

Salvá's Electric Telegraph Based on Volta's Battery

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Abstract—Contemporary of such important figures as d'Alembert, Buffon, Franklin, Kant, Betancourt or Goya, Francisco Salvá y Campillo was also a prominent Enlightenment scientist who shared with all of them his passion for knowledge and his support to the empiricism and to the scientific method. Five years before Samuel Thomas von Sömmering demonstrated his electro-chemical telegraph to the Munich Academy of Sciences, Salvá proposed a very innovative electric telegraph based on Volta's pile, for generating an electric current, and the electrolysis of the water, for detecting such a current flow. Salvá presented his electric telegraph to the Academy of Sciences at Barcelona, Spain, in 22 February 1804, and left his thoughts written in a not very well known essay titled: 'Second Report about Galvanism as applied to Telegraphy' which will serve as the basis for this paper.

Index Terms—Electric Telegraph, Electrolysis Process, Francisco Salvá, Galvanism, Volta's Battery.

I. INTRODUCTION

Although the Spaniard Francisco Salvá y Campillo (1751-1828) is well known by his early proposal of an electrostatic telegraph system in 1795, it is not usually recognized his valuable contributions in the field of electrical telegraphy carried out a few years later, in 1803-1804.

Francisco Salvá proposed a very innovative electric telegraph system based on two novel discoveries that had recently been made in Europe: the Alessandro Volta's electric battery and the electrolysis process leading to the decomposition of water found by William Nicholson and Anthony Carlisle, both achieved in 1800.

Salvá's Electric Telegraph system was presented to the Royal Academy of Natural Sciences and Arts in Barcelona, Spain, (or Barcelona Academy of Sciences) in 22 February 1804, five years before a very similar one developed by the Polish Samuel Thomas von Sömmering (1755-1830) which is, by contrast, more recognized at present. Francisco Salvá left written his thoughts about this electric telegraph system in a non very well known report titled: 'Memoria Segunda sobre el Galvanismo aplicado a la Telegrafía', in Spanish, or 'Second Report about Galvanism as applied to Telegraphy', in English, which will serve as the basis for this paper.

Manuscript received on August 29, 2008.

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II. LIFE OF SALVÁ

Francisco Salvá y Campillo was born in Barcelona, Spain, in 12 July 1751 [1]-[2], although some researchers refers to his birth date as July 11 [3]-[4]. His father was a Doctor in Medicine, who served as a staff Physician at Barcelona General Hospital, and his mother was the daughter of a well-off Pharmacist. With this background, it was not surprising that Francisco Salvá early showed a keen interest in Health Sciences. He studied for three years in the University of Valencia, Spain, and obtained his B.Phil. degree in Medicine from the University of Huesca (Spain), in 1771, after which he received his Ph.D. degree in Medicine from the University of Toulouse (France), to finally obtain the homologation of his doctoral degree from the University of Huesca (Spain).

He established a medical practice in Barcelona in 1773, at the age of 22 and, at the same time, he entered the Academy of Practical Medicine located at the same town, now called the Royal Academy of Medicine of Catalonia. This institution supported a kind of medicine more scientific and less traditional in order to progress in the cure of diseases. Along the years, he became Vice Secretary, first, and Secretary, afterwards, of this Academy, and he used to take part in all its sessions and initiatives.

Influenced by the *Enlightened* ideas coming from France, Salvá not only devoted his life to Medicine, but he also spread time and thought over many fields for productive cultivation of his inventive ideas. In 1780 he started his meteorological activities, collecting different atmospheric variables by means of self-made instruments located at his home address on Petritxol Street, Barcelona. In 1783 he made, joint with his colleague Francisco Santponç, a new fiber removing machine for hemp and flax and, in 1784, both men together with Priest Mariano Oliveres carried out the first experiences with a hot-air balloon ever conducted in Barcelona [5]. Moreover, his studies on Physics let him to be proposed as a member to the Royal Academy of Natural Sciences and Arts in Barcelona, taking his seat in it on February 8, 1786 [1]. His main field of interest in this Academy was Electricity, to which he made some remarkable advances, such as a type of electrostatic telegraph and a proposal of an electric telegraph, which is the reason for this paper.

Salvá was also a regular contributor to the Magazine 'Memorial Literario, Instructivo y Curioso de la Corte de

Madrid' and to the newspaper 'Diario de Barcelona'. Furthermore, he took part in different scientific contests developed by the *Société Royale de Médecine de Paris*, of which he was a Correspondent Member. He had time to write four essays conducting to solve different problems raised by this institution, all of them awarded to him [4].

He moved to the capital of Spain, Madrid, from 1796 to 1799, where he lobbied for obtaining a Chair in Clinical Medicine managed by the Academy of Practical Medicine in Barcelona. In fact, Salvá became a joint holder of this Chair, in 1801, along with his colleague Vicente Mitjavila [3].

In 1802, at the age of 51, Salvá got married to Lucía Steva, daughter of Juan Steva, one of the founders of the Academy of Practical Medicine, with whom he had no children. She was much younger than him and, in Prof. Sánchez Miñana's words, had a character very distinct to Salvá [1].

At the time of the French occupation of Spain, from 1808 to 1814, Salvá took a neutral stance toward the invasion. That was the reason why a legal proceeding was initiated against him to clarify responsibilities once the Napoleonic troops were defeated. This proceeding was terminated with no consequences for him [6].

In his last years, Salvá carried on with his medical practice and with his lectures, in spite of his frequent memory losses. Salvá died in 13 February 1828, because of a cerebral disease,



Fig. 1. Portrait of Francisco Salvá y Campillo painted by José María Marqués in 1900. Source: Eurotelecom-90 [19].

receiving a humble burial, as was his wish. At that time, he had become an important figure in the scientific scene of Barcelona, to the point that Pedro Díaz de Valdés, Bishop of

Barcelona, came to say that *whether he was not the Prince of Physicians, he deserved to be called the Physician of Princes* [4].

There is no portrait of Salvá made during his lifetime, but there are two made after his death. The older one was painted by Juan Llimona, in 1886, and the second one was painted by José María Marqués, in 1900. This is, for sure, the best known image of Salvá, which was part of the catalog edited with the occasion of the Eurotelecom Forum hold in Madrid in 1990. It is shown in Fig. 1.

III. WORK OF SALVÁ

Contemporary of such important figures as Jean le Rond d'Alembert, Georges-Louis Leclerc (Comte de Buffon), Benjamin Franklin, Immanuel Kant, Agustín de Betancourt or Francisco de Goya, Francisco Salvá was also a prominent Enlightenment scientist who shared with all of them his passion for knowledge and his support to the empiricism and to the scientific method. He spread time and thought over many fields of research. Medicine, Meteorology, Mechanics and Electricity were the most remarkable ones.

A. Medicine

Medicine was the field where he obtained his doctoral degree and the area where he started his professional activities. As a Physician, he introduced in Spain the practice of the smallpox inoculation to prevent this serious disease, in opposition to the opinion of Anton van Haen, a prominent Dutch scientist contemporary of his. He was one of the first in carrying out this practice before Edward Jenner found out that inoculating a young boy of 8 years old with cowpox, gave him immunity to smallpox.

He also studied how to macerate hemp and flax with no risk for human health, preventing inhalation of fumes, and how the human organism can be positively or negatively affected by climate and feeding conditions. It is also worth mentioning that he carried out a detailed study about causes and cures of spotted fever (*fiebres pútridas*) [3].

B. Meteorology

Salvá was one of the first people who were aware of the great influence that meteorological forecasts had in the progress of Agriculture, Physics and Medicine. He made his own instruments and placed them at his home in order to collect different atmospheric variables. At first, he had a thermometer and a barometer that were later completed with a hygrometer. He made observations three times every day: in the morning, in the afternoon and at night, at 11 pm, registering data from the instruments and from his watching of the sky. He also took notes about diseases happened every year, from 1780 to 1794. All his records, from the very beginning, were regularly hand written in four diaries and one notebook, from January 1780 to December 1824, which are

the oldest meteorological data available from Spain at the present time [1].

C. Mechanics

The first known mechanical apparatus proposed by Salvá was a new type of fiber removing machine for hemp and flax, which he built in 1783 joint with his colleague Francisco Santponç and the help of a craftsman called Pedro Gamell. Salvá and Santponç also developed a new type of portable burner that was safer and cheaper than other existing ones. In 1784, both men together with Priest Mariano Oliveres carried out the first experiences with a hot-air balloon ever conducted in Barcelona and, at the turn of the century, is also known that Salvá was involved in two amazing projects: a dry canal for transportation and a submarine vessel.

The dry canal was conceived as a track made of wood rails placed on an incline plane, over which a wheeled supporting carriage could be moved by pulling it with a rope. Salvá carried out a successful demonstration of his apparatus on a vegetable garden adjacent to the Barcelona Academy of Sciences in 1800 [5].

On the other hand, the submarine vessel was indeed an idea conceived with the aim of *making ships to be able to walk under the sea in order to rescue shipwrecked people*. In Salvá's own words, the main difficulty was to guarantee the ventilation air flow of the vessel, which he tried to solve by generating oxygen from water [4]. Unfortunately, he had neither the necessary funds nor the available time to progress in this matter.

D. Electricity

Salvá first started to study the atmospheric electricity coming from thunderstorms and lightning. In relation to this question, he improved the lighting rod conductor devised by Franklin. Following the theories of the American scientist, Salvá also argued in favour of a one-fluid theory of electricity, carrying out some demonstrations to check it out. Moreover, he run again some of the experiments that were being carried out by Volta and Galvani, before writing the essay that was going to give him a well-earned reputation. This essay was titled '**Electricity Applied to Telegraphy**' and was presented to the Barcelona Academy of Sciences in 16 December 1795 [7].

Salvá supported electric telegraphy as a better option for communications than optical telegraphy so, working on the basis of the experiments carried out by Watson and Bewis in which a Leyden jar was discharged through a wire, he proposed his well-known electrostatic telegraph. Salvá's apparatus called the attention of Godoy, Counselor of State (this position would be equivalent to a Prime Minister at the present time), who invited him to show his electrostatic telegraph in the presence of the Royal Family in Aranjuez, what he did in 1796.

In the following years, Salvá conducted some experiments

on galvanism that he reported again to the Barcelona Academy of Sciences. The first one was presented in 19 February 1800 under the title '**On the Galvanism**' [8], and the second one was presented in 14 May 1800 under the title '**On the Application of the Galvanism to the Telegraphy**' [9]. In his proposal, Salvá made use of frogs to communicate by means of the twitching of their limbs.

Meanwhile, some remarkable progresses were being done in Europe: Alessandro Volta, in Italy, as the result of a professional disagreement over the galvanic response advocated by Galvani, had invented the electric battery, which was able to produce a steady electric current; and William Nicholson and Anthony Carlisle, in England, had discovered the electrolysis process leading to the decomposition of water when an direct current passed through it, producing bubbles of oxygen and hydrogen.

Salvá should devise the advantages that these both discoveries could have over his previous telegraph systems because, in 22 February 1804, he presented a new essay to the Barcelona Academy of Sciences, titled '**Second Report about Galvanism as applied to Telegraphy**' [10], where he reported his ideas for making use of a voltaic pile, in preference to Leyden jars, to generate an electric current and of the electrolysis process, instead of the electric shock, the attraction of a pith ball or the twitching of a frog leg, to detect such a current flow.

IV. PREVIOUS STUDIES ON SALVÁ'S ELECTRIC TELEGRAPH

In contrast to his 1795 Electrostatic Telegraph, not very much has been written in English about the 1800 Salvá's Galvanic Telegraph and even less on his 1804 Electric Telegraph. In fact, only a few references have been found about it and none of them are detailed enough.

Ellison Hawks refers to Salvá as the inventor of the first electro-chemical telegraph when he talks about the Spaniard and his description of how insulated wires might be laid under the oceans and the water used, instead of return wires, to complete the circuit [11].

A second historian, John Munro, says Salvá was apparently the first to recognize the application of Volta's pile to the telegraphy, in such a way he proposed to use it and, then, to interpret the signals by the twitching of a frog's limb or by the decomposition of water [12].

And more recently, Anton A. Huurdeman also refers to Salvá as the first one to make use of the electrolytic decomposition of water as a signal indicator in 1798, whereas he mentions to Sömmering as a German anatomist who conceived the same idea and demonstrated it to the Munich Academy of Sciences in 1809 [13]. Of course, neither the date of 1798 is right, because it was not until the year of 1800 when the electrolytic decomposition of water was discovered, nor Sömmering was a German citizen, unless his birth place was considered to be located at the Kingdom of Prussia, then a part of the German Empire. Moreover, the same author is

confused when he mentions some experiments carried out by the Spaniard Agustín de Betancourt, in 1787, using Leyden jars and static electricity to send telegraphic messages between Madrid and Aranjuez, a small village sited 47 kilometers south of Madrid. Indeed, Betancourt did establish a communication system between Madrid and Aranjuez although it was not an electrostatic telegraph but an optical one. And, finally, it has also to be mentioned the study carried out by Romeu and Elías on the occasion of the 2001 IEEE Antennas and Propagation Society International Symposium, where they made a very brief reference to a certain 1807 Salvá's Electric Telegraph –obviously a mistake– when they really referred to the 1804 one.

On the other hand, there are more references about the 1804 Salvá's Electric Telegraph in Spanish literature. The first person who claimed the pioneering work of Salvá was Félix Janer, a disciple of Salvá, in an Elegy to his Master written in 1832 [6]. Janer always kept that Salvá was the first person to make use of Volta's battery with the intention of conveying knowledge at a distance by means of electricity. In fact, when it was known, in 1837, a certain article published in the Magazine 'Scotsman', from Edinburgh, with information about the invention of a type of electric telegraph [14], Janer quickly made a mention about this information to the Barcelona Academy of Sciences taking advantage of this occasion to recall the work of Salvá. By the way, the electric telegraph that refers the Magazine 'Scotsman' was the one patented by Wheatstone and Cooke that year.

Suárez Saavedra, a telegrapher and well known Spanish historian, also recalled the pioneering work of Salvá in his famous book 'Tratado de Telegrafía' (Treatise of Telegraphy). Suárez Saavedra refers to the three models of Salvá's Telegraphs and to the experiments that were carried out. Furthermore, he also makes a very detailed explanation of how they worked [15]. Suárez Saavedra also took the relay from Janer in such a way that he claimed the work of Salvá both in a paper sent in 1876 to the 'Telegraph Exposition' that took place in South Kensington, London, and in a letter sent in 1879 to the Director of 'Journal Télégraphique', the official publication of the International Telegraphy Union (ITU) [16].

Two contemporary Spanish historians who have also claimed the figure of Salvá are Sebastián Olivé [16] and Jesús Sánchez Miñana [1]. The more detailed study, which has been done, up to now, on the 1804 Salvá's Electric Telegraph, comes from the second author. Prof. Sánchez Miñana, in his book 'Vida y Obra del Doctor Salvá i Campillo' (Life and Work of Dr. Salvá y Campillo), makes a very interesting description of Salvá's biography and a very detailed explanation of the work he carried out, including his 1804 Electric Telegraph.

There are some other references to the figure of Salvá and his contributions, which are written in Catalan language. Among them can be cited Josep Iglésies [5], Santiago Riera i Tuèbols [17] and David Jou i Mirabent at al. [18].

V. SALVÁ'S ELECTRIC TELEGRAPH

With no doubt, the most important document on Salvá's Electric Telegraph is the essay that the own Salvá reported to the Barcelona Academy of Sciences in 1804 [10]. He begins his report by making a review about the state of the art in optical telegraphy, with special references to the line projected and constructed by Agustín de Betancourt y Molina (1758-1824) between Madrid and Aranjuez. He also mentions his previous telegraph systems based on static electricity and galvanic electricity, referring that electric telegraphs are more favorable for long distance communication than optical telegraphs.

After that, he describes the state of the art of Volta's electric battery, including a detailed explanation of its positive and negative aspects but remarking, above all, its capacity to produce a steady and long-lasting electric current in contrast to the electrostatic machines or the frog legs. Curiously, Salvá was sure that the electric current produced by frog legs was of a different nature than the electric current produced by voltaic cells, but that was not an inconvenience for the development of his telegraph.

Afterwards, Salvá analyzes two different phenomena for detecting a current in a wire: the melting of metals and the decomposition of water, paying special attention to the second one. He refers that when an electric circuit is closed through a mass of water, the end of the wire which is in contact with the zinc disc in the voltaic pile (negative pole), produces hydrogen bubbles that accumulate around the other end of the wire (cathode), whereas the wire which is in contact with the silver disc in the voltaic pile (positive pole), causes an oxidation in the other end (anode).

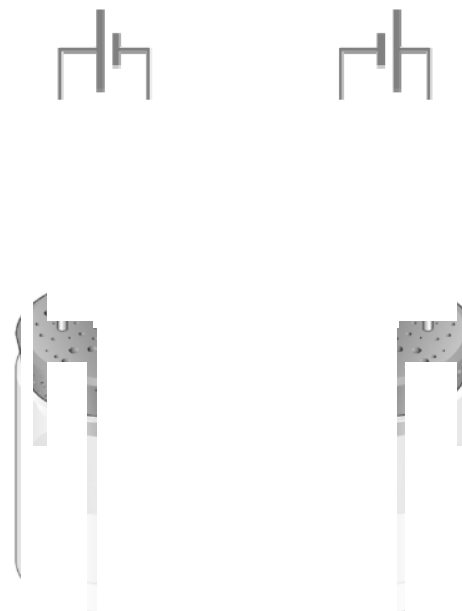


Fig. 2. Image which shows how encode two different signals by using only one jar of water. Source: Antonio Pérez Yuste.

Finally, Salvá puts all these things together to conclude that to build an electric telegraph system is perfectly feasible, describing next how to do it. He first suggests a way to encode two different signals with one jar of water, by only changing the polarity of the voltage applied to the ends of the wires submerged in water. In such a way, hydrogen gas will be seen to bubble at one end up or at the other one, depending on the polarity of the battery. In short, he could encoding two signals with only one circuit as it is shown in Fig. 2.

Next, he suggests making use of several circuits with a common return wire to encode so many signals as required, so everyone can conclude that to encode 'n' signals are required ' $n/2+1$ ' wires, if n even, or ' $(n+1)/2 +1$ ' wires, if n odd. However, this question is not clear enough in Salvá's report. He talks about using six wires to build a complete telegraph system but, at the same time, he admits this question can be difficult to understand, in such a way that he prefers to deal with the explanation in subsequent experiments. This is why it seems that Salvá could make some practical demonstrations to the members of the Academy of Sciences the same day he read his report before them, but it is not easy to infer from this situation that he ever showed a complete communication system. This opinion is also maintained by Prof. Sánchez Miñana who says Salvá was not able to make long distance trials, since he regretted not having enough time to prepare the required wires [1]. Suárez Saavedra, as far as he is concerned, is also confused about this part of the report, although he finally assumes that the system could be something like the one shown in Fig. 3.

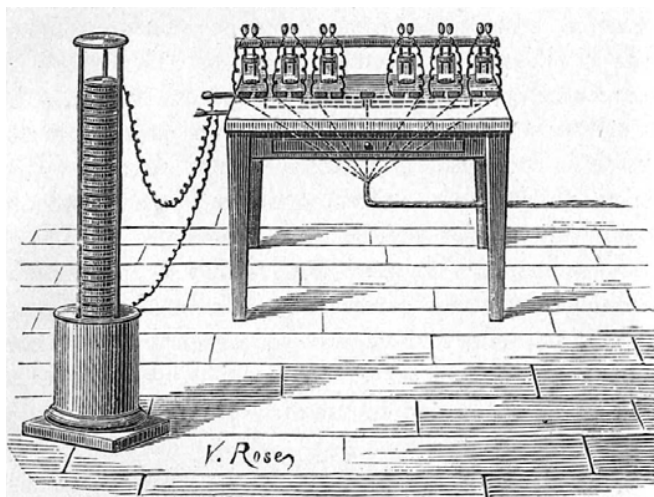


Fig. 3. This is a view of Salvá's Electric Telegraph as was imagined by Suárez Saavedra. Source: Suárez Saavedra-1880 [15].

In this figure, there are two plugs on the left side of the table, which are connected to an electric battery. There are also two metallic sheets in front of each water jar and a common metallic sheet on the center of the table. In addition, the common metallic sheet is connected to one sheet of every water jar. So, by connecting one plug to the free sheet of a water jar and the other one to the common sheet on the center

of the table, a signaling communication system can be finally established.

VI. CONCLUSION

The electric telegraph conceived by Francisco Salvá was presented to the Barcelona Academy of Sciences, Spain, in 22 February 1804, five years before a very similar one developed by the Polish Samuel Thomas von Sömmering which is, by contrast, more recognized at present. In this paper, a description of life and work of Salvá has been done, paying a special attention to his different fields of research. A review of previous studies carried out in relation to Salvá's Electric Telegraph, both in English and Spanish, has first been done in order to be continued, next, with a detailed description of this telegraph. The data included in this paper is based on the original report that Salvá presented to the Barcelona Academy of Sciences in 1804. It seems that Salvá also made some practical demonstrations to the members of the Academy of Sciences the same day that he read his report before them, but it is not easy to infer from this situation that he ever showed a complete communication system. In spite of this fact, there is no doubt of his pioneering contributions to electric telegraphy and on the importance that his 1804 report has now in the history of telecommunications.

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