Mechanism of Lightning Discharge

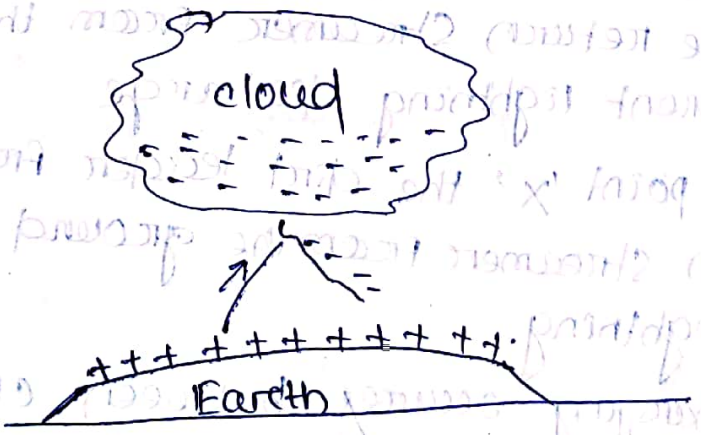
During the up-rush of warem moist air from earth to the atmosphere, the friction between the air & tiny particles of water causes the building-up of charge particles.

When drop of water are formed, the large drop becomes positively charged & smaller drop became negative -ly charged.

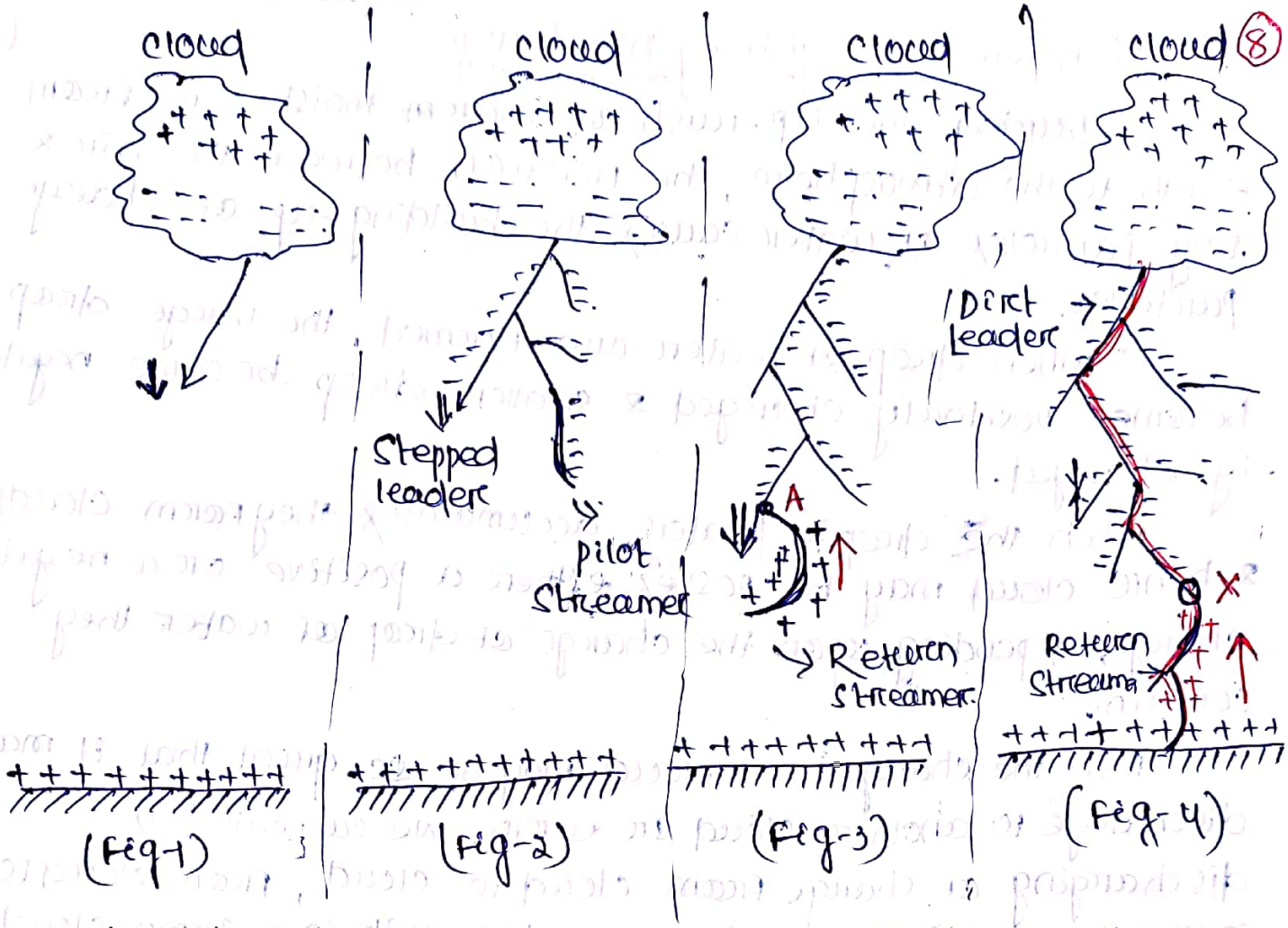
When the drop of water accumulates they form clouds. & hence cloud may be posses either a positive or a negative charge, depending upon the charge of drop of water they contain.

Then the charge on a cloud may be so great that it may discharge to another cloud or earth. We can call this discharging of charge from cloud to cloud, from cloud to earth or from separate charge centres with in a same cloud is Lightning.

The thunder which accompanies the lightening is due to the fact that lightning suddenly heats up the air, there by causing it to explain, the surrounding air pushes the explained air back forth causing wave motion of air which we recognize as thunder.



Mechanism of cloud production & charge discharging



* As the charge acquired by the cloud increases, the potential between cloud & earth increases & therefore, gradient in the air increases.
* when the potential gradient is sufficient i.e (5 KV/cm to 10 KV/cm) to breakdown the surrounding air, the lightning streake starts. (< 30 KV/cm → standard value)
* In Fig-3 point 'A' the pilot leaderis from the cloud connects the return streamers from the ground to occure a high current lightning discharge
* In Fig-4 point 'x' the dirt leader from the cloud connects the return streamers from the ground to occure a high current lightning.
* More discharging occures between clouds or with in clouds rather than cloud & ground discharge.
* Ground gets +ve charged because of induction & cloud is -ve (lower part rain (-ve) upper part (ice cubes +ve))

* when the air insulation breaks down and a streamer starts from cloud to earth. the initial streamer is called 'pilot leader'
* Depending upon the surrounding air's ionization level it branches into several paths and are called as stepped leader. (in a zig-zag shape)
* Thus it produces a channel/medium towards earth & if feed by cloud gradients, it continues travelling till it reaches to earth/object, if gradient is cannot maintained by cloud then leader stops & charge dissipates.
* As leader approaches the earth, the electrostatic field increases & the gradient at earth increases it causes upward streamer to make contact with leaders. As both of them connects with each other, produces a huge spark called Lightning.
* After neutralization of most of -ve charges in the cloud it will have single branch associated with high current this type of streamer discharge is called direct leader.

Types of Lightening Stroke :-

There are 2 main ways in which a lightning may stroke the power system (eg:- overhead lines/towers/ substations ... etc)

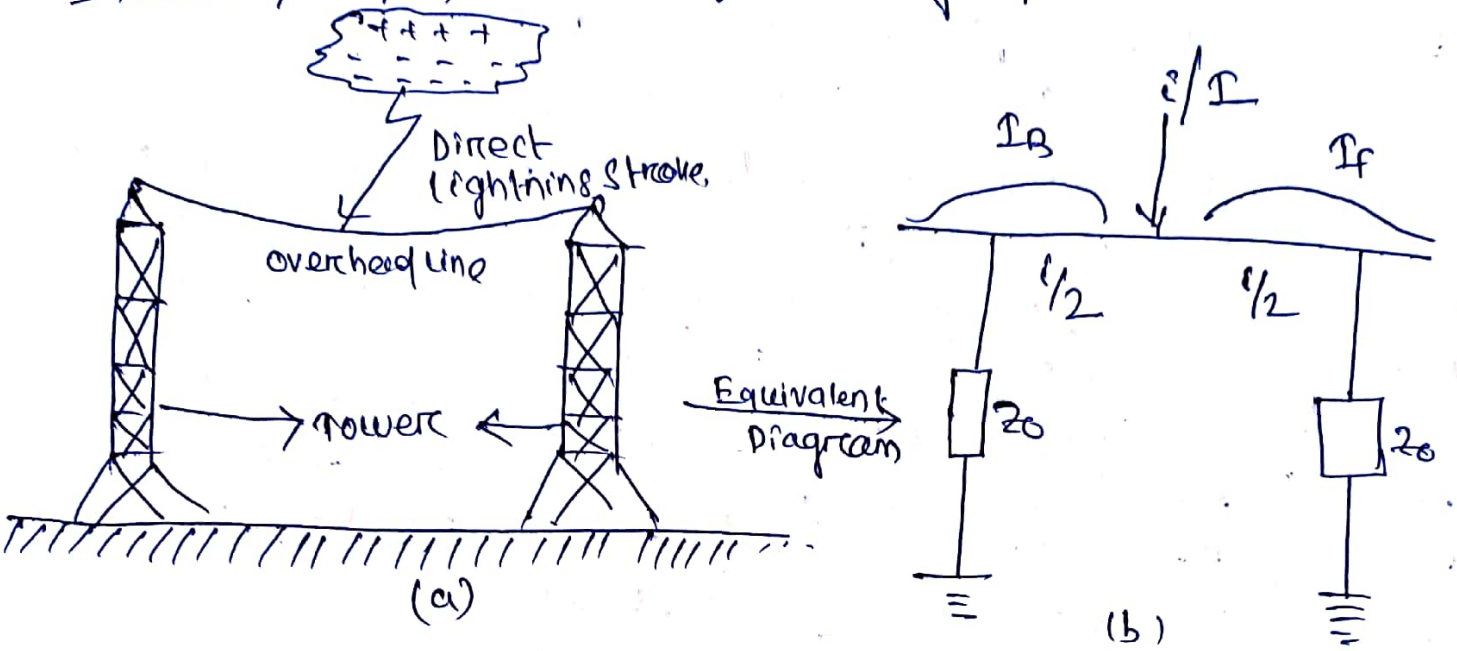
1. Direct stroke
2. Indirect stroke

Direct-Stroke :-

In the direct-stroke the lightning discharge is directly from cloud to the subject equipment like over-head line or other surface.

The over-voltage set-up due to the stroke may be large enough to flash over this path directly to ground.

* if this type of stroke strikes the overhead line, which is long distance from the substation, the over voltage & current will flow along the line in both direction shattering insulators & poles. till it gets totally spent.



[Lightning strikes a over head line]

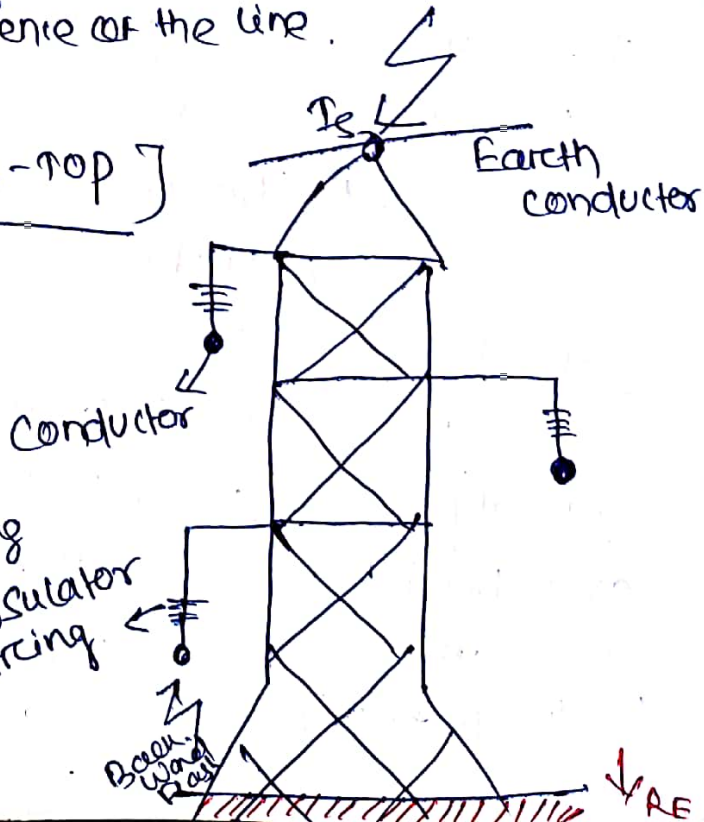
$$V_L = I_S \frac{Z_0}{2}$$

where V_L = voltage rise at the point of stroke
I_S = stroke current
Z_0 = surge impedence of the line.

Case-2

[lightning strikes a tower-top]

$$V_m = I_S R_E + L\frac{di}{dt}$$



* A Back ward flash starts flowing which generates travelling waves on conductor in both directions.
* Damages the Equipments.

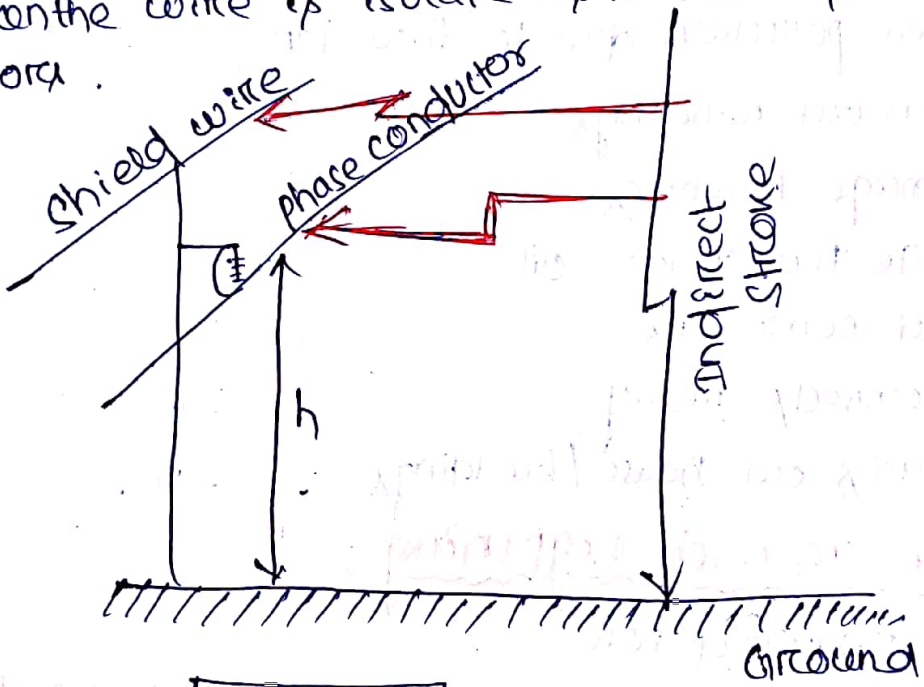
Indirect stroke :-

* Indirect stroke results from the electro statecally induced charges on the conductor due to the presence of charge clouds

* A positive charge cloud is above the line & induces a negative charge on the line by electrostatic induction.

* This 've' charge will be only on that portion of the line right under the cloud & the portion of the line away from, it will be 'tve' charge

* when the cloud discharge to earth or another cloud the 've' on the wire is isolate as it flow quickly to earth over Isolators.



$$V = Eh$$

E = Mean electric field near ground
(0.5 KV/cm to 2.8 KV/cm)

h = = Height of phase-conductor above earth

V = conductor potential raised due to stroke

$$I_F = I_B$$

F - Forward
B - Back ward

$$V_F = V_B = V/2$$

* occurs in LV lines of 33KV & below

Harmfull effects of Lightning :-

1. Lightning can kill people
2. volcanic Erruption
3. Forest Fire
4. Nuclear Detonation
5. Heavy snow Stream
6. Damages Electrical Equipments (G - T - D)
7. Damages Home / commercial / Industrial appliances
8. can kill Birds / Animals
9. It can fire trees / Agricultural Farming
10. Noise pollution due to thunder
11. Burn out windings
12. Damage Machines
13. Ignite transformer oil
14. Melt conductors
15. disconnects relay
16. Burns out house / buildings ... etc.

Protection against Lightning :-

It is required for

(i) power station & substation from Direct Stroke
(ii) over-head transmission line " " "
(iii) Electrical apparatus from travelling waves.

(i) ① Interception
② conduction
③ Dissipation

(ii) ① By shielding trans. line by ground wire
② By providing Aux. device such as protector tube

(iii) ① BY surge diverter // L-A // L- Absorber