convenience of electrical generating machinery when he bears in mind that each of those swiftly rotating machines, any one of which could be placed within the walls of an ordinary cottage living room, is generating the enormous total of 5,000 horse power. Around the roof of each rotating field is arranged a series of hoods which serves to catch the air and cause a draught of cold air to pass through the generator. The hazy effect caused by the swift rotation of these hoods is noticeable in the illustration.

The enormous two-phase 2,200-volt currents from the

ALESSANDRO VOLTA.
From an engraving by Morghen.

generators are led to a special switchboard, operated entirely by compressed air, on which a panel containing an ammeter, wattmeter, and voltmeter for each phase and a direct-current ammeter in the exciter circuit, is provided for each main generator. On the opposite side of the canal from the power house is a smaller building, which contains the transformers, a covered passageway between the buildings serving to carry the mains. It is impossible within the limits of this article to describe in detail the various transformations of the current which are made to suit the needs of the various users. The diagram, Fig. 5, showing the wiring of the main generators, and also of the static and rotary transformers in which the current for the Niagara Falls railways is converted to direct current, will be of interest. The 2,200-volt two-phase current from the main generator is transformed by a static transformer in each phase to 440-volt current, and then led to a rotary transformer, where it is changed to 550-volt direct current for use on the local street railways. Of these the Niagara Falls and Suspension Bridge Company takes 250 horse power and the Buffalo and Niagara Falls Electric Railway 350 horse power. Perhaps the most interesting transmission is that of 6,000 horse power to Buffalo, twenty-six miles distant. The current for this purpose is stepped up from 2,200-volt two-phase to 11,000-volt three-phase in two huge static transformers located in the transformer building. These have been so arranged that by a change of connections the pressure may at any time be raised to 22,000 volts if it should be deemed advisable.

The company owns a continuous tract of land which includes two miles of river water front, and embraces over a thousand acres. Located upon this and other adjacent property are a large number of electro-chemical establishments which have been attracted to the locality. The names of some of these concerns and the horse power they are receiving from the Niagara Falls Power Company are as follows: Union Carbide Company, 6,000 horse power; Pittsburg Reduction Company, 3,600 horse power; Carborundum Company, 1,100 horse power; Mathieson Alkali Company, 2,000 horse power; Niagara Electro-Chemical Company (sodium), 650 horse power; Oldbury Electro-Chemical Company, 500 horse power; Buffalo and Niagara Falls Electric Light and Power Company, 800 horse power. Altogether the company is supplying over 22,000 horse power, and it is now under contract to supply 20,000 additional horse power for various purposes. Two additional 5,000 horse power wheels are now being installed, so that before long the present power house will have reached its designed capacity of 50,000 horse power.

In addition to its sale of electrical power the company supplies 7,200 hydraulic horse power to the Niagara Falls Paper Company, whose large establishment is located near the power house. The water received from the power company is utilized by the paper company in turbines located in its own wheel-pit, which is connected with the main tunnel tailrace by a branch tailrace 7 feet in diameter.

The visitor to this splendid plant is impressed with the great care that is taken to keep everything up to the highest state of efficiency, a care that extends to the smallest details. We present a cut of an attachment designed by the chief electrician, Mr. P. M. Lincoln, for securing an even wear on the commutators and also on the journals of the generators, converters, etc. It consists of an electro-magnet, *D*, which is held by means of three legs bolted to the frame of the generator, outside one end of the armature shaft, and a current interrupter which may be placed in any convenient corner of the building. The object of the device is to give the shaft a continuous reciprocating motion in the direction of its axis so as to prevent irregular wear in the brushes and journals. When the magnet, *D*, is excited the shaft is drawn outward, and when it is demagnetized the shaft returns by the attraction of the field on the armature. When the coil, *A*, of the interrupter is excited it lifts its core, trips a small weighted lever, and breaks the contact at the carbon points, *B*, when the coil is demagnetized and the core and arm drop, the fall being retarded by a dashpot, *C*. The device is giving good results on the machines to which it has been attached.

It will be remembered that when the Niagara Falls Power Plant was first set in motion, there was a confident prediction by the press that before many years the energy of the Falls would be transmitted electrically to cities that were 100 miles or more distant. The statement was not generally indorsed by expert opinion, and it is significant that the tendency to-day is for the manufacturers to locate at the Falls rather than for the power of the Falls to be carried long distances to the consumer. Although the current, in the present state of the art, could probably be transmitted for 100 miles with a loss in transmission of less than 20 per cent, it would cost so much more to the consumer as to render the erection of works at Niagara a more profitable alternative.

ALESSANDRO VOLTA.

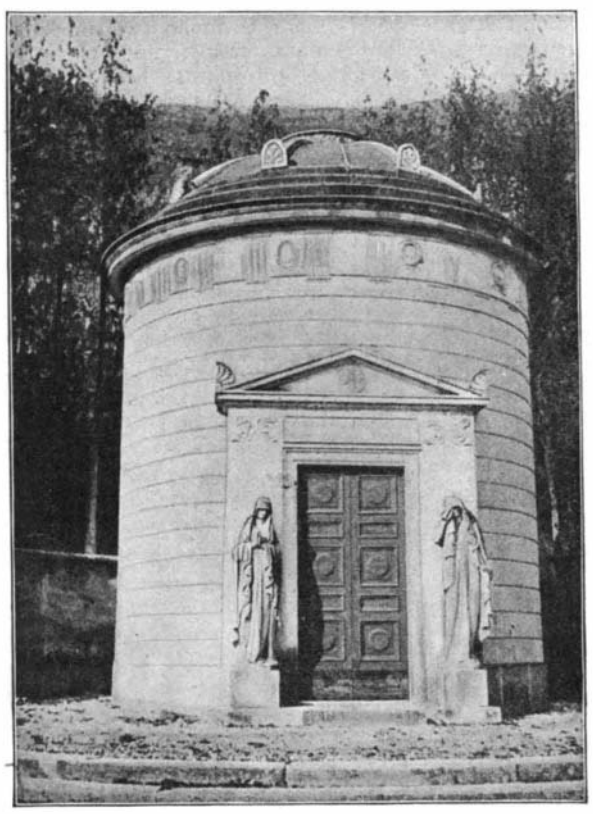
The hundredth anniversary of the invention of the electric battery by Volta was celebrated by an International Electrical Exposition at Como, which was opened with due ceremony in the presence of the King of Italy, on the 20th of May, and certainly no more fitting tribute could have been paid by the people of his native place to its most illustrious citizen.

The Volta Electrical Exhibition at Como, Italy, including the many relics of Alessandro Volta, was entirely destroyed by fire on July 8, the cause being a defective electric wire. The fire broke out in the marine gallery, and spread with marvelous rapidity, owing to the combustible nature of the buildings and their contents. Many visitors were in the buildings, and they fled in a panic. Two gasometers exploded, adding to the disaster. No lives were lost, but many exhibits and scientific records, which cannot be replaced, were burnt.

The Volta relics were contained in a receptacle built of solid masonry, but, notwithstanding this fact, they were all destroyed with the exception of some of the personal effects of Volta, including the Senatorial sword presented to him by Napoleon, and his decorations. Fortunately, we are enabled to present engravings of a number of the interesting exhibits. The illustrations were published originally in our esteemed Italian contemporary, L'Illustrazione Italiana.

Volta was born at Como, on February 18, 1745, in the house that was occupied by the Volta family for 326 years. His father was Filippo Volta, who wasted his patrimony by imprudence and prodigality, and his mother was Countess Maddalena Inzaghi. He had three brothers and three sisters; all of the former were connected with the church, and two of his sisters were nuns, but the third married Count Reina. The first two years of his life Alessandro spent in the house of his nurse. He developed so slowly, intellectually as well as physically, never speaking a word, that his parents feared that he might be a mute, until one day, when he was four years old, he uttered an emphatic "No." Afterward his progress was rapid, and even in childhood he manifested a passion for observing natural phenomena and investigating their cause, and this propensity very nearly cost him his life, for one day, when endeavoring to find something, which he supposed to be gold, in a fountain, he fell in and was in danger of drowning.

In 1758 he entered the School of Rhetoric, where he remained for three years. While there he showed a most unusual aptitude for writing poetry. When still a youth he wrote a poem of eight hundred verses on the Seasons, in Latin, which has recently been translated and published by one of his descendants, Zanino

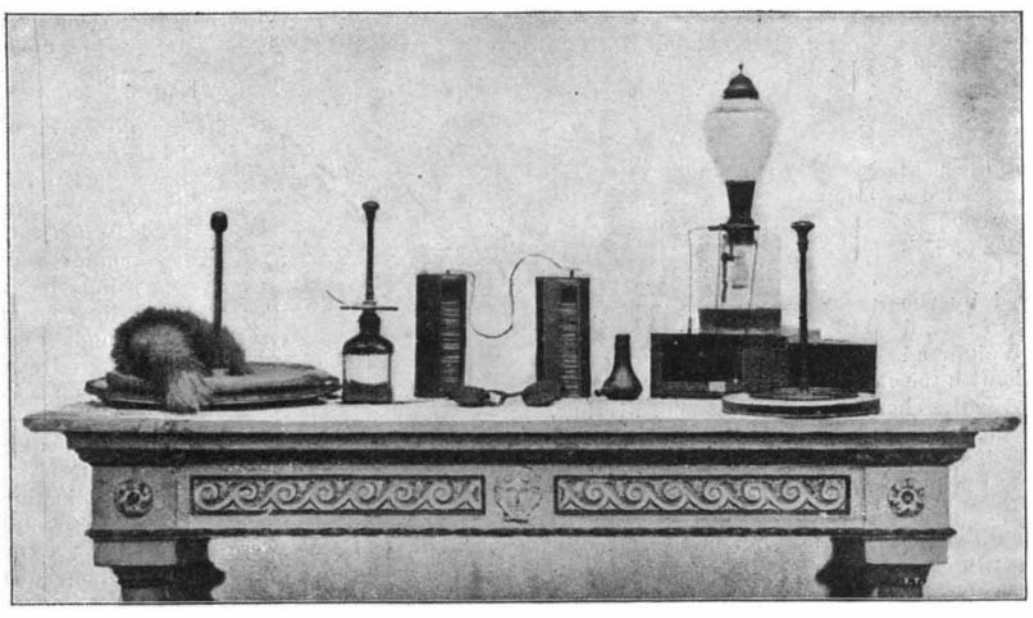


TOMB OF ALESSANDRO VOLTA IN THE CEMETERY AT CAMNAGO.

Volta. His study of philosophy began in the College of the Jesuits, where he, however, remained only one year, and was continued in the Bensi Seminary. He devoted much time to physical and natural sciences and wrote more poetry. About this time he wrote an ode, in French, on the ascent of Mont Blanc, and sent it to De Saussure. When eighteen he corresponded on scientific subjects with the Abbé Nollet, who encouraged him to publish a paper on the causes of electrical phenomena, in which he referred to the unity of physical forces, foreseen by him as well as Spallanzani and other physicists and naturalists of that time. At twenty-four he published and dedicated to Beccaria, the great Piedmont physicist, a Latin memoir, which was followed by another in 1771 on an electrical apparatus of his invention, and this was dedicated to Spallanzani.

In 1774 he was made regent of the schools of Como; an interesting account of this period has been published by Zanino Volta. The following year he invented the electrophorus, which caused a great stir in the electrical world, in other countries as well as Italy, and brought him many honors from numerous academies, leading to his appointment as professor of experimental physics in the gymnasium of Como. One of his innovations in former customs worthy of mention in connection with his work as a professor is the writing of theses in Italian instead of Latin; this he caused to be done because he thought that physical truths which were to be demonstrated by experiments, during which it was necessary to refer to apparatus and the manipulation of the same, could be more clearly set forth in the language of the students.

Investigations pursued by Volta at the hot springs of Pietra Mala and di Velleia led to his discovery of the



VOLTA'S APPARATUS AT THE INSTITUTO LOMBARDO DI SCIENZE, IN MILAN.

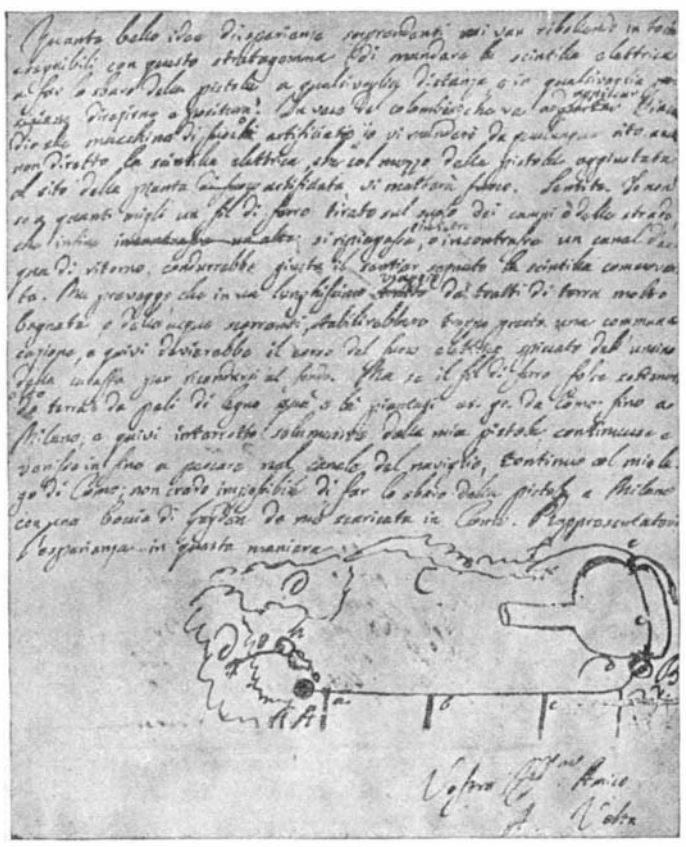
organic origin of marsh gas; and other studies to the invention of the inflammable air pistol, generally known as the "Volta pistol," and the "perpetual lamp," with which he connected his electrophorus as a means of igniting the lamp. He believed that this lamp would lead to the use of hydrogen for illuminating purposes. In 1777 he invented the eudiometer, for testing the amount of oxygen in the air. That same year he went to Switzerland, where he was received with great honor by the Academy of Physical Science in Zurich. The following year, during which he published his memoir "On the Capacity of Conductors," he was called to the chair of physics in the University of Pavia, and soon after he invented the electroscopic condenser. In 1782, after having visited the cities of the Rhine, Brussels, and Amsterdam, he went to Paris to obtain apparatus, and remained there several months, studying, visiting schools, and forming friendships with the greatest scientists of his time, among whom were Franklin, Buffon, Lavoisier, and Leroy. From Paris he went to London, where he read his memoir on the condenser before the Royal Academy, which presented to him the Copley gold medal; and then he went to Germany, where he was received by the Emperor Joseph II., who also awarded to him a gold medal. On his return he wrote his letters to Lichtenberg on "Electrical Meteorology" and the papers on "The Formation of Hail" and "The Expansion of Air."

The discovery of Galvani and the publication of his "De viribus electricitatis" brought Volta back to his electrical studies, with the well known result; that is, the invention of the electric battery. Galvani, the great anatomist and physicist, having already studied the effect of artificial electricity on animal organisms, and desiring to see whether similar results could be obtained from atmospheric electricity, suspended the thigh of a frog from an iron railing by means of a copper hook; a strong wind forced the hook against the railing, and the muscles contracted violently, and by further experiment Galvani found that whenever the nerves and muscles were connected by metal the contractions were produced, but were more violent when two metals were used instead of one. He tried to explain this phenomenon by assuming that the nerves and muscles of the animal formed a kind of Leyden jar which was discharged whenever an external circuit brought them into electrical contact. At first Volta accepted this explanation, but after having made many experiments of his own, he was convinced that the results must be accounted for in some other way. The letters and essays in which Volta describes the observations and reasoning which gradually led to the construction of the electric battery are extremely interesting. He soon came to look upon the muscles of the frog as simply a delicate electroscope which indicated the electric current developed by two unlike metals, for he attributed the electrical effects, which Galvani thought to be due to animal electricity, to the contact of dissimilar substances. This was the origin of the celebrated "contact theory." Galvani never accepted Volta's theories. The former devoted the rest of his life to the study of animal electricity, in which department he did most excellent work that was not appreciated in his time, and died before the voltaic battery or "pile" was given to the world. Volta's original apparatus consisted of a pile of alternate silver and zinc disks, with disks of cloth or paper between them moistened with brine or acid water. Copper disks were afterward used in place of the silver disks. The terminal disks were arranged with ears for convenient attachment of the wires.

September 1, 1801, Volta started for Paris with Brugnatelli, also a professor in the University of Pavia, whose experiments gave to Italy the priority in the application of the electric current to gilding. In Geneva a grand fête was given in honor of the two illustrious scientists. September 28 they arrived in Paris, where their reception was indescribable. Cuvier, Fourcroy, Berthollet, Biot, Hauy, Vauquelin, Pfaff, Lalande, Laplace, Coulomb, vied with one another in showing them honor. October 3, they attended a meeting of the National Institute, and a commission was appointed to discuss the question of galvanism.

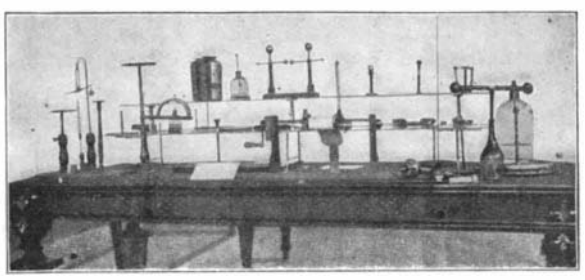
On November 6, Volta was received by the First Consul, Napoleon, who desired to attend the meeting of the Institute in which Volta read his paper and repeated the experiments with the electric battery. Bonaparte was amazed to see the chemical decompositions effected by means of the electric battery, and it is said that he exclaimed, turning to his physician, Corvisart, "Doctor, this is the image of life; the vertebral column is the battery, the liver is the negative pole, and the kidneys the positive pole."

He then spoke as a member of the Institute, declaring that the Institute owed an immense debt of gratitude to foreign scientists who, like Volta, cast such a bright light on science by means of their discoveries, and proposed that he should receive a gold medal. This was sanctioned by the vote of the commission which had been appointed to investigate galvanism, and Volta's triumph was complete. The First Consul presented him with 6,000 lire ($1,140) and an annual allowance, and made him a knight of the Legion of Honor and of the Iron Cross, a senator and a count. Bonaparte always desired to be present at any meetings in the Institute in which Volta participated, and, in fact, showed Volta such deference that some of the French scientists were jealous. Napoleon never forgot him. When visiting the library of the Institute one day, in 1803, Napoleon saw a wreath of laurel, on the bronze scroll of which was inscribed "Au Grand Voltaire," and, it is said, he erased the last three letters so that it read "Au Grand Volta." When he visited the University at Pavia, his first question was, "Where is Volta?"



AUTOGRAPH LETTER WRITTEN BY VOLTA, RELATING TO ELECTRIC WAVES.

Volta passed the last years of his life at Como, and in his villa at Camnago. His mind remained perfectly clear so that he was able to converse about his favorite science and to keep up a constant correspondence with the scientists of his time.



SOME OF VOLTA'S APPARATUS, BATTERIES, ETC., EXHIBITED AT COMO.

ONE OF THE TABLES ON WHICH VOLTA TRIED HIS EXPERIMENTS.

July 28, 1823, he had an apoplectic stroke from which he recovered only partially, and died March 5, 1827, of a slow fever, having attained the great age of eighty-two. His remains were carried to Camnago to be interred in the old cemetery, and in 1851 they were placed in a tomb erected by the family in the form of a little temple decorated by statues and allegorical bass-reliefs and a marble bust by Comolli. On August 15, 1838, Como unveiled a statue of him, the work of Marchesi, that stands in the square which has since been given his name. In the aula at Pavia, where Volta taught so many years, the configliacchi placed, at their own expense, a bust by Comolli, and in 1878, the centenary of the appointment of Volta to the chair of physics at the University of Pavia, a statue of him, executed by Tantardini, was placed in the court of the university by Francesco Rocca.

In 1875 Volta's descendants acceded to the desire expressed by the two anthropologists Cesare Lombroso and Paolo Mantegazza and the request of the University of Pavia, and allowed the disinterment of his remains. The ceremony was attended by representatives of the government and of all the Italian universities. The craniometrical examination gave the following results: Cranial capacity, 113·815 cubic inches; anterior-posterior diameter, 7·5 inches; greatest transverse diameter, 6 inches; circumference, 21·8 inches; facial angle, 73°. Cesare Lombroso calculated the weight of the brain to be 72 ounces avoirdupois weight, 15·5 ounces more than the average weight. In size, the skull resembles those of the ancient Romans. He found no depressions nor bumps except in the location that phrenologists usually assign to acquisitiveness. When this portion of Lombroso's paper was read before the Instituto Lombardo de Scienze e Lettere, there was a general laugh, for scrupulous rectitude was one of Volta's best known characteristics.

We hear very little of Volta's private life, but it is said that he was a most devoted son, husband, and father, and had many loyal friends. In 1794 he married Teresa Pellegrini, of a noble family of Como, and they had three sons, Giovanni, Flamino—who died when eighteen at Milan, where his family were living to enable Volta to attend to his duties as senator—and Luigi.

The chief relics of Volta were preserved until the time of the fatal exhibition in a hall of the R. Instituto Lombardo, where there were sixteen large portfolios of his works, published and unpublished, the decorations and medals presented to him at London and Paris, a cast of his skull, and three hundred instruments and objects used by him in his experiments, including the batteries used by him in his demonstrations before the Institute at Paris, the hydrogen lamp which was ignited by the electrophorus, the first eudiometer, the condenser by means of which he demonstrated the electricity of metals, the dry battery which he constructed before Zamboni and De Luc, and other things that are too often attributed to the inventive genius of others. Still other relics are in the possession of the University of Pavia, Il Museo Civico di Como, and of the descendants of Volta.

Internal Resistance of an Eight-wheel Passenger Locomotive.

An important article by Prof. Goss on the internal resistance of an eight-wheel passenger locomotive as determined by experiments on the Purdue testing plant, appeared in the latest issue of The Railroad Gazette. From the results of locomotive road tests and tests of stationary engines, the internal resistance of locomotives has been variously estimated at different times, but because of the very meager data upon which these estimates were based, the question has always been surrounded with a good deal of uncertainty. Prof. Goss finds a marked variation in the percentage due to changes in cut-off and speed. The highest observed value of the engine friction in percentage of the indicated horse power was 23·3 per cent, corresponding to fifty-five miles an hour and 6 inches, or one-fourth, cut-off; while the lowest value obtained was 5·5 per cent at twenty-five miles an hour when cutting off at 10 inches of stroke. The wide variations when percentages are considered are rather misleading, and are due to the horse power absorbed by friction, varying directly with the speed, while the indicated horse power does not so vary, but shows, when plotted with speed as ordinates, a curve concave downward. Because of this, says our contemporary, probably a clearer idea is got by considering the friction losses as measured in drawbar pull.

When thus taken, it appears that between 75 pounds and 130 pounds boiler pressure, other things being equal, the friction loss is practically constant; and that the friction loss in pounds pull at the drawbar does not change materially with changes in speed, but decreases as the cut-off is lengthened.

One of the most violent hailstorms of which we have any record burst over Madrid on June 9 toward six o'clock in the evening, lasting for twenty minutes. Trees were stripped of their foliage, window-panes were broken by thousands, and outhouses were demolished. The hailstones which fell are said to have been as large as nuts. On one of the principal avenues—Paseo de la Castellana—the hail descended in an avalanche, and in melting, formed a perfect river.