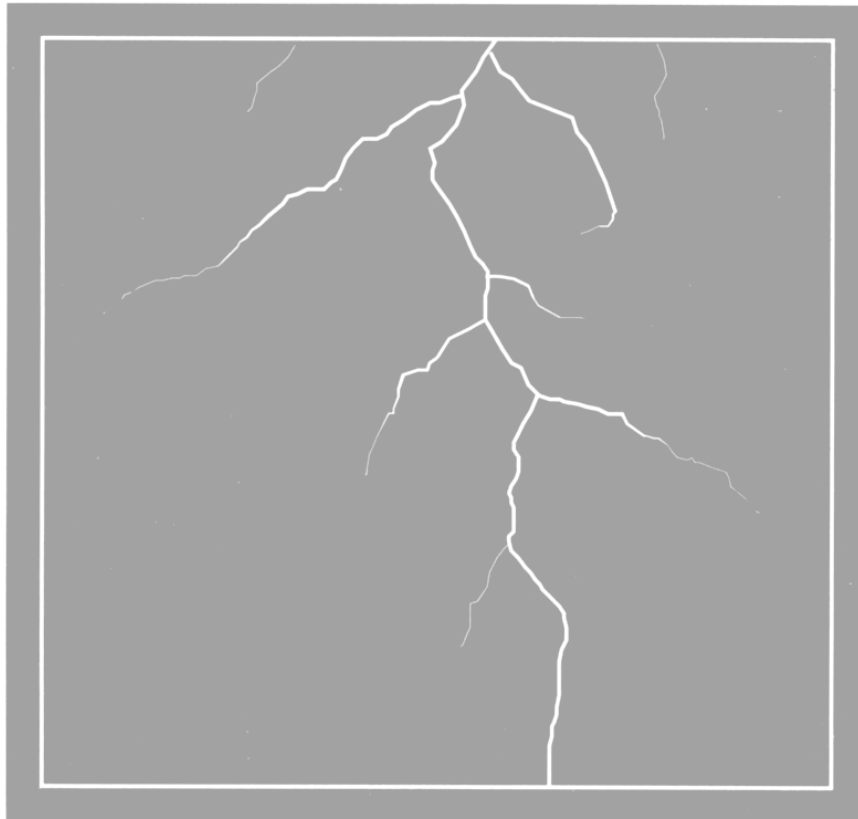


LIGHTNING

PHENOMENON & PRECAUTIONS



CENTRE FOR EARTH SCIENCE STUDIES
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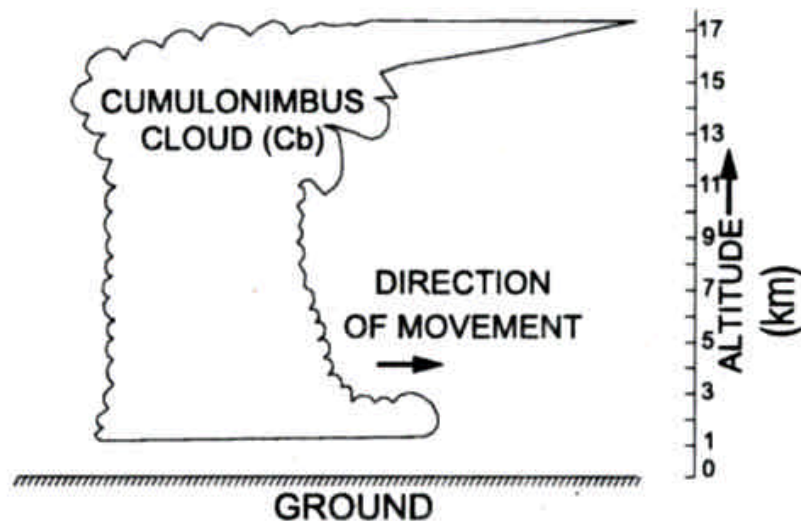
I. THE PHENOMENON

1. What is lightning?

Lightning is a high-energy luminous electrical discharge from a thundercloud to the ground accompanied by thunder. In our atmosphere, three types of discharges take place: one within a thundercloud (*intra-cloud*), the second from one cloud to another (*inter-cloud*) and the third, from **cloud to ground** (CG). The last type takes a toll on our life and property and so is of concern to us. An exception to this is the aircraft hit by inter cloud and intra-cloud lightning. Lightning is very fast, takes only about 1710^{th} of a second. Lightning discharge occurs at millions of volts with a current of a few tens of kilo amperes and the discharge creates temperature of about $30,000^{\circ}\text{C}$ within a few tens of milliseconds. Prediction of lightning as to the precise time and location is very difficult or impossible. However, somewhat a season or period of lightning occurrence at many regions is known. In Kerala, thunderstorms normally occur from October 15th to June 1st (Malayalam months *TJiulam* to mid *Edavatri*). Lightning activity is more in the afternoon than in the forenoon hours. The present year 2002 has been an exception to this. Lightning has been found to occur at almost all times of the day with a maximum occurrence after 7 pm.

2. What Causes lightning?

The largest of all types of clouds, namely the *Cumulonimbus* (Cb) cloud is responsible for lightning. Mainly two types of processes lead to formation of such clouds. Based on the type of formation they are classified as Frontal or Convective thundercloud. Frontal thunderclouds form by the interaction of cold and warm air masses and so such clouds can form at any time of the day or night. The convective Cb cloud formation commences in the forenoon with the onset of convective cycle initiated due to heating by the solar radiation. Usually they mature by the afternoon. Majority of the lightning strikes from this type occur in the afternoon hours. In Kerala, most of the thunderclouds are of the convective type and are formed mostly during the northeast monsoon. (October to December) and during the pre-monsoon (March to May). The present year has been an exception with frontal thunder clouds causing lightning at almost all times of the day. Charging mechanisms of the cloud, the number of charged cells formed and the regional meteorology decide the thundercloud formation in a region. Therefore, the Cb cloud behaviour varies over regions of the globe. A typical cumulonimbus cloud grows up to tropopause (15 to 18 km in tropics).



3. Charging processes in the thunderclouds

Cloud top develops a positive electrical charge, the lower level a negative electrical charge. A flow of current between these does not occur, as the air is a poor conductor of electricity. As a thundercloud passes overhead, positive charge accumulates on all objects below the cloud. Since these positive charges attempt reaching the negative charge of the cloud, they tend to accumulate at the top of the highest object in the vicinity. Lightning results when the difference between +ve & -ve charges, the electrical potential difference, is enough to overcome the resistance of air to force a conductive path between the cloud and ground. This potential may be as much as 100 million volts.

4. Science behind lightning & thunder

A heavy electrical discharge in the atmosphere leaves the air heated to a very high temperature, of about 30,000°C in a few tens of milliseconds. This process invokes shock waves, the propagation of which we hear as thunder. Thunder helps in estimating the distance roughly. It takes three seconds for thunder(sound) to travel 1 km and so the time (seconds) between sighting a lightning flash and hearing sound, divided by 3 gives the slant distance in kilometres. Further, the higher the pitch of sound of thunder, the closer is the lightning.

II. PRECAUTIONS FOR ALLEVIATION OF THE HAZARD

Once the event is initiated, it is impossible to move off to escape from a lightning flash. This is because the whole phenomenon of one lightning flash is over within about 1/10th of a second and the minimum time of response of a human being is also of the same order. However, an understanding of lightning can go a long way in reducing the hazard due to lightning. In this regard one of the foremost requirements is to know the probable time, in terms of season and time of the day, of lightning occurrence in a region. This helps us to take precautions to avoid getting involved in an accident. As is mentioned above, Kerala has somewhat a season for lightning and so during this period precautionary measures can be taken well before, say in the forenoon, a lightning incident.

PRECAUTIONS AND GUIDELINES

Many aspects of escaping a lightning accident are presented here. One of the most important things to be remembered is that a thunder cloud or lightning will be active in an area only for about one hour. So, observing what is given below for an hour may save one from a serious injury.

1. Locations which provide Protection

(A) Locations with good protection:

Locations, surrounded partially or fully by unbroken metallic surfaces or nets do not allow lightning to penetrate to the interior and hence a person is safe inside. Examples are:

- Buildings of concrete with steel reinforcement (RCC), which is vertically coherent.

However, inside these buildings: Stay away from doors and windows. Avoid water. Do not use the hand telephone. Take off head sets. Turn off, unplug, and stay away from appliances, computers, power tools and TV sets. Unplugging power cord and antenna should be done well before, say in the forenoon of a possible day of lightning occurrence. Lightning may strike exterior electric, TV cable and phone lines, carrying the energy to inside equipment. Keep away from all loose wires and wall sockets of power, phone etc. If possible, keep away from the large metallic objects such as stoves and ranges, bath tubs, furnaces, water and gas pipes, and also from electric lines especially at points where these enter the house from outside. If there is an assembly of people, disperse into different rooms to the extent possible and individuals should take the above precautions. Cordless or Cell phones can be used cautiously inside a RCC roof building. If there is lightning around crouch at the centre of the room.

- Steel-framed buildings.
- Buildings with sheet metal coverings on roofs and walls, with the joints connected electrically to ensure a complete conductive surface.
- Automobiles with coherent metal bodies, but no open cars or convertibles.

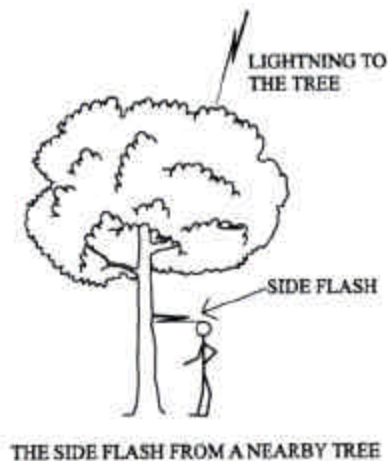
(B) Locations Offering at Least a Minimum of Protection:

- Inside buildings of large or at least of medium size. The protective value of such buildings is better when at least some unbroken vertical metallic conductors exist, such as rain gutters with down-pipes, water mains, rails for elevators, vertical metal strips, steel braces or reinforcement etc., electrical installations and wires, etc.
- Large mountain-caverns, in which one can stand, crouch or sit without being close to or in contact with the ceiling or the walls.

2. Locations and situations to be avoided during thunderstorms:

Lightning prefers to strike the tallest of all objects in the location of strike. Also it prefers metal objects; the larger the metal more is the preference. Avoid:

- Individual trees in the open country and on mountain tops. The greatest danger is under trees, especially just under low branches extending far sideways. All kinds of trees are dangerous. The taller *he tree, the greater is the danger. A small group of isolated trees is also as dangerous as one isolated tree. Being near a tree can result in a lightning flash from the tree to terminate on a person nearby as shown in figure.



Also dangerous are:

- The edges of forests with large trees.
- Unprotected objects in an open country such as barns, small churches, chapels, haystacks, wooden carts, observation towers, elevated points, lean-tos, huts, shelters
- Small wooden huts with practically no metallic parts apart from water pipes. Avoid approaching these pipes.
- Unprotected neighbourhood of electric lines or metallic structures.
- Do not go near a flag mast, TV antenna mast, pipe or any vertical metal fixture.
- Lakes and swimming pools. This has the additional aspect of being far away from help. A canoe in the open water body, like lakes and lagoons, is highly susceptible.
- Golf courses and other open grounds. Here the probability of a strike is high.
- The edge of steep vertical cliffs and mountains.
- Hill tops. Lightning strikes hill top than a valley.
- Boats and tents without lightning protection.
- Extended metallic fences made of wire or otherwise, hand rails, rails and other big metallic constructions.
- Riding a horse, bicycle, motorcycle or open tractor.
- Metal tools such as poke, spade, axe, pickaxe, umbrella, metallic swing, metallic garden chair etc.
- Assemblies of people in the open air or in small-unprotected rooms.

- Standing close to a car, outside or leaning on the car.
- Vicinity of road-roller or tipper truck or any giant metal body vehicle.
- Flying in non-metallic aircraft. Even with metallic aircraft, avoid high cumulus if your safety depends on the electronic equipment.

3. Recommended Precautions when Surprised by a Thunderstorm:

- a. Avoid close proximity to metal objects like umbrellas, scythes, knives and golf clubs; especially if they project above your body. Danger is acute if you see or hear St. Elmo's Fire (corona discharge).
- b. Crouch on the floor with both feet and knees pressing each other and hands circling the knees with the chin pressing on the knees. The position is shown in figure.



- c. If you happen to be near a tall tree in the open, sit and crouch as above a little away from the branch of the tree, as shown in the figure below



SOME USEFUL TIPS

Avoid using metallic pipes to fix lamps on terrace of buildings. Also for drying clothes on the terrace, iron poles with metallic or plastic wires are used. Avoid using metallic poles and wires.

III. LIGHTNING PROTECTION

There are many locations and buildings, which have to be protected from lightning damage. Storage location of inflammable material is an example. High rise buildings and structures housing equipment etc. also have to be protected as precautions taken for personnel safety is of little use in such places. A device which gives a good amount of protection and which has been in use is the Lightning Conductor.

1. The Lightning Conductor:

The Lightning Conductor which is also known as Lightning Rod or Air Terminal is one of the best known form of shielding device and has been in use in protecting buildings and facilities where protection is mandatory such as, storage tanks for petroleum products, warehouses for explosives etc. The main purpose of the lightning rod is to provide a point well above the structure to be protected with a very good, earthed connection so that the lightning energy gets diverted into ground without damaging the structure. It has no role in preventing a lightning occurrence.

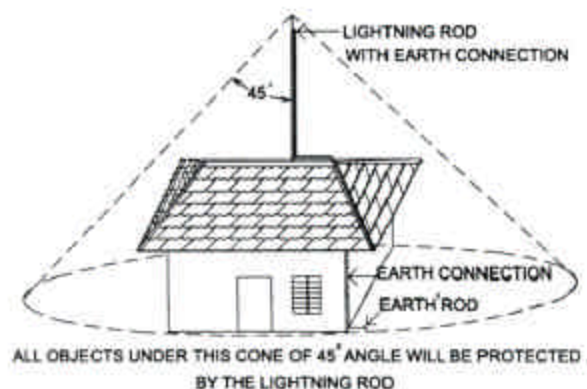
Lightning Conductors must be exposed and should be placed at the highest levels. They may be painted for protection against corrosion. There is a code of practice on Lightning Conductor and its installation published by the Bureau of Indian Standards. Conformance to this will make the Lightning Conductor effective.

2. Earthing:

The earthing done for domestic power supply is not at all sufficient for lightning conductor earth. This is evident from the magnitude of currents involved in lightning which is more than two orders of magnitude higher than the domestic supply currents. However, because of the high voltage involved, proportionally heavy earthing is not needed as the voltage itself will drive it into ground.

3. Cone of Protection:

This is a term used to describe the volume of protection offered and it provides a simple graphical tool for installing a Lightning Conductor protection system. Arrangement of a Lightning Rod showing the cone of protection is given in figure.

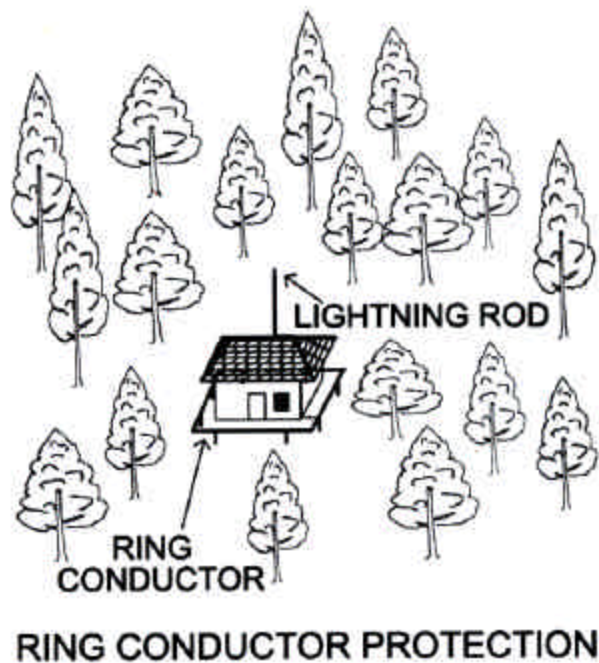


The ratio of height to radius of area expected to be protected defines the volume. The safe ratio is 1:1 (equal to 45° angle to either side) for sensitive installations and for others ratios as high as 1:1.75 are also used. When large buildings are to be protected a single rod will not suffice. Multiple rods with several earths are done in such cases. These rods are interconnected at the top of the building using thick copper, brass or GI strips of sufficient thickness and connections from several points are run to each earthing rod or grid. These interconnecting strips also provide an additional protection all along the length of the strip similar to the lightning rod.

4. A Special Case for Kerala Region:

Kerala is a region with high density of vegetation. This results in most of the houses, RCC roofs otherwise, having a good number of trees nearby. In most of the cases the nearby trees are quite taller than the building. This results in the lightning conductor installed on the building in not being able to protect the tree. On lightning hitting one of the trees nearby, because of the electrical wiring of the house, it's earth and other metal objects inside the house the lightning energy enters the house through the ground. The lightning rod does not prevent this. A ring conductor installed around the house can prevent such destruction to a large extent. A schematic of the ring conductor along with the lightning conductor is shown in the figure. The ring conductor should be buried 1.5 m below ground and about 1 m away from the basement/ walls of the house. The ring conductor should be connected to power earth, lightning conductor earth and water pipes.

At places where good earthing cannot be provided also the Ring conductor with several earth rods should be used. An example is a house or tower on a rock surface.



5. The Lightning Arrester:

Electrical and electronic equipment, irrespective of whether they are inside a safe building or not, can go bad due to lightning energy entering their circuit directly or by some other path. These equipment can be protected to a considerable extent from damage by installing a Lightning Arrester. Lightning Arresters provide a means by which lightning currents may enter or leave the earth without passing through the circuitry to be protected. Lightning Arresters installed in equipment behaves as if it is absent so that the normal operation of the equipment is not *at all* affected. During a lightning event if the voltage in the installed circuit goes up beyond a value due to lightning energy the arrester becomes active due to the high voltage leading to a short circuit of the lightning energy to earth. The time taken for the arresters to become active is of the order of $1/10^9$ second. Hence the arrester prevents the lightning energy from entering the equipment.

IV. PERSONNEL INJURY, FIRST AID

Of the people who die in lightning accidents the number of deaths due to direct hit and burns due to it are very low. Most of the deaths happen due to respiratory arrest. This can happen due to many reasons, the main one being the respiratory centre of the brain, located at the back of the head, getting affected. Giving artificial respiration can save a lot of people who get involved in lightning. This is one first aid that can be given to a victim and can be done while reaching for medical aid. There are other causes like heart getting affected etc. for which medical aid should be sought immediately.