



Santos-Dumont

AND THE INVENTION
OF THE AIRPLANE

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Ministério da Ciência e Tecnologia - MCT
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FOREWORD

For more than two centuries, scientists, engineers, inventors, visionaries and flying enthusiasts were challenged by the construction of flying machines and the ability to control them in the air.

The unimpressive demonstrations of the small hot air balloon carried out by the Brazilian Jesuit Bartolomeu de Gusmão, in 1709, showed that the dream of flying could become reality. In 1880, another Brazilian, Julio Cezar Ribeiro de Souza, born in the State of Pará, made some achievements in the maneuvering of balloons but it was not until October 19, 1901, when the Dirigible No. 6 of Santos-Dumont flew around the Eiffel Tower in Paris, that controlled flight was proved. In 1906 the extraordinary impact of the airplane invention was felt worldwide. The airplane became the main form of transcontinental transportation drastically changing relations among nations and impacting modern life style.

The work that Alberto Santos-Dumont accomplished in the aeronautical field reflects his impressive creativity. He was the inventor of the first internal combustion engine in aerostation and the engine with opposite cylinders. He was an innovator in the use of materials that had not yet been applied and in the use of the wristwatch among other contributions. Santos-Dumont's career had two highlights: the presentation of the first airplane, the 14-Bis, which he managed to make a complete flight before a committee of specialists and the public and the other one was the invention of the first ultralight airplane, the small Demoiselle.

Santos-Dumont's innovative approach in the technological field is a rare accomplishment. He designed, built, tested and publicly demonstrated his models, motivating other inventors to follow his steps.

His flights with his balloons, his dirigibles and his airplanes provided important elements to the subsequent aeronautics development. Santos-Dumont came from a wealthy family who gave him the opportunity to broaden his education and his technological talent. Many of his innovative activities were carried out in Europe because at that time the technological conditions in Brazil were not suitable.

The Ministry of Science and Technology is involved with the national and international celebration of the 100th anniversary of the 14-Bis flight. This Ministry is working with various Government agencies as well as with the scientific and technological community in the distribution of educational materials and the release of information related to the occasion. It is important for all Brazilians, especially the younger generations, to get an opportunity to learn about the life and work of this great fellow Brazilian, to discern the impact of his inventions and to understand the scope of science and the technological environment that made his success possible. We ought to explore the curiosity of the mind, to boost creativity and to promote innovation in all aspects of social life. One of the current challenges for the Government and the Brazilian society at large is to provide millions of young Brazilians – an extraordinary human potential – with the opportunity to have quality Education particularly in science. When this becomes a reality, we will certainly have many other scientific and technological achievements to celebrate, as the one we are doing now with great national pride with Santos-Dumont.

Sergio Machado Rezende

Minister of Science and Technology

EDUCATIONAL BACKGROUND



Childhood on the Farm. Alberto Santos-Dumont was born on July 20, 1873, in the small farm of Cabangu, near the city nowadays called Santos Dumont, in the state of Minas Gerais. In 1879, the Dumonts settled in the Ribeirão Preto region in the state of São Paulo, where his father, Henrique Dumont (1832-1892), started a successful coffee farm named Arindeúva. During his childhood years on the farm, Alberto acquainted himself with the

*Santos-Dumont
in 1901*

coffee production machinery, as well as with the locomotives, which helped transporting the production of coffee beans. This innovation was introduced by his father in the Imperial time.

The Future is in Mechanics. The young Alberto briefly studied at the Cult to Science School, in the city of Campinas, state of São Paulo. In 1892, he moved to Paris, France, where he took tutoring classes. He followed his father's advice: "In Paris, with the help of our cousins, you will find a specialist in physics, chemistry, mechanics, electricity, etc.; study these subjects, and do not forget that the future of the world is in Mechanics. Do not concern yourself about earning a living. I will be leaving you with large enough estate for you to live comfortably."

A Man of Ingenuity. Santos-Dumont never had a regular education. He was a sportsman. As a friend said: "He did not apply himself as a student; furthermore, he was not inclined to theoretical studies, but showed extraordinary mechanical and practical talent and, above all, ingenuity".



AEROSTATION AND FAME

The Brazil and the Dirigibles.

In 1897, Santos-Dumont returned to Paris and began to focus on the problem of aerostation, the science that studies the basic principles of aerostats (balloons and dirigibles). He learned to fly balloons and, in 1898, he built one of his own, and named it 'Brazil'.

He was an innovator, always searching for new solutions, using materials not yet used to obtain the lightest weight. The Brazil was the smallest hydrogen balloon ever built, with a capacity of 113 cubic meters of gas, in a silk enclosure measuring just 6 m (19.6 ft) in diameter.

Innovative Solutions. Also in 1898, he built a new balloon, the *Amérique*, as well as his first

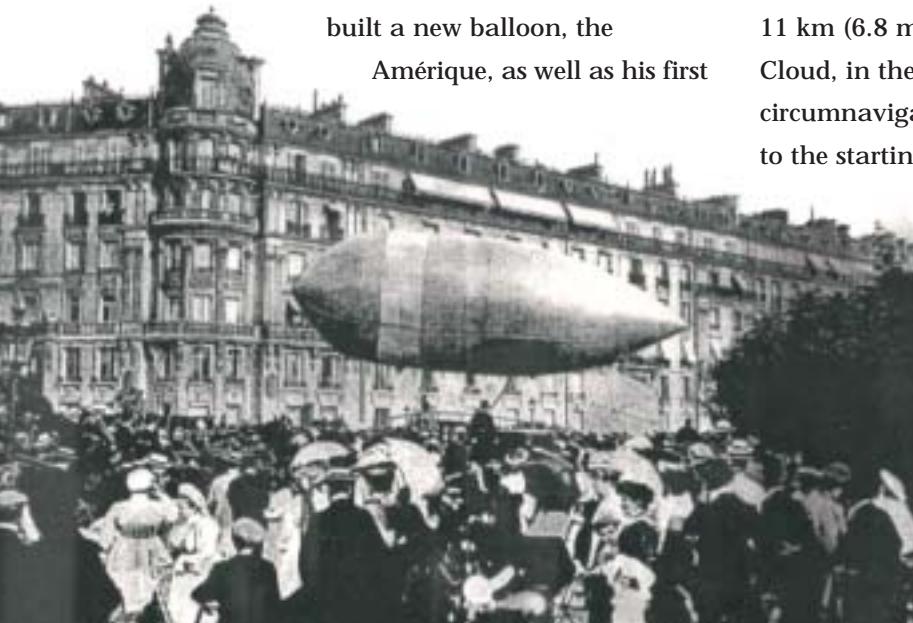
dirigible which was not successful. In two attempts it crashed twice because the machine was not rigid enough. Despite this problem, the machine had revolutionary innovations and the most important one was the use of

an internal combustion engine. In fact, it was the first successful gasoline engine used in aeronautics. The following year, he presented his second dirigible – almost the same as of the first one –, but it also crashed. That same year, after several design changes, he finally succeeded flying his third dirigible, which had flying innovations.

Accidents and Prize. In 1900, Santos-Dumont was eager to win the Deutsch Prize offered to the first person who could fly the 11 km (6.8 mi.) circuit – taking off from Saint Cloud, in the surroundings of Paris, circumnavigating the Eiffel Tower and returning to the starting point in less than thirty minutes.

He made some experiments with his *Dirigible No. 4*, but it was not successful. After making some

On June 23, 1903, Santos-Dumont parked the Number 9 in front of his apartment, in the heart of Paris. The City of Light stopped to see it. Soon after, he made several public demonstrations with his dirigible, bringing the world's attention.



changes in its design, Santos-Dumont decided to face the challenge, with a bigger balloon, the Number 5. On August 8, 1901, in one of his attempts, he was in a serious accident when he fell on the roof of the Trocadero Hotel. Twenty two days later, however, he built a new dirigible, the Number 6, and after making several trial runs and going through accidents, on October 19, 1901, he was able to fly around the Eiffel Tower. For this feat he was awarded the Deutsch Prize, despite questioning from some prize committee members.

One of his Facets. Generosity was one facet of Santos-Dumont's character. Before flying, he made a public announcement that he was not interested in the prize of 100,000 francs and that, if he won it, he would donate half of the prize money to his team workers, and the other half would be given to the city of Paris, to be distributed to the unemployed city workers.



The dirigible flight test was on October 19, 1901, when Santos-Dumont flew around the Eiffel Tower.

HEAVIER
THAN AIR

International Criteria. On October 14, 1905 the Federation Aéronautique Internationale (FAI) was founded in the mold of the International Olympic Committee. Its creation arose from the need of establishing worldwide criteria to decide if, in fact, a heavier-than-air machine was viable. The criteria were: a) the flight should be done before an official organization, qualified to ratify it; b) the flight should be done in calm weather and over a plain ground, and properly documented; c) the machine should be able to take off from a designated area by its own means with a man on board; d) the machine should carry on board the

necessary source of energy; e) the machine should fly in a straight line; f) the machine should make a change of direction (turn and circle); g) the machine should return to the starting point.

More than 100 Meters. FAI members knew that it would be difficult to fulfill all the criteria in a first attempt. Therefore, the organization established a prize for the first ratified flight that could fulfill only the criteria a) to e), leaving for a later occasion the other two criteria. It was also established that the flight in straight line should exceed the mark of 100 m (328 ft). FAI analyzed previous flight reports before the organization was formed and it concluded that no one had fulfilled those criteria.



In 1907, Santos-Dumont inspects the Number 15, the airplane that never flew.

Previous Reports. Many reports had already been done about flights by airplanes.

In the 1890s, the Frenchman Clément Ader (1841-1926) made a flight demonstration before officers of the French Army with his Avion III. Although the official report was confidential, the aeronauts had information that the flight test was unsuccessful. At the same time, the German Otto Lilienthal (1848-1896), who had been conducting safety glides, made an experiment with a single-engine model. Jumping from the top

of a hill, he managed to maintain himself in the air without, however, improving his performance. He returned to work with gliders until he died in an accident.

Wind and Catapult. In 1901, the Teutonic-American Gustave Whitehead (1874-1927) announced that he had managed to take off and to fly in his machine. Whitehead's feat was witnessed by almost 20 people, but no appropriate commission was there to observe it. In 1903, the Wright American brothers, Orville (1871-1948) and Wilbur (1867-1912) announced, by telegram, that they flew with the Flyer, starting from a field with an inclination of about nine degrees, and wind around 40 km/h (24.9 mph). In the following two years, they announced that they were making turns and long flights in closed circuits, but their machine depended on wind conditions or the use of catapult to take off. Other reports were released, but none of them complied with all the criteria adopted by FAI.

SUDDEN CHANGE OF REASONING



No Real Flight. The FAI criteria were considered difficult to comply by the members of the Aero Club of France. Following the tradition of that time, the Frenchman Ernest Archdeacon (1863-1950) established a less strict challenge. Maintaining the first five FAI criteria, he offered a prize for who could manage to reach the mark of 25 m (82 ft). To up the challenge, Archdeacon and his countryman Deutsch de la Meurthe (1846-1919) offered a prize for who could fly 1 km (0.6 mi) in a closed circuit. By 1905, there had been no real flights on a heavier-than-air machine yet.

Serious Deficiencies. In Paris, Santos-Dumont participated in the discussions about flying and came to the conclusion that the course of the aeronautics pointed out to the airplane. He, who had demonstrated the possibility to fly a balloon, knew that the dirigible could

not compete with the airplane. Although the world was astonished with the demonstrations of Dirigible No. 9 in 1903, it was clear that the lighter-than-air machines still presented serious deficiencies.

Helicopter and Single-Engine Aircraft. In the middle of 1906, Santos-Dumont published a sketch of two of his heavier-than-air flying machines: a helicopter and a single-engine aircraft. In a twist of designs, in July 1906, the 14-Bis was practically ready for the first tests.

Santos-Dumont in his Dirigible No. 9 in 1903 (on left). Deutsch de La Meurthe was an enthusiastic supporter of the art of flying. He awarded prizes for inventions. Deutsch's postcard (below) has an inscription to Santos-Dumont (1901).



THE FIRST RATIFIED FLIGHT

220 Meters in the Air. On November 12, 1906, by the end of the day, the 14-Bis ran on the grass of the Bagatelle fields, at the Bois de Boulogne, in Paris. After few meters, it took off. It reached the speed of 41.3 km/h (25.6 mph), flying over 82 m (269 ft) of distance. Half an hour later, Santos-Dumont started his forth and last test of the day. In the air, he covered 220 m (721.7 ft) in 21 seconds, at an average speed of 37.4 km/h (23.2 mph), leaving the spectators astonished.

Emotion of the Spectators. The report of the Aero Club of France Commission, the organization responsible for flight ratification, mentioned the



The 14-Bis arrives in Bagatelle on November 12, 1906 (prior page). That day, he made the first ratified flight (on right).



emotion of the spectators: “The fourth attempt was done in a reverse direction of the previous three attempts. It took off against the wind at 4:45 p.m. at the end of the day. The headwind and the slight terrain inclination provided an immediate airborne that displayed beauty to the public and left the yet unseated

spectators in awe. To avoid the crowd, Santos-Dumont increases the speed and reaches the altitude of more than 6 m (19.6 ft), before the speed decreases. Has the brave experimenter hesitated for a moment? The machine seems a little bit off-balance and makes a turn to the right. Santos-Dumont, always admirable for his cold blood and his skills, cuts the engine and returns to the ground. But the right wing reaches the ground before the wheels and the aircraft suffers light damages. Luckily, Santos-Dumont is unhurt and is welcomed passionately by the spectators who enthusiastically acclaim him as Jacques Fauré carries triumphantly on his shoulders the hero of this glorious feat.”

A Complete Flight. For the first time in history, a heavier-than-air machine managed to make a complete flight, taking off, flying and landing without external assistance. After several previous trials, Santos-Dumont finally learned how to balance and to control his aircraft in the air. This was the result of a work of extreme accuracy, with tests and experiments carefully carried out and always in the eyes of the public. Just after the November 12 flight, Ferdinand Ferber (1862-1909), a captain of the French Army and one of the most important inventors in the aeronautics field, said the following:

“Step by step, leap by leap, flight by flight, Santos-Dumont has made great advances in conquering the space.”

14-BIS FLIGHTS

Lessen Weight. The 14-Bis was built quickly: in about two months. The exact date Santos-Dumont started its design it is not known. The only thing known is that the machine was almost finished by the end of the first semester of 1906. In fact, on July 18, 1906, Santos-Dumont joins the Aero Club of France to participate in two competitions of heavier-than-air

machines: the Archdeacon Cup and the Aero Club of France Prize for the one who could fly farther than 100 m (328 ft). He soon made experiments with his prototype attached to the Dirigible No. 14, creating a heavier-than-air machine, but with its weight lessened due to the ascensional force of the dirigible balloon.

Journal of a Brave Experimentalist. • July 18, 1906: The machine is finished. • July 19 to 29: Tests with the airplane attached to the Dirigible No. 14 and suspended in an inclined cable. • August 21: Tests in the polo field. • August 22, 4:00 a.m.: The 14-Bis rose from the ground. Santos-Dumont verified that the 24 hp engine was insufficient. • September 3: A new 50 hp engine was installed. • September 4, Bagatelle, 5:00 a.m.: The 14-Bis ran but Santos-Dumont could not control it. • September 7, around 5:00 p.m.: It reached an altitude of about 2 m (6.5 ft). At 6:55 p.m.: The 14-Bis slid on the ground. At 7:20 p.m.: New attempt, no success. • September 8 to 12: Changes in the design. • September 13, 7:50 a.m.: The 14-Bis ran 350 m (1148.2 ft) on the ground. Changes in the machine. • 8:40 a.m.: New attempt and it flew a distance of approximately 7 m (22.9 ft). • October 23, 9:15 a.m.: It runs

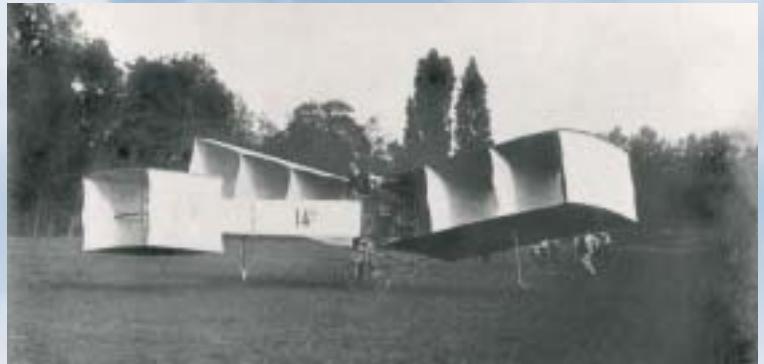
*Photograms
of the film
of the 14-Bis
flight on
November 12,
1906.*



in Bagatelle. The 14-Bis had been varnished in order to improve lift, and changes were made in the nacelle frame (pilot's place) to reduce weight. At 4:45 p.m.: The 14-Bis takes off and flies 60 m (196.8 ft) at an altitude of 3 m (9.8 ft). Santos-Dumont wins the Archdeacon Cup. • November 12: Santos-Dumont installed an octagonal aileron (a device to control roll). Four

trials, each one with a series of flights: I) 10:00 a.m.: It flew about 40 m (131.2 ft); II) 10:25 a.m.: Two flights, one of 40 m (131.2 ft) and one of 60 m (196.8 ft). III) 4:09 p.m.: Two flights, one of 50 m (164 ft) and one of 82.6 m (271.2 ft), in 7.2 seconds, with an average speed of 41.3 km/h (25.6 mph); iv) 4:45 p.m.: 220 m (721.8 ft) flown in 21 seconds, at a speed of approximately 37.4 km/h (23.2 mph).

The Last Flight. After the November 12, 1906 flights, Santos-Dumont made some modifications in the 14-Bis. The most important one was the change of the octagonal aileron placed in the middle of the outer cells of the wings. During the same period, he built a new airplane, invention No. 15, drastically changing its configuration. On April 4, 1907, at Saint Cyr, the 14-Bis flew for the last time. It flew about 50 m (164 ft) and crashed. Santos-Dumont did not attempt to repair it.



The 14-Bis (above) on October 23, 1906, in Bagatelle, runs to take off and win the Archdeacon Cup for flying 60 m (196.8 ft)



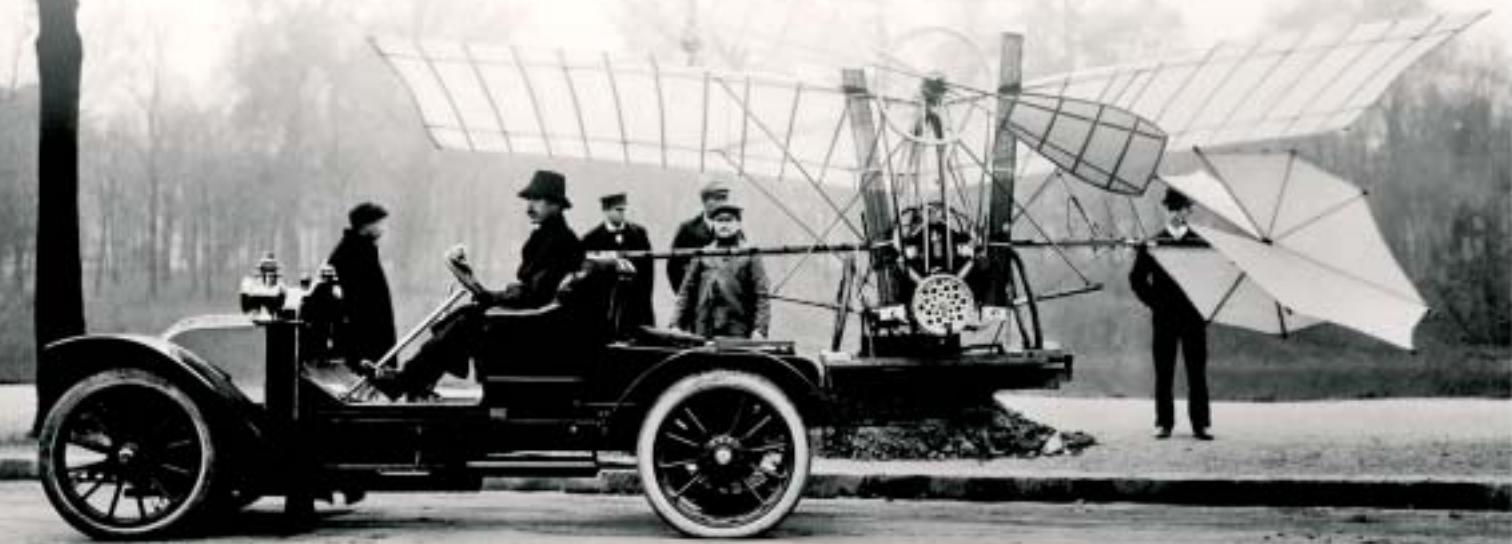
THE DEMOISELLE

Invention No. 19. Santos-Dumont knew that the 14-Bis was not a functional airplane. In less than a year he designed, built and tested five new inventions. In November 1907, he tested the first Demoiselle, his invention No. 19. Its fuselage consisted of a single bamboo pole. Although it took off and flew about 200 m (656.1 ft), it was clear that this new airplane model had serious structural flaws.

Take-off and Maneuver. On January 13, 1908, the Frenchman Henri Farman (1874-1958) was the first one to fly 1 km (0.6 mi) in a closed circuit. The two basic flight challenges – take-off and the capacity of maneuvering – had been demonstrated: the first, by Santos-Dumont, on November 12, 1906, and the second by Farman, on that day.

Long Distances. By the middle of 1908, a new flight challenge emerged: the ability to fly long distances. Take-off became secondary. The Wright brothers returned to flying. It was only at that moment that they released the pictures of their December 17, 1903 flight, the specifications of their machines, and began flying in public in France and in the United States. In fact, the Flyer III, a machine very different from the one they flew in 1903, made great achievements. In the end of 1908 Wilbur flew 124 km (77 mi) under the French sky.

*The first
Demoiselle on
November 16,
1907.*

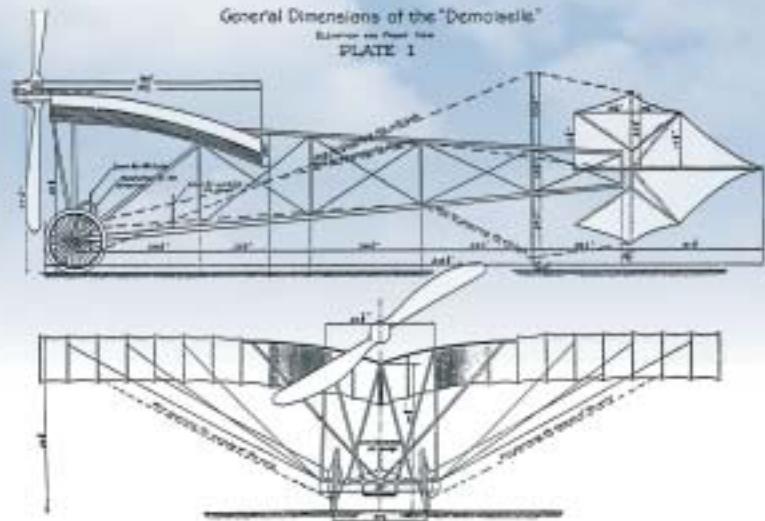


The First Ultralight.

In 1909 another Frenchman, Louis Blériot (1872-1936), crosses over the English Channel, showing the military importance of airplanes. In that same year, Santos-Dumont presents his last aeronautical invention: Demoiselle No. 20 is the first ultralight in history. Small, weighing only 115 kg (253.5 lb), with a wingspan of 5.5 m (18 ft) and a length of 5.5 m (18.2 ft), it worked with a 24 hp engine.

World War I Ace.

In 1910 Santos-Dumont announced his intention of abandoning his flying experiments. He was tired, exhausted and debilitated. He was probably starting to feel the symptoms of multiple sclerosis, a disease he had to carry until the end of his life. The Demoiselle was sold to an aspiring pilot that later on would become one of the greatest World War I Aces: Roland Garros (1882-1918).



Drawings of Santos-Dumont's last Demoiselle published in the 1910 Popular Mechanics magazine.

Aviation Enthusiast. Santos-Dumont published the drawings of Demoiselle No. 20 and allowed it to be built by some companies. The machine was copied and became a popular model. After abandoning his flying experiments, Santos-Dumont started to dedicate himself to flight socialization, showing that flying was safe and could change relations among nations. He attended conferences and called the attention of all American nations for the need of a fleet of airplanes for defending that continent. He was concerned about the role of the airplane in the war.

LIVING THE CONFLICT



*Santos-Dumont and Gago Coutinho
(the last on right) in the 1920s*

Several Contributions.

The airplane came as the result of the contributions from several inventors. Among the early contributions (end of the nineteenth century) were: Lilienthal's glides and early experiments using engines; the creation of double-winged gliders (biplanes) with light and rigid structures. Later contributions were the development of gliders by many, among them Orville and Wilbur Wright. At the same time, it was necessary to understand what was a heavier-than-air machine and define the criteria that could guarantee that a given invention would

CONCLUSIONS, INVENTIONS AND LEGENDS

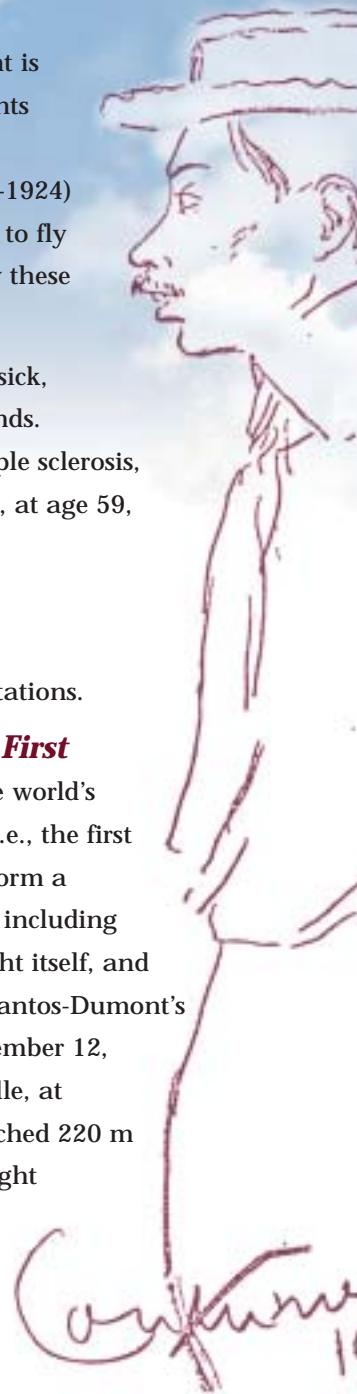
Pilots leader. From the 1920s on, Santos-Dumont is a changed man. He worries about the flying accidents and complains about his health. He honors fearless aviators like the Portuguese Sacadura Cabral (1881-1924) and Gago Coutinho (1869-1959), who were the first to fly across the South Atlantic, in 1922. He is honored by these pilots as the leader of them all.

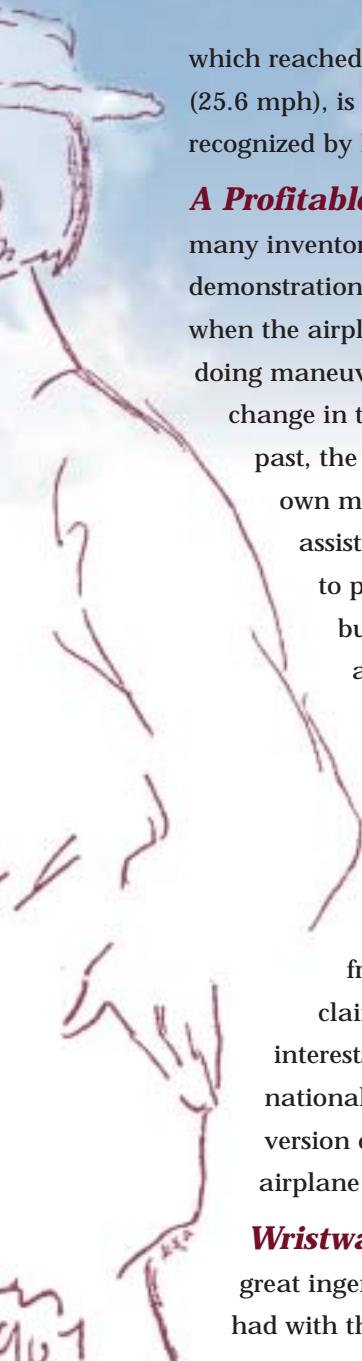
Depressed and Worried. Santos-Dumont felt sick, depressed, worried and often complained to his friends. He was probably depressed by the advancing multiple sclerosis, a disease that drove him to suicide on July 23, 1932, at age 59, in a hotel room in Guarujá (SP).

fulfill the expectations.

The World's First Airplane. The world's first airplane – i.e., the first airplane to perform a complete flight, including take-off, the flight itself, and landing – was Santos-Dumont's 14-Bis. His November 12,

1906 flight, performed in Bagatelle, at 4:45 p.m., when his airplane reached 220 m (721.1 ft), was the first ratified flight in history and is still considered today by FAI as the first distance record of a heavier-than-air machine. His previous flight,





which reached the speed of 41.3 km/h (25.6 mph), is the first speed record recognized by FAI.

A Profitable Market. By 1907 many inventors were performing their demonstrations and in the following year, when the airplane was already flying and doing maneuvers in the air, there was a change in the notion of flight. If, in the past, the take-off through the machine's own means, without any external assistance, was an essential condition to prove that it was possible to build an airplane, after the advances made in those early years what became important was the duration of the flight and the distance reached. That is when the Wright brothers came with their Flyer III, an airplane totally different from the 1903 first Flyer, claiming the primacy. Now other interests were at stake and particularly nationalistic issues arose to create a new version of the facts. After all, the airplane created a profitable market.

Wristwatch. Santos-Dumont showed great ingenuity. From a conversation he had with the owner of one of the major

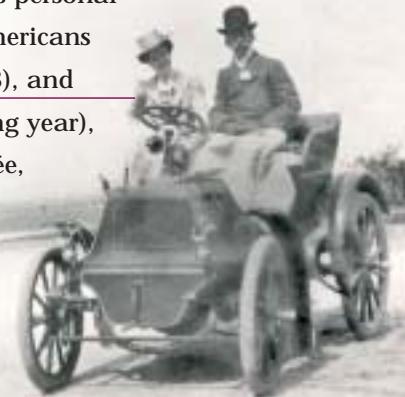


watch companies, Louis Cartier (1875-1942), emerged the idea of making a wristwatch to keep track of the flight time.

Not that the wristwatch did not exist before, but Cartier Santos, a sophisticated model, worn by a personality such as Santos-Dumont, arose the interest of a society eager for new things.

Alternate Steps. A Encantada ('The Enchanted'), his little house in Petrópolis, Brazil, built in 1918, is another example of his creativity. In the entrance there is a very steep staircase, although very comfortable to climb. Santos-Dumont built it with alternate steps, making the climb easier. The first step forces the visitor to use the right foot. Was it done on purpose? From a naïve point of view, it seems impossible for anyone to live there. But the house was his place of rest and retreat, a reserved space. Across Rua do Encanto there still exists the house where his servants stayed.

Stories and Legends. There are stories and legends about Santos-Dumont, and facts not much talked about, as his personal relationships with the Americans Lurline Spreckels (in 1903), and Edna Powers (the following year), who appears as his fiancée, as well as with the Brazilian Yolanda Penteadó in the 1920s.



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