ENRICO FORLANINI'S CONTRIBUTION TO AVIATION

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Abstract

Enrico Forlanini was one of the first students of Politecnico di Milano, where he graduated in 1875. Very well known in Milan, where he was born in 1848, is much less known elsewhere, especially outside Italy since he operated only at home even though some of his patents were also deposited abroad.
Precursor of many developments that aviation would have had in a few decades, he is famous in particular for airships, of which he designed, built and flew several models of the semi-rigid structural type.
However, his first interest, and he was still very young, was for heavier than air. After having tested smaller models with different propulsive solutions, he built a large helicopter model which flew in 1877, the first flying machine able to rise from the ground carrying its steam engine.
One of the most important achievement of Forlanini are the hydrofoil designs that he tested, starting from 1898 until 1911, on Lake Maggiore close to Milan. He called them *idrotteri* and Graham Bell, who had to become famous for his own inventions, had the chance to have a ride in one of them.
Forlanini has left many sketches in which we see the evolution of *idrotteri* that prefigures the realization of vehicles able to rise from the water and take flight as a seaplane.
Keywords: Enrico Forlanini, Helicopter, Hydrofoil, Airship

1 Introduction and biography

Enrico Forlanini is much better known in Italy, much less elsewhere. It is worth recalling him as a thoroughly committed engineer, who, from the original idea of a device or innovative design, pursues the necessary experiments until the product is built. He was a true aviation practitioner who loved to test by himself the machines he made. He was an engineer in various industrial sectors.

We refer to the volume edited by Sara Calabrò [1] where you can find more detailed information and a complete bibliography.

In the historic section of the present European Rotorcraft Forum held at the Politecnico di Milano we like to remember him as one of the first graduates from our Politecnico who in 1877, after six years of accurate studies and experiments on models of propellers, built an helicopter model, with steam propulsion, capable to reach 13 meters of height, thus realizing the first heaviest than air craft able to rise from the ground carrying its own propulsion system.

Enrico Forlanini was born on 13 December 1848 in Milan. He belonged to a family of well-established scientific tradition. The father was a physician and his brother Carlo, a physician and university professor, had the idea and later, in collaboration with Enrico, he built the first artificial pneumothorax for the treatment of tuberculosis.

Enrico, after the completion of the high schools attendance in Milan, went to Turin to attend the courses of the military Academy of the Corp of Engineers to become lieutenant. In the mean time he completed his degree in Industrial Engineering in 1875 at the Politecnico di Milano. He was one of the first graduates of the new academic institution that was founded at the end of 1863. One of the two founders of Politecnico was Prof. Giuseppe Colombo who had to play an important role in the activity of Forlanini as an engineer, an inventor and an industrialist, too.

When in 1877 he held the public demonstrations of his helicopter model, he was still an officer of the Italian Army. He resigned in the next year to become the brilliant director and later the owner of a mechanical firm located in Forlì, devoted to make industrial gases and the hardware for the production and use of them. Nevertheless in that period Forlanini didn't abandon his passion for aviation and immediately after the return to Milan in 1897 he started his career as an airship designer, for which he is still famous, with the collaboration of Cesare Dal Fabbro, an officer of the Corp of Engineers specialized in balloons, who had to become the first professor of an aeronautical discipline at Politecnico in 1910.

The activity in lighter than air field absorbed him, giving origin to a family of airships, anyway he was able to build the prototypes of two different kinds of an innovative machine, called by him *Idroplano*, he successfully tested on the Lake Maggiore waters, that are to be considered the precursors of the modern hydrofoils. Perhaps this is the most significant Forlanini's contribution to the engineering science.

Forlanini passed away in 1930, leaving his experimental airship *Omnia Dir*, characterized by the propeller thrust vectoring, uncompleted.

His memory survives in the denomination of Milan's

[1] Calabrò Sara (Editor), *La passione dell'invenzione. Enrico Forlanini, ingegnere e aeronauta*, Telesma Edizioni, Milano, 2004

Linate Airport, inaugurated in 1937, and in other well known places of the town. Moreover the first Italian chapter of the American Helicopter Society brings his name.

2 Forlanini and the helicopter

In an article of his own of the *Il Politecnico, giornale dell'ingegnere e dell'architetto civile e industriale* journal, in 1877, Enrico Forlanini describes the device he had begun to design in 1875 and he had flown in Alessandria (Italy) on June 29^{th} of that year.

His proposal was to build a steam engine, which, when powered by propellers, could freely lift into the air and indeed what he accomplished and tested was a small machine with a steam engine moving two vertical-axis propellers, he called *elici*, placed one under the other and turning each one in an opposite way.

The Forlanini's *elici* have a wooden structure and the surfaces were made with tissue. The vapor was provided by a small spherical boiler, 2/3 filled with pre-heated water to a pressure of about 8 atmospheres. The total weight was 3.5 kg and the surface of the propellers was 2 m^2. The power was variable according to the pressure between a quarter and an eighth horsepower. The weight of the mechanical linkages was 1.6 kilograms and that of the propellers of 0.6 kg. The spherical boiler with the water charge weighted 1 kilo and, at last, the pressure gauge and other accessories 0.2 kg. The successful event in Alessandria was the result of a long journey of research, experimentation and passion for the flight that was born, in the words of Forlanini himself, in 1871 thanks to the reading of an article by Prof. Colombo, published in the *Annuario Scientifico Industriale* of 1868. With Colombo the relationship would become personal when Forlanini returned to Milan to enroll at the Politecnico, but at that time, 1871, he had just graduated from the Scuola di Applicazione di Artiglieria e Genio School of Turin, a military academy of the Corp of Engineers. At Casale Monferrato, where he served as a lieutenant and where he could use a well-equipped military workshop, he started the experimentation of various propeller models, checking performance step by step in a meticulous and exhaustive way arranging different combinations of power, weight and lifting surfaces.

Among the experiments carried out and described in the report submitted for participation to the Cagnola Prize, Forlanini won in 1879, a special attention has to be devoted to a testing article weighing about 1 kg, equipped with two vertical axis *elici*, located at the ends of a small horizontal beam and made to rotate in the opposite direction to each other by an elastic connection, that managed to lift the device up to 6 meters.

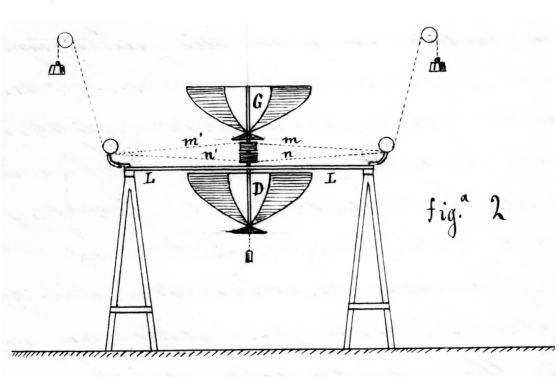

Figure 1: Test equipment for double superimposed propellers

A trial, crucial to determine the final disposition of the propellers and most importantly their sizing, was carried out with two contra-rotating propellers superimposed, see Figure 1[2]. In this respect, the description of Forlanini is very detailed and the results of the experiments were decisive.

Unlike similar achievements made by other designers, as the Pénaud's machine of 1870, destined to become a toy, this creation of Forlanini was a real test machine: equipped with an effective electro-optical device to measure rotational speeds it would be the progenitor of other experimental equipment designed to study the optimal characteristics of propellers and, with further improvements, to measure the performance of steam drive units.

The thrust obtained with two superimposed propellers with blades of equal size and length was slightly higher than that produced by a single propeller. Indeed, the interference between the air flows generated by the movement of the two propellers dropped drastically the efficiency. The weight raised was much lesser than the one it should be lifted by the total propeller surface. At that time he was not able to manage the aerodynamic inflow interference but from the experiments he made, he decided for a design with the reduction of the blades width and the different diameters, both inside and outside, of the upper and lower propellers, and this configuration was adopted for the apparatus that flew in Alessandria and later in Milan.

The top *elice* had a diameter of only 1,8 m, the mean pitch was much lesser at the upper end of the vane and much greater at the lower end. Forlanini realized that this pitch variation gave a greater efficiency to the propeller. Each of the two vanes were 80 degrees in width and they stretched to the axis until 35 cm from it. The projection on an horizontal plane, normal to the axis, of the vane surfaces was about 1 square meter. The bottom *elice* had a diameter of 2.8 m and a pitch of about 20 degrees. Its two vanes were 0.5 m wide and they extended about 1.05 m.

The lifting surfaces had a total area of about 2 m^2, see Figure 2[3].

[2] From *Relazione per il premio Cagnola, Archivio Istituto Lombardo Accademia di Scienze e Lettere, Milano*

[3] Library of the Department of Aerospace Science and Technology, Politecnico di Milano, FONDO CESARE DAL FABBRO

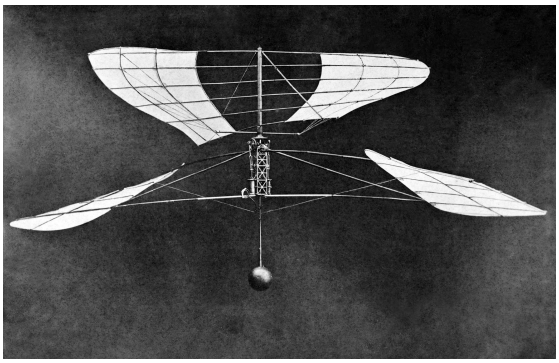

Figure 2: Forlanini's helicopter model

The tests carried out with these propellers allowed him to estimate the load they could lift up to 4.5 kg - having the power of $1/4$ of an horsepower - and since they weighed 0.6 kg there were 3.9 kg for the machine and boiler.

Forlanini started to develop the engine, at least as a concept, since 1875. On the assumption that the power needed was about a quarter of a horsepower, he had designed two 1/8 horsepower engines that had to act coupled, see Figure 3[3], powered by the vapor produced by a boiler of great lightness and productivity, weighing only 0.75 kg, containing up to 900 g of water and able to vaporize it up to 13 kg per hour.

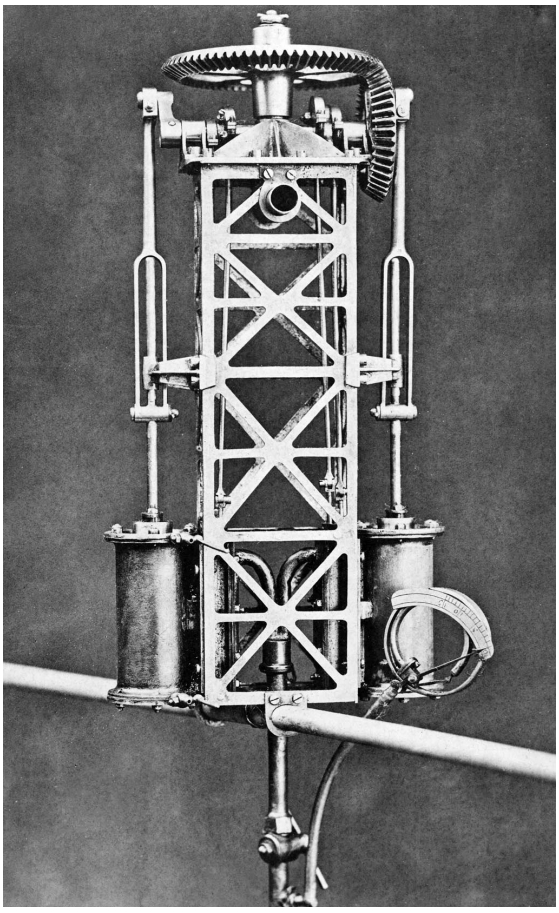

Figure 3: Forlanini's helicopter engine

When it was coupled to the rest of the drive unit, the results were disappointing. Indeed, the low performance of the transmission system, consisting of two conical gears, together with the presence of the airflow generated by the propellers, that interfered with the boiler, affected the total efficiency of the system severely. Moreover, the flow was unsymmetrical, due to the unavoidable disparities of the blades of the propellers, and it was such as to impart a more or less accentuated conical motion to the whole apparatus. This convinced Forlanini to replace the boiler with another one of a spherical shape, fire-free and filled with two-thirds of overheated water able to bring the initial pressure in it up to 8 and even to 10 atmospheres. The weight savings were remarkable: about 900 grams, see Figures 2 and 3[3].

These studies and experiments, which continued in the years when Forlanini alternated his military life with the one as a student of the Politecnico of Milan and, later, as a civil engineer in the town of Gallarate, ultimately carried out to the construction of the machine that arose and flew for the first time in Alessandria. To this goal, Forlanini was able to arrive thanks to the valuable collaboration of his attendant, Pietro Torresini. To him, when he was in Gallarate in May 1877, he wrote some technical notes on improvements to be made to the boiler under construction and added: *.... Everything is subordinate to a condition, that is, that such work does not cost more than 10 or 12 lire [....], with another 10 lire the expense would go to 90.*. This annotation, freely translated in English, underscores the efforts and the economic commitment - backed by Forlanini both in person and thanks to the generous contribution of inspired entrepreneurs - which had become necessary to accomplish the realization of a device that, for the first time in the world, actually lifted bringing its steam engine with it.

In a 1877 letter sent to the newspaper *La Perseveranza* and quoted in full by the leading press organs, Giuseppe Colombo, with reference to the first flight of the model, stated: *This is a date that will perhaps have some importance in the history of aeronautics*.

Experiences were repeated several times in Milan during the month of July at the *Salone dei Giardini Pubblici* in the presence of a large audience, and of leading personalities in business and scientific fields such as Ponti and Cantoni, and Colombo himself. The helicopter managed to reach 13 meters high *... With ease and regularity of movement really remarkable*, says Colombo, who concluded his letter by giving his best wishes that Forlanini would succeed into improving his creation towards a useful device, also if this goal was uncertain and possible only in the long range.

This event had an important echo also in the international arena, so that Monsieur Abel Hureau de Villeneuve, a member of the Paris Academy of Sciences, in 1879 invited Forlanini to *take some time away* from his occupations to repair and send the steam helicopter and then to realize a flying experience similar to the one of Milan. The assignment of a gold medal was in fact subjected to this practical demonstration. Monsieur Hureau concluded the letter affirming that he would be very happy to attend a demon-

stration of what he believed to be the biggest progress in the aeronautical field of the last years. However this chance was not caught.

Despite the unanimous acknowledgments, Forlanini was far from being satisfied with the results and, in particular, he was eager to advance in his studies. Actually he wrote, at the conclusion of his experiments, that the first improvements had to concern the engine. Instead of a specific weight of 12 kg for a unit of power (horsepower), he deemed to be able to have a steam engine with a boiler heated by a continuous burner of the specific weight of six kilos for horsepower. Indeed the tests and experiments, which would have involved Forlanini in the following years were not meant to achieve records of height or airborne time, but to experience the characteristics of a steam engine suitable for aeronautical use.

In a letter to Colombo of the end of 1877 he went farther and, besides a detailed dissertation on the engine improvements, a new disposition of the propellers side by side is suggested. The financial implications are also discussed and from this point of view the prospect looked very dim. For sure there are no reports of other public experiments, such as that of Milan and we do not know if further testing activities were carried on. Despite the achievements, therefore, the time for a real rotating wing was still distant and Forlanini, engaged in his professional activity in Forlì, slowed down the experiences but continued his studies, as evidenced by his writings and notes.

Among these, a remarkable handwritten note of extraordinary interest appeared in 1889.

While attending his little son Guido, who rested ill, during the night he made some considerations on fixed-wing aircraft and on the layout of the propellers in tandem (A) or side by side (B) and noted that:

better than of A and B is still the pure and simple helicopter with inclined shaft, perhaps it is possible and convenient making elici with variable pitch wings during the rotation and at each revolution,

see Figure 4[4].

With these argumentations, Forlanini had a kind of inspiration for the cyclic pitch and this was just an appropriate insight, in fact only in 1906, Italy's Gaetano A. Crocco had patented *cyclic pitch control* [5] of helicopter allowing the

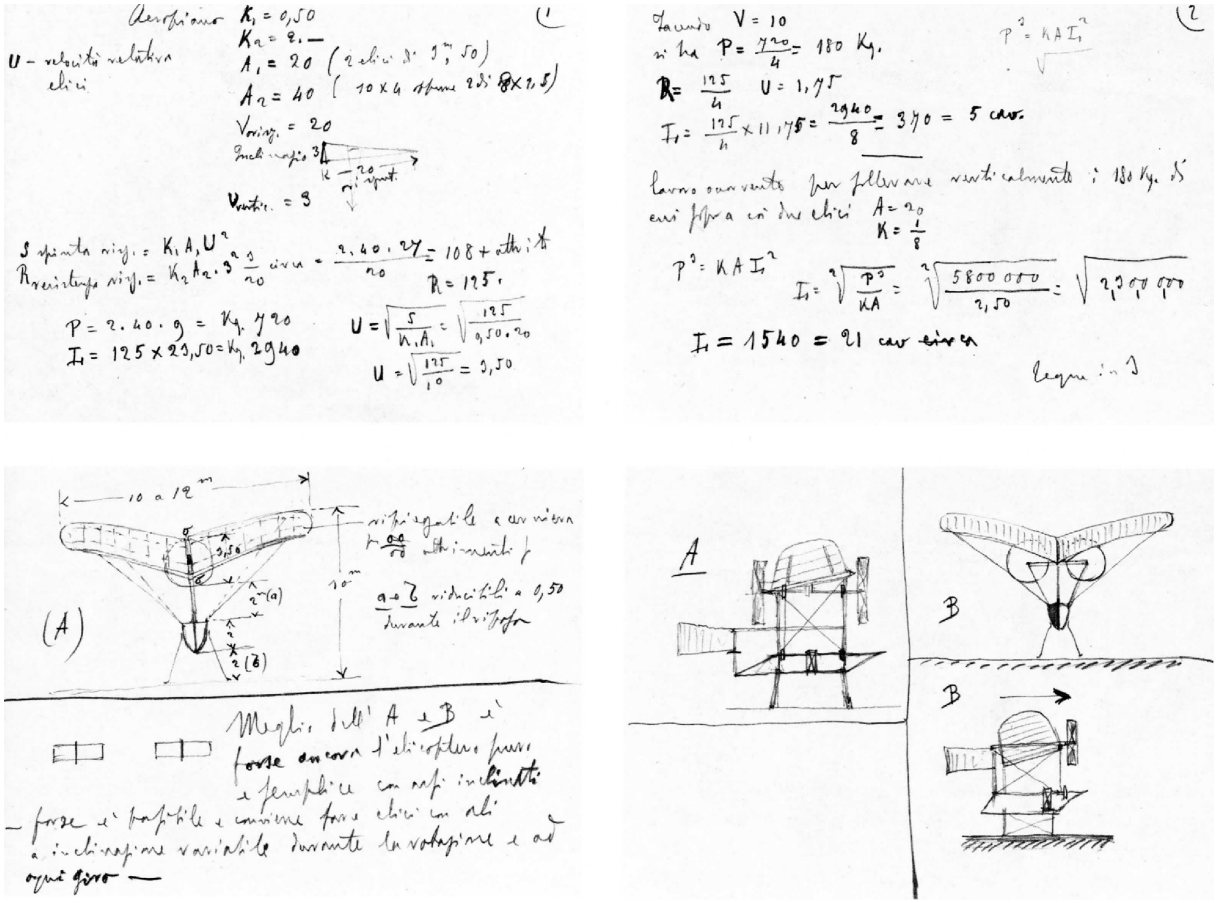

Figure 4: Forlanini's sketch about cyclic pitch

[4]Library of the *Museo Nazionale della Scienza e della Tecnologia, Leonardo da Vinci, Milano* , FONDO ENRICO FORLANINI

[5]The Evolution of Aviation's Most Exotic Technology, Copyright 2004 by Richard Harris, http://home.iwichita.com/rh1/hold/av/avhist/helo/helohist.htm

entire spinning *rotor disk* to be tilted in flight for directional control and translation to horizontal flight, later on the concept of swash plate was adopted, by Hele-Shaw in building a variable stroke and reversible pump[6].

We can finally note that Forlanini in its 1890 design also had preconceived a possible use of tip jets of overheated steam to move the helicopter rotor, obviously single one in this case, may be in order to increase efficiency avoiding the negative aerodynamic interference effects previously tested and to simplifying the entire solution.

3 The Hydrofoils

The documentation of Forlanini's work on the machines he himself described as *idrotteri*, or hydroplanes, is very rich, thanks to an unusual wealth of sources: sketches, notes, daily test reports and especially the patent depositions of 1904 and 1906.

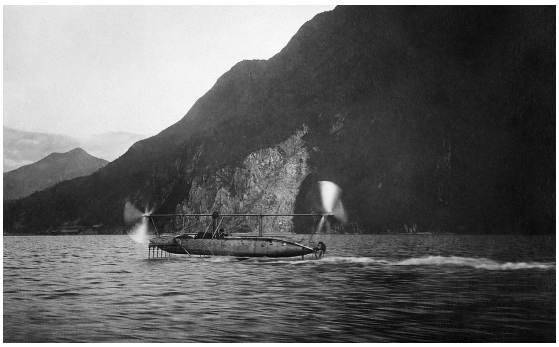

Figure 5: Forlanini's *idrottero* on Lake Maggiore

His achievements in this field, see Figure 5[7], for which in the following years he had patents in Switzerland, Austria and the United States, too, gained wide recognition from contemporaries in the international arena. Emblematic is the interest in Forlanini's work by Alexander Graham Bell (1847-1922), American, but Scottish born, inventor and entrepreneur. Bell and Casey Baldwin, his principal collaborator, had long been conducting an experimentation of hydrodynamic lift devices and, since 1908, Forlanini's results were a sure reference for their research. This led them to meet him on the occasion of their world tour between 1910 and 1911, and to experience Forlaninii's hydroplane on the waters of Lake Maggiore.

They described the sensation as most wonderful and delightful, Casey said it was as smooth as flying through the air.

Bell's enthusiasm took the form of a license to use Forlanini's patent in the United States, an event that favored the development of various machines in North America and the conquest of the world speed record on water in 1919 with 114.04 km/h [8].

The fundamental aspect is that he guessed the enormous difference between seagoing and traditional floating navigation that he described by its own words:
Abbiamo un apparecchio la cui propulsione richiede una spinta decrescente col crescere della velocità e ciò fino ad una data velocità limite, al di là della quale la spinta rimane all'incirca costante per ulteriori aumenti di velocità.

that can be translated as:
We have a device whose propulsion requires a decreasing thrust as the speed increases, up to a given limit speed, beyond which the thrust remains roughly constant for further increase in speed.

In the report accompanying the patent of 1904, Forlanini defines hydroplanes as a means intended to travel on water by dynamic reaction, rather than by static reaction, as is the case of ships and floating devices in general, through the action of water impinging on planes and surfaces, connected to the hull, with small angles, and he compares the water action on the vanes with that of the air on a bird wings.

In these developments Forlanini was assisted by Cesare Dal Fabbro who describes the architecture of the hydroplane as a hull with two symmetrical groups of small wings forming a sort of venetian blind, see Figure 6[9]. He states that at a certain travel speed the submerged wings give rise to a dynamic vertical thrust equal to the total weight and the consequent lifting of the hull off the water. It is then born by the only dynamic reaction affecting the small lower fins still immersed in the water. Under these conditions, the formidable resistance to the hull progression disappears and it is replaced by the much smaller drag of the inferior fins, so that, at the same power consumption, the device can reach speeds far superior to those obtainable in the usual hull travel.

The 1904 Forlanini patent presents a clarity of concepts and a theoretical precision that result from a careful testing aimed to achieve a machine capable of operating with good performance. Unlike the most of his predecessors and many contemporaries, Forlanini had a working method based on a rigorous experimentation and a scrupulous detection and scoring of results, coupled with a constant passion for applied research.

His activity has to be seen in connection with the widest field of research and experimentation on the flight Forlanini was carrying on and the experiences began already during his stay in Forlì, anyway it was after a season of tests conducted in 1903 on the waters of Lake Maggiore that the first patent was claimed. During this phase, Forlanini used small models - one of which weighed about 5 kilograms - he called them *canoes*, built in tin with brass parts and towed by a rowboat at a variable speed from 1 to 3 m/s. Following these experiences between 1903 and 1904, he focused on research on the shape of the fins and, by using a small Froude tank and an instrumentation he designed and built by himself, obtained a series of important data in the field of hydrodynamic shapes, not yet explored.

[6] S.R. Craddock (1961) H.S. Hele-Shaw, The Vocational Aspect of Education,13:27, 172-177.
[7] Library of the Department of Aerospace Science and Technology, Politecnico di Milano, FONDO CESARE DAL FABBRO
[8] Cfr. H. F. King, Aeromarine Origins, Putnam and Company Ltd., London 1966.
[9] *Archivio Centrale dello Stato, Roma*

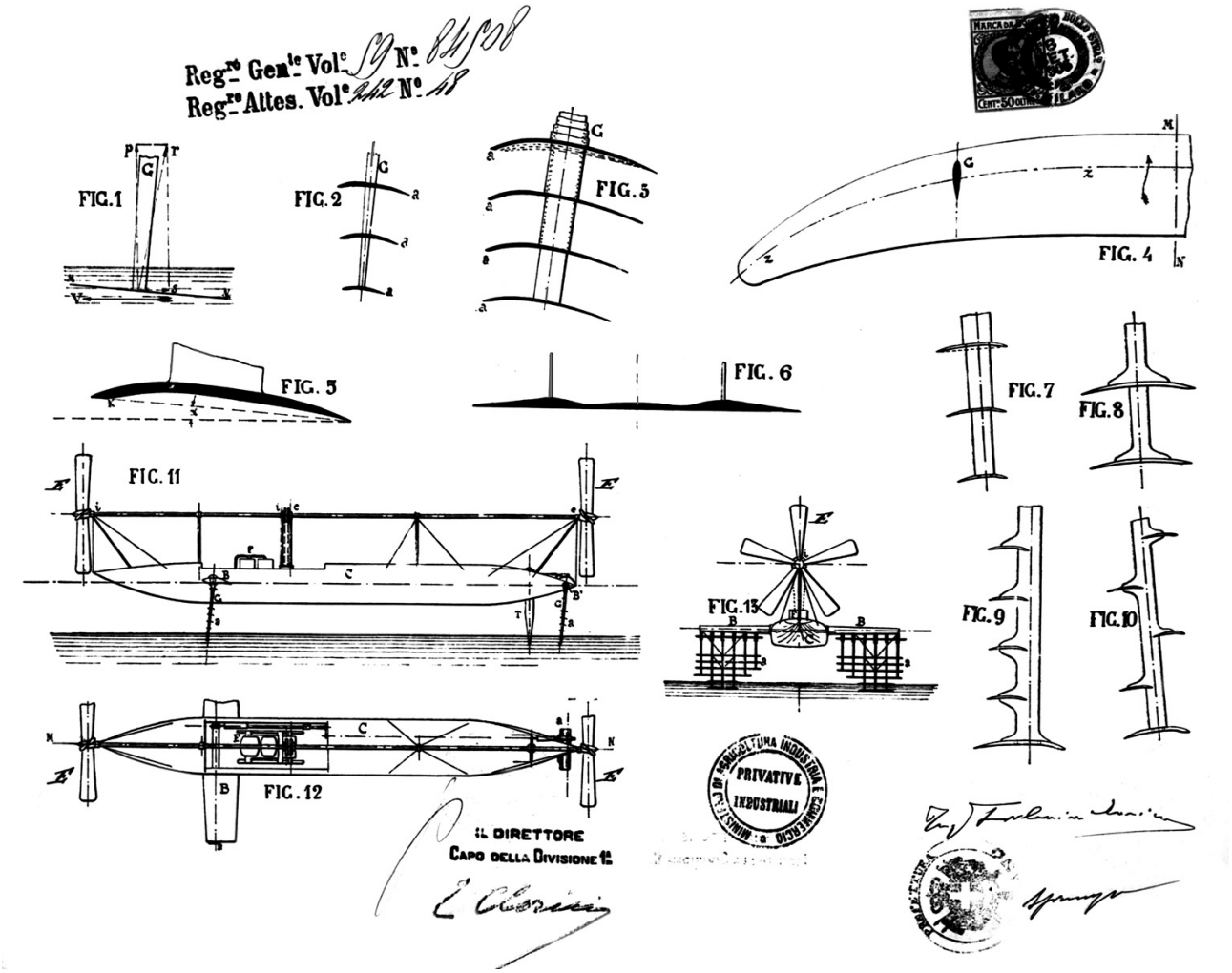

Figure 6: Forlanini's *idrottero* patent

The following year a model of real size, still without any propulsion mean, was towed by a powerboat and was able to support the weight of one or even two people often including Forlanini himself, always ready to personally test the results of his research. The tests were conducted in the Stresa basin of Lake Maggiore and their outcome confirmed the accuracy of the results set out in previous experiences, so that in October 1905 the new machine was ready. The *N.1* - the largest hydroplane among those made by Forlanini with air propellers - had a weight of 1650 kg and was fitted with a 75 HP Fiat engine. The two 5-bladed counter-rotating propellers were 2.70 m in diameter and 6 m in average pitch and could push the boat to a speed of 70 km/h by raising it to a height of 0.55 m over the water. The rudder was of a lamellar type, very wide and very thin and narrow in the lower area, and allowed a perfect steering of the device both at low initial speeds, that is, with a partially submerged hull, as far as at the maximum speed, with the hull emerged. In a note attributed to him, Forlanini claimed that the surface of the submerged fins under running conditions was only 0.15 m^2, corresponding to a weight of 11 ton/m^2. Though he was extremely pleased with the results of the experience, extended over the course of three years, he complained about the poor reliability of the engine.

Subsequent prototypes followed, some were actually built others remained in the stage of study and project. Among them, the most studied and improved models were *N.3* and *N.7*. The *N.3* was tested between 1908 and 1909 with a White steam engine of only 25 HP, but much more reliable of the more powerful Antoinette. Pushed by a submerged propeller, it reached 50 km/h several times, despite the weight was over one ton. It is to be noted that the criteria for choosing the type of the propeller, in the air or submerged, were not dictated by the search for an overall optimal solution: each design had characteristics suitable for the specific performance Forlanini wanted to achieve. He writes: *Large and not too fast hydroplanes can conveniently have a water propeller (*N.7*). High-speed, racing devices will necessarily have the propeller, or usually the propellers, in the air (*N.5*).*

After testing other engines, in particular some Antoinette 35 HP engines, in 1910 Forlanini built the *N.7* prototype, with a water propeller and of the weight of two tons, including the crew of two people. It was able to accommo-

date four more people on board. On the 23rd of December, the hydroplane, with a 100 HP Fiat engine, completed the 34 km route from Laveno to Locarno and return in 29 minutes at a remarkable average speed of 70 km/h.

Forlanini's *idrotteri* took part in races in open sea too and, despite the discontinuous performance of the engines, in every occasion the speed record was established. Anyway the development of a true hydrofoil, in modern terms, dedicated to the people transportation over the water, was not in the purpose of Forlanini. Instead, as he writes in the 1904 patent deposition, he saw in the *idrottero* a possible solution to switch from fast navigation over the water to the flight airborne. He expected to reach the airplane solution by progressively increasing upper wing surfaces so that he could run experimental flights with limited risks for the pilot, who would soon find the necessary trim on the surface of the water to control the unit. This was one of the dearest themes in Forlanini vision: to study solutions to the problem of flying that did not require excessive risks. He, like Lilienthal or the Wright brothers, liked to test the implementation of his designs in person, and his aim was to avoid or limit the sacrifice of human lives, unfortunately a recurring event during the pioneering period of aviation. In his own words he felt himself too old, he was over sixties, to further explore the heavier than air devices and the whole attention was dedicated to the lighter than air ships he had started to study and design at the very beginning of the 20^{th} century.

4 The Airships

The design and construction of airships is the activity that has made Forlanini popular amidst Italian and international public. For sure it is to this activity that he devoted most of his attentions and business not only as an engineer but also as an entrepreneur after his departure from Forlì in 1897. He was engaged not to build experimental models, but he had to create operative machines or, at least, prototypes that could be used in operating conditions with substantial development and execution costs. We have Forlanini's autographed sketches of lighter than air vehicles, and in particular of airships since 1885, however it is with the return to Milan that he regularly resumes his research, particularly with regard to propellers and hulls. To this purpose he built a simplified wind tunnel with a test chamber of 1.1 meters and a maximum speed of 19 meters per second. Of the results of these experiments, however, there is no trace. Forlanini was not a partisan of lighter or heavier than air. He still regarded himself as an aviation amateur in 1896 and, as a free spirit in this field, he was attracted towards both the solutions for possible applications.

It is at the turn of the century that the idea of building a first airship took shape, thanks also to the obtained collaboration of Captain Cesare Dal Fabbro, who, while remaining in service in the army, would have assiduously assisted Forlanini in all the stages of design. The development and realization of *Leonardo da Vinci*, the first airship produced by the company with the same name, that Forlanini established after various vicissitudes, particularly economic, started only in 1907, despite the project went back to 1900 when they were full of hope to realize it in the time span of a couple of years. The same designer complains in a letter of his that it was for outer reasons that the airship completion was delayed and preceded by Zeppelin's and Lebaudy's constructions and that *Leonardo da Vinci* design was old when it took the air. However, he claimed the unsurpassed aerodynamic quality and, although it could not be counted as the first semi-rigid airship, it was the first with the gondola directly connected to the keel. About 40 m long, it had a maximum diameter of 14 meters and the engine was an Antoinette, a ready available gasoline engine, appropriately modified.

The first flight took place on November 27, 1909 and the airship remained in use until the 1st of February 1910, flying 38 times and reaching a speed of 47 km/h. The flights attracted a lot of enthusiasm in public opinion and in popular memory the flight over the Duomo of Milan was particularly remembered. When, as a result of an accident, *Leonardo* was put out of use, the second airship was funded by a popular subscription and appropriately named *Città di Milano*. It was a much more performing machine, considerably greater in size, it was 72 m long with an equatorial diameter of 18 m. The first unofficial ascension took place on August 17, 1913, and on 21 December of the same year it was officially presented and donated to the Italian Army, in the ranks of which it entered as *F.2*.

Figure 7: *The Omnia Dir* airship

Equipped with two Isotta Fraschini engines of 75 and 80 HP, it reached 2400 meters of altitude and a speed of 65.4 km/h carrying up to 14 people. It was the victim of an accident, too. It led to the complete loss of the airship on April 9, 1914, however, it had attracted the interest of the British Admiralty, that ordered three units. They were not supplied due to the vicissitudes of the first world war, that broke out shortly, anyway the *F.2* was followed in a short time by the new model *F.3*, also as *F.4* and *F.5* versions, all supplied to the Italian armed forces. The latest one was used in war actions, as a bomber, too. With the *F.6* model, actually built, and the *F.7* and *F.8* only designed, Forlanini also conceived high-altitude airships with a range and a speed that would allow them to be used for long distance bombardment mission. The *F.6* was used for civil activities at the end of the conflict. The latest creature of Forlanini, now 80 years old, was the *Omnia Dir* airship, a small airship but capable of being maneuvered in all directions on the ground, see Figure 7[10], even with the engine not operating, through the air jets produced by a fan and vectored through valve openings. Moreover, the airship was almost entirely made of light aluminum alloys. The airship could only be completed after the death of its creator. Forlanini died in October of 1930 and *Omnia Dir* flew in 1931, for the perseverance and the determination of Silvio Bassi, a pupil and collaborator of

Figure 8: Forlanini and Bassi

Forlanini, who had to be the Professor of the course *Costruzioni Aeronautiche* at the Politecnico di Milano for many years.

The figure 8[10] portrays Forlanini (left) and Bassi (right) on the car of the airship *F.2 Città di Milano* on 1913.

5 Conclusions

In the present article we shortly recall the main contribution of Enrico Forlanini to aviation. For sake of brevity we didn't mention the experiments on rocket airplane models and many other details of his wide engineering activity. We aim to remember him as a smart engineer who, in the face of an arduous problem, believes that the first thing to do is to find out which part to attack it, or, in other words what is the way to go to the solution, moreover he conceived the desirable future of aviation, indeed it was an astonishing looking forward to talk about aviation development when the only flying objetcs were aerostatic balloons.

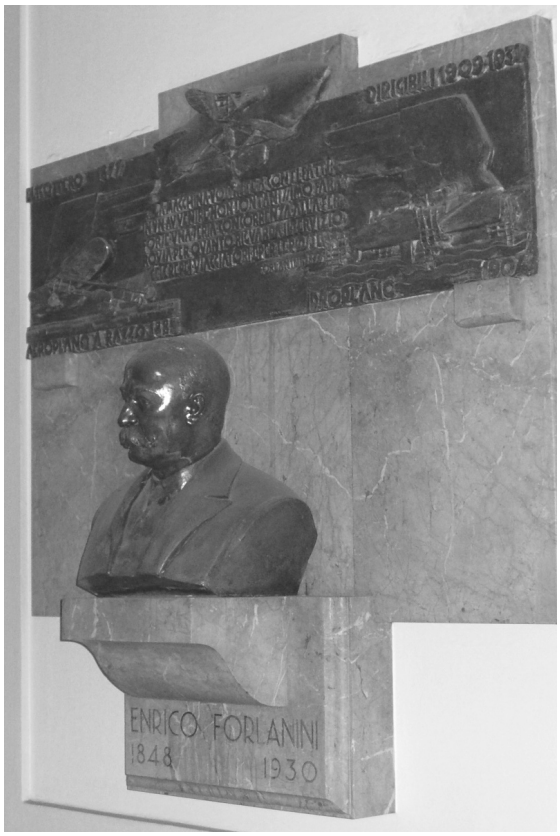

Figure 9: Forlanini's commemorative plaque in the atrium of the Politecnico di Milano

In 1877 as recalled by the words engraved on a commemorative plaque visible in the atrium of the Politecnico di Milano, see Figure 9, Forlanini had to say:
La macchina volante, a conti fatti, in un avvenire non lontanissimo farà forse una seria concorrenza alla ferrovia per quanto riguarda il servizio celere viaggiatori e per le poste.
that translated in English sounds as:
The flying machine, in the near future, will make a serious competition to the railroad as far as the speedy passenger service and the mail.

[10] *Archivio Giancarlo Forlanini, Milano*