COOK 107

voice of the storm

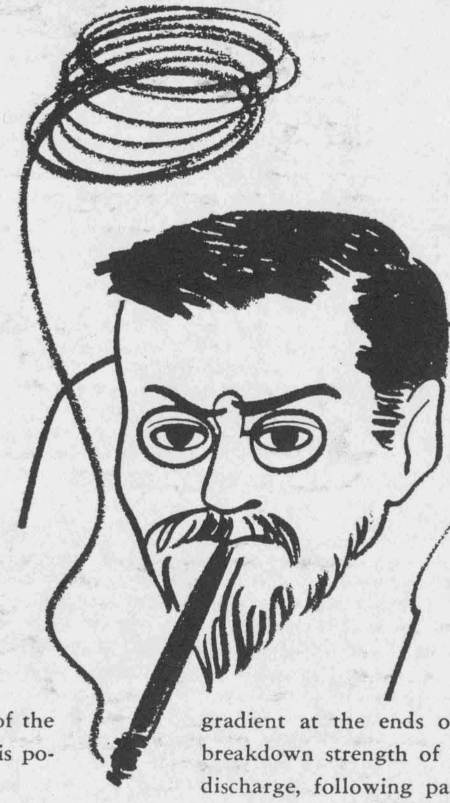
Recorded in the rain, thunder, wind and tempest.

The stark and terrible forces of nature at bay

released through electronics*

*INDEX OF PERFORMANCE: moves 15″ speaker cone 7½″.
Lash down all small children and objets d'art.

THE VOICE OF THE STORM 1077



LIGHTNING PHENOMENA IN THE CLOUDS

The first man who attacked the problem of lightning and lightning protection, a century and a half ago, was our great citizen, Benjamin Franklin. He gave us the lightning rod, which is now universally recognized as the most effective and only protective device for such isolated points as steeples, chimneys, etc.

Naturally, as soon as determinations of spark voltages became available, attempts were made to estimate the voltage of a lightning flash. Requiring about 10,000 volts per inch, a lightning flash of two miles, or about 10,000 feet in length, would require a potential difference of about 1200 million volts. The existence of such voltages in the clouds does not appear possible: a potential difference of 1000 million volts would produce a brush discharge of about one-half mile in length before the final lightning flash occurs. In the brush discharge the air is electrically broken down and becomes conducting. But it is also mechanically and chemically broken down, that is, the molecules are dissociated and recombine after the discharge, in all possible combinations. That is, we may get ozone and nitric acid, and a lightning flash produced by a thousand million volts would thus be followed by a deluge of nitric acid. This fortunately is not the case.

There exists normally a potential gradient in the air. That is, a potential difference exists between the air at different elevations, reaching sometimes several hundred volts per foot, so that we can estimate as a fair average, a natural potential gradient in the air, in the vertical direction, of about 100 volts per foot. A point 100 feet above ground may show a potential difference of about 10,000 volts vs. ground. Usually the higher strata of the air are positive against the lower. The cause of this potential gradient may be terrestrial or cosmic.

Assuming water vapor in a higher stratum of the atmosphere to condense to moisture particles, these particles have the potential of the air in which they float, perhaps hundred thousands of volts vs. ground. The moisture particles conglomerate with each other to form larger moisture particles and ultimately rain drops. By the collection of n^3 particles into one, the diameter of the particle has increased n fold. Its capacitance has also increased n fold (the capacitance of a sphere being proportional to the diameter). The particle contains, however, the accumulated charges of n^3 smaller particles, and n^3 times the charge, with n times the capacitance, gives n^2 times the potential. It follows herefrom that with the conglomeration of water particles, their potential must increase rapidly, proportionately to the square of their diameter.

Let us estimate the average diameter of moisture particles as 10^{4} inches at the beginning of agglomeration, when the potential gradient in the cloud is about 100 volts per foot. The breakdown potential of air, of between 100,000 and 200,000 volts per foot, would be reached when the drops have reached about . 1 to .2 inches diameter, that is, the size of rain drops.

Potential gradients in the cloud thus gradually rise, until somewhere the disruptive strength of the air is reached and a discharge passes, equalizing the voltage at this spot. This, however, causes a greater potential gradient at the ends of the discharge, exceeding the breakdown strength of the air, and so causes a second discharge, following partly over the path of the first, then a third and so on, until all of the potential differences or inequalities of the potential distribution in the cloud, are leveled down by a series of successive discharges. The phenomenon is similar to that of a landslide, setting off another and another landslide.

The potential gradient in the air may rise to disruptive values in still another slightly different manner, and lead to lightning discharges without being accompanied or followed by rain. By conglomeration of moisture particles the potential gradient rises as described above, but before the water drops have reached sufficient size to precipitate as rain, evaporation again sets in: for instance by the drops falling to a lower and warmer stratum of the air, or by intercepting the heat of the sun's rays, when the drops dwindle away. The decrease in size of the drops represents a decrease of capacitance, being proportional to the diameter, and as each drop retains the same charge, its potential increases with the decrease of size, without limit, and so also the potential gradient until its disruptive value is reached and the lightning discharge occurs. This phenomenon is frequently observed towards the evening of a hot summer day, and is called "heat lightning", and, being the result of evaporation, thus does not lead to rain.

Dr. Charles P. Steinmetz,
before the Annual Convention
of the National Electric Light
Association, 1907.