THE FIRST WIRELESS REMOTE-CONTROL: THE TELEKINE OF TORRES QUEVEDO

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Introduction

Nowadays, remote-control has become an electronic device widely used everyday. So much it is that is very usual to operate more than one of these devices every day without giving any importance.

To open the doors of our car, to switch on the air-conditioned machine in our office, to turn on the TV in our home or to enjoy with our children's radio controlled car in the park, they are some common examples that give us a quite clear idea of its importance.

Basically, a remote-control system requires both a transmitter capable of sending a family of codewords and a receiver able to react in different ways to each codeword.

The first person who understood these two necessities and who found a solution to both ones was the Spanish engineer Leonardo Torres Quevedo who began in 1901 and 1902 working on such a system, which he called the "Telekine".

In 1903, he presented the Telekine for the Academy of Sciences in Paris together with a detailed memory and a practical demonstration of its operation to its members. The same year, he applied for a Spanish patent in Madrid.

In this talk, a biographical sketch about the figure of this ingenious Spanish engineer will be done. It will be also presented the work that Torres Quevedo carried out in order to get the "Telekine" and a brief description of its operation will be shown. The talk will be illustrated with some different photographs of a real prototype owned by the Universidad Politécnica of Madrid at his Civil Engineering Faculty.

Leonardo Torres Quevedo

The Spanish engineer, Leonardo Torres Quevedo, was born on December 28, 1852, in Santa Cruz de Iguña, a small village located at north of Spain, near Santander (see figure number 1). From his mother, Valentina Quevedo de la Maza, who was also born in Santa Cruz de Iguña, he inherited the Castilian austerity and her love for the highlands. Whereas from his father, Luis Torres Vildósolo y Urquijo, who came from Bilbao, he inherited his scientific rigour and his love for Mathematics, a passion very useful in his long career as an inventor.

He received his first education in Bilbao (Spain) and Paris (France). In 1871, he began his Higher Education at the Civil Engineering Faculty of Madrid, obtaining his graduation degree five years later. He was number four in a graduating class with just seven students.

After graduation, he made a long trip around Europe to know the state of the art in technology. He traveled to France, Switzerland and Italy, countries where he was mainly interested in everything related to electrical applications. That trip let him to know a scientific environment more advanced than the Spanish one at the time. For example, he met in Paris some great scientist as were: Henry Poincaré, Paul Apell, Edouard Branly, Koening y Maurice d'Ocagne.

When he came back to Madrid, he brought a lot of ideas in his head. His first researches were about funiculars and algebraic machines, although he did not publish any paper at this time.

On April 16, 1885, Torres Quevedo was married to Miss Luz Polanco y Navarro, with who he had eight children. The couple moved to Molledo-Portolín, a small village very close to Santa Cruz de Iguña, where they spent their first married years. At this time, he designed and built a small funicular that was the first in a row done by the Spanish inventor. This one was pulled by bullocks but the second one, constructed over the River León, at the Valley of Iguña, in Santander, was already pulled by means of a motor. Afterwards, he built another one at Mount Ulía, next to San Sebastián (1907). But his most famous funicular was the Whirpool Aero Car over the Niagara Falls in Ontario, Canada (1916), which is still working at present without having any problem in its almost ninety years of working.

Figure 1. House where Torres was born in Santa Cruz de Iguña, Santander, as it looks at present time. Source: Antonio Pérez Yuste.

In 1893, at the aged of 41, Torres Quevedo presented his first paper to the Spanish Royal Academy of Sciences. It was devoted to an algebraic machine able to calculate the roots of an any-grade equation. That was the first automatic calculator built by Torres Quevedo in a long list of them.

That delay in Torres Quevedo creativeness shows a personality that does not match with the typical image of an intuitive inventor who bases his work in brilliant improvisations. In fact, all the Torres Quevedo projects were much elaborated and were characterized by an exhaustive study of the existent bibliography and all the previous works done by other inventors.

Another field of interest for the Spanish inventor was Aerostatics. Torres Quevedo presented his first project for the Spanish and French Academies of Sciences in 1902, receiving immediately the recognition from both institutions.

In 1906 he built the first dirigible balloon and two years later he built the second one with the partnership of the French constructor Astra, whose company bought the patent to Torres Quevedo.

A proof for the success of this dirigible could be found during World War One when French and English Armies used Torres Quevedo dirigibles balloons in order to counteract the German Zeppelins.

Curiously, his work in Aerostatic drove Torres Quevedo to the invention of the Telekine. His purpose was to control the flight of dirigible balloons from ground, without risking human lives. Almost without expecting that, Torres Quevedo had invented the remote control, device that was extended immediately to other applications like remote control of vehicles and boats.

Torres Quevedo was also interested in Automatics. His wonderful work titled: "Essays about Automatic. Its definition. Theoretical improvement of its applications", published in the Proceedings of the Spanish Royal Academy of Sciences, on January 1914, established the foundations of Automatics. In this paper, Torres Quevedo goes ahead to his time by advancing postulates that later would be the basis of Computer Science. For example, he introduced the idea of logic circuits and built them by means of relays, the only possibility at the time.

His work in Automatics was started, however, two years before with the construction of a chess automaton-player, which he completed in 1920 with a second version. In both machines, the automaton played with the White King and the White Tower against the Black King, moved by a person. Naturally, it is known the final result: the white pieces, played by the machine, gave successive mates to the Black King, moved by the human adversary, until it gets the final checkmate independently how the human plays.

The devices before the Telekine

The invention of wireless telegraph systems, at the end of the XIX century, and their quick advance, at the beginning of the XX century, brought the possibility to operate any machine at distance, something that was considered as science-fiction at that moment.

For example, Marconi's original idea was to drive a Morse Inker at distance in order to transmit a telegraph message without using wires. In a wide sense, the prototype developed by Marconi when he lived with his parents at their house in Pontecchio, Italy, in 1895, could be considered as the first remote control in history. However, there are some questions that prevent us from understanding in this way. A remote control is not intended to transmit a message –although it could do it–, but is intended to cause a reaction, in a particular way, from an action deliberately chosen among a finite set of possible ones.

In this sense, the device that was presented by Marconi, together with William Preece, in the Toynbee Hall of London, on December 12, 1896, could be already considered as a true remote control, although quite simple. The gadget consisted on a black-box, with a bell, which rang when some button was pushed in a second black-box. This one was separated from the first box without any cable connecting both ones[1].

Figure 2. Marconi after arrival in England. Source: Marconicalling Exhibition.

After Marconi's first experiments, an important number of scientists and engineers saw wireless telegraphy as the solution to transport energy, from one location to another, without any material medium. According to this, some different

[1] Antonio Pérez Yuste, Marconi. Gesta de 1901, Foro de Historia del Colegio Oficial de Ingenieros de Telecomunicación de España, January 2003.

studies and essays began, both in Europe and America, in order to move mechanisms at distance by using modified wireless telegraph systems.

One of the most renowned experiments was done by the English electrician, Sir Cecil Varicas. Varicas designed a system in order to control the direction of movement of a torpedo. His prototype was tested in 1898, first at the public baths of Jewil, close to Weymouth, and afterwards, in 1900, in open sea beside the Weymouth coast, at south of England.

The idea consisted on moving the torpedo rudder by means of an electric motor that was driven by a wireless telegraph system. The electric motor had to overcome the antagonist strength of a spring that made the rudder to turn on the opposite direction. As it can be seen, basis of operation was quite simple and, perhaps for that reason, the results were not as satisfactory as the inventor expected to be[2].

After Varicas, there were some other inventors who tried to improve the guiding of torpedoes by means of radio signals but, in all cases, the action was limited to the easy movement of the rudder in one direction or another. That is to say, the systems that were developed belonged to the type "on/off", like the Morse telegraph indeed.

Even, great inventors such as Tesla and Edison were also interested in the transmission of electrical energy at distance without the use of wires.

In a paper written in 1904 by Tesla, he remembered the basis for the transmission of electrical energy through a non material medium and he also remembered his early works in wireless[3]. However, his experiments were closer to get its own wireless telegraph system, different to the Marconi's one, than to obtain a true wireless remote control system.

Edison, by his part, also studied the phenomenon of electric waves and made a system of wireless telegraphy, by induction, to and from trains in motion, or between moving trains and railway stations. In 1900, it was announced the assistance of Edison to the Universal Exposition in Paris, showing a remote controlled boat able to navigate

[2] Eduardo Gallego, El Telekino y la Telegrafía sin Hilos (I), Revista La Energía Eléctrica, pp. 426-430, Madrid, 25 de noviembre de 1905.

[3] Nikola Tesla, The Transmission of Electrical Energy Without Wires, Electrical World and Engineer, Twenty First Century Books, Breckenridge, 1904 (reprinted).

on the Sena River. But that big notice was not finally confirmed. Edison, of course, assisted to the Exposition but he did not show any wireless remote control system.

Another illustrious inventor who also worked on the transmission of energy at distance was Edouard Branly, the French physicist and inventor of the coherer employed in early wireless telegraph receivers. In 1905, he experimented with the possibility to switch on an incandescent lamp or an electric motor and with causing controlled explosions at distance too. But, once again, as it happened with Varicas' torpedo, the prototypes developed by Branly were "on/off" type systems.

In order to get a wide set of different actions over some given mechanical element, two things were required: first, to create a family of different and easily readable codewords, by using the signal generated with some common wireless telegraph transmitter; and second, to build a completely new type of receiver which was able to react in different ways to each one of the codewords sent by the transmitter.

The first person who guessed these two necessities and who tried to find a solution for both ones was the Spanish Engineer Leonardo Torres Quevedo (see figure number 3), who began to mature the idea of a device with such characteristics in 1901 and 1902.

According to José García Santesmases –a well known computer scientist and one of the biographers of Torres Quevedo–, the idea that moved to Torres Quevedo into the study of "Telemecanics" –name that was commonly used for this technological area at the time– was the possibility to make tests with aerostatics balloons without risking human lives[4].

As it will be shown next, Torres Quevedo thought up a new and simple telegraphy code, based on pulse modulation, and invented an ingenious electromechanical receiver, called "Telekine", which was able to understand each codeword from the transmitter in order to make different operations at distance.

At the beginning, each codeword that was sent from the transmitter should be created by manual procedures but, afterwards, the mechanism was simplified by using

[4] Obra e Inventos de Torres Quevedo, José García Santesmases, Ed. Instituto de España, p. 137, Madrid, 1980.

a front panel with different buttons, so each codeword was automatically generated by pushing one of them.

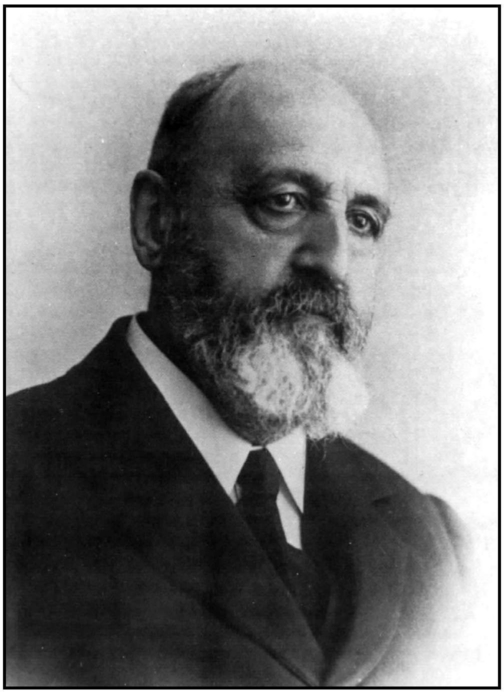


Figure 3. A well known photograph of Torres Quevedo.
Source: "Obra e Inventos de Torres Quevedo", J. García Santesmases, Ed. Instituto de España, Madrid, 1980.

The Telekine

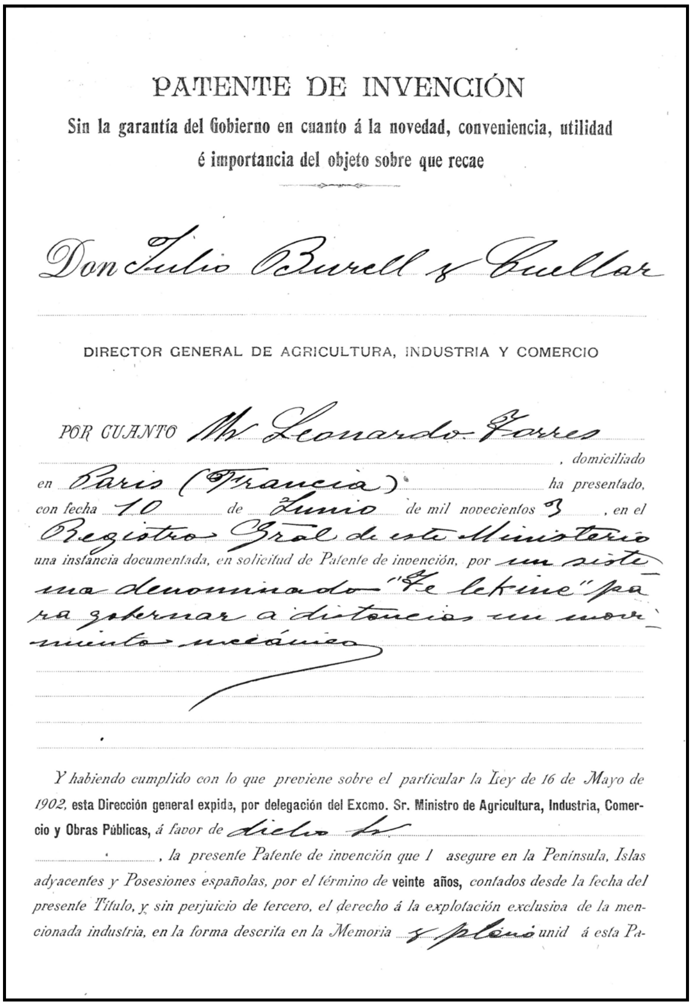
On June 10, 1903, Leonardo Torres Quevedo submitted an instance to the Ministry of Agriculture, Industry, Commerce and Public Works requesting the patent of a system called Telekine, which was able "to do a mechanical movement at distance" (see figure number 4). In the description of the patent, the Spanish inventor wrote about this device[5]:

It consists on a telegraph system, with o without wires, whose receiver sets the position of a switch that switches on a servomotor, operating any mechanism.

The possibility to act over a mechanism at distance was an application that, as it has just been said, was expected since the same time that the wireless telegraphy

[5] L. Torres Quevedo, Patente de Invención por un Sistema Denominado Telekino para Gobernar a Distancia un Movimiento Mecánico, p. 1, Madrid, 10 de junio de 1903.

was discovered. However, all the early systems developed were limited to the movement of a single piece in one direction or another. That is to say, they were always "on/off" type systems, more or less complex, such as the telegraph itself was.



PATENTE DE INVENCIÓN

Sin la garantía del Gobierno en cuanto á la novedad, conveniencia, utilidad é importancia del objeto sobre que recae

Don Julio Burell y Cuellar

DIRECTOR GENERAL DE AGRICULTURA, INDUSTRIA Y COMERCIO

POR CUANTO Mr Leonardo Torres, domiciliado en Paris (Francia) ha presentado, con fecha 10 de Junio de mil novecientos 3, en el Registro Gral de este Ministerio una instancia documentada, en solicitud de Patente de invención, por un sistema denominado "Telekine" para gobernar a distancia un movimiento mecánico

Y habiendo cumplido con lo que previene sobre el particular la Ley de 16 de Mayo de 1902, esta Dirección general expide, por delegación del Excmo. Sr. Ministro de Agricultura, Industria, Comercio y Obras Públicas, *á favor de* dicho Sr. *, la presente Patente de invención que l asegure en la Península, Islas adyacentes y Posesiones españolas, por el término de* veinte años, *contados desde la fecha del presente Título, y sin perjuicio de tercero, el derecho á la explotación exclusiva de la mencionada industria, en la forma descrita en la Memoria* y planos *unid á esta Pa-*

Figure 4. First page of the instance, submitted by Torres Quevedo, requesting the patent of a system called "Telekine". Source: Spanish Office of Patents and Trademarks.

It was not until Torres Quevedo turned his attention towards the study of this matter, that the problem of controlling remote machines was solved in a general sense. Torres Quevedo guessed that to achieve a finite but not limited set of actions based on a binary system as the telegraph was, with only two states; "on" and "off", it was necessary to create a non limited number of codewords by means of sequence of binary states, as long as needed. In that way, for instance, with a sequence of two binary states, so called binary characters, it is known that we can achieve up to four different codewords (see table number 1).

Off	**Off**
Off	**On**
On	**Off**
On	**On**

Table 1. Codewords that can be achieved with two telegraphic characters.

The problem at the time was the impossibility to have a synchronisation mechanism that was able to detect the end of one character and the beginning of the next. In this situation, the only way to resolve this difficulty was using an asynchronous synchronisation method based on the change in the state of the telegraph signal.

Moreover, Torres Quevedo also known that he had to use a type of codewords that could be easily understood for an electromechanical receiver, so each codeword produced only one action.

By putting together both requirements, the final proposal was as simple as using a code based on the number of pulses consecutively sent. In this way, to one pulse corresponded the action, let's say number 1, to two pulses corresponded the action number 2, to three pulses the action number 3 and so on (see figure number 5).

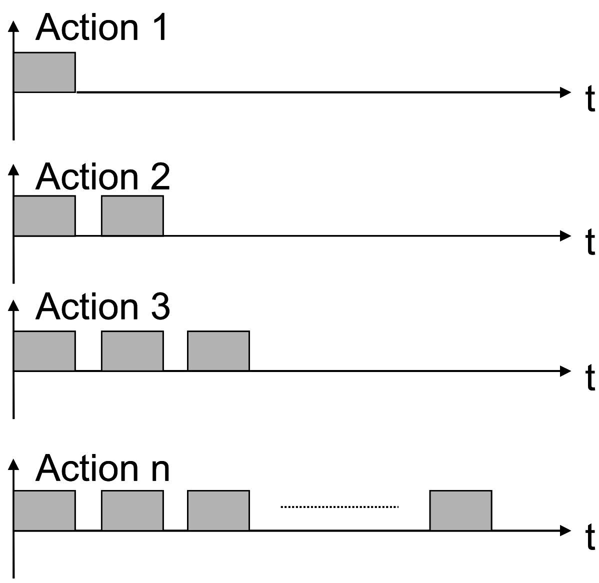


Figure 5. Codewords using by Torres Quevedo in its Telekine.

In figure number 6, it is shown a very simplified block diagram of the Telekine. It has three different parts: a wireless telegraph receiver, a multi-position switch unit and, finally, the servomotors that can be used to drive a mechanical element. In this case, there are two servomotors: one acts over the propeller of a hypothetical boat and the other acts over its rudder.

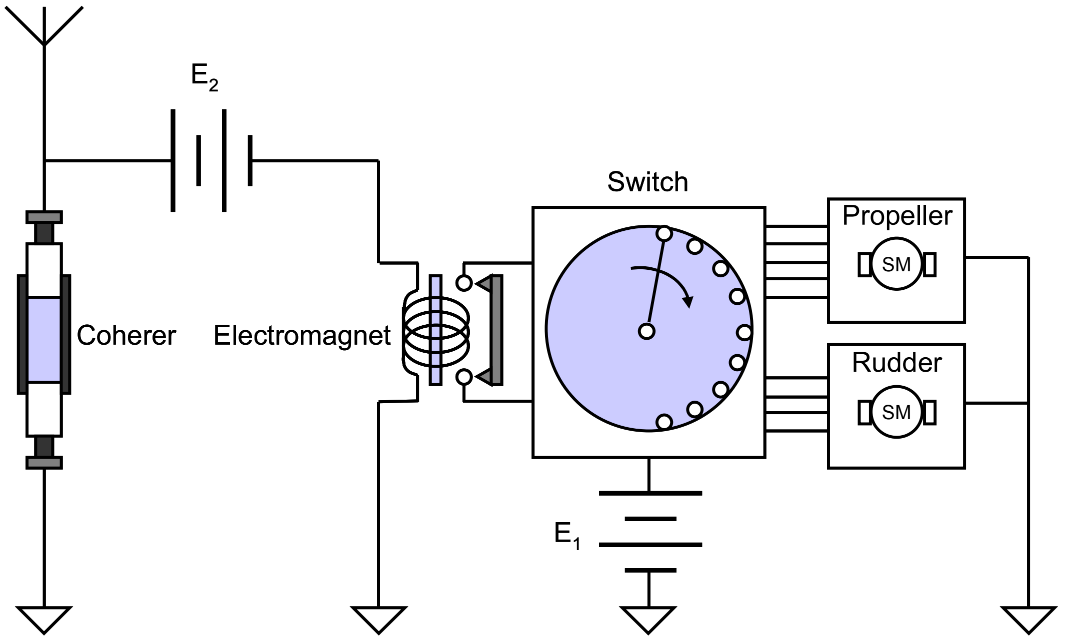


Figure 6. Block diagram of the Telekine designed to act over the propeller and the rudder of a boat.

In figure 6, the signal is received by the antenna and is transformed into electric pulses by the coherer. Each pulse drives an electromagnet, which close its secondary circuit causing the multi-position switch unit goes one step forward. This operation is repeated automatically so many times as impulses have got the signal.

When the multi-position switch gets its final position, the battery marked as E1 is connected supplying current to the terminal of the servomotor that was chosen. Then, the servomotor is put in motion causing a known and predefined action to be executed.

Once this action is verified, the battery E1 is disconnected and the switch returns to its original position waiting for a new order.

The name "Telekine" was chosen by Torres Quevedo as a combination of two Greek words: "tele" and "kine", which means "at distance", the first, and "movement", the second, resulting both together "movement at distance", which was what Torres

Quevedo wanted to get. However, there were also some people who called the invention of Torres Quevedo "telecine", for the same reason that it is said "cinematic" and not "kinematic", but it didn't prosper.

On June 10, 1903, Torres Quevedo applied for a patent at the Spanish Ministry of Agriculture, Industry, Commerce and Public Works and, a few days later, on August 3, he presented the first version of the Telekine to the Academy of Sciences in Paris. The equipment he shown consisted, basically, on a big box with a propeller and a rudder, which movements were driven at distance by means of wireless telegraph transmitter. The prototype, now placed at the Civil Engineering Faculty of Madrid, can be seen in figure number 7.

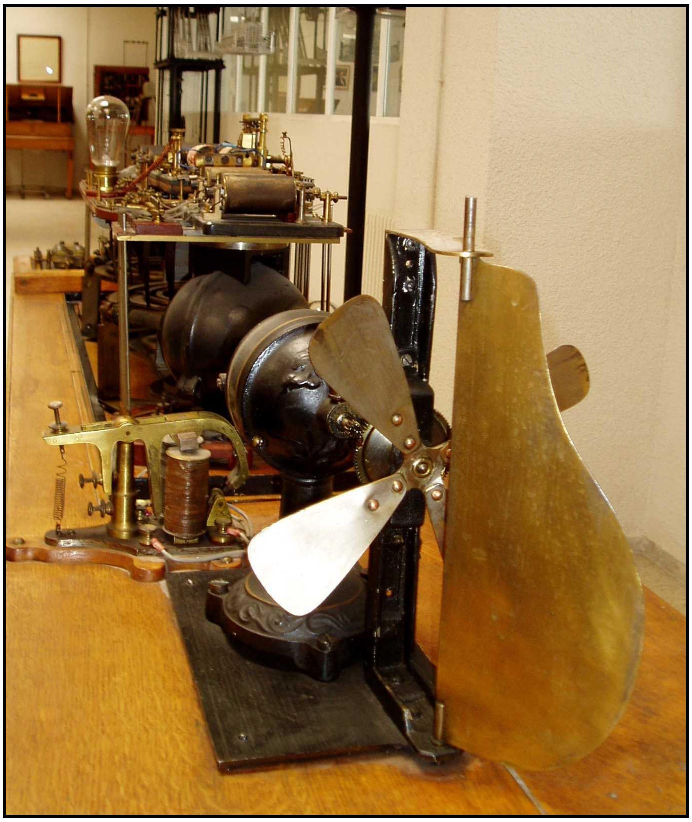


Figure 7. Prototype of the Telekine in the Museum of Torres Quevedo at the Civil Engineering Faculty, in Madrid (Spain). Source: Antonio Pérez Yuste.

The success obtained for the Telekine in Paris was immediately followed for a warm reception at the Ateneo Society, in Madrid. This important Spanish cultural institution was realized the importance of Torres Quevedo's invention and asked the

Spanish Government for granting a subvention to him in order to continue the experiments in this promising area[6].

The subvention was included in the 1904 General Budget and its amount was equal to 200.000 (two hundred thousand) pesetas. The Spanish Government also authorized the creation of a Centre for Essays in Aeronautics which was located at a pelota-court called Beti-Jai, in number 5 of Marqués de Riscal Street, in Madrid. Torres Quevedo was designated as its Director.

In this Centre, Torres Quevedo carried out some new experiments with the Telekine, improving its working. It is known he installed the Telekine on a tricycle, which followed the orders given by a wireless transmitter at distance from 20 to 30 meters. The tricycle went forward and backward, turned to the right and to the left, stopped and started to move again without any problem. The experiment was described as follows at the time[7]:

> *The transmission of orders is done by means of an emitter and an antenna that sends the electrical waves to the atmosphere. These orders are received by other antenna and a coherer installed on a tricycle, moving around the pelota-court, which is the place where the tests were performed.*
>
> *Up to this point, it consists on a simple wireless telegraph transmission, but the receiver is not enough by itself to generate the necessary strength to cause the movement of the tricycle, and here is where the Telekine comes to transform that insignificant energy into another bigger one.*
>
> *A multi-position switch, acted by the electromagnetic wave, is installed on the tricycle, which can close a circuit much more powerful produced by an independent generator made of a battery of accumulators.*
>
> *The circuit obtained with each switch position drives an electric motor causing different strengths which, mechanically transmitted to the wheels of the tricycle or to its steering, is able to cause different velocities or different directions of its course.*

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[6] Eduardo Gallego, El Telekino y la Telegrafía sin Hilos (I), Revista La Energía Eléctrica, pp. 426-430, Madrid, 25 de noviembre de 1905.

[7] Boletín Industrial, Ed. Asociación de Ingenieros Industriales, Madrid, abril 1905.

At the same time, Torres Quevedo carried out some experiments with a remote controlled boat at Lake of Casa de Campo, in Madrid. In one of these experiments the Mayor of Bilbao was present, resulting so impressed that he decided to collect funds in order to organize a big demonstration at the Estuary of Bilbao.

A boat with an electric motor was bought in Germany and everything was prepared to make some preliminary tests in Algorta, a village located at the mouth of the Estuary of Bilbao. The first experiment was done on March, 1905, and it was only for a few people. The results were very successful. Because of this, a public demonstration was programmed to September, although it was delayed several months for different reasons. Finally, the demonstration could be performed on November 7 in the Abra de Bilbao. Both, the public and private tests were done with the same boat, which was baptized with the name "Vizcaya".

The Spanish Magazine, "La Energía Eléctrica", talked about these tests on December, 1905[8]:

> *The tests consisted on guiding a boat, the Vizcaya, whose had the Telekine installed on board, to the middle of the Estuary of Bilbao, turning right towards Algorta, stopping, going back and forcing, in few words, to follow accurately the orders sent from the transmitter sited on the Balcony of the Yacht Club at the Abra de Bilbao. The success was complete: the Vizcaya, which had eight people on board, moved with mathematical precision to a distance more than two kilometres from the transmitter, which was controlled by Torres Quevedo (…).*
>
> *The transmission station was not different to a common wireless telegraph station. It was used a Telefunken system, which was born from the joining of Braun and Slaby-Arco and which is managed by the AEG Company here in Spain.*

After his successful experiences with boats, Torres Quevedo wanted to extend the use of the Telekine for guiding of torpedoes and submarines. Therefore, he requested the financial support to the Spanish Ministry of Navy. However, on May, 1906, the Minister refused to grant the experiments. That was the end of the Telekine.

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[8] Eduardo Gallego, El Telekino y la Telegrafía sin Hilos (II), Revista La Energía Eléctrica, pp. 445-447, Madrid, 10 de diciembre de 1905.

The Telekine was not finally used neither for guiding dirigible balloons. At least, no bibliographical references have been found about it, despite it was the main reason that drove to Torres Quevedo to invent such system.

As a curiosity, during a test performed by Torres Quevedo with a dirigible balloon on October 1908, at Satrouville Park, in the surroundings of Paris, it happened an accident when the airship crashed to a telegraph line, resulting both pilots on board seriously hurt. Obviously, the accident had not happened if the Telekine had been installed on the dirigible balloon.

And we have neither found any reference pointing out the Telekino was traded or used by other engineers or scientists. The work done by Torres Quevedo was unjustified forgotten and we have wanted to recover it here with this talk.

Conclusions

The idea behind the Telekine was to make tests with aerostatics balloons without risking human lives.

Torres Quevedo used a conventional wireless telegraph system but he invented a new code, easily implemented with the transmitter, and a new electromechanical receiver able to react in different ways to each codeword. With all of these, he got to control the velocity and the direction of any vehicle at distance.

Torres Quevedo made tests with tricycles and boats, which are well documented, but he could not extend them to torpedoes, submarines or aerostatic balloons because of economical constraints.

Torres Quevedo applied for a Spanish patent in 1903 and presented the first version of his Telekine to the French Academy of Sciences, in Paris, the same year.

Acknowledgements

I wish to thank Professor Edelmiro Rua, Head of the Civil Engineering Faculty at Universidad Politécnica de Madrid (Spain), his valuable assistance to visit the Museum of Torres Quevedo and for letting me to take the photographs shown in this talk.