Clockmakers, makers and collectors of scientific instruments in Verona in the first half of the 19th Century

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Abstract: In the first half of the 19th century, a positive technical-scientific environment developed in Verona, thanks to the fortunate presence of the physicist Giuseppe Zamboni, designer of several and important scientific instruments, professor of experimental physics and member of the "Academy of Agriculture". Zamboni was able to gather around his lively scientific activities a good deal of local people devoted most of all to precision mechanics and to the study of experimental sciences and their apparatuses. These people's activities mainly revolved around two important institutions in the city of Verona: the "Imperial real Liceo Convitto" and the "Academy of Agriculture, Commerce and Arts". Among these people, Gaetano Spandri's work stands out: he was a friend and collaborator of Zamboni's, an enthusiast of physical sciences, a private collector and a maker of scientific instruments. The paper will also consider other Veronese mechanicians' scientific activity, who worked with the "Academy of Agriculture" and with Zamboni, contributing to the creation of innovative scientific instruments.

Keywords: Scientific instruments, Giuseppe Zamboni, Gaetano Spandri, Carlo Streizig, Giacomo Bertoncelli, Antonio Camerlengo.

1. A scientific leader: Giuseppe Zamboni

In the first half of the 19th century, the city of Verona became a place of lively technical-scientific activity mainly thanks to the work of abbot Giuseppe Zamboni, a famous physicist who took advantage of the presence, in the city of Romeo and Juliet, of a great deal of skilled clockmakers, mechanicians and makers of scientific instruments. In addition to these people, Zamboni was able to work together with an eclectic local scientist, Gaetano Spandri, defined by the physicist Francesco Zantedeschi as a "dedicated enthusiast of physical sciences" (Zantedeschi 1842, p. 74). Zamboni, as is known, practiced his didactic and technical-scientific activity mainly at the "Imperial reale Liceo Convitto" (today the "Scipione Maffei High School" in Verona) where, from 1805 to his death, he taught experimental physics. At the same time, he was also an influential member of the "Academy of Agriculture, Arts and Commerce", a Verona institution since 1768 and which today is called "Accademia di agricoltura, scienze e lettere". This institution played an essential role in promoting the technical-scientific culture in Verona, from its foundation through the 19th century. In fact, this diligent promoting activity involved not only the fields of Agriculture, Meteorology and Agricultural Engineering, but also the products of the technology of the time, which were then spreading in the fields of Mechanical Arts, Commerce and Industry. As a matter of fact, from the end of the 18th century until the 1870s, the Academy organised public industrial exhibitions every three years where inventors, engineers and mechanicians presented their bright products. The worthiest were evaluated and awarded by a designated panel made up of some members of the Academy. Back to Zamboni, his name is linked mainly to the design and making of several and important scientific instruments. We will briefly illustrate only his most meaningful apparatuses (for a complete examination see Mantovani, Negrini 2012).

In 1812 he published a memoir on the dry pile (Zamboni 1812), a variation of Volta's battery he had been working on since 1800, as proof a letter answering Luigi Sebastiano Alloy, sent by Zamboni on 4th July 1800, where he gave some advice for the making of a dry pile. His idea was to make a more powerful and, at the same time, more lasting apparatus than Volta's column pile. The result was a pile capable of running on charge and working for a very long time, even several years. It did not have any acids or other liquids that could damage the metals, and it could result in very high potential differences (from hundred to thousand volts) supplying low-intensity currents, within the μA. By using this pile, the abbot from Verona made a couple of somewhat interesting scientific apparatuses. The first one, designed around 1812, was the "electromotive perpetual pendulum", that is a spectacular electric pendulum for demonstration purposes only and in perpetual motion. This apparatus was made up of a thin metallic ring pivoted on a light pendular axis. The ring was attracted and repulsed alternately by the poles of a pair of Zamboni dry column piles, so that the pendular axis could keep its oscillations continuously for several years. In Italy we have very few existing examples of this electrostatic pendulum.[1] The oldest one is a model given by the grand duke of Tuscany, Ferdinand III, to the Sienese Athenaeum in 1816, and is kept at the Museum of physics instruments of the University of Siena (Fig. 1). The second apparatus was made in 1814 and came from the idea of changing the previous model. The main change concerned the mechanics of the pendulum axis, which could activate a cogged wheel.

This modification turned the electromotive perpetual pendulum into a verge escapement clock, but with an electric propulsion system, an apparatus Zamboni perfected in the following years. To produce, repair and improve his apparatuses, Zamboni took advantage of a lot of clockmakers, makers and mechanicians from Verona, whose activities mainly gravitated between the "Imperial reale Liceo Convitto" and the Academy of Agriculture of Verona. But, he had the worthiest and most personal collabora-

[1] Three models are kept in the ancient cabinets of Physics of High Schools and, precisely, Liceo Classico "Scipione Maffei" of Verona, Liceo Classico "Virgilio" of Mantua and Liceo Classico "Marco Foscarini" of Venice (piece incomplete), today known as Museum of Physics "Antonio Maria Traversi".

tion with the already mentioned Gaetano Spandri, a local scientist, well-off and holding no official task, with whom he was both friend and scientific partner for all his life. So, who was Spandri?

Fig. 1. Electromotive perpetual pendulum dated 1816. By courtesy of Physics Collection of Scientific Instruments, Department of Physical Sciences, Earth and Environment, University of Siena.

2. A physics outsider: the amateur scientist Gaetano Spandri

Spandri was born in Verona on 30th July 1796. We have very little information on this eclectic scientist, an enthusiast of Astronomy, Meteorology, Natural Sciences and, above all, Physical Sciences. He was interested in electricity, optics, geomagnetism and electroplating. He was one of Zamboni's friends and scientific partners and was appreciated by several Italian physicists of the time, such as Francesco Zantedeschi (1797-1873), Giuseppe Belli (1791-1860), Francesco Carlini (1783-1862) and father Giambattista Pianciani (1784-1862) who defined him a "very learned and diligent person in experimenting" (Pianciani 1844, vol. II, p. 71). As a matter of fact, he was a truly skilled experimenter, but he was appreciated most of all as a maker of sundials and scientific instruments[2], a skill everybody recognized. He owned a remarkable private collection of scientific apparatuses that he kept in a large room of his private flat in Verona; it can still be visited today in the old town, in *via Mazzini* (*via Nuova* at that time), on the corner of *Via Quattro Spade*. His father, a rich and very religious merchant, gave him a strict religious upbringing which was to mark his entire life. In Verona he attended the Catholic schools of the Stigmata and St. Sebastian's, standing out for his strong interest in the scientific subjects. He was a close and devoted friend of father Gaspare Bertoni (1777-1853), founder of the "Stimmatini" religious Order, who encouraged him to an intensely Christian life. When he was twenty-one, he married Virginia, the young and educated daughter of an aristocratic man from Verona, Domenico Monga, who gave him a son, Giuseppe (1819-1881)

[2] Anyway, we know that, for more complex works, Spandri relied on his own trusted instrument makers.

who became a rather unsuccessful poet and philosopher. Marriage improved Spandri's social status; without regard to the cost, he equipped his home with a fine library, an observatory and a large collection of scientific instruments, which he patiently increased for all his life. From 1838 on, he was a member of the "Accademia di agricoltura, arti e commercio" of Verona. Here he was appointed several offices, which he kept until his death. Among his responsibilities we should remember when, in 1848, the Academy asked him to regularly monitor the weather in Verona, which he did at his private observatory. Spandri also wrote several scientific memoirs for the Academy – almost all of them are unpublished and are now kept at the archive of the "Accademia di agricoltura, acienze e lettere" of Verona.

In 1847, by notary deed, Spandri gave his whole collection of scientific instruments to the Jesuit College in Verona. Anyway, the collection was in fact given only after his death, in February 1860. Spandri died on 30th September 1859. For his works of genius, he was buried, as an eminent citizen, at Verona monumental cemetery, in the central body of the "Pantheon Ingenio Claris" (Mantovani, Briganti 2017, p. 208).

2.1. Spandri's Cabinet of Physics

Giovanni Antonio De Campostrini (1792-1846), member and president (from 1842 to 1845) of the "Academy of agriculture, arts and commerce" of Verona, in outlining a brief profile of Spandri, underlined how he had spent gold and silver in creating his rich cabinet of physics:

> Mr. Gaetano Spandri, an impeccable man, very clearly showed his love and study in the experimental disciplines, collecting at his house a rich cabinet of physics, not out of conceited vanity, but for the benefit of studies; because of the things they love the most, men are used giving gold and silver, and when they spend they reveal themselves better than in any other thing (De Campostrini 1840, p. 131).

From a handwritten source, we learn that Spandri started to collect scientific instruments in 1829. In a few years, he was able to buy apparatuses of physics and astronomy thanks partly to his wife's financial help and partly to his passion and talent. From a handwritten inventory, dated 1847, we learn that his collection consisted of 122 pieces, some of which equipped with numerous accessories (ASVR, IV.15.III-VIII).

Magnetism and static and dynamic electricity are the most represented fields. Among the most important pieces, there was an electroplating apparatus to make medals, a "Dal Negro temporary magnet", one Newman's magneto-electric machine commissioned by Zamboni to Spandri himself (for the building of this machine see Mantovani, Briganti 2017, pp. 209-210; pp. 213-216), an induction coil called Callan's machine (for its history see Mantovani 2015, pp. 88; 90) and some instruments designed and commissioned by Zamboni, such as the dynamical electroscope, the electromotive perpetual pendulum and the electric clock. As regards Optics, some microscopes by Giovanni Battista Amici and a telescope by the Viennese instrument-maker Plössl. For Meteorology, some instruments by the maker canon Angelo Bellani (1776-1852) from Monza. Lastly, for Pneumatics, at number 57 of the inventory, a double-barrelled air pump, with three accessories, stands out. Chronicles have it that Spandri used this pump for a curious religious purpose.

2.2. The air pump and blessed Bertoni

We have already hinted at the fact that Spandri was fascinated by blessed Gaspare Bertoni, founder of the "Stimmatini". He loved and esteemed this person for all his life. When Bertoni died, in 1853, the chronicles of the time reported a curious episode regarding Spandri. Some followers of Bertoni's – and particularly Spandri – demanded that the government buried the venerable Bertoni's body in the Church of the Stigmata and not at the town cemetery. The request called for a long procedure before approval; so, in the meantime, the health authorities imposed a temporary burial according to the rules of the time. They wanted that a second zinc coffin closed the first one through tin welding. During this procedure, it was decided to put a parchment in Latin with biographical data on the saint's "holy life" and "sublime virtues" in the entombment. Spandri himself carried out this task: between the two coffins he put the parchment inside a metal tube, about one meter long, and this, in turn, was closed inside a second glass tube from where he pulled out the air with the air pump (Giacobbe 1858, pp. 187-189; Dalle Vedove 1991, pp. 694, 700).

To this purpose Spandri almost certainly used the double-barrelled air pump described at n. 57 of the 1847 inventory of his machines. In this inventory the apparatus is referred to as a "pneumatic machine with professor Belli's improvement, so that vacuum arrives at a pressure of just one-third of mercury line" (ASVR, IV.15.III-VIII). It was a typical double-barrel brass air pump having a "crystal plate (for the crystal bell) reinforced in brass with a pedestal and a tap, portable, for vacuum". It had the following accessories: five crystal bell jars of the open, closed and reinforced type, the last one with a manipulator or a sliding brass rod to operate from the outside; some maintenance mechanical wrenches; an air-pump gauge; a couple of apparatuses for the experiments in vacuum, namely the expansive force of bladder (using an armed box with above double lead weights) and the fishes placed in water, both under an exhausted receiver.

From a mechanical point of view, the main innovation of this air pump was the presence of a special pneumatic air tap devised in 1827 by the physicist Giuseppe Belli (1791-1860) who, thanks to appropriate changes of the connections between the barrels and the plate, greatly improved the machine's ability of rarefaction. With this machine, Spandri tried to experiment with the burning of phosphorous in contact with iodine in a vacuum. He came up with the idea while he was reading a memoir by Gazzaniga published in 1833 in the *Annals of Sciences of the Lombard-Venetian Kingdom* (Gazzaniga 1833). At the end of the memoir abstract, written to validate Gazzaniga's entrance as an honorary member of the Academy, Spandri added:

> Then, thanks to my pneumatic machine with Belli's improvement, I tried to make this phenomenon also happen in a vacuum, whose remaining pressure was almost half a barometric line (AASLVR, 1839.08.283, synthesis of memory n. 4).

3. Other makers and mechanicians from Verona

In Verona Zamboni and Spandri enjoyed a scientific environment, which was extremely lively and active, thanks to the presence of a good deal of mechanicians and makers of scientific instruments. We mean Carlo Streizig, Antonio Pozzi,[3] Domenico Zamboni and Giovanni Bianchi[4]. As regards the *Academy of Agriculture*, instead, we are referring to people like Giacomo Bertoncelli, Antonio Camerlengo, and the mechanical engineer Bartolomeo Avesani.[5] Without claiming to be complete, I am going to introduce some short scientific profiles of some of them.

3.1. Carlo Streizig

We have very little information about this talented clockmaker and mechanician. He was a machinist at the Cabinet of Physics of the "Imperial reale Liceo Convitto" of Verona and worked with the physicist Giuseppe Zamboni for several years. At the same time, he ran a mechanical workshop in Verona, where he would sell apparatuses of Physics and Mechanics. Under Zamboni's supervision, he made some models of the "electromotive perpetual pendulum", at first for the "Liceo Convitto" Cabinet of Physics and then on his own to the benefit of his mechanical workshop. From an undated price list named *Catalogue of instruments that can be sold in the shop of the clockmaker and machinist Streizig in Verona* (Pieri 1950, p. 49), we learn that Streizig sold three models of the electromotive perpetual device: the basic model with the Zamboni piles, costing 5 Luigi (the Lombardo-Veneto currency); the clock model, marking hours and minutes, with an enamelled dial, decorated in gilded metal, costing 10 Luigi; an identical model but "with a fine gilded clock machinery", costing 12 Luigi.

As Zamboni himself says, the first model of a clock obtained by modifying the electromotive perpetual pendulum was made by Streizig in 1814. At first, it only had the hour hand on its dial. A jointed lever pivoted on the vertical pendulum, swinging, pushed the tooth of one wheel every two oscillations (Zamboni 1822, p. 345). Starting from February 1815, thanks also to the evolution of the dry pile, Straizig improved the clock mechanics, developing a 2-wheel mechanism which marked hours and minutes (Zamboni 1816, pp. 32-36). A model signed "Streizig Verona", the only surviving one, is preserved in Modena at the Civic museum of art, section "scientific instruments". The design and construction of this electrostatic clock were claimed by Francis Ronalds in England and by the machinist of the "Royal academy of sciences" of Munich, Mr Ramis. Zamboni defended with many reasons the precedence of his apparatus.

Streizig proposed and also produced other scientific instruments. For instance, he simplified Read's syringe to extract poison from the stomach (Zamboni 1831, p. 277) and

[3] In 1817, this mechanical watchmaker applied the anchor escapement to the "electromotive perpetual pendulum".
[4] At the "Liceo Scipione Maffei" of Verona is still preserved a fine electric clock built and signed by G. Bianchi (1780-1858).
[5] Avesani is mainly remembered for the invention of a new "simple and cheap" steam machine (Scopoli 1831), awarded with the gold medal and for this, he was appointed corresponding member of the Veronese Academy.

made for Giacomo Bertoncelli a new hypsographic scale for barometers (Bertoncelli 1817, pp. 16; 110).

At the Scales Museum in Campogalliano (Modena) there is a hydrostatic scale signed "Made by Streizig in Verona 1816". Finally, at the "Scipione Maffei" High School in Verona there is a rare brass microtome for histological sections, which has engraved on the base: "Made by Streizig in Verona 1815" (Fig. 2).

Fig. 2. Microtome signed by C. Streizig. By courtesy of "Scipione Maffei High School" in Verona.

3.2. Giacomo Bertoncelli

The Veronese Giacomo (sometimes Jacopo) Bertoncelli (1783-1848), eclectic scientist and technician, was a pharmacist, botanist, chemist, physicist and meteorologist. At first, he was assistant in the Physics and Chemistry classes at the "Imperial reale Liceo Convitto" in Verona, then, until 1820, teacher of Chemistry, Botany and Drawing, and finally professor of Pharmaceutical chemistry at Verona civic hospital. In 1817 he published a work, that was somewhat criticised by the physicists of the time.[6] It was divided into two parts: the first part was a compendium on theory and practice of barometric levelling; the second one described in practice the use of a new scale, invented by the author, called hypsographic (Bertoncelli 1817). This scale was adopted for barometers and allowed measuring the height of places without calculating or consulting the barometric and hypsometric tables.[7] From a letter published by Dandolo (1819, pp. 266-272), we learn that, starting from 1818, he engaged in sericulture, an activity he practiced thanks to a silkworm nursery placed in St. Anastasia in Verona; next to it there was a shop, called "Ber-

[6] Specifically, the opinions dealt with the lack of corrections due to air humidity and to the capillary action of the barometric tube.
[7] The value, then, had to be correct for air and mercury temperatures.

toncelli's spicery", where he even sold thermometers for silkworms.[8] In August 1826, he became a member of the "Academy of agriculture, arts and commerce" of Verona where he made agrarian observations from 1831 to 1847. In 1841 he was officially appointed "meteorological observer" (Bertoncelli 1842) at the "Botanical-agrarian garden" of the Academy. In 1842, after De Campostrini's appointment to director of the Academy, Bertoncelli was appointed director of the "Botanical-agrarian garden"; his position of meteorological observer was given to Giuseppe Zamboni, who held it until the end of 1845, while still taking advantage of Bertoncelli's cooperation. With the death of Zamboni in 1846, the position of meteorological observer returned to Giacomo Bertoncelli who kept it until his death in August 1848.[9] In 1842 and 1844, he joined the fourth and sixth meeting of Italian scientists, held in Padua and Milan (Cantù 1842, p. 40; Riunione degli scienziati italiani 1844, pp. 15; 26). Finally, in 1842, in cooperation with Gaetano Spandri, he became interested in Electroplating, a new electro-chemical technique invented some years earlier, which permitted the reproduction of small objects by depositing a thin layer of metal on a special non-conductive mold that acted as the cathode of an electrolytic cell. On this subject, Bertoncelli and Spandri presented a memoir that is still preserved today in the Academy's archives, and that was read in a public session on May 12, 1842 (AASLVR, b. III, 21).

3.3. Antonio Camerlengo

Clockmaker from Verona and a fine producer of scientific instruments, Antonio Camerlengo (1768-1836) mainly worked as mechanician for the "Academy of agriculture" of Verona. He submitted to the Academy some of his inventions, and collected several awards, deserving the high qualification of academic machinist since 1815 (Carli 1815, pp. 439-441). In 1802, Camerlengo presented the Academy a pendulum clock with a new escapement, followed, two years later, by a machine for making and shaping clocks' toothed wheels, both awarded by the Academy.[10] In 1806, as suggested by Zamboni, he built, among the first in Italy, the Atwood machine, an apparatus to test the Newton's laws of motion (uniform and uniformly accelerated) that Zamboni used for several years when teaching at high school (Zamboni 1843). This machine, which is now kept in the Cabinet of Physics of "Scipione Maffei" High School in Verona, bears the signature "Made by Antonio Camerlengo in Verona, 1806" engraved on the low friction brass tribometer.[11]

In 1808 he presented the "Macchina correzionale dell'argano" (Camerlengo 1808), namely a Corrective machine of the hoist. It was a hoist that multiplied the acting force,

[8] Some of these thermometers were made by Bertoncelli, others were made by canon Angelo Bellani (famous maker of scientific instruments for Meteorology) who kept, at the "Bertoncelli's spicery", his own store of scientific instruments (Bertoncelli 1838, p. 242).

[9] Giacomo's son, Bartolomeo Bertoncelli, also a member of the "Academy of agriculture" of Verona, carried on his father's activity and became a meteorological observer of the Academy in 1854, an office he kept without interruption until 1898 (Accademia di agricoltura, scienze e lettere di Verona 1971, p. 60).

[10] The machine for toothed wheels was donated by the Academy to Napoleon I, emperor of the French and king of Italy, during his visit to Verona on 13th June 1805.

[11] A similar machine, but with a much simpler tribometer, signed "Made by Giuseppe Stefani in Padua in 1806", is now kept at the Museum of Physics "Antonio Maria Traversi" in Venice.

corrected some typical defects of its usage, and made it safer in the civil, military or nautical field. For instance, it safely blocked a load at a given height, or winched it up/down with no danger.

From 1820, Camerlengo stood out in the improvements to the electric clock. In 1821, he made one with two wheels: it operated with a drive power of about one third the power needed to operate the previous models (Stratico 1839, pp. 316-317). Then there was the invention, in 1823, of a pocket watch with a "perpetual" cord that kept the watch always charged by means of a weight and a counterweight, both powered by Zamboni's electrostatic clock. The next improvement was to eliminate the cord and weights to keep it loaded. From this moment on, the electric clock entered the stage of its best perfection. Zamboni relied on Camerlengo's technical-scientific skills to make a particularly innovative clock as regards its mechanics and power electric source. The mechanism was equipped with a gridiron pendulum (iron and brass system) to neutralize the thermal expansion and with a low-friction gear train to facilitate the motion of the pendulum. The brand-new pendulum regulator wall clock, called "royal", was introduced by Camerlengo to the Academy in a letter of May 1827, which is now preserved in the archives of the "Academy of agriculture" of Verona (AASLVR, b. 1827). This sophisticated athermic "royal pendulum" was accurate to the second.

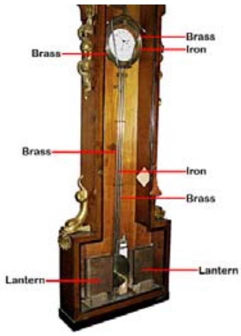

Fig. 3. The Royal Pendulum built by A. Camerlengo in 1827. By courtesy of "Accademia di agricoltura scienze e lettere" in Verona.

The clock was housed in a wooden and glass case about one meter long (Fig. 3) and the pendulum moved isochronously between the opposite poles of two Zamboni dry piles. Its propulsive mechanics was based on the oscillatory motion of the circular brass mass of the pendulum within two brass plates, both bent into a "U" shape, called "lanterns". The mass controlled the movement of a three-wheeled gear train which marked the hours, minutes and seconds on the clock face. The most meaningful innovation were the lanterns themselves, which were charged with opposite electric charges by two Zamboni dry piles. When the pendular mass entered a lantern, it touched the curved plate, charged itself with the same electric charge and was repulsed towards the second lantern which, meanwhile, being charged with the opposite electric charge, attracted it to its side; the pendular mass came into contact with the second lantern, was repulsed, and so on, cyclically powering the pendular motion.

This clock was tested in the "Liceo Convitto" Cabinet of Physics in Verona by Zamboni who, with satisfaction, in a letter dated May 29, 1827, certified for the Academy its very good structural quality and its undeniable mechanical advantages.

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