The Long History of Electricity

Ismo Lindell

Original title:
Sähkön pitkä historia
Translation: Owen F. Witesman

The translation was kindly subvented by
Finnish Literature Exchange FILI.

Gaudeamus Helsinki University Press 2009

454 pages, softbound
ISBN 9789516723580

Table of Contents

Overview

Ismo Lindell's *The Long History of Electricity* examines how humanity's knowledge of electricity and magnetism has evolved over three millennia.

The story of electricity and magnetism is examined as part of broader cultural history: How knowledge of them has increased in stages through a dialectic between theory and experimentation, and how they have been applied in different branches of technology and industry. The book uses interesting examples to explain how electricity replaced earlier modes of lighting, uses of power and methods for transferring information.

The Long History of Electricity offers fascinating, thought-provoking reading for anyone interested in the history of science and technology. Professor emeritus Ismo Lindell received the 2010 Finnish Information Publishing Prize for The Long History of Electricity.

Reading sample

The Early Stages of Electricity

Chapter 1
Amber and Magnetic Rock

There is only scattered information available from the early days of electricity and magnetism. The weak power effect of rubbed amber is considered to be the first electrical phenomenon created by man, whereas magnetism was connected to naturally occurring minerals. It was not until the late sixteenth century that the first systematic experiments began to shed light on the behavior of electricity and magnetism.

The Early Stages of Electricity
Amber

Observation of electrical phenomena began in ancient Greece when the philosopher Thales of Miletus (624–547 BC) became interested in the wool fibers sticking to spinners' spindles that were not easy to remove by wiping. The cause was the amber decorations on the spindles: When the amber was rubbed, it created a strange attractive power.

The first written account of the attractive power of amber comes from Theophrastus (372–287 BC). In his Physics, Aristotle (384–322 BC) also mentioned Thales' amber experiments, which is how the account was transmitted down through the centuries to sixteenth century Europe. The reason for the power of amber, according to the understanding of Antiquity, was the soul. According to Aristotle, life was directed and preserved by the conscious soul, the psyche. For plants it was nourishing, for animals it was also sensible, and for humans it was thinking. Aristotle was also the first person to examine psychology systematically.

Thales lived in Miletus in Ionia, on the south-west coast of present day Turkey. He is considered to be the founder of the Ionian school of philosophy, which later included Socrates, among others. Latter-day Greeks have considered Thales to be the father of nearly all of the Greek branches of science. Miletus was a busy port city where merchant ships brought culture from other Mediterranean lands. Thales was an avid traveler and learned about astronomy and geometry in the Egyptian cities of Memphis and Thebes. In Miletus he was a teacher, debater, philosopher and statesman. There he also developed Egyptian geometry into an abstract science by researching ideal lines and circles and by creating logical proofs, but his writings have not survived to the present day.

Thales knew how to calculate the height of a pyramid from its shadow (by measuring it at the time when a man's shadow was the same length as he was tall) and knew how to calculate the distance to a ship on the horizon by measuring angles from a tower. He is also said to have predicted a solar eclipse, which most likely refers to the total eclipse visible in the Middle East on May 28, 585 BC (according to the Julian calendar). The Babylonians had recorded the intervals of eclipses and it is likely that Thales received his information from them. When later Greeks compiled a list of the "Seven Sages of Antiquity," Thales was placed at the top of the list. He died of heat stroke at a stadium while watching the Olympic games.

Other electrical materials

Theophrastus mentioned in his 321 BC work De Lapidipus on rocks a jewel called lyncurium, which had the same characteristics as amber. The rock was also known as Lapis lyncurius (the rock of the

lynx) and today we call it tourmaline. Tourmaline played an important role in the eighteenth century in the unification of the theories of electricity and magnetism. The Roman admiral Giaus Plinius Secundus, or Pliny the Elder (23–79 AD) performed a mammoth task in compiling his encyclopedia of natural history Naturalis Historia. He hardly slept at all and constantly assigned his secretary to read books out loud, from which he dictated information into his own collated works. It is said that he didn't even walk; he just sat in a wagon or sedan chair with his secretary by his side. The only Natural History that has survived for later generations includes 37 books (about six books by modern standards), which touch on 20,000 different subjects. The encyclopedia references 146 Roman and 327 foreign authors, as well as a number of unnamed sources. Pliny's encyclopedia was copied by hand in the Middle Ages and in 1469 in Venice it was one of the first Latin language books to be printed.
When Mount Vesuvius erupted in 79 AD and buried the city of Pompeii, Pliny sailed to the area to save people but died himself, probably by suffocating in the sulfuric smoke. The last book of Pliny's work, which concerns precious stones, includes the following numbered passages about amber, tourmaline and ruby:

> 48. When a vivifying heat has been imparted to it by rubbing it between the fingers, amber will attract chaff, dried leaves, and thin bark, just in the same way that the magnet attracts iron.
> 103. [Lychnis (presumably Tourmaline)] is found in the vicinity of Orthosia, throughout the whole of Caria, and in the neighbouring localities; but the most approved stones are those that come from India. I find other varieties also mentioned, one with a purple radiance, and another of a scarlet tint. It is asserted, too, that these stones, when heated or rubbed between the fingers, will attract chaff and filaments of paper.
> 104. Carchedonia [ruby], too, is said to have the same property, though far inferior in value to the stones already mentioned.

The Arabs observed later that jet (lignite), a mineraloid of organic origin, also had similar characteristics. The Arabs did not, however, add any further to the knowledge of electricity. From Antiquity to the end of the sixteenth century, the characteristics of static electricity were not researched much or any such findings have been lost to history. It is unlikely that any significant discoveries were made, because they would have led to further developments. This is not at all unusual, since everyday life did not contain obvious electrical phenomena that would have been easy to investigate.

Electrical phenomena of Antiquity

In addition to static electricity, some other electrical phenomena were also recognized during Antiquity. However, no one knew to connect them to each other or to the attractive power of amber. Examples included lightning, electric fish and St. Elmo's fire. The Egyptians knew about the stunning effects of fish as early as year 2750 BC and, for example, Plato and Aristotle mention the electric ray (torpedo mamorata). According to Pliny's Natural History, when you touched the fish with a spear, your muscles would be paralysed and even the legs of the fastest would not move. The therapeutic effects of electric rays were found in 46 AD, when Scribonius Largus, one of the first doctors in the Roman Empire, explained in his work Compositiones Medicae that the electric ray could be used to cure headaches and gout. There is no further advice given for headaches, but for gout the text provides treatment instructions, on the basis of which Scribonius could be considered the inventor of electrotherapy. When the pain associated with gout begins starting, one must place a living electric ray under one's feet. The patient must stand on a damp beach washed by the sea and he must stand there until he has no feeling in his legs up to the knees. This removes and blocks the oncoming pain. This method cured Anteros, Tiberius' freed slave.

St Elmo's fire is a light phenomenon on sharp tips of metal called a corona. This can be seen, for example, at the tips of ship masts in the dark, as Pliny relates in his Natural History. Caesar also described how the tips of his legionnaires' spears burst into flame during a storm. The phenomenon is similar to fluorescent lamps and it can take place in normal air pressure, when the strength of the electric field is between 100 V/mm and 3,000 V/mm. This can happen during thunder storms at metallic tips as electric charge builds up in them. The light is emitted when the electrons separated by the electric field ionize the surrounding air. In normal weather the field strength of the atmosphere is just a few volts per centimeter, so it requires extraordinary weather and a sufficiently long conductive item with a sharp tip to act as an antenna. When the field strength grows higher than the atmosphere's normal dielectric breakdown value, approx. 3,000 V/mm, electrons no longer return to the ions and they create a spark discharge, like lightning.
According to one theory, the fire of the LZ 129 Hindenburg in 1937 was started by a spark that ignited the hydrogen gas leaking from the zeppelin. The gas reservoir ignited from the rear and spread to the front, at which time the ship crashed within 30 seconds into a pile of rubbish on the ground. It was quite a miracle that 62 out of the 98 passengers survived.
Saint Elmo, who is also known by the name Ermo or Erasmus of Formiae, was the bishop of Formia and amartyr, as well as one of the patron saints of sailors. He died ca. 304 during the Christian persecutions of the Emperor Diocletian. His name was not connected to the electrical phenomenon until the Middle Ages. St. Elmo's fire was described by Columbus, Magellan and Darwin in their ocean travel journals. Benjamin Franklin was the first, in 1749, to connect St. Elmo's fire to electricity. Some ancient writers also described a light phenomenon created when removing clothing, which was similar electrostatic discharges. The spark created when striking a flint is a piezoelectric phenomenon. Mechanical tension, stress, can generate

an electronic charge in some materials. The force of a blow can cause the stress to grow so large that the discharge limit is exceeded.

The Baghdad Battery was found in an ancient tomb in a suburb of Baghdad in June 1936 during the construction of a railroad. The tomb has been dated to the time of the Parthians (250 BC). It has been hypothesized that this clay pot was a chemical battery, because it contained a copper cylinder and a corroded iron rod. The vessel could have acted as an electrical battery if vinegar or citric acid were added to it. No other explanation has been found. More similar vessels have been found in surrounding areas. It has been speculated that they were used 2,000 years ago by the Babylonians for the silver and gold plating of jewelry. If so, this ancient method of electrolysis was hidden well, because it had to be reinvented in the nineteenth century.

Thunderstorms and lightning have been objects of wonder for humanity throughout the ages, often being explained through religious concepts. Lightning protection was naturally an important goal, giving rise to many different methods based on superstition. In Central Europe they used thunder stones (Donnerstein, pierre de tonnerre), which were supposed to protect the individual or home from lightning strikes. Precious stones were still being sold in Germany in the seventeenth century which were purported to have this property. In France, the stone was kept in the pocket and asked to protect from lightning by chanting "pierre, pierre, garde-moi de la tonnerre." On the other hand, it has been suggested that ancient Egyptian temples used high metal-coated wooden masts as lightning rods. Hindu culture in India also used similar masts made of iron. The Romans observed that large bronze statues served as protection from the lightning of Jupiter. The Etruscans are said to have known how to turn lightning aside by shooting metal arrows into threatening thunderheads around 600 BC. The modern lightning rod was not developed until the eighteenth century, however.

The naming of electricity

The Greek name for amber, electron, is a permanent reminder of the earliest observations of electricity. The names for electricity of most civilized languages are based on this word. Finnish (as well as Hungarian, Hebrew, Chinese and Japanese) is one of the exceptions to this rule. The word sähkö was adopted after its introduction by Samual Roos in his translation from the German of Otto Ule's Warum und Weil, which required the invention of a Finnish analog to elektriciteit. The name was derived from the characteristic of electricity to hiss and scintillate (the name is a portmanteau of the Finnish words sähähtää and säkenöidä). The book also explained the natural phenomenon in the style of a catechism by presenting a question and answer.

> 39. Why is electricity called sähkö and where does the name come from?
>
> Because the Bernstein of the Germans, the amber considered precious by ancient peoples and excavated from the moldering sludge of the Baltic Sea at that time, which the Greeks call Elektron, was observed when rubbed on wool to draw to itself all sorts of small objects and to suddenly push them away, and which in larger pieces also gave off a hissing scintillation which also stung any finger held close… …This hissing scintillation has drawn me to name this previously nameless power or material the sähkö power or material.

Elias Lönnrot, the compiler of the Kalevala, had already suggested the neologism lieke (a new noun with connections to lightning or flame) in 1837, which led to conductors and insulators being called liekejohdattaja ("lieke guide") and lieketukkio ("lieke stopper"). This word apparently was not sufficiently electrifying for Finns to use.

About the Author

Ismo Lindell is professor emeritus of electromagnetic theory at the Helsinki University of Technology and has also served as an academy professor for the Academy of Finland. Lindell has authored textbooks on electromagnetic field theory, along with scientific books and journal articles. He has lectured on the history of electrical engineering since 1988.