How Practical Was Benjamin Franklin's Science?

"The scientist does not study nature because it is useful; he studies it because he delights in it and he delights in it because it is beautiful." —*Henri Poincaré.*

In the minds of most people, Benjamin Franklin will ever personify the practical cast of the American mind. Many scholars and historians share this opinion. Typical of the point of view is the statement made by Curtis P. Nettels, in his excellent book of recent vintage, "Franklin, the most significant American of the eighteenth century and a utilitarian *par excellence*, directed his scientific thought to the improvement of material conditions. . . ."[1] The same writer also tells us, "Franklin's early life as a printer—his practice of applying hand-work to ideas—explains in large measure the practical cast of his thought. No activity satisfied him so much as scientific inquiry—a mistress who did not have to be flattered and cajoled as did the human beings through whom he sought to accomplish his useful aims. His experiments that proved the identity of lightning and electricity established his international renown as a scientist. The invention of the Franklin stove (which sent the heat into the room instead of up the chimney), of the lightning rod, and of a clock having only three wheels and two pinions, all testify to the practical nature of his work. . . ."[2]

Any discussion of the practical or utilitarian character of Franklin's work in science must begin by making it clear that judgment should be made in terms of eighteenth-century values, not in our own present-day values. In many ways the eighteenth century, like the seventeenth century, was somewhat more avowedly utilitarian-

[1] Curtis P. Nettels, *The Roots of American Civilization. A History of American Colonial Life* (NewYork, 1938), 454. Mr. Nettels' book is not being singled out for criticism; it is a profound, significant, and masterly contribution to American scholarship.

[2] *Ibid.*, 497–498.

minded in things pertaining to science than our own age. The influence of Lord Bacon was strong, especially in England (and therefore in the American colonies), and the Baconian spirit embodied an element of putting scientific discoveries to work for the improvement of man's material condition. No one would deny that Benjamin Franklin, a follower of the English school, was interested in putting his own scientific discoveries, *once they were made*, to some practical use. But this is greatly different from saying that he "directed his scientific thought to the improvement of material conditions." Let us examine some examples to see what he really did.

One of the statements usually quoted to illustrate Franklin's point of view is one which he made after a description of how he had discovered that the calorific effects of the sun's rays were absorbed in varying degrees by the same material dyed in different colors. This statement reads:

> What signifies Philosophy that does not apply to some Use? May we not learn from hence, that black Clothes are not so fit to wear in a hot Sunny Climate or Season, as white ones; because in such Cloaths [!] the Body is more heated by the Sun when we walk abroad, and are at the same time heated by the Exercise, which double Heat is apt to bring on putrid dangerous Fevers? That Soldiers and Seamen, who must march and labour in the Sun, should in the East or West Indies have an Uniform of white? That Summer Hats, for Men or Women, should be white, as repelling that Heat which gives Headaches to many, and to some the fatal Stroke that the French call *Coup de Soleil?* That the Ladies' Summer Hats, however, should be lined with Black, as not reverberating on their Faces those Rays which are reflected upwards from the Earth or Water? That the putting a white Cap of Paper or Linnen *within* the Crown of a black Hat, as some do, will not keep out the Heat, tho' it would if placed *without*? That Fruit-Walls being black'd may receive so much Heat from the Sun in the Daytime, as to continue warm in some degree thro' the Night, and thereby preserve the Fruit from Frosts, or forward its Growth?—with sundry other particulars of less or greater Importance, that will occur from time to time to attentive minds? [Franklin to Mary Stevenson, September 20, 1761].[3]

This document can be interpreted in one way only. It is an example of how Franklin, *having made* his discovery, thought of ways in which it could be used. He did not make the original experiments with any practical end in view; in fact, when he made the experiments, he could not have known that there would be any possible practical application, since at that time the fact of varying absorption as a

[3] Quoted from A. H. Smyth (editor), *The Writings of Benjamin Franklin* (New York, 1905–1907), IV, 111ff.

function of color was not even known to exist. It was discovered as a result of his experiments. Furthermore, the original experiments on which the application was based had been made at least twenty-five years before the letter quoted above was written, and probably had been made as early as 1729, if not earlier. And yet there was no thought of possible application, at least according to the available writings of Franklin, until 1761![4]

The statement is also made that "utilitarianism governed Franklin's conception of science—he once apologized for spending time in a mathematical exercise which could have no useful bearing . . . ."[5] The mathematical exercise referred to by the various writers who make such a statement is presumably that of making magic squares and magic circles. The story of Franklin's interest in these mathematical curiosities is best told by himself:

> Being one day in the country, at the house of our common friend, the late learned Mr. *Logan*, he shewed me a folio *French* book, filled with magic squares, wrote, if I forget not, by one M. Frenicle [Bernard Frénicle de Bessy. *Traité des triangles rectangles en nombre.* (Paris, 1676)], in which, he said, the author had discovered great ingenuity and dexterity in the management of numbers; and, though several other foreigners had distinguished themselves in the same way, he did not recollect that any one *Englishman* had done any thing of the kind remarkable.
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> I said, it was, perhaps, a mark of the good sense of our *English* mathematicians, that they would not spend their time in things that were merely *difficiles nugæ*, incapable of any useful application. He answered, that many of the arithmetical or mathematical questions, publickly proposed and answered in *England*, were equally trifling and useless. "Perhaps the considering and answering such questions," I replied, "may not be altogether useless, if it produces by practice an habitual readiness and exactness in mathematical disquisitions, which readiness may, on many occasions, be of real use." "In the same way," says he, "may the making of these squares be of use." I then confessed to him, that in my younger days, having once some leisure, (which I still think I might have employed more usefully) I had amused myself in making these kinds of magic squares, and, at length, had acquired such a knack at it, that I could fill the cells of any magic square, of reasonable size, with a series of numbers as fast as I could write them, disposed in such a manner, as that the sums of every row, horizontal, perpendicular, or diagonal, should be equal. . . .[6]

[4] *Cf.* I. Bernard Cohen, "Franklin's Experiments on Heat Absorption as a Function of Color," *Isis*, XXXIV (1943), 404ff.

[5] Merle Curti, *The Growth of American Thought* (New York and London, 1943), 98. This splendid book tends to be more moderate than many others. Thus, the statement quoted above is modified by the statement that despite the fact that Franklin's conception of science was governed by utilitarianism, "it did not exclude a larger vision."

[6] Smyth, *Writings*, II, 456ff., 460ff.

Franklin's interest in these magic squares, and in magic circles, continued despite his acknowledgment that they were useless and even a trivial waste of time. He corresponded about them and even consented to having one of them reproduced in the supplementary portion of the fourth English and third French edition of his book, *Experiments and Observations on Electricity*.[7] And he wrote to his English friend and patron, Peter Collinson, "I am glad the perusal of the magical squares afforded you any amusement. I now send you the magical circle."[8]

Among the uses that these magic squares might have, Franklin notes the possibility of affording a means of perfecting one's skill in arithmetic. In Franklin's own case, it seems to have worked. In his autobiography he tells us that at the "school for writing and arithmetic" which he attended until he was ten years old, "I failed in the arithmetic, and made no progress in it."[9] Yet, the letter above indicates that he had, in the end, acquired considerable arithmetical skill. Franklin's earlier ideas on this subject may be found developed at large in an article entitled, "On the Usefulness of the Mathematics," published in the *Pennsylvania Gazette*, October 30, 1735.[10] It begins with the statement that arithmetic is useful in "business, commerce, trade, or employment," even for the "merchant and shopkeeper." As for geometry, "no curious art, or mechanic work, can either be invented, improved, or performed, without its assisting principles." This subject, therefore, is of great and indispensable use to astronomers, geographers, mariners, architects, engineers, surveyors, and so on.

But the "usefulness of the mathematics" is not limited to such obviously practical ends. We are told, for example: "*Mathematical demonstrations* are a logic of as much or more use, than that commonly learned at schools, serving to a just formation of the mind,

7 The various editions of this book are listed and collated in I. Bernard Cohen (editor), *Benjamin Franklin's Experiments, a new edition of Franklin's "Experiments and Observations on Electricity," edited with a critical and historical introduction* (Cambridge, 1941), introduction, 139ff.

8 Smyth, *Writings*, II, 460.

9 "Autobiography," in Smyth, *Writings*, I, 233.

10 Reprinted in Jared Sparks (editor), *The Works of Benjamin Franklin; containing several political and historical tracts not included in any former edition, and many letters official and private not hitherto published; with notes and a life of the author* (Philadelphia, revised edition, n.d.), II, 66ff.

enlarging its capacity, and strengthening it so as to render the same capable of exact reasoning, and discerning truth from falsehood in all occurrences, even subjects not mathematical." "To give a man the character of universal learning, who is destitute of a competent knowledge of the mathematics" is not, we are told, unreasonable or unjust.

In this instance, the fact of the matter is that Franklin made protestations of his lack of interest in non-useful subjects, even to the point of being glad that Englishmen had not bothered to waste time on such wills-o'-the-wisp as magic circles. Alas, they were not simply being Baconians uninterested in things of no use, nor were they following the precept of Robert Boyle: "The other humane studies I apply myself to are natural philosophy, the new mechanics and husbandry, according to the principles of our new philosophical colledge that value no knowledge but *as it hath a tendency to use.*" One of the interesting facts of the history of mathematics is that in contrast to the great period of the seventeenth century and that of the nineteenth and twentieth centuries, English mathematicians of the eighteenth century produced little of great value, especially as compared to that produced on the Continent, in France for example. And if Franklin seems to have apologized for so wasting his time, he nevertheless continued to spend a good bit of his leisure and interest on this useless subject. We must judge his scientific interests by their own nature, not what he said about them.

Magic squares and circles appealed to Franklin's curiosity. They were a kind of game or puzzle. During the debates in the Assembly, he tells us, "I was at length [so] tired with sitting there . . . that I was induc'd to amuse myself with making magic squares or circles, or any thing to avoid weariness."[11] The pursuit of higher mathematics is in any case, according to the late great German mathematician, David Hilbert, like playing a game in which one sets up the rules or operations and sees what results arise from the proper manipulation of the meaningless entities represented by the symbols.

The true test of Franklin's scientific interest must come from the field in which he did his most significant work and which brought about his everlasting international fame, that of electricity. In this connection, most accounts lay great stress on his kite experiment and

[11] "Autobiography," in Smyth, *Writings*, I, 374.

his invention of the lightning rod. One writer tells us: "The invention of the lightning rod was only one illustration of Franklin's conviction that science should promote general well-being."[12] No one in his right mind would think for a moment of denying that Franklin's invention of the lightning rod was a practical one. But it was an invention, and it must be classed along with other inventions like bifocal eyeglasses, the so-called Franklin stove, and others.

There is only one difference between Franklin's invention of the lightning rod and other inventions of his. This particular invention was made possible by Franklin's own investigation into the phenomena of pure science. Franklin's interest in the subject of electricity was aroused by his contact with an itinerant lecturer on scientific subjects, Dr. Adam Spencer, whom he met first in Boston in 1743 and whom he saw again when Spencer visited Philadelphia in the following year.[13] Soon after, he received a gift of some electrical apparatus with directions as to how to use it and began to experiment. Franklin wrote a letter to Collinson thanking him for the gift on March 28, 1747, stating: "I never was before engaged in any study that so totally engrossed my attention and my time as this has lately done."[14]

Two letters describing the experiments and the conclusions to be drawn from them followed on May 25, 1747, and July 28, 1747.[15] It is very interesting to note that these two letters, of some length, nowhere refer to any practical matter, or to any possible practical use to the new discoveries. Franklin was simply interested in a new subject, one in which he found that he had considerable talent for investigation. As results were forthcoming, he continued his experiments with nothing other than the motive which impels any other scientific investigator: he wanted to find the truth of the matter at hand, and that was all there was to it. On August 14, 1747, after the two long letters just mentioned had been sent, Franklin wrote a very interesting, short note to Collinson, in which he declared that some of his theoretical conclusions appeared to have been a little hasty, that new experimental data seemed not to accord with his principles

12 Curti, *Growth*, p. 98.

13 *Cf.* I. Bernard Cohen, "Benjamin Franklin and the Mysterious Dr. Spencer, the Date and Source of Franklin's Interest in Electricity," *Journal of the Franklin Institute*, 235 (1943), 1ff.

14 *Cf.* Cohen, ed., *Franklin's Experiments*, p. 170.

15 *Ibid.*, 171ff., 179ff.

as originally laid down. Thereupon he added: [italics are his own] "In going on with these Experiments, how many pretty systems do we build, which we soon find ourselves oblig'd to destroy! If there is no other Use discover'd of Electricity, this, however, is something considerable, that it may *help to make a vain Man humble.*"[16] Another long letter to Collinson followed on April 29, 1749. This letter contained much new material and ended on the following humorous note:

> Chagrined a little that we have been hitherto able to produce nothing in this way of use to mankind; and the hot weather coming on, when electrical experiments are not so agreeable, it is proposed to put an end to them for this season, somewhat humorously, in a party of pleasure, on the banks of *Skuylkil.* Spirits, at the same time, are to be fired by a spark sent from side to side through the river, without any other conductor than the water; an experiment which we some time since performed, to the amazement of many. A turkey is to be killed for our dinner by the *electrical shock*, and roasted by the *electrical jack*, before a fire kindled by the *electrified bottle:* when the healths of all the famous electricians in *England*, *Holland*, *France*, and *Germany* are to be drank in *electrified bumpers*, under the discharge of guns from the *electrical battery*.[17]

Thus far, surely, despite Franklin's statement that he and his coworkers were "chagrined a little," nothing of practical use had come out of the research.

Yet much of great value to the world of science had been found. Franklin had completed his analysis of the capacitor, or condenser, then known as the Leyden jar; he had formulated his great theory of a single fluid "plus or minus," "positive or negative," he had found the effect of shape of conductors, he had discovered the function of insulation and grounding in charging bodies, and had unified all existing knowledge of this subject as well as made his own additions thereto. As yet, this subject was of *no practical value.* His work was acknowledged by the members of the Royal Society as a significant contribution to our knowledge of nature and his findings were printed in a small pamphlet that was soon translated into French.

Franklin's experiments and observations had led him to notice the similarity between an electric spark and a flash of lightning and his own work showed him the way to test this hypothesis. This test took

[16] *Ibid.*, 63.
[17] *Ibid.*, 199–200.

the form of the guard-box experiment and was successfully carried to its conclusion by the French translator of his book. As an afterthought, Franklin proposed the experiment of the kite and carried this through himself as we all know.[18]

The practical invention of the lightning rod followed directly from Franklin's own research. If lightning is electrical, it must follow the same laws as those governing electrical action. Thus, the electricity of clouds will be attracted best by means of a pointed conductor (a discovery of his). But the pointed conductor must be grounded (another discovery of his). Finally, the electricity will choose to pass through a good metallic conductor rather than through the poor conductor of which the protected edifice is built (another discovery of his). Only after Franklin had made these discoveries could an experimental test be devised to see whether lightning were truly an electrical phenomenon. Others before him had guessed at the truth of this matter but could not prove it. The same discoveries of Franklin's also laid the basis for his invention of the lightning rod. He thought, however, that the clouds were charged plus and had an excess of fluid which could be drawn out of them, thereby *preventing* a stroke. As it turned out, the rod did not work in this way so much as it did to *conduct* the stroke when it actually occurred.

The success of his invention of the lightning rod must have given him great pleasure in discovering something useful to man. All scientists, of whatever century and in any field, experience the same pleasure when a discovery of theirs eventually leads to some useful application. But, in this case as in many others, no one could have predicted the practical result since no one knew at the beginning of the research where the experiments would lead. Franklin was interested in discovering truths; he did not know beforehand that he would discover the nature of the condenser, the function of grounding and insulating, relative conductivities, the nature of pointed conductors, much less the electrical nature of lightning. The latter was the crowning element in the public mind that set the seal to his fame. But his interest and enthusiasm were never dampened in the early days by the fact that he was simply discovering interesting and curious aspects of the world of nature. Had "utilitarianism governed

[18] The chronology of the kite has been worked out in Carl Van Doren, *Benjamin Franklin* (New York, 1938).

Franklin's conception of science," or had "a utilitarianism *par excellence* directed his scientific thought to the improvement of material conditions," he would never have begun to investigate the subject of electricity at all. For this was a subject, when he began his investigations, of little, if any, practical use. Only one application of electrical knowledge was "known" at that time, the therapeutic use of the electrical shock in certain cases of paralysis and other bodily disorders. Franklin himself did not believe in this type of treatment and noted that the supposed cures came less from the shock than from the idea in the patient's mind that he would be so cured. Franklin could not have chosen any other subject so apparently without practical application as the field of electrostatics.

One of the most practical results of Franklin's career in the field of electricity is usually not noted. It is the fact that the spectacular success and fame arising from his work made possible his successful diplomatic career. At the time of the Revolution, Franklin was one of the most distinguished living scientists and one of the most well known.[19] His book on electricity had been published in ten editions in four languages: five in English, three in French (in two different translations), one in German, and one in Italian. He was a member of the two most important scientific societies in the world, the Royal Society (London) and the Académie Royale des Sciences (Paris); he was one of the eight "foreign associates" of the latter. Almost the entire scientific world accepted his theory of electricity and his book had become the *vade mecum* of electrical style;[20] all who wrote on that subject did so in terms of the words which he used in an electrical sense for the first time. His book, in the words of a contemporary, "bids fair to be handed down to posterity, as expressive of the true principles of electricity; just as the Newtonian philosophy is of the system of nature in general."[21] When Franklin went to the court of France, he was not an unknown man from an English colony; he was one of the best known living scientists and benefactors of the age!

19 The relation of Franklin's fame and reputation as a scientist to his political and diplomatic career has been discussed in I. Bernard Cohen, "Benjamin Franklin as Scientist and Citizen." *The American Scholar* (1943), 474ff.

20 *Cf.* Lois Margaret MacLaurin, *Franklin's Vocabulary* (Garden City, New York, 1928. Franklin Monographs).

21 Joseph Priestley, *The History and Present State of Electricity, with original experiments* (London, 1775), I, 193.

Franklin was interested in advancing knowledge, as all scientists are. In one of his communications on electricity, he wrote:

> These thoughts, my dear friend, are many of them crude and hasty; and if I were merely ambitious of acquiring some reputation in philosophy [i.e. natural philosophy or science], I ought to keep them by me, till corrected and improved by time, and farther experience. But since even short hints and imperfect experiments in any new branch of science, being communicated, have oftentimes a good effect, in exciting the attention of the ingenious to the subject, and so become the occasion of more exact disquisition, and more compleat discoveries, you are at liberty to communicate this paper to whom you please; it being of more importance that knowledge should increase, than that your friend should be thought an accurate philosopher.[22]

Benjamin Franklin undoubtedly believed, as most scientists have always believed, that all scientific discovery is eventually of some use—if not leading to immediate practical application, then at least in affecting the growth of some other branch of knowledge. When Franklin saw the first balloon ascent in Paris, he overheard the remark, "What good is it?" His reply, "What good is a newly born infant?"[23] has been the standard reply of scientists and other types of innovators ever since. It was used with particular effectiveness by Michael Faraday, who added, "The answer of the experimentalist would be, 'Endeavor to make it useful.'"[24] In inventing the lightning rod, Franklin endeavored to make his electrical discoveries useful.

In an age which was interested in the production of useful things, and in a cultural milieu which set great stock on being practical, Franklin nevertheless investigated subjects primarily because they aroused his curiosity, because some particular topic excited his interest. When his investigations seemed far removed from the practical or useful sphere, he could not help having twinges of conscience about not being able to justify the expenditure of effort in terms of some practical return. But, nevertheless, as a scientist, his interest was primarily in science itself and in scientific research for its own sake, and was never limited by considerations only of what might be useful.

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22 Cohen, ed., *Franklin's Experiments*, p. 279.

23 *Cf.* Van Doren, *Franklin*, p. 700; also, I. Bernard Cohen, "Benjamin Franklin and Aeronautics," *Journal of the Franklin Institute*, 232 (1941), 104.

24 *Cf.* Bence Jones, *Life and Letters of Faraday* (London, 1870), I, 218.