# Superbly Small: Alberto Santos-Dumont

# and his Demoiselle Airplanes



The classic Demoiselle, the fourth version of the Santos-Dumont 20, in flight September 1909.

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The *Demoiselle* – the *Dragonfly* or *Damselfly* – is the name of five or more versions of one early airplane in 1907-1909, and later built for sale by a manufactuer. In its final form it was the first small light airplane with reasonably good performance for its time. In the earliest days of aviation it and its creator were famous. The *Demoiselle* is so appealing, partly due to its appearance in a movie from 1965, that more than a dozen modern flying "replicas" (of varying authenticity) have been made, and dozens of modern aircraft of similar configuration have been built and flown for recreation, incorporating improvements based on a century of aircraft construction and flying.



The original Demoiselle, Santos-Dumont's 19, of 1907, in Neuilly.

The *Demoiselles* were creations of Alberto Santos-Dumont, a wealthy young Brazilian residing in Paris, beginning in 1907. He was an accomplished and leading inventor, designer, and pilot of balloons and small pressurized non-rigid airships who operated his own workshop and hanger in Paris.

In October 1906 Santos-Dumont achieved the first powered flight of a heaver-than-air airplane in Europe, in a flying machine he called 14bis, and was celebrated then in France as the first man to fly. The classic *Demoiselle* is now perhaps Santos-Dumont's better remembered aircraft, and certainly was a far better flying machine than 14bis. Much of the modern material about Santos-Dumont concentrates on his personal life and exploits but with few technical details about the aircraft he created and flew, despite his flying inventions being the center of his life. For example, one recent biography has only a very short, and very erroneous, description of the famous *Demoiselle* despite its importance to Santos-Dumont. Authoritative sources for technical details about the several *Demoiselles* designed and built by Santos-Dumont and others are difficult to find, and there are errors, confusion, and inconsistencies in what is available. Many modern sources do not recognize that there were several different versions of the *Demoiselle*; some authors write as if there were only one *Demoiselle*.

This report reviews the history and technical specifications of the *Demoiselle* airplanes, the process of development, flying characteristics, and all of Santos-Dumont's important flights. The motivation for this article was interest in finding complete and correct technical information about Santos-Dumont's *Demoiselles*. This

report is possible because archived copies of newspapers (*Le Matin* and *Le Figaro*, Paris) and aviation newsletters (*Flight*, London and *L'Aérophile*, Paris) are now available online. Another essential set of clues lies in the many original period photographs online, usually undocumented and often poorly or incorrectly labeled. All of these were examined in detail as in a detective investigation. Using the usual methods of scholarship when working from old or incomplete and sometimes erroneous sources a fairly consistent and full picture has emerged. The photographs by themselves reveal versions of the *Demoiselle* never before described in print, so far as I know. In some ways the research has been more like solving a mystery than compiling information. Gaps and questions remain in the story, but the outline and many details are now clear.

One reason why information about Alberto Santos-Dumont and his aircraft is incomplete is that he burned all his papers in 1914 during World War I, including one supposes his designs and notes for his flying machines. He had been falsely accused of being a German agent, he who done so much for French aviation in both airships and airplanes, who was an officer of the Légion d'honneur, and who had offered to freely give his powered airship fleet of three ships to the French military. He was quickly cleared but the insult was bitter. His reputation in the development of aviation might otherwise be greater than it is. Another result is that the development and details of the *Demoiselles* can only be reconstructed from old photographs and from brief reports of varying accuracy written by others. Years later Gabiel Voisin said "He left us, as a legacy, nothing but his name engraved on our hearts."

Santos-Dumont numbered his flying machines in order. Through number 14 they were balloons and powered airships; the next, the "14bis" (meaning "14 second") was his first heavier than air flying machine. In the autumn of 1906 he achieved the first powered aircraft flights in Europe in the 14bis. On October 23, 1906 Santos-Dumont won the Archdeacon Prize on for the first flight of 25 meters, and then on November 12 he won the Aero Club Prize for the first flight more than 100 meters. That second flight lasted 21 seconds, covered 220 m (722 feet), and reached about 7 meters (20 feet) high. He was acclaimed as the leading flyer of Europe. Santos-Dumont's machines 15 through 17 were either untested or not successful. Number15 was a large heavier-than-air biplane flying machine which collapsed attempting takeoff, 16 another powered dirigible, and 17 another large airplane with a V16 engine which apparently was considered too dangerous to attempt to fly. His 18 was a propeller-driven hydroplane which he worked on extensively in 1907.

In October 1907 Santo-Dumont was designing a very small heavier-than-air flying machine, his number 19. He intended to use it to compete for the Deutsch-Archdeacon "Grand Prize of Aviation" (50,000 francs, about \$200,000 today) for the first fight of a kilometer (0.62 miles) including a half turn around a flagpole to return to the starting line. Other aviators of the time in France were eagerly striving to fly half a kilometer and make a turn.

Several locations in and near Paris saw Santos-Dumont's flying activities. He lived at 5 rue Washington close to the Avenue des Champs-Élysées. His first airplane flights were at Bagatelle, a large field in the Bois de Boulogne park in western Paris. His "airship station" or "aerodrome," consisting of two houses, a hanger, and a large enclosed yard, where the *Demoiselles* were built, was in the suburb of Neuilly, between Bagatelle and the Seine, now 83-87 Boulevard de General Koenig. Early tests were at Issy-les-Moulineaux, a suburb of Paris often called Issy, on a large open military field used by many early aviators where Santos-Dumont had hanger, 4 miles (7 km) west of the center of Paris. And he flew *Demoiselles* from Saint Cyr, 8 miles (13 km) west of Paris where he also had some kind of facility, perhaps a hanger for one of his airships. The aerodrome at St. Cyr was, and remains, just west of the gardens of the Palace of Versailles. In 1909 and 1910 you could have seen a *Demoiselle* flying over Versailles on a rare occasion.

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Side view of Santos-Dumont's 19 in the yard at Neuilly.

## The Santos-Dumont 19, The First Demoiselle

The new plane, number 19, became the first *Demoiselle*. The name *Demoiselle* now refers to a series of similar airplanes numbered from 19 through 21, and perhaps there was a 22. There is no single *Demoiselle* design; indeed at first it seems like every photograph of a *Demoiselle* shows a different machine. Santos-Dumont was constantly revising his designs. Owning his own workshop and employing his own machinists, he could easily make significant changes. For example, there were two different versions of 19, and several photographs show what are heretofore undescribed prototypes of the Santos-Dumont 20, the classic *Demoiselle*.

The French word *demoiselle* has the conventional translation of "young lady" in English. By the 1900 period in France the word demoiselle had a popular meaning of a higher paid member of the demi-monde. Both *demoiselle* and the English word damsel are close to an older English word *damosel*. The even older *damoisele* is the root of damosel and damsel, and the same word was used in both Middle English and French when French was the language of the English court.

In recent French *demoiselle* is also used as a name for the dragonfly. The name *Demoiselle* was given by Santos-Dumont's friend Cristina Prado. "She saw the plane under construction and thought it looked like a dragonfly" because the wings and tail were covered in translucent yellow silk cloth, and you can see ribs through the covering. She named the airplane for the dragonfly, not young lady or courtesan. Considering that some dragonflies in English are called damselflies, and that demoiselle also means damsel, perhaps the best English equivalent for the aircraft name *Demoiselle* really is *Damselfly* (thanks to Marc Webster).

Number 19, of which there was only one, established the basic conceptual design for all *Demoiselles*: the engine with a propeller is in front, and there is a single high wing just behind the engine, connected via an open frame to the tail empenage, consisting of a rigid combined elevator and rudder, which jointly pivoted in all directions on a universal joint. The pilot sat below the wing and behind the front wheels, and there was usually a tail wheel behind the pilot or a skid further aft.

## **Santos-Dumont 19 Specifications**

Wingspan	about 5 m (16.5 feet)	
Wing chord	2 m (6.5 feet)	
Wing area	about 9 square meters or less	
Wing ribs	7 per wing	
Length overall	8.4 m (27.5 feet)	
Engine	Dutheil-Chalmers "17 to 20 horsepower"; bore 125 mm; stroke 100 mm.	

Weight with Santos-Dumont 110 kg (242 pounds)



Santos-Dumont flying 19 at Issy-les-Moulineaux in November 1907, about as high as he flew that day.

This general arrangement, but not the construction, is that of many aircraft built since: a single pair of high wings above the pilot, the an engine in front with a tractor propeller, all connected by some structure to a tail with vertical rudder and horizontal elevators. Today all the original *Demoiselles* look like a 'normal' airplane, if primitive in construction, whereas this 'cruciform' layout was new in 1907 (it was not invented by Santos-Dumont: three or four other cruciform monoplanes had been built in 1907). Despite limitations in materials, construction techniques, engines, and any established knowledge of aircraft dynamics, control, and stability, Santos-Dumont from this beginning created a later model *Demoiselle*, his final version of number 20, with the performance of a modern ultralight airplane.

The 19 was a truly miniature aircraft for any period; one French source called it "miniscule." With the pilot

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Santos-Dumont, this aircraft weighed only 110 kg (242 pounds). It was distinguished by a propeller made of fabric over a light aluminum frame, a single bamboo pole (!) connecting the tail to the rest of the aircraft, two vertical six-sided panels ("lateral rudders") under the wings next to the pilot, and a similar horizontal panel (the "forward stabilizer") in front of the wheels. The six-sided panels were omitted in most later *Demoiselles*. The tail wheel was immediately behind the pilot and was as large as the front wheels. The wings had dihedral: they sloped upward some 10 or 12 degrees on each side. There were 7 curved ribs in each wing, probably made with thin steam-bent bamboo stems for ribs. The engine was a two-cylinder, horizontally opposed, Dutheil-Chalmers of "17 to 20 horsepower."

An Autochrome photo of balloons made with yellow silk in Paris in 1909. Santos-Dumont may have begun the common practice of using this bright, light fabric for balloons, with his first balloon in 1898. He used the same material for the covering fabric of the wings and tail of the *Demoiselles*.



The covering was translucent pale yellow varnished silk, the same material Santos-Dumont used for the envelops of his successful airships. The frame was made of bamboo, with steel tubing for the vertical struts and fittings. There is little U-shaped tube under the wheel's axle in photographs of 19: this was a stirrup for the pilot's feet, under the axle. The pilot sat *very* close to the ground! The fabric-on-frame propeller was perhaps a hold-over from his airships.

The 19 was built by Santos-Dumont's staff in fifteen days and completed on November 15, 1907. The next day, at Issy-les-Moulineaux, on his third take-off attempt, Santos-Dumont flew 19 for the first time, covering a distance of almost 200 meters, but with no turns. Without any further trials, he then informed the Aero Club of France that he would fly again early the next morning for the Deutsch-Archdeacon Grand Prize. He may have been under pressure to try for the prize, since Farman had scheduled an official test on November 18.



On the 17th he made eight ascents, with observers following closely in a car. The greatest distance flown was 200 meters in one flight, while reaching an altitude of "4 to 5 meters" (13 to 16 feet) in another flight; one flight reached only 1.5 to 2 meters (4 to 7 feet) high: "not very high with voluntary oscillation ... attesting that the airman manoeuvers and that the device obeys." One attempted flight was "a circle on the ground with a few leaps." (*L'Aerophile*). There were some problems and breakages, repaired on the spot, but no prize. On the 21st there was a flight of 145 meters (*Flight*), and a "fall" caused by a propeller blade breaking. Photos survive from these occasions.

Santos-Dumont stopped flight tests of the 19 and made changes to it. Judging by the high angle of attack for maximum lift in the photograph of 19 (above) and the height of these flights, only barely adequate lift was available. I expect that once he flew up out of the ground effect no further ascent was possible. Perhaps he thought lack of power was the first problem to solve.



The second version of 19, the "dual-propeller 19," probably in December 1907.

Santos-Dumont's modification of the 19 was to change to a pair of propellers driven by belts from the engine. This variation probably had trouble synchronizing the two propellers or balancing their thrust (my guess). In any case putting the same horsepower into two propellers connected by belts will simply reduce total propeller power or thrust, not increase it. The "forward stabilizer" panel in front of the wheels was removed. This model was unnamed, or still just "19," or maybe "19bis," at the time. To clarify things now it could be called the "dual-propeller 19." In December 1907 "several attempts to fly with the *Demoiselle* were made by Santos-Dumont on the 17th of that month, but the device failed to take off." For nearly a year the *Demoiselle* idea was neglected if not forgotten.

Santos-Dumont did no flying in 1908, but that year was transformative for aviation. On January 13 Henri Farman won the Deutsch-Archdeacon Grand Prize of Aviation (50,000 francs) for the first flight longer than 1 kilometer (0.6 mile) over a closed course, and requiring one 180 degree turn around a flagpole. On a cold overcast winter day in his big Voisin machine, he churned along at 60 kph (34 mph), 10 m (33 feet) off the ground for two minutes. In July he won another prize for a flight lasting a quarter of an hour. On October 30 Farman made a cross-country flight of 27 km (17 miles) in 20 minutes at about 81 kph (51 mph), reaching 30 meters high (100 feet).

For comparison on October 5, 1905 Wilbur Wright in Ohio had flown 24 miles (39 km) in 38 minutes and 4 seconds, circling the flying field in the U.S. 29 times before the gas ran out. That 1905 flight was the 161<sup>st</sup> flight of a Wright *Flyer*, but all this was poorly known in France, where the reports were discredited at the time. In August 1908 Wilbur Wright traveled to France and began several months of demonstration flights on a field near Le Mans, astonishing the French with what was then very advanced flying. His first day's flights were only a few minutes long, but they showed "complete mastery of flight" according to one observer who was there. One French newspaper said "It was a triumph." One of the skeptical members of the Aero Club, Edouard Surcouf, a balloonist, exclaimed about doubts: "C'est le plus grand erreur du siècle!" - it's the biggest error of the century.

"Over the next several weeks he made headlines around the world with one stunning flight after another" (Tom Crouch). Wright was universally acclaimed as the best flier in the best machine. Wright flew demonstration flights every week for months, sometimes daily. Hundreds of spectators appeared. After one day of flights a news report said the "excitement was almost beyond comprehension."

At a U.S. Army drill field in Virginia on October 12 1908 Orville Wright made a flight of 1 hour and 2 minutes, the first airplane flight over an hour. On October 7 he had taken up a passenger. On October 21 Wilbur Wright in France made a flight lasting 1 hour and 31 minutes. On December 18 Wilbur Wright won a prize for reaching 100 m (328 feet) altitude, and on the last day of 1908 he made a single flight of 124 km (77 miles) lasting 2 hours and 20 minutes.

Farman's achievements in January and thereafter, the long flights by the Wrights under complete control, and numerous other airplanes in development, meant that in 1908 Santos-Dumont was no longer *the* aviator. From being the highly celebrated "first man to fly," when the Wright flights were not believed in France, he was no longer the premier flyer; in fact he had no usable flying machine. He was not making contributions or doing something significant in aviation, other than his continuing active role in the community of aviation enthusiasts and in the Aero Club, serving on committees, offering prizes, appearing at surprisingly-frequent banquets, and so on.



A period postcard of Santos-Dumont's "new airplane" of November 1908, with its low V8 Antoinette engine, and Santos-Dumont in the pilot's seat. The propeller is made of fabric over a frame, and is driven by a belt from the engine powering a large wheel. Note that the "lateral rudders" and the "forward stabilizer" of number19 were omitted. The two dark vertical structures, outboard of the large wheel on the propeller shaft, are tube radiators for engine cooling.

Then on November 1, 1908, *L'Aerophile* reported Santos-Dumont was "occupied with the construction of a new machine," called a "replica of the *Demoiselle*." The new plane had 24 hp V8 "Antoinette" engine, a more powerful engine than he had used in the 19, mounted between the pilot's legs. Leon Levavasseur had built two "Antoinette" engines for Santos-Dumont's 14-bis, so perhaps Santos-Dumont simply used an Antoinette engine he already had in his workshop. The wings had more ribs than in 19, and appear to be larger in area than on the 19. A new cloth-on-frame propeller was belt-driven from the engine, with about a 2.2 to1 speed reduction. This *Demoiselle* weighed 150 (*Le Figaro*) to 200 kg (*L'Aerophile*) in flying order, of which 50 kg (110 pounds) was for the pilot. The wingspan was 5 meters (16 feet) and the wing area "did not exceed" 9 square meters (97 square

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feet). The propeller rotation rate was 700 rpm, giving a tractive force of 70 kg or 154 pounds (*L'Aerophile*, 15 Nov. 1908). Test flights were planned "at the aerodrome Santos-Dumont owns in Saint-Cyr."

## 1909 -- A New Year and a New Airplane

On January 1, 1909 *L'Aerophile* called this "the new monoplane" and the "aéroplane Santos-Dumont-XX," the first reported use of number 20. A photograph in that report (reproduced below) showed the 20 in the yard at Neuilly. At this stage the 20 retained some features of the 19, such as the long single tail boom. Only after several modifications, in September 1909, did the classic and famous form of Santos-Dumont's 20 emerge.



This first "20", which you could term the "first prototype" of number 20, differed from the 19 in having new wings, a new engine and propeller, and in omitting the extra elevator and rudders in front. The long tail boom remained from 19. Really this new airplane was closer to 19 than to the eventual final form of number 20. The January 1, 1909 *L'Aerophile* report had nothing about *flying* the new airplane, only stating "This device that had been transported to Issy [from St. Cyr] for the purpose of continuing tests has been brought back to the Neuilly-Saint-James aerodrome" so Santos-Dumont could make some "necessary transformations." It sounds like there were some tests, but no details were given. Neither *Flight* nor *L'Aerophile* reported anything further about this airplane. Possibly this first version of 20 was too heavy to fly, or perhaps it had poor stability or control. It appears there was no provision for roll control.

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A gentleman of style, invention, and courage. Detail of a high-quality photograph of Alberto Santos-Dumont and his "new" aircraft of late 1908, the first version named number "XX" (Nov. 12, 1908. National Library of France). Note the low-mounted V8 Antoinette engine and belt drive, and the cloth-on-frame propeller, perhaps not very efficient. The engineering and construction of the *Demoiselles* appears to have been innovative and of good quality, especially for someone with no professional training or degree in engineering. He did employ talented craftsmen. However this airplane failed to take off. Santos-Dumont usually appeared in the height of fashion, and set fashions, even when flying, and was noted for hats of this style, in light or dark colors as appropriate.

# The Santos-Dumont 20, the Classic Demoiselle



Santos-Dumont flying an early version of his 20, in summer 1909. (the third prototype: note the large tail wheel and no radiators under the wings)

Santos-Dumont had long sought and encouraged the idea of affordable personal flight. After January 1909 he began considerably modifying the new "20." The primitive aircraft 20 of early 1909 eventually became his classic *Demoiselle*, in September 1909.

Reports and photographs reveal development of what can be described as three prototypes of the 20 in 1909. These prototypes of the 20 have not been previously identified or described in any literature seen by me, nor have technical details been specified. although many photographs survive of them. The various forms of Santos-Dumont's 20, the three prototypes and the final version, appear to all be modifications of one airplane.

There was a new, second, prototype of the *Demoiselle* 20 beginning in March 1909, with an entirely new main frame of three bamboo longerons ending in a long point just ahead of the tail unit. The three longerons were connected with cross struts of steel tubing. This three-longeron frame of bamboo was an improvement that was used in all future *Demoiselles*. Both the tail unit and the wings appear to be from the first prototype. There was a solid wooden propeller and a new engine. It appears both the second and third prototypes used an air-cooled 24 horsepower Dutheil and Chalmers engine, lacking the radiators visible under the wings typical of the final 20, and the 21. This *Demoiselle* had roll control using wing warping, controlled by a lever fitting into a tube on the back of the pilot's jacket. The rear wheel, tail unit, and skid were retained from the 19 for all three prototypes, but the rear wheel was moved back starting in March. The "forward horizontal stabilizer" from number 19 of 1907 reappeared briefly on the second prototype.

Santos-Dumont acquired a hanger at Issy-les-Moulineaux on February 27, 1909. Early photos – there survive a group of photographs made with snow on the ground at Issy from about March 9,1909 – show the second prototype of the 20 with the distinctive three-longeron frame and new engine and propeller. On March 9 Santos-Dumont "succeeded in making a flight of 500 meters" in this second prototype, perhaps with no turns. This was the first flight of any *Demoiselle* since November 1907, and the first *Demoiselle* flight over 400 meters.



The second prototype of the *Demoiselle* 20, at Issy-les-Moulineaux, about March 9, 1909. A new engine, a better propeller, wing warping, and the three-longeron bamboo frame were all important improvements. These wings look like the wings of the first prototype of the 20, and this version retained the previous tail unit, now mounted aft of the pointed end of the long frame. The thin vertical lever behind the seat controls the wing warping. Note the temporary 'forward horizontal stabilizer' previously seen on the 19, which was removed in mid-May 1909. The overall length

was 2 meters longer than the later classic and final 20. Santos-Dumont stands behind the aircraft.

Flight Mar. 13, 1909

Santos Dumont and his "Demoiselle."

On Tuesday, March 9th, Santos Dumont recommenced his experiments with his miniature monoplane, "La Demoiselle," when he succeeded in making a flight of 500 meters. A very high speed was necessary to effect a flight with such a small machine, and in landing the elevator was broken, but the damage was not serious and Santos Dumont himself was in no way hurt.

L'Aerophile Mar 15, 1909

Santos-Dumont prepares. - After encouraging tests in Issy, marked by a flight of about 200 meters Santos, immobilized by bad weather, ... continues preparation of his tiny monoplane already described here. March 9, a superb flight of 400 m.

Flight Mar. 20, 1909

Santos Dumont Goes to Saint Cyr.

Santos Dumont has taken his miniature monoplane back to his trial ground at Saint Cyr, and anticipates making some sensational flights with it after a few more preliminary experiments. Already, as our readers know, he has done remarkably well with his little machine.

By March 20 he had moved the *Demoiselle*, then the second prototype of 20, to Saint Cyr outside of Paris for more flight trials. A flight at Saint Cyr, on April 8, 1909, 2.5 km long and at a height of 60 to 70 feet, got quite a lot of attention in France: "one of the most interesting which has yet been accomplished by any aviator apart from Wilbur Wright" (*Flight*). Prior to that, in March and early April Santos-Dumont probably had made shorter flights in the second prototype of 20, to become accustomed to flying this airplane, and among other things learning how to make turns. There is no report of Santos-Dumont making even a quarter turn before then.

#### Flight

Apr. 17, 1909

Santos Dumont's Cross-Country Flight.

Santos Dumont has performed a bold, not to say hazardous feat with his "Demoiselle," that little pocket monoplane with which, as our readers know, he has for some few weeks past been making experiments. While practicing at Saint Cyr on Thursday, April 8th, he commenced a flight which extended for a distance of about 2.5 kiloms., during the course of which he flew at a height of about 60 to 70 feet and cleared several hedges and telegraph wires. In the end, too, he only came down in order to avoid the danger of dropping in a large pond which he might at that stage of the journey have been unable to fly across had he continued aloft. This achievement is, in some ways, one of the most interesting which has yet been accomplished by any aviator apart from Wilbur Wright, and it can hardly fail to arouse a still greater interest in one-seated monoplanes as a popular type of flying machine. Many would-be pilots, like Santos Dumont himself, regard the full-sized biplane of the present day as an unattractive conveyance, and it was solely because Santos Dumont did not find sufficient fascination in trying to fly with such an apparatus that he decided to see what could be done on a smaller scale.... The main wings have a span of about 17 ft., and the machine over all is about 19 ft. 8 ins. long. In running order it only weighs about 250 lb. The main wings make a slight dihedral angle, and in the corner thus formed is placed the twin-cylinder Dulheil-Chalmers engine which drives the two-bladed tractor screw. At the rear is a cross tail which can be used for elevation and steering.

### L'Aerophile

#### May 1, 1909

Santos-Dumont has resumed, at his aerodrome of Saint-Cyr, testing his tiny monoplane nicknamed the Demoiselle, with which he had already managed several beautiful flights at Issy-les-Moulineaux. On the afternoon of April 8, the small monoplane was elevated a few meters by the action of his 24 horsepower Dutheil and Chalmers engine, crossed the field, crossed at 8 meters high the Versailles-Rambouillet road and telegraph lines, continued his flight over fields, but was forced to land, a few meters from the pond of Saint-Quentin. The Demoiselle had executed, in a straight line, a magnificent flight of two kilometers. This is an interesting excursion across the fields, above many obstacles, bays, trees, telegraph lines. The training exercises of Santos-Dumont will continue in Issy-les-Moulineaux.

On May15, 1909, at Issy the "forward horizontal stabilizer" was removed after it was damaged when striking the ground in a gust (*Le Matin*). About the same time another important change was installing a new propeller, which looks like the propeller built by Lucien Chauviere and used later on the final form of number 20 in September 1909. These changes created the third prototype of number 20. The new airplane, the Santos-Dumont *Demoiselle* of mid-May to late August 1909, could maneuver with good control, fly for a few kilometers, and ascend to at least 80 feet (25 m) to pass over local obstacles. Finally, after a year and a half of *Demoiselle* development, Santos Dumont had created an airplane with enough lift, stability, and control to fly fairly well. By the standards of May 1909 it was a decent flying machine.



The *Demoiselle* is now an airplane: Santos-Dumont flying the third prototype of his number 20 at a typical altitude, late spring or summer of 1909.

Why did this airplane fly so much better than the 19? It must have been due to a combination of improvements: a better engine (but the engine was only a little more powerful than on the original 19: 24 hp compared to 20 hp.), larger and better wings, roll control, and the new propeller which was far better in design and construction than the ones before May 1909. The propellers on 19 and on the first "20" prototype looked little better than something from an eighteenth century hand-cranked balloon; the new propeller would not have been out of place on a WW I fighter plane. But the engine, rated at 24 hp, was not quite powerful enough, a problem Santos-Dumont must have recognized, and solved by September.

Note that no-one at the time thought of Santos-Dumont's little flyers as "prototypes" of anything; each was simply his latest flying machine, his *Demoiselle*. Design changes and trial flights were an ongoing process among all aviators at that time.

#### Flight

May 22, 1909

Santos Dumont at Issy.

Although Santos Dumont has not made any advance on his performance of April 8th, when he flew for 2 kiloms., he has not been idle. On Saturday last he had the "Demoiselle" out, and in the morning made three good flights, one of them being for more than a kilom. A slight mishap occurred when landing after the third flight, the tail striking the earth rather suddenly and getting a little damaged. Repairs, however, were soon executed, and in the evening the little flyer was out again. Upon this occasion, after making a flight of about 200 yards, Santos Dumont attempted to turn, when the wind rather upset his calculations, with the result that one wing came into somewhat rude contact with the earth. In consequence three fractured tubes resulted, and as soon as these are repaired M. Dumont will resume his trials.

#### *L'Aerophile* June 1, 1909 The tests of Santos-Dumont.

In calm weather, on May 15, from ten o'clock to noon, Santos-Dumont aboard his monoplane Demoiselle made some successful flights, including one more than one kilometer. Around noon, he bent one of the wheels: the repair was easy, the famous aviator was able to resume his tests at the end of the afternoon. They were stopped around 7 o'clock by a landing a little too hard; a wheel and three tubes were bent.



An early view of the third prototype of the 20 at Issy on or after 15 May 1909. The 'foward horizontal stabilizer' has been removed but apparently there is, as yet, no Chauviere propeller.

#### Flight

June 26, 1909

Santos Dumont has a Tumble.

After making several short flights about 500 metres in length at a height of 15 to 20 metres, M. Santos Dumont met with an accident at Issy on Saturday last. By some means the longitudinal stability of the "Demoiselle" was interfered with, and the little flyer fell back on her tail. Santos Dumont escaped without injury, and although it was feared at first that the machine was seriously damaged, the worst was a damaged wheel. M. Santos Dumont left Issy on Tuesday, and his flyer has been packed up and sent to St. Cyr.

## L'Aerophile

July 1, 09

The "Blériot XII" lifts three people.

On June 12, Blériot achieved a remarkable performance, flying about 250 meters, with MM. Santos-Dumont and A. Fournier on board; this is the first time that a heavier than air machine lifts three people! Blériot then executes several flights with a passenger: the longest, about 2 kilometers, to 6 meters of height, with our colleague Ed. Poillot, of "The Auto," then ends with a flight, alone on board, for 5 kilometers.

## Santos-Dumont and notable aviation events of 1909.

The most important and celebrated achievement of 1909 in aviation happened early in the morning of July 25 when Louis Bleriot flew across the English Channel in his *Bleriot XI* monoplane, covering more than 23 miles (37 km) in 36 minutes. On his return to Paris on July 28, by more conventional means of transportation, a naval ship and railroad, a hundred thousand "almost delirious" Frenchmen turned out to see him.

Another major aviation event of 1909 was the "Grand Week of Aviation of the Champagne," August 22 through 29, in the countryside near Reims, France, in the heart of champagne country. It was planned long in advance, and in July and August both of the newsletters *Flight* (London) and *L'Aérophile* (Paris) listed the registered entrants, including Santos-Dumont and the *Demoiselle*.

The Grand Week was a sensation. An enormous covered grandstand was used for the meet, including a restaurant. Tens of thousands of spectators attended, among them the French President, Lloyd George and 3000 others from Britain, and 2000 from the U.S. including the U.S. Ambassador to France and Mrs. Theodore Roosevelt. Flying was an exciting novelty and surely many of the spectators had never seen an airplane before. There were serious competitions to demonstrate and push the best capabilities in aviation, with 200,000 francs in prizes, approximately \$800,000 today. Many of the most famous flyers in the world participated (and two complete beginners), with the notable exceptions of the Wrights and Santos-Dumont. Twenty-six aircraft participated, but no *Demoiselle*. There were several Bleriot, Wright,



Voisin, and Antoinette aircraft at the aviation week with their new owners, but at that time there was only one *Demoiselle* in the world, Santos-Dumont's personal airplane, the only famous airplane not at Reims.

Trials included distance, speed, and altitude. Henri Farman won the distance contest with a flight of the thenastonishing record distance of 180 km (112 miles), lasting 3 hours 4 minutes 56.4 seconds, ending only when his gas ran out at twilight. Glenn Curtiss of the U.S. won the Gordon Bennett speed trophy over two 10-km laps, in 15 minutes 30 seconds (51 kph or 31.7 mph), with Louis Bleriot coming in only 6 seconds behind. Louis Bleriot won another speed race of one 10 km lap in 7 minutes 48 seconds (77 kph, 49 mph). Hubert Latham set the official altitude record of 155 m (508 feet), and he claimed he reached several times that.

Santos-Dumont attended only as a spectator, on the first day August 22, a day when wind, rain, and mud frustrated efforts to fly. Late in the afternoon conditions improved and finally ten airplanes were in the air at the same time, a sensational sight never seen before. The enthusiastic spectators surely would have been delighted to see the famous and popular Santos-Dumont fly in his miniature airplane any time during the week, but for some reason he did not appear at Reims. He may have been reluctant to compete with other aircraft whose potential for speed, altitude, and duration were clearly superior to what the *Demoiselle* had achieved so far. Santos-Dumont's airplane, after improvements completed just two weeks later, performed very well and could have made a good showing at Reims, and probably won one or more speed prizes, but that was too late.

## Finalizing the Santos-Dumont 20, the classic Demoiselle.



Santos Dumont flying the final version of his number 20, the Demoiselle, at St. Cyr France in September 1909.

The news items from summer 1909 suggest only limited involvement in flying by Santos-Dumont before the Reims aviation week. *Le Figaro* and *Flight* reported just a few days of flying all summer of 1909. *L'Aérophile* said (1 October 1909) "Only lack of time had prevented the Brazilian airman taking part in the meeting in Reims," apparently referring to installation of the new Darracq 30 hp engine and other improvements. The air meet was planned months before. Simply mounting a new engine would not have blocked attendance at this major event, if the engine were available. I suspect that Santos-Dumont was waiting for the new Darracq engine to be delivered in August, but it did not arrive in time to install it before Reims.

At the same time that photos first show the Darracq engine and its radiators, photos also show the main frame of the airplane had been shortened, the first appearance of the squared-off aft end of the frame, a distinctive feature of the final 20, making an airplane shorter than the 19 by about 2 meters. A new large conical fuel tank behind the pilot also appeared for the first time.

The new engine, its radiators under the wings, the squared-off frame at the aft end of the frame, no rear wheel, and the big conical fuel tank are distinctive features of the final *Demoiselle*, number 20. After a year and 10 months of development, in September 1909 Santos-Dumont had a good flying machine.

As soon as the new engine was in place and the modified airplane was ready, Santos-Dumont began a series of his best flights, from St. Cyr. Large numbers of the public traveled to St. Cyr to watch. Newspapers reported the first use of the airplane with the new Darracq engine on September 5, 1909.



#### Flight

#### Sep. 11, 1909

Santos Dumont, after an interval of a month or so, has re-commenced his experiments at St. Cyr with a miniature flyer of the Demoiselle type, and made several short flights on Tuesday. The machine which he is at present using is fitted with a 2-cyl. Darracq engine, which, weighing 45 kilogs. complete, gives 30-h.p., the bore and stroke being 130 mm. by 120 mm.

#### Flight

#### Sep. 18, 1909

Santos Dumont Flies Again.

Since M. Santos Dumont made his short cross- country journey in April last he has done very little flying beyond a few "jumps" of 500 metres or so in May and June. But on Monday he once more came into the limelight with a bound by paying a visit to M. Guffroy at Buc. Some time ago these aviators made a friendly wager as to who should be the first to visit the other by aeroplane, and M. Dumont has won. He started off from St. Cyr at five o'clock, and covered the five miles which intervene between there and Buc in about five minutes, thus showing that his tiny "Demoiselle" is the fastest machine which has so far flown. On the following day he flew back again to St. Cyr.

#### M. Santos Dumont's Machine.

The little machine with which M. Santos Dumont made this splendid flight has a carrying surface of only 9 sq. metres, and fitted with a 2-cyl. 30-h.p. Darracq special aeroplane motor, and with the aviator on board only weighs 118 kilogs. The bore and stroke of the motor is 130 by 120 mm. According to the *Journal*, M. Dumont has decided to make the patents relating to his flyer public property, so that anyone may build one. It is said that the cost of it is less than 5,000 francs.

#### Flight

Sep. 25, 1909

Santos Dumont Holds "Jumping Off" Record.

It is a long time since M. Santos Dumont had a flying record standing to his name, but he has now secured the honour of being able to rise from the ground in the shortest distance. The official record of the Aero Club of France states that M. Santos Dumont rose from the ground after traveling 70 metres in 6 seconds, thus beating the record of Mr. Glenn Curtiss, who got up in 80 metres. The "Demoiselle" actually rose when only 40 metres had been covered, but it touched earth again, and 70 metres were traversed before the little flyer got clear away.



Santos-Dumont, the Demoiselle number 20, and the Chateau de Wideville on September 17, 1909

## Flight

#### Sep. 25, 1909

M. Santos Dumont had an interesting experience on the 17th inst, which illustrates how it will be possible to visit one's friends by aeroplane when they become more reliable and more common. He started off from St. Cyr for one of his little excursions, but was so enraptured with the flight that he kept on until miss-firing of the motor reminded him that his petrol supply was limited. He then found he had lost his bearings, but seeing a house in the distance he determined to come down in the surrounding park. This was safely accomplished, and needless to say that the Comtesse de Galand, for it was in her park at Wideville that the aviator landed, was pleased to see her strange visitor, and he was prevailed upon to stay. No sooner was little "Demoiselle" tucked away in the shed than a violent thunderstorm broke over St. Cyr and the patient watchers for the return of Santos Dumont grew anxious, and eventually started searching the surrounding neighbourhood for tidings of him. Subsequently one of the sons of the Comtesse, who had seen Santos Dumont start, returned home, and was somewhat astounded to see him calmly sitting down at supper. The distance flown was about 17 kiloms., which was covered in about a quarter of an hour.

## Flight

#### Sep. 25, 1909

On the previous day ... he demonstrated the ability of his little machine to carry weights out of balance. A weight of about 40 lbs. was attached to one side of the frame, but in spite of this the flyer kept an even keel, and, moreover, maintained it when the weight was suddenly released. On Saturday last at St. Cyr M. Santos Dumont further demonstrated the stability of his machine by flying without holding the steering wheel, waving a handkerchief in each hand to show that he was not controlling the machine, which flew on as usual.

### *L'Aerophile* Oct. 1, 1909 New tests of Santos-Dumont.

8 kilometers in 5 minutes. -- Santos-Dumont, the friendly sportsman, seemed, for some time, to have withdrawn from the fray. He who executed in Europe the first mechanical flight, would he so give up the struggle and lose interest in a science of which he had been the most ardent promoter? But no! Santos-Dumont worked in calm and meditation. He had built by Darracq a 30 hp engine, with 2 horizontal cylinders of 130 x 120, weighing not more than 45 kilos in working order, a motor that he mounted on his Demoiselle. The device thus weighed 118 kilograms, without the pilot. Only lack of time had prevented the Brazilian airman taking part in the meeting in Reims.

The Château de Wideville (12 km from St. Cyr in a straight line) remains today as it was then, recorded in photos of Santos-Dumont and the *Demoiselle* in front of the Château. These flights were celebrated in reports at the time but they had already been surpassed as aviation records by others, except for the speed record. Still, this activity was interesting news. Santos-Dumont's flying activities often had an appealing sense of flair, style, and adventure about them. Two days later on September 19 more than five thousand Parisians came to St. Cyr to watch *Demoiselle* flights, and Santos-Dumont made two, one of eight minutes and another of three. The excitement from the Grand Week was still urging people to see flying machines.



An excellent photograph of Alberto Santos-Dumont with his final number 20, the *Demoiselle*, at Saint Cyr, France, just before the Paris aeronautical Salon. His flight from Saint Cyr to Buc, when he set a unofficial speed record of about 60 miles per hour, occurred on September 13, 1909, the day before the date of this photograph. This is Santos-Dumont's most successful flying machine, the result of nearly two years of development, and this was Santos-Dumont's most notable week of aeroplane flying.

Features distinguishing the final 20 from preceeding (and later) versions are the overall length, the new 30 hp Darracq engine, the radiators under the wings, the rear skid at the fourth set of vertical struts behind the pilot, no rear wheel, no spars or wires above the wing, the squared-off end of the frame immediately in front of the tail, and the large conical fuel tank behind the seat for the pilot. The Darracq engine and other changes were complete about September 5, 1909.

If one photograph could represent Alberto Santos-Dumont and his two-year creation, the *Demoiselle*, this is it.

Typically for the times, *everyone* has a jacket and a hat.

## Technical Details of the classic Demoiselle, the Santos-Dumont 20

The third prototype of what became the 20 *Demoiselle*, was first described in the May 1, 1909 issue of the French magazine *l'Aérophile*. A more detailed description of the final form of 20 was published later by the British aviation weekly *Flight* in "Santos-Dumont's Demoiselle" (issues of October 2 and 9, 1909) with several diagrams, and in the *American Mechanic* (November 4, 1909, pp 793-797) which had the report "The Santos Dumont 20 – La Demoiselle." The *Flight* articles are important sources for details on the new airplane. The report in *American Mechanic* has some errors and reads like a poor translation from an uncredited source in French.

The next year the U.S. magazine *Popular Mechanics* (in the June and July issues of 1910) had articles by A. E. Joerin and A. Cross titled "How to Build the Famous Demoiselle" with numerous technical drawings. The first article was illustrated with Plates I to III; the second article was illustrated with Plates IV to VI. Popular Mechanics also offered "working drawings" by mail for \$2.00, with "Sheets" numbered 1 to 7, similar to the Plates but redrawn and larger than in the magazine. The dimensions on the Sheets are not always exactly the same as in the Plates.

The *Popular Mechanics* plans are the single best source for details of the final form of the Demoiselle. Sheets 1 and 2, showing the 20 design, are reproduced below. The measurement units in the drawings by *Popular Mechanics* were naturally in English units, but are converted from simpler metric values, for example one length shown several times, 2 feet 11 ½ inches, is simply 90 centimeters, and the wing chord is really just 2.0 meters ("78 and 7/8 inches").

I do not believe that plans for the *Demoiselle* were published anywhere other than in *l'Aérophile*, *Flight*, *American Mechanic*, and *Popular Mechanics*. Santos-Dumont himself did not publish any plan or description. Based on those plans, photographs, and other sources the following summary is made. The 20 was a very different airplane from the 19, for example, the take-off weight increased by some 60%, and it was shorter by a 2.2 meters (7.2 feet).

The chassis or fuselage of the 20 *Demoiselle* consisted of a frame of three main longitudinal members of bamboo tapering from 1 3/8 inch (35 mm) diameter at the front to 1 inch (25 mm) at the rear. The three members in a triangle were connected and braced by cross members of steel tube with oval cross section (10 mm by 25 mm). Diagonal bracing piano wires included turnbuckles less than an inch (2.5 cm) long. The main frame was 4.6 meters (15.0 feet) long from the front to the point at the rear where the universal joint mounting the tail was located. The wheels are 20 inch bicycle wheels; the tail skid was a steel tube extending from the main frame and curved to form a runner at the end.

The wing chord was 2.0 meters (6.56 feet) and the wing span was 5.5 m (18 feet  $\frac{1}{2}$  inch ). The wing area was about 110 square feet (10.3 square meters), and the wing aspect ratio (span/chord) had the low value of 2.8. The two wing spars were ash, 2 inches (5 cm) wide and 1 1/8 inch (3 cm) high at the largest point, slightly tapering to the outer ends. Looking from at the front, the front wing spar was curved downward for 0.8 m (31 inches) towards the inboard end with radius of 126 inches (3.2 m), and straight elsewhere. The aft wing spar was straight.

The wing ribs were bamboo and the fabric covering the wing and tail was varnished silk. The covering was a double layer, above and below the ribs. The wing curvature from the front edge to back edge was an arc of a circle with radius of 202 inches (5.1 m), so the maximum wing camber was 3 or 4 inches, 4 or 5 %. The wings' leading and trailing edges were formed by wires giving sharp edges. The front inner edge of each wing had a 30 cm (11.9 inch) deep recess for the propeller. The wing dihedral was 5 to 7 degrees. The angle of incidence of

the wings was about 11 degrees when the top longeron of the main frame was horizontal

The outer end of the wings may have naturally bent downward a little due to their weight when the airplane was sitting on the ground, but straightened up in flight. The maximum lift coefficient for this wing may have been about 1.0.

The 20 had no bracing struts or wires above the wings, but several bracing wires to the bottoms of the wings. The later model 21 had two vertical struts above the wings.

The entire tail including rudder and elevator surfaces was a single unit, pivoting on a universal joint (see drawing to right, from *Flight* October 1909). This tail concept seems to date from the first number 19. The rudder was controlled with small wheel for the left hand, on the left side of the seat. Elevation was controlled by a lever for the right hand. All control wires included springs to maintain tension.

Roll control, or 'balancing the airplane' as it was then called, was by wing warping. Steel wires from the outer aft corners of the wings sloped downward to a lever behind the pilot, which fitted into a copper tube sewn in a pocket in the back of a kind of vest or harness worn by the pilot. Roll control was done naturally by leaning a little into a turn; if a gust lifted a wing the pilot leaned towards the high wing to regain level flight. This was probably inspired by riding bicycles, where the rider instinctively leans into a turn in the same fashion to maintain balance on curves.



There were no brakes on the wheels. The large air drag of the structure combined with landing on grass meant to slow down and stop, all you had to do was land and cut the gas. Some pilots with gloves dragged their hands on the wheels for an extra bit of braking; one report says Santos-Dumont dragged his feet. The seat was a sling of leather or canvas between the two lower main longerons just behind the wheels.

The entire airplane was really designed for, or around, Santos-Dumont, who weighed about 50 to 54 kg (110 to 119 pounds). More than one *Demoiselle* pilot found he could not take off because he weighed too much. A newspaper report in the U.S. later called a local *Demoiselle*, which hopped around on the ground rather than fly, the "infuriated grasshopper."

Following page: Sheets 1 and 2 (in reduced size) from the set of plans sold by *Popular Mechanics* in 1910, showing the final design of the 20.

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Side elevation of the Demoiselle, the final version of the Santos-Dumont 20, from Flight magazine Oct. 2, 1909.

# Santos-Dumont 20 Demoiselle Specifications

Figures compiled from Flight, Popular Mechanics, L'Aerophile and other sources of the period.

Wing span	18 feet $\frac{1}{2}$ inch (5.5 m)	
Wing	chord 6 feet 6 inch (2.0 m), incidence 7 degrees, dihedral 1 in 11 (5.2 degrees).	
Wing area	108 sq. feet ( <i>Flight</i> ); 110 sq. feet (10.3 sq. m) computed from plans	
Control surfaces	wing warping. elevator 12 sq. feet (1.1 m <sup>2</sup> ). rudder 7 sq. feet (0.65 m <sup>2</sup> )	
Weight empty	240 to 250 lbs (109 to 114 kg, <i>Flight</i> ); 118 kg (260 lbs., <i>L'Aerophile</i> )	
Weight, take off	530 pounds ( <i>Flight</i> , Apr. 9, 1910); (400 to 450 lbs. is much more plausible)	
Length overall	20 feet (6.1 m)	
Engines (horsepower	ratings are those given in the period, which may differ from modern values):	
Dutheil-Chalr	ners air-cooled 24-hp (prototypes of the 20 from March to August 1909)	
30-horsepower Darracq (from Sep. 1909) bore 130 mm, stroke 120 mm, disp. 1.59 liter		
(used o	on the final Demoiselle 20, from September 1909; water-cooled.)	
32-horsepowe	r Clément-Bayard (provided for Clément-Bayard Demoiselles of 1910)	
40 horsepowe	r Clément-Bayard (possibly tested December 1909 or later)	
propeller	Chauviere wooden Integrale; 6 feet 6 inches (2 m) diameter; 2.5 ft pitch	
speeds	40 mph (64 kph) to top speed of 60 mph (97 kph) with the Darracq engine	
	(also some claims for a speed of 69.8 mph, or 112.6 kph, in one test flight)	

## **Computed parameters**

Wing aspect ratio	2.8
Wing loading	3.6 to 4.2 pounds / square foot; depending on weight
Power loading	about 16 pounds / hp; depending on weight and engine choice
Takeoff and stall speed	estimated at 38 mph (62 kph), assuming wing max $C_1 = 1.0$ .



Front view of 20 showing the 2 meter propeller built by Lucien Chauviere, the Darracq 30 horsepower engine, and the radiator tubes under the wings. The radiators and the sloping tubes above the engine are typical of the Darracq engine. This photograph is very probably from St. Cyr on Sep. 14, 1909.

The first engine on the 20 was an air-cooled Dutheil-Chalmers 24 horsepower unit. Then Santos-Dumont himself improved the Dutheil-Chalmers engine design to give more horsepower. Santos-Dumont took his modified engine to Alexandre Darracq, an automobile and engine builder, to be used as the basis for a new engine, which became the water-cooled Darracq 1909 twin cylinder engine of 30 horsepower. With a Chauviere propeller the thrust was 85 kg (187 pounds). This was the engine first used in early September 1909, an essential new component of the final, and finally successful, Santos-Dumont *Demoiselle*.

Beginning in September1909, the *Demoiselle* engine was that new horizontally opposed, water-cooled, 1.6 liter Darracq engine (bore 130 mm, stroke 120 mm). Ignition was by magneto. Normal operating speed was reported from 1400 to 1800 rpm; Darracq specified 1500 rpm. Engine cooling was provided by a new feature, a radiator made of 100 1/8-inch (3 mm) diameter tubes under the inboard bottom of both wings, extending the full chord of the wing, front to back. These radiators are visible in photo-graphs of this final version of the 20 *Demoiselle*, and are not seen in photographs of the prototypes of 20. Gas in a conical tank behind the pilot was forced to an auxiliary tank over the engine by a small air pump. The throttle was a lever controlled by the left foot. An ignition cut switch was on top of the elevator stick, perhaps not the best location. The propeller was of high quality in solid wood, of diameter near 2 meters (6.6 feet) and pitch 1.8 m (6 feet), built by Lucien Chauviere under the early years of aviation." (This Chauviere propeller may have been first used on the third prototype, as early as April 1909.) In many ways the final 20 *Demoiselle* was similar to modern ultralight aircraft (by the U.S. FAR 103 definition) and in fact it could be legally classed and flown as a ultralight in the U.S now.



The propeller and engine on a Clement-Bayard *Demoiselle* in January 1910. This engine differs somewhat from the Darracq 30 hp engine on Santos-Dumont's airplane of September 1909: it may be a "Clement 32 hp."

The Darracq engine used by Santos-Dumont in SEptember 1909 was stated to provide 30 horsepower. Horsepower ratings of engines from over a century ago can differ a lot from a modern power rating for the same engine, depending on how the "horsepower" was then measured or computed. For example the "RAC horsepower" of British automobile engines from the early 1900s were computed – not measured – using a highly simplified formula which assumed key specifications such as the bore / stroke ratio. A better estimate of the "indicated" horsepower of a single cylinder 4-cycle gas engine is given by this formula (Hodgson, 2001)

ihp = 
$$(\pi P_m D^2 L R f) / (132000) = (P_m D^2 L R) / 84036$$

using English units, where P<sub>m</sub> is the mean effective pressure (in pounds per square inch) acting on the piston, D is the bore diameter of the cylinder in inches (25.4 mm/inch), L is the stroke in feet (304.8 mm/foot), R is the revolutions per minute, and f is the "frequency" of the power stroke, 0.5 in this case. Using an R of 1500, and P<sub>m</sub> of 90 pounds per square inch the value used in the RAC formula and probably appropriate for engines of the 1909 period, the ihp estimate is 16.6 per cylinder, giving 33.1 ihp for the 2 cylinder Darracq engine. However this is the "indicated" horsepower, that expected from an ideal, perfectly frictionless, engine. The actual horsepower, available on the propeller shaft, called the "brake" (bhp) horsepower, will be reduced by friction and by power used for extra equipment such as a magneto and pump. The brake horsepower might be about 75% of the ihp, 25 horsepower in this case. A modern measured rating for the *Demoiselle* 20's Darracq engine probably would be closer to 25 horsepower than 30. These are estimates, and measurements using an original engine would provide valuable insight. Modern engines of similar size and weight develop more horsepower because they have higher pressure, higher compression ratios, better gasoline, and other factors. For example the Robertson B1-RD U.S. ultralight of the 1980s was similar to the *Demoiselle* and used the Cayuna 430R engine. The Cayuna 430R has a bore of 67.5 mm and stroke 60 mm (for a displacement of 0.428 liter, a quarter of the *Demoiselle's*), and a compression ratio of 12.5, producing 30 bhp horsepower (22 kW) at 5,500 rpm, a very different engine created after seventy years of development. The 1909 Darracq engine would have more torque than a modern engine of the same horsepower at a higher rpm, since torque = hp / R. Lower rotation rate at the same horse power has more torque.

The engine weighed 52 kg, 115 pounds, and cost 6,000 francs in October 1909, about \$24,000 in 2019.

The ihp horsepower of the engine on the first version of 19 (1907) is estimated to be 12.75 per cylinder using this formula, with R of 1500, for an effective brake horsepower of 19.1 hp for the 2 cylinder engine, close to the "17 to 20 horsepower" listed at the time. Horsepower values stated in historical reporting, and values from calculations, can only be a guide to what modern tests of horsepower would indicate.

## The Paris Aeronautical Salon of 1909

After the Reims aviation week, the next big aviation event of 1909 was the Paris air show, the *Première Exposition Internationale de Locomotion Aerienne*, usually called the Aeronautical Salon, held in the Grand Palais of Paris from September 25 to October 17. There were 115 vendors of airplanes, engines, and equipment. A *Demoiselle* – apparently Santos-Dumont's personal airplane – was prominently displayed by Clément-Bayard, a manufacturer of bicycles, autos and large dirigible balloons, who planned to manufacture and sell *Demoiselles*.



The *Demoiselle* exhibited by the Clément-Bayard company at the September 1909 Paris aeronautical exposition, labeled "Le Santos No 20." Very likely this is Santos-Dumont's personal airplane. The *Demoiselle* was at the peak of its fame.

#### Flight Oct. 2, 1909

#### SANTOS DUMONT'S "DEMOISELLE"

DETAILS OF THE SMALLEST KNOWN FLYER IN THE WORLD.

Although the historic cross-Channel Bleriot is a close rival to it, there is no doubt but that the chief centre of interest in the exhibition now open in Paris is that stand on which reposes Mons. Santos Dumont's "Demoiselle," or, to give it the title it bears, "Le Santos 20." Partly all the world flocks round this monoplane because it is the smallest practical flyer which is known to have accomplished its primary object. But everyone also goes to see it in consequence of Mons. Santos Dumont's announcement of the free presentation of any rights he might maintain in connection with it, to the world at large. In connection with the exhibit, the designer has issued a printed circular for distribution, and in this he announces that whereas he had originally hoped that anyone could obtain these machines by having them built for themselves at a total cost of from some six to seven thousand francs (£240 to £280), yet he found that the prices charged by manufacturers for engines would inevitably increase that figures at the moment. The circular announces, however, that arrangements have been made by him with Mons. Clement and Mons. Charron, whereby a thousand of

these little voiturettes of the air are to be turned out at a reasonable price, and within a short period. Apart from the more popular reason why so much attention is being devoted just now to the "Santos 20," there are many excellent technical reasons that warrant that attitude from all serious well-wishers of the science of flight. After all said and done, this machine has flown, and flown with ease and certainty almost from the first moment that it saw the light of day outside the factory, and yet its total weight is but 240 lbs. or thereabouts, while its external dimensions do not exceed some 20 ft. across by 18 ft. fore and aft.

Flight Oct. 2, 1909

Clement to Build "Demoiselles"

At the opening of the Paris Salon it was announced that arrangements had been made by the Clement-Bayard firm to build 200 monoplanes to the same design as Santos Dumont's "Demoiselle," and the machine is exhibited at the Paris Show under the aegis of this firm, who are selling the machine complete at 7,400 fr. (£300). These machines will be fitted with a special engine built by the Clement firm, while the manufacture of the flyers is to be supervised by M. Santos Dumont.

So the October 2 issue of *Flight* says that Clément-Bayard planned to build either 200 or a thousand of the airplanes. Later reports suggest the actual number built may have been as few as ten or fifteen. Certainly there was no flood of *Demoiselles* flying in 1910, and only one original *Demoiselle* airplane appears to survive. The individual machine on display at the 1909 Salon seems to have been Santos-Dumont's personal airplane, not built by Clément-Bayard. In January 1910 *Flight* published a photograph of a Clément-Bayard *Demoiselle*, Clément-Bayard showed a *Demoiselle* 20 at the Olympia show in Britain in March 1910, but further details of planes they made and sold are unknown to me.

Clément-Bayard issued a sales brochure titled "Le Santos-Dumont N° 20 Aeroplane." The price was 7,500 francs, about \$30,000 in 2019 – without the engine. It was offered with a choice of engines including, most commonly, the Darracq two-cylinder water-cooled "light 30 hp motor for aviation," a four cylinder Wright of 30 hp, and a new Clément-Bayard 40 hp engine designed by Pierre Clerget of 4 cylinders. The 30 hp Darracq engine cost 6,000 francs, and the 40 hp engine 7,500 francs. So one possible total price was 13,500 francs or about \$54,000 in 2019 dollars. Not exactly inexpensive. The Clément-Bayard-built 20 may have differed in some ways compared to Santos-Dumont's personal 20, such as better wing ribs.

#### Flight

Oct. 2, 1909

[at the Paris Salon]

The next most conspicuous novelty is the small Santos Dumont monoplane in which a very good flight was made recently, after which it was announced that M. Santos Dumont was going to give his plans to the public. It now appears, however, that he has come to an arrangement with the Clement-Bayard firm, of which MM. Adolf Clement and Charron are the chief partners, for manufacturing these machines at a retail price of £300 each, while a good deal of publicity is being secured for the three parties that are concerned by the mention that the type of Darracq engine which M. Dumont used on his famous flight will be made by the Clement-Bayard firm—an arrangement which, of course, gives the Darracq firm an admirable opportunity of saying, "Certainly not."

The Santos Dumont aeroplane is a thing which, apart from the question of the engine and the propeller, costs next to nothing to make, nor should any lengthy wear be expected out of it. It does not strike one as being a high-class engineering proposition or a machine built to outlast more than one brief season; but as a voiturette of the air, which it is intended to be, or, to quote M. Dumont's own phrase, "un aeroplane de vulgarisation," it is bound to enjoy a widespread vogue. In view of the special interest attaching to this little flyer, we give elsewhere in this issue a description in detail, together with drawings to scale, so that any of our readers can

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avail themselves of the generous offer made by M. Dumont of throwing his patent rights open to the world without return of any sort.

Flight

Oct. 9, 1909

Santos Dumont's "Darracq" Motor

First blood, in the legal conflict between the Darracq Co. and M. Dumont, as to with whom rests the property and patent rights of the motor, made by Messrs. Darracq and Co., with which M. Dumont accomplished his recent splendid flights, has been drawn by the Darracq Co. This week an order from the French Courts was issued appointing M. Max Richard as "sequestrator" of the engine in dispute, the main question of rights being left to subsequent proceedings.

*Le Figaro* (Sep. 14, 1909) quoted Santos-Dumont saying "wanting to spread aerial travel, I put the rights to my airplane in the public domain. Anyone has the right to build it and may, for the doing; come ask me for the plans." He never published plans – no plans by Santos-Dumont are known -- but he did allow publication of detailed specifications and drawings, prepared by others, in *Flight* in October 1909 and in *Popular Mechanics* in June and July of 1910. Simple as they seem today, these reports were as detailed as other construction plans then published for airplanes. Also at the time of the air show, Santos-Dumont was involved in a legal matter with Clément-Bayard and the Darracq company over who held the rights to the Darracq engine he had improved and that they built. Perhaps he wanted to publish plans of the engine Darracq was manufacturing along with the airplane drawings. As *Flight* said, "which, of course, gives the Darracq firm an admirable opportunity of saying, Certainly not." By January 1910 Clement-Bayard was selling their own sinilar 32 hp engine on their Demoiselles.

## Santos-Dumont's Last Flights and a Fatal Day

The end of 1909 and the beginning of 1910 saw Santos-Dumont's final activities in aviation. The photograph above is probably the airplane described by *Flight* on Dec. 4, 1909: "M. Santos Dumont ... recently fitted a 40-h.p. engine to his Demoiselle," and of an accident flying it on November 23 (below). Santos-Dumont is said to have made a flight clocked by officials of the Aero Club of France at 112.6 kph (69.8 mph), perhaps achieved with the 40 hp engine, but I have not yet seen any report from the time mentioning that speed record.

Flight

Dec. 4, 1909 Santos Dumont at Issy.

M. Santos Dumont has recently fitted a 40-h.p. engine to his "Demoiselle " and had a somewhat exciting experience while testing it at Issy on the 23rd ult. The little flyer developed an extraordinary speed and rose rather over easily. The unusual pace caused M. Dumont to immediately descend. He, however, was unable to bring the machine to a standstill, although he used his hands as brakes on the wheels, before it collided with the railings. M. Dumont was uninjured, but the wings and screw being somewhat damaged have been sent to St. Cyr for repair.

L'Aerophile

Dec 15, 1909

In Issy-les-Moulineuux, November 23, Santos-Dumont resumed the tests of his Demoiselle, but the famous monoplane was equipped this time with a Clément-Bayard engine of 40 horses, and given its lightness and its minimal resistance to penetration, we can guess the fantastic speed of the machine thus equipped. It left the ground in a few meters and crossed the field at full speed and lands without the pilot having sought to turn. The aviator took off, crossed the manoeuvering field, and returned to the ground properly. But the device continuing to roll, would collide with the barrier, when Santos-Dumont braked, applying hands on the wheels. The device, too

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abruptly stopped, turned over. The aviator was released absolutely unscathed. Repairs will require some days. The tests will continue at the aerodrome of Saint-Cyr, the Issy field being really too small for such fast airplanes.

*Flight* Dec. 18, 1909 Santos Dumont Capsized.

While flying in a strong wind at St. Cyr on the 10th inst., M. Santos Dumont's machine was caught by a sudden gust and capsized, with the result that one wing was broken. Just previously he had flown for a quarter of an hour at a height of about 20 metres.



Santos-Dumont and a 20 *Demoiselle* with a large four-cylinder engine. From the airplane, engine, trees and weather I expect that the photo was made in late in 1909 or early in 1910. The engine is large, perhaps the 40 hp engine reported by *Flight* and *L'Aerophile*, and tested Nov. 23, 1909. *Le Matin* reported that Santos-Dumont crashed on January 4, 1910 caused by "a Demoiselle powered by a motor much too heavy;" possibly this was that aircraft, and maybe that day. This may also be the mysterious "22" *Demoiselle*. Santos-Dumont stands in front wearing his distinctive hat and the special vest: you can see the little tube sewn on its back to fit over the wing-warping lever. San Diego Air and Space Museum number 01\_00087149.

The photograph above may be from around the time of a more serious crash on January 4, 1910. Everyone said January 4, 1910 was "a bad day for aviation." The aviator Léon Delagrange was killed that day near Bordeaux when a wing of his aircraft collapsed, and Santos Dumont and Madame Delaroche, the first woman pilot, were injured in separate accidents. Delagrange was a very prominent leader of early flying in France. Just five days earlier he had broken the airplane speed record, at Juvisy-sur-Orge, and had also flown for 124 miles in 2 hours and 32 minutes. The same day, January 4, Santos-Dumont had his most serious crash when one of *his* aircraft's wings collapsed. He was "only injured, rather strongly, but not gravely, to the head".

## Le Figaro

Jan. 5, 1910

A Santos-Dumont Fall

Yesterday had to be bad for aviation. While Delagrange was killed at Croix-l'Hins, Santos-Dumont, in Saint-Cyr, miraculously escaped from death, in a fall whose circumstances seem to be the same. ... Santos-Dumont had made a first flight and completed a second, 25 meters high, when suddenly the tensioner of one of the wings broke and the wing collapsed; the helpless machine fell immediately, whirling around, to break on the ground. We thought the airman was dead; we cleared some debris from his machine, among which we had the joy of finding him alive. Santos-Dumont was only injured, rather strongly, but not gravely, to the head. After some care he returned to Paris where he reassured some friends telephonically ....

Flight

Jan 8, 1910

Santos Dumont's Accident.

The accident which befell M. Santos Dumont at St. Cyr, on Tuesday, emphasises the importance of seeing that all stays, &c, are in good condition, especially on monoplanes. Owing to one of the wires snapping while the machine was at a height of 80 ft., one wing collapsed and the machine dropped to the ground. M. Santos Dumont says the machine turned over three times while falling, but he was protected to some extent by the network of ropes and wires, and so escaped with nothing worse than bruises to the head and legs.

L'Aérophile

Jan. 15, 1910

Mortal Fall of Leon Delagrange

If faith in progress *anyhow*, if the spirit of sacrifice, the stoic acceptance of the possible danger, were not deeply rooted in the soul of our airmen, their valiant phalanx could hesitate before the cruelty of some cruel blows of fate and the persistence of death. January 4th, a day that was also nearly fatal to the great initiator Santos-Dumont and to Miss Delaroche, the first woman who controlled an airplane, Léon Delagrange was a victim in Croix-d'Hins of a mortal accident.

The problem with "a motor much too heavy" would be extra weight to lift, more power leading to more speed, more drag, and increased strains on the airplane and on its control surfaces, and also the real chance that the center of gravity of the machine shifted which alone could make control difficult or impossible. It's likely the forces on the controls increased, and "the tensioner" – a turnbuckle in a metal wire – "of one of the wings broke and the wing collapsed" (*Le Figaro*).

## **Flying in Spain**

The flying accident on January 4, 1910 has been called Santos Dumont's final flight. But there are these next two brief news reports – not mentioned in biographies of Santos Dumont – from *Flight* and *L'Aérophile*, of Santos-Dumont flying his *Demoiselle* in April 1910 in Madrid, Spain:

*L'Aérophile* (Paris) April 15, 1910 Aviation in Spain From a letter dated April 2, from our friend Mr. Serrat, the distinguished director of the Societad Anonima dos Automovites Renault, in Madrid, we offer interesting aviation information ... "Santos-Dumont arrived in Madrid where, on his Demoiselle, he made experiments in front of the king, at the Polo."

*Flight* Apr. 23, 1910 Santos Dumont at Madrid Last week M. Santos Dumont was staying for several days with friends at Madrid, and made several short flights on his little Demoiselle over the Hippodrome golf course.

This is a complete surprise. Santos-Dumont and his *Demoiselle* in *Spain*? In *April 1910*? These events have certainly been forgotten. If true, this was untypical of Santos-Dumont; he had never before taken his airplanes further than fifteen miles from Paris. The reports appear to mention different flights: *L'Aérophile* indicates flights prior to April 2 at the polo grounds, while *Flight* (April 23) says flying was "last week" at the Hippodrome. Did he really ship an airplane to Madrid for a visit? Did he fly a *Demoiselle* in Madrid, on two or more days in March and April 1910? It seems he did. A check in the archives of Madrid newspapers would be fascinating.

It appears that Santos-Dumont was diagnosed with multiple sclerosis in 1910. He never piloted an aircraft again, one biographer suggesting he might have been concerned about causing a crash, and injuring others. The symptoms of multiple sclerosis include weakness, double vision, and impaired coordination, not a good thing for a pilot. Whatever the causes, he abruptly ceased flying and designing flying machines. From being very active in aviation and in the news he withdrew from public life.

## A Summary of Santos-Dumont's Demoiselle Flights

Together *Flight* and *L'Aérophile* reported sixteen days in 1909 when Santos-Dumont flew his *Demoiselle*. Eight of those days had some kind of flying accident, or breakage on landing. Only two days of flying were reported by *Flight, L'Aérophile, Le Matin,* and *Le Figaro* all the summer of 1909, on June 12 and 19. Six days of the sixteen days flying were in one week in September. There are no news reports that he made flights by air to visit friends, other than that flight to Buc on September 13, at a time in when aviators were celebrities and every flight was news no matter how short. Most of Santos-Dumont's flights in *Demoiselles* were less than a kilometer long. The longest flight by Santos-Dumont, on September 17, connected points 12 miles apart, St. Cyr and the Château de Wideville near Davron. The highest altitude reported all year was 80 meters (250 feet) above the ground. On January 4, 1910, he had a serious crash, and Santos-Dumont flew a Demoiselle only a few more times after that, in Madrid in March and April 1910.

Several top airmen in 1909, including both of the Wrights, Curtiss, Farman, Bleriot, Latham, de Lambert, and Delagrange, (and possibly Paulhan, Sommer and Tissandier) each made one or more individual flight with a single flight time and distance surpassing the total of the year's flying by Santos-Dumont.

Santos-Dumont's most sustained period of flying occurred in September 1909. He first flew thr final version of the number 20 *Demoiselle*, with the 30 hp Darracq engine essential to good performance, on September 5. On September 13 Santos-Dumont flew the five miles from St. Cyr to Buc, in "about five minutes" to win a bet with his friend Maurice Guffroy (for fifty Louis, of value 1000 francs) about who would first visit the other by air. This flight was celebrated for setting an informal aviation speed record at 60 mph (the official record was 47.8 mph set by Bleriot at Reims, which would stand for almost a year). The next day he flew back to St. Cyr, and made short flights there to demonstrate stability and control, once waving a handkerchief in each hand while piloting the *Demoiselle*. On the 16<sup>th</sup> he set a record for the shortest takeoff run: "after running 70 meters timed in 6 1/4 s., the small monoplane took off sharply" (*L'Aerophile*) for a takeoff speed near 50 mph. On the 17<sup>th</sup> he made a flight of a few kilometers at 4:30 PM, and again at 5:30 he began a "little excursion" flying at 80 kph and 70 meters height and, becoming lost and low on gas with the engine misfiring, he landed on the "magnificent"

lawn" of the Château de Wideville, home of the Comte and Madame de Galand, where the "unexpected guest" dined and stayed the night. The next morning he drove the *Demoiselle* back to St. Cyr in his auto; photographs show his departure from the Château by car with the airplane on its special back platform. That afternoon at St. Cyr he made a five minute flight, once with his arms stretched out and hands off the controls. Sunday the 19<sup>th</sup> Santos-Dumont made two flights of a few minutes duration each "in front of more than 5000 Parisians," again showing tests of stability. These flights of the *Demoiselle* profited from the new and more powerful Darracq engine, demonstrating significantly more speed, distance, and altitude than the *Demoiselle* had previously achieved. This week of flying may have been Santos-Dumont's response to missing the Reims aviation week. It certainly was the peak of his achievements in the *Demoiselle*.

# Flying a *Demoiselle*

The 19 could only barely get off the ground, and made no turns. The final version of number 20 – Santos-Dumont's classic *Demoiselle* – flew well for the times when the Darracq engine was installed in September 1909. At 60 mph (97 kph), it was the fastest airplane that month. It had a performance something like the U.S. ultralights of the same size made in the past 40 years.

An original *Demoiselle* would give prudent modern pilots pause, and would not be able to lift many of them. *Flight* reported Santos-Dumont's own 20 *Demoiselle* was lightly built and not very durable: "... nor should any lengthy wear be expected out of it. It does not



strike one as being a high-class engineering proposition or a machine built to outlast more than one brief season" (*Flight* 1909). About half of Santos-Dumont's *Demoiselle* flights in 1909 involved some kind of breakage. The Clement-Bayard 21 had better construction but it too was lightly built.

Journalists of 1909 lacked technical words to describe flying, but they did call *Demoiselle* flights of only a few hundred meters (yards) "marvelous," "beautiful," and "magnificent." Other airplanes of the time routinely flew that far and much farther with less admiration. So what was going on? I suspect that simply the *Demoiselle* flew better. Before 1910 airplanes were mostly large and slow, often trundling along about 40 miles an hour and making wide, cautious, shallow, slow turns. The *Demoiselle* was a pleasant contrast. It was small and agile. It darted into the air. Its wing loading of about 4 pounds per square foot was higher than other planes of the day, and the power per pound was higher, both of which would have given it quicker response, and tighter, faster turns. And the flair of the *Demoiselle* was matched by the colorful personal style of Alberto Santos-Dumont.

One *Flight* columnist said the *Demoiselle* was hard to learn to fly, and surely it was, having no two-seat trainer airplanes and probably being pretty responsive (touchy) on the controls. But two famous exhibition pilots of 1910, Roland Garros and Edmund Audemars, used the 20 in air shows and were called "acrobats."

The most common accident was turning over when landing; the French reporters called this manoeuver "capsizing." Everybody did it. You ended up facing the wrong way. The wheels were too far back and too close to the center of gravity.

There are no reports of a fatal accident in a *Demoiselle*. One cause of no crashes with grave injuries was simply that the *Demoiselle* was not flown very much, compared to say the popular Bleriot model XI airplane of the same time. Also, all those snapping spars, struts, and wings in a bad landing soaked up energy. Audemars crashed a *Demoiselle* in Bournemouth England in 1910, ending upside down in a field, and walked away. He had a spare *Demoiselle* there, just in case something like that happened. Audemars was reported to "rarely rise more than 30 ft."



## 1910 and After

The world of aviation was rapidly changing and expanding. On January 1, 1910 there were only 17 aircraft pilots in the world issued a license by French authorities (Santos-Dumont was among the first group of eight). During 1910 the number soon passed 100. Some of the new pilots learned to fly in *Demoiselles (all* solo hours), pilots who went on to play important roles in early aviation. For example, Roland Garros, who received his French license, number 147, on July 19, 1910, flying a *Demoiselle*. That year he flew in exhibitions in Europe and in the U.S. The *Demoiselle* provided concepts or at least inspiration for other early aircraft, most notably Hans Grade's monoplane, first flown on 17 August 1909, and Anthony Fokker's first aircraft, the *Spin* of 1910.

A Demoiselle Over the Palace of Versailles *Flight* Sep. 3, 1910 ROUND-ABOUT FRENCH NOTES. By OISEAU.

For some time past intending aviators have fought shy of the "Demoiselle" type owing to the great difficulty of learning to fly one satisfactorily. The small area of the planes makes a high speed necessary before the machine will commence to rise at all, and then unless one is careful, very careful, it will leave the ground with a spasmodic leap, only to fall a second later, probably turning over backwards on the way. Again, the smallness of the "Demoiselle" has created a doubt in the minds of many as to the possibility of performing a "vol plane" safely in the case of engine trouble. Audemars, whose courage I imagine is unquestioned, invariably flies low, rarely rising more than 30 ft. My own personal experience of the type had certainly led me to take the same view of its entire unsuitability for any other purpose save causing much amusement at aviation meetings. As an acrobatic machine it is unrivaled. But a few days ago I was given another point of view by M. Roland Garros. Not only did he fly on his Demoiselle at the first attempt, but he has since made a number of quite long flights at a height of 1,200 ft. He says he has never found the slightest difficulty in gliding safely to earth at any time. On the morning of the 17th August M. Garros left Saint Cyr for Issy on his Demoiselle (which is that used previously by M. Santos Dumont himself) intending if all went well to be present at the arrival of the competitors in the Circuit de l'Est. His engine failing whilst over the Palace of Versailles he commenced to plane down from a height of 1,000 ft., only to hit an unseen telegraph wire in the Place d'Armes, completely turning turtle before reaching the pavement. Neither the machine nor the pilot was greatly damaged. He speaks highly of the general control of the Demoiselle, and states that it is possible to perform evolutions with ease that on other aeroplanes would require the greatest skill. The position of the pilot, below the engine and wings, he considered was ideal, as one has an uninterrupted view of all happening

in front or on the ground. After a descent the machine can be stopped in a few yards by using one's feet as brakes. Replacements are cheap and easily made. M. Garros says he thinks so highly of the Demoiselle monoplane that he has no intention of forsaking it for any other type.

Beginning in 1910 aircraft quality, performance, and records improved at a remarkable pace. Aeronautical knowledge became much more advanced: in one small example by mid-1910 *Flight* had articles about what we now call wing-tip vortices (still a problem in 2010) whereas two years before basic three-axis control had been a puzzle to some designers. And in 1910 social interest turned from brilliant inventors of airplanes and the novelty and delight of pure flight to air shows, air races, and "heroic" pilots flying faster and setting records. The word acrobat began to used. Aircraft performance surpassed the *Demoiselle*. The last time an original *Demoiselle* flew in public which I know of was at an air show in 1911 in Houston, Texas.

In a few more years the progress was remarkable. On September 6, 1912 Garros set a new record for altitude, reaching near 16,400 feet (5000 m) near Trouville France, flying a Bleriot. On September 23, 1913 he flew a Morane-Saulnier Type G across the Mediterranean Sea from Fréjus, Côte d'Azur, France, to Bizerte, Tunisia, covering 470 miles (758 kilometers) in 7 hours 53 minutes at an average ground speed of 59 mph (96 kph), and landing with only about one gallon (4 liters) of gas left in the tank. Long gone were the days when five thousand people would travel to see Santos-Dumont or Wilbur Wright fly for a few minutes just above the trees.

In August 1914 the first world war swept the workers from the champagne vineyards near Reims where five years before hundreds of thousands of spectators had delighted in pure flight. The trenches of the western front ran right through the flying field of the great 1909 Reims air meet, and combat ruled there for four years. Armed aircraft became a regular part of combat. Thousands of airplanes were built, and thousands of pilots were killed. Roland Garros became a celebrated French fighter pilot, and he was killed flying a fighter in the last month of the war. The war ended in late 1918 after destroying, among many other things, most of an entire generation of French men. After the end of the war the French shoved five hundred SPAD biplane fighters into a pile and burned them. France "won" the war but, set back by the calamities of the war, France lost its position as a premier country of the world in many areas. During the war Santos-Dumont deplored using airplanes to kill people and was criticized and falsely accused of being a German agent. Also, he strongly felt personally responsible for persons killed flying, both in war and by accident. By 1920 he had long been severely depressed, partly by the use of flying for combat, a depression ultimately leading to his death in 1932.

Santos-Dumont's *Demoiselle*, and the ideal light personal airplane it represents, still delights those who seek the joy of pure and simple flying. The configuration of the *Demoiselle* became common in airplane design. When you look up and see a small, high-wing, single-engine monoplane with the pilot under the wing flying overhead, you see a descendent of the *Demoiselle*. The *Demoiselle* continues to inspire builders of similar small airplanes, now built with better materials, not to duplicate the past, but for recreation, for pure flying.

This reports should clarify the historical development and technical specifications of the *Demoiselles*. Some questions and gaps in knowledge remain, which perhaps could be resolved by research in libraries in France, looking through newspapers, magazines, other publications of the times, personal letters, photograph collections, and accounts, and by examination of museum holdings, and working with the Aero Club of France.

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# The *Demoiselle* models: 19, 20, and 21

In accounts about Santos-Dumont or the *Demoiselles* there are frequent errors, and confusion about numbering. In the original period the word *Demoiselle* meant whatever airplane Santos-Dumont was flying at the moment; a number was rarely used in reports.

There were two different basic forms of the *Demoiselle*, Santos-Dumont's 19 and 20. Each form had variants. First there was the original 19 (flown in November 1907), then the dual-propeller 19. 19 and its variant flew poorly or not at all. The original 19 was able to take off but flew only about 200 meters, could only ascend a few meters, and made no turns. I have seen no reports of the dual-propeller 19 attempting to fly.

In the 20 line there were three prototypes (all named 20 by Santos-Dumont) between 19 and before the final version of 20, from January through August 1909. Then came the classic Santos-Dumont 20 of September 1909, shown at the aeronautical Salon. This is what is now generally meant by the *Demoiselle*. It had the the new Darracq engine adopted in September 1909. Finally came airplane models built by Clément-Bayard for commercial sales, the first named the Santos-Dumont 20, and then the 21, perhaps in late 1909 or 1910.

Santos-Dumont's final 20, the Clément-Bayard "Santos-Dumont No. 20," and its successor the 21, were successful fliers, at least for small pilots. A Clément-Bayard 21, the aircraft now in the Paris-Le Bourget air museum, is a surviving original *Demoiselle* and it is a key source of information about original *Demoiselles*. To compare 20 and 21 see the diagram on the next page where both designs are shown in side and front elevations at the same scale.

The 21 built by Clément-Bayard is clearly distinguished by two vertical struts above the wings and a dozen or more wires from those struts to the top of the wings, holding the wings straight out. The 20 and its prototypes had no wires above the wings. , and the wings may droop a little when on the ground. The wings of 21 were carefully made with wood spars and built-up wood ribs, an improvement over Santos-Dumont's original bent bamboo wing ribs. 21 has a longer main frame than 20, tapering nearly to a point. 21 was 22 feet long (6.7 m; 20 was 20 feet long), with a wing span of 21.0 feet (6.4 m; 20 had a span of 5.5 m). The tail looks a little smaller than the tail on 20, and its u-joint is much smaller. The tail skid is at the third rather than fourth set of vertical cross struts behind the pilot, and there are Bleriot style controls, with rudder pedals and a 'cloche' which acts like a modern stick, replacing Santos-Dumont's original elevation lever for the right hand and a control wheel for the rudder by the left hand. The canvas sling seat was replaced with a metal one. 21 is a slightly improved design over 20, and has better construction.

A 22 occasionally is mentioned in some modern lists but it is a mystery. I have found nothing yet of that name published in the original period. It may have been simply a single test by Clément-Bayard with a different engine installed on a 20. Perhaps it was just Santos-Dumont's plane with the 4 cylinder engine reported in December 1909 and shown in photographs, or the plane with "over-heavy engine" of the crash on January 4, 1910 which may also have been Santos-Dumont's plane with the 4 cylinder engine.

In 1907 Santos-Dumont's new airplane had "19" prominently painted on it; no other later plane by him had a painted number. Writers in newspapers and aviation weeklies generally called Santos-Dumont's airplane the *Demoiselle*, "his miniature flyer," the "little pocket monoplane," "his little machine," or something like that, and did not use a number. L'Aerophile first reported the name "Santos-Dumont-XX" on January 1, 1909. In mid summer 1909 a couple of news reporters still called Santos-Dumont's airplane "19" but it was the 20. The final form of 20 was achieved in September 1909.

Santos-Dumont wrote a book called "My Airships." Unfortunately he never wrote a companion book "My Aeroplanes" which would have improved our knowledge of what he did and what he thought.



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An original Clément-Bayard *Demoiselle* 21, now in Paris. The struts and wires above the wing easily distinguish the model 21 from 20. Note the bamboo longerons, like on the *Demoiselle* 20 made by Santos-Dumont. ("Demoiselle model n° 21 from Alberto Santos-Dumont (1909), Musée de l'Air et de l'Espace, Paris Le Bourget (France). ... motor flat-twin Darracq 30 HP." Accessed from

https://commons.wikimedia.org/wiki/File:Demoiselle\_de\_Santos-Dumont\_Musee\_du\_Bourget\_P1010409.JPG.)



Side view of the Clément-Bayard 21 in Paris, showing the bamboo longerons as used by Santos-Dumont, and the much longer frame than on 20. The tail is slightly smaller, and its u-joint much smaller, than on 20. Note the thin wing section. The wings are carefully made with wood ribs, not the bamboo stems used by Santos-Dumont.

# **More Original Photographs**

# Number 19, late 1907



Santos-Dumont's first *Demoiselle*, his 19, November 1907. The single long boom of bamboo is clear. This machine had little in common with the later successful 20.



The 19 in flight in November 1907, at Issy-les-Moulineaux. This is close to its maximum altitude, and no turns were achieved. This is the only *Demoiselle* by Santos-Dumont with a painted number.

The initial Santos-Dumont 20: first prototype, November 1908 – January 1909



Santos-Dumont and the first "20," in late 1908 or January 1909. Little of this machine survived to become part of the final version of the 20 of September 1909, except possibly the wings and two wheels.



Alberto Santos-Dumont moving the first airplane called number 20 in his personal automobile in Paris, in late 1908, possibly on November 12. This aircraft has 12 or 13 ribs per wing, while number 19 had only 6 or 7, so these are new wings. The propeller also is improved from the original 19's propeller, and of course the engine is completely different from that of 19. Other photographs show Santos-Dumont transporting his later final model 20 *Demoiselle* the same way in September 1909.



Santos-Dumont, correctly attired in suit, cravat, hat, and gloves, in the pilot's seat of his current Demoiselle, probably in November 1908. The Antoinette V8 engine is *between his legs*. No reports exist that this took off.

## The Santos-Dumont 20: second version or prototype, March-April 1909



The second version or prototype of number 20, at Issy-les-Moulineaux, probably on March 9, 1909. The new frame, long and pointed, was made of three bamboo spars with steel tube cross struts. This version of the 20 has the forward "horizontal stabilizer" as on the earliest 19. Several other photographs survive from this occasion; the same footprints in the snow appear in them. The wings and the tail empenage may be from the first prototype of 20. The forward horizontal stabilizer shown here was omitted in the next prototype of 20. Note the dark seat sling, and the thin lever behind the seat used for wing-warping roll control, which first appeared on this version of the *Demoiselle*.



Santos-Dumont in the second version or prototype of the 20 *Demoiselle*, in March 1909. Note the "forward horizontal stabilizer, found on this version of the 20. The struts ending on the exterior ends of the wheel hubs, typical of this and later versions of the 20, first appeared. The solid propeller is an improvement on the propeller on all previous airplanes by Santos-Dumont. The engine is a air-cooled Dutheil-Chalmers 24 hp.



The second prototype of the 20 *Demoiselle*, in a characteristic scene of early days of aviation in France, at Saint Cyr, on April 10, 1909. The long frame is made of three bamboos ending in a point. Note the forward 'horizontal stabilizer.' The small tapered gas tank above the wing would only supply flights of a few kilometers. If the date of this photograph is correct, just two days previously Santos-Dumont had made the first long flight in a *Demoiselle*. *Flight* reported "Santos Dumont has performed a bold, not to say hazardous feat with his 'Demoiselle,' that little pocket monoplane with which, as our readers know, he has for some few weeks past been making experiments. While practising at Saint Cyr on Thursday, April 8th, he commenced a flight which extended for a distance of about 2.5 kiloms., during the course of which he flew at a height of about 60 to 70 feet and cleared several hedges and telegraph wires." That was Santos Dumont's first flight longer than half a kilometer (0.3 mile) in any airplane.

The Santos-Dumont 20: third version or prototype, May 15 - August 1909



The third prototype of the 20 *Demoiselle* at Issy, exact date unknown but probably about May 15 1909. The 'forward horizontal stabilizer' of the second prototype was removed after being damaged ina wind gust. The large tail wheel, the air-cooled engine, and the long frame tapering to a point, are all typical of the second and third prototypes of 20.



Detailed view of the third prototype of the 20 *Demoiselle*, from about mid-May through August 1909. As before, the upright frame struts were made of welded oval steel tubes; the longerons were bamboo. This propeller is new, and better than the propeller on the second prototype; it is a different and larger propeller with a different hub. Struts ending on the exterior wheel hubs are clear. The Dutheil-Chalmers 24 hp air-cooled engine, clearly shown here, probably was used on all forms of the 20 *Demoiselle* up to early September 1909. In September 1909 this airplane was improved, with several changes, to become the final form of 20.





Santos-Dumont flying the third prototype of his 20 *Demoiselle*, at St. Cyr, sometime from mid-May to before September 1909. The lack of the forward horizontal stabilizer distinguishes this aircraft from the earlier second prototype of the 20. The lack of radiators under the wings differs from the later and final form of the 20, as does the pointed aft end of the long tapering three-longeron frame, and the tail wheel. The engine of the second and third prototypes, a Dutheil-Chalmers 24 hp air-cooled engine, was not quite powerful enough for the airplanes, and flights only reached a few kilometers in length, at most, and altitudes of only a few tens of meters above ground. This is Santos-Dumont's airplane of the summer of 1909, but not the final *Demoiselle*. The Santos-Dumont 20, the classic *Demoiselle*, from September 1909.



Santos-Dumont's final, classic, *Demoiselle*, 20, very likely photographed in Saint Cyr in mid-September 1909. The wing radiators show the airplane has the 30-hp Darracq engine. The main frame is now shorter and squared off at the back end. The prototypes' large tail wheel is gone, but the tail skid remains at the end of a vertical tube. Note the new large conical gas tank behind the pilot: gas was pumped from it to a smaller tank above the engine. Total flying weight with Santos-Dumont may have been close to 400 pounds (181 kg); the empty aircraft weighed about 118 kg (250 pounds). This probably was the airplane shown in the Paris aeronautical Salon in September and October 1909.



Roland Garros in a Clement-Bayard "Santos-Dumont 20," probably in 1910. Note the two little vertical uprights above the wing and the fuel tank. The bamboo longerons are clear.



Cover of the Clément-Bayard sales brochure for "Le Santos-Dumont N<sup>o</sup> 20," autumn 1909. Price (without engine): 7,500 francs. The larger photo shows Santos-Dumont, his personal *Demoiselle*, and the Château de Wideville.



A *Demoiselle* 20, perhaps the one with a "motor much too heavy". The engine may be a Clement-Bayard four cylinder 40 hp unit of late 1909. A conical gas tank like this became part of Santos-Dumont's personal aircraft in September 1909. This appears to be the same airplane: the propeller and hub also look identical.



A photograph of Edmond Audemars in a *Demoiselle*, probably in 1910, giving a good indication of the strength and rigidity of the aircraft, or lack thereof. The horizontal tubes are bamboo poles. The shorter and more vertical struts are oval steel tubes, 10 by 25 mm in cross-section. With no springs or elastic in a wheel suspension to absorb shocks, landing this plane must have called for a light touch, to avoid breakages.



One of the original magnificent men in their flying machines: Roland Garros in a Clément-Bayard *Demoiselle* at the Rennes air meet in 1910. Garros and Edmond Audemars were the premier *Demoiselle* pilots of 1910. A small gas tank is placed over the engine. No vertical struts appear above the wing so it's not a 21. Part of the starboard wing is removed, clearly showing the wing section.

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The most recent version of this report is online at <u>http://www.westernexplorers.us/Demoiselle-original-history.pdf</u>.

Versions of this report:
Original: July 4, 2017
Recent revisions:
Oct. 29, 2018 extensive revisions based on material from the *Flight* archive.
Nov. 2, 2018 more information from *L'Aérophile*, and reordered words in the title.
Nov. 5, 2018 info from *Le Figaro*, and numerous changes of details.
Nov. 7, 2018 added quotations from *Le Matin*.
Nov. 9, 10, 11 and 14, 2018 nuanced conclusions.
Nov. 12, 2018 added to "Flying a Demoiselle"
Nov. 16, 2018 improved the selection of photographs.
Jan. 28-31, 2019 added the large photograph of the second prototype in air; some rewriting and clarifications.
Feb 23, 2019 extensive revisions following the discovery that the number 20 was used as early than Jan. 1, 1909
Mar. 2, 2019 now have an exact date for the change from the second to third prototype of number 20.
Mar. 29, 2019 improved wording, and added the drawing of the tail unit.

May 5, 2019 minor wording changes

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Contributions, suggestions, and questions are very welcome. I would like to hear from historians, museums, airplane builders, and fellow enthusiasts who use this material. Please send your information to:



A description of replica "Demoiselles" and modern Demoiselle-inspired airplanes is at <u>http://www.westernexplorers.us/Demoiselle-Originals-and-Replicas-Santos-Dumont.pdf</u>.

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A photograph of the Wright Flyer III in 1905, above Huffman Prairie, Ohio, USA. On October 5 1905 Wilbur Wright flew this airplane 24 miles (39 km) in 38 minutes.

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