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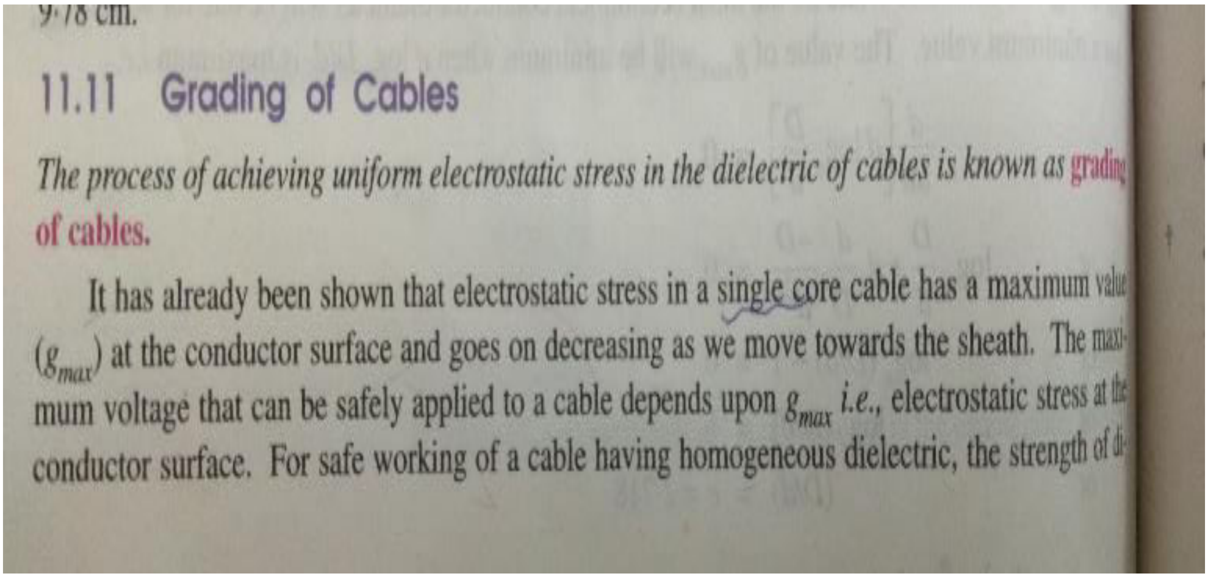
Internal Assesment Test - III

Sub:	Transmission & distribution							Code:	17EE43
Date:	14/05/2019	Duration:	90 mins	Max Marks:	50	Sem:	4	Branch:	EEE

Answer Any FIVE FULL Questions

		Marks	OBE	
			CO	RBT
1	What is meant by grading of cables. Explain about capacitance grading and inter sheath grading	[10]	CO2	L2
2a	Explain Ferranti effect	[5]	CO1	L2
2b	Explain about the phenomenon of corona in over head transmission line.	[5]	CO2	L2
3	A single core lead sheathed cable has a conductor diameter of 3 cm; the diameter of the cable being 9 cm. The cable is graded by using two dielectrics of relative permittivity 5 and 4 respectively with corresponding safe working stresses of 30 kV/cm and 20 kV/cm. Calculate the radial thickness of each insulation and the safe working voltage of the cable.	[10]	CO4	L3
4a	Drive an expression for the capacitance of a single core cable	[5]		
4b	Draw the cross sectional view of a single core underground cable and explain about its construction	[5]		
5a	Explain the following terms with reference to corona: 1)Critical disruptive voltage 2)Critical visual disruptive voltage	[5]	CO2	L2
5b	Explain about radial & ring distributors	[5]	CO3	L2
6	An electric train taking a constant current of 500 A moves between the two substations 6 km apart. The two substations are maintained at 580 V and 600 V respectively. The track resistance is 0.05Ω/km both go and return. Calculate 1) The point of minimum potential 2) The currents supplied by each substation at the point of minimum potential.	[10]	CO3	L3
7	A single phase ac distributor AB 300 metres long is fed from end A and is loaded as under : 1)100 A at 0.707 pf lagging 200 m from point A 2)200 A at 0.8 pf lagging 300 m from point A. The load resistance and reactance of the distributor is 0.2 Ω and 0.1 Ω per kilometer. Calculate the total voltage drop in the distributor .The load power factors refer to the voltage at the far end			

1 What is meant by grading of cables. Explain about capacitance grading and inter sheath grading



9·78 cm.

11.11 Grading of Cables

The process of achieving uniform electrostatic stress in the dielectric of cables is known as **grading of cables.**

It has already been shown that electrostatic stress in a single core cable has a maximum value (g_{max}) at the conductor surface and goes on decreasing as we move towards the sheath. The maximum voltage that can be safely applied to a cable depends upon g_{max} *i.e.*, electrostatic stress at the conductor surface. For safe working of a cable having homogeneous dielectric, the strength of dielectric must be more than g_{max}. If a dielectric of high strength is used for a cable, it is useful onl near the conductor where stress is maximum. But as we move away from the conductor, the electro static stress decreases, so the dielectric will be unnecessarily overstrong.

The unequal stress distribution in a cable is undesirable for two reasons. Firstly, insulation o greater thickness is required which increases the cable size. Secondly, it may lead to the breakdown of insulation. In order to overcome above disadvantages, it is necessary to have a uniform stress distribution in cables. This can be achieved by distributing the stress in such a way that its value is increased in the outer layers of dielectric. This is known as grading of cables. The following are the two main methods of grading of cables :

(i) Capacitance grading *(ii)* Intersheath grading

11.12 Capacitance Grading

The process of achieving uniformity in the dielectric stress by using layers of different dielectrics is known as **capacitance grading.**

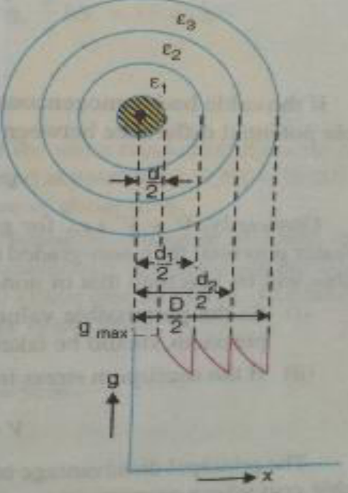


Fig. 11.15

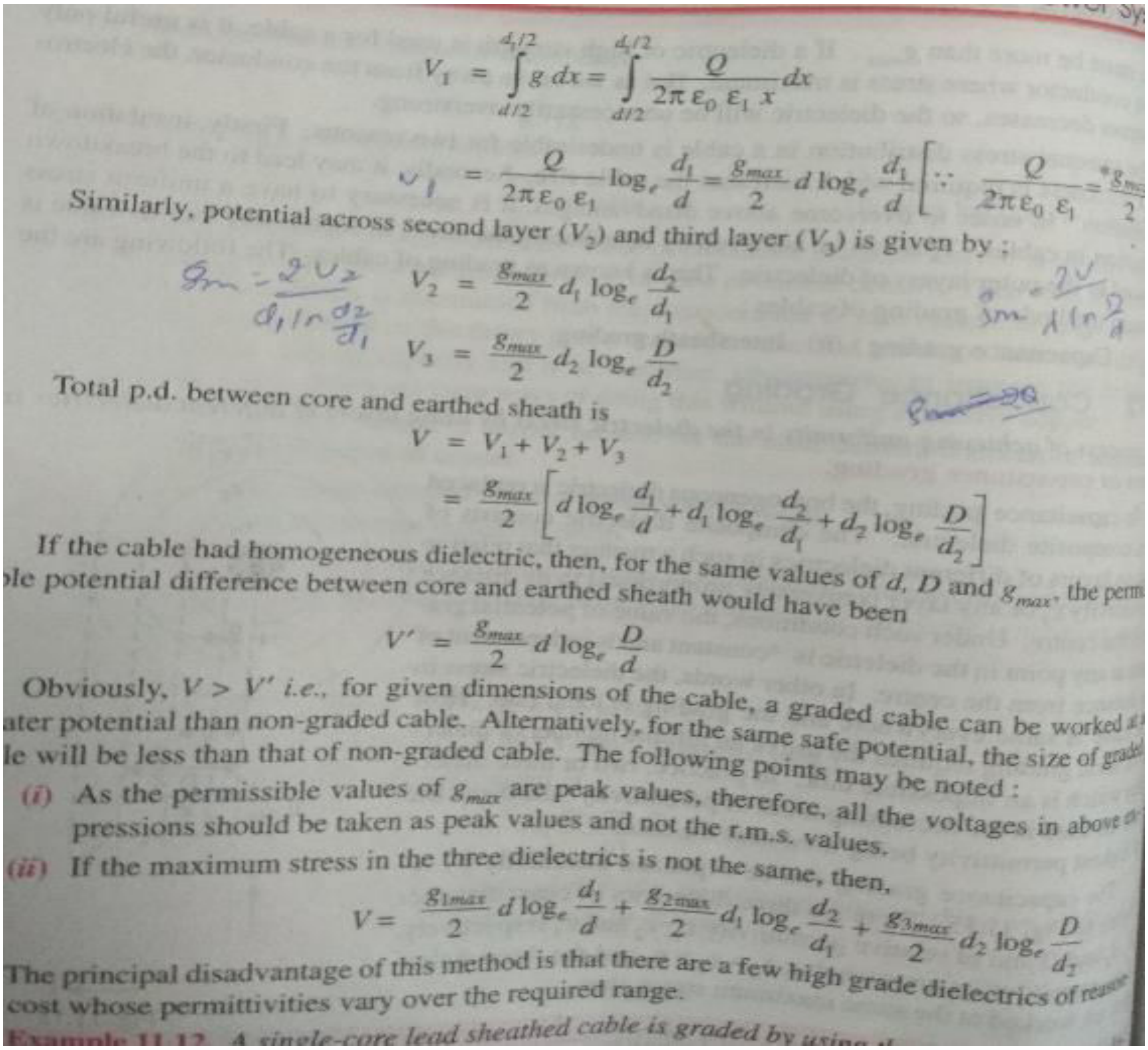
In capacitance grading, the homogeneous dielectric is replaced by a composite dielectric. The composite dielectric consists of various layers of different dielectrics in such a manner that relative permittivity ε_r of any layer is inversely proportional to its distance from the centre. Under such conditions, the value of potential gradient at any point in the dieletric is *constant and is independent of its distance from the centre. In other words, the dielectric stress in the cable is same everywhere and the grading is ideal one. However, ideal grading requires the use of an infinite number of dielectrics which is an impossible task. In practice, two or three dielectrics are used in the decreasing order of permittivity ; the dielectric of highest permittivity being used near the core.

The capacitance grading can be explained beautifully by referring to Fig. 11.15. There are three dielectrics of outer diameter d_1, d_2 and D and of relative permittivity ε_1, ε_2 and ε_3 respectively. If the permittivities are such that $\varepsilon_1 > \varepsilon_2 > \varepsilon_3$ and the three dielectrics are worked at the same maximum stress, then,

$$\frac{1}{\varepsilon_1 d} = \frac{1}{\varepsilon_2 d_1} = \frac{1 \dagger}{\varepsilon_3 d_2}$$

or
$$\varepsilon_1 d = \varepsilon_2 d_1 = \varepsilon_3 d_2$$

Potential difference across the inner layer is



$$V_1 = \int_{d/2}^{d_1/2} g\,dx = \int_{d/2}^{d_1/2} \frac{Q}{2\pi\varepsilon_0\varepsilon_1 x}\,dx$$

$$v_1 = \frac{Q}{2\pi\varepsilon_0\varepsilon_1}\log_e\frac{d_1}{d} = \frac{g_{max}}{2}\,d\log_e\frac{d_1}{d}\left[\because \frac{Q}{2\pi\varepsilon_0\varepsilon_1} = \frac{g_{m}}{2}\right.$$

Similarly, potential across second layer (V_2) and third layer (V_3) is given by ;

$$g_m = \frac{2V_2}{d_1 \ln\frac{d_2}{d_1}} \qquad V_2 = \frac{g_{max}}{2}\,d_1\log_e\frac{d_2}{d_1} \qquad g_m = \frac{2V}{d\ln\frac{D}{d}}$$

$$V_3 = \frac{g_{max}}{2}\,d_2\log_e\frac{D}{d_2}$$

Total p.d. between core and earthed sheath is

$g_{max} = 2Q$

$$V = V_1 + V_2 + V_3$$

$$= \frac{g_{max}}{2}\left[d\log_e\frac{d_1}{d} + d_1\log_e\frac{d_2}{d_1} + d_2\log_e\frac{D}{d_2}\right]$$

If the cable had homogeneous dielectric, then, for the same values of d, D and g_{max}, the perm
ble potential difference between core and earthed sheath would have been

$$V' = \frac{g_{max}}{2}\,d\log_e\frac{D}{d}$$

Obviously, $V > V'$ *i.e.*, for given dimensions of the cable, a graded cable can be worked a
ater potential than non-graded cable. Alternatively, for the same safe potential, the size of grade
le will be less than that of non-graded cable. The following points may be noted :

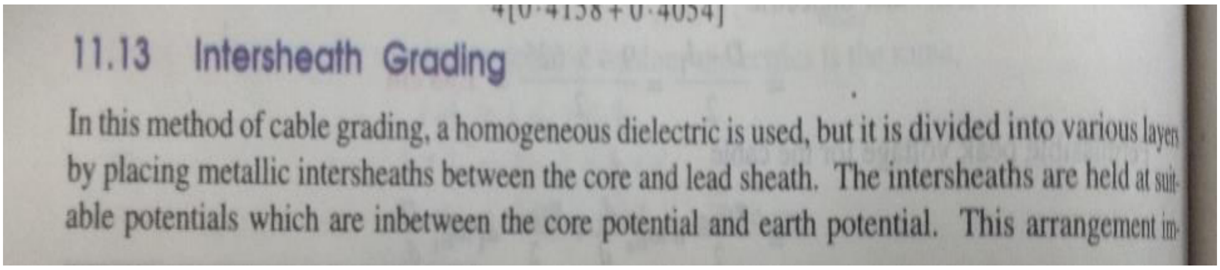
(*i*) As the permissible values of g_{max} are peak values, therefore, all the voltages in above ex
pressions should be taken as peak values and not the r.m.s. values.

(*ii*) If the maximum stress in the three dielectrics is not the same, then,

$$V = \frac{g_{1max}}{2}\,d\log_e\frac{d_1}{d} + \frac{g_{2max}}{2}\,d_1\log_e\frac{d_2}{d_1} + \frac{g_{3max}}{2}\,d_2\log_e\frac{D}{d_2}$$

The principal disadvantage of this method is that there are a few high grade dielectrics of reaso
cost whose permittivities vary over the required range.

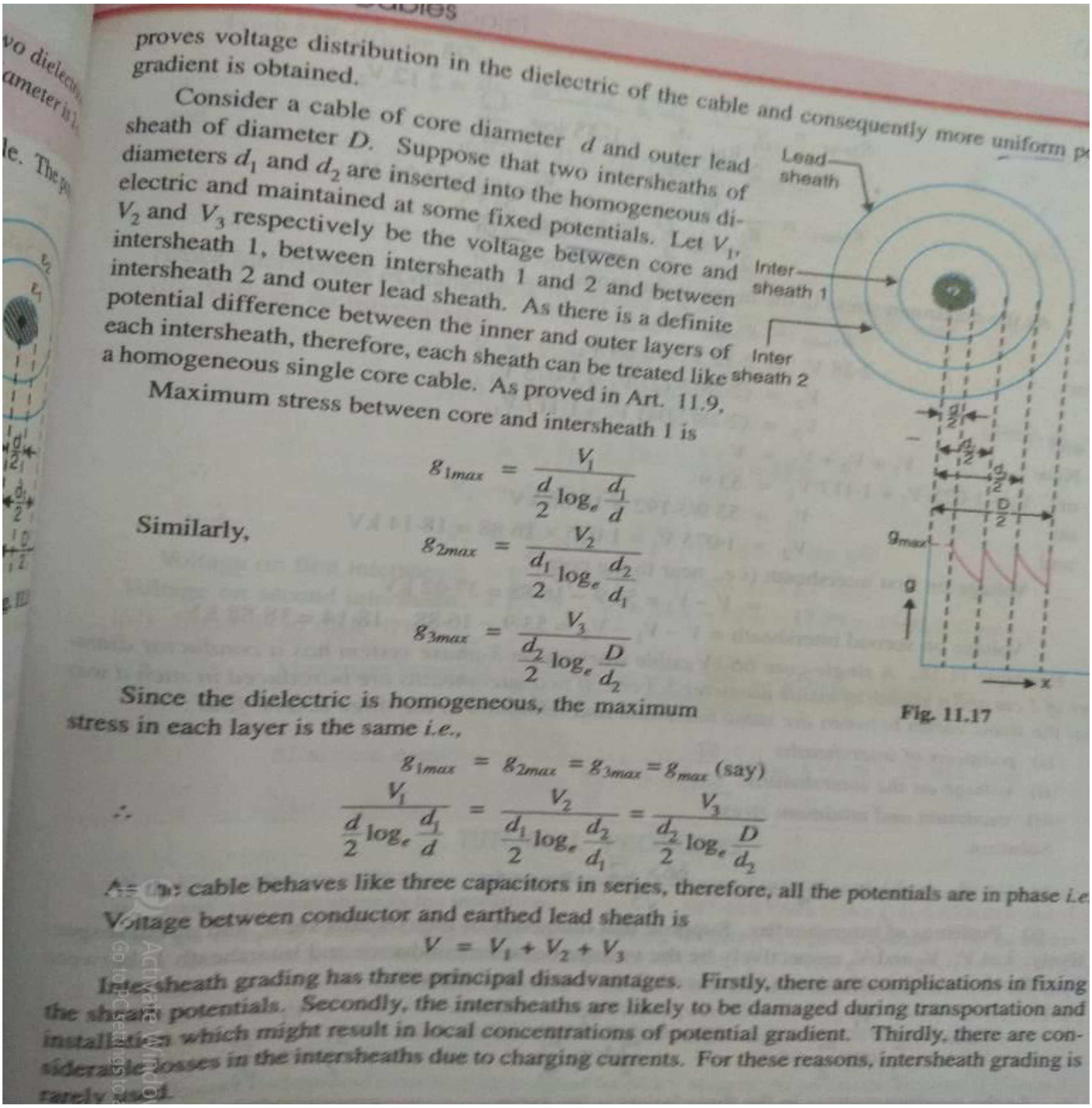
Example 11.12 *A single-core lead sheathed cable is graded by using*



$4[0\cdot4138 + 0\cdot4054]$

11.13 Intersheath Grading

In this method of cable grading, a homogeneous dielectric is used, but it is divided into various layers by placing metallic intersheaths between the core and lead sheath. The intersheaths are held at suitable potentials which are inbetween the core potential and earth potential. This arrangement im



proves voltage distribution in the dielectric of the cable and consequently more uniform p
gradient is obtained.

Consider a cable of core diameter d and outer lead sheath of diameter D. Suppose that two intersheaths of diameters d_1 and d_2 are inserted into the homogeneous dielectric and maintained at some fixed potentials. Let V_1, V_2 and V_3 respectively be the voltage between core and intersheath 1, between intersheath 1 and 2 and between intersheath 2 and outer lead sheath. As there is a definite potential difference between the inner and outer layers of each intersheath, therefore, each sheath can be treated like a homogeneous single core cable. As proved in Art. 11.9,

Maximum stress between core and intersheath 1 is

$$g_{1max} = \frac{V_1}{\frac{d}{2}\log_e \frac{d_1}{d}}$$

Similarly,

$$g_{2max} = \frac{V_2}{\frac{d_1}{2}\log_e \frac{d_2}{d_1}}$$

$$g_{3max} = \frac{V_3}{\frac{d_2}{2}\log_e \frac{D}{d_2}}$$

Fig. 11.17

Since the dielectric is homogeneous, the maximum stress in each layer is the same *i.e.*,

$$g_{1max} = g_{2max} = g_{3max} = g_{max} \text{ (say)}$$

$$\therefore \quad \frac{V_1}{\frac{d}{2}\log_e \frac{d_1}{d}} = \frac{V_2}{\frac{d_1}{2}\log_e \frac{d_2}{d_1}} = \frac{V_3}{\frac{d_2}{2}\log_e \frac{D}{d_2}}$$

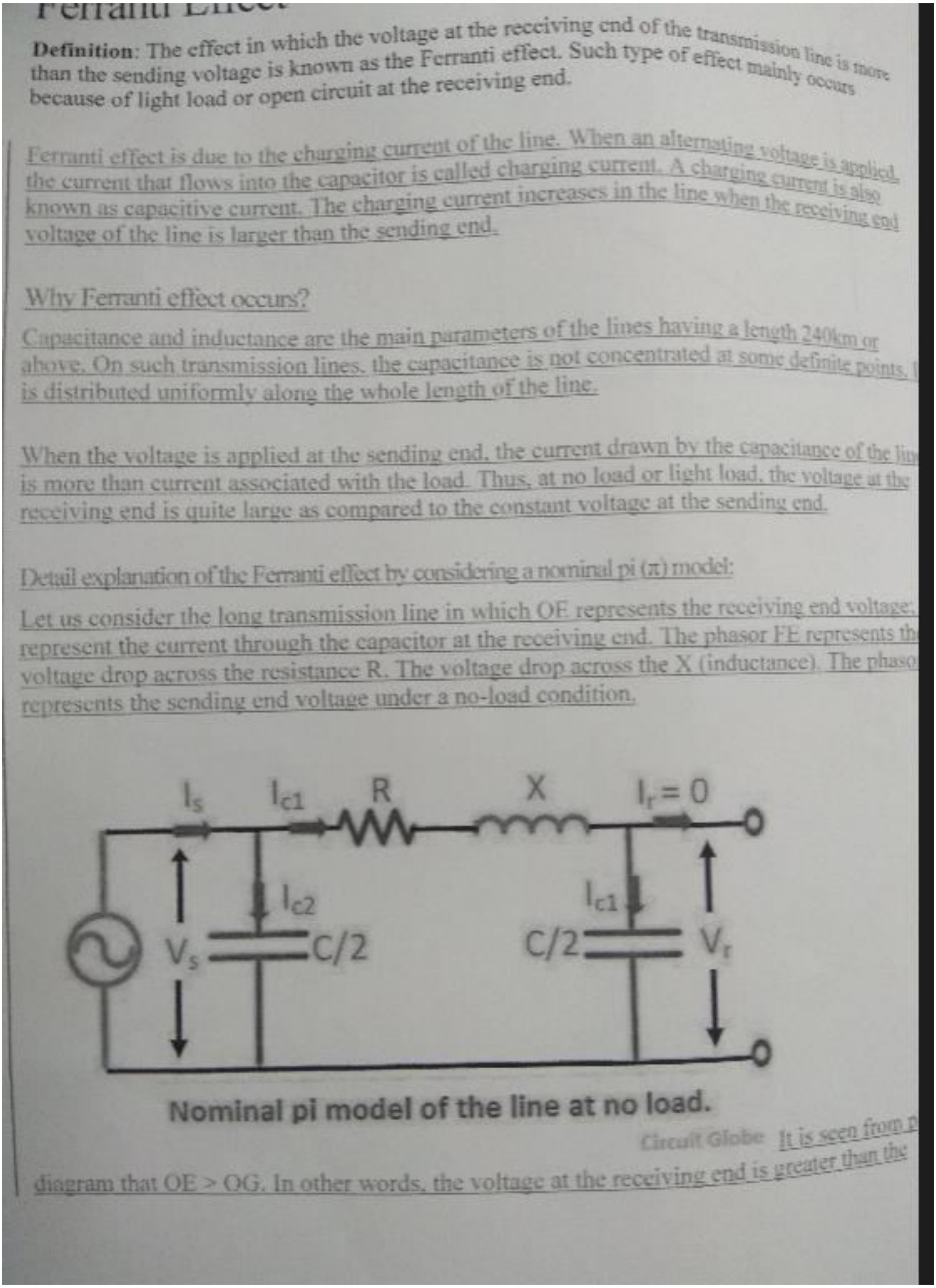
As the cable behaves like three capacitors in series, therefore, all the potentials are in phase *i.e.*

Voltage between conductor and earthed lead sheath is

$$V = V_1 + V_2 + V_3$$

Intersheath grading has three principal disadvantages. Firstly, there are complications in fixing the sheath potentials. Secondly, the intersheaths are likely to be damaged during transportation and installation which might result in local concentrations of potential gradient. Thirdly, there are considerable losses in the intersheaths due to charging currents. For these reasons, intersheath grading is rarely used.

2A Explain Ferranti effect



Ferranti Effect

Definition: The effect in which the voltage at the receiving end of the transmission line is more than the sending voltage is known as the Ferranti effect. Such type of effect mainly occurs because of light load or open circuit at the receiving end.

Ferranti effect is due to the charging current of the line. When an alternating voltage is applied, the current that flows into the capacitor is called charging current. A charging current is also known as capacitive current. The charging current increases in the line when the receiving end voltage of the line is larger than the sending end.

Why Ferranti effect occurs?

Capacitance and inductance are the main parameters of the lines having a length 240km or above. On such transmission lines, the capacitance is not concentrated at some definite points. I is distributed uniformly along the whole length of the line.

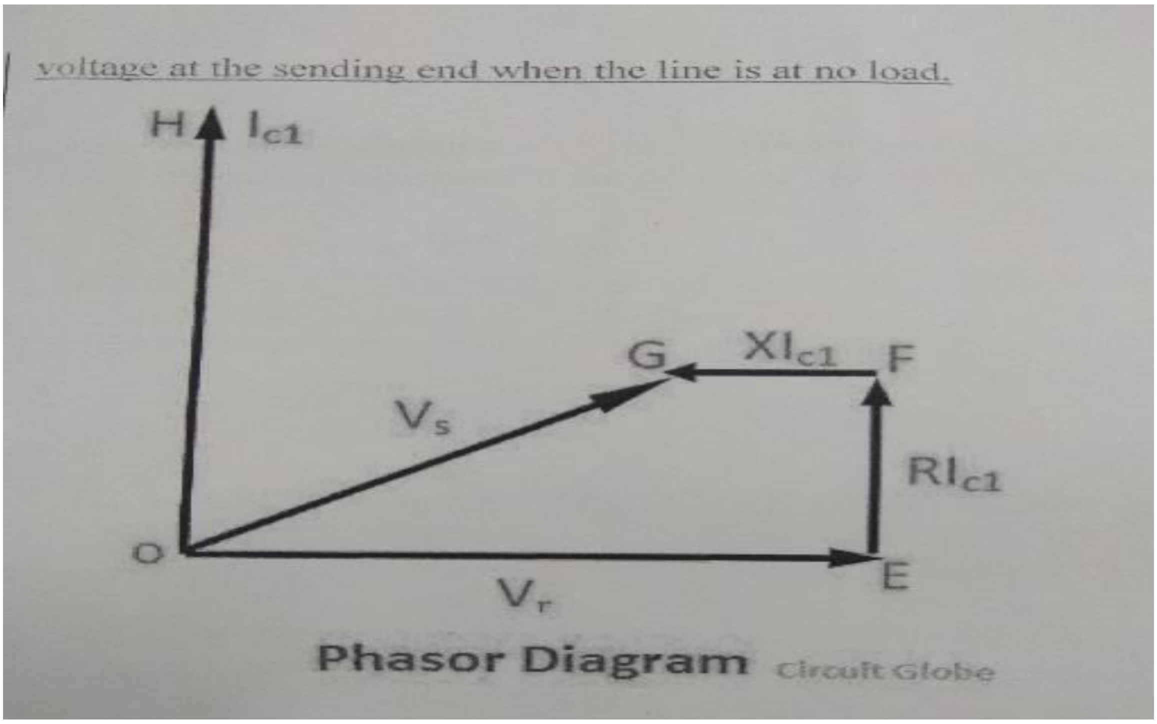
When the voltage is applied at the sending end, the current drawn by the capacitance of the lin is more than current associated with the load. Thus, at no load or light load, the voltage at the receiving end is quite large as compared to the constant voltage at the sending end.

Detail explanation of the Ferranti effect by considering a nominal pi (π) model:

Let us consider the long transmission line in which OE represents the receiving end voltage: represent the current through the capacitor at the receiving end. The phasor FE represents th voltage drop across the resistance R. The voltage drop across the X (inductance). The phaso represents the sending end voltage under a no-load condition.

Nominal pi model of the line at no load.

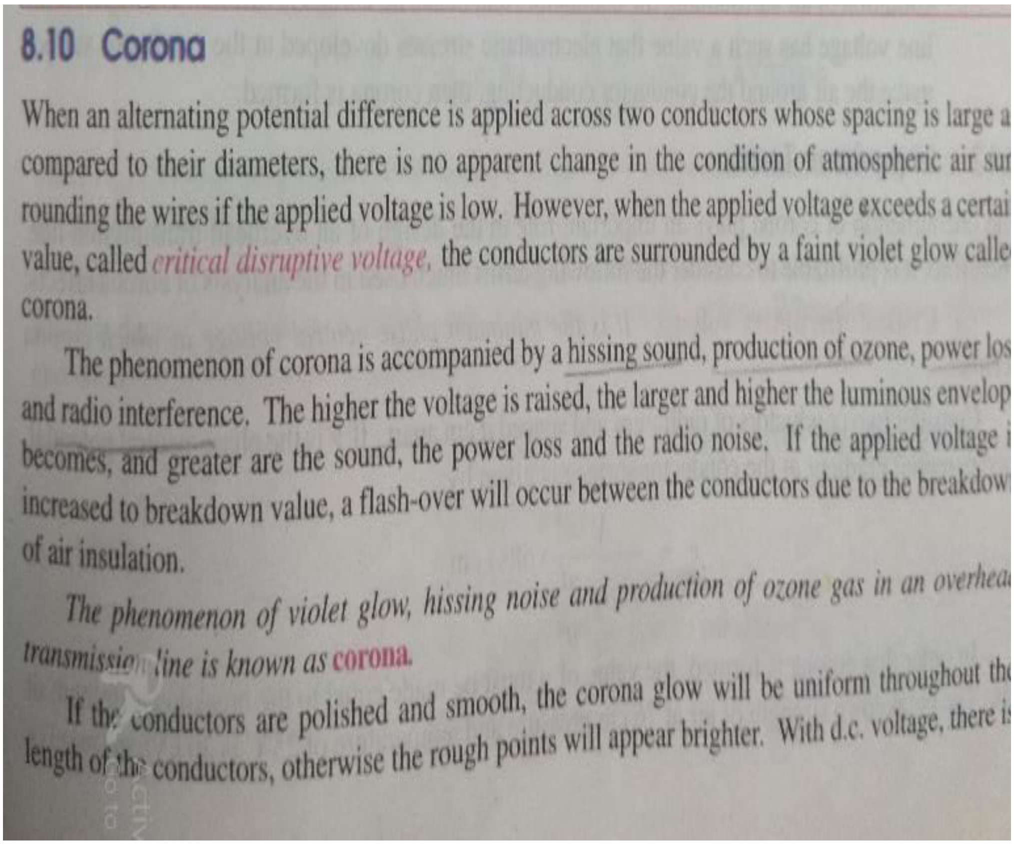
Circuit Globe It is seen from p diagram that OE > OG. In other words, the voltage at the receiving end is greater than the



voltage at the sending end when the line is at no load.

Phasor Diagram Circuit Globe

2B Explain about the phenomenon of corona in over head transmission line



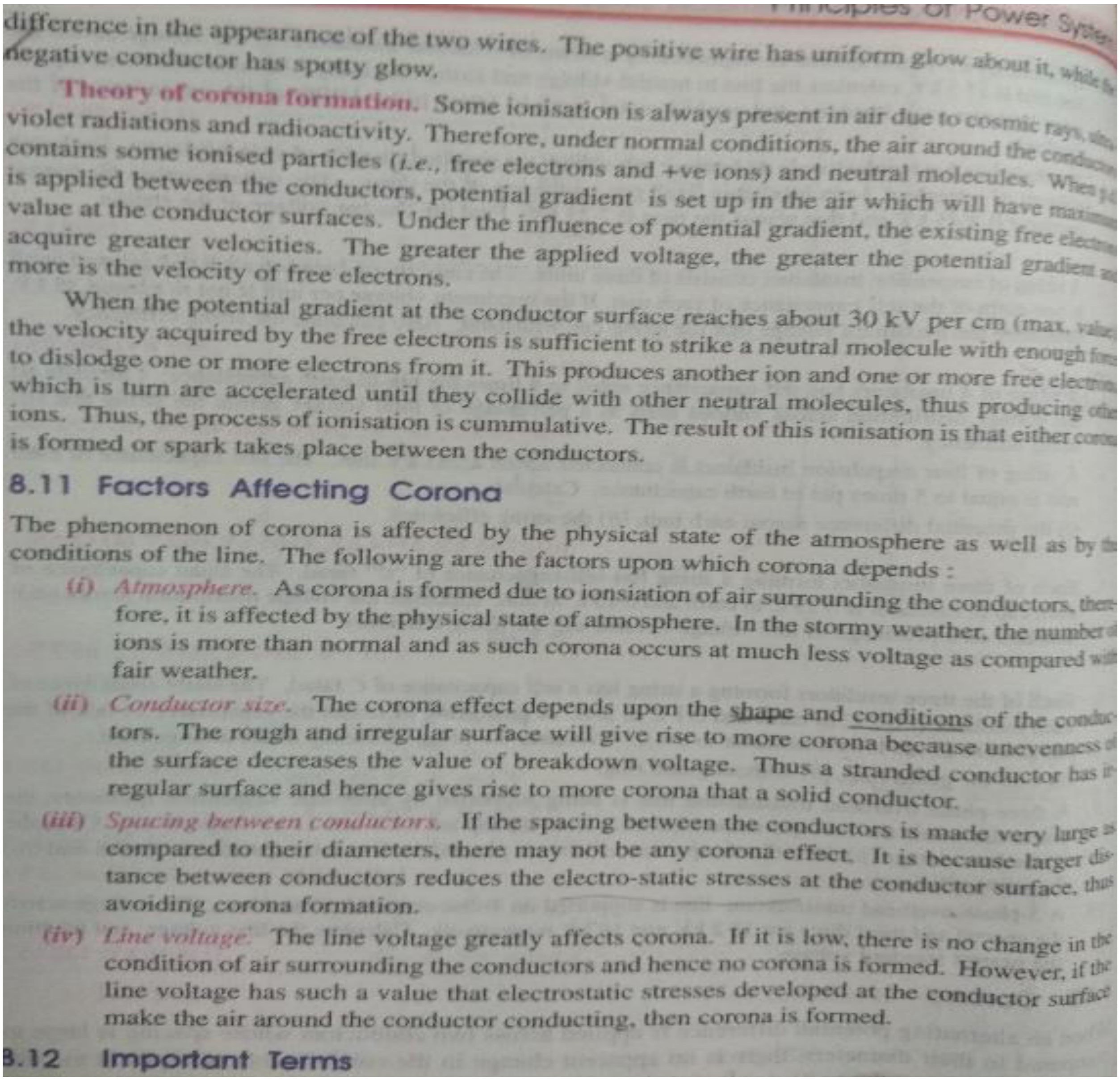
8.10 Corona

When an alternating potential difference is applied across two conductors whose spacing is large a compared to their diameters, there is no apparent change in the condition of atmospheric air sur rounding the wires if the applied voltage is low. However, when the applied voltage exceeds a certai value, called *critical disruptive voltage*, the conductors are surrounded by a faint violet glow calle corona.

The phenomenon of corona is accompanied by a hissing sound, production of ozone, power los and radio interference. The higher the voltage is raised, the larger and higher the luminous envelop becomes, and greater are the sound, the power loss and the radio noise. If the applied voltage i increased to breakdown value, a flash-over will occur between the conductors due to the breakdow of air insulation.

The phenomenon of violet glow, hissing noise and production of ozone gas in an overhea transmission line is known as **corona**.

If the conductors are polished and smooth, the corona glow will be uniform throughout th length of the conductors, otherwise the rough points will appear brighter. With d.c. voltage, there i



difference in the appearance of the two wires. The positive wire has uniform glow about it, while t negative conductor has spotty glow.

Theory of corona formation. Some ionisation is always present in air due to cosmic rays, ul violet radiations and radioactivity. Therefore, under normal conditions, the air around the conduc contains some ionised particles (*i.e.*, free electrons and +ve ions) and neutral molecules. When p is applied between the conductors, potential gradient is set up in the air which will have maxim value at the conductor surfaces. Under the influence of potential gradient, the existing free electr acquire greater velocities. The greater the applied voltage, the greater the potential gradient an more is the velocity of free electrons.

When the potential gradient at the conductor surface reaches about 30 kV per cm (max. value the velocity acquired by the free electrons is sufficient to strike a neutral molecule with enough for to dislodge one or more electrons from it. This produces another ion and one or more free electron which is turn are accelerated until they collide with other neutral molecules, thus producing othe ions. Thus, the process of ionisation is cummulative. The result of this ionisation is that either coro is formed or spark takes place between the conductors.

8.11 Factors Affecting Corona

The phenomenon of corona is affected by the physical state of the atmosphere as well as by th conditions of the line. The following are the factors upon which corona depends :

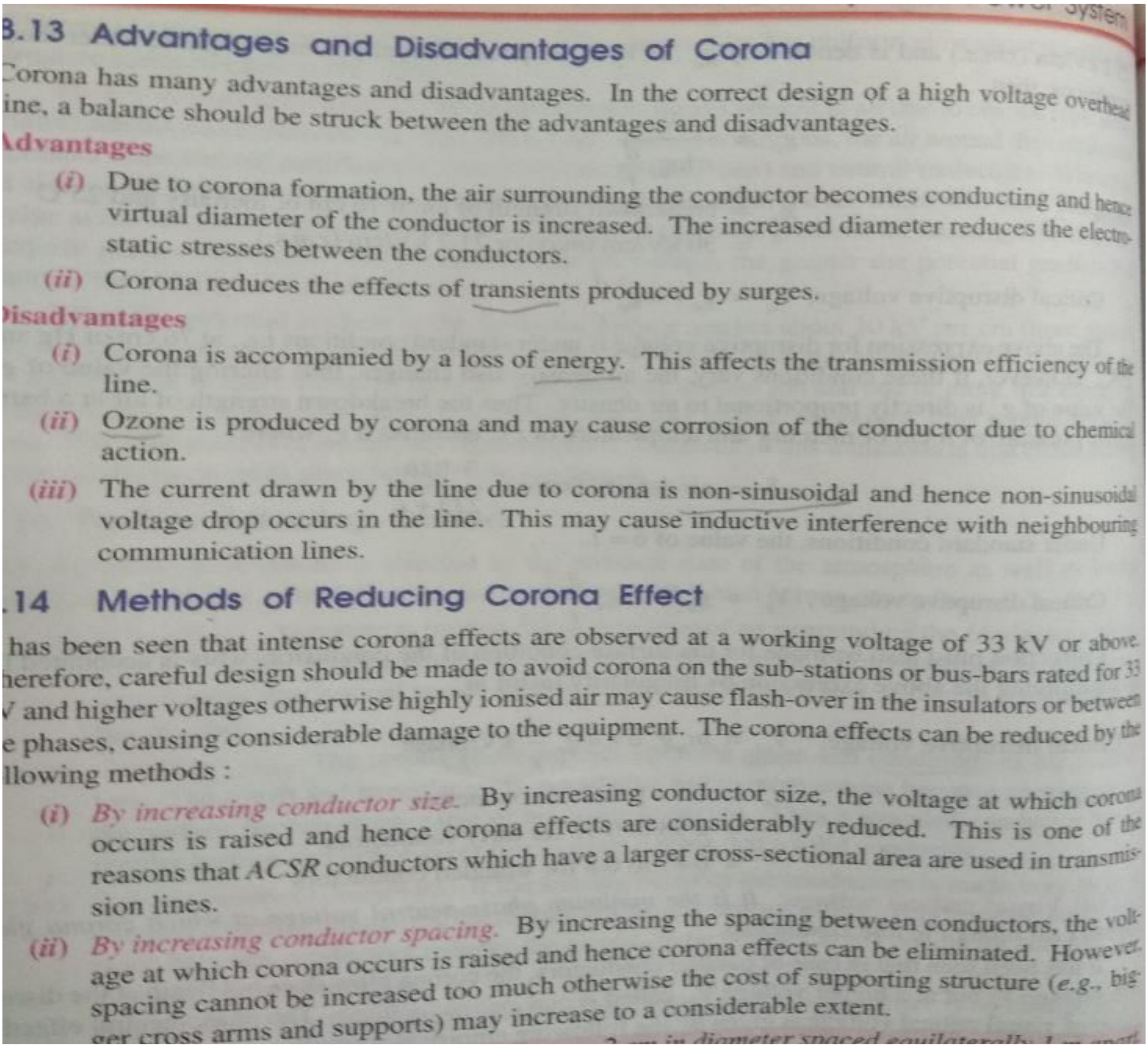
(*i*) *Atmosphere.* As corona is formed due to ionsiation of air surrounding the conductors, therefore, it is affected by the physical state of atmosphere. In the stormy weather, the number of ions is more than normal and as such corona occurs at much less voltage as compared wit fair weather.

(*ii*) *Conductor size.* The corona effect depends upon the shape and conditions of the conductors. The rough and irregular surface will give rise to more corona because unevenness of the surface decreases the value of breakdown voltage. Thus a stranded conductor has irregular surface and hence gives rise to more corona that a solid conductor.

(*iii*) *Spacing between conductors.* If the spacing between the conductors is made very large as compared to their diameters, there may not be any corona effect. It is because larger distance between conductors reduces the electro-static stresses at the conductor surface, thus avoiding corona formation.

(*iv*) *Line voltage.* The line voltage greatly affects corona. If it is low, there is no change in the condition of air surrounding the conductors and hence no corona is formed. However, if the line voltage has such a value that electrostatic stresses developed at the conductor surface make the air around the conductor conducting, then corona is formed.

8.12 Important Terms



8.13 Advantages and Disadvantages of Corona

orona has many advantages and disadvantages. In the correct design of a high voltage overhead ine, a balance should be struck between the advantages and disadvantages.

dvantages

(*i*) Due to corona formation, the air surrounding the conductor becomes conducting and hence virtual diameter of the conductor is increased. The increased diameter reduces the electrostatic stresses between the conductors.

(*ii*) Corona reduces the effects of transients produced by surges.

isadvantages

(*i*) Corona is accompanied by a loss of energy. This affects the transmission efficiency of the line.

(*ii*) Ozone is produced by corona and may cause corrosion of the conductor due to chemical action.

(*iii*) The current drawn by the line due to corona is non-sinusoidal and hence non-sinusoidal voltage drop occurs in the line. This may cause inductive interference with neighbouring communication lines.

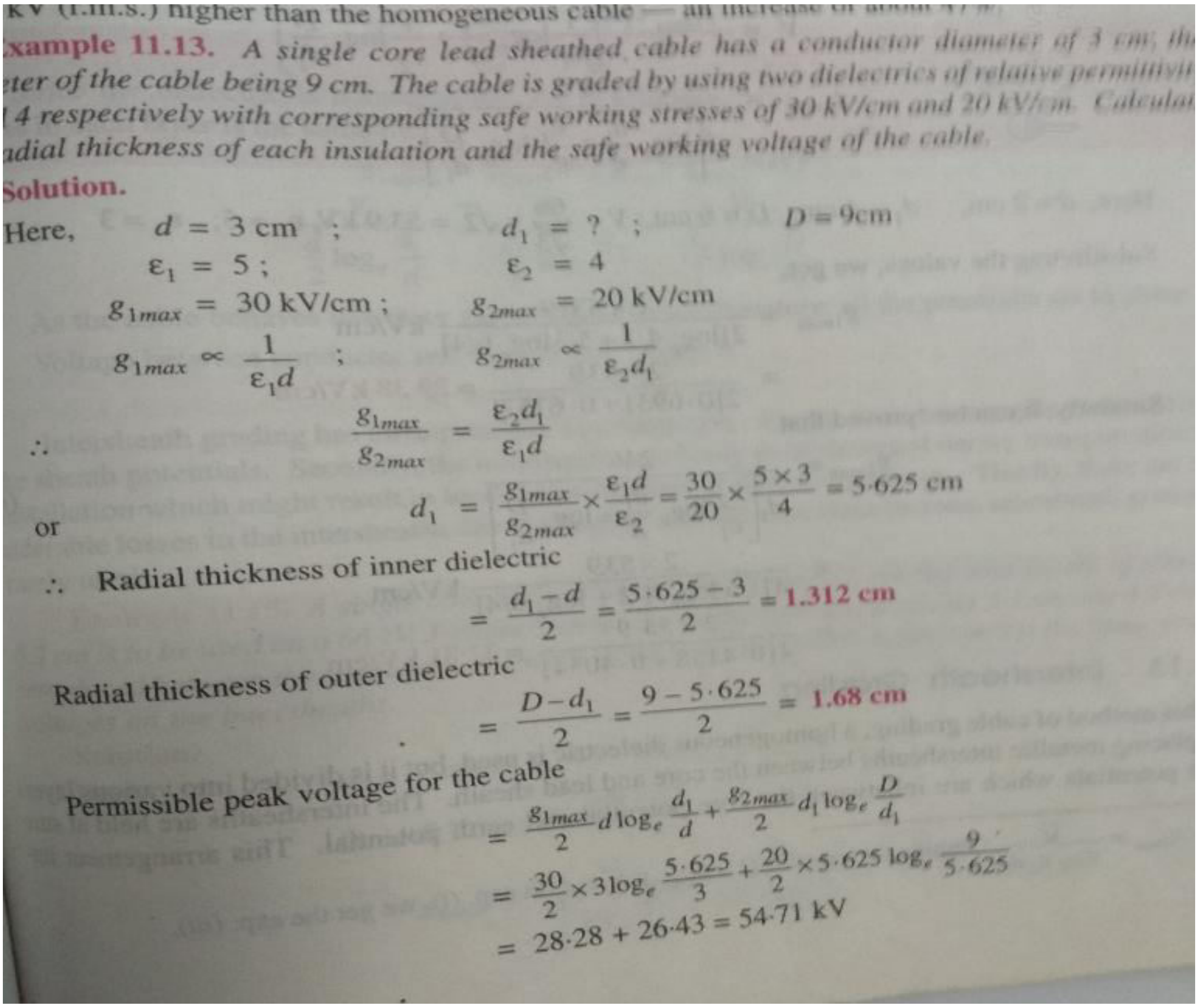
.14 Methods of Reducing Corona Effect

has been seen that intense corona effects are observed at a working voltage of 33 kV or above. herefore, careful design should be made to avoid corona on the sub-stations or bus-bars rated for 33 V and higher voltages otherwise highly ionised air may cause flash-over in the insulators or between e phases, causing considerable damage to the equipment. The corona effects can be reduced by the llowing methods :

(*i*) *By increasing conductor size.* By increasing conductor size, the voltage at which corona occurs is raised and hence corona effects are considerably reduced. This is one of the reasons that *ACSR* conductors which have a larger cross-sectional area are used in transmission lines.

(*ii*) *By increasing conductor spacing.* By increasing the spacing between conductors, the voltage at which corona occurs is raised and hence corona effects can be eliminated. However, spacing cannot be increased too much otherwise the cost of supporting structure (*e.g.*, bigger cross arms and supports) may increase to a considerable extent.

3 A single core lead sheathed cable has a conductor diameter of 3 cm; the diameter of the cable being 9 cm. The cable is graded by using two dielectrics of relative permittivity 5 and 4 respectively with corresponding safe working stresses of 30 kV/cm and 20 kV/cm. Calculate the radial thickness of each insulation and the safe working voltage of the cable.



kV (r.m.s.) higher than the homogeneous cable — an increase of about

xample 11.13. *A single core lead sheathed cable has a conductor diameter of 3 cm; the ter of the cable being 9 cm. The cable is graded by using two dielectrics of relative permittivi 4 respectively with corresponding safe working stresses of 30 kV/cm and 20 kV/cm. Calcula adial thickness of each insulation and the safe working voltage of the cable.*

Solution.

Here, $d = 3$ cm ; $d_1 = ?$; $D = 9$cm

$\varepsilon_1 = 5$; $\varepsilon_2 = 4$

$g_{1max} = 30$ kV/cm ; $g_{2max} = 20$ kV/cm

$$g_{1max} \propto \frac{1}{\varepsilon_1 d} \; ; \qquad g_{2max} \propto \frac{1}{\varepsilon_2 d_1}$$

$$\therefore \quad \frac{g_{1max}}{g_{2max}} = \frac{\varepsilon_2 d_1}{\varepsilon_1 d}$$

or

$$d_1 = \frac{g_{1max}}{g_{2max}} \times \frac{\varepsilon_1 d}{\varepsilon_2} = \frac{30}{20} \times \frac{5 \times 3}{4} = 5{\cdot}625 \text{ cm}$$

$\therefore$ Radial thickness of inner dielectric

$$= \frac{d_1 - d}{2} = \frac{5{\cdot}625 - 3}{2} = \mathbf{1.312 \text{ cm}}$$

Radial thickness of outer dielectric

$$= \frac{D - d_1}{2} = \frac{9 - 5{\cdot}625}{2} = \mathbf{1.68 \text{ cm}}$$

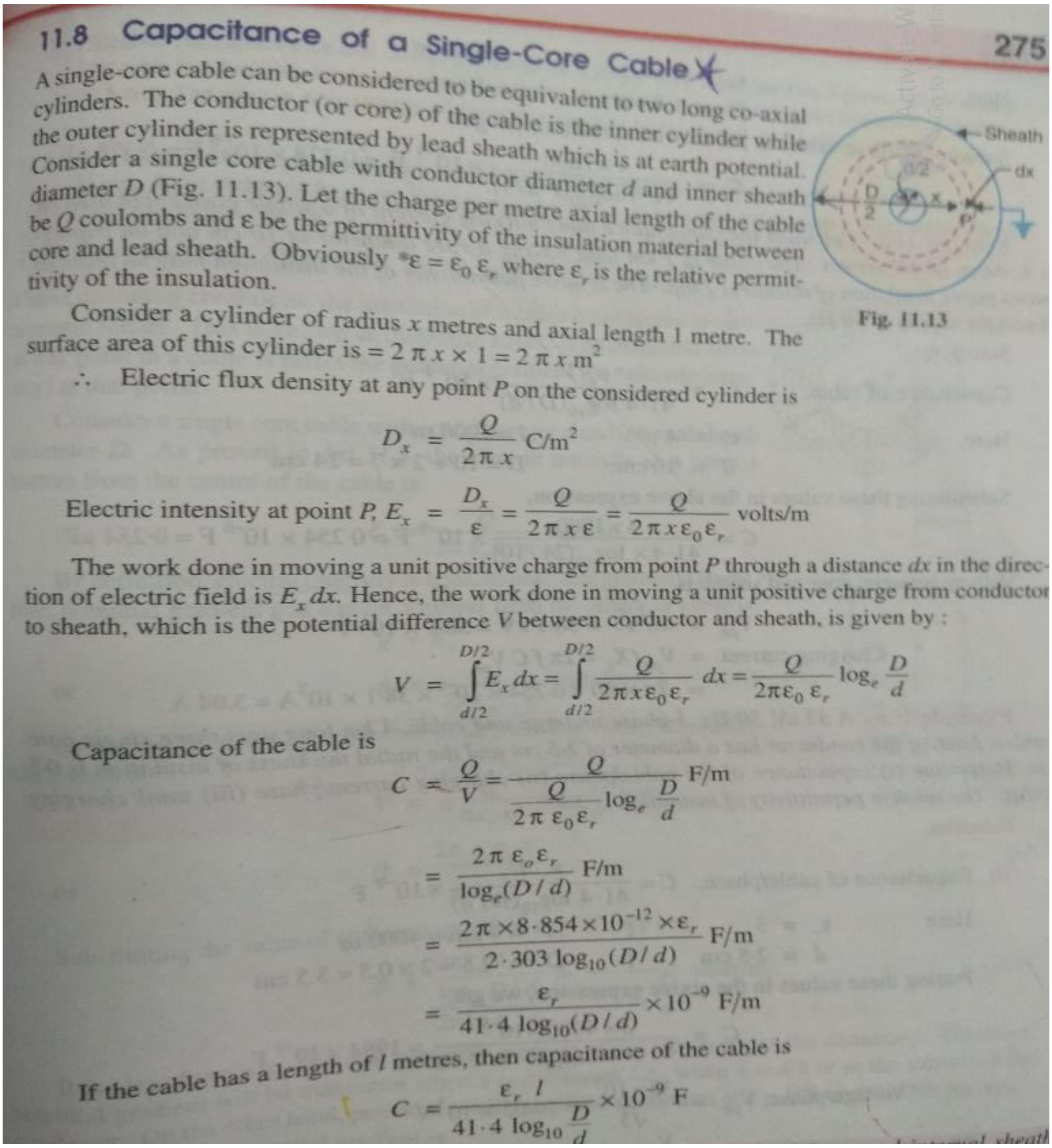
Permissible peak voltage for the cable

$$= \frac{g_{1max}}{2} d \log_e \frac{d_1}{d} + \frac{g_{2max}}{2} d_1 \log_e \frac{D}{d_1}$$

$$= \frac{30}{2} \times 3 \log_e \frac{5{\cdot}625}{3} + \frac{20}{2} \times 5{\cdot}625 \log_e \frac{9}{5{\cdot}625}$$

$$= 28{\cdot}28 + 26{\cdot}43 = 54{\cdot}71 \text{ kV}$$

4A Drive an expression for the capacitance of a single core cable



11.8 Capacitance of a Single-Core Cable

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A single-core cable can be considered to be equivalent to two long co-axial cylinders. The conductor (or core) of the cable is the inner cylinder while the outer cylinder is represented by lead sheath which is at earth potential. Consider a single core cable with conductor diameter d and inner sheath diameter D (Fig. 11.13). Let the charge per metre axial length of the cable be Q coulombs and ε be the permittivity of the insulation material between core and lead sheath. Obviously $^*\varepsilon = \varepsilon_0\,\varepsilon_r$ where ε_r is the relative permittivity of the insulation.

Fig. 11.13

Consider a cylinder of radius x metres and axial length 1 metre. The surface area of this cylinder is $= 2\,\pi\,x \times 1 = 2\,\pi\,x\ \text{m}^2$

∴ Electric flux density at any point P on the considered cylinder is

$$D_x = \frac{Q}{2\pi x}\ \text{C/m}^2$$

Electric intensity at point P, $E_x = \dfrac{D_x}{\varepsilon} = \dfrac{Q}{2\pi x\varepsilon} = \dfrac{Q}{2\pi x\varepsilon_0\varepsilon_r}$ volts/m

The work done in moving a unit positive charge from point P through a distance dx in the direction of electric field is $E_x\,dx$. Hence, the work done in moving a unit positive charge from conductor to sheath, which is the potential difference V between conductor and sheath, is given by :

$$V = \int_{d/2}^{D/2} E_x\,dx = \int_{d/2}^{D/2} \frac{Q}{2\pi x\varepsilon_0\varepsilon_r}\,dx = \frac{Q}{2\pi\varepsilon_0\,\varepsilon_r}\log_e\frac{D}{d}$$

Capacitance of the cable is

$$C = \frac{Q}{V} = \frac{Q}{\dfrac{Q}{2\pi\,\varepsilon_0\varepsilon_r}\log_e\dfrac{D}{d}}\ \text{F/m}$$

$$= \frac{2\pi\,\varepsilon_o\varepsilon_r}{\log_e(D/d)}\ \text{F/m}$$

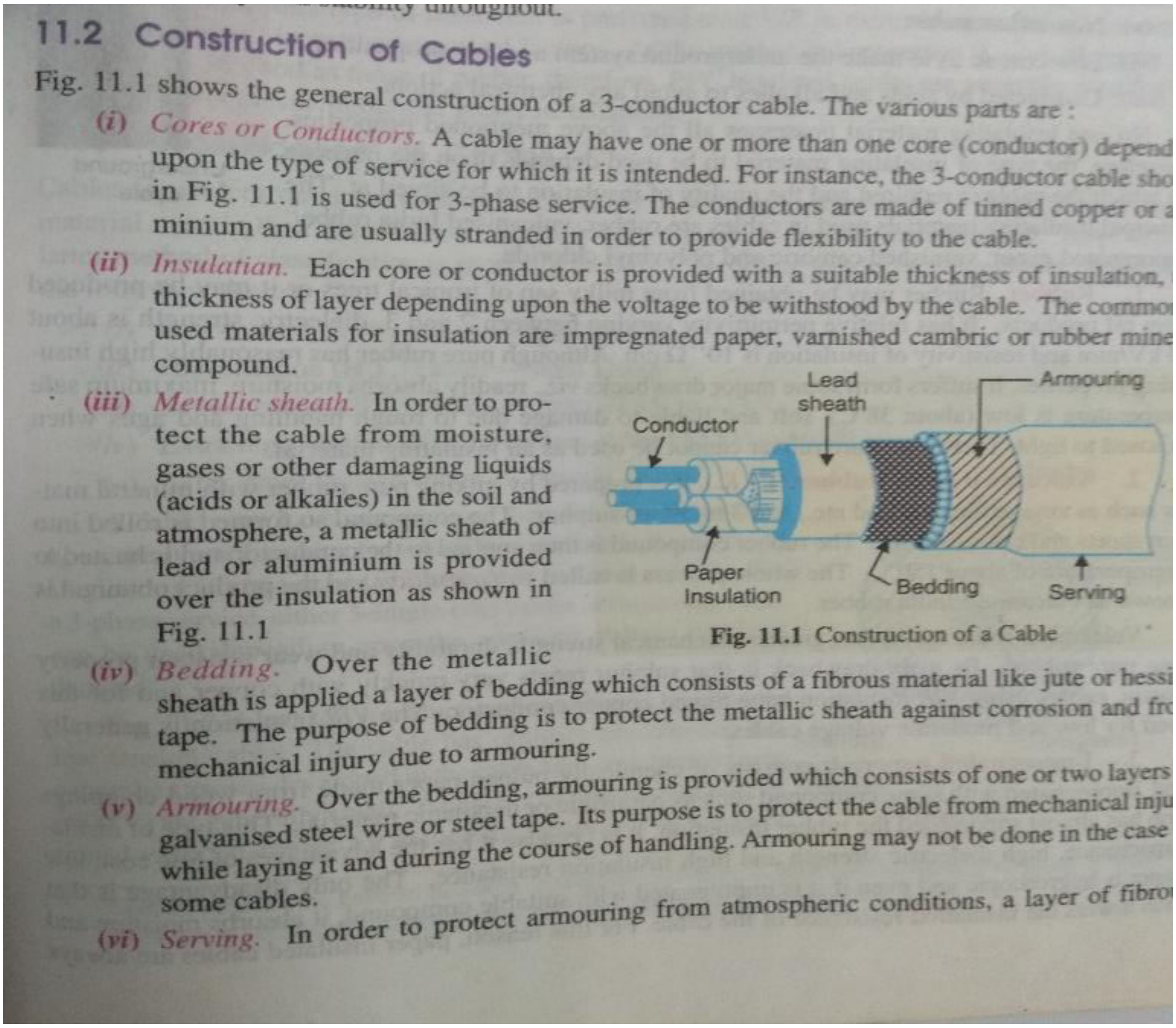
$$= \frac{2\pi\times 8{\cdot}854\times 10^{-12}\times\varepsilon_r}{2{\cdot}303\,\log_{10}(D/d)}\ \text{F/m}$$

$$= \frac{\varepsilon_r}{41{\cdot}4\,\log_{10}(D/d)}\times 10^{-9}\ \text{F/m}$$

If the cable has a length of l metres, then capacitance of the cable is

$$C = \frac{\varepsilon_r\ l}{41{\cdot}4\,\log_{10}\dfrac{D}{d}}\times 10^{-9}\ \text{F}$$

4B Draw the cross sectional view of a single core underground cable and explain about its construction



throughout.

11.2 Construction of Cables

Fig. 11.1 shows the general construction of a 3-conductor cable. The various parts are :

(i) *Cores or Conductors.* A cable may have one or more than one core (conductor) depend upon the type of service for which it is intended. For instance, the 3-conductor cable sho in Fig. 11.1 is used for 3-phase service. The conductors are made of tinned copper or a minium and are usually stranded in order to provide flexibility to the cable.

(ii) *Insulatian.* Each core or conductor is provided with a suitable thickness of insulation, thickness of layer depending upon the voltage to be withstood by the cable. The commo used materials for insulation are impregnated paper, varnished cambric or rubber mine compound.

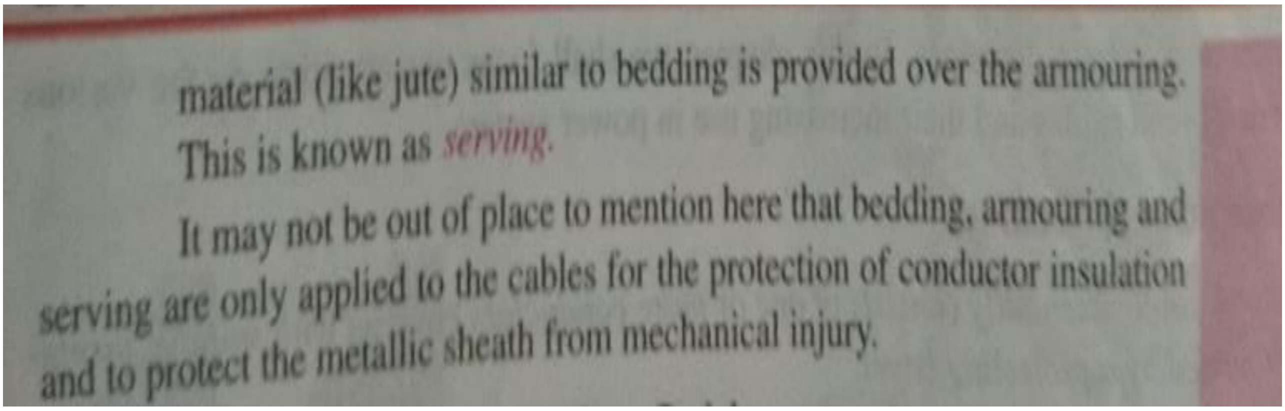
(iii) *Metallic sheath.* In order to protect the cable from moisture, gases or other damaging liquids (acids or alkalies) in the soil and atmosphere, a metallic sheath of lead or aluminium is provided over the insulation as shown in Fig. 11.1

Fig. 11.1 Construction of a Cable

(iv) *Bedding.* Over the metallic sheath is applied a layer of bedding which consists of a fibrous material like jute or hessi tape. The purpose of bedding is to protect the metallic sheath against corrosion and fr mechanical injury due to armouring.

(v) *Armouring.* Over the bedding, armouring is provided which consists of one or two layers galvanised steel wire or steel tape. Its purpose is to protect the cable from mechanical inju while laying it and during the course of handling. Armouring may not be done in the case some cables.

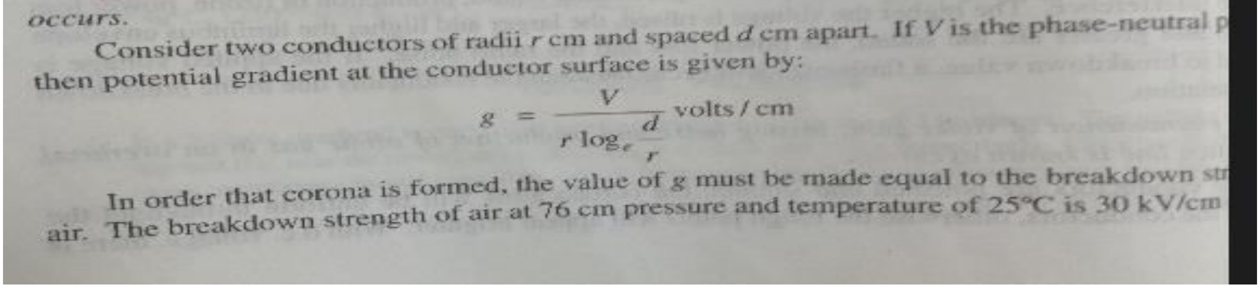
(vi) *Serving.* In order to protect armouring from atmospheric conditions, a layer of fibro



material (like jute) similar to bedding is provided over the armouring. This is known as *serving*.

It may not be out of place to mention here that bedding, armouring and serving are only applied to the cables for the protection of conductor insulation and to protect the metallic sheath from mechanical injury.

5A Explain the following terms with reference to corona: 1)Critical disruptive voltage 2)Critical visual disruptive voltage



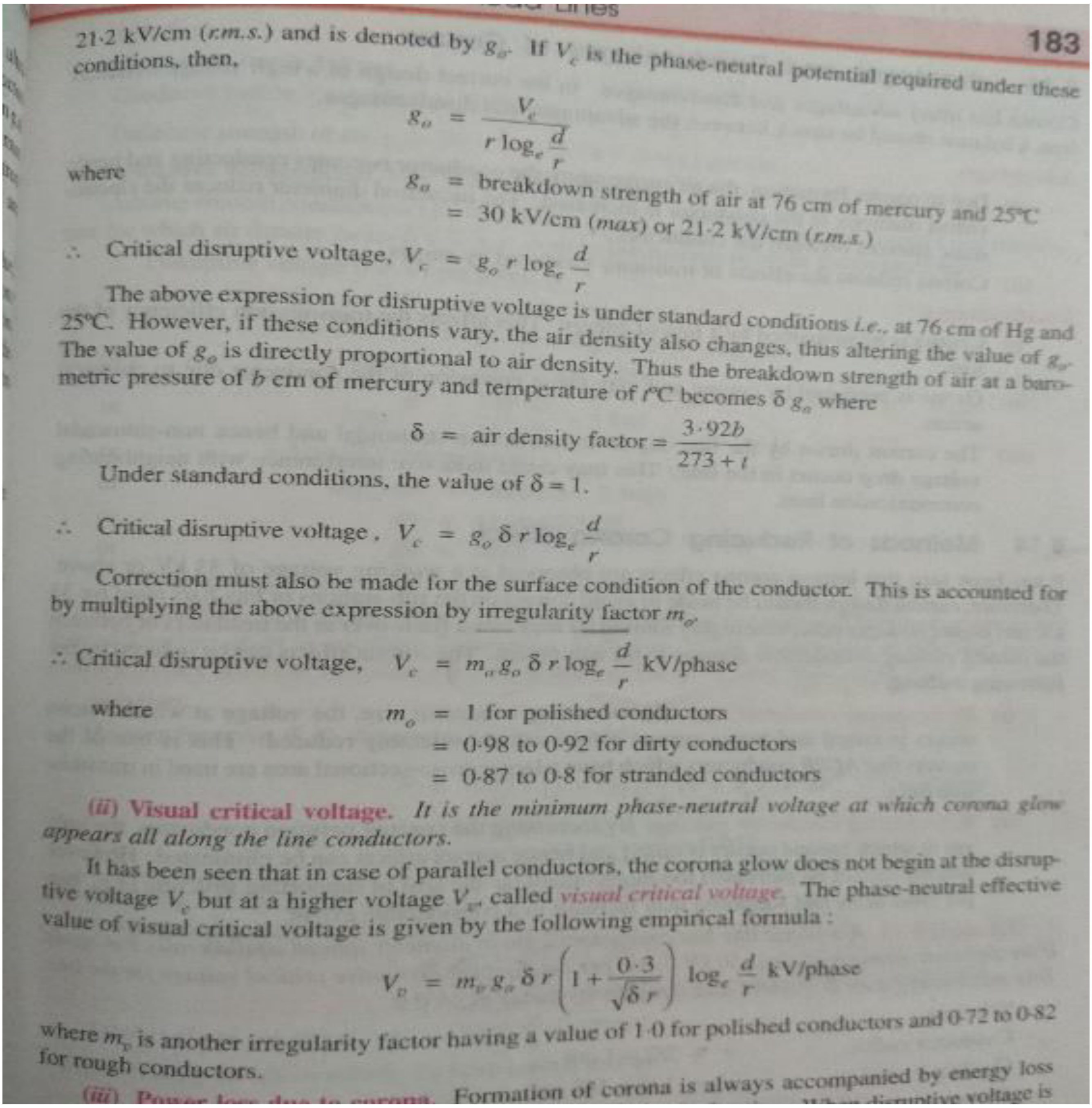
The phenomenon of corona plays an important role in the design of an overhead
Therefore, it is profitable to consider the following terms much used in the analysis of corona

(*i*) **Critical disruptive voltage.** *It is the minimum phase-neutral voltage at which*
occurs.

Consider two conductors of radii r cm and spaced d cm apart. If V is the phase-neutral p
then potential gradient at the conductor surface is given by:

$$g = \frac{V}{r \log_e \frac{d}{r}} \text{ volts / cm}$$

In order that corona is formed, the value of g must be made equal to the breakdown str
air. The breakdown strength of air at 76 cm pressure and temperature of 25°C is 30 kV/cm



21·2 kV/cm (*r.m.s.*) and is denoted by g_o. If V_c is the phase-neutral potential required under these conditions, then,

$$g_o = \frac{V_c}{r \log_e \frac{d}{r}}$$

where g_o = breakdown strength of air at 76 cm of mercury and 25°C
= 30 kV/cm (*max*) or 21·2 kV/cm (*r.m.s.*)

$$\therefore \text{ Critical disruptive voltage, } V_c = g_o \, r \log_e \frac{d}{r}$$

The above expression for disruptive voltage is under standard conditions *i.e.*, at 76 cm of Hg and 25°C. However, if these conditions vary, the air density also changes, thus altering the value of g_o. The value of g_o is directly proportional to air density. Thus the breakdown strength of air at a barometric pressure of b cm of mercury and temperature of t°C becomes δg_o where

$$\delta = \text{air density factor} = \frac{3 \cdot 92b}{273 + t}$$

Under standard conditions, the value of $\delta = 1$.

$$\therefore \text{ Critical disruptive voltage, } V_c = g_o \, \delta \, r \log_e \frac{d}{r}$$

Correction must also be made for the surface condition of the conductor. This is accounted for by multiplying the above expression by irregularity factor m_o.

$$\therefore \text{ Critical disruptive voltage, } V_c = m_o \, g_o \, \delta \, r \log_e \frac{d}{r} \text{ kV/phase}$$

where m_o = 1 for polished conductors
= 0·98 to 0·92 for dirty conductors
= 0·87 to 0·8 for stranded conductors

(ii) Visual critical voltage. *It is the minimum phase-neutral voltage at which corona glow appears all along the line conductors.*

It has been seen that in case of parallel conductors, the corona glow does not begin at the disruptive voltage V_c but at a higher voltage V_v, called *visual critical voltage*. The phase-neutral effective value of visual critical voltage is given by the following empirical formula :

$$V_v = m_v \, g_o \, \delta \, r \left(1 + \frac{0 \cdot 3}{\sqrt{\delta r}}\right) \log_e \frac{d}{r} \text{ kV/phase}$$

where m_v is another irregularity factor having a value of 1·0 for polished conductors and 0·72 to 0·82 for rough conductors.

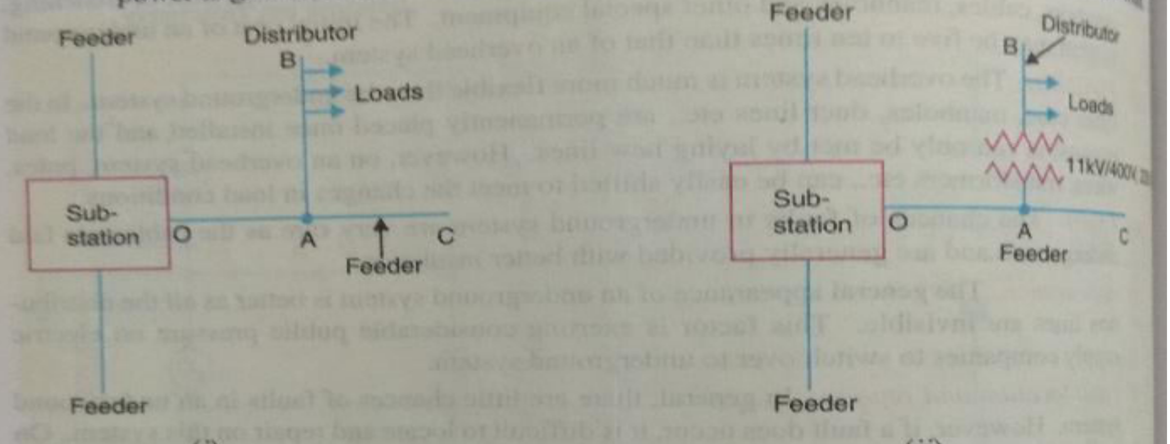
(iii) Power loss due to corona. Formation of corona is always accompanied by energy loss

5B Explain about radial & ring distributors

All distribution

distribution circuits are generally used :

(*i*) **Radial System.** In this system, separate feeders radiate from a single substation and the distributors at one end only. Fig. 12.8 (*i*) shows a single line diagram of a radial sy for d.c. distribution where a feeder *OC* supplies a distributor *AB* at point *A*. Obvious distributor is fed at one end only *i.e.*, point *A* is this case. Fig. 12.8 (*ii*) shows a single diagram of radial system for a.c. distribution. The radial system is employed only power is generated at low voltage and the substation is located at the centre of the load



(*i*) (*ii*)

Fig. 12.8

This is the simplest distribution circuit and has the lowest initial cost. However, it suffers the following drawbacks :

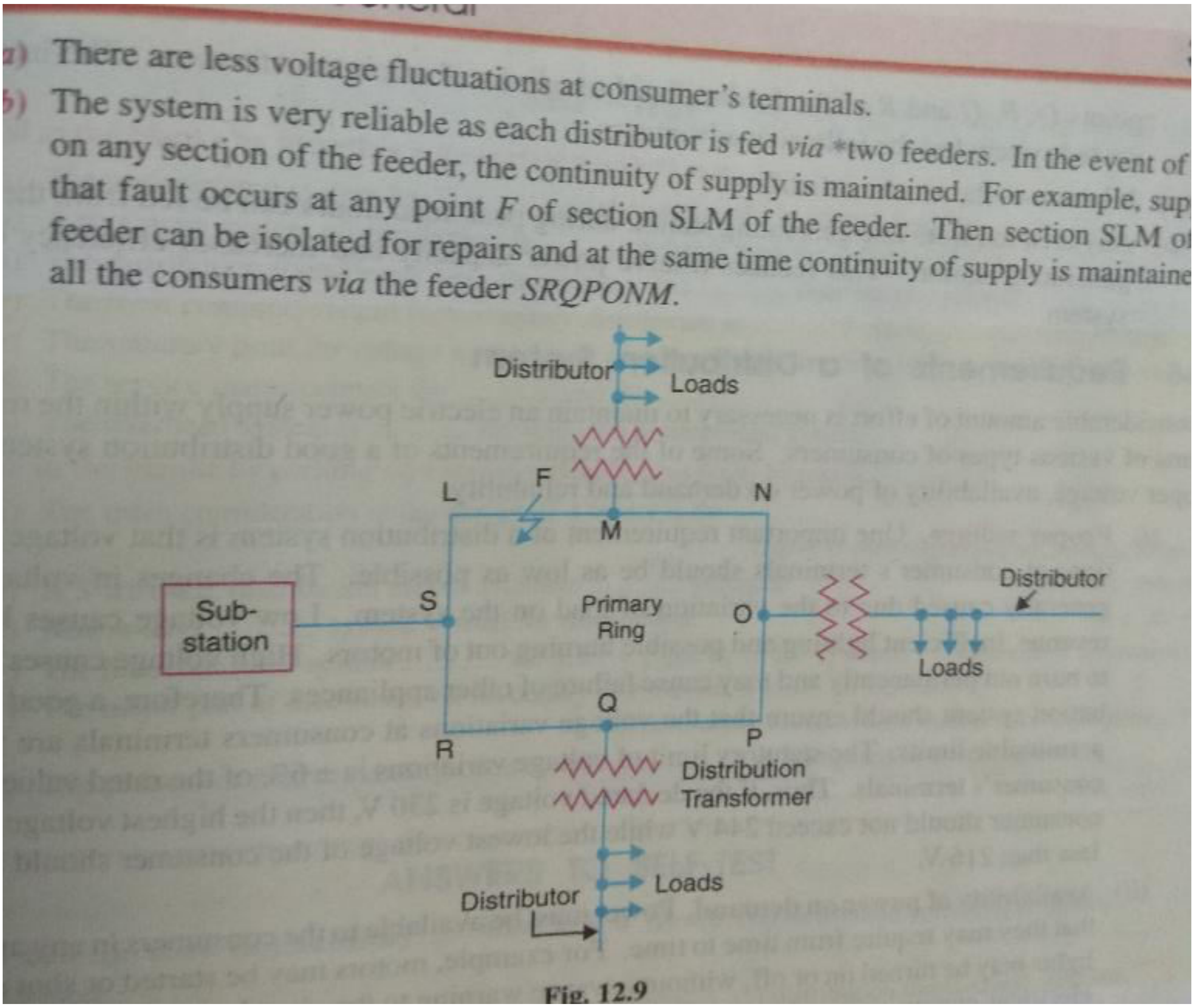
(*a*) The end of the distributor nearest to the feeding point will be heavily loaded.

(*b*) The consumers are dependent on a single feeder and single distributor. Therefore, any on the feeder or distributor cuts off supply to the consumers who are on the side of the fault away the substation.

(*c*) The consumers at the distant end of the distributor would be subjected to serious fluctuations when the load on the distributor changes.

Due to these limitations, this system is used for short distances only.

(*ii*) **Ring main system.** In this system, the primaries of distribution transformers form a The loop circuit starts from the substation bus-bars, makes a loop through the area served, and returns to the substation. Fig. 12.9 shows the single line diagram of ring system for a.c. distribution where substation supplies to the closed feeder LMNO The distributors are tapped from different points *M*, *O* and *Q* of the feeder through dis tion transformers. The ring main system has the following advantages :



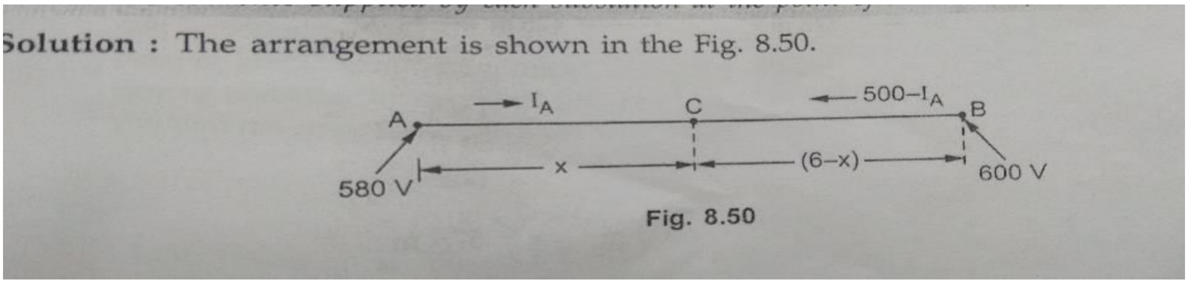
a) There are less voltage fluctuations at consumer's terminals.

b) The system is very reliable as each distributor is fed *via* *two feeders. In the event of on any section of the feeder, the continuity of supply is maintained. For example, sup that fault occurs at any point *F* of section SLM of the feeder. Then section SLM o feeder can be isolated for repairs and at the same time continuity of supply is maintaine all the consumers *via* the feeder *SRQPONM*.

Fig. 12.9

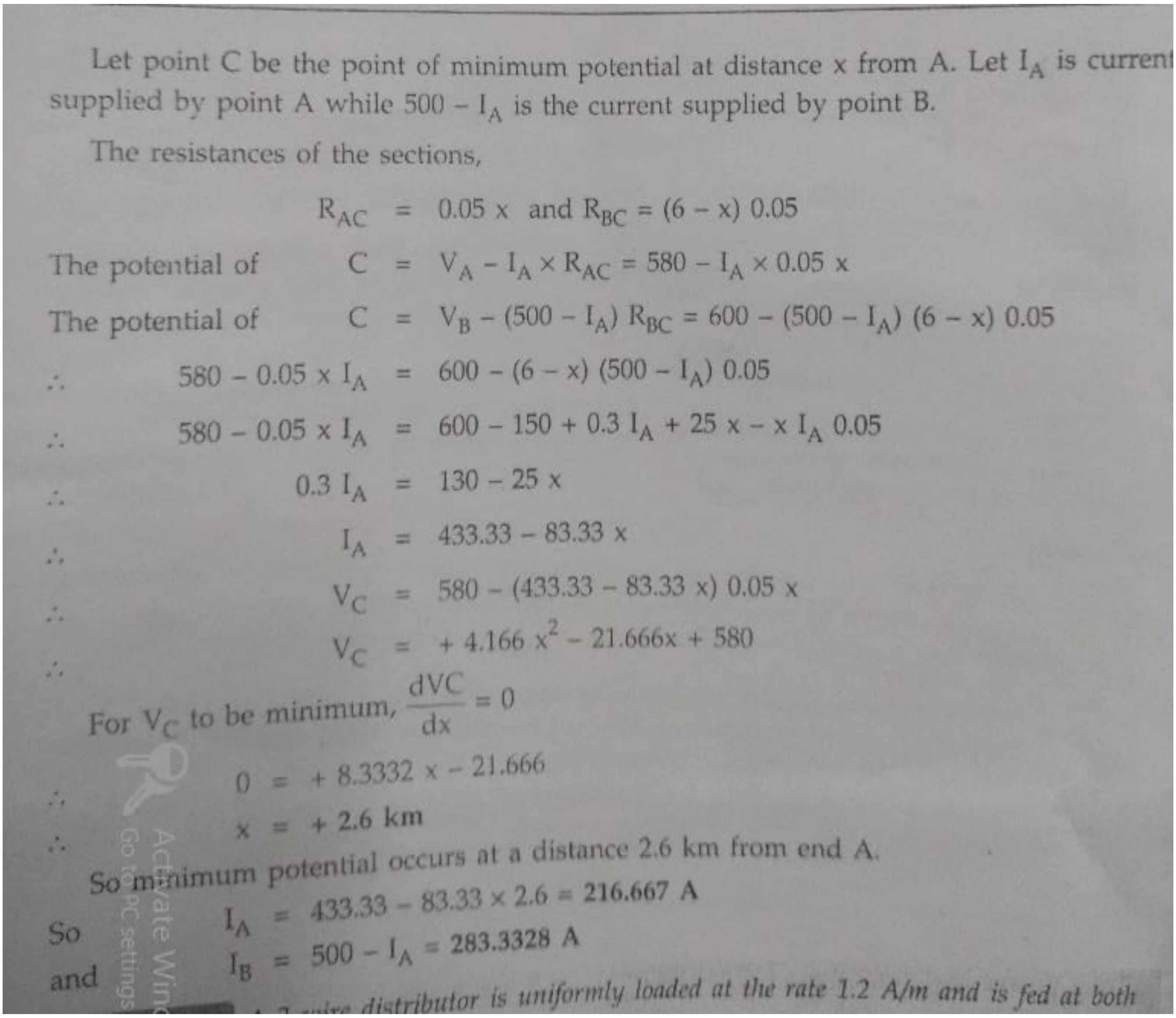
6 An electric train taking a constant current of 500 A moves between the two substations 6 km apart. The two substations are maintained at 580 V and 600 V respectively. The track resistance is 0.05Ω/km both go and return. Calculate

The point of minimum potential 2) The currents supplied by each substation at the point of minimum potential.



Solution : The arrangement is shown in the Fig. 8.50.

Fig. 8.50



Let point C be the point of minimum potential at distance x from A. Let I_A is current supplied by point A while $500 - I_A$ is the current supplied by point B.

The resistances of the sections,

$$R_{AC} = 0.05\,x \text{ and } R_{BC} = (6 - x)\,0.05$$

The potential of $C = V_A - I_A \times R_{AC} = 580 - I_A \times 0.05\,x$

The potential of $C = V_B - (500 - I_A)\,R_{BC} = 600 - (500 - I_A)\,(6 - x)\,0.05$

$\therefore \quad 580 - 0.05 \times I_A = 600 - (6 - x)\,(500 - I_A)\,0.05$

$\therefore \quad 580 - 0.05 \times I_A = 600 - 150 + 0.3\,I_A + 25\,x - x\,I_A\,0.05$

$\therefore \quad 0.3\,I_A = 130 - 25\,x$

$\therefore \quad I_A = 433.33 - 83.33\,x$

$\therefore \quad V_C = 580 - (433.33 - 83.33\,x)\,0.05\,x$

$\therefore \quad V_C = +\,4.166\,x^2 - 21.666x + 580$

For V_C to be minimum, $\dfrac{dVC}{dx} = 0$

$\therefore \quad 0 = +\,8.3332\,x - 21.666$

$\therefore \quad x = +\,2.6$ km

So minimum potential occurs at a distance 2.6 km from end A.

So $\quad I_A = 433.33 - 83.33 \times 2.6 = 216.667$ A

and $\quad I_B = 500 - I_A = 283.3328$ A

wire distributor is uniformly loaded at the rate 1.2 A/m and is fed at both

7 A single phase ac distributor AB 300 metres long is fed from end A and is loaded as under : 1)100 A at 0.707 pf lagging 200 m from point A
2)200 A at 0.8 pf lagging 300 m from point A. The load resistance and reactance of the distributor is 0.2 Ω and 0.1 Ω per kilometer. Calculate the total voltage drop in the distributor .The load power factors refer to the voltage at the far end

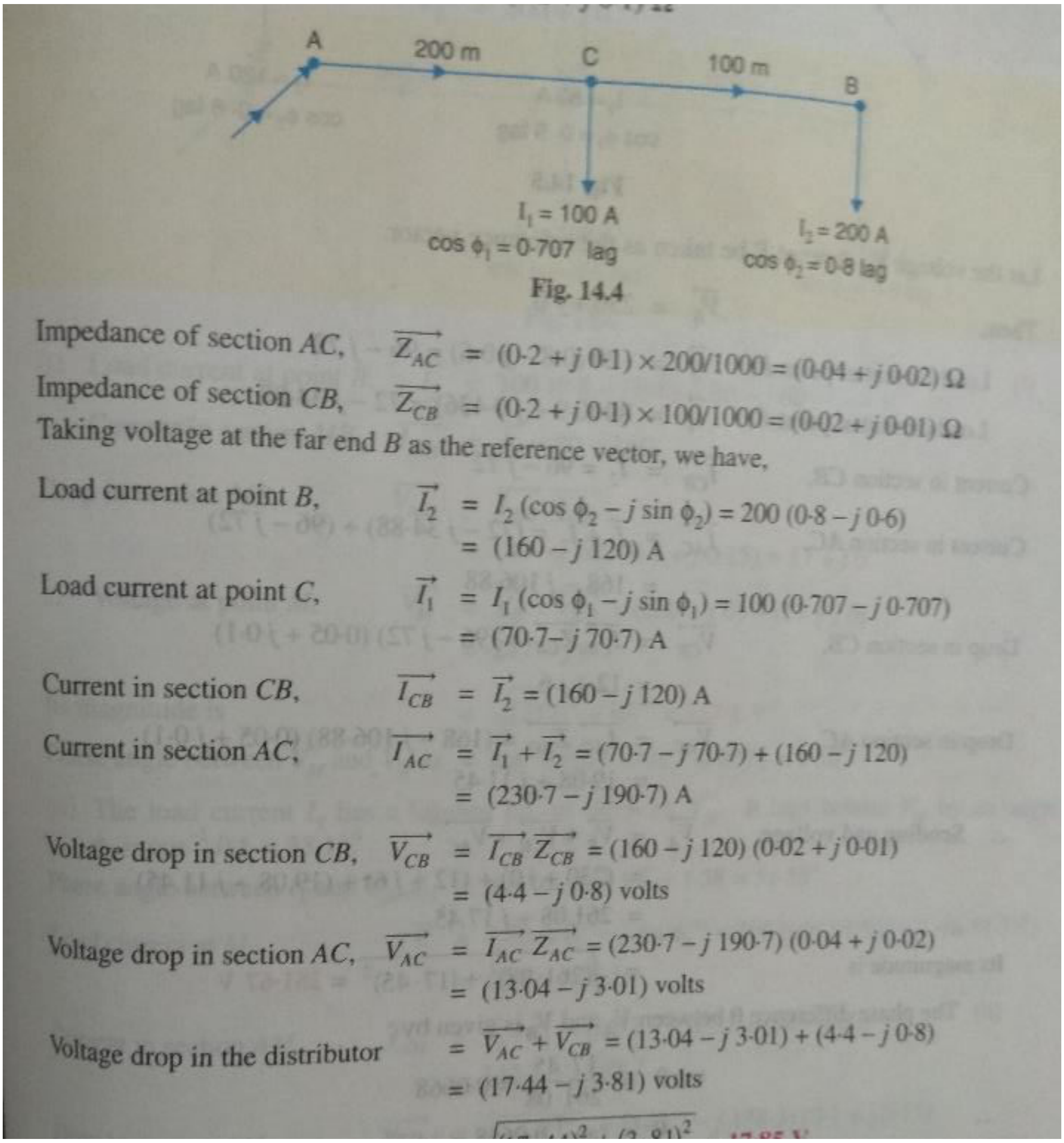


Fig. 14.4

Impedance of section *AC*, $\overrightarrow{Z_{AC}} = (0{\cdot}2 + j\,0{\cdot}1) \times 200/1000 = (0{\cdot}04 + j\,0{\cdot}02)\ \Omega$

Impedance of section *CB*, $\overrightarrow{Z_{CB}} = (0{\cdot}2 + j\,0{\cdot}1) \times 100/1000 = (0{\cdot}02 + j\,0{\cdot}01)\ \Omega$

Taking voltage at the far end *B* as the reference vector, we have,

Load current at point *B*, $\overrightarrow{I_2} = I_2\,(\cos\phi_2 - j\sin\phi_2) = 200\,(0{\cdot}8 - j\,0{\cdot}6)$

$= (160 - j\,120)$ A

Load current at point *C*, $\overrightarrow{I_1} = I_1\,(\cos\phi_1 - j\sin\phi_1) = 100\,(0{\cdot}707 - j\,0{\cdot}707)$

$= (70{\cdot}7 - j\,70{\cdot}7)$ A

Current in section *CB*, $\overrightarrow{I_{CB}} = \overrightarrow{I_2} = (160 - j\,120)$ A

Current in section *AC*, $\overrightarrow{I_{AC}} = \overrightarrow{I_1} + \overrightarrow{I_2} = (70{\cdot}7 - j\,70{\cdot}7) + (160 - j\,120)$

$= (230{\cdot}7 - j\,190{\cdot}7)$ A

Voltage drop in section *CB*, $\overrightarrow{V_{CB}} = \overrightarrow{I_{CB}}\,\overrightarrow{Z_{CB}} = (160 - j\,120)\,(0{\cdot}02 + j\,0{\cdot}01)$

$= (4{\cdot}4 - j\,0{\cdot}8)$ volts

Voltage drop in section *AC*, $\overrightarrow{V_{AC}} = \overrightarrow{I_{AC}}\,\overrightarrow{Z_{AC}} = (230{\cdot}7 - j\,190{\cdot}7)\,(0{\cdot}04 + j\,0{\cdot}02)$

$= (13{\cdot}04 - j\,3{\cdot}01)$ volts

Voltage drop in the distributor $= \overrightarrow{V_{AC}} + \overrightarrow{V_{CB}} = (13{\cdot}04 - j\,3{\cdot}01) + (4{\cdot}4 - j\,0{\cdot}8)$

$= (17{\cdot}44 - j\,3{\cdot}81)$ volts