The Invisible Rainbow

A History of Electricity and Life

Arthur Firstenberg

The INVISIBLE RAINBOW

A History of Electricity and Life

Arthur Firstenberg

Chelsea Green Publishing
White River Junction, Vermont
London, UK

Originally published in 2017 by AGB Press, Santa Fe, New Mexico; Sucre, Bolivia.

This paperback edition published by Chelsea Green Publishing, 2020.

Book layout: Jim Bisakowski
Cover design: Ann Lowe

Printed in Canada.
First printing February 2020.
10 9 8 7 6 5 4 3 2 1 20 21 22 23 24

Our Commitment to Green Publishing
Chelsea Green sees publishing as a tool for cultural change and ecological stewardship. We strive to align our book manufacturing practices with our editorial mission and to reduce the impact of our business enterprise in the environment. We print our books and catalogs on chlorine-free recycled paper, using vegetable-based inks whenever possible. This book may cost slightly more because it was printed on paper that contains recycled fiber, and we hope you’ll agree that it’s worth it. *The Invisible Rainbow* was printed on paper supplied by Marquis that is made of recycled materials and other controlled sources.

Library of Congress Control Number: 2020930536
ISBN 978-1-64502-009-7 (paperback) | 978-1-64502-010-3 (ebook)

Chelsea Green Publishing
85 North Main Street, Suite 120
White River Junction, VT 05001
(802) 295-6300
www.chelseagreen.com

In memory of Pelda Levey—friend, mentor, and fellow traveler.

Author’s Note

FOR EASE OF READING I have kept the endnotes to a minimum. However, all sources referred to in the text can be found in the bibliography at the back of the book, together with other principal works I have consulted. For the convenience of those interested in particular subjects, the literature in the bibliography is organized by chapter, and within some chapters by topic, instead of the usual single alphabetical listing.

A.F.

Contents

Prologue

ONCE UPON A TIME, the rainbow visible in the sky after a storm represented all the colors there were. Our earth was designed that way. We have a blanket of air above us that absorbs the higher ultraviolets, together with all of the X-rays and gamma rays from space. Most of the longer waves, that we use today for radio communication, were once absent as well. Or rather, they were there in infinitesimal amounts. They came to us from the sun and stars but with energies that were a trillion times weaker than the light that also came from the heavens. So weak were the cosmic radio waves that they would have been invisible, and so life never developed organs that could see them.

The even longer waves, the low-frequency pulsations given off by lightning, are also invisible. When lightning flashes, it momentarily fills the air with them, but they are almost gone in an instant; their echo, reverberating around the world, is roughly ten billion times weaker than the light from the sun. We never evolved organs to see this either.

But our bodies know that those colors are there. The energy of our cells whispering in the radio frequency range is infinitesimal but necessary for life. Every thought, every movement that we make surrounds us with low frequency pulsations, whispers that were first detected in 1875 and are also necessary for life. The electricity that we use today, the substance that we send through wires and broadcast through the air without a thought, was identified around 1700 as a property of life. Only later did scientists learn to extract it and make it move inanimate objects, ignoring—because they could not see—its effects on the living world. It surrounds us today, in all of its colors, at intensities that rival the light from the sun, but we still cannot see it because it was not present at life's birth.

We live today with a number of devastating diseases that do not belong here, whose origin we do not know, whose presence we take for granted and no longer question. What it feels like to be without them is a state of

vitality that we have completely forgotten.

“Anxiety disorder,” afflicting one-sixth of humanity, did not exist before the 1860s, when telegraph wires first encircled the earth. No hint of it appears in the medical literature before 1866.

Influenza, in its present form, was invented in 1889, along with alternating current. It is with us always, like a familiar guest—so familiar that we have forgotten that it wasn’t always so. Many of the doctors who were flooded with the disease in 1889 had never seen a case before.

Prior to the 1860s, diabetes was so rare that few doctors saw more than one or two cases during their lifetime. It, too, has changed its character: diabetics were once skeletally thin. Obese people never developed the disease.

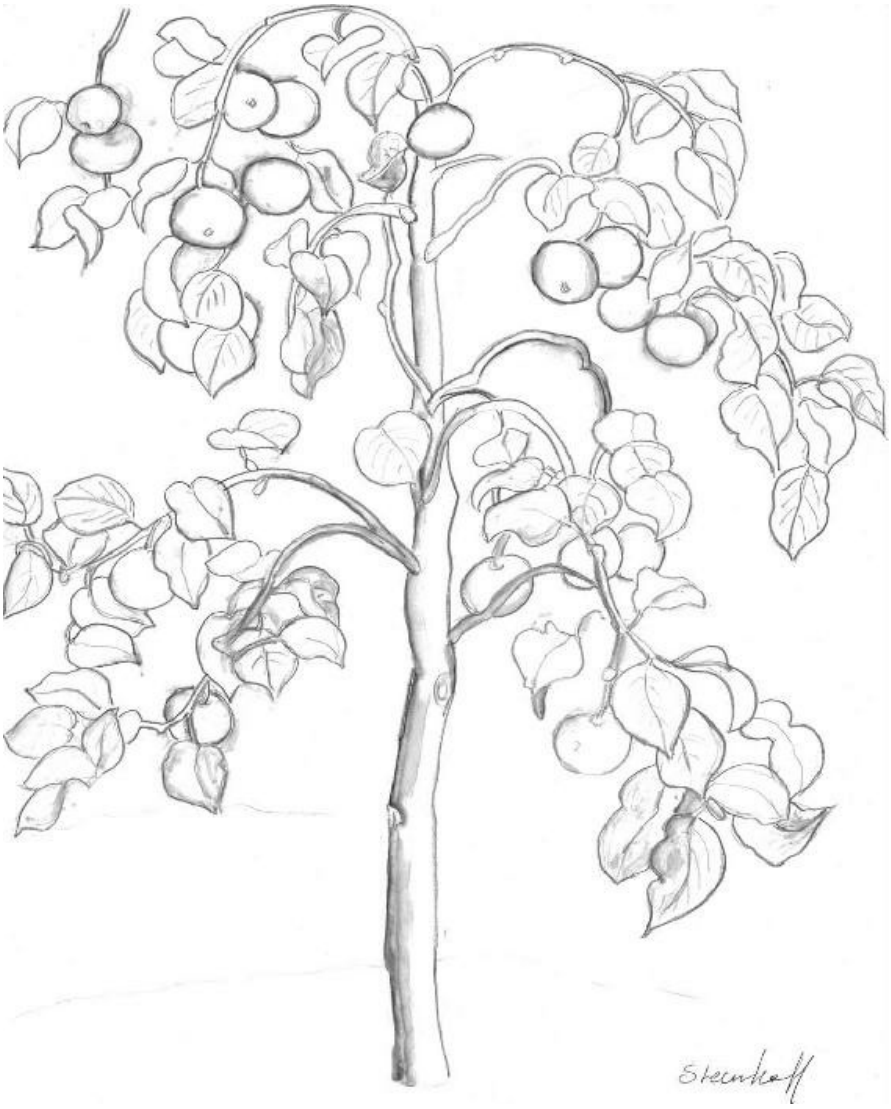
Heart disease at that time was the twenty-fifth most common illness, behind accidental drowning. It was an illness of infants and old people. It was extraordinary for anyone else to have a diseased heart.

Cancer was also exceedingly rare. Even tobacco smoking, in non-electrified times, did not cause lung cancer.

These are the diseases of civilization, that we have also inflicted on our animal and plant neighbors, diseases that we live with because of a refusal to recognize the force that we have harnessed for what it is. The 60-cycle current in our house wiring, the ultrasonic frequencies in our computers, the radio waves in our televisions, the microwaves in our cell phones, these are only distortions of the invisible rainbow that runs through our veins and makes us alive. But we have forgotten.

It is time that we remember.

PART ONE

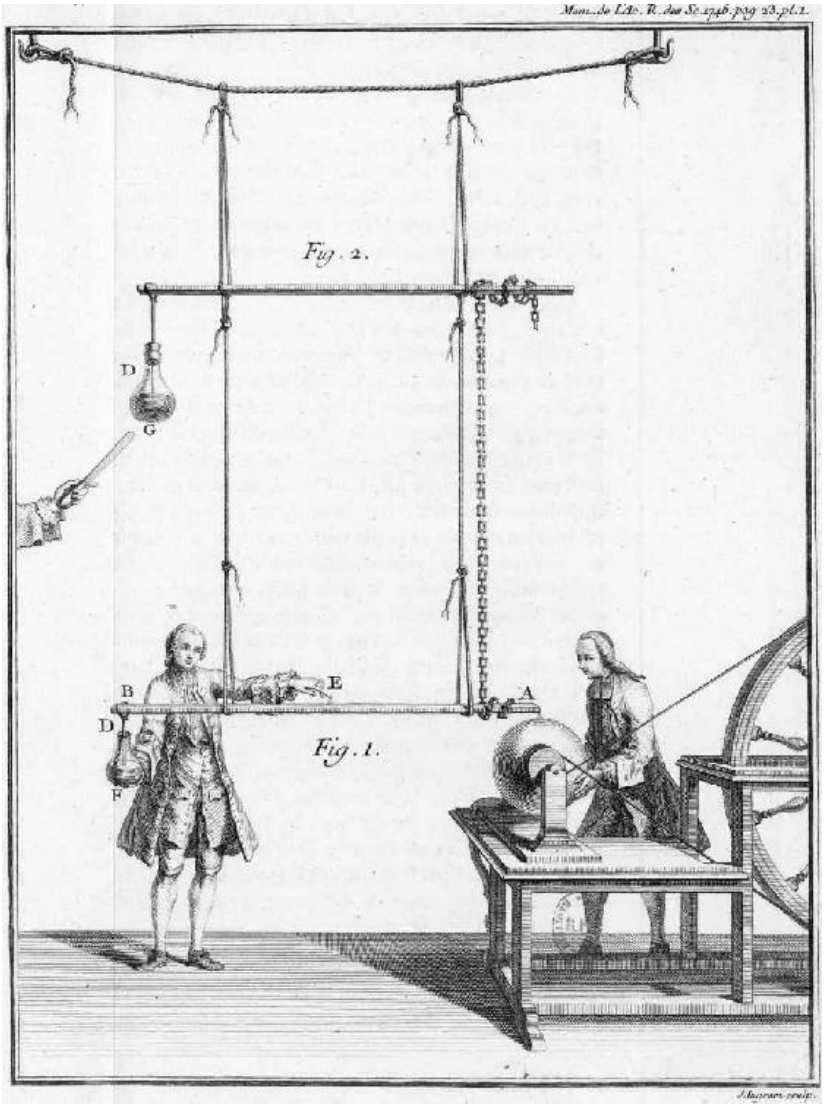


1. Captured in a Bottle

THE EXPERIMENT OF LEYDEN was a craze that was immense, universal: everywhere you went people would ask you if you had experienced its effects. The year was 1746. The place, any city in England, France, Germany, Holland, Italy. A few years later, America. Like a child prodigy making his debut, electricity had arrived, and the whole Western world turned out to hear his performance.

His midwives—Kleist, Cunaeus, Allamand, and Musschenbroek—warned that they had helped give birth to an *enfant terrible*, whose shocks could take away your breath, boil your blood, paralyze you. The public should have listened, been more cautious. But of course the colorful reports of those scientists only encouraged the crowds.

Pieter van Musschenbroek, professor of physics at the University of Leyden, had been using his usual friction machine. It was a glass globe that he spun rapidly on its axis while he rubbed it with his hands to produce the "electric fluid"—what we know today as static electricity. Hanging from the ceiling by silk cords was an iron gun barrel, almost touching the globe. It was called the "prime conductor," and was normally used to draw sparks of static electricity from the rubbed, rotating glass sphere.



Line engraving from *Mémoires de l'Académie Royale des Sciences* Plate 1, p. 23, 1746

But electricity, in those early days, was of limited use, because it always had to be produced on the spot and there was no way to store it. So Musschenbroek and his associates designed an ingenious experiment—an experiment that changed the world forever: they attached a wire to the other end of the prime conductor and inserted it in a small glass bottle partly filled with water. They wanted to see if the electric fluid could be stored in a jar. And the attempt succeeded beyond their wildest expectations.

"I am going to tell you about a new but terrible experiment," Musschenbroek wrote to a friend in Paris, "which I advise you never to try yourself, nor would I, who have experienced it and survived by the grace of God, do it again for all the Kingdom of France." He held the bottle in his right hand, and with the other hand he tried to draw sparks from the

gun barrel. “Suddenly my right hand was hit with such force, that my whole body shook as though struck by lightning. The glass, although thin, did not break, and my hand was not knocked away, but my arm and whole body were affected more terribly than I can express. In a word, I thought I was done for.”[1] His companion in invention, biologist Jean Nicolas Sébastien Allamand, when he tried the experiment, felt a “prodigious blow.” “I was so stunned,” he said, “that I could not breathe for some moments.” The pain along his right arm was so intense that he feared permanent injury.[2]

But only half the message registered with the public. The fact that people could be temporarily or, as we will see, permanently injured or even killed by these experiments became lost in the general excitement that followed. Not only lost, but soon ridiculed, disbelieved, and forgotten. Then as now, it was not socially acceptable to say that electricity was dangerous. Just two decades later, Joseph Priestley, the English scientist who is famous for his discovery of oxygen, wrote his *History and Present State of Electricity*, in which he mocked the “cowardly professor” Musschenbroek, and the “exaggerated accounts” of the first experimenters.[3]

Its inventors were not the only ones who tried to warn the public. Johann Heinrich Winkler, professor of Greek and Latin at Leipzig, Germany, tried the experiment as soon as he heard about it. “I found great convulsions in my body,” he wrote to a friend in London. “It put my blood into great agitation; so that I was afraid of an ardent fever; and was obliged to use refrigerating medicines. I felt a heaviness in my head, as if I had a stone lying upon it. It gave me twice a bleeding at my nose, to which I am not inclined. My wife, who had only received the electrical flash twice, found herself so weak after it, that she could hardly walk. A week after, she received only once the electrical flash; a few minutes after it she bled at the nose.”

From their experiences Winkler took away the lesson that electricity was not to be inflicted upon the living. And so he converted his machine into a great beacon of warning. “I read in the newspapers from Berlin,” he wrote, “that they had tried these electrical flashes upon a bird, and had made it suffer great pain thereby. I did not repeat this experiment; for I think it wrong to give such pain to living creatures.” He therefore wrapped an iron chain around the bottle, leading to a piece of metal underneath the

gun barrel. “When then the electrification is made,” he continued, “the sparks that fly from the pipe upon the metal are so large and so strong, that they can be seen (even in the day time) and heard at the distance of fifty yards. They represent a beam of lightning, of a clear and compact line of fire; and they give a sound that frightens the people that hear it.”

The general public did not react as he planned, however. After reading reports like Musschenbroek’s in the proceedings of France’s Royal Academy of Sciences, and his own in the *Philosophical Transactions* of the Royal Society of London, eager men and women by the thousands, all over Europe, lined up to give themselves the pleasure of electricity.

Abbé Jean Antoine Nollet, a theologian turned physicist, introduced the magic of the Leyden jar into France. He tried to satisfy the insatiable demands of the public by electrifying tens, hundreds of people at once, having them take each other by the hand so as to form a human chain, arranged in a large circle with the two ends close together. He would place himself at one of the ends, while the person who represented the last link took hold of the bottle. Suddenly the learned abbot, touching with his hand the metal wire inserted in the flask, would complete the circuit and immediately the shock would be felt simultaneously by the whole line. Electricity had become a social affair; the world was possessed, as some observers called it, by “electromania.”

The fact that Nollet had electrocuted several fish and a sparrow with the same equipment did not deter the crowds in the least. At Versailles, in the presence of the king, he electrified a company of 240 soldiers of the French Guard holding each other by the hands. He electrified a community of monks at the Carthusian monastery in Paris, stretched out in a circle more than a mile around, each connected to his neighbors by iron wires.

The experience became so popular that the public began to complain of not being able to give themselves the pleasure of an electric shock without having to wait in line or consult a physician. A demand was created for a portable apparatus that everyone could purchase for a reasonable price and enjoy at their leisure. And so the “Ingenhousz bottle” was invented. Enclosed in an elegant-looking case, it was a small Leyden jar joined to a varnished silk ribbon and a rabbit skin with which to rub the varnish and charge the jar.[4]

Electric canes were sold, “priced for all pocketbooks.”[5] These were Leyden jars cleverly disguised as walking canes, which you could charge

surreptitiously and trick unsuspecting friends and acquaintances into touching.

Then there was the “electric kiss,” a form of recreation that even preceded the invention of the Leyden jar but became much more exciting afterwards. Physiologist Albrecht von Haller, at the University of Göttingen, declared incredulously that such parlor games had “taken the place of quadrille.” “Could one believe,” he wrote, “that a lady’s finger, that her whale-bone petticoat, should send forth flashes of true lightning, and that such charming lips could set on fire a house?”

Line engraving c. 1750, reproduced in Jürgen Teichmann, *Vom Bernstein zum Elektron*, Deutsches Museum 1982

She was an “angel,” wrote German physicist Georg Matthias Bose, with “white-swan neck” and “blood-crowned breasts,” who “steals your

heart with a single glance" but whom you approach at your peril. He called her "Venus Electrificata" in a poem, published in Latin, French, and German, that became famous throughout Europe:

> If a mortal only touches her hand
> Of such a god-child even only her dress,
> The sparks burn the same, through all of one's limbs,
> As painful as it is, he seeks it again.

Even Benjamin Franklin felt compelled to give instructions: "Let A and B stand on wax; or A on wax and B on the floor; give one of them the electrised phial in hand; let the other take hold of the wire; there will be a small spark; but when their lips approach, they will be struck and shock'd."[6]

Wealthy ladies hosted such entertainment in their homes. They hired instrument makers to craft large, ornate electrical machines that they displayed like pianos. People of more moderate means bought off-the-shelf models that were available in an assortment of sizes, styles, and prices.

Aside from entertainment, electricity, assumed to be related to or identical with the life force, was used primarily for its medical effects. Both electrical machines and Leyden jars found their way into hospitals, and into the offices of doctors wanting to keep up with the times. An even greater number of "electricians" who were not medically trained set up office and began treating patients. One reads of medical electricity being used during the 1740s and 1750s by practitioners in Paris, Montpellier, Geneva, Venice, Turin, Bologna, Leipzig, London, Dorchester, Edinburgh, Shrewsbury, Worcester, Newcastle-Upon-Tyne, Uppsala, Stockholm, Riga, Vienna, Bohemia, and The Hague.

The famous French revolutionary and doctor Jean-Paul Marat, also a practitioner of electricity, wrote a book about it titled *Mémoire sur l'électricité médicale* ("Memoir on Medical Electricity").

Franklin treated patients with electricity in Philadelphia—so many of them that static electric treatments later became known, in the nineteenth century, as "franklinization."

John Wesley, the founder of the Methodist Church, published a 72-page tract in 1759 titled *Desideratum; or, Electricity Made Plain and Useful*. He called electricity "the noblest Medicine yet known in the World," to be used in diseases of the nervous system, skin, blood,

respiratory system, and kidneys. “A person standing on the ground,” he felt obliged to add, “cannot easily kiss an electrified person standing on the rosin.”[7] Wesley himself electrified thousands of people at the headquarters of the Methodist movement and at other locations around London.

And it wasn’t just prominent individuals who were setting up shop. So many non-medical people were buying and renting machines for medical use that London physician James Graham wrote, in 1779: “I tremble with apprehension for my fellow creatures, when I see in almost every street in this great metropolis a barber – a surgeon – a tooth-drawer – an apothecary, or a common mechanic turned electrical operator.”[8]

Since electricity could initiate contractions of the uterus, it became a tacitly understood method of obtaining abortions. Francis Lowndes, for example, was a London electrician with an extensive practice who advertised that he treated poor women gratis “for amenorrhea.”[9]

Even farmers began testing electricity on their crops and proposing it as a means of improving agricultural production, as we will see in chapter 6.

The use of electricity on living beings in the eighteenth century was so widespread in Europe and America that a wealth of valuable knowledge was collected about its effects on people, plants, and animals, knowledge that has been entirely forgotten, that is far more extensive and detailed than what today’s doctors are aware of, who see daily, but without recognition, its effects on their patients, and who do not even know such knowledge ever existed. This information is both formal and informal—letters from individuals describing their experiences; accounts written up in newspapers and magazines; medical books and treatises; papers read at meetings of scientific societies; and articles published in newly founded scientific journals.

As early as the 1740s, ten percent of all articles published in the *Philosophical Transactions* were related to electricity. And during the last decade of that century, fully seventy percent of all articles on electricity in the prestigious Latin journal, *Commentarii de rebus in scientis naturali et medicina gestis*, had to do with its medical uses and its effects on animals and people.[10]

But the floodgates were wide open, and the torrent of enthusiasm about electricity rushed on unhindered, and would continue to do so during the coming centuries, sweeping caution against the rocks, crushing hints of

danger like so many bits of driftwood, obliterating whole tracts of knowledge and reducing them to mere footnotes in the history of invention.

2. The Deaf to Hear, and the Lame to Walk

A BURMESE ELEPHANT has the same set of genes whether it toils in a logging camp or runs free in the forest. But its DNA will not tell you the details of its life. In the same way, electrons cannot tell us what is most interesting about electricity. Like elephants, electricity has been forced to bear our burdens and move great loads, and we have worked out more or less precisely its behavior while in captivity. But we must not be fooled into believing we know everything important about the lives of its wild cousins.

What is the source of thunder and lightning, that causes clouds to become electrified and discharge their fury upon the earth? Science still does not know. Why does the earth have a magnetic field? What makes combed hair frizzy, nylon cling, and party balloons stick to walls? This most common of all electrical phenomena is still not well understood. How does our brain work, our nerves function, our cells communicate? How is our body's growth choreographed? We are still fundamentally ignorant. And the question raised in this book—"What is the effect of electricity on life?"—is one that modern science doesn't even ask. Science's only concern today is to keep human exposure be-low a level that will cook your cells. The effect of nonlethal electricity is something mainstream science no longer wants to know. But in the eighteenth century, scientists not only asked the question, but began to supply answers.

Early friction machines were capable of being charged to about ten thousand volts—enough to deliver a stinging shock, but not enough, then or now, to be thought dangerous. By way of comparison, a person can accumulate thirty thousand volts on their body in walking across a synthetic carpet. Discharging it stings, but won't kill you.

A one-pint Leyden jar could deliver a more powerful shock, containing about 0.1 joules of energy, but still about a hundred times less than what is

thought to be hazardous, and thousands of times less than shocks that are routinely delivered by defibrillators to revive people who are in cardiac arrest. According to mainstream science today, the sparks, shocks, and tiny currents used in the eighteenth century should have had no effects on health. But they did.

Imagine you were a patient in 1750 suffering from arthritis. Your electrician would seat you in a chair that had glass legs so that it was well insulated from the ground. This was done so that when you were connected to the friction machine, you would accumulate the "electric fluid" in your body instead of draining it into the earth. Depending on the philosophy of your electrician, the severity of your disease, and your own tolerance for electricity, there were a number of ways to "electrize" you. In the "electric bath," which was the most gentle, you would simply hold in your hand a rod connected to the prime conductor, and the machine would be cranked continuously for minutes or hours, communicating its charge throughout your body and creating an electrical "aura" around you. If this was done gently enough, you would feel nothing—just as a person who shuffles their feet on a carpet can accumulate a charge on their body without being aware of it.

After you were thus "bathed," the machine would be stopped and you might be treated with the "electric wind." Electricity discharges most easily from pointed conductors. Therefore a grounded, pointed metal or wooden wand would be brought toward your painful knee and you would again feel very little—perhaps the sensation of a small breeze as the charge that had built up in your body slowly dissipated through your knee into the grounded wand.

For a stronger effect, your electrician might use a wand with a rounded end, and instead of a continuous current draw actual sparks from your ailing knee. And if your condition were severe—say your leg was paralyzed—he could charge up a small Leyden jar and give your leg a series of strong shocks.

Electricity was available in two flavors: positive, or "vitreous" electricity, obtained by rubbing glass, and negative, or "resinous" electricity, originally obtained by rubbing sulfur or various resins. Your electrician would most likely treat you with positive electricity, as it was the variety normally found on the surface of the body in a state of health.

The goal of electrotherapy was to stimulate health by restoring the

electrical equilibrium of the body where it was out of balance. The idea was certainly not new. In another part of the world, the use of natural electricity had been developed to a fine art over thousands of years. Acupuncture needles, as we will see in chapter 9, conduct atmospheric electricity into the body, where it travels along precisely mapped pathways, returning to the atmosphere through other needles that complete the circuit. By comparison electrotherapy in Europe and America, although similar in concept, was an infant science, using instruments that were like sledgehammers.

European medicine in the eighteenth century was full of sledgehammers. If you went to a conventional doctor for your rheumatism, you might expect to be bled, purged, vomited, blistered, and even dosed with mercury. It's easy to understand that going to an electrician instead might seem a very attractive alternative. And it remained attractive until the beginning of the twentieth century.

After more than half a century of unceasing popularity, electrotherapy fell temporarily out of favor during the early 1800s in reaction to certain cults, one of which had grown up in Europe around Anton Mesmer and his so-called "magnetic" healing, and another in America around Elisha Perkins and his "electric" tractors—three-inch-long metallic pencils with which one made passes over a diseased part of the body. Neither man used actual magnets or electricity at all, but they gave both those methods, for a while, a bad name. By mid-century electricity was again mainstream, and in the 1880s ten thousand American physicians were administering it to their patients.

Electrotherapy finally fell permanently out of favor in the early twentieth century, perhaps, one suspects, because it was incompatible with what was then going on in the world. Electricity was no longer a subtle force that had anything to do with living things. It was a dynamo, capable of propelling locomotives and executing prisoners, not curing patients. But sparks delivered by a friction machine, a century and a half before the world was wired, carried quite different associations.

There is no doubt that electricity sometimes cured diseases, both major and minor. The reports of success, over almost two centuries, were sometimes exaggerated, but they are too numerous and often too detailed and well-attested to dismiss them all. Even in the early 1800s, when electricity was not in good repute, reports continued to emerge that cannot