ELECTRICITY
THE SPARK OF LIFE
Large print guide

Please return at the end of the exhibition
GENERATION:
THE GREAT INVISIBLE
Pendant carved in the form of a frog or toad
Origin unknown
550–450 BCE
Amber

The frog, long regarded as a symbol of life and fertility, is here represented in amber, the source of the earliest documented manifestations of static electricity. Amber’s ability to acquire an electric charge has fascinated people ever since ancient Greek philosophers first discovered that spontaneous sparks were created when amber was rubbed with animal fur. Amber’s light-inducing effect prompted them to name it *elektron* (meaning “formed by the sun”), the word from which “electricity” was eventually derived many centuries later.
Plate for serving fish
Campania, Southern Italy
325-300 BCE
Terracotta

Humanity’s earliest understandings of electricity were developed through encounters with phenomena in the natural world, such as the torpedo fish, or electric ray (seen here on the left). In his discourse *Meno*, Plato attests to the charged qualities of these creatures by comparing Socrates to “a flat sea torpedo who torpifies those who come near him and touch him” and “stunning” people with his puzzles. Ancient medical uses of torpedo fish included numbing the pain of childbirth and treating headaches.
Temple of the Muses: Semele and Jupiter
Bernard Picart
1731
Engraving

Before the Enlightenment, elemental displays such as thunder and lightning were generally regarded as acts of God. Later attempts by scientists to recreate these effects in the laboratory began to push the boundaries between the divine and material realms. This engraving depicts the myth of Jupiter, the Roman god of lightning, and his mortal lover Semele. Semele is tricked by Jupiter’s wife, the goddess Juno, into asking him to reveal himself in all his divine splendour. His almighty thunder and lightning causes her violent death.
God, suspended in the clouds, creates light
Thomas de Leu
c.1600
Line engraving

The celestial vision of the creation of light, as described in Genesis, reflects the belief, still dominant in the post-classical era, that all natural forces were divinely created. Early experiments conducted by scientists on the potential of electricity and illumination would begin to challenge this attitude. Humankind’s ability to tame nature and control the wrath of God symbolised the end of an era of miracles and the beginning of a new world order where science and rationality would challenge religious authority.
The Aurora Borealis
Charles H Whymper
19th century
Coloured wood engraving

Published on behalf of the Society for Promoting Christian Knowledge, this engraving of the Aurora Borealis captures the awe-inspiring beauty of this ethereal spectacle, while the accompanying text contemplates the mystery of how it is created. It alludes both to the “wonder-working power of the Divine Hand” and to electrical activity. This hints towards our contemporary understanding of the Aurora as the result of a dramatic interaction between electrically charged particles from the sun and molecules in the earth’s atmosphere.
French scientist and clergyman J A Nollet (1700–1770) was one of the great investigators and popularisers of the new electrical science in the salons and court of 18th-century France. He wrote several treatises on electricity and invented one of the first electrometers – the electroscope – which detected the presence of electric charge by using electrostatic attraction and repulsion. Following the invention of the Leyden jar (a device for storing electrical charge) by Pieter van Musschenbroek in 1745, Nollet promoted it as a special type of flask to his market of wealthy, scientifically curious men and arranged some spectacular demonstrations of its power.
This illustration depicts Nollet’s 1746 experiment in which he electrified a human chain of 180 royal guards in front of King Louis XV, by emitting an electrical charge from a Leyden jar. When all the participants held hands the circuit was completed and an electric shock passed instantaneously around the circle with startling results. This, and a previous experiment performed on 200 Carthusian monks, helped Nollet formulate his theory of electricity that assumed the existence of a continuous flow of matter between charged bodies, facilitated through “pores”.
In the 1700s, the Dutch inventor and director of Teylers Museum, Martinus van Marum (1750–1837), designed the largest electrostatic generator of its time. Built in Amsterdam by an English instrument maker, John Cuthbertson, the generator was capable of creating giant sparks over 60 centimetres long. Stretching across an entire room at Teylers Museum (where it can still be seen), it could produce potentials of approximately 300,000 volts. With the addition of an array of Leyden jars to store the energy, the discharge could be lethal.
Discharger

John Cuthbertson
1800
Copper, brass, mahogany

This electrostatic discharger consists of two perfect copper spheres attached to a mahogany baseboard and set at a fixed distance apart. When connected to an electrostatic generator, the discharger converted peaks in the voltage into sparks and regulated the output, enabling a constant spark to be maintained. This allowed experiments to be carried out on different materials placed between the spheres to investigate the effects of electrification.
By the end of the 17th century, researchers had developed practical means of generating electricity by friction. But the development of electrostatic generators, or “friction machines”, did not begin in earnest until the 18th century, when they became fundamental instruments in the new study of electricity, as depicted in this 19th-century still life. On the right is a hand-powered electrostatic generator which sends electricity to a Leyden jar in the foreground, triggering the “Franklin bells” in the red jar. These bells were used in demonstrations as an indicator of electric charge.
Trouvelot figure
Photograph of electrical effluvia around a coin
Étienne Léopold Trouvelot
1888–89
Reproduction

The ambition to capture electricity in visible form was advanced in the late 1880s by the French astronomer and artist Étienne Léopold Trouvelot (1827–1895), who created a series of mesmerising photographs of electric sparks, known as Trouvelot figures. Trouvelot generated his images without a camera, directly exposing photosensitive plates to brief bursts of electrical energy from a Ruhmkorff induction coil or Wimshurst machine (a type of electrostatic generator).
Discharge patterns
Verhandelingen, uitgegeeven door Teyler’s Tweede Genootschap
Coenradus Henricus Koning
1787

Three large volumes of the Proceedings of the Teylers Second Society (a learned society founded to promote research in art and science) document a number of experiments carried out with the electrostatic generator, which itself attracted scientific interest from all over the world. These striking patterns give an impression of the spectacular electrical effects achieved by van Marum in an attempt to capture the elusive moment of the spark.
Van Marum also conducted tests on the fusion of metal wires and the effect of battery discharge on different metals and alloys. From these experiments he concluded that copper was the best material for lightning conductors and lead the worst. This print is an exact copy of the effects of calcination on metals (in this case lead and tin) by sending a spark through them. The metals react with oxygen (oxidation) caused by the energy from the spark.
Lichtenberg figures

V S M van der Willigen
Pre-1862
12 copper plates

Lichtenberg figures take the form of branching, tree-like patterns created by high-voltage electric discharges that sometimes appear on the surface of insulating materials. They are named after the German physicist Georg Christoph Lichtenberg, who discovered and studied them. It was originally thought that their characteristic shapes might help to reveal the nature of positive and negative electric “fluids”.

Teylers Museum, Haarlem
In the mid-18th century, American polymath Benjamin Franklin embarked on a series of experiments to establish whether the properties of lightning were the same as those of electricity. His most significant development was a rod-like device that, when mounted on top of a building, attracted lightning from a passing thunderstorm and conducted the current away and into the ground. Models such as this were used to demonstrate the effectiveness of the lightning rod in protecting houses and other tall structures.
Thunder-ship
1775–99

In public demonstrations an operator would make a spark strike the pointed metallic conductor on top of the ship (or house), simulating lightning. If the conductor was grounded, nothing would happen. However, if the conductor was not grounded, the spark would ignite some gunpowder placed inside, resulting in a dramatic explosion.
Discharge globe or Aurora globe
John Cuthbertson
c.1789
Glass

English instrument maker John Cuthbertson (1743–1821) was amazed that a spark, which is so insignificantly small in normal air, has so much effect in a rarefied gas. With his Aurora globe, Cuthbertson was able to demonstrate this phenomenon. The globe, which contains a partial vacuum, can be connected to an electrostatic generator. As soon as an electric discharge takes place, bands of light are formed in the globe (emulating the Aurora Borealis), which can generate enough light to read by, depending on the strength of the charge.

Teylers Museum, Haarlem
Electrophorus electricus (electric eel)
Date unknown
Specimen

The electric eel is the living embodiment of the potentially deadly nature of electricity, with its extremely powerful electric shock used to stun its prey and keep predators at bay. Its body contains electric organs with about 6,000 specialised cells called electrocytes that store power like tiny batteries. When the eel is threatened or attacking prey, these cells discharge simultaneously, emitting a burst of at least 600 volts.
The Electric Eel
Moody Institute of Science
1954
Video excerpt (2 mins)

In this educational film, Dr Irwin Moon and his lab assistants demonstrate the electric eel’s power to deliver electric shocks using a similar technique to that of Nollet in the 18th century, where the participants held hands and the current passed from one person to the next.
Early studies on electric fish were fundamental to demonstrating the relationship between electricity and animal physiology. The engraving in this volume by the father of electrophysiology, Emil Du Bois-Reymond (1818–1896), depicts a dramatic story recounted by naturalist and explorer Alexander von Humboldt (1769–1859). During an expedition in Venezuela von Humboldt observed fishermen driving horses into a lake to exhaust the feared electric eels. The eels would expend repeated electric discharges on the horses until they became defenceless and could be captured.
Electrical signals in our cells are essential to everything we think and do. Augustus Desiré Waller (1856–1922) was a British physiologist who researched the electrical activity of the human body, most notably the heart. In 1887 he used a capillary electrometer to record the first human electrocardiogram. He attached his equipment to a slowly moving toy train, allowing him to record the heart’s activity in real time. In this illustration Waller visualised the electric field of the heart and the current flow lines.
The study of bioelectricity is concerned with the electric potentials and currents produced by or occurring within living organisms. The popular 19th-century scientific writer J O N Rutter believed that “all substances, animate and inanimate, contain electricity” and that the human body in particular was a generator of energy. He developed an instrument known as a galvanoscope, which could measure human electricity, as demonstrated by the young woman depicted in the frontispiece of his book.
Electrotherapeutic chair
1890–1900
Wood and velvet

This imposing chair may look more like an instrument of torture, but it was used for therapeutic purposes. Electrotherapy was a popular treatment for a range of ailments during the late 1800s and early 1900s. It was based on the belief that passing electric currents over the skin stimulated the body to recovery. The electrotherapeutic chair produced a current that was passed through wires to the metal hand grips. It bears a disconcerting resemblance to the electric chair used for executions, which was designed around the same time.
The electric chair has long been a symbol of the death penalty in the United States, but it was originally proposed as a more humane means of capital punishment than hanging. When the prolific inventor Thomas Edison was appointed to develop the design, he took the opportunity to demonstrate the lethal capacity of alternating current (AC), which at the time he argued was more dangerous than lower-voltage direct current (DC). The first execution took place in New York in 1890 using an electric shock of 2,000 volts AC.
Bovril, the beef extract product developed as a war food, takes its name from a combination of “bovine” (cattle) and “Vril” – the fictional substance inspired by electricity in Edward Bulwer-Lytton’s science fiction tale – which endows the superior race with superhuman powers. Despite the sinister connotations of the electric chair, in this advertisement the electrocution method used to kill the cattle suggests that the animals are infused with the vital energy of electricity, adding even greater nourishment value to the final product.
Edward Bulwer-Lytton’s science fiction tale features a subterranean master race that possesses special powers related to an “all-permeating fluid” called Vril, a latent source of energy that can destroy or replenish life, and can even be used for telepathic communication. In developing his idea of Vril, Bulwer-Lytton was primarily inspired by electricity (along with contemporary occult theories, such as mesmerism). When the character Zee explains Vril, she makes references to Galvanism and magnetism, as well as to Michael Faraday himself.
Italian physicist Giovanni Aldini (1762–1834) popularised the animal electricity experiments pioneered by his uncle, Luigi Galvani (1737–1798), in which static electricity was applied to the nerves and muscles of a dead frog, causing it to move. Aldini’s more sensationalist demonstrations famously included a public experiment on the body of an executed murderer, at Newgate Prison in London in 1803. When metal rods, connected to a large battery, were inserted into the mouth and ear of the corpse, “the jaw began to quiver, the adjoining muscles were horribly contorted, and the left eye actually opened”.
Frankenstein observing the first stirrings of his creature
Frontispiece to Mary Shelley’s Frankenstein
W Chevalier after Theodor von Holst
1831
Engraving with etching

The novelist Mary Shelley (1797–1851) was familiar with the work of Galvani, Aldini and other leading electrical researchers of the time, some of whom were friends of her father. Her keen interest in electricity and the reanimation experiments prompted by Galvanism is said to have been the central inspiration for her gothic novel, in which she describes the creature as infused with “a spark of being”.

The British Library
In Whale’s classic 1931 film based on Mary Shelley’s book, the moment of the creature’s awakening is suffused with all the wild and mystical qualities of electricity, as well as referencing much of the technical apparatus used in early electricity experiments. The final catalyst is the bolt of lightning from above which creates the perfect fusion of natural and manmade electricity that combine to shock the monster into life.
Stephen Gray’s flying boy experiment
Frontispiece to Novi Profectus in Historia Electricitatis (New progress in the history of electricity)
Christian August Hausen
1743

As the new science of electricity emerged, demonstration and spectacle became fundamental to claims of discovery and innovation. One of the best-known of these displays was the static electricity experiment conducted by English scientist Stephen Gray (1666–1736). The young human subject was suspended on silk cords as a charge was passed through his body, by means of electrostatic friction, causing tissue paper, chaff and other light objects to become attracted to his hands. The famous “flying boy” experiment became widely celebrated around Europe.
Demonstration of the Great Electric Induction Coil at the Polytechnic Institution in London in 1869 by Professor Pepper

London Illustrated News

17 April 1869

The Polytechnic Institution, founded in 1838 to provide an educational service for Londoners, frequently featured popular demonstrations of science, famed for their “abominable smells and the occasional explosion”. In 1869, its director, John Henry Pepper (1821–1900) – widely known as “Professor” – presented the most spectacular electrical demonstration yet. He unveiled a giant induction coil, over three metres long, which produced a “flash of lightning” as much as 76 centimetres long, to the amazement of his audience.
The boundaries between serious scientific displays and showmanship were continually in dispute as entertainers such as the Scottish “Dr” Walford Bodie took advantage of the fascination with electricity, claiming curative powers in staged performances of mesmerism and magnetism. Billed as “The Man who Tamed Electricity” and “The Human Resistance Coil”, Bodie created a sensation when he used an electric chair for mock electrocutions performed on terrified audience members, whom he shocked with a harmless static electric charge.
Opened in 1881, the Savoy Theatre was the first building in the world to be lit throughout with electricity, using over 1,000 swan lamps. The electricity was generated by steam engines on an adjacent site. On the opening night, the theatre’s owner, Richard D’Oyly Carte, stepped on stage and broke a glowing lightbulb before the audience to demonstrate the safety of the new technology. The following year, Gilbert and Sullivan’s *Iolanthe* featured a chorus with electrically lit head-dresses, powered by batteries hidden in the performers’ costumes.
Equipment used in Galvani’s experiments
1780–98

Electrostatic machine
Prime conductor from plate electrostatic machine
Leyden jar (glass, filled with gold leaf)
Insulating stands (glass and wooden blocks)
Glass rods
Metal rod
U-shaped brass rod

Galvani’s historic experiments were inspired by a chance event in which he accidentally electrified a dead frog on his workbench and its legs started to spasm. In the experiments that followed, Galvani used an electrostatic machine to produce a charge to stimulate the muscles or nerves of the frog’s legs. After numerous tests with this equipment, different metals and even lightning, Galvani concluded that animal electricity was different from atmospheric or machine-generated electricity, that it was a vital force intrinsic to animal tissue, and was responsible for muscle contractions and nerve conduction in living organisms.

Science Museum Group
Irish artist John Gerrard’s newly commissioned simulation responds to Luigi Galvani’s 18th-century experiments that studied the effects of electricity on the amputated legs of dead frogs.

Henry Wellcome collected Galvani’s laboratory equipment from those pioneering tests, alongside a first edition of *De viribus electricitatis in motu musculari commentarius* (Commentary on the effects of electricity on the motion of muscles), in which Galvani published his findings.

In response to this, Gerrard has developed a work in which the absent frog takes centre stage. The experiment it represents, however, is one that occurred more than 200 years after Galvani’s work, during the second mission of the space shuttle *Endeavour* in 1992. This experiment established that vertebrates, in the form of the African clawed frog (*Xenopus laevis*), could reproduce in zero gravity – perhaps in anticipation of
a future in which sustaining life beyond Earth becomes critical to human survival.

Producer: Werner Poetzelberger
Programmer: Helmut Bressler
Modeller: Max Loegler
Rigging and posing: Michael Buettner
Installation development and technical design: Jakob Illera/Inseq Design
Game engine: Unigine
Italian scientist Luigi Galvani was one of the first to explore the relationship between the activity of nerves and muscles and electricity. As seen in this illustration, he predominantly used dissected frogs to test his theory, as they were cheap, abundant and very sensitive. Galvani found that sparks from his electrical generator made the frog legs twitch even when they were electrically insulated. Further experiments convinced him the sparks were only a trigger and the force making the legs twitch came from inside the frog. Galvani named this new phenomenon “animal electricity”.
SUPPLY:
WIRING THE WORLD
Early voltaic pile
Alessandro Volta
1800–24
Copper and zinc

The voltaic pile is the first electrical battery, created in 1799 by Italian scientist Alessandro Volta (1745–1827). It consists of 49 pairs of copper and zinc plates, separated by pieces of cloth drenched in saline or acid. Volta’s pile demonstrated that electricity could be chemically generated and flow steadily like a current of water instead of discharging itself in a single spark or shock, and that it could be made to travel from one place to another.
Barlow’s wheel
W M Logeman
1856
Metal, mahogany

In 1821 English scientist Michael Faraday (1791–1867) was the first to demonstrate that electricity could be converted into movement, thus inventing the electromotor. This instrument was devised in 1822 by English mathematician Peter Barlow (1776–1862) to visualise the principle of the electromotor. The brass star wheel dips into a trough of mercury (a conductive medium) between the poles of a horseshoe magnet. When connected to a battery, a current flows through the wheel. This current and the magnetic field interact with each other, resulting in a force that causes the wheel to turn.
The discovery of magnetic fields around charged wires – by Hans Christian Ørsted and André Marie Ampère – prompted Faraday’s discovery of magnetic induction in 1831. Creating current by placing a magnet within a coil of wire, Faraday brought together electricity, magnetism and motion. As well as the electromotor, Faraday also produced the electromagnetic generator, which converts mechanical energy into electrical current and remains essential in producing virtually all electric power today, whether the energy source is coal, oil, gas, nuclear or renewable.
As electrical pioneers began to concentrate on how to transmit current over greater and greater distances, a central focus became the application of electricity to communications. Building on previous advances in telegraph technology and the development of Morse code in the USA, the next major innovation was the transmission of messages across the sea. This ambition led to one of the world’s greatest engineering feats: laying a telegraph cable along the floor of the Atlantic Ocean.
On 16 August 1858, the first official telegraph message sent from England read: “Europe and America are united by telegraphy.” Queen Victoria then sent a telegram of congratulation to the American President, James Buchanan. But the system had its limitations: the message of 98 words took 16 hours to send, and in September 1858, after several days of deterioration, the cable failed. By 1866 the much-improved cable could transmit eight words a minute. This revolutionary, almost instant form of communication created the first truly global network and brought about widespread social and economic change.
Atlantic telegraph cable (inner core)
1858

The cable, which stretched for 2,500 miles, consisted of seven copper wires, insulated with gutta-percha (a type of tree resin similar to rubber), and wound with tarred hemp, over which a sheath of iron wires was laid in a close spiral. The cable conducted short electrical impulses that appeared as a series of dots and dashes that could be translated into a decipherable message. A distance previously measured in weeks could now be traversed in a matter of hours or even minutes.
Written to celebrate the laying of the transatlantic cable in 1858, E. J. O’Reilly’s poem enthusiastically prophesied the conquest of the world by electrical technology. Presenting a vision of the earth enfolded by an electrical embrace, O’Reilly eulogized the seemingly unstoppable march of progress promised by electricity, and the international prosperity and friendship it would inspire. As ‘Old Ocean’ was made to ‘yield to man’s victorious will/
The crown long placed on Neptune’s brow,’ humankind’s mastery of nature was an integral feature of that vision of modernity.
The transatlantic cable

Six thousand years have passed o’er earth,  
While Science, like a stripling, bore  
The trophies of its timid birth,  
In various forms, from shore to shore;  
But now her latest, mightiest child,  
Which Franklin viewed and Morse caressed,  
With glory ripe and undefiled,  
Is laid within the ocean’s breast!

The might lightning herald sleeps,  
Till human touch awakes its fires,  
To send beyond the morning reach  
New tidings ere a pulse expires!  
’T is laid! Old Ocean feels a thrill  
Throughout his time-sealed bosom now,  
And yields to man’s victorious will,  
The crown long placed on Neptune’s brow.

Calm as the deep in summer’s reign  
And wild, as in its wintry wrath,  
Shall be, with varied joy or pain,  
Each message through its ocean path!  
Within its grave, beneath the storm,  
It lives, a breathing thing of life,  
As they shall live who gave it form,  
In fame, when called from mortal strife!
Soon, like Orion’s belt of fire,
Its broad electric arm shall hold,
With all a monarch’s strong desire,
The world and all its varied fold!
And from its tongue through every sphere,
Till Time and Earth together cease,
Mankind the glorious tale shall hear
Of commerce, brotherhood and peace!
Map of electricity supplied from the generators beneath the Grosvenor Gallery, Mayfair, London
c.1890
Glass lantern slide

This map shows the meandering patchwork of small supply networks that started to spread from the Grosvenor Gallery as the trend for electric lighting grew, laying the foundations of the first official electricity network in London.
Ferranti was commissioned by the London Electricity Supply Corporation to design and build the first high-voltage coal-fired power station in London, of which the Grosvenor Gallery would become a substation. A site was identified on Deptford Creek, providing easy access to cooling water and a transport route for incoming coal. In response to concerns about the dangers of alternating current (AC), Ferranti carried out an audacious test at Deptford by hammering this chisel into a live 10,000-volt AC cable to prove its safety.
As distribution networks began to grow, a major debate known as the War of the Currents surrounded the introduction of competing electric power systems: direct current (DC), championed by Thomas Edison, and Nikola Tesla’s high-voltage alternating current (AC). In Britain, a leading proponent of AC was Sebastian Ferranti, a young electrical engineer, whose first invention at the age of 13 was an arc light for street lighting. Three years later he patented an electrical generator called the Ferranti dynamo.
The Grosvenor Gallery in London was one of the first buildings in the city to install electric lighting. After some initial problems with the generator, Ferranti, one of the few experts in alternating current (AC) at the time, was appointed chief engineer and soon the gallery was supplying electricity to nearby shops and residences. Incorporated into these sketches of the Grosvenor engine room are tiny elf-like figures and smiling faces on the machinery, a regular playful feature of Ferranti’s drawings.
Opened in 1890, the large generating plant at Deptford was the first of its kind, and existing cables were unable to cope with the 10,000-volt current that it was due to supply to substations. As a result, Ferranti had to manufacture his own mains cables and convince the authorities of their safety. These were paper-insulated concentric cables designed to limit the risk of fire and electric shock, and they were subsequently used for high-voltage underground electricity lines all over the world.
The Modern Colossus steps from the Grosvenor Gallery to Deptford Electrical Plant
May 1889
Reproduction

In this advertisement produced by the London Electricity Supply Corporation, the scale of Ferranti’s achievement in connecting the city is symbolised by the vast Colossus straddling the Thames. Although Ferranti was undoubtedly a pioneer in the public supply of electricity, the Deptford Power Station would encounter a number of setbacks before the full potential of his vision was finally realised, eventually becoming the prototype for large-scale distribution systems still in use today.
Siemens circuit keys
Late 1880s
Wood

From August 1887, the Grosvenor Gallery supplied electricity to customers throughout the West End. The installation included five major circuits all radiating from the rooftop of the gallery. The advantage of this high-level supply was that cables could be installed without the need to dig up the roads. The place names on these circuit keys indicate some of the exclusive addresses that benefited from this new distribution system.
The moving spirit of London
1910
Reproduction

Following the arrival of the power station at Deptford, ever bigger stations began to rise up along the Thames in response to the growing demand for electric power needed to bring light to the city. These included Lots Road in south-west London, which was commissioned in 1905 principally to supply the rapidly expanding London Underground system. In this poster, Lots Road is depicted as a temple to the all-powerful “spirit” of electricity responsible for providing transport to millions of Londoners.
Mimic board from Becca Hall

1983
Metal and plastic

A mimic board is used to provide a graphic representation of power distribution networks and serves as a visualisation tool to support control and management processes. This section of tiles is just a fragment of a much larger board from the UK National Grid’s Leeds regional control centre at Becca Hall in West Yorkshire. The mimic board epitomises the rational, ordered grid format that has become synonymous with modern perceptions of electricity networks.
Looking up in Osaka – Minamisemba 1 cho-me

João Penalva
2005–06
Archival pigment print

The sense of order suggested by grids and networks is not always reflected in day to day experiences of electricity systems. In this photograph, one of a series of more than 300 taken in the Japanese city of Osaka, Portuguese artist João Penalva has created a vibrant portrait of the urban landscape through its intricate web of interconnecting electricity cables. These “drawings in the sky”, as Penalva described them, serve as a reminder of how electricity has become so integral to modern life but is so often overlooked.
In contrast to the somewhat free-form and potentially lethal overhead AC cable network, Edison was deeply concerned with safety and insisted on a more ordered approach to installing his rival DC system in New York. He had the cables buried below street level, winning a great public-relations battle in the War of the Currents. However, a major drawback of DC was that generating plants had to be situated in densely populated areas, owing to the short transmission ranges that could only reach customers less than a mile away.
In 1888 the high-voltage AC networks had already started to spread across New York with little regulation, resulting in a tangle of power lines stretching above the city streets. Despite the significant advantages of AC in enabling the transmission of voltage over much greater distances, it was also extremely hazardous. The dangers of high-voltage cables in built-up areas became particularly evident when an extreme snowstorm brought down AC power lines, causing several deaths and subsequently prompting a move to relocate the cables underground.
German director Walter Ruttman’s documentary montage vividly portrays a day in the life of a city in five acts. In the fifth and final act, shown here, Ruttman captured how city life was transformed by the possibilities of electrification, particularly at night. In bringing light to the darkness, apartment windows flicker to life one by one, trams weave through sparkling streets illuminated by flashing neon signs, while social and leisure activities extend into the early hours in the theatres, cinemas, bars and even ice rinks of 1920s Berlin.
The first International Electrical Exhibition was held in Paris in 1881 at the Palais de l’Industrie. Following numerous great advances in electrical technology, especially in lighting, the exhibition was an important showcase for a new branch of electrical engineering. The scope of the exhibition encompassed “The Works of Electricians of all ages” and offered visions of the future as well as historical innovations such as van Marum’s giant electrostatic generator.
Among the multitude of ground-breaking exhibits were Alexander Graham Bell’s telephone, the Théâtrophone (or “theatre phone”, allowing subscribers to listen to live performances over the telephone) and an electric tram designed by Werner Von Siemens, which ran between the exhibition hall and Place de la Concorde. However, the star attraction was the dazzling display of arc lights and incandescent bulbs presented by rivals Edison, Swan, Lane-Fox and Maxim, demonstrating interior and external illumination and transforming Paris into a city of lights – from the leafy boulevards to the Grand Hotel, the Opera House and the Gare St Lazare.
Panorama from the moving boardwalk, Paris World Fair

Thomas A Edison, Inc
1900
Film extracts (2 mins 55)

After the success of the 1881 exhibition in Paris, large displays of electrical innovation became extremely popular. Paris’s Exposition Universelle in 1900 had its own Palais de l’Électrique, and for the 50 million visitors to the exposition, one of the greatest marvels was an electric moving walkway, known as the Trottoir Roulant, that ran for two-and-a-quarter miles above the streets of Paris, captured here in film by Thomas Edison.
Model of Associated Electrical Industries (AEI) transformer group
Severn Lamb Ltd, Stratford-upon-Avon
c.1960

In 1926 Parliament passed the Electricity (Supply) Act in order to solve the problem of Britain’s inefficient and fragmented electricity system. The Prime Minister, Stanley Baldwin, promised cheap and abundant free-flowing power for all. This resulted in the single biggest peacetime construction project that Britain had ever seen: the National Grid. The introduction of the grid enabled the transmission of higher electrical loads, which required more powerful transformers. These transformers, commissioned in 1949, were capable of handling in excess of 200,000 volts.
Electricity pylons from around the world
(Australia; New Zealand; USA and Canada; Asia; France and Africa)
1920–29

The now-familiar steel army of electricity pylons that punctuate vast swathes of terrain all over the world first appeared on Britain’s skyline in the 1920s. Completed in 1933, the National Grid comprised 4,000 miles of cables, mostly overhead, linking 122 of the most efficient power stations. These lattice-structured transmission towers that relay vital power from one end of the country to the other have now become an icon of design in many countries, though they are often a contentious feature of the landscape.
Le Monde and Le Souffle
Électricité
Man Ray
1931
Photogravures

These two images are from Électricité, a series of ten “rayographs” by Man Ray, which was commissioned by the Paris electricity company to promote the uses of electricity. Ray used electrical appliances (lightbulbs, a toaster, an iron, a fan) and electric light to cast the objects’ shadows on photographic paper. He then added wave-like trails of power cords and heating coils – symbolic traces of the unseen effect of electric current – to demonstrate how this invisible force could improve the lives of working-class Parisians.
The Museum of Science and Industry in Manchester is home to the Electricity Council archive, which includes 130 technical, educational and commercial films from the mid-20th century. These films were originally made to educate and prepare the consumer public for the ubiquitous presence of electricity in their households and daily lives.

In a newly commissioned film, American artist and film maker Bill Morrison has mined this material to create a visual journey that explores the production and distribution of electricity and its profound impact on our daily lives. In this animated world Morrison shows how electricity, when abstractly represented as elemental units moving through space, can mirror a broader reading of our natural state as intrinsically electric beings.
Working with an original score created by his frequent collaborator, the guitarist and composer Bill Frisell, Morrison has recontextualised familiar graphic themes as a reflection on who we are as energy-dependent beings with interconnected lives across the planet.

Produced by Neil Karbank

Courtesy of the artist and Hypnotic Pictures

*Electricity* was commissioned by the Museum of Science and Industry in Manchester and supported by Wellcome Collection as part of the exhibition *Electricity: The spark of life*
CONSUMPTION: THE SILENT SERVANT
Miner’s electric safety lamp
Gustave Trouvé
1885
Iron, zinc, carbon, brass, nickel

An important development in the evolution of electric lighting was prompted by the need for a safe alternative to the flame lamps used by miners – often the cause of deadly underground explosions due to the presence of methane and other flammable gases. Although the Davy lamp, designed in 1815, had partially reduced this danger by enclosing the flame with a protective mesh, the portable electric miner’s lamp significantly improved safety as well as providing superior illumination.
The first form of electric lighting was the arc lamp, invented by Sir Humphrey Davy in the early 1800s. Arc lamps were very bright and were used to illuminate outdoor spaces, but many people felt they created a harsh, unearthly glare. The development of domestic lighting took longer, but in 1880 Edison was granted a patent for his electric lightbulb, one year after his rival Joseph Swan had created the first viable incandescent prototype. The Edison lamp contained a loop of carbon filament which glowed when a current of electricity passed through it, creating a steady source of light.
Various bulbs from John Rylands Library, Manchester
c.1900

As filaments improved with tungsten replacing carbon, the development of electric light would become one of the most important applications of electricity in transforming the modern world. In Manchester, the John Rylands Library, which opened in 1900, was one of the first electrically lit buildings with its own onsite DC generator. At a time when electricity was not yet the dominant power source, the library opted for electric lighting over gas to protect antique books and manuscripts from fumes.
The emergence of electric lighting coincided with the rise of the arts and crafts movement and is often associated with the design of early light fittings. It was fashionable to display the often highly ornamented bulbs quite prominently, to emphasise the variety of their shapes and patterns. But as the novelty value wore off and the short lifespan of the bulb was recognised, attention returned to the shades and fittings themselves.
When the distribution of electric light became possible, thoughts turned to manipulating it into patterns for display. This late-18th-century handwritten compilation records the studies of medical electrician John Fell of Ulverston and includes demonstrations of how to compose words of “electric fire” in the dark, using simple foil-based circuits. His instructions on illuminating words, such as “electricity”, “light”, “brilliant” and “sun”, are strikingly similar to neon signs that Tesla produced around a century later.
At the 1893 World’s Fair, Nikola Tesla bent gas-filled glass tubes into the shape of famous scientists’ names, generating light through electric discharge and in effect creating the first neon signs. His initial aim was to approximate the frequency of sunlight and create lamps of revolutionary brightness and configurations. This, he hoped, would supersede Edison’s incandescent lamp, which used only 5 per cent of the available energy to generate light.
Discharge tubes containing the noble gases helium, neon, argon, krypton and xenon have been used for advertising signs since the 1920s, though their colour and low brightness made them unsuitable for general lighting use. Neon light was invented by French chemist George Claude (1870–1960), and was first displayed to the public in Paris in 1910.
Archer electric kettle
Premier Electric Heaters
c.1902
Copper

By the 1950s electricity had revolutionised domestic living through a new range of labour- and time-saving devices, from cookers and heaters to clocks, radios and television sets. Perhaps the most archetypal of all these modern conveniences is the humble electric kettle. Electricity initially transformed the kettle into a luxury item only affordable to the rich, but eventually it became an everyday object and a marker of the democratic spread of electric power.
The invisibility of electricity created fear and mistrust among early consumers but by the end of the 19th century electricity was increasingly associated with wonder, pleasure and convenience. Products were promoted – largely to women, whose role remained within the home – using seductive metaphors such as the “Electric Fairy” and the “Silent Servant”, with the promise of quieter, faster and more efficient housekeeping. Published to accompany a new electric refrigerator, this booklet provided recipes and hints on organising, using and cleaning the fridge.
Woman modelling the latest permed hairstyles for the hairdresser Eugène Limited
Alexander Bassano Photographic Studios
1923

The advent of electricity in the home created a perception that women had more spare time to enjoy leisure activities, including a new range of electrical beauty treatments. Salon owner Eugène Suter became aware of the possibilities of electrical technology to create the fashionable hairstyle of the permanent wave. The 22 tubular heaters of this machine hung from the “chandelier” by their wires, which also served to take the weight of the heaters. However, the developing technology was difficult to regulate and could result in singed or burnt hair.
The All-Electric House was commissioned by the Bristol Branch of the Electrical Association for Women (EAW) and built in 1935. The EAW aimed to demonstrate the potential of new electrical technology to make the lives of women less onerous. In assuming that the domestic tasks would be largely undertaken by the householder rather than maids and cooks (who had been in short supply since World War I), the house featured all kinds of electrical appliances and gadgets, from a cooker and refrigerator to drying cupboards, clocks and food warmers.
The EAW All-Electric House at Bristol
1935
Photographic prints

Designed for people of moderate means, the All-Electric House aimed to encourage women to request the inclusion of electrical equipment in the price of a house and to stimulate a greater interest in general design, construction and wiring. These photographs show details such as the built-in sliding ironing board, and the kettle on the kitchen corner table, which was designed “allowing for a mid-morning cup of coffee with the greatest of ease”. In the entrance hall, a woman using the telephone is seated by a phone stand combined with an electric heater.
Electrical Association for Women tea towels
Mid-20th century
Cloth
Reproductions by Class Printing

The Electrical Association for Women (EAW) was founded in 1924 and grew out of the work of the Women’s Engineering Society, which was founded in 1919. The EAW educated women about electricity, acted as an advisory body and encouraged women to be consumers of electrical apparatus. The EAW also acted as a mediator in the design process of domestic appliances and opened its Electrical Housecraft School in 1933. In the 1950s and 1960s, the EAW produced a series of tea towels, dusters and aprons with practical advice on wiring a plug, reading a meter and changing a fuse.
The Electric House (starring Buster Keaton)
Produced by Joseph M Schenck and
Buster Keaton Productions
1922
Silent film excerpt (2 mins)

In this short comedy directed by and starring Buster Keaton, a botany student is accidentally awarded an electrical engineering degree and is then hired to wire up a large new house. When the owners return, Keaton inadvertently demonstrates the potentially disastrous consequences of domestic electrical improvements, which in this case take the form of a range of haphazard gadgets including a moving staircase, a bathtub that appears at the touch of a button, an electric pool table, and a toy train to deliver the dinner to the dining room.
Parisian chemist Francisque Crôtte founded the Institut Médical Crôtte in Lyon to cure people of tuberculosis. With a machine of his own invention, Crôtte administered antiseptic medicines – such as formaldehyde – by means of static electricity, using a sponge electrode saturated with the medicine applied externally over the diseased tissue. Crôtte claimed that his treatment would cure every case of tuberculosis in the first stages of the disease, 75 per cent in the second stage and 30 per cent in the third or so-called “hopeless” stage.
Electrotherapeutic treatments date back to Antiquity, when electric fish were used to numb pain. By the 19th century there was an explosion of interest in using electricity to study or cure the body. French neurologist Guillaume Duchenne (1806–1875) studied the effects of electrical stimulation on diseased nerves and muscles by applying currents to make them twitch and mapping the pathways of the current through the body. By isolating certain muscles he demonstrated how the facial muscles are used to create expressions such as smiles and frowns, which he captured in a striking series of photographs.
Since the 18th century electricity has been used in various forms for the treatment of cancerous growths. In 1910 French electrotherapist Joseph Alexandre Rivière (1859–1946) developed a technique to treat breast cancer using the high-frequency (low-current) apparatus pioneered by physician and physicist Jacques-Arsène d’Arsonval – a therapy still available today.
Davis and Kidder magneto-electric therapy machine
1860–1900

The makers of this electrotherapy machine claimed it could relieve pain and numerous “nervous diseases”, as well as cancer, consumption (tuberculosis), diabetes, gangrene, heart disease, tetanus and spinal deformities. While the patient would receive a small electrical shock through hand-held brass electrodes using alternating current, the strength and frequency was controlled to ensure it only produced a mild tingling sensation. A machine like this could be considered an early form of TENS machine (transcutaneous electrical nerve stimulation), still widely used for pain relief in physiotherapy and during labour.
Galvanic brooch
1890s–1920s
Vulcanite, cardboard, paper, silk, copper

This brooch is decorated with a picture of a flying cupid whose hands are emitting an electrical charge. The brooch was sold as a form of electrotherapy that claimed to rely on Galvanism: electricity by chemical action. Galvanism was named after Luigi Galvani, who first observed the phenomenon. Brooches such as this and other jewellery were widely available to treat nervous complaints and rheumatism.
The Chanteclair Embrocation
Michel Liebeaux
1910
Colour lithograph

The energising and health-giving properties of electricity were increasingly claimed for non-electrotherapeutic remedies, such as in this advertisement for a lotion to relieve aches and sprains, showing an electrified naked athlete springing from the bottle. It claims that the lotion “softens, fortifies, and electrifies”.

Wellcome Library, London
Advertisement for Harness Electropathic Belts
1890

Historically, electrotherapy was based on more speculative methods than other forms of medical treatment such as pharmaceuticals, which developed out of an established academic tradition with classical roots. Devices such as electropathic belts, which worked by relieving discomforts or diverting the attention from them, were regarded by unsympathetic critics as the products of swindlers. Other popular commercially available electrotherapeutic appliances included electric “invigorators”, vibration devices, and magnetic collars. The rationale claimed for these was that they created new energy for the body and replaced lost energy.
The X-ray is a form of electromagnetic radiation, best known as a medical imaging technique for seeing inside the body. Using wavelengths shorter than visible light and imperceptible to the naked eye, X-rays can penetrate a wide range of objects. Wilhelm Röntgen was alone in his laboratory when he accidentally took the first X-rays, and, believing himself to be deluded, asked his wife to come and confirm what he was seeing. It is said that when she saw the image of her radiated hand, she exclaimed, “I have seen my own death.”
Taking an X-ray image using an early Crookes tube

The X ray, or, Photography of the invisible and its value in surgery
William J Morton
1890s

Developed from the earlier Geissler tube – used for demonstrating electrical glow discharge similar to neon lighting – the Crookes tube consisted of a glass bulb containing a partial vacuum. It was used to discover and study cathode rays (streams of electrons) and, later, X-rays. This photograph shows how the Crookes tube was used to create a radiograph (a photographic image produced by X-rays) – also described by Tesla as a “shadowgraph”.

Wellcome Library, London
Wilhelm Röntgen’s discovery of X-ray technology transformed diagnosis of surgical traumas and within a year the first radiology department had opened in a Glasgow hospital. The ability to observe and document medical conditions with still radiography images provided surgeons with an invaluable new tool for diagnosis and unprecedented insight into fractures, bullet wounds and the like. Although the capture of real-time moving images was a more complex challenge, the pioneering practice of cineradiography was later developed by taking a series of radiographs in rapid succession, as seen in this film showing articulated finger and wrist joints.
This newly commissioned artwork by French artist Camille Henrot takes the form of a zoetrope – from the Greek meaning ‘life-turning’. It is inspired by characteristics ascribed to the first month of the year and by the holdings of Teylers Museum in Haarlem, which has a rich collection of objects relating to early experiments with and applications of electricity.

The work comprises a series of animated characters, including a frog and a cardinal butterfly, hand-crafted from electricity bills. These characters fold and unfold as the mechanism rotates, recalling early experiments in bioelectricity, while a succession of life-sized hands each spark a lighter to ignite a bill.

The lighter and its flame reference the discovery of electricity and some of the first electrostatic generators, while the burning bills allude to a state of exhaustion arising from a never-ending excess of spending and consumption.
Courtesy of the artist

January 2017 Horoscope was commissioned by Teylers Museum in Haarlem, Netherlands and supported by Wellcome Collection as part of the exhibition *Electricity: The spark of life*
Grid Music
Mike Fell
2013
Audio and video (2 mins 21)

The classic illustration of consumer impact on power systems is the moment when television audiences simultaneously rush to boil the kettle during the commercial break of a popular show, causing a massive surge in electrical use. Grid Music explores this relationship between behaviour patterns and energy use by converting electricity data gathered by the UK National Grid into sound. Half-hourly data from January 2013 is represented by a series of beeps whose frequency is determined by the extent of the demand. This eerie soundscape conveys a powerful sense of the rhythm of energy consumption.
Electricity consumption graph
Central Electricity Generating Board
1950s

Networks such as the National Grid are responsible for generating and transmitting electricity in accordance with continuously fluctuating demand, from maintaining excess capacity to deal with maximum load peaks to adapting to temporary drops in demand or power cuts. This 3D graph, compiled by the planners at the Central Electricity Generating Board, represents the daily electrical energy consumed over a period of two years during the 1950s. The recognisable pattern shows peaks during the winter months and dips during the warmer months.
Electrolytic prepayment electricity supply meter
British Insulated and Helsby Cables Ltd
1910

As commercial use of electric energy spread in the 1880s, it became increasingly important to introduce a metering system to ensure that customers were properly billed for the energy they used, instead of charging for a fixed number of lamps per month. This early-20th-century meter is similar to one of the first electrochemical meters designed by Edison in 1881. When a coin was inserted it acted as connector between the internal mechanism and the handle, which connected the current when turned.
Electric vehicle manufacturing has experienced a recent renaissance due to growing environmental concerns, yet the first electric cars were already in mass production over 100 years ago and in the 1890s almost 99 per cent of New York taxis were electrically powered. Gallia was one of the most successful models of the period, seen here at the Paris Motor Show in 1903. By the 1920s expanding road systems and worldwide discoveries of large oil reserves led to the decline of the electric car, as petrol-powered cars were cheaper to operate and could cover much longer distances.
The 1960s and 1970s saw renewed interest in research on electric vehicles in the US and Europe, prompted by soaring oil prices and fuel shortages and a need to reduce air pollution generated by the internal combustion engine. The electric Ford Comuta was one of several prototypes of the time, destined to revolutionise the future of motoring. It performed well, with expected limitations, but it did not seem to offer enough to warrant further development.
In the electric city of the future
Harmsworth Popular Science
Arthur Mee
1912

Published in the early 20th century, Harmsworth Popular Science was a fortnightly magazine which formed an encyclopedic series of science and technology articles with a humanist tone. This edition explores the story of humanity’s liberation through power sources such as electricity, gas and steam, also including a vision of a future in which electricity is generated centrally and one man assumes almost God-like control of the “stream of power”, delivered from his bubble in the sky to the community below.
Ground-breaking inventor and electricity visionary Nikola Tesla’s greatest legacy was his contribution to the development of the alternating-current distribution system. But Tesla’s ambitions ran far beyond the supply of electricity, and he continued to conduct ever more dramatic experiments. While based in his laboratory in Colorado Springs during the early 1900s he embarked on a series of high-voltage, high-frequency experiments using a Tesla coil (transformer) to produce artificial lightning, with discharges consisting of millions of volts and up to 135 feet long.
The New Wizard of the West
Chauncy Montgomery M’Govern
Pearson’s Magazine
May 1899

Through his experiments with high-frequency technology, Tesla produced a range of demonstrations, the most significant of which was wirelessly illuminating a vacuum tube having transmitted energy through the air. This development formed the basis of a lifelong obsession with creating a wireless communication system and with providing free electricity throughout the world – foreseeing an era of wireless technology that would only become a reality over 100 years later. In this interview Tesla describes his vision involving an arrangement of “balloon stations” to transmit electricity, as well as his ambitions to harness solar and hydroelectric power.
Solar City was submitted to the German Landstuhl Solar Housing Competition in 1982. “An assembly of space-economic structures with extended surfaces of photovoltaic cells. Warm-up territory is sheltered and pocketed. Each dwelling has a supplementary circular armature that can be seasonally encased.” This competition came at a time of a growing environmental consciousness, as the need for greener technologies and renewable energy came sharply into focus. Though unbuilt, in Cook’s words the proposal was “eminently buildable” and was influential in expanding the horizons of how to harness cleaner power for the home.
Model of Masdar City, Abu Dhabi
Foster + Partners
2008

Designed by British architects Foster + Partners in 2007, Masdar City is a major urban development intended to become the world’s most sustainable eco-city, powered by renewable energy. Situated on the edge of the desert near Abu Dhabi, the city combines traditional Arabic planning principles with state-of-the-art technologies. As well as other renewable sources, Masdar harnesses clean energy from rooftop solar technology and a field of 87,780 solar panels. Still a work in progress, it may be many years before we know if bespoke green cities such as Masdar will become a blueprint for our future relationship with electricity.
Electricity – where now?
Audio installation
Produced by Simon Hollis
2016
15 mins

What is the future of our relationship with electricity? In this audio installation a number of interviewees offer their insights into the reliability and sustainability of electricity systems and reflect on our place within “the grid”. Their perspectives raise questions about how we deal with increasing electricity consumption.

Contributors:
Donald Boyd, Development Manager, Huntly wind turbine
Kris de Dekker, Writer, Lo-Tech magazine
Lars Falch, Founder, Powerpeers
Geraint Wyn Jones, Operations Manager, Dinorwig power station
David Nye, academic and writer on blackouts
Annabel Pinker, energy researcher
Robin Preece, power systems researcher
Elizabeth Shove, energy researcher
Jonathan Taggart, documentary maker
Dale Vince, Founder, Ecotricity