The Key to Electricity

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Abstract

The name "Benjamin Franklin" often evokes the image of an avuncular man flying a kite on a stormy night. It is indeed a striking picture: one of the founders of our country, a successful businessman, a diplomat, and the public face of the American Revolution spending his time contributing to the advancement of science-and putting his life at risk in the process.

Disciplines

Philosophy

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The name "Benjamin Franklin" often evokes the image of an avuncular man flying a kite on a stormy night. It is indeed a striking picture: one of the founders of our country, a successful businessman, a diplomat, and the public face of the American Revolution spending his time contributing to the advancement of science—and putting his life at risk in the process.

Copious mythology surrounds Franklin and his kite experiment. Students are often told that Franklin discovered electricity, or, even more ridiculously, that he invented it. Even a cursory look at the history of science would show that these claims are false, yet Franklin's experiment is justly famous. He did not discover electricity, but he did conclusively show that lightning is an electrical phenomenon. The kite experiment also paved the way for the lightning rod, perhaps his most important invention.

In 1746, Franklin met "a Dr. Spence[r], who was lately arrived [in Boston] from Scotland, and show'd me some electric experiments." Some of Dr. Spencer's experiments would be familiar to students in modern physics courses. Upon rubbing a glass tube with felt, he caused small flakes of brass or gold to jump around or be attracted to the tube. More dramatically, an associate of Franklin describes a boy who "was suspended horizontally and the Dr. rubbed a glass tube, a little distance from his feet, which made sparks of the fire fly from his face and hands." Although Dr. Spencer was not an expert on electricity and his experiments were "very imperfectly perform'd," Franklin's interest was piqued.

Much was known about the behavior of electricity before Franklin encountered Dr. Spencer, so the often-heard claim that Franklin discovered electricity is clearly false. Franklin did perform many electrical experiments and contributed to the growing stock of experimentally derived knowledge about electricity. However, his most important contributions to electrical research lay elsewhere. The first of these contributions was theoretical: the electrical fluid theory.

Franklin posited that an electrical fluid is present in all bodies. This electrical fluid is *subtle*, meaning that it can permeate even the densest of objects. All bodies have a natural quantity of the electrical fluid, but this quantity can be increased or decreased by contact with other electrified bodies or by friction. Franklin used this theory to account for most electrical phenomena, including the most basic electrical properties: attraction and repulsion.

Two charged bodies sometimes exhibit repulsion, moving away from one another when brought together. In Franklin's theory, this is attributed to both bodies possessing excess electrical fluid, or being *positively* charged. When a body possesses excess fluid, the fluid flows around the body's surface and forms what Franklin called an *electrical atmosphere*. The atmospheres of two positively charged bodies repel one another because they cannot occupy the same space.

Franklin's theory also accounted for electrical attraction. In an essay describing his electrical theory, he described matter as "a kind of sponge to the electrical fluid." When a body lacks electrical fluid relative to its normal state, its sponge-like character draws fluid from a positive body.

Although Franklin was justly proud of these and other theoretical explanations of well-known phenomena, he was also interested in more practical matters. Eighteenth-century Philadelphia suffered from frequent fires caused by lightning strikes. The density of buildings increased the probability that lightning would start a fire, and the proximity of the buildings meant that a fire could ravage a whole block. About ten years before Franklin's kite experiment, he had devised a volunteer fire company which ensured that Philadelphia "never lost more than one or two houses at a time" from fire. Lightning-induced fire could be contained, but it could not be prevented. Franklin sought a way to keep lightning from starting fires in the first place.

The first step involved determining what kind of phenomenon lightning actually was. In a notebook entry dated November 7, 1749, Franklin made the following observations:

> Electrical fluid agrees with lightning in these particulars: 1. Giving light. 2. Colour of the light. 3. Crooked direction. 4. Swift motion. 5. Being conducted by metals. 6. Crack or noise in exploding. 7. Subsisting in water or ice. 8. Rending bodies it passes through. 9. Destroying animals. 10. Melting metals. 11. Firing inflammable substances. 12. Sulphurous smell.—The electric fluid is attracted by points.—We do not know whether this property is in lightning.—But since they agree in all the particulars wherein we can already compare them, is it not probable they agree likewise in this? Let the experiment be made.

It is clear from this entry that by 1749 Franklin already suspected that lightning was an electrical discharge. However, all he had was an argument by analogy. He thus implored himself: Let the experiment be made! Lightning needed to be captured in order to analyze its properties.

The first successful attempt to capture lightning took place in France, not Philadelphia, by one of Franklin's European admirers. On May 10, 1752, Thomas-François Dalibard brought a forty-foot pointed bar of iron to a garden in Marly, and "a storm cloud having passed over the place where the bar stood, those that were appointed to observe it, drew near, and attracted from it sparks of fire, perceiving the same kind of commotions as in the common electrical Experiments" (from a letter addressed to Franklin by G. Mazeas, a French correspondent, which Franklin included in his book about electricity).

While we know that the experiment in Marly was performed before Franklin flew his kite, we do not know whether news of it had reached Franklin before he performed his own experiment. Subsequently alluding to the success of the Marly experiment, Franklin told his friend and patron Peter Collinson that "the same experiment has succeeded in *Philadelphia*, although made in a different and more easy manner," and went on to give instructions for repeating his experiment.

> Make a small cross of two light strips of cedar, the arms so long as to reach to the four corners of a large thin silk handkerchief when extended; tie the corners of the handkerchief to the extremities of the cross, so you have the body of a kite; which being properly accommodated with a tail, loop, and string, will rise in the air, like those made of paper; but this being of silk is fitter to bear the wet and wind of a thunder-gust without tearing. To the top of the upright stick of the cross is to be fixed a very sharp pointed wire, rising a foot or more above the wood. To the end of the twine, next the hand, is to be tied a silk ribbon, and where the silk and twine join, a key may be fastened.

In his *Autobiography*, Franklin declines to "swell this narrative with an account" of the experiment performed in Marly. He also modestly declines to elaborate on "the infinite pleasure I receiv'd in the success of a similar one I made soon after with a kite at Philadelphia." While Franklin's letter to Collinson recounts the procedure undertaken, it is to Franklin's friend Joseph Priestley we must turn for an account of what actually transpired.

Franklin and his son walked out into an open field with their silk kite, standing just inside a shed for shelter. Franklin allowed the kite to fly through ominous looking clouds, yet nothing happened at first.

> At length, just as he was beginning to despair of his contrivance, he observed some loose threads of the hempen string to stand erect, and to avoid one another, just as if they had been suspended on a common conductor. Struck with this promising appearance, he immediately presented his knuckle to the

key, and (let the reader judge of the exquisite pleasure he must have felt at that moment) the discovery was complete. He perceived a very evident electric spark. Others succeeded, even before the string was wet, so as to put the matter past all dispute, and when the rain had wet the string, he collected electric fire very copiously.

Showing that lightning produced an electrical spark and that "electrical fire" could be collected from it was the experimental confirmation of Franklin's hypothesis about lightning. He had shown that, as he suspected, lightning was an electrical discharge. The experiment also suggested how buildings might be protected from lightning-induced fires with the aid of a lightning rod. The rod's construction was described in detail in the 1753 edition of *Poor Richard's Almanac.*

Provide a small iron rod . . . of such a length, that one end being three or four feet in the moist ground, the other may be six or eight feet above the highest part of the building. To the upper end of the rod fasten a foot of brass wire, the size of a common knitting-needle, sharpened to a fine point. . . . A house thus furnished will not be damaged by lightning, it being attracted by the points, and passing thro the metal into the ground without hurting anything.

The use of Franklin's invention quickly spread throughout the colonies. Writing from London twenty years later, Franklin reported that "hitherto there has been no instance of a house so guarded being damaged by lightning; for wherever it has broke over any of them the point has always receiv'd it, and the conductor has convey'd it safely into the earth, of which we have now 5 authentic instances."

Franklin's kite experiment was the culmination, not the beginning, of his research on electricity. It showed that lightning was an electrical phenomenon and suggested how buildings could be protected from it. Franklin's discovery was not just a practical one, as it is sometimes portrayed. Like Newton, Franklin showed how a phenomenon of the heavens behaved exactly as a phenomenon on earth. His demonstration that lightning is electrical gave his theory of electricity tremendous unifying power, helping to lay the foundations of electrical science. This achievement alone would have earned Franklin an illustrious place in the history of science, but this was far from his only scientific contribution. And science was only his part-time occupation, of course, for he was also helping to lay the foundations for a new nation.