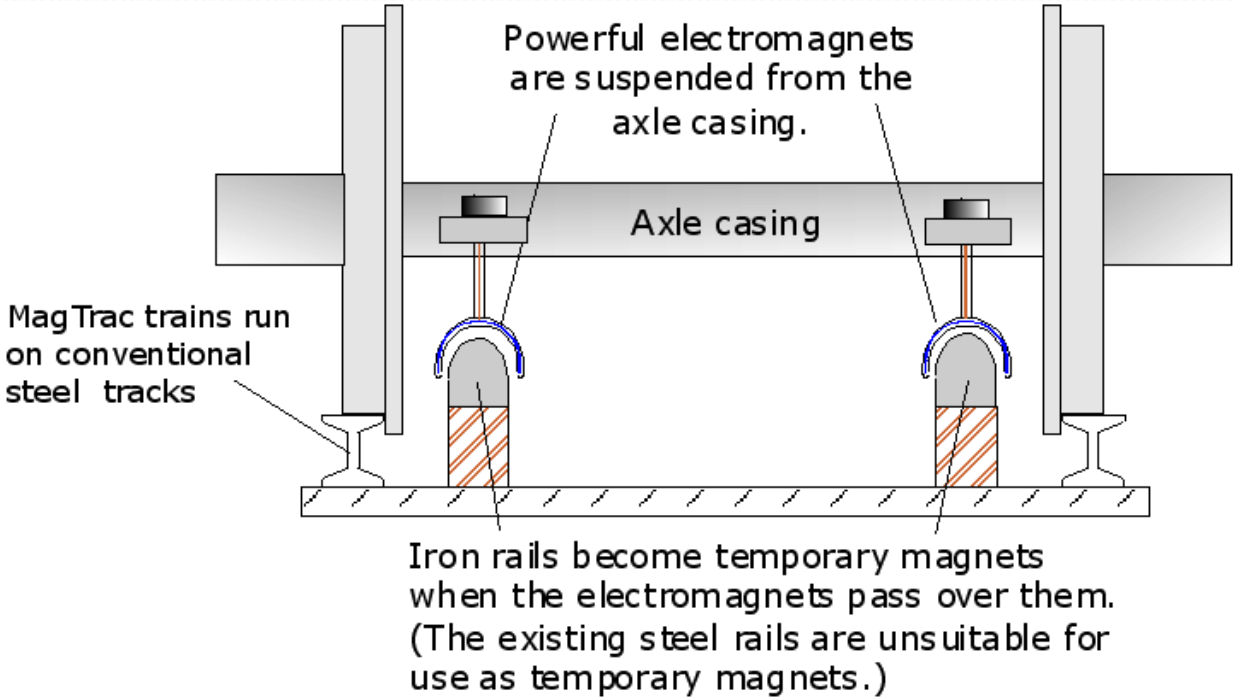
Braking

- Mechanical Braking
  - **Magnetic Track Brakes**
    - **Pole faces are strongly attracted** to rail and provide a retarding force



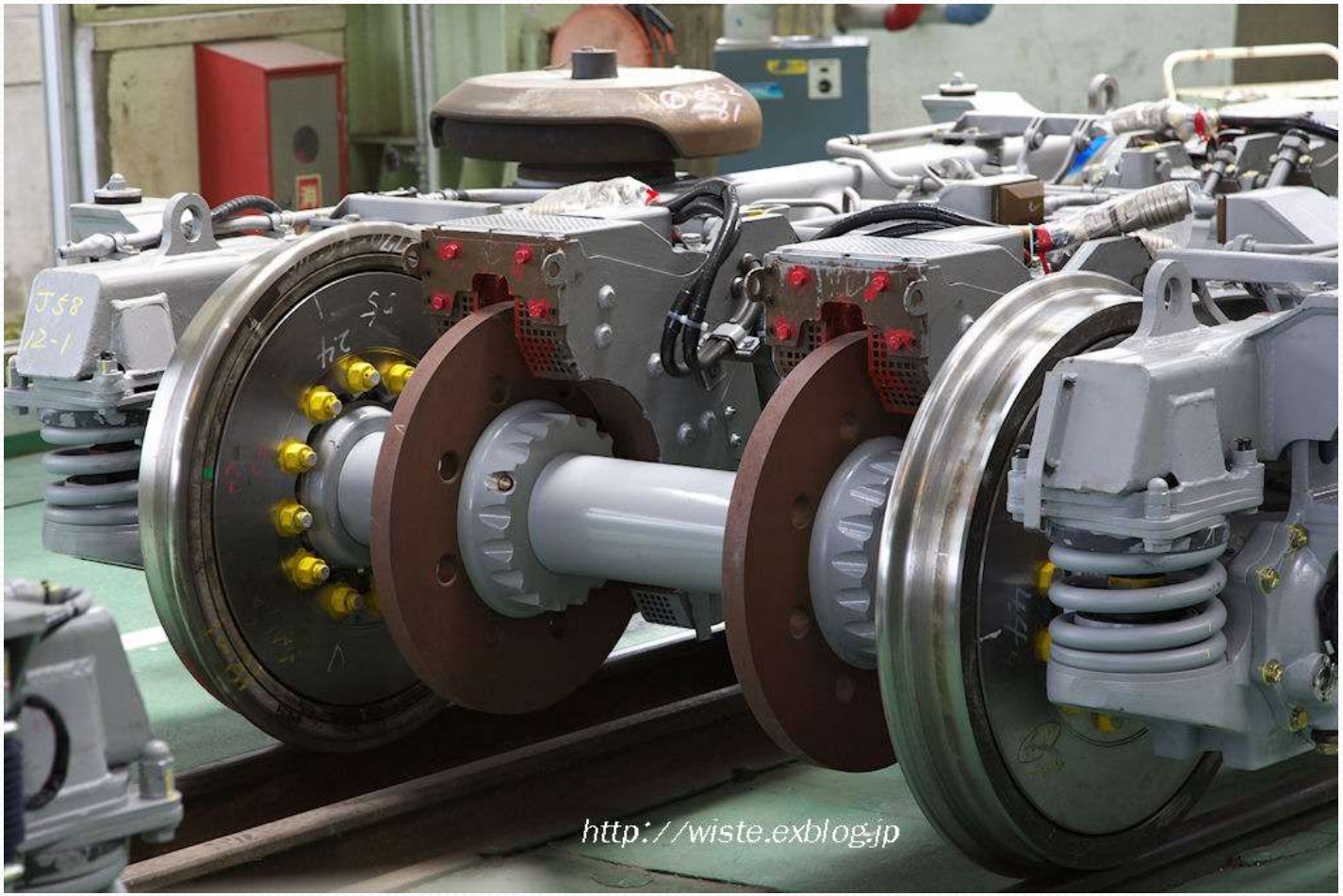
Braking

- Mechanical Braking
  - **Magnetic Track Brakes**



Braking

- **Eddy Current Braking**
  - A **conductive surface moving past a stationary magnet** will have circular electric currents called **eddy currents**
  - By Lenz's law, the circulating currents will create their own magnetic field which **opposes the field of the magnet**
  - The **moving conductor will experience a drag force** from the magnet that **opposes its motion**, proportional to its velocity
  - The kinetic energy of the moving object is **dissipated as heat** generated by the **current flowing through the electrical resistance** of the conductor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