Solution for Electrical Power Utilization – 10EE72

Internal Test 2

1. Faraday's Laws of Electrolysis

Faraday's First Law : According to this Law, the chemical deposition due to the current through an electrolyte is directly proportional to the quantity of electricity coloumbs) passed through it.

Mass of chemical deposition, m α Q, m α It, m = ZIt

Here Q = Quantity of electricity

I = steady current in Amperes

t = time of current flow in seconds

Z = constant of proportionality called the electrochemical equivalent of the substance

Faraday's Second Law : This law states that when the same quantity of electricity is passed through several electrolytes, the mass of the substances deposited are proportional to their respective chemical equivalents or equivalent weights.

Chemical Equivalent = Atomic weight/ Valency

Throwing Power : This is the ability of the electrolyte to produce uniform deposit on an article of irregular shape. The distance between the various portions of cathode and anode will be different due to the irregular shape of the cathode. Due to unequal distance the resistance of the current path through the electrolyte for various portions of the cathode will be different. Throwing power can be improved by increasing the distance between anode and cathode and by reducing the voltage drop at cathode.

Polarization : The rate of deposition of metal increases with the increase in electroplating current density up to a certain limit. Use of current density beyond this limit causes the electrolysis of water and hydrogen liberation on the cathode. This hydrogen evolved on the cathode covers the base metal which reduces the reduces the rate of metal deposition. This phenomenon is called polarization. With reverse current electroplating in which at regular intervals plating current is reversed sufficient electron concentration is established around the base metal and the polarization effect becomes negligible. -----------------(10 Marks)

2. Laws of Illumination : (1)Inverse Square Law (2)Lambert's Cosine Law

Inverse Square Law

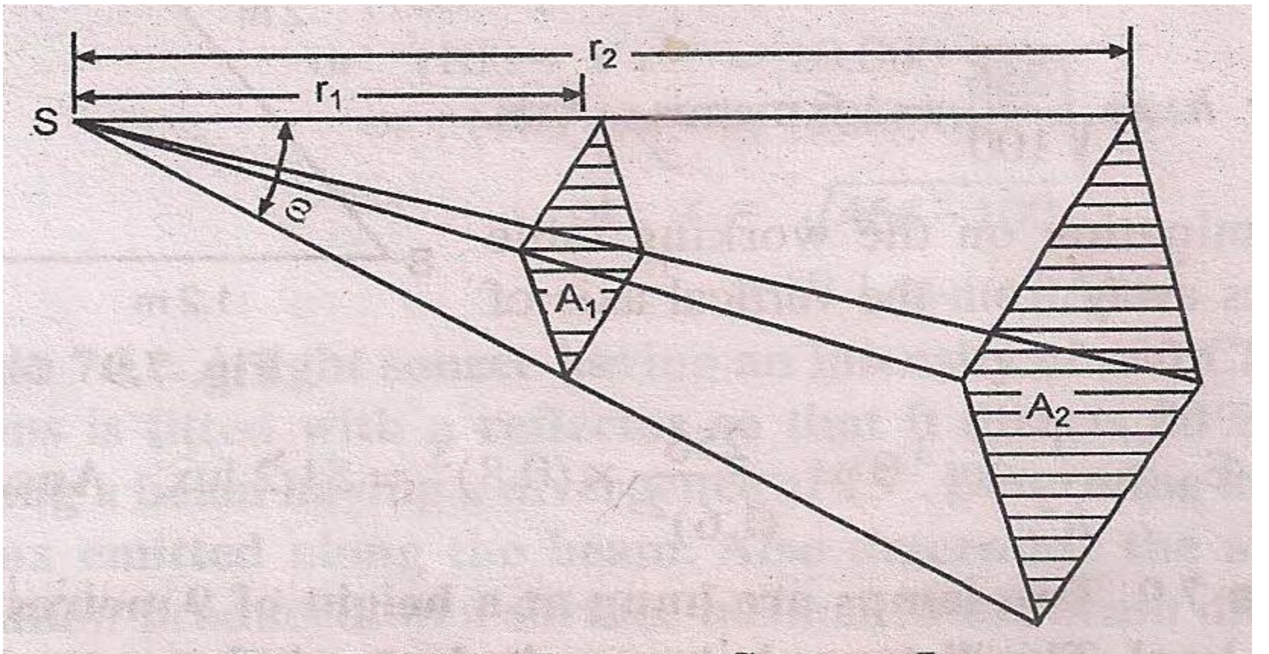


Fig. 7.6 (*a*). *Inverse Square Law*

This law states that the illumination of a surface is inversely proportional to the square of the distance of the surface from the source.

$E \alpha 1/r^2$

Consider surface areas A1 and A2 at distances r1 and r2 respectively from the point source S of luminous intensity I and normal to the rays.

Let the solid angle subtended be ω

Total luminous flux radiated = Iω lumens

Illumination of the surface area A1 , E1 = I ω / A1

$E1 = I \omega / \omega r_1^2 = I/ r_1^2$ lumens per unit area

Similarly, illumination on the surface of area A2, E2 = I ω / A2

$E2= I \omega / \omega r_2^2 = I/ r_2^2$ lumens per unit area

Hence the Illumination of a surface is inversely proportional to the square of the distance between the surface and the light source provided that the distance between the surface and the source is sufficiently large so that the source can be regarded as a point source.

Lambert's Cosine Law

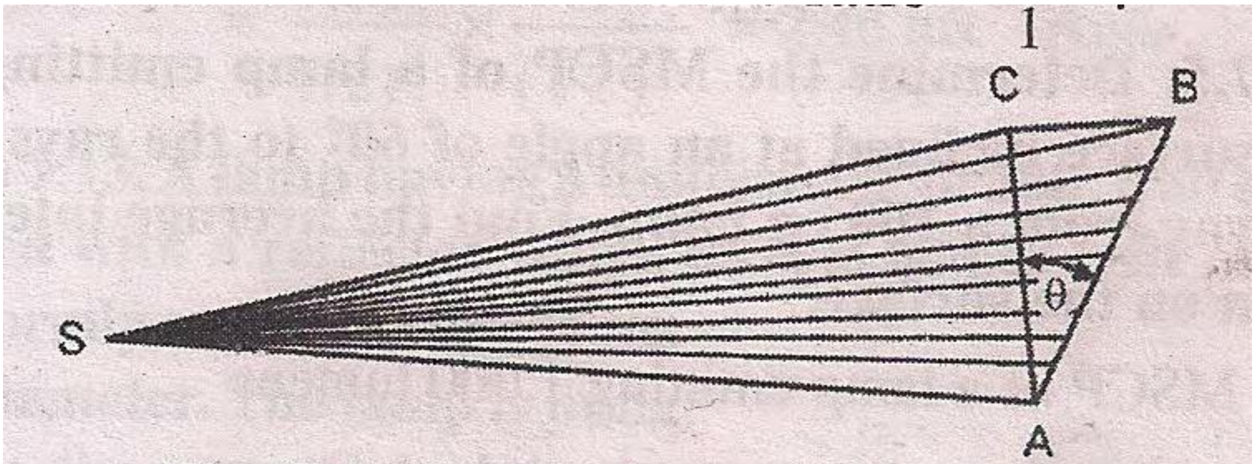


Fig. 7.6 (*b*). *Lambert's Cosine Law*

According to this law, Illumination at any point on a surface is proportional to the Cosine of the angle between the normal at that point and the direction of luminous flux.

- Here the illuminated surface is not normal to the direction of light as AC but is inclined as AB.
- The area over which the light is spread is then increased in the ratio AB / AC = 1/Cos θ
- Illumination decreases in the ratio Cos θ / 1
- The expression for the Illumination then becomes $E = I \cos \theta / r^2$ -----------(10 Marks)

3. High Pressure Mercury Vapour Lamp

Construction

- It consists of two bulbs – an arc tube containing the electric discharge and outer bulb which protects the arc tube from changes in temperature.
- The inner tube(arc tube) contains a small amount of mercury and argon gas.
- In addition to two main electrodes, an auxiliary starting electrode connected through a high resistance (about 50 k ohms) is also provided.
- The main electrodes consists of tungsten coils with electron emitting coating or elements of thorium metal.

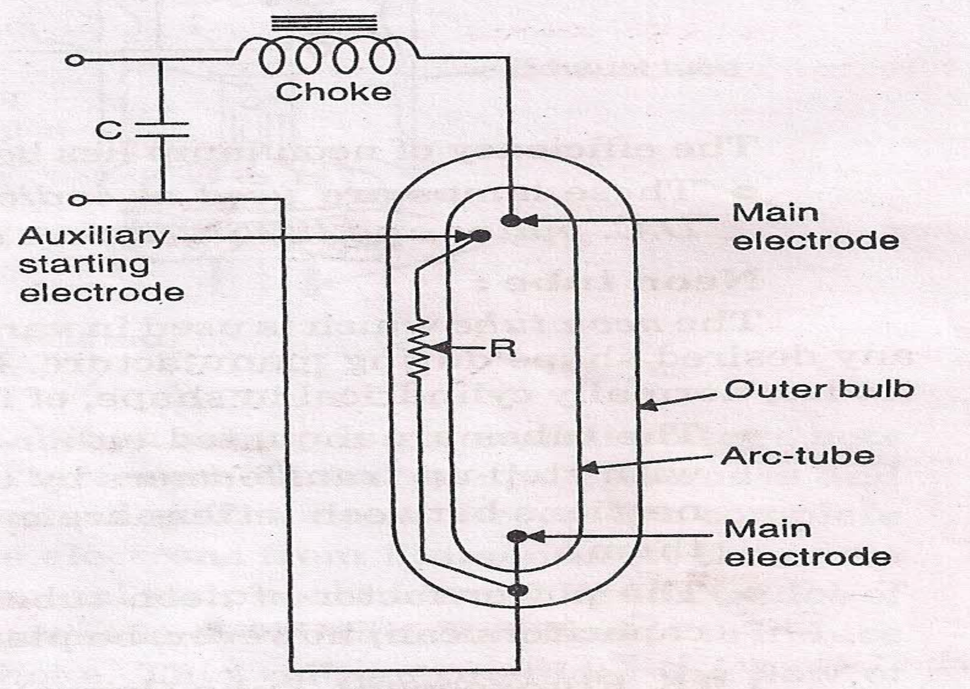


Fig. 1.39. High pressure mercury vapour discharge lamp.

Working

- When the supply is switched ON, the initial discharge for a few seconds is established in the argon gas between the auxiliary starting electrode and the main electrodes.
- The heat produced due to this discharge through the gas is sufficient to vaporise mercury.
- The pressure inside the arc tube increases to about 1 to 2 atmospheres and potential difference across the main electrodes grows from about 20 to 150V.
- The operation takes about 5 to 7 minutes.
- During this time, discharge is established through the mercury vapours which emit greenish – blue light. ---------------------------(10 Marks)

4. Advantages of Electric drives

Here the drive is by means of electric motors which are fed from overhead distribution system. The drive of this type is most widely used.

Advantages

- As it has no smoke, electric traction is most suited for the underground and tube railways.
- The motors used in electric traction have a very high starting torque.

- High schedule speed.
- Increased traffic handling capacity.
- Due to high schedule speed and high traffic handling capacity, less terminal space is required, which is an important factor in urban areas.
- An electric locomotive is ready to start at moment's notice against about two hours required for steam locomotive to heat up.
- An electric locomotive can negotiate curves at higher speeds quite safely.
- The maintenance cost of an electric locomotive is 50 % of that of steam locomotive, its maintenance time is also less.
- By the use of electric traction high grade coal can be saved.
- In electric traction system it is possible to use regenerative braking.
- Owing to the complete absence of smoke and fumes, this system is healthier from the hygienic point of view.

Disadvantages

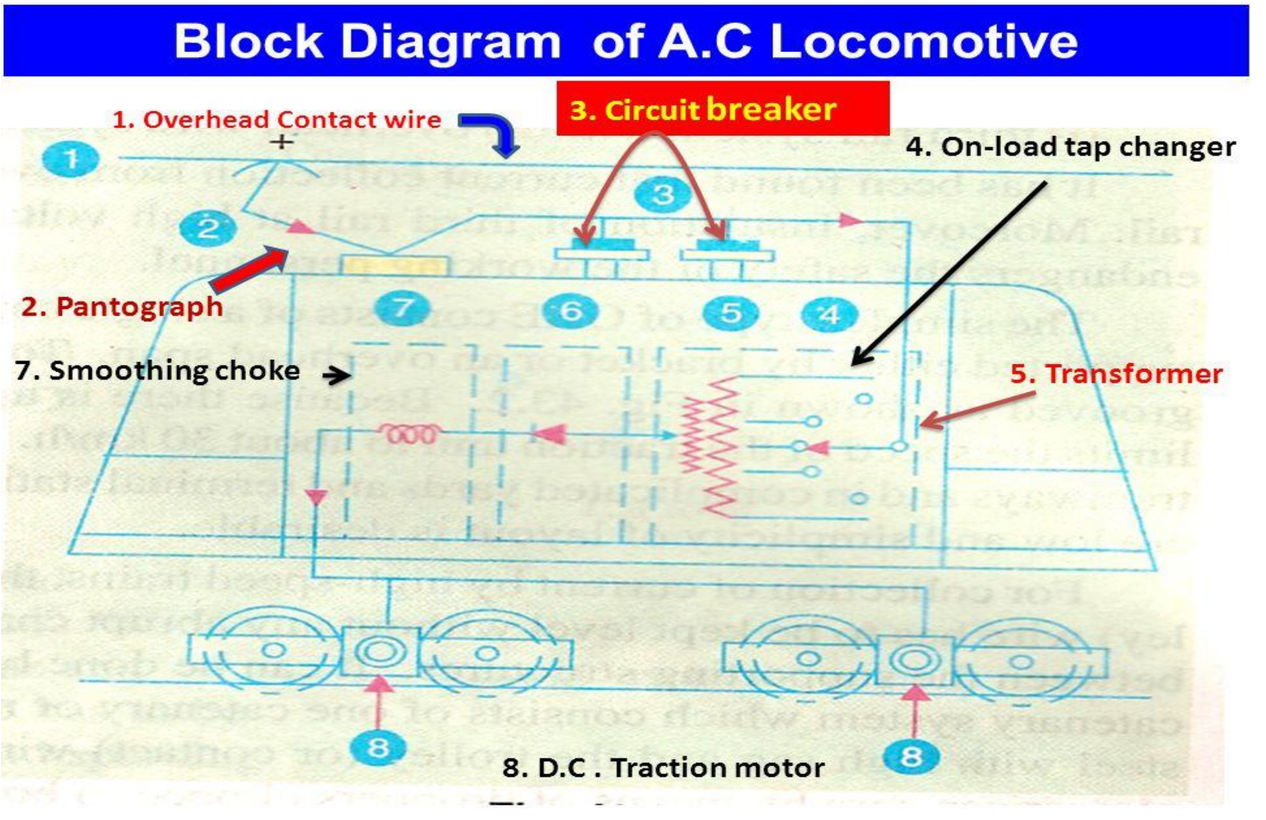
- High initial cost of laying out overhead electric supply system.
- Power failure for a few minutes can cause traffic dislocation for hours.
- The electric traction system is tied up to only electrified routes.
- Communication lines which usually run parallel to the power supply lines suffer from electrical interference.
- Additional equipment is required for regeneration.
- Whereas steam locomotives can use their steam for heating the compartments in cold weather very cheaply, the electric locomotives have to do it at an extra cost.
- In cold countries a service locomotive is required to run up and down the line in order to prevent the formation of layer of ice on the conductor rails.

---------------------(10 Marks)

5. AC Locomotive

- A locomotive or engine is a rail transport vehicle that provides the motive power for a train.
- An electric locomotive is powered by electricity from overhead lines, a third rail or on – board energy storage such as a battery or fuel cell.

- Electricity is used to eliminate smoke and take advantage of high efficiency of electric motors.
- The locomotives in India presently consists of electric and diesel locomotives.
- Steam locomotives are no longer used in India.
- A locomotive is also called ‘loco’ or ‘engine’.



- Power at 25 kV is taken from the overhead contact wire, via a pantograph and fed to the step down transformer in the locomotive.
- A pantograph is an apparatus mounted on the roof of an electric train, tram or electric bus to collect power through contact with an overhead catenary and conveying current to train, tram or other electric vehicle.
- The low AC voltage so obtained is then converted to pulsating DC voltage by means of rectifier.
- The pulsations in the DC voltage are then removed by the smoothing choke before it is fed to DC Series motor which are mounted between the wheels.
- The circuit breakers are provided to immediately disconnect the locomotive from the overhead supply in case of any faults in the electrical system.
- The no load tap changers are employed to change the voltage across the motors and regulate their speed. -------------------(10 Marks)

6. Trapezoidal Speed Time Curve

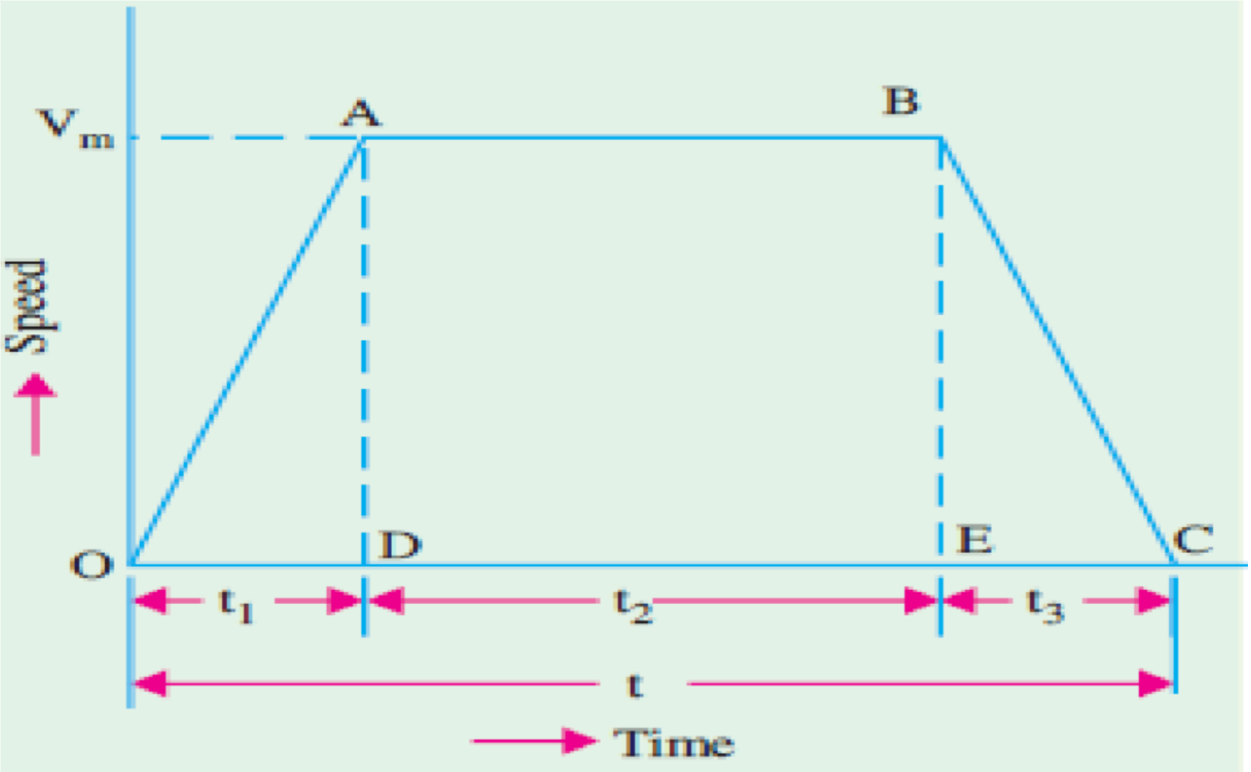


Fig. 43.11

Relationship between Principal Quantities in Trapezoidal Diagram

$\alpha = V_m / t_1$ or $t_1 = V_m / \alpha$

$\beta = V_m / t_3$ or $t_3 = V_m / \beta$

Total distance *D* between the two stops is given by the area of trapezium *OABC*.

D = area OABC = area OAD + area ABED + area BCE

$$= \frac{1}{2} V_m t_1 + V_m[t - (t_1 + t_3)] + \frac{1}{2} V_m t_3$$

$$= V_m \left[\frac{t_1}{2} + t - t_1 - t_3 + \frac{t_3}{2}\right]$$

$$= V_m \left[t - \frac{1}{2}(t_1 + t_3)\right]$$

$$= V_m \left[t - \frac{V_m}{2}\left(\frac{1}{\alpha} + \frac{1}{\beta}\right)\right]$$

Let, $K = \frac{1}{2}\left(\frac{1}{\alpha}+\frac{1}{\beta}\right)$. Substituting this value of K in the above equation, we get

$$D = V_m(t - KV_m)$$

or $KV_m^2 - V_m t + D = 0$ ...(*i*)

$$\therefore \quad V_m = \frac{t \pm \sqrt{t^2 - 4KD}}{2K}$$

Rejecting the positive sign which gives impracticable value, we get

$$V_m = \frac{t \pm \sqrt{t^2 - 4KD}}{2K}$$

From Eq. (*i*) above, we get

$$KV_m^2 = V_m t - D \qquad \text{or} \qquad K = \frac{t}{V_m} - \frac{D}{V_m^2} = \frac{D}{V_m^2}\left(V_m \cdot \frac{t}{D} - 1\right)$$

Now, $V_a = \frac{D}{t}$ $\therefore$ $K = \frac{D}{V_m^2}\left(\frac{V_m}{V_a} - 1\right)$

Obviously, if V_m, V_a and D are given, then value of K and hence of α and β can be found (Ex. 43.2).

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7. Consider a point P on the plane surface AB where illumination due to light source S of candle power CP at a height h from the surface AB is to be determined.

Let d = distance between the Source S and point P

Here Cos θ = h/d

Also d = h / Cos θ

By Laws of Illumination, Illumination at point P =(CP / d^2) Cos θ

= (CP/h^2) $\text{Cos}^3\ \theta$

Luminous intensity of the lamp, CP = 180

Illumination directly below the lamp, E = 80 lm/m^2

(a) Illumination at point A, $E_A = I / h^2$

$80 = 180 / h^2$

Height at which the lamp is suspended, h = 1.5 m

(b)Illumination at a point 1.5 m away

EB =(I / h^2) $\text{Cos}^3\ \theta$

Cos θ = 1.5 / 2.12 = 0.7075

$E_B = 180 /(1.5)^2 \times 0.354 = 28.33$ lux ------------------(10 Marks)

8. Area, A = 60 x 15 = 900 m^2

E = 100 lux

UF = 0.42

MF = 0.8

Space height ratio = horizontal distance between the lamps /Mounting ht

1 = x/5

X = 5 m

Length = 60 m

Number of lamps lengthwise = 60 /5 12 lamps

Number of lamps breadthwise = 15/5 = 3 lamps

Draw the spacing layout also.

Luminous efficiency = 16 lm/ W

Gross lumens required = N x O = EA / UF x MF = 100 x 900/ 0.42 x 0.78 = 274725 lumens

Total wattage required = Gross lumens /(Lumens /Watt)

= 274725/16 = 17170.3 W

Wattage of each lamp = Total wattage / No : of lamps = 17170.3 / 36 = 476.95 W

We will take the nearest standard value of wattage , 500 W

--------------------------(10 Marks)