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For more than two and a half centuries, most of mankind has assumed that Benjamin Franklin intended for his famous lightning rod to attract a lightning strike so that the damaging current could be directed to ground. But is this true? It is far more likely that he intended to simply discharge the energy from which the lightning comes, preventing a strike, rather than causing one.

When Franklin realized that electricity would flow into the air from a grounded, sharp pointed metal rod in what he called a “silent current,” the term “electric field” had not been invented. Franklin worked on this mystery current during the middle of the 18th century but the concepts of the fields of electricity and magnetism were not defined and certainly not well understood until the middle of the 19th, by Michael Faraday and James Clerk Maxwell.

Early in the 18th, though, the first Leyden jar was fabricated at a university in Holland. It was the earliest device in which electricity could be stored. News of it traveled rapidly around the world — rapidly, that is, for the 18th century. The electricity that it stored was relatively high voltage, as it was usually generated by friction between two dissimilar materials, such as you’ve experienced walking across a rug made of synthetic material wearing rubber or leather soled shoes and then touching a doorknob. We know today that this voltage can fall within the range of 25,000 to 35,000 volts (similar to the voltage that generates the ignition spark in your automobiles spark plug). However, it is not fatal because the electric current is extremely small. But it is still enough to make a person jump when he or she encounters it. We often call it static electricity, but it is definitely not static when it discharges into your finger!

Early versions of the Leyden jar had a wire projecting out of the top; that’s all that is necessary to provide an electric terminal. But experimenters learned that for some reason, the jar would quickly lose its charge. What was happening?

Many ideas were forthcoming; but they learned that the energy was flowing out into the air from the sharp tip of the wire — the principle of the silent current that Franklin had discovered and described. While we don’t know why, someone at some point in time placed a ball on the tip of the wire projecting from the jar. Did it change anything? Did the charge stay in the Leyden jar for much longer? Yes. But why and how well did it work?

THE LIGHTNING ROD

Franklin learned from his experiments that a sharp point might have an advantage in dissipating an electric charge. He knew from his own remarkably dangerous experiments that when a storm cloud with its electric field was approaching, for some reason, electricity would flow from the sharp point of a rod stuck into the ground (remember his silent current) into the air. And he also knew from his experiments, and those of others, not to place a spherical ball on the tips of his rods because the ball would somehow retard the flow of the silent current. So the tips of his metal rods were sharpened to fine points. This was the principle of his original lightning rod, dissipating the electric charge and reducing the likelihood that a lightning strike would take place.

Interestingly, and exactly backwards, well-intended but ignorant folks later assumed that Franklin's device was intended to lead a strike to ground, rather than to *discharge the electrical energy to prevent one.* They placed Franklin's sharply-pointed rods on tall structures in an attempt to prevent a lightning strike — and unwittingly actually attracted more strikes. From that experience, they concluded that this was the intended purpose of the lightning rods, rather than to prevent a strike by discharging the electrical energy.

Curious scientists wanted to know: If a ball were placed on the tip of a rod in order to minimize the amount of electricity flowing out of a Leyden jar, how would the *diameter* of the ball affect the *voltage threshold* at which the silent current flow begins?

So the experiments began. After considerable testing, they developed a formula. It stated that for *each centimeter of radius* increase of the ball placed on the tip of the rod, the ionization voltage would increase by about 54,000 volts (54 kV/cm of radius). Is this value sacred? Not at all, but it does provide a starting point. Whatever value of voltage causes the onset of silent current, the discharge into the air begins and is defined as corona (in darkness, the discharge may often be seen as a ghostly glow at the tip of the pointed conductor). Now we know that this value is a threshold voltage and can be modified by several things. One is humidity of the air. Another is presence of free ions available in the air. In most cases, ionization begins at something less than 54 kV/cm of radius in normal atmospheric conditions. An application of this principle is the corona rings used on high-voltage power lines and transformers, which surround the electrical connections with smooth curves, eliminating any sharp points, thus minimizing or stopping completely any electrical discharge into the air.

Everyone who deals with very high voltage has learned these things, sometimes the hard way. In most cases, particularly electric power transmission and distribution, corona is to be avoided because it is a waste of energy. Conversely, however, in the case of lightning damage prevention, creating this discharge, often as visible corona, it is extremely valuable. Why? It is because we have learned that there is something called the *first (lowest) ionization potential of the air,* which means that when the voltage in the air is high enough and is applied to a very sharp grounded conductive point, the air (composed mostly of nitrogen and oxygen atoms) will begin to break down by *ionization and electricity actually flows out into the air*. In practice, this process begins prior to the onset of a thunderstorm because the electric field voltage often builds up before the storm arrives and often miles ahead of it.

Depending on atmospheric conditions, this is nominally 6 to 8 kV. An electric current (ions) will begin to flow into the air from the grounded sharp point in the presence of a strong *DC electric field*. The energy contained in the *electric field* will then begin to discharge. If the energy within the electric field is not replenished from some source, the field voltage will diminish. If a large number of sharp points are available and properly located, the field voltage will diminish rapidly. Eventually, the field voltage will become so low that further ionization will not occur. This can be a very valuable tool for minimizing the likelihood of getting a lightning strike.

Note that the field voltage may not diminish all the way to zero, but down to a value that will not be sufficient to initiate a lightning strike. The *field voltage* necessary for a lightning strike is nominally 8 to 10 kV per meter of elevation in normal atmospheric conditions. To visualize this, hold your hand about one meter (39.37 inches) above the ground. Then imagine that there are 10,000 volts DC between your hand and the ground. If it's really there, you will feel tingling of your skin and if you or someone nearby has long, fine hair, it will float up into the air. If this occurs, find shelter or get down on the ground in a hurry! Bear in mind that every meter of elevation above ground adds another 8 to 10 kV, so by the time it reaches the cloud, the voltage gradient can reach into the *millions.* That's where the lightning comes from, and that's why during or before a lightning storm you should not stand on a hill holding a conductive golf club up into the air!

The problem with the *electric field* associated with a lightning strike is that it replenishes its field energy rapidly. It is a thermodynamic/electrodynamic process involving billions of charged particles (water droplets and ice particles) moving *within* and *on the surface* of a storm cloud. We know that during a severe thunderstorm, many lightning strikes may occur. Each strike partially depletes the electric field, but the dynamic processes rapidly recharge it. So a question arises: How can we continuously discharge the electric field fast enough to minimize lightning strikes?

AN EXPERIMENT

What about placing long metal wires with sharp ends across the opposite poles of the electric field? Atmospheric scientists know that there is typically a huge *difference of potential (voltage)* between the top of a cloud and its bottom. It is analogous to a gigantic capacitor with the cloud top having one polarity and the bottom the opposite polarity. Vertical wires from top to bottom would provide a short circuit between the two poles, discharging the energy of the virtual capacitor. Obviously, the problem is that it is just not practical to place long wires inside the cloud in appropriate locations.

THE SOLUTION

The practical alternative is to place large numbers of grounded, conductive sharp points on all earthbound tall structures at as high elevations as practical. Measurements of electric currents flowing from ground into these devices indicate that *they are discharging the electric field above the surface of the earth*. Remember, it is not necessary to discharge the electric field to zero, but only below the *threshold voltage* required to initiate a strike. Scientists have instruments that measure this threshold voltage and have learned that it can be 8 to 12 kV/m or more of elevation above ground. It can be seen that the taller the structure, the more effective multiple sharp points will be in discharging the electric field. This scientific phenomenon is called *point discharge and is described in scientific literature*.

POWER FROM THE ATMOSPHERE

It was once believed that there was so much electricity in the atmosphere that it could be harvested for use by mankind. There is a great deal of power there, but under normal weather conditions, it is so widely dispersed that it is not practical to try to harvest it.

For example, it was once believed that each individual lightning strike contained a massive amount of energy, but science has now learned from actual measurements that whatever energy is delivered by a damaging lightning strike is not the result of mass energy, but by the extremely short time frame involved. A lightning strike is damaging because it is like a hammer blow, not like a bulldozer pushing forward. However, when the energy of a strike is released slowly over several minutes time, it is harmless. An average lightning strike may contain about the same energy that is consumed by a 100-watt light bulb for a few minutes. But concentrate those few watts of energy for one minute into a few billionths of a second, and you can arc-weld. That's how a relatively few watts of energy can do so much damage. And that little actual power is delivered in such an extremely short burst. We simply cannot harvest that energy in any practical way.

Years ago, other groups of scientists conducted experiments during fair weather in which they lifted a very long wire up into the atmosphere by a balloon in an attempt to harvest the electrical energy that, when it all comes crashing down in one spot very quickly, makes lightning, but the power they obtained was only sufficient to run a tiny electric motor. There is simply very little energy within a particular volume of the atmosphere to draw from. Planet-wide, there is a great deal of energy, but it is dispersed all over the face of the earth and not concentrated in any one area enough to harvest it in practical quantities. Again, a lightning strike is like a hammer blow, concentrating the kinetic energy within a speeding hammerhead onto one small spot. It's all about time.

SUMMARY

Every time a person is outdoors, he or she is in an electric field, a virtual ocean of electricity. We live inside a big capacitor that extends from the earth's surface up to the ionosphere, hundreds of miles up in the sky. The earth is one plate of the capacitor and the ionosphere is the other with an electric charge gradient in between. On a sunny, clear day the voltage per meter is low. However, if a thunderstorm approaches, this voltage begins to increase and can reach very high values. When it gets high enough, the air breaks down and lightning happens.

By applying modern scientific and engineering methods, the damage from lightning can be reduced to a minimal amount. The technology is extremely simple. The electric fields associated with all thunderstorms can be discharged down to levels too low to initiate a lightning strike. Obviously, the materials must be rugged and weatherproof and placed in proper locations. Many electric power plants, substations, and communications and broadcast towers have been protected, but also many automated facilities such as remote solar-powered oil and gas wells have been protected from both lightning and static electricity damage by this method. Playgrounds and athletic fields place people in lightning-vulnerable locations, but they, too, can be economically protected by electric field discharge. Lighting poles provide perfect locations for them.

For centuries, mankind has assumed that Franklin intended that his lightning rods attract and draw lightning strikes. This is simply not true. His original intent was to *prevent* lightning by discharging the energy source from which it comes. Likely, he was extremely surprised when lightning struck one of his rods. However, it has become tradition to believe otherwise. Tradition makes things easy, but is often untrue. It is simply tradition. Do not assume anything. Learn the facts. Lightning and static electricity can be eliminated simply by discharging their energy sources.

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