Engineering Professional Societies in Italy: a historical perspective

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Abstract *– The history of professional societies is examined starting with the medieval Corporations and Universities, through the Renaissance, the scientific revolution, the industrial revolution and the birth of the electromagnetism and its applications, up to the foundation of national professional associations at the end of the XIX century with the emergence of the IEEE as an international institution. Its role is discussed.*

Corporations and Universities in the Middle-Age

In today's society, characterized by science and technology, we usually assume that professions at all levels are totally different from what they used to be. This is not completely true. We can show that modern professions are evolutions of past professions. More precisely, the same concept of profession has been introduced in a formal way in the middle age, when society was organized in a number of *Corporations*, i.e. associations of professionals performing similar tasks, mostly at an artisan level, requiring specific *skills* and working *tools*.

Such Corporations were considered in texts (e.g. laws) since the V century. and also represented in paintings and sculptures in cathedrals of the epoch, see figures 1 and 2

In the late middle age we can see something peculiar: the creation of a new institution, the university, more precisely called initially *Studium generale*, then *Universitas studiorum* (officially used today in Italy: *Università degli Studi*). This institution plays the role of representing the whole *knowledge*, organized in four branches: *theology and philosophy, arts and literature, law, medicine.* They compose the *quadrivium (crossroad)*, determining the basic structure of all universities for many centuries, including the first half of the XIX century. The university has two main tasks: organize, represent and store (in libraries), develop the *knowledge*, transfer it to future generations through teaching.

This institution is still active today, across the whole world. It is surprising that a historical period considered as a "dark" one has generated a concept still valid after almost a millennium. The first university is recognized to be the one in Bologna (1088 a.d.).

The Universities generated new professions that we can consider "*knowledge- based*" in order to distinguish them from those "*skill-based*" of the Corporations.

Fig. 1: The Cathedral of Lodi, Italy

Fig.2: A bas-relief representing the Corporation of the "Shoemakers"

The "Maestri Comacini": a peculiar long lasting corporation

During the middle age Corporations evolved in various forms. We choose here to illustrate one of them, mostly because its development originated a particularly successful organization, initially in the north east of Lomdardy (including the northern sub-region that became a Suisse canton) but spreading then in other italian regions (e.g. Tuscany and Lazio) and in other European countries.

The name, Maestri Comacini, tells that they were top-level workers and some of them also artists. They could accept the task to construct buildings (also churches) taking care of their decoration. The "comacini" term can be interpreted in two ways: first as indication of their origin, the city of Como (an old roman city) and the Como lake. The second interpretation (by Ugo Monneret de Villard, a French historian) considers "comacini" as derived from the original latin expression "cum machinis" ("with (using) machines"), since it was common for them to use, for instance, tools like systems of ropes and pulleys for lifting construction materials (usually done by bare-hand men) with the help of horses. The corporation was composed from a number of specialized mobile small enterprises.

The first document concerning Magistri Comacini is signed by the longobard king *Rotari* the 22 November 643, followed by a decree of king *Liutprandus* of 28 February 713, that contains a *memoratorium de mercedibus commacinorum*, i.e. the tariffs of their works.

Some of the Magistri were artists, in particular sculptors and decorators. Besides Italy, some of the Magistri Comacini are known to have been working also in Germany, Denmark and Sweden. It is interesting to note that the *Longobards* are known to come from Scandinavia, going first to Pannonia (today Hungary), then to Lombardy in northern Italy.

Being composed by numerous independent individuals moving to work in different places they developed a secret vocabulary permitting to recognize fellows members, becoming de facto a secret society and giving origin eventually to *masonry*. With such an evolution the Magistri comacini originated a society in which the initial task became just a metaphore. Note that in the changing working places they used to live in modest houses, adjacent to the building being constructed. Those houses were called "*loggie*" (*lodges* in English, from latin *loculi*, small rooms).

The Renaissance; two special professionals: *Leonardo da Vinci* and *Michelangelo Buonarroti*

The Renaissance (XIV to XVI centuries) is a very special period in the history of Italy, characterized by an astonishing development of all kind of arts and by a revival of the greek and roman culture. We wish to mention here two personages: *Leonardo da Vinci (1452-1519)* and *Michelangelo Buonarroti (1475-1564)*, for their very special characters: both can be said to be excellent artists (one as a painter, the other as a sculptor) and, at the same time, two engineers. *Leonardo* with his *Codice Atlantico* has shown the design of totally new machines performing a variety of tasks, including flying machine (a dream represented in the greek culture by Icarus). A number of such machines are shown in the Museum of Science and Technology in Milano. His most famous painting, la *Gioconda*, is in the Louvre in Paris. His most famous fresco, the *Last Supper*, in a monastery in Milano.

Michelangelo designed the defensive wall system of Florence, took part in the conception and construction of Saint Peter cathedral in Rome. For the same church he implemented the most famous statue of *Moisé*. He is also the author of the *Pietà* in Milan and the *David* in Florence.

It is difficult to identify other artists who are at the same time also excellent engineers. It is also difficult to determine who of the two can be assumed as the archetypal Renaissance man.

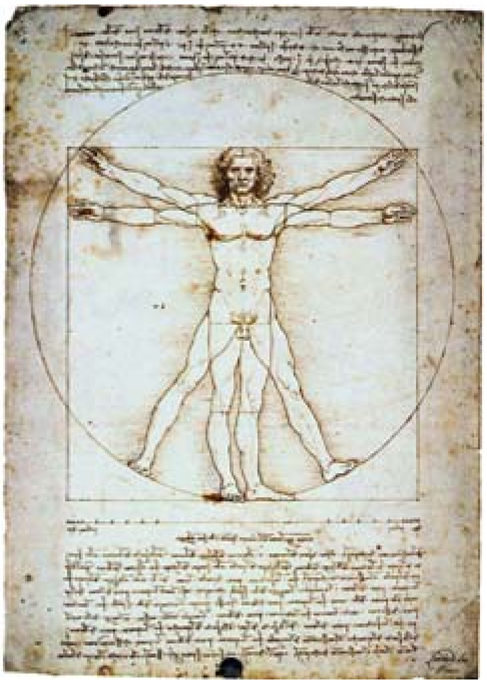


Fig.3: Leonardo da Vinci logo

The above Logo signifies that man is the term of comparison for everything: it represents the "humanism" as the synthesis of the Renaissance.

Few quotes reveal the thinking of Leonardo on science and scientific methodology:

"He who loves practice without theory is like the sailor who boards ship without a rudder and compass and never knows where he may cast."

"Nessuna umana investigazione si puo' dimandare vera scienza s'essa non passa per le matematiche dimostrazioni", or: "*No human investigation can be said true science if it doesn't stand a mathematical proof"*

The "Collegio degli Ingegneri ed architetti" (College of Engineers and Architects), Milano, 1563.

It can be considered a revival of a medieval corporation, with a relevant difference: to be admitted to the Collegio it was required to have a university degree; typically, in Lombardy, from Pavia University.

From 1563 to 1797, officially recognized by the Spanish and the Austrian governments (ruling the Lombardy region) the Collegio took care of the education of those who wanted to become engineers or architects, obtaining the "patente" (license) of professional engineers and architects. In those times the

Collegio was recognized also in the function of judging about legal disputes concerning members, its decisions being officially recognized.

A candidate engineer had to work under the guidance of a member of the *Collegio* for four years (then increased to six). At the end of this study and practice period a final examination was performed for obtaining the license.

In 1797 with the new napoleonic Repubblica Cisalpina (created by Napoleon in 1797 and dissolved in 1821), the Collegio was closed due to a general law that abolished all the existing corporations. The functions of teaching and giving professional diplomas were transferred to the University of Pavia.

In 1963, under the regime of the new Italy kingdom, an *Istituto Tecnico Superiore* (later called *Politecnico*) was founded in Milano. The previous functions concerning the formation of engineers and architects were then transferred to the new institution.

Simultaneously, the new regime decided also the creation of official professional "*orders*" for the most socially relevant professions: lawyers, medical doctors, engineers and architects.

The existing engineers decided to create a new *Collegio*, with the sole task of organizing cultural events as a sort of continuing education. The admission of the *Politecnico* graduates to the *Ordine deglii Ingegneri* was obtained after few years of practice through an exam controlled by the *Collegio*.

The original tasks of the *Collegio*, namely the teaching and the professional functions were then split in three independent bodies: the *Politecnico* , the *Order* and the new *Collegio degli ingegneri.*

The scientific revolution

Science in the modern sense starts circa in XVI century with *Nicolaus Copernicus (1473-1543)*, *Galileo Galilei (1564-1642)*, *Johannes Kepler (1571-1630), Isaac Newton (1642-1727)*. Mathematical theories and experiments are the basis of science. One of the most relevant new concept in science is the recognition that the physical world is based on *laws-of-nature* valid everywhere anytime. *Galileo Galilei* is known for having defined the laws of the motion of object due to forces, obtained through laboratory experiments or through natural systems (the fall of objects from the leaning *Torre di Pisa*, the oscillation of lamps in the *Pisa cathedral*). He also formulated the operation of the "thin lens", building the telescope ("cannocchiale") and the microscope ("cannocchialino"). He pointed the telescope to the sky and discovered four moons rotating around Jupiter. *Isac Newton* formulated the *universal gravitation law*.

Science was not discussed in Universities, rather in new institutions: the *Academies*. *Newton* (who wrote his basic text in latin) reported to the *Royal Society*, not in Cambridge university where he was professor of "natural philosophy". *Galileo* was teaching in *Padova*, the second oldest university in Italy, but strongly interested in the ship-building activities in *Venice*, thirty kilometers apart. He has been member of the *Accademia dei Lincei*, active in *Tuscany*. He wrote in italian, since he wanted to address common people. The official language in the universities was latin. *Alessandro Volta*, teaching in *Pavia* (the third oldest university in Italy) was the only one teaching officially physics. He was among the founders of the *Accademnia Nazionale delle Scienze* and was member of the british *Royal Society*. He wrote mostly in italian and French but also in latin. He has been the first president of the *Istituto Lombardo, Accademia di Scienze e Lettere* in Milano, as a model the *Institut de France* in Paris (where he presented to *Napoleon* its main invention, the electric battery, in 1800, being awarded by Napoleon of the title of Count).

Some of the European Academies

Accademia dei Lincei, in Florence, 1603
The Royal Society of Arts , in London, 1660
Academie des Sciences, in Paris, 1666 (or Institut de France)
Accademia Nazionale delle Scienze, Italy, 1780
Istituto Lombardo, Accademia di Scienze e Lettere in Milano, 1800

The enlightenment

The *enlightment* is a general cultural movement emerged in the XVIII century, having not direct impact on science and technology, but determining the general cultural environment, in which the human reason can be used to fight ignorance and tyranny, creating a new world. The enlightenment spread in Europe and also in America.

A historic important event inspired by the enlightenment took place in *Berlin* in 1800. Two eminent brothers, *Alexander* (1759-1869) and *Wilhelm Von Humboldt* (the first a geographer who discovered in the Pacific Ocean the stream *El Nino*, the second an enlighted politician) founded a new university, the *Von Humboldt Universität*, inspired by a basic principle: the scientific method applied in all disciplines even the humanities. The idea spread across Germany in the following half century and was adopted in other European universities in the second half of the XIX century.

The industrial revolution

During and after the Renaissance and due also to the science revolution, the Europeans have invented and used new and more complex machines. The main innovations occurred in the textile activities, in the use of steam power and in the iron founding. We had an important innovation also in communication, due to the invention of mobile characters in printing by *Johannes Gutenberg (1398-1468)*. In *Academies* and in *philosophical societies* members discussed themes on *natural philosophy* (i.e. science) and its application to manufacturing. The Royal Society of Arts in London published a volume on new inventions; *Denis Diderot* (1713-1784) in France published his *Enciclopedie*.

This movement has been particularly effective in Great Britain, were the industrial revolution became a reality in the second half of the XVIII century. The scientific concepts at the basis of the emerging technologies were taught in the *Philosophical Societies* The profound impact in manufacturing, mining, agriculture and transportation induced a radical change in the socioeconomic and cultural structures.

The industrial revolution, started in Great Britain, spread soon in the continent, the Vallonie (the French speaking part of Belgium) being the first step, followed by the spread in the adjacent regions of Germany and of France. This region was then called *Little Britain*, due to the large number of british engineers looking for new opportunities.

The first industrial revolution was followed by a second industrial revolution in the mid of XIX century, with the improvement of ship powered by steam engines. This engines were also inducing the invention of new machines, in particular of machines tools, i.e. machines that can produce other machines.

The steam engine solved in general the problem of obtaining mechanical energy from coal. This result has been important for a further step: the adoption of electricity for the easy transportation of energy in any place. Such a possibility gave to electricity a unique role.

Birth and development of the electrical science and engineering

At the end of the XVIII century electricity was known for the lighting phenomena during thunderstorms and as attraction effects obtained by mechanical rubbing two objects of different nature. The first phenomena have been studied extensively for their dangerous effects. *Benjamin Franklin (1706-1790)* invented the “lighting rod” as a mean for the protection of buildings. *Charles Augustine De Coulomb (1736-1816)* formulated the law that determines the force attracting or repulsing two objects electrically charged. Machines capable of generating high electrical potentials were invented. The only industrial activity generated has been the production of the *lightning rods,* used worldwide.

In 1791 *Luigi Galvani* (1737-1798) a professor in the school of medicine of the university of Bologna, during experiments in the dissection of frogs discovers that a dissected (i.e. dead) frog shakes its legs when touched by a metallic object. Galvani explains the experiments by postulating an *animal electricity*.

In Pavia university *Alessandro Volta (1745-1827),* professor of physics, repeats the frog's experiment and concludes, after a long series of experiments using different metals and non-metal conductors, that the phenomena observed are due not to a new kind of electricity, but to the known kind of electricity. Its experiments conclude in 1800 with the invention of the *electric pile*, composed from piling up a disc of copper, a disc of tissue imbibed with salted water, a disc of zinc, repeated many times. The last zinc disc, connected with a metal wire touching the bottom copper disc generates a strong spark, whose intensity increases by adding more discs to the pile.

The pile was described by *Volta* in a letter to the *Royal Society*. Many researcher experimented the pile in two directions: finding a composition of the pile capable of obtaining a better and long lasting operation, study the effects of the steady electric current. Two main results are mentioned here: the generation of a magnetic field by an electric current, by *Hans Christian Oersteds (1772-1851)*, professor of physics at *Copenhagen University* (1821); the generation of electromagnetic forces in a circuit caused by a changing magnetic field in 1855, by *Michael Faraday (1791-1867).* In same year a similar discovery was done in USA by *Joseph Henry (1797-1878).*

In 1855, *James Clerk Maxwell (1831-1879)*, (professor of physics at the Edinburgh University) wrote a *Treatise on electricity and magnetism* giving unity and coherence to the concepts composing the *electromagnetism*, a new discipline where electricity and magnetism are shown to be tightly connected. The work of Maxwell can be considered the second great unification in physics after the first one obtained by Isaac Newton.

The applications of electromagnetism: a survey

We are not giving here a detailed description of the theme (beyond the scope of this writing), but rather a scheme of its evolution, showing that the creation of many new concepts needs new professionals for their exploitation.

The development of concrete applications of electromagnetism follows soon, with the inventions of new devices performing useful tasks. Looking *a posteriori* we can classify the new applications, originating a number of new, different *scientific* and *technical professions.*

A first application domain consists in the development of new better *piles or batteries*, suitable for different applications. As an example consider the reversible piles that generate electric power and can also store it for later use. It is needed in all automobiles and in portable devices.

More generally, the study of the pile has originated a new branch of chemistry, the *electrochemistry*, allowing to devise methods of producing chemicals otherwise more difficult, or even impossible to be obtained.

A specific application is the *cathodic protection* for preventing the corrosion of metallic object. The principle of such application were first formulated by Volta.

Electromagnetism found applications in two main areas: ***information*** and ***energy***.

The first application of electromagnetism has been the *telegraphy,* using a simple new device: the electromagnetic relay. The modest required energy could be provided by batteries.

This kind of application was conceived by *Volta*: his proposal was to use wires for obtaining the effect of a pile at a distance, where it could be used to explode an inflammable gas contained in a metal container closed with a cork. Certainly it was not very practical!

William Cooke (1811-1880) and *Charles Wheatstone* (1802-1875) implemented the first working telegraph in 1839. In 1850 England and France were connected through a submarine cable crossing the Channel.

The transatlantic connection was studied and originated several attempts. In 1858 a successful line was laid down. Communication speed: 2 minutes to transmit 1 Morse-coded character, despite the use of a very sensitive *mirror galvanometer*, invented by *lord Kelvin (1824-1907)* involved in the interested companies as a consultant. The first full message took 17 hours to transmit. In 1866 the speed obtained through various improvements reached a value 50 times higher (8 words per minutes). *Oliver Heaviside (1850-1925)* and *Michael Pupin (1858-1935)* understood that the reason of the delay was the too small inductive reactance of the cable, to be corrected by inserting coils (*Pupin*) or by placing an iron tape in the cable (*Krarup (1878-1929*). In the next century the speed reached 129 words per minutes. Intermediate relays were also used as amplifiers. London became the world center in telecommunication with 11 cables connected to America and to the whole Commonwealth.

Telegraphy was soon followed (but not replaced) by *telephony*, diffused by *Graham Bell (1847-1922)*. It has been recently recognized that *Antonio Meucci (1808-1896),* born near Florence, Italy, and emigrated in USA, has to be recognized the inventor of the telephone. In 2002 the U. S. House of Representatives passed a resolution recognizing Meucci's accomplishment and stating that *"if Meucci had been able to pay the $10 fee to maintain the caveat after 1874, no patent could have been issued to Bell".*

An **"*energy* oriented"** application was also soon possible: the *lightning* (in those days obtained through candles or gas, used mostly for street lightning and also in houses). This could be obtained by using electric current to bring a piece of conducting wire to a suitable high temperature. Not an easy task. The idea was brought to practical use by *Thomas Alva Edison (1847-1931)*, who obtained the result via a carbon wire, after many experiments.

A number of researchers were active for reaching an important goal: replacing the pile (functioning on the basis of electro-chemical reactions), with a mechanical device, where the primary energy is not chemical but given by a moving (e.g. rotating) part. A number of solutions were found. A notable one was given by *Antonio Pacinotti (1841-1912)* professor of physics in Pisa university. His solution was further developed by the belgian *Zenobe Theophile Gramme (1826-1901)*, who obtained a practical system, suitable to be used in industrial applications, both as an electrical generator (called *dynamo*) as well as a motor**.**

The use of electrical *alternating current* gave origin to new machines like *transformers* and *induction motors and generators* particularly simple and reliable, allowing transmission lines voltages to be chosen according to the needs. An important contribution was given by *Galileo Ferraris (1847-1897)* with the proposal of the induction motor. Ferraris was assistant of technical physics at the Royal Italian Industrial Museum in Torino. Ferraris researched the rotary magnetic field in 1885. He experimented with types of asynchronous electric motors. The research resulted in the development of an alternating current motor. In 1888, Ferraris published his research in a paper to the Royal Academy of Science in Torino (later, in the same year Tesla gained U.S. Patent 381.968). In 1896, Ferraris joined the Italian Electrotechnical Association and became the first national president.

The development in this direction has been extremely important. It became clear that electricity could become a tool for generating electrical energy in whatever place primary energy was available and distributing it in whatever place it was needed. In the following century this idea has been fully exploited.

The foundation of the Institutes of Technology, Ecoles Polytechniques, Technische Hochschulen, Politecnici

In the middle of the XIX century and in different countries new kind of university- level institutions appear, dedicated explicitly to technology, namely the Institutes of Technology, Technische Hochschulen, Ecoles Polytechniques, Politecnici, distinct from universities. This is a clear sign of the need for a scientific technology as the base of the flourishing industry. Science, conceived with the scope of discovering the laws of nature was also seen as a key for a more advanced technology. The scientific method is a tools not only for knowing the world (science) but also for changing it (engineering).

In 1963, two years after *Milano*, previously part of the Austro-Hungarian Empire, becames part of the new Italian Kingdom, an *"Istituto Tecnico Superiore",* later called *Politecnico*, was founded with the sponsorship of several public and private institutions. Note that Milano didn't have a university. The university of the region, Lombardy, was in Pavia (30 Km apart and the longobard's capital of the region). The industrialization process had just begun and the need for engineers strongly felt. Those wanting to become engineers had few choices: Berlin, Paris, Vienna or Zürich.

The need for a school of engineering was strongly felt, both by the public institution and by the industrial environment, in its initial phase of development. Similar institutions were been founded in other countries.

In Germany, Berlin, in 1770 a *Bergakademie Berlin* is founded by Frederich II, becoming in 1799 a *Bauakademie,* in 1821 a *Technische Hochschule*, in 1879 a *Königlichen Technische Hochschule* or *Technische Hochschule - Charlottenburg.* Same kind of schools were founded: in 1868 in Munich, in 1870 in Aachen, in 1877 in Darmstadt.

In 1797 in Paris an *Ecole Politechnique* was founded by Napoleon, with the task of forming managers for the public administration with an important scientific background.

In Vienna, Austria, the *k.k. polytechnische Institut* (*k.k.* stands for *kaiserlich königlich, i.e. empirial royal*) was founded in 1815 by *von Prechtl* (a liberal thinker, humanist and pedagogue) taking as a model the *Ecole polytechnique* of Paris. In 1872 the school was renamed *k.k. Technische Hochschule*, in 1975 *Technische Universität.*

The Massachusset Institute of technology was founded in 1865.

In Torino, Italy, in 1858 a *Scuola di perfezionamento per ingegmeri* was created within the University of Torino. In same year a *Museo Industriale Italiano* is created, having also the scope of giving courses in physics.

Electrical power engineering: first attempts and developments in Italy. The role of engineers graduates of the Politecnico di Milano

Fig.4 shows the first graduates from the Politecnico di Milano in 1866. Three among them became protagonists in the industrial development of the country as founders of three relevant enterprises: the Officine Meccaniche Riva, specialized in the construction of water-turbines, the Pirelli Company, producer of electric cables and of tires, the Cantoni Company, active in the textile field.

Fig.4: The firs tent graduates of Politecnico di Milano (1966)

A success story: *G.B. Pirelli* has been the best student, graduated in 1966. Countess Kramer, an Austrian lady who decided to live in Milano, offered a scholarship to the best student in order to go abroad and specialize in whatever new discipline, at his choice. The young Pirelli, after a period spent as a volunteer soldier with *Giuseppe Garibaldi* (fig.5), obtained the prize, deciding also to follow the advice of professor Giuseppe Colombo: specialize in rubber technology as a new promising field. He went to Germany, Belgium and France. He got help from his Alma Mater to obtain the necessary financing and founded a company for producing object in rubber, some years later tires and electric cables. A strong research division characterized the company. The company got several patents applied to the very high voltage cables.

A grandson of G.B. Pirelli became an AIEE Fellow in 1962.

Fig. 5: G.B. Pirelli as a volunteer soldier with Giuseppe Garibaldi

A summary of Gian Battista Pirelli and his company's achievements:
In 1872 : he founds in Milano the *Pirelli & C.* at the age of twenty-four; a year later, the first factory for production of rubber articles.
In 1879 : the founding of *Pirelli Group* for the production of insulated telegraph cables
In 1886 a facility in La Spezia for the production of *submarine telegraph cables* used for a line in the floor of the *Red Sea.*
In 1902 : oversea plants in *Spain*, then in *Great Britain* (1914), in *Argentina (*1917), in *Brazi l*(1929);
In 1925 : first transatlantic submarine telegraph cable of 5.150 Km;
In following years: power cables installed in Chicago and New York
Transatlantic link between northern Africa and Brazil;
Cable production in Canada.
In 1982: Pirelli Group becomes the first company in Italy to produce *optical fibers* for telecommunication and data transmission.

Fig 6: Pirelli's tires

Electrical events in Milano

In 1870 a first "electrical" event took place in Milano; in piazza del Duomo, see fig.7 , a provisional tower was built, carrying at its top a lamp composed from an electric arc. The electric power was provided by a dynamo built by *Gramme*.

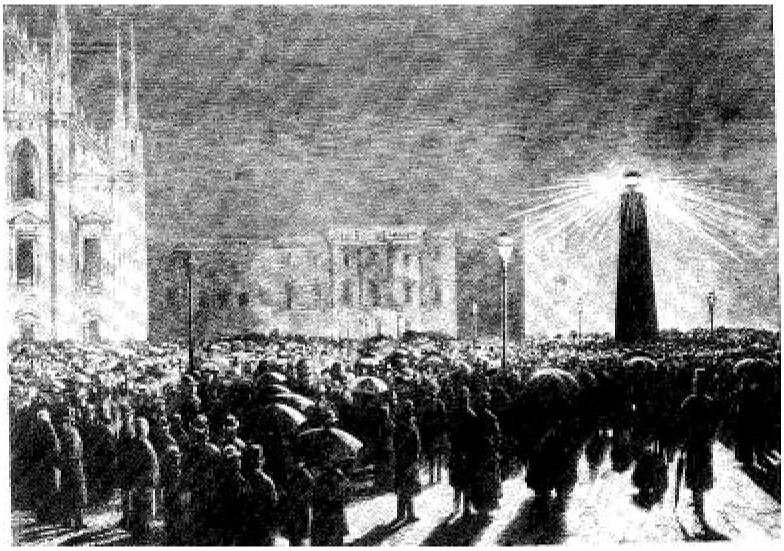


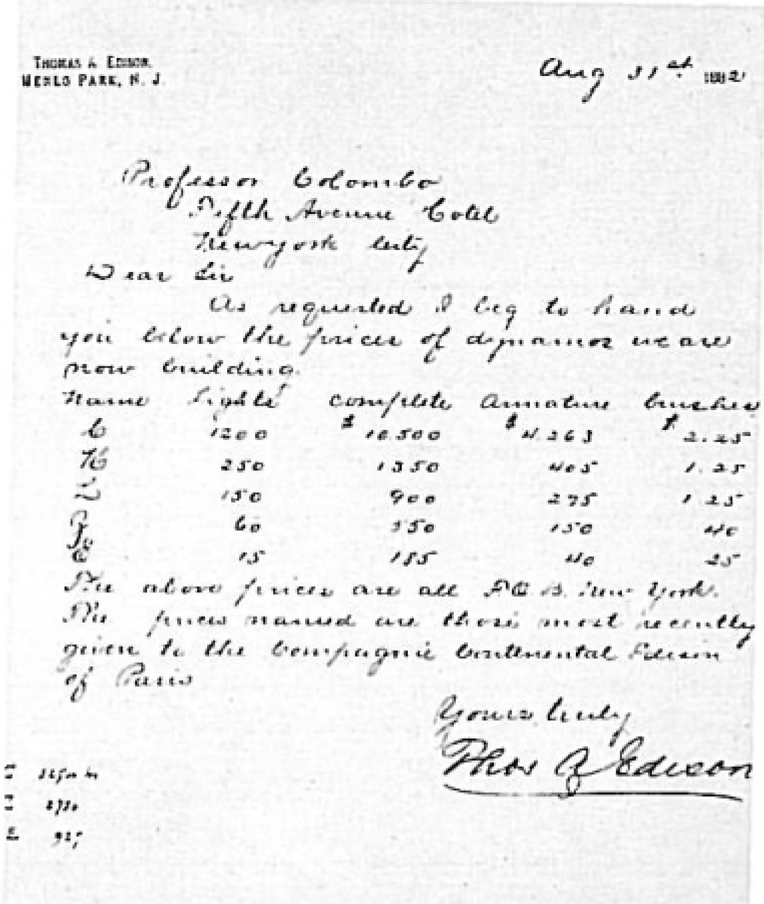
Fig.7: Piazza del Duomo, Milano, lighted with an electric arc fed by a Gramme dynamo (1870)

The involvement of Thomas A.Edison

When the Politecnico was founded in 1863 two curricula in engineering were offered: *civil (construction) engineering* and *industrial engineering*. The second was essentially based on mechanical technology. Electricity didn't have important application except in telecommunication through the only technology known, i.e. telegraphy. As such it wasn't considered so important to justify a specific engineering activity. When, however, electricity started to promise application as a technology for generating, transporting and distributing energy it became evident that it could play an extremely important role in human life. An engineering school should take care of it in preparing engineers specifically trained in the new technology.

The vice-director prof. *Giuseppe Colombo (1836-1931)* was constantly monitoring the evolutions taking place in Europe and in USA. He understood that the first step had to be a contact with those in the world were already operating in the field with practical application. He decided then to cross the Atlantic and have a direct contact with T.A.Edison, who had implemented in New York an electrical power station generating electric power for a specific application: lighting, using the lamps by himself invented.

In 1883 prof. *Giuseppe Colombo*, went in the USA where he met *Thomas A. Edison,* to whom he made two proposals: to provide machines for a first power station in Milano and to be a founding member of a new industrial company: the *Società italiana di Elettricità, sistema Edison*. Both proposal were accepted. Fig.8 is a copy of the letter signed by Edison concerning the machines. Fig.10 shows one of the machines, now placed in the entrance hall of the Department of Electrical Engineering of the Politecnico di Milano: fig. 9 is a view of the machines installed in the power station.



THOMAS A. EDISON.
MENLO PARK, N. J.

Aug 31st 1882

Professor Colombo
Fifth Avenue Hotel
New York City

Dear Sir

As requested I beg to hand you below the prices of dynamos we are now building.

Name	Lights	complete	Armature	brushes
C	1200	$ 16.500	$ 11.263	$ 2.25
K	250	1350	405	1.25
L	150	900	275	1.25
Z	60	350	150	40
E	15	185	40	25

The above prices are all F.O.B. New York. The prices named are those most recently given to the Compagnie Continental Edison of Paris

Yours truly
Thos A Edison

Fig.8: Letter of T.A. Edison to prof. Giuseppe Colombo (1982)

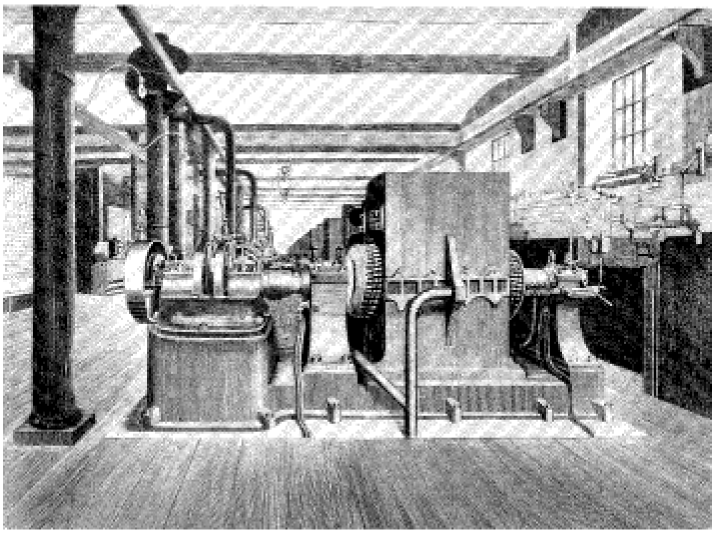


Fig.9: Edison dynamos in the power station of via Santa Radegonda, Milano (1983)

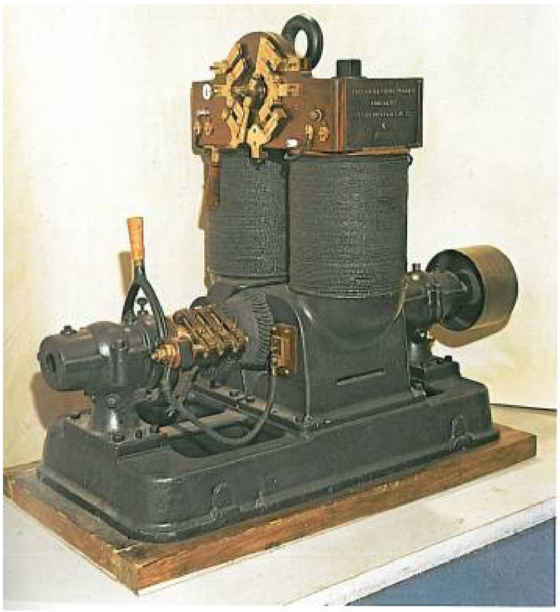


Fig.10: One of the Edison machines of the Santa Radegonda power station, now in the entrance hall of the Electrical Engineering Department, Politecnico di Milano

This was placed at a short distance from the Cathedral and was known as the station of via Santa Radegonda. It was the first station in the continental Europe. The first station was installed in New York in 1982, the second in London in 1983 (for the lighting of a viaduct). The two Edison dynamos generated 275 kW, feeding 4800 light bulbs for the lightning of the stores in piazza Duomo, in the Galleria, in the Teatro alla Scala, in the Teatro Manzoni (no more existing today) and in a number of private apartments. The cost of the new electric lightning was about twice the cost of the gas lightning. The company providing the gas reduced its tariff, but the request for the electric lightning increased soon, so that the number of the dynamos was also increased for satisfying the request: a very good start for the new Company.

The first station was replaced by a larger one at the border of the city. The Società Edison expanded its activity first in increasing the electrical power generation for the city of Milano, then expanding its activities in north Italy with the construction of dams and power stations in the Alps, with powerful transmission lines for feeding Milano and several other towns.

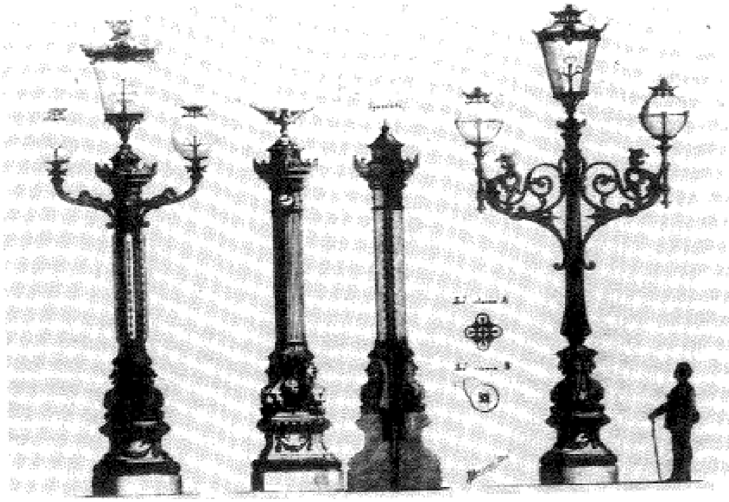


Fig11: New lighting towers proposed for the electrical street lightning.

An important step has been the power station on the Adda river, 30 km from Milano, for which a line of 30KV was needed.

The period 1880 to 1940 has been characterized in Italy by the exploitation of energy given by hydraulic systems. Italy doesn't have coal of gas sources, so that in this period all efforts have been directed to exploiting the hydraulic sources.

Professor Colombo was again in USA ten years later, bringing back a new initiative: establishing a telephone network in Milano with the creation of a new company.

The "Carlo Erba" foundation.

In the late 1800 it was evident in general that the electrical power technology was a key new resource for the country. The Politecnico has been fast in understanding its role. The feeling was, anyhow, rather general. This explain an initiative aimed at reinforcing the Politecnico's role with a decision of an industrialist operating in the farmaceutical field, *Carlo Erba*. He decided to provide a substantial fund to the Politecnico for establishing an Institute specifically directed to perform research and provide teaching in the new Electrical Engineering technology. New courses were then added to the engineering curriculum. The first electrical engineering course started in 1883. Simultaneously it was understood that the new industry needed not only electrical engineers, but also electrical technician for working effectively and also safely on the electrical machines and systems. Courses for that level were given at the Politecnico for several decades, until they were offered by specific public schools.

Simultaneously with the initiatives of the Carlo Erba institute of the Milano Politecnico, in Torino, *Galileo Ferraris* started in 1883 courses in the emerging electrical engineering in the *Museo Industriale Italiano.*

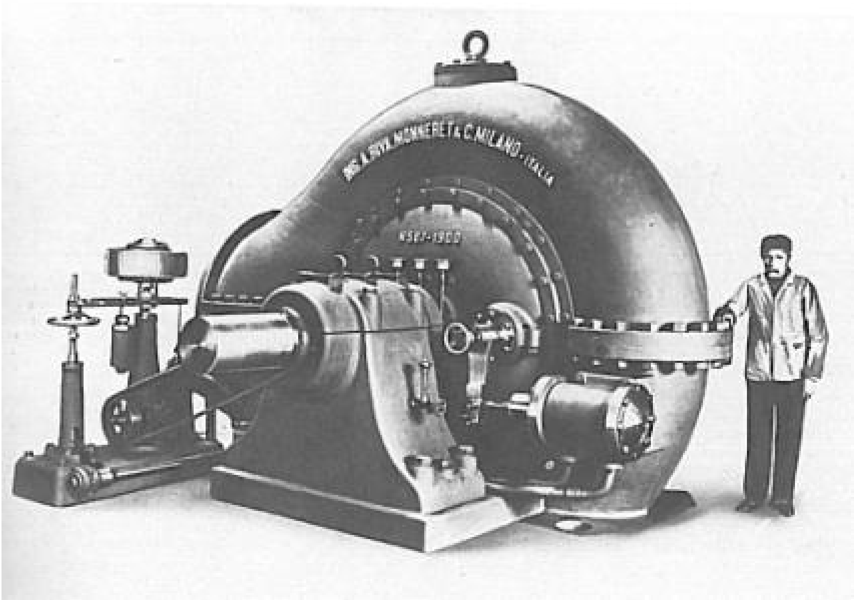


Fig.12: An hydraulic turbine for the first Niagara Falls Power station, built by the Officine Meccaniche ing. Riva-Manneret in Milano *(1897) (founded by ing, Riva, one of the first graduates from the Politecnico (fig.5)*

The foundation of national electrical associations. The role of IEEE as an international institution

In 1884 the ***American Institute of Electrical Engineers*** is founded. Similar institutes are founded in several european countries.

In Italy, after more than 30 years from the foundation of the Politecnico in Milano and the teaching and research activity in Torino, with over ten years of teaching electrical engineering, quite a number of engineers were active in the manufacturing industry and in the production –distribution of electric energy. The idea of creating a technical association emerged. This was happening also in other major technology areas, namely in cold and in hot mechanics and in hydraulics. Almost simultaneously, three associations were founded, the *AEI, Associazione Elettrotecnica Italiana* among them. The three Associations decided also to join their efforts by founding the *Federazione delle Associazioni Scientifiche e Tecniche - FAST*, in Milano. AEI created the magazine *L'Elettrotecnica.* In 1923 a new magazine, *Alta Frequenza,* was added in order to cover the *radio* field, emerged with the works of *Guglielmo Marconi (1974-1937).*

The new Associations recall, to some extent, the Academies of the XVII century, playing a similar role. Academies membership was composed from scientists, Associations membership includes a large variety of members involved in various ways with science and engineering.

The main scientific events in the first half of the XX century can be considered the following:

The discovery of the *properties of the atmosphere* relevant for the transmission of electromagnetic waves, by *Guglielmo Marconi.* For his work in this subject Marconi got the Nobel prize in 1909.

The invention of the *triode* in 1912 by *Lee de Forrest (1973-1961).*

The *radar* developed during the second world war by a team of researchers in the Lincoln Lab, MIT.

The first fully electronic digital computer, ENIAC , designed and built by John Mauchly and John Presper Eckert in 1946 at the Moore School of Electrical Engineering of Pennsylvania University, Philadelphia. It was composed from almost 18000 vacuum tubes.

The conception and construction of the first *nuclear reactor, Chicago Pile-1, in 1942,* by a team led by *Enrico Fermi.* It is a new kind of primary energy for electric power stations.

-The invention of the *transistor* by *John Bardeen, Walter Brattain* and *William Shockley* in 1947. They received the Nobel Prize in 1956.

-The *architecture of general purpose programmable electronic computers,* formulated by *John Von Neumann (1903-1957)*. Note that this includes the *software,* a new very special technology.

In the same period the main scientific and industrial events in **Italy** have been the following:The creation of institutes for the formulation of *standards,* to be agreed between producer and consumer of electrical apparatus. Some Associations, e.g. IEEE, has created structures for defining such standards. Other Associations, e.g. the italian AEI, has promoted in 1909 the establishment of a specific independent organization: *CEI – Comitato Elettrotecnico Italiano*.

At the international level, in the same year, it has been founded the IEC – International Electrotechnical Commission. IEC Standards are approved by specific committees composed from members appointed by national committees In 1938 IEC published a multilingual international vocabulary to unify electrical terminology.

In *telephonic switching* electro-mechanical technologies were adopted (mostly Siemens and Ericsonn).

Radio broadcasting started in 1924 by enterpreneurs and Marconi Group. In 1934 one state-controlled Company. RAI was founded (3 channels).

For electronic component manufacturing (vacuum tubes) in 1930 the company FIVRE was founded,

For the electric energy, only the water resources were available (with a modest contribution from a geothermal station). At the end of the second world war, most of the energy stations were still operating. The "reconstruction" period required much more energy and this led to the construction of new power stations using coal, to be imported since unavailable in Italy. A *European Community for Coal and Iron* was established: it has been the first step toward the *European Union.*

The main scientific and technological innovations in the second half of the XX century can be considered the following:

-The *software engineering* as an indispensable new discipline, launched by a group of experts convened by the NATO science committee in *Garmisch Partenkirchen*, Germany in 1968.

-The *optical fibers as a new transmission medium*, proposed in 1966 by *Kao and Hockh* at STC Laboratories (STL), Harlow, U.K. and successfully developed in 1970 by Corning Glass Works.

-The conception and implementation of *Internet* (Vint Cerf, Bob Kahn) and of the *World Wide* Web (Tim Berners-Lee).

The main events in the second half century in Italy have been the following.

In the early fifties a number of advanced programs in electronic such as:

-the design and construction of the first electron-synchrotron, designed in Pisa university and installed in Frascati (near Rome) .

-a first programmable digital electronic computer was given donated in 1954 by the Marshal Plan to Politecnico di Milano; the CRC102A, built by the Computer Research Corporation of California.

-a first electronic computer designed and built in Pisa university (a suggestion from *Enrico Fermi*) was completed in 1956.

- *Olivetti Company* created an electronic division for designing, building and installing commercial computers: ELEA 9902 (1956), joined by General Electric in 1980, closed in 1985.

- in 1957 SGS-Società Generale Semiconduttori (Fairchild-Olivetti-Telettra) is founded, in 1987 merged with Thomson Semiconducteurs (France), called in 1998 STMicroelectrinics (still in operation)

- Magneti Marelli SpA, in Milano, develops microwave radio links with 3000 channels in the 50s and 60s. Later it closes.

- Selenia SpA, in Rome, develops radar systems for air traffic control. It changes in Alenia in the Finmeccanica Group. Still operating.

-A project for the development of a geostationary satellite, SIRIO, for propagation experiments in very high frequency bands, launched from Cape Canaveral at 21 September 1977. After three years moved over China, where it operated for two more years.

- as a last (but not least) initiative in Italy in the post war period, the creation of new curricula in electronic engineering. In 1955 we started in Politecnico di Milano teaching computers, in a course, decided by the Engineering Faculty, on "*Calcolatrici elettroniche*". In the following year we started a fully new curriculum in *Electronic Engineering*, having the first graduates in 1959. This curriculum was implemented in several more universities in 1962, after a specific law was approved.

Italian industries that entered the electronic field (e.g. Olivetti) found therefore what was indispensable for any electronic activity i.e. well prepared engineers.

Electronic, used initially only in electrical communication, was applied in several new fields, i.e. computers and control systems.

It is beyond the scope of this writing to give a full exposition on what is considered electronics: it is suggested to look at the list of the titles of the 38 IEEE Societies. This tell also how big is the amount of new knowledge generated in the second half of past century, compared with the pre-war situation.

We underline here few points that, for general consensus, have characterized the electronic fields in the recent decades (and certainly also the near future).

The rate of development in semiconductors integrated circuits is well described by the well known Moore Law: the doubling every 18-24 months of the number of transistors that can be integrated in a chip. It is no more valid due to the too small size of the connections on the chip. Then: what will be the future of the logical components?

The growing extension of Internet (connecting humans) becoming an Internet of Things.

But: such questions are no more history: it's future! We, then, stop here.

IEEE will certainly offer the right ideas and the infrastructure for solving the future's problem.

Acknowledgment

Figure 1 and 2 were provided by Mrs. Laura Riccabono, architect in Lodi. The other figures were found in the archives of Politecnico di Milano, Società Edison. Società Pirelli and Società Riva, placed also in the book: *Politecnico di Milano 1963-1914, Electa, Milano, 1981.* I thank them all. Most of the information on biographies was found in Wikipedia or through Google.