Lecture Number	**12**
Lecture Title	**LIGHTNING**

Lecture Items

Lecture 12 – LIGHTNING

12.1 ELECTRICITY BASICS

- There are two kinds of charge; positive and negative
- Opposite charges attract; like charges repel each other
- Electricity is the flow of charge from one region to another
- If a substance readily allows electricity to flow through it, it is a *conductor*
- If a substance is highly resistant to the flow of electricity, it is an *insulator*
- The electrical potential between two charged regions is measured in *Volts*

12.2 LIGHTNING AND THUNDER

- **Lightning** is simply a discharge of electricity, a giant spark, which occurs in mature thunderstorms
- Lightning may take place within a cloud, from one cloud to another, from a cloud to the surrounding air, or from a cloud to the ground
- The majority of lightning strikes occurs within the cloud **80** percent (**80%**), while only about **20** percent (**20%**) or so occur between cloud and ground

- The lightning stroke can heat the air through which it travels to an incredible **30,000°C** (54,000°F), which is 5 times hotter than the surface of the sun
- This extreme heating causes the air to expand explosively, thus initiating a shock wave that becomes a booming sound wave—called **thunder**—that travels outward in all directions from the flash
- Light travels so fast that we see light instantly after a lightning flash
- But the sound of thunder, traveling at only about **330 m/sec** (1100 ft/sec), takes much longer to reach the ear
- If we start counting seconds from the moment we see the lightning until we hear the thunder, we can determine how far away the stroke is
- Because it takes sound about (**3** seconds) to travel (**1** kilometer), if we see lightning and hear the thunder **(15** seconds) later, the lightning stroke occurred (**5** km) away

12.3 ELECTRICAL PROPERTIES OF A THUNDERSTORM

- The top of a thunderstorm (**cumulonimbus**) cloud becomes positively charged , while the bottom of the cloud becomes negatively charged as shown in figure (**12.1**)
- The frozen hydrometeors are positively charged, and are found at the top of the cloud
- The liquid hydrometeors are negatively charged, and are found at the bottom of the cloud
- The negative charge at the bottom of the cloud *induces* a positive charge at the ground
- Lightning is a discharge of electricity between the oppositely charged centers, either from the cloud to the ground (***CG***), or within the cloud (***IC***) , or between clouds (***CC***)

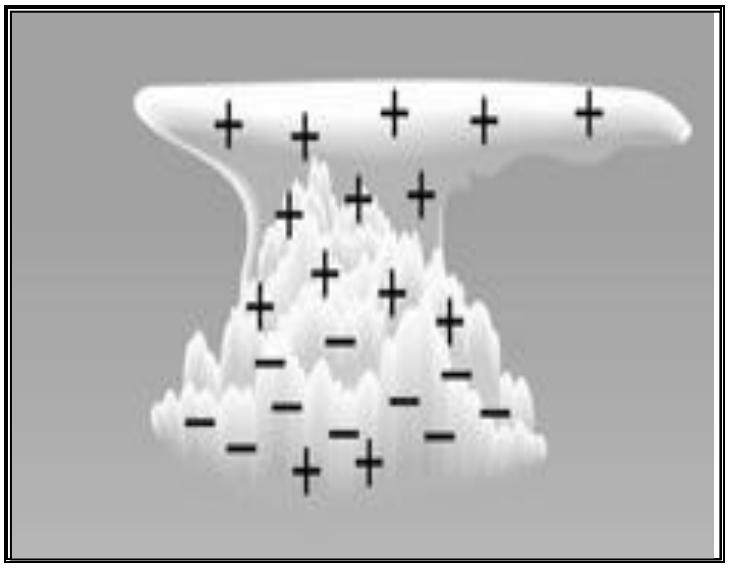


Fig.(12.1) : Charges distribution in the cumulonimbus cloud

12.4 CLOUD-TO-GROUND (CG) LIGHTNING

- *Cloud-to-ground (**CG**) lightning* is a lighting discharge from the cloud to the ground
- (***CG***) lightning proceeds in a distinct sequence (in a series of steps)

12.4.1 Stepped leader **: –**

- For cloud-to-ground lightning to occur, a ***stepped-leader*** must emanate from the cloud base as shown in figure (**12.2**)
- The stepped leader is an ionized path that forms from the cloud to the ground
- The leader is essentially an ionized particle chamber about **10** cm (**4** in) in diameter which forks repeatedly from a main channel
- Usually it is not even visible
- The sections continue until contact is made with an unlike charged area (the ground)

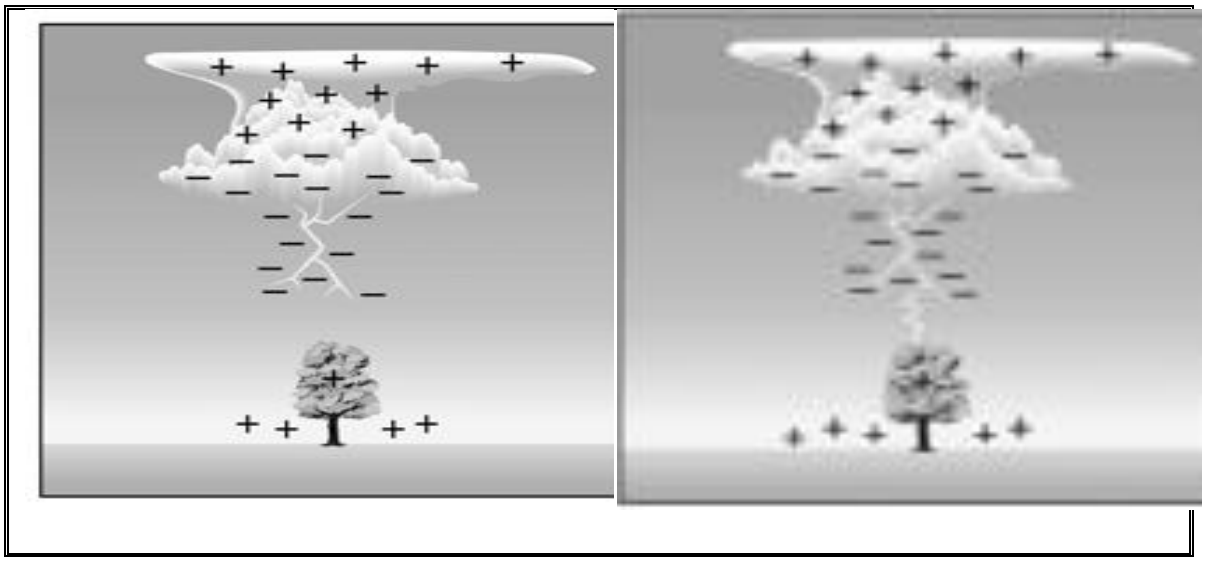


Fig.(12.2) : Stepped leader of cumulonimbus clouds

12.4.2 Return stroke : –

- Once the stepped leader reaches to within **50** meters or so above the ground, a positive charge flow is initiated from the ground back toward the cloud as shown in figure (**12.3**)
- Although the electrical current is from the cloud to the ground (moves downward), the return stroke is in the opposite direction (move upward)
- This is the **return stroke**, and it is the brightest and most energetic part of the lightning flash
- The upward return stroke happens so fast, our eyes cannot resolve its upward direction

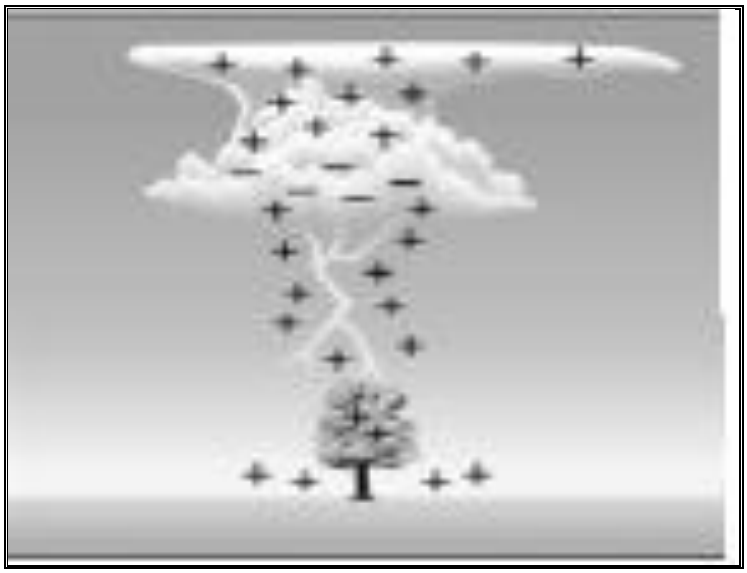


Fig.(12.3) : Return stroke and Dart leader of cumulonimbus clouds

12.4.3 Dart leader : –

- After the return stroke subsides, another subsequent leader progresses back down the lightning channel as shown in figure (**12.3**)
- The subsequent leader, called a **dart leader,** proceeds from the cloud along the same channel as the original stepped leader; however, it proceeds downward more quickly because the electrical resistance of the path is now lower
- This leader is similar to the stepped leader, but is not branched

12.4.4 Subsequent Return stroke : –

- As the dart leader approaches the ground another return stroke is initiated from the ground back to the cloud
- The dart leader-return stroke sequence continues until enough charge is neutralized that the atmosphere is able to once again act as an insulator
- On average there are 3 or 4 return strokes per (***CG***) flash, though there may be more
- Individual strokes are almost impossible to detect
- We call a combination of all strokes a ***lightning flash***

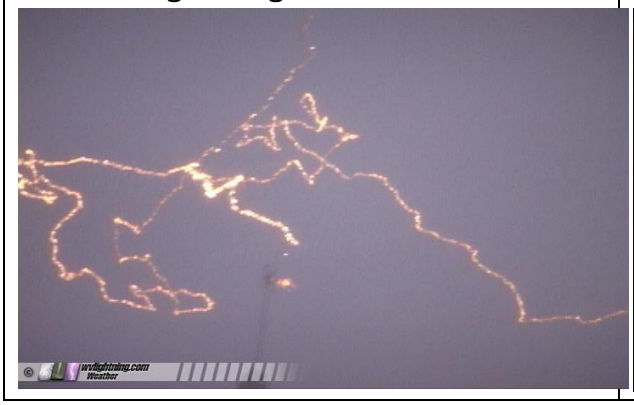
NOTES :

- The entire sequence of a (***CG***) flash lasts for only a few-tenths of a second
- Note that the return stroke travels from the ground upward to the cloud
- The peak electrical current in a (***CG***) flash is typically **30** to **40** KAmps
- The lightning channel is only a few centimeters in diameter
- The air in the lightning channel is heated to temperatures as high as **60,000**°F
- Lightning **TYPES** are :
  - *cloud to the ground (**CG**)*
  - *within the cloud (**IC**)*
  - *between clouds (**CC**)*
- Lightning **SHAPES or FORMS** are shown in figure (**12.4**)

- ***forked lightning***

- ***ribbon lightning***

- ***bead lightning***



- ***Ball lightning***

Fig.(12.4) : Forms of Lightning