LIGHTNING, NATURAL AND ARTIFICIAL.

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Lightning is an electrical discharge taking place either between two charged clouds or between a charged cloud and the earth's surface. Arago distinguishes three kinds of lightning: (1) Forked lightning, of ordinary occurrence; (II) sheet lightning, probably the reflection of distant forked lightning hidden from view by intervening clouds or by the horizon; (III) globular lightning, usually described as a luminous ball which travels slowly and finally bursts with explosive violence. The latter is comparatively rare but must be admitted as a real phenomenon; it has occasionally been imitated on a small scale in the laboratory.

Occurrence of Electricity in Clouds. It has been suggested that the electric charge in clouds originates from evaporation proceeding from the earth's surface. It may also arise from the friction between solid and liquid particles suspended in the air or between these and the earth's surface; or, again, from friction between masses of air at different temperatures. That bodies even in close proximity frequently possess slight differences of potential can easily be shown by means of Kelvin's electric doubler.

Thompson[1] describes the mechanism of the accumulated charge in a cloud by assuming that minute water particles floating in the air fall by gravity and unite. Thus should eight similar droplets unite into one the radius of the latter will be twice that of any of the original eight; and its capacity will, therefore, be twice that of one of its components. Hence its electrical potential must be four times as great as that of one of its components. Furthermore, the electrification at the lower surface of a cloud consisting largely of such spheroids will constantly increase and induce on the surface of the earth beneath it a charge of the opposite kind.

Steady Strain and Disruptive Discharge. Sir Oliver Lodge[2] distinguishes between two distinct types of atmospheric discharge. Thus, if a thunder cloud extending over part of the earth becomes gradually charged, or if a charged cloud moves gradually over a particular spot, the air between the cloud and the earth experiences a steadily increasing electric stress under which points will tend to discharge better than blunt objects; and they are more likely to receive the lightning spark when it occurs. However, if a cloud is suddenly charged by receiving a lightning spark from an adjacent cloud, a pointed rod under it has

[1] S. P. Thompson, "Elementary Lessons in Electricity and Magnetism." (Macmillan) 1918.

[2] Jour. Inst. Elec. Engrs., *XVIII*, 80.

"Proc. Ind. Acad. Sci., vol. 38, 1928 (1929)."

had no opportunity for preparatory action and is no more likely to take the discharge than a blunt conductor of equal height.

These two cases have been imitated in the laboratory by arranging the apparatus as shown in figures 1 and 2. The former illustrates the condition for a steady strain while the latter represents the condition for a disruptive discharge.

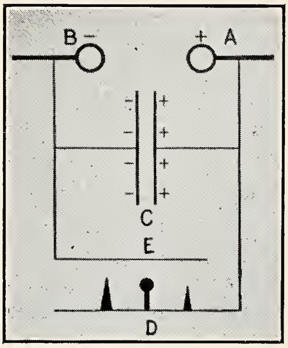

Fig. 1—Condition of Steady Strain.

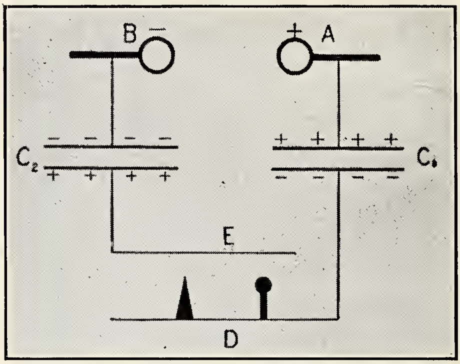

Fig. 2—Condition of Sudden Strain.

A flat piece of tin, E, is connected to one terminal of an electrostatic generator, while several points of varying height and a ball are connected to the opposite terminal of the generator. Capacities are arranged as indicated in the figures. When thus arranged the space between E and D in figure 1 will be in a condition for a steady strain, and either point is more likely to be struck than the round conductor. On the other hand, in figure 2, the space between E and D is in a condition for a disruptive discharge which will occur whenever a spark

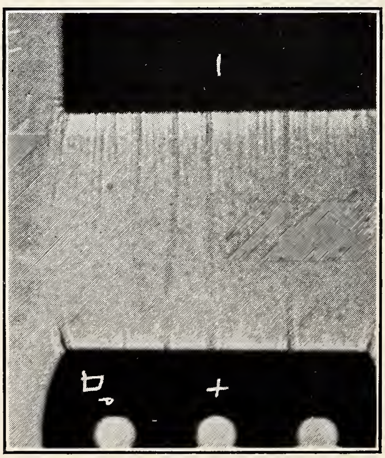

Fig. 3—Field due to a Steady Strain.

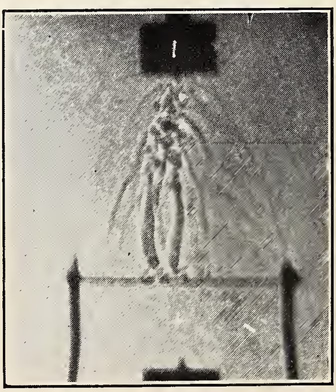

Fig. 4—A disruptive Discharge.

passes between the terminals of the generator. Under the latter condition the resultant discharge across E and D will occur as frequently between the ball and the plate as between the point and the plate. Instantaneous views of such discharges were obtained by the writer[3] and appear in figures 3 and 4. The former represents a steady discharge between sharp parallel edges, while the latter represents a sudden discharge between an horizontal wire and a point.

Natural Lightning. Figure 5, by Brown,[4] shows a natural forked discharge of the disruptive type, while figure 6 shows the effect of such a discharge. The tree in the latter figure is a large locust standing near the entrance to the library at Hanover College. The library is located on a level bluff about 400 feet above the Ohio River. Close scrutiny of the picture will reveal a number of wires fastened to the tree. An interesting fact about this particular bolt is that its course of destruction continued down the trunk of the tree to the very place where the wires are attached. Two responsible witnesses of this crash testify that so great was the quantity of electricity involved that the various chips and splinters torn loose from the tree emitted light flashes of their own as they struck the earth.

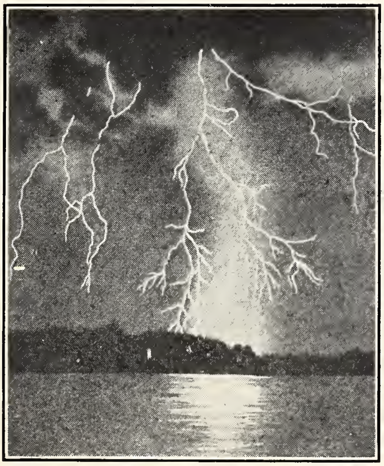

Fig. 5—Natural Lightning.

Figure 7, by Peek,[5] shows a test oscillogram of a two and a half million volt lightning bolt striking a transmission line of the Pennsylvania Power and Light Company. This is the first record of the voltage of a lightning surge obtained in this country by the cathode ray oscillograph. The record shows that the duration of the surge was 40 microseconds.

[3] Phil. Mag. *5*, 1098, (1928) ; Proc. Ind. Acad. Sci. *37*, 197, (1927).

[4] Millikan, Gale and Edwards, "First Course in Physics for Colleges," (Ginn & Co.) 1928.

[5] General Electric Review *31*, 467, (1928) ; *31*, 404, (1928).

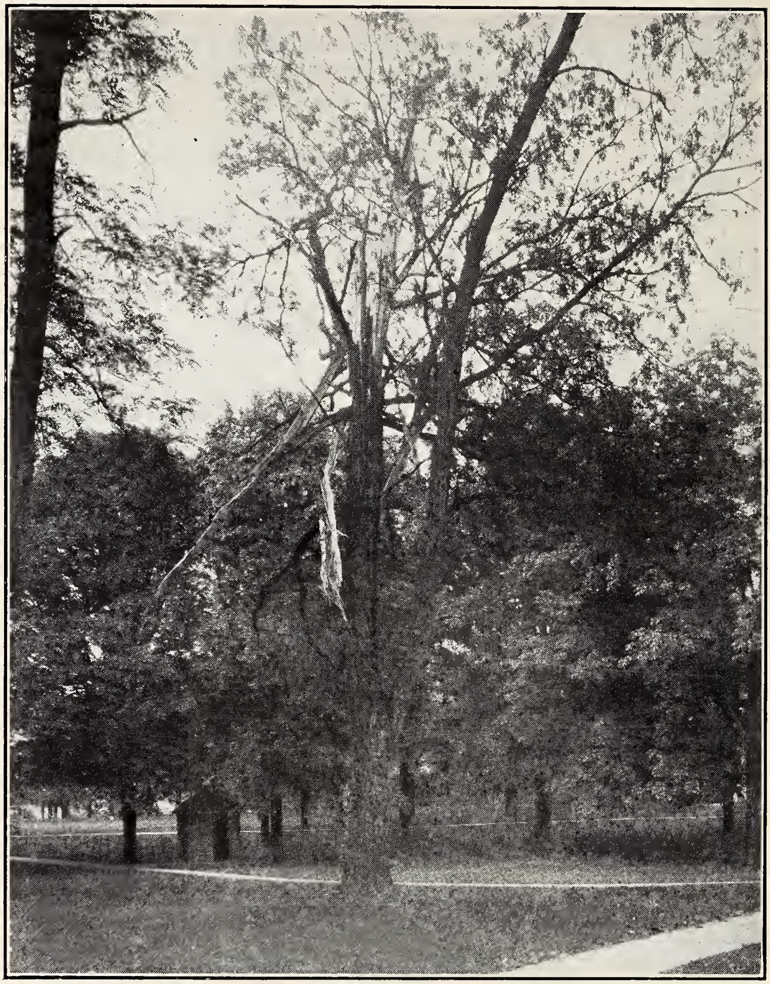

Fig. 6—Result of a Natural Discharge.

Fig. 7—Oscillogram of Lightning Surge.

Artificial Lightning. Apart from the study of its mechanism, the most important factors concerning lightning are the ideas of protection and utilization. The first suggestion for the protection of property from destruction by lightning was made by Franklin in 1749. Later, Lodge[6] made a number of investigations which resulted in his paper on "Lightning and Its Protectors." Investigations of the effects of lightning, particularly upon power transmission lines, where a single discharge may cause considerable damage to valuable machinery, are constantly being conducted in various laboratories where the natural phenomenon is simulated by means of static generators of enormous voltage and frequency and the characteristics of the wave disturbance are studied by means of improved cathode ray oscillographs.[7]

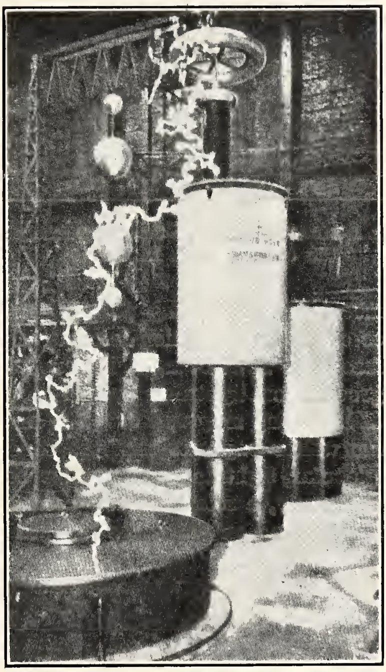

Fig. 8—Artificial Lightning.

A view of a giant man-made lightning bolt of several million volts jumping an irregular arc of 18 feet appears in figure 8. This artificial discharge was produced in the laboratory of the General Electric Company at Pittsfield, and it is by means of such contrivances that engineers can test the efficiency of circuit breakers, strain insulators and other devices designed to safeguard power lines.

Figure 9, by George and Oplinger of the Purdue University Engineering Experiment Station, shows a 100,000-volt, high-current discharge

[6] Loc. cit.

[7] General Electric Review *28*, 622, (1925).

Fig. 9—100,000-Volt High-Current Discharge.
(By courtesy of R. H. George)

from a point to a metal pan containing a solution of salt water. Although the resistance of the salt solution is relatively low, the RI drop is so great as to cause it to flash over. This emphasizes the necessity for low resistance grounds on lightning protection apparatus, and explains why strokes of lightning may run over the surface of the ground where it strikes. The writer suggests that the conditions for the production of natural globular lightning are similar to those which prevailed in this picture, namely, a relatively low conducting surface, more or less equally distributed, and an enormous potential difference.