museo galileo

Masterpieces of Science

edited by
Filippo Camerota

introduction by
Paolo Galluzzi

GIUNTI

Museo Galileo's new permanent exhibition

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The Spectacle of Science

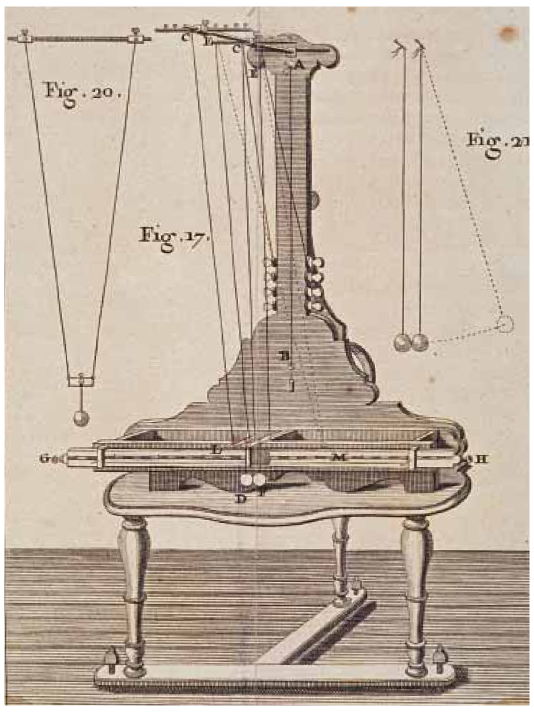
Paola Bertucci

In 1780 the painter Filippo Lucci was commissioned to finish the ceiling decoration in a new section of the Mathematics Room (Stanzino delle Matematiche) in the Uffizi Gallery. Taking as model the older part, which illustrated mathematical instrumentation from the Medicean collection, Lucci depicted instruments used at the time of the Lorraines to perform entertaining and spectacular experiments (fig. 1). Most of the instruments depicted were taken from the plates of a book by Carlo Alfonso Guadagni, professor of physics at the University of Pisa from 1748.[1] Guadagni's career exemplifies the success that could be achieved by combining science and entertainment. Before being appointed to the University of Pisa, Guadagni had become well known in Florence for his courses of experimental physics, taught for a fee in his home or those of local aristocrats. These paid courses were based on a hundred or so spectacular experimental demonstrations that accompanied lectures on Newtonian natural philosophy and the most recent discoveries in the fields of electricity and magnetism.[2]

Guadagni was not the only one engaged in activities of this kind. Public lectures in experimental physics were widespread in 18th-century European capitals, and some of the itinerant demonstrators could boast international reputations. In London these courses were continually advertised in newspapers and magazines. The fame of Isaac Newton, "who wrote a book that neither he nor anybody else can understand,"[3] depended significantly on the work of such public lecturers, who illustrated the main tenets of Newtonian physics by replacing mathematics, hard to understand for a non-specialized public, with experimental demonstrations. In 1734, John Theophilus Desaguliers, author of popular books on experimental physics, a member of the Royal Society and lecturer of experimental physics to the royal family, gave his hundred and twenty-first cycle of lessons in London.[4]

In Paris, the most popular demonstrator was the Abbot Jean-Antoine Nollet, who combined his intense activity as a public lecturer with a profitable career as an instrument maker. Nollet had been summoned to Versailles to work as the physics tutor to the Dauphin of France. His lectures being highly popular, he had stayed there for some time to entertain the royal family and the whole court with spectacular demonstrations (fig. 2). At Versailles, Nollet set up a complete physics cabinet with instruments made in his own workshop, wich attracted even the philosopher Voltaire, who became one of the abbot's customers. Nollet's instruments, distinguished by a typical black-and-gold lacquering, were decorated with exotic scenes, in line with the French vogue for *chinoiserie*.[5] Nollet published his lectures to the Dauphin in a volume that met with great success, the *Leçons de physique experimentale*.[6] This book, translated into various languages, contained numerous plates illustrating the abbot's

Fig. 1. Filippo Lucci, Friezes on the ceiling of the Mathematics Room depicting electrical instruments, *circa* 1780; Florence, Uffizi Gallery.



machines and instruments. The book was especially popular with the well-educated European *élites*, since it gave them a chance to follow the path taken by the young prince in learning experimental physics. With the aid of instruments bought from Nollet's atelier, the text could be accompanied by the spectacular demonstrations that the abbot staged at the French Court.

In Leyden, Professor William Jacob 'sGravesande offered popular courses in experimental physics using apparatus produced by the local instrument maker Petrus van Musschebroek, himself the author of an illustrated physics textbook. The instruments and machines used by itinerant lecturers to teach experimental philosophy and its laws became collectors' items, displayed in the physics cabinets of princes and aristocrats all over Europe.

In Florence the plates of Nollet's *Leçons de physique*, along with Musschebroek's and 'sGravesande's textbooks, served as models for making the instruments of the Reale Museo di Fisica e Storia Naturale (Royal Museum of Physics and Natural History) inaugurated by Felice Fontana in 1775 at the order of Grand Duke Peter Leopold.[7] The instrument makers who built the great machines displayed today in the halls of the Museo Galileo drew inspiration from the apparatus described in these volumes, in particular that by Nollet (figs. 3-6). As expert craftsmen and suppliers to the court, they put their skill at work on oriental woods and other precious materials, creating a collection designed to be the most sumptuous and complete in Italy. In the ambitions of the Director Fontana, the machines of the Reale Museo had to be spectacular in size, number, perfection and beauty: "This nascent Museum thus embraces not only all of nature to the greatest possible extent, but still more, everything most beautiful and most useful and most ingenious that mankind has been able to find, or to imagine. But in beauty, novelty, perfection and number, the collection of physics machines alone […] surpasses all of the Museums that have been founded in Europe up to now."[8]

In the 18th-century museum – as today in the Museo Galileo – even the material aspect of the instruments and

Fig. 2. Jean-Antoine Nollet, A lecture in experimental physics (Nollet 1743-1748, frontispiece).

Fig. 4. Jean-Antoine Nollet, Device for studying elastic and anelastic impacts (Nollet 1743-1748, vol. I, pl. 7).

Fig. 3. Device for studying elastic and anelastic impacts, second half of the 18th century; Museo Galileo, inv. no. 981.

machines was a spectacle. Adam Walker, an itinerant lecturer who was active in Britain in the second half of the 18th century, after a visit to the Reale Museo di Fisica e Storia Naturale, called what he had seen "a wonderful collection indeed!"[9]

In salons and private libraries, as in public museums and universities, the instruments and machines of physics represented a new approach to studying the natural world, based on manipulating the powers of nature recreated in a controlled setting. The air pump, for instance, an icon of 18th-century experimental philosophy, could be used to study the effects of vacuum on the motion of bodies and on animal life. A vacuum was artificially created inside a glass vessel, allowing observers to see how the absence of air induced violent convulsions, and even death, in small birds (see *infra*, p. 226). In the experimental demonstrations, the spectacle of nature was mediated by machines and instruments. The armony of solar system was illustrated by the regular motions of orreries, or planetariums (fig. 7). By replicating the solar system on a reduced scale, these machines demonstrated the illusory nature of the planets' irregular motions. The laws of motion and impact were illustrated with pendulums and simple wooden devices (fig. 3), the effects of the density of air on the propagation of sound were explained using pressure pumps, while the artificial eye showed the formation of images on the retina and the effects of myopia and presbyopia on vision.

Fig. 5. Electrical machine built in Florence
in the last quarter of the 18th century, Nollet type;
Museo Galileo, inv. nos. 2737, 1341, 1342.

Even the vast and complex microcosm became a spectacle to be comfortably admired from an armchair, while the solar microscope projected eerie images of giant insects on the walls (figs. 8-9).

In the 18th century, the invention of the "electrical machine" gave rise to a new and remarkably spectacular kind of entertainment (see *infra*, p. 227). This simple device manifested to the senses the existence of a matter called electric "fluid" or "fire" that was normally invisible in nature. The production of sparks with the electrical machine, and later with the Leyden jar, disclosed this invisible powers of nature and went to enrich the repertoire of experimental physics lecturers. Aristocratic palaces and salons became the theatre of "electric soirées" staged by itinerant lecturers specialized in electrical demonstrations, who conducted amusing experiments suitably choreographed as theatrical performances. Travelling from one city to another, itinerant electricians played a crucial role in sparking the craze for everything electrical throughout Europe.[10]

The explosive nature of electrical phenomena, from crackling sparks to convulsions induced by shock (also called "electric commotion"), was a fundamental element in the performances staged by the electricians. In 1749 Benjamin Franklin described an "electric party" in these words: "A turkey is to be killed for dinner by the electric shock, and roasted by the electric jack, before a fire kindled by the elec-

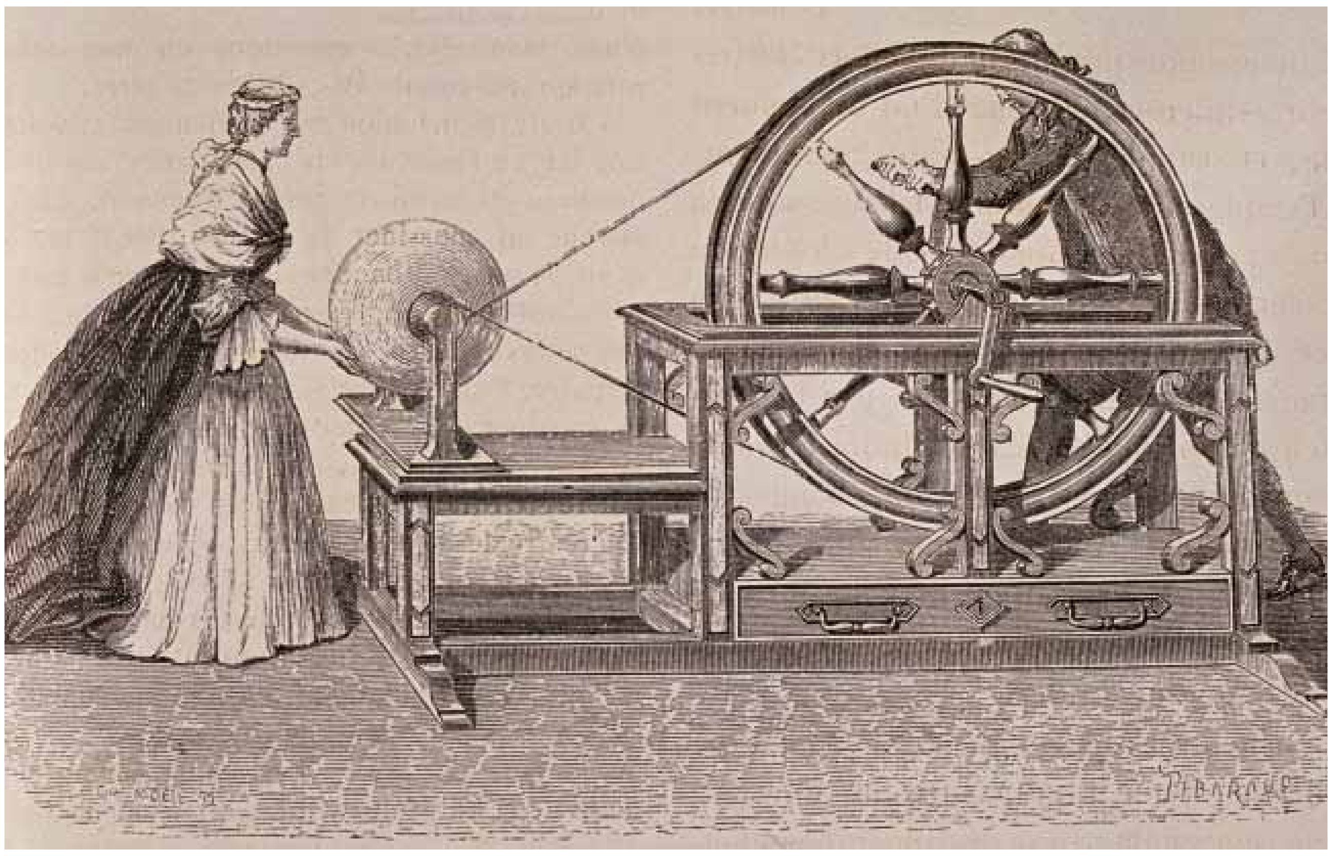


Fig. 6. Electrical machine (Nollet 1746).

trified bottle; when the healths of all the famous electricians of England, France, Holland, and Germany, are to be drunk in electrified bumpers, under the discharge of guns from the electrical battery."[11] The redundant usage of the term "electric" reveals the enthusiasm for a branch of knowledge that was perceived as *the* science of the century. Although the etymology of the word reminds us that the attractive properties acquired by amber (*elektron* in Greek) when rubbed had been known since antiquity, in Franklin's day electricity was still considered a young science, and in 1767 the theologian and natural philosopher Joseph Priestley hailed it as the "youngest daughter of science."[12]

The transformation of natural philosophy into polite entertainment that took place in salons and courts was crucial to the success of electricity. During electric soirées, the demonstration hall was darkened to accentuate the livid light of sparks and flashes. When all lamps and candles had been extinguished the demonstrators performed their repertoire, offering the audience a full immersion of the senses in the mysterious "electric fire." In demonstrations of electrical phenomena, all of the senses were involved: the electrical matter appeared to the eye in the form of bluish flashes of light, to the ear as a typical crackling noise, to the touch as pinches and punctures, to the sense of smell as a distinctive odour "very similar to the phosphorus of urine, and a little to that of garlic."[13] But it was on the human body above all that the touch of the ineffable "electric fire" left the most vivid impressions. In 1730 Stephen Gray, a member of the Royal Society of London, devised an experiment to demonstrate that the human body conducted the "electric fire." The so-called "flying boy" experiment became one of the most popular demonstrations in Europe (fig. 10). In this experiment, a boy was placed on a wooden board suspended from the ceiling on thick ropes of silk. When the boy's body was connected to the electric machine, it took on a mysterious "attractive power," allowing him to pull light objects toward him or turn the pages of a book without touching them. The boy's body could even emit little sparks if one of the spectators brought a finger close to his nose.

Fig. 10. The "flying boy" experiment (Nollet 1746).

Fig. 7. Planetarium or *orrery* made in Florence in the third quarter of the 18th century; Museo Galileo, inv. no. 581.

Some of the most popular electrical experiments imitated gallant interaction between ladies and their cavaliers. In the surrounding darkness, the electric soirées created a naughtily allusive atmosphere. During the "electric kiss," for instance, a gentleman tried to approach his lips to those of a lady (called for the occasion the "electrifying Venus"), but was stopped by a powerful spark, to the great amusement of the audience. The electrical vocabulary was generously invoked to arouse knowing smiles on the faces of readers: the "rubbing together of bodies" that "excited" the discharge of "electric fluid" was especially well-suited to such purposes, and was even used in erotic poetry.

Inaugurated by Gray, the practice of including the human body in the experimental apparatus stimulated the creativity of other experimenters, who invented new demonstrations, equally spectacular and charged with suspense. The new experiments provided the novel thrill of feeling on one's own body the effects of the "electric fire": "An electrified person cannot approach a glass tube without darting forth towards it a visible flame, attended with a small noise like the cracking of hair set on fire. But if instead of an electrified tube the person himself be placed upon pitch, and touched an electrified tube of iron, he will be then electrified himself, and whoever shall approach his finger to the body of the person thus electrified, will cause a spark to issue from the surface, accompanied with a crackling noise, and a sudden pain of which both parties are both too sensible."[14] Despite the not always pleasant sensation of electric shock, it was precisely the involvement of the human body in the experiments to arouse the curiosity of ladies and gentlemen in search of novelty and entertainment. The ladies in particular became assiduous frequenters of electric soirées, arousing the sarcasm of a contemporary commentator: "Could one believe 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? The ladies were sensible of this new privilege of kindling fires without any poetical figure, or hyperbole, and resorted from all parts to the public lectures of natural philosophy, which by that means became

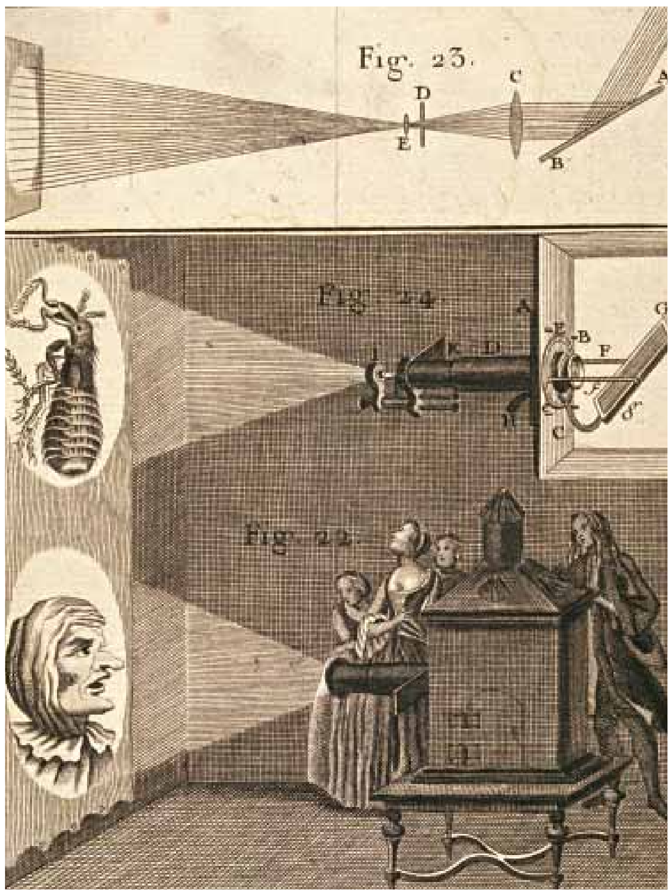


Fig. 8. Isidoro Gaspare Bazzanti, Solar microscope, *circa* 1760; Museo Galileo, inv. no. 3229.

Fig. 9. Solar microscope and magic lantern (Nollet 1743-1748, vol. V, pl. 10).

Fig. 11. Thunder house with lightning rod and gunpowder, late 18th century; Museo Galileo, inv. no. 1211.

Fig. 12. Aurora flask, late 18th century; Museo Galileo, inv. no. 423.

brilliant assemblies."[15] In the 1740s, electricity had become a cultural fashion attracting the attention of princes and nobles throughout Europe: the stadtholders of Holland, the Royal Princess of Prussia, the Countess of Bruhl, the Duke and Duchess of Gotha, and even the Grand Chancellor of Poland ordered electrical machines. The English ladies, instead, not only had electrical machines made for them, but began to perform experiments themselves… "and electricity took the place of the quadrille."[16]

In Italy this phenomenon spread widely thanks to the frenetic activity of a group of itinerant demonstrators from Saxony who travelled North to South organizing spectacular electric soirées. The Saxons sent around printed leaflets listing the electrifying demonstrations they planned to hold in the palaces of the local nobility. The leaflets were filled in by hand with indication of the place, the cost and the duration of the performances. Starting from Venice, the wonders of electricity conquered practically all the Italian cities in only one year (1746).[17] With the success of these demonstrations, the electrical machine became another iconic instrument of experimental philosophy, never absent from public or private physics cabinets.

Benjamin Franklin believed that all bodies contained a natural amount of "electric fluid" that could be altered by accidental causes, whether natural or artificial (such as the wind, or by rubbing). The electric fluid had a natural ten-

Fig. 14. Volta pistol, signed Nairne & Blunt, late 18th century; Museo Galileo, inv. no. 1244.

Fig. 13. Electric bells, second half of the 18th century;
Museo Galileo, inv. no. 3116.

dency to restore balance, moving from bodies containing too much of it to those where it was lacking. In the 18th century, a whole series of unpredictable natural phenomena – thunderstorms, bolts of lightening, earthquakes, volcanic eruptions and the Aurora Borealis – was interpreted as caused by the electric fluid moving between the atmosphere and the bowels of the Earth. The "electrification" of the natural world gave rise to a growing demand for electrical apparatus to be used for entertaining experiments at home. The manufacturers produced a range of toy instruments designed to illustrate the role of electric fire in the economy of nature according to the most recent theories. The debate over the effectiveness of lightning rods produced a particularly theatrical instrument: the "thunder house" (fig. 11). Designed in various shapes and sizes to be sold at different prices – from the simplest models composed of a single wooden façade to elegant toy houses with paper figurines inside – the "thunder houses" gave a stunning demonstration of how pointed metal conductors could protect buildings from the devastating effects of lightning. The sparks produced by the Leyden jar simulated lightning, while a grounded metal conductor represented the lightning rod. When the conductor was disconnected from the ground, a sudden spark between the two metal ends ignited a charge of gunpowder inside the house, bursting it open in a sensational explosion.

Transformed into a new marvel of electricity, the Aurora Borealis too could be recreated on a reduced scale thanks to the "aurora flask" (fig. 12). With this device and a simple electrical machine, the amateurs of electricity could observe in a darkened room the marvellous spectacle of the Northern Lights generated in a glass flask by a myriad of tiny sparks. Texts such as *An Introduction to Electricity* by James Ferguson gave instructions on how to perform what was deemed the most refined among the experiments in electricity.[18] In addition to the "thunder house" and the "aurora flask," the electric soirées were enlivened by other toy instruments: "magic squares" that formed words composed of sparks, "electric snakes" winding through the darkness, bells that rang by themselves, and paper dolls that danced frenetically.

The toy instruments displayed at the Museo Galileo are concrete evidence of the playful nature of science in the 18th century. Even such authoritative electricians as Benjamin Franklin and Alessandro Volta contributed to the invention of "electrifying" toys; the former invented the "Franklin's bells" (a set of small bells that were repeatedly struck by an electrified ball; fig. 13), the latter the "pistol" that bears his name (fig. 14). In a society that abhorred boredom, experimental demonstrations choreographed and staged as theatrical performances combined entertainment, learning and sociability. Participation in the spectacle of science was a form of citizenship in the Republic of Letters.

[1] Guadagni 1764.
[2] Guadagni 1745.
[3] Cit. in Whiteside 1970, p. XIII.
[4] Stewart 1992; Schaffer 1983.
[5] Pyenson-Gauvin 2002; Sutton 1995.
[6] Nollet 1743-1768.
[7] Contardi 2002.
[8] *Saggio* 1775, p. 2.
[9] Olmi 2006.
[10] Bertucci 2007.
[11] Franklin 1769, pp. 37-38.
[12] Priestley 1767.
[13] Nollet 1746, p. 64.
[14] Haller 1745, p. 194.
[15] *Ibidem*.
[16] *Ibidem*.
[17] Bertucci 2007.
[18] Ferguson 1770, p. 74.

The Air Pump

Paola Bertucci

An icon of 18th-century experimental science, the air pump is an instrument used to extract air from a bell-shaped glass vessel and perform spectacular experiments in rarefied air. The artefact here illustrated was made according to the design of Abbott Nollet, who improved on the single-barred model dating to the 17^{th}-century. In the course of the 18^{th} century more efficient double-barrel versions appeared. To extract the air, a crank was turned to drive a piston inside the brass barrel. A faucet between the cylinder and the glass vessel allowed for the operation to be repeated several times in order to get better results. The air pump was used in spectacular demonstrations to observe the effects of the absence of air on small animals, which fell into convulsions and died (unless air was let back into the bell-jar), and the muffled sound of a small bell ringing.

Single-barred air pump made in Florence around 1780; Museo Galileo, inv. no. 1534.

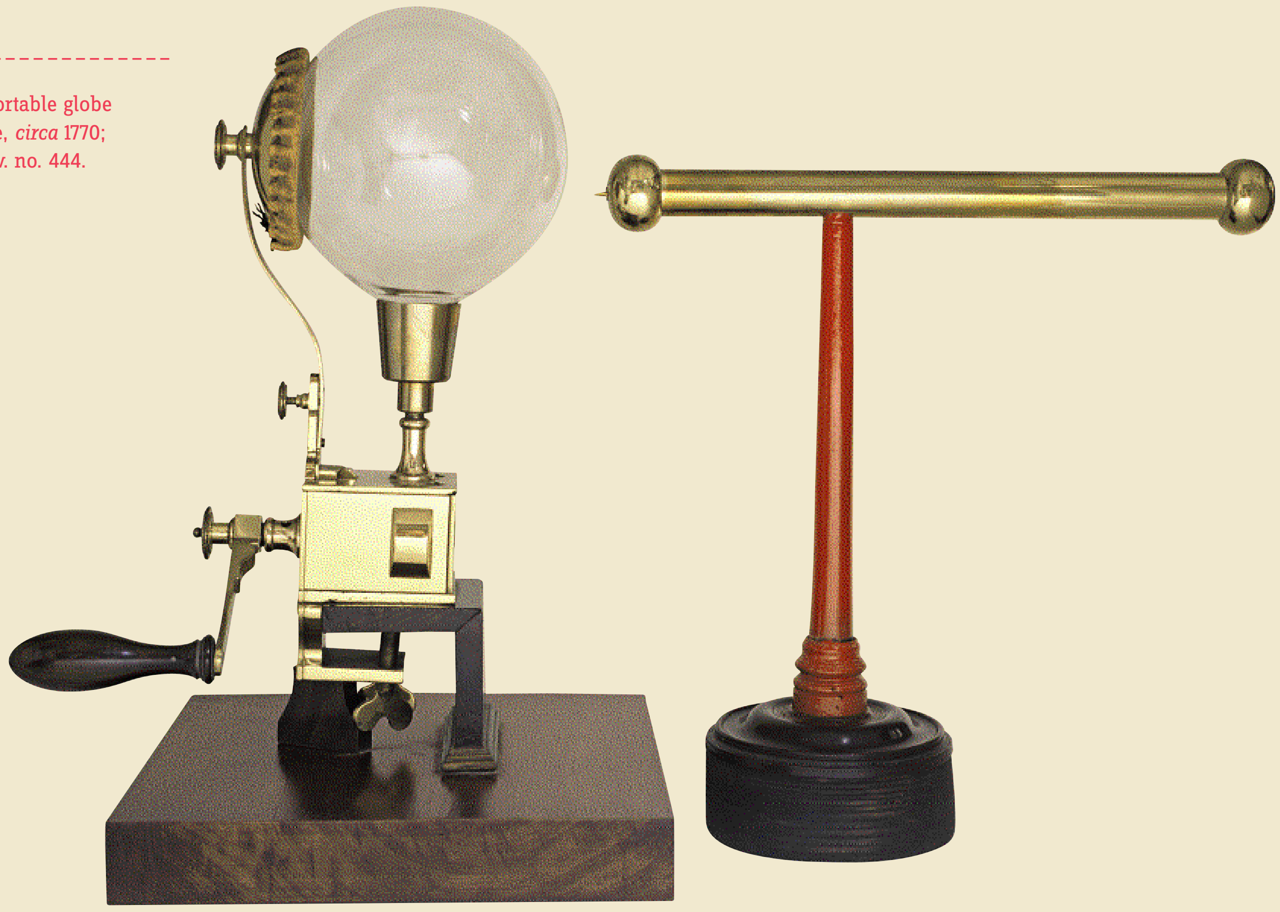
The Portable Electrical Machine

Paola Bertucci

Regardless of their design, all 18th-century electrical machines have the same basic components and operate by means of electrification by rubbing. A glass element – typically a globe, cylinder or disk – is rotated by a crank and rubbed by leather pads (or by the hands) as it turns.

The electric charges produced on the surface of the glass are transferred through metal tips to a cylindrical conductor, which is thus electrically charged. In 18th-century salons, electrical machines were used to perform exhilarating experiments, such as the "electric kiss."

A lady standing on an insulated stool was asked to touch the metal conductor with her hand, while a gentlemen (not insulated from the ground) strolled over to give her a kiss. But as his lips approached hers, a sudden – and not especially pleasant – spark exploded between them.



Edward Nairne, Portable globe electrical machine, *circa* 1770; Museo Galileo, inv. no. 444.

Science in the Domestic Sphere

Paola Bertucci

In 1737 the Venetian Francesco Algarotti published *Il Newtonianismo per le dame* (Newtonianism for ladies), a volume that proposed to "recall savage philosophy from the solitary closets and libraries of the learned, to introduce it into the circles and boudoirs of ladies."[1] The method employed by the author to carry out this mission was that of literary fiction, consisting of a polite conversation between a gentleman and a marchioness who, over the course of five days, discuss physics within the charming context of a villa on Lake Garda (fig. 1). Through the dialogue between these two characters, Algarotti describes the learning process of the lady who, guided by her cavalier, is introduced to the principles of Newtonian science. The volume offered 18th-century society a brilliant example of "tamed Newtonianism," a science rendered pleasant and suited to the style of that century's worldly conversations. "I have endeavoured to soften, so to say, Newtonianism, and render its severity agreable," stated the author.[2] The book, a bestseller throughout the 18th century, was modelled on the *Entretiens sur la pluralité des mondes* published in Paris in 1686 by Bernard le Bovier de Fontenelle. This work too consisted of a series of dialogues between an initially ignorant marchioness and a highly cultivated gentleman who instructs her in the principles of natural philosophy, in this case Cartesian. As in Algarotti's text, in Fontenelle's too the scenario for the meetings is a villa, a domestic sphere that becomes the theatre of scientific learning and discussion.[3]

The *Newtonianismo per le dame* and the *Entretiens* reflected a reality contemporary to the two authors. The "conversations" held in their homes by aristocratic ladies were in fact one of the most fashionable forms of 17th-18th century sociability. Friends and visitors, sometimes including foreigners, met in the lady's salons to discuss politics and science, or to play games of chance. The conversations mingled learned sociability and entertainment, depending on the inclinations of the hostess.[4] The texts of Algarotti and Fontenelle insert science into these conversations and cast a revealing light on women's interest in natural philosophy. The heroines of these two books, however, offer the model of a learned woman who is strongly influenced by the gender relationships of 17th- or 18th-century society. The ladies of Algarotti and Fontenelle, devoid of any scientific knowledge, are initiated into the pleasures of science in a setting of sophisticated flirtation. In the cultural project of both authors, ladies and gentlemen play different roles in the process of acquiring natural knowledge.[5]

The gender relationships illustrated by Algarotti and Fontenelle find a fascinating material counterpart in two instruments displayed in the Museo Galileo. The Lady's telescope (fig. 2) is an elaborate dressing-table ornament made of carved ivory and wood, containing jars for beauty cream, eye shadow and face powder. Two small ivory telescopes with their eyepieces are housed in a slender wooden column. This artefact is a concrete representation of a natural philosophy that has

Fig. 1. Frontispiece of *Il Newtonianismo per le dame* by Francesco Algarotti, Naples 1737.

Fig. 4. Experimenting with chemicals in the domestic sphere (Poncelet 1766, frontispiece).

been "tamed" and brought into the boudoirs of the ladies, as described by Algarotti. The expensive materials constituting this object, and the low magnifying power of the telescopes, clearly show that it was designed for aristocratic women whose participation in scientific knowledge was limited to polite conversation and social life of the salon. The telescope in the form of a walking stick (fig. 3), on the other hand, can be interpreted as the masculine counterpart of the Lady's telescope. In this case the telescope – it too of low magnifying power – is concealed in a walking stick. While strolling with a lady, its owner could surprise her by suddenly aiming it at a planet, going on to engage her in conversation on the plurality of worlds, or on Newtonian universal attraction.

The learned ladies of Algarotti and Fontenelle were not, however, the only models available to women in the 18th century. The authors themselves were personally acquainted with a real marchioness who had little in common with their fictitious ones. Émilie du Châtelet, author of the first French translation of Newton's *Principia*, was well known in Paris for her devotion to experimental physics, a study she cultivated together with her lover, the philosopher Voltaire. The couple performed experiments in the residence of the marchioness at Cirey, where Voltaire had set up a physics cabinet with instruments produced by Nollet. The French philosopher publicly acknowledged his intellectual debt to the marchioness. The title page of his *Eléments de la philosophie de Newton* (1738) shows Newton illuminating with a beam of light Émilie du Châtelet, who is in turn reflecting the light onto Voltaire from a mirror.[6] Even in works of fiction, other models began to emerge along with that of Fontenelle. When the vogue for experiments in electricity reached the Italian states, a "philosophic and gallant novella" was published in Venice. Its heroine was a lady who, unlike the marchionesses of Fontenelle and Algarotti, was "highly versed in philosophical matters" and directed with great authority a conversation on the "glories of electricity" in the setting of a villa on Lake Garda.[7]

18th-century experiments were conducted mainly in the domestic sphere, and it was not unusual for the women of the house to participate. In the homes of pharmacists, perfume

Fig. 2. Lady's telescope in wood and ivory,
18th century; Museo Galileo, inv. no. 3725.

Fig. 3. Telescope in the form of a walking stick,
late 17th-early 18th century; Museo Galileo, inv. no. 2547.

Fig. 6. Gregorian telescope signed Selva, 18th century;
Museo Galileo, inv. no. 1419.

Fig. 5. Pietro Patroni or François de Baillou (attr.),
Compound microscope, wood and ivory,
early 18th century; Museo Galileo, inv. no. 3248.

manufacturers, instrument makers and astronomers, as well as in aristocratic salons, the whole family could be involved in handling the apparatus, either out of necessity or for entertainment (fig. 4). Numerous examples, not all of which are well known, testify to women's participation in the experimental activity conducted in the domestic sphere. A brief list includes: Mariangela Ardinghelli, who took part in the experiments carried out in the Prince of Tarsia's palace in Naples; Countess Guarienti Gazola, who worked beside her husband to measure the "electric fluid" velocity; Laura Bassi, professor of physics at the University of Bologna, who engaged in teaching and experimentation in her home laboratory; Marie-Anne Pierrette Paulze, the esteemed collaborator of her husband Antoine Lavosier; and Lucia Galvani, who assisted her husband Luigi in searching for the causes of muscular motion.[8]

Science entered the homes of 18th-century upper classes to serve various purposes, not necessarily linked to teaching or research. While private libraries became enriched with texts describing the operation of such instruments as the microscope and the electric machine, rooms were adorned with terrestrial and celestial globes along with pendulum clocks and table models. The scientific sociability of the upper classes created a new market for instrument makers who, especially in England, published numerous texts on the operation of the various devices, complete with instructions for conducting experiments. While the success of Newtonian physics was due

Fig. 7. Peter Dollond, Compound microscope, chest type, late 18th century; Museo Galileo, inv. no. 3230.

Fig. 8. Mantel clock with alarm, 18th century; Museo Galileo, inv. no. 3584.

in good part to texts that avoided the difficulties of mathematics, other sciences too reached a vast public thanks to works addressed to non-specialists. In 1743 the English microscopist Henry Baker published *The Microscope Made Easy*, a text describing the recreational use of the microscope invented by John Cuff. In 1771 the instrument maker George Adams published *Micrographia illustrata*, a compendium of microscopy presenting the most interesting results published in the various parts of Europe.[9]

In the Italian countries the "optics professors" (makers of optical instruments) differentiated their offer in the face of competition from foreign firms. In Venice the workshop of Domenico Selva, which served the nearby University of Padua, offered a wide range of items to the curious amateurs of astronomy and microscopy. In 1761 Domenico's son, Lorenzo (who retained his father's famous signature), dedicated to his fellow citizen Francesco Algarotti his *Esposizione delle comuni, e nuove spezie di Cannocchiali, Telescopj, Microscopj, ed altri Istrumenti Diottrici, Catottrici, e Catodiottrici* presenting the range of instruments made in his workshop to the general public.[10] In addition to microscopes and telescopes, the Selva workshop produced camerae obscurae, magic lanterns, prisms, solar microscopes and anamorphoses – optical devices that, by demonstrating the deceptive responses of the sense of sight, constituted a rich source of entertainment and philosophical reflection. In the Duchy of Milan the Frenchman François de Baillou built fine microscopes of ivory and leather, modelled on the earlier ones by Giuseppe Campani.[11] A Gregorian telescope signed Selva and a microscope by Baillou (figs. 5-6) are displayed in the halls of the Museo Galileo. These were typical collector's items, signed by the maker like design objects, and probably displayed together with costly volumes in aristocratic reading rooms.

The microscopes were frequently sold in wooden cases containing slides prepared for observations – an obvious advantage, especially for scientific instruction and entertainment (fig. 7). The domestic collections usually included, along with objects built by local craftsmen, at least one or two pieces from the most prestigious European workshops. In the second half of the century, English instrumentation came into great demand. The Lorraine family, which continued the tradition of scientific collecting inaugurated by the Medici, owned a microscope by George Adams, scientific instrument maker to the King of England. This microscope was donated by Grand Duke Peter Leopold to the Reale Museo di Fisica e Storia Naturale (Royal Museum of Physics and Natural History) and displayed there at its inauguration in 1775.

Some scientific instruments became decorative objects, others conversation pieces. In 18th-century homes, along with terrestrial and celestial globes, table clocks, scales, wall thermometers and barometers soon appeared (figs. 8-10). Framed in elaborate rococo supports made of gilded or painted wood, the two instruments were sometimes coupled (see *infra*, p. 296), with pressure and temperature shown on different scales. In Florence, meteorological instruments bore important symbolic significance. Meteorology was one of the chief experimental activities of the Accademia del Cimento, and the experiments of Evangelista Torricelli – Galileo's successor at the Medici Court – had laid the bases for the invention of the barometer.[12] Discussing the weather could be a way of participating in the scientific culture of the Republic of Letters. The magazines of the time, whether academic or addressed to a broader public, devoted much attention to the study of meteorology, pointing out its utility to commerce, agriculture and public health. Each month the newspapers published weather

Fig. 9. Youngs & Son, Domestic scales, 19th century; Museo Galileo, on deposit from the Soprintendenza P.S.A.E. of Florence.

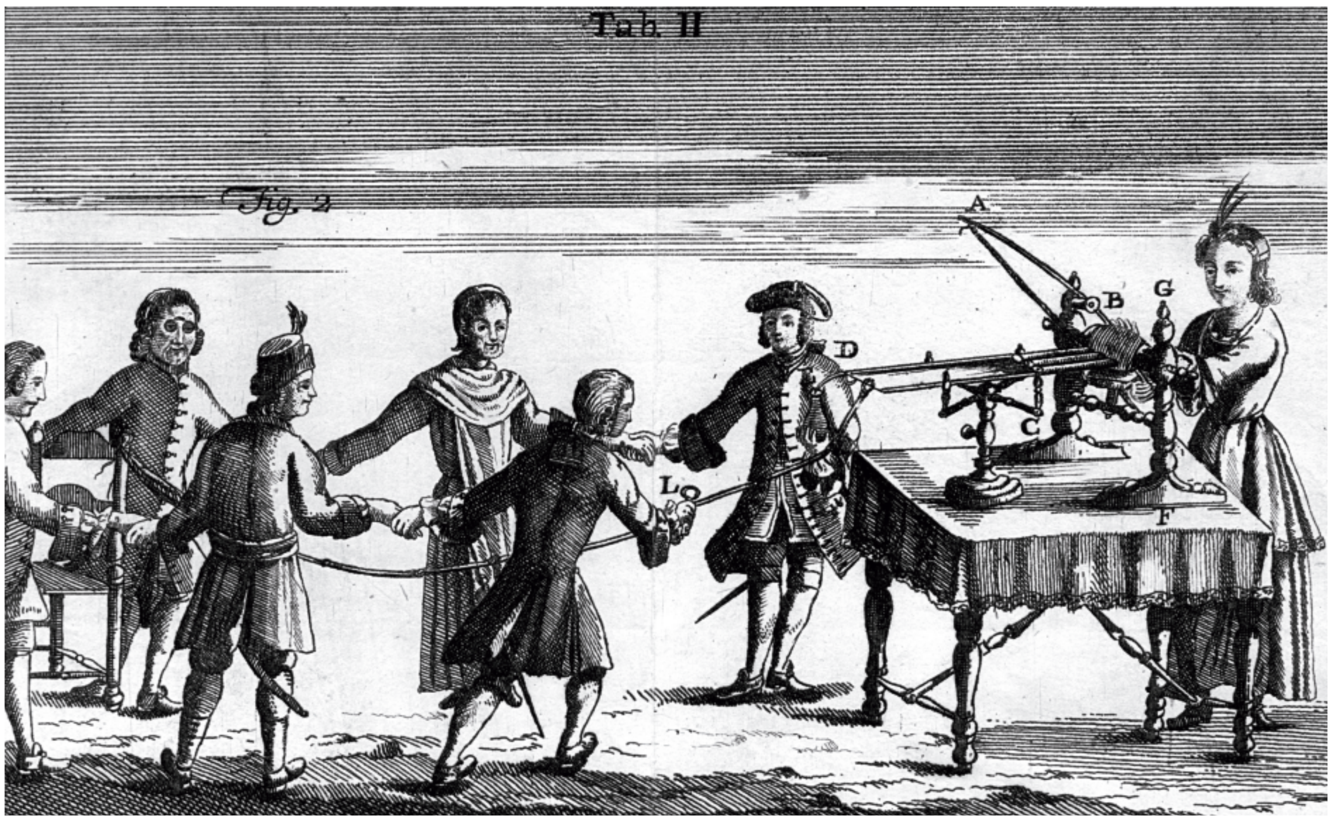
Fig. 10. Wheel barometer, late 18th century; Museo Galileo, inv. no. 1139.

calendars listing the data collected in different localities over a certain period of time. With a barometer/thermometer hanging on the wall, the educated classes of the 18th century could test the relationship between atmospheric pressure and meteorological conditions on a daily basis. Comparing the reading of one's own instrument with the data appearing in the magazines or journals aroused reflections on local climatic variations, the effects of weather on seasonal crops, and the quality of the air. These "homemade" meteorological findings could lead to a critical attitude toward superstitions and popular beliefs, but the significance of a reading was subject to varying interpretations.[13] Giuseppe Toaldo, for instance, a professor of "astronomy, geography and atmospheric phenomena" at the University of Padua, devoted several works to meteorology attempting to reconcile the results of the new science with local folklore. He thought that the influence of the Moon on sowing and harvesting, a typical popular culture belief, could be explained by the gravitational attraction exerted on the Earth by its satellite, recorded and displayed by the barometer, whose level varied in relation to the phases of the Moon.[14]

Both the barometer and the thermometer, however, being "sensitive" to variations in the atmosphere, could easily become metaphors for human qualities – most notably the presumed feminine inconstancy – in witty satirical compositions. Hence in 1754 *The Connoisseur* published a description of the "female thermometer," an (imaginary) instrument to measure "the exact temperature of a lady's passions." The "female thermometer" functioned by means of a complicated mixture placed in a glass tube, which included "distilled extracts of lady's love and maiden hair and wax of virgin-bees." The mixture interacted with the lady's "animal spirits," aroused by the passions to be measured, by rising or falling inside the tube. The instrument was set to indicate the level reached in the perilous ascent from "inviolable modesty" to "abandoned impudence," through "indiscretions," "innocent freedoms," "loose behaviour" and "gallantry."[15]

In 18th-century homes, barometers, thermometers, microscopes, walking-stick telescopes and ladies' telescopes became part of the furnishings, embodying in their materiality the val-

Fig. 11. Portable pharmacy, late 18th-early 19th century;
Museo Galileo, inv. no. 3814.



ues of the new experimental science. In the domestic sphere, along with these new furnishing objects and cultural pastimes, the "do-it-yourself" trend also found expression in medical therapies. Well-to-do families owned luxurious "portable pharmacies" with a set of phials containing various pharmaceutical compounds, ready to be used as needed to cure disturbances of various kinds (fig. 11), even while travelling. For those attracted to less conventional therapies, more in line with recent developments in experimental science, the so-called "medical electricity" offered an avant-garde alternative.

The physiological effects of applying electricity to the human body had been known since the early 1740s, when rashes and blisters appeared on the skin of persons repeatedly subjected to the experiment of the "electric kiss" or "electric commotion." The experimenters began to record pulse rates before, during and after applying electricity to the human body, noting an increase that indicated faster respiration and heartbeat. These effects suggested that sick persons might benefit by being subjected to electric shock. According to the beliefs of the time, a healthy body contained a certain amount of "natural" electricity that, if altered, could cause illness. Hence electrifying the human body could help to restore the electrical balance necessary for good health.

The technical applications of electricity became especially popular around 1746, after the introduction of the Leyden jar. This instrument, which would be called a cylindrical condenser today, was used to administer strong electric shocks to a patient who had closed the circuit between the external and internal armature (see *infra*, p. 297). The Leyden jar was normally utilized in the spectacular demonstrations described in the chapter *The Spectacle of Science*; its therapeutic applications emerged from that context. "Electric commotion" for instance, was a famous experiment that consisted of discharging a Leyden jar through a chain of people holding hands. When the first and last persons in

Fig. 12. Electric commotion experiment (Della Torre 1748-1749, pl. 2).

the chain closed the circuit by touching the outside and the inside of the jar, a violent shock was felt simultaneously by all present (fig. 12). Apart from the spectacular nature of this demonstration, the phenomenon of the electric shock demonstrated that the "electric fluid" could produce involuntary movements in muscle fibre. The Leyden jar was thus used as a therapeutic instrument in numerous diseases thought to be cured – or at least alleviated – by inducing involuntary contractions of the muscles affected. Many cases of paralysis were treated with electricity and, despite the general scepticism of the medical profession, electrical therapy was greeted as a sort of cure-all that could be applied without the supervision of a doctor.[16]

The manufacturers of electrical instruments specialised in designing devices for "do-it-yourself" electrical therapy. In 1783 one of the most successful English manufacturers, Edward Nairne, obtained a patent for his "medical electrical machine" that could be used to apply the electric fluid to any part of the body.[17] The Leyden jar was also transformed into a "medical bottle," a slightly modified version where the intensity of the electric shock administered to the patient could be controlled. In the field of self-treatment, the popularity of portable electrical machines lasted well into the 19th century, when the advent of electric current and electromagnetism held a special relationship with "vital energy," and consequently with the state of health (fig. 13).

[1] Algarotti 1737, p. 3.
[2] *Ibidem*.
[3] Fontenelle 1686.
[4] Betri-Brambilla 2004.
[5] Mazzotti 2004.
[6] Terrall 1995.
[7] Bertucci 2007, chap. 6.
[8] Dal Prete 2008; Cavazza 1995; Piccolino-Bresadola 2003.
[9] Ratcliff 2009.
[10] Lualdi 2001
[11] Lualdi 1996.
[12] Beretta-Clericuzio-Principe 2009.
[13] Golinski 1999.
[14] Pigatto 2000.
[15] Castle 1995, p. 21.
[16] Bertucci 2007; Bertucci-Pancaldi 2001.
[17] Bertucci 2001.

Fig. 13. Medical magneto-electric machine, Clarke pattern, second half of the 19th century; Museo Galileo, inv. no. 3547.

The Wheel Barometer

Paola Bertucci

The barometer, invented in the 17th century, is an instrument used to measure atmospheric pressure. Its simplest version consists of a tube filled with mercury open at the top, which is turned upside down in a basin. The pressure is indicated by the height of the mercury remaining in the tube. In the wheel model instead, the mercury is placed in a siphon tube containing a small floater connected to an indicator. This part of the instrument is not visible. The atmospheric pressure can be read on a graduated scale engraved on the dial. Decorated in rococo style, the model shown here also has an alcohol thermometer with a Réaumur scale, allowing pressure changes to be seen in relation to changing temperature.

Santino Donegani, Wheel barometer with thermometer, late 18th century; Museo Galileo, inv. no. 1140.

The Leyden Jar

Paola Bertucci

The Leyden jar was first described by Petrus van Musschenbroek in 1746. The instrument consists of a glass vessel, with an outer tin foil coating and an inner coating, usually water or gold leaf. A metal electrode was connected to the inner coating. To produce an electric shock, the jar was first charged by connecting the central electrode to an electric machine, while the outside coating was grounded (for example, by holding the jar in the hands while charging). Then the two coatings were short-circuited by using one's hands as in the "electric commotion" experiment. To treat paralysis with electrotherapy, the part of the body affected was connected to two electrodes that closed the circuit between the Leyden jar's coatings. The "medical bottle" is a Leyden jar connected to a simplified version of Lane electrometer.
This device regulates the intensity of the shock by fixing the distance between the electrode on the jar and the one on the electrometer.

Medical bottle, late 18th century;
Museo Galileo, inv. no. 446.