

Early Flying Machines



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Chapter- 1

Early Flying Machines



A 1786 depiction of the Montgolfier brothers' balloon

There are conflicting views as to what was the **first flying machine**. The controversy of invention is not limited to flight e.g.: Debates over the tallest building tend to break into debates around what constitutes a building and what is the most important measure of such structures' height. In the same way some records of flying machines can come down to the exact definition of what, for example, constitutes a "flying machine", or "flight", or even "first".

Theories

Early attempts at flight are the subject of much debate, both for the often sketchy details of machines and people that have vanished away in time and perhaps as a matter of pride for some given group, like a country. The main focus is the attempts at gliders and powered aircraft in the decades before and soon after the Wright Flyer. Ancient flying machines, gliders, or balloons if they existed are not generally known about or recorded at any level of accepted validity.

Along with many inventions developed during the Industrial revolution, such as the steam engine, flying machines followed a slow process of study and analysis by various people but culminated in a pivotal design. Following this pivotal design, development continues but with the benefit of some new breakthrough or a slightly new direction. Who receives the award for a specific achievement can be difficult to decide with some developments due to the nature of *what was developed*, the *definition of the award*, and *veracity of claims*. Also, if something was invented independently by different people, conflict can arise as well.

The various benchmarks awarded to flying machines are especially vulnerable to all these.

Veracity of claims

Early flying machines, such those that predated the development of practical photography are often doubted for lack of proof, and ancient machines are almost entirely dismissed for a lack of credibility. Recreations or claims made long after events can add confusion to even the more straightforward cases. The number and quality of witnesses is also often analyzed. Various governments and other organisations will often only give some claims a 'official' approval in attempt to elevate one attempt over another, usually in the interest of a national or cultural pride, or in order to set themselves up as technical and historical authority figures. A great deal of disinformation and revisions can take place as well with some claims, both from individuals and governments, to adjust the level of importance of some respective claims.

Definition of the title

It can be especially rough for more general titles falling prey to technical definitions versus common usage, or differences between languages. More general titles can be favoured for their greater weight, such as a title like 'Father of flight', but could be greatly

debated because of being open to interpretation. On the other hand very specific claims can begin to sound trivial, carry less weight, and in being so specific fall prey to debates over accuracy of the claim. What constitutes the most important criteria for a given award is also a matter of debate in early aircraft. Is the 'oldest ancestor of modern aircraft' the earliest design, the earliest prototype, one that actually flew? The arbitrary nature of many titles will automatically create controversy if its not defined specifically. For example, debates over the tallest building tend to break into debates around what constitutes a building and what is the most important measure of such structures height. In the same way some records of flying machines can come down to the exact definition of what constitutes a fixed-wing aircraft.

The nature of what was developed

This is an especially important source of controversy for early flying machines. The source of trouble is the transition between what are considered gliders and what are powered aircraft. Just as objects that displace less water than their weight will sink, objects that displace less than their weight in air sink also. Balloons and other lighter-than-air craft 'fly' by displacing more than their weight in air to rise, but a flying machine must supply an upward force some other way to remain aloft. Supplying this force requires energy, which brings us to the benchmarks given to the various flying machines. With gliders this energy comes out of potential energy of their height as they trade the energy "stored" by their height for lift and forward speed (aside from taking advantage of air currents).

In powered flight, energy comes from fuel stored aboard (or given to) the machine which is turned into lift in some way. For example, in many aircraft gasoline fuels an internal combustion engine which turns a propeller causing forward motion, which in turn allows the wing to generate lift. Also considered to be important is the ability in early flying machines to control where the device goes, very important for making the device practically useful.

Energy to lift

Anything that falls can trade height for some forward motion, so what becomes very important with powered flying machines is turning stored energy into lift. With a wing, turning forward motion into lift requires turning energy into forward motion or with helicopters directly into lift. The end result requires a moving airfoil to generate an upward force. A good breakpoint for powered flight in design would be if it can not lose altitude or speed in level flight by turning energy into lift. Unfortunately such a device could not take off under its own power(barring numerous complicated exceptions), and such a benchmark would also depends on the conditions of the air, especially the air density. Of course wind conditions can have a big effect as well, with wind from behind extending range and from the front shortening it (for both gliders and powered aircraft).

Also, for example, an engine could be used to build up speed (as could going down a hill) and then forward speed could be traded for lift while maintaining level flight. Other

difficulties include a fixed-wing aircraft that derives some lift from attaching itself to lighter than air objects, thus becoming a hybrid. Other matters expand to other facets of claims. Since claims are event based, the veracity of a claim is thought to be capable of being tested by making a recreation of the event. Unfortunately, improvements to a new model can be added or removed, weather condition can vary significantly and even things such as the quality of fuel used can effect a recreation attempt. To make matters worse accurate blueprints are usually difficult to find, and for often the borderline designs small changes can have a big effect. The inability to recreate exactly results in most attempts being of dubious value to the ultimate credibility of a claim, but regardless, a success or a failure can figure heavily in analyzation of a flying machine.

Other issues include a design taking advantage of ground effect which is an aerodynamic effect that adds lift when very close to the ground. If a design is not reported to have risen high enough it is often considered a 'hop', or unsustained leap into the air. Also, starting height, and any additional energy given to aircraft can become a subject of debate. If a motorised design is given energy, and does not demonstrate the ability to climb it may or may not be considered a power flight.

Conclusion

The end result of all this is that it ends up becoming very complicated giving definitions at the borderline of flying machines that are gliders and flying machines that are powered aircraft. Disputes over important titles, such as 'first powered heavier than air flight' can descend into the particulars of design. More general titles like 'father of aviation' add another layer of complexity by implying a societal effect and an effect on other machines.

Many of titles given to various claims vary from country to county, and indeed among various references and encyclopedias - that all use different criteria when considering the validity of a claim, the meaning of the title used, and all the other issues mentioned above. Various advancements are presented here, mostly prototype machines and also some important pieces of literature.

Claims to first piloted flight by date

Pre-19th century

Archytas, Ancient Greece

According to Aulus Gellius, Archytas, the Ancient Greek philosopher, mathematician, astronomer, statesman, and strategist, was reputed to have designed and built the first artificial, self-propelled flying device, a bird-shaped model propelled by a jet of what was probably steam, said to have actually flown some 200 meters. This machine, which its inventor called *The Pigeon* (Greek: *Περιστέρα* "Peristera"), may have been suspended on a wire or pivot for its flight.

Bartolomeu de Gusmão, Brazil and Portugal, an experimenter with early airship designs
In 1709 Bartolomeu de Gusmão demonstrated a small airship model before the Portuguese court, but never succeeded with a full-scale model.

Pilâtre de Rozier

Pilâtre de Rozier made the first trip by a human in a free-flying balloon (the Montgolfière): 9 km covered in 25 minutes, 21 November 1783, near Paris.

Professor Jacques Charles and Les Frères Robert, (Anne-Jean and Nicolas-Louis)

1. *Le Globe*, the first hydrogen gas balloon flew on 26 August 1783.
2. On 1 December 1783 *La Charlière* piloted by Jacques Charles and Nicolas-Louis Robert made the first manned hydrogen balloon flight.
3. On 19 September 1784, *La Caroline*, an elongated craft that followed Jean Baptiste Meusnier's proposals for a dirigible balloon, completed the first flight over 100 km from Paris to Beuvry.

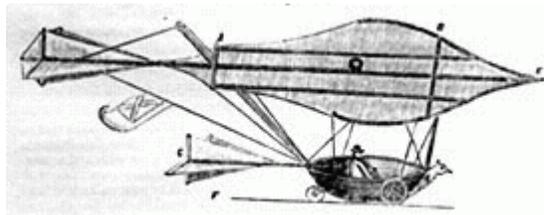
19th century

Hans Andreas Navrestad, Norway — 1825

Allegedly flew manned glider.

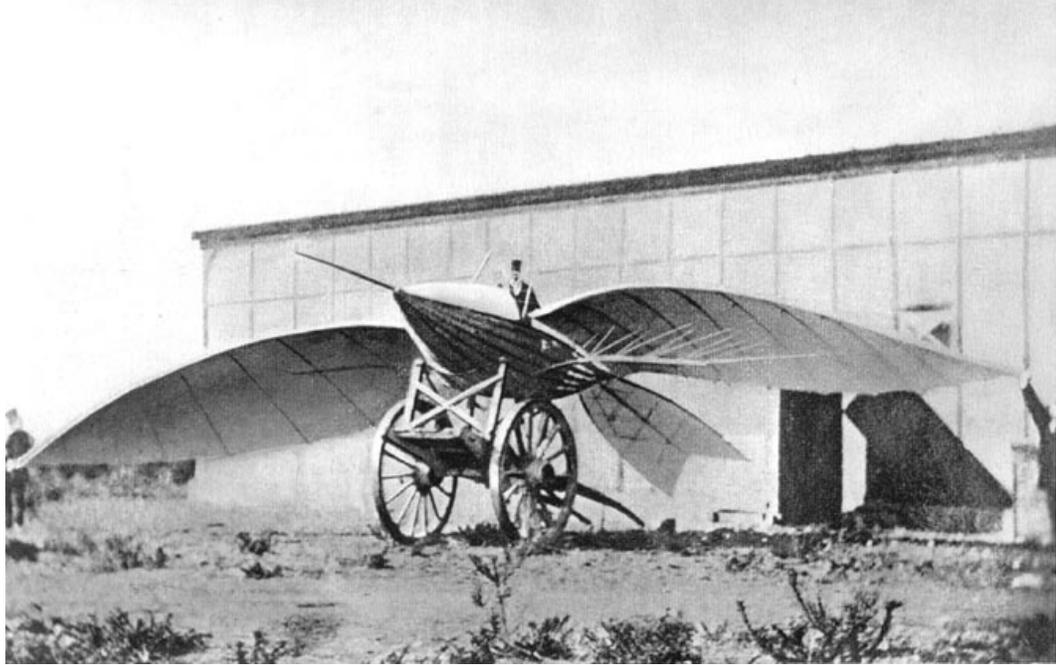
John Stringfellow, England — 1848

First heavier than air powered flight, accomplished by an unmanned steam powered monoplane of 10-foot (3.0 m) wingspan. In 1848, he flew a powered monoplane model a few dozen feet at an exhibition at the Crystal Palace in London.



George Cayley, England — 1853

First well-documented Western human glide. Cayley also made the first scientific studies into the aerodynamic forces on a winged flying machine and produced designs incorporating a fuselage, wings, stabilizing tail and control surfaces. He discovered and identified the four aerodynamic forces of flight - weight, lift, drag, and thrust. Modern airplane design is based on those discoveries including cambered wings. He is sometimes called the "Father of aviation".



Matias Perez, Havana, flight in 1856

Matias Perez was a Portuguese pilot, canopy maker and Cuban resident who, carried away with the ever increasing popularity of aerostatic aircraft, disappeared while attempting an aerostatic flight from Havana's "Plaza de Marte" (currently Parque de la Fraternidad) on June, 1856.

Jean-Marie Le Bris, France, flight in 1856

Jean-Marie Le Bris was the first to fly higher than his point of departure, by having his glider pulled by a horse on a beach, against the wind.



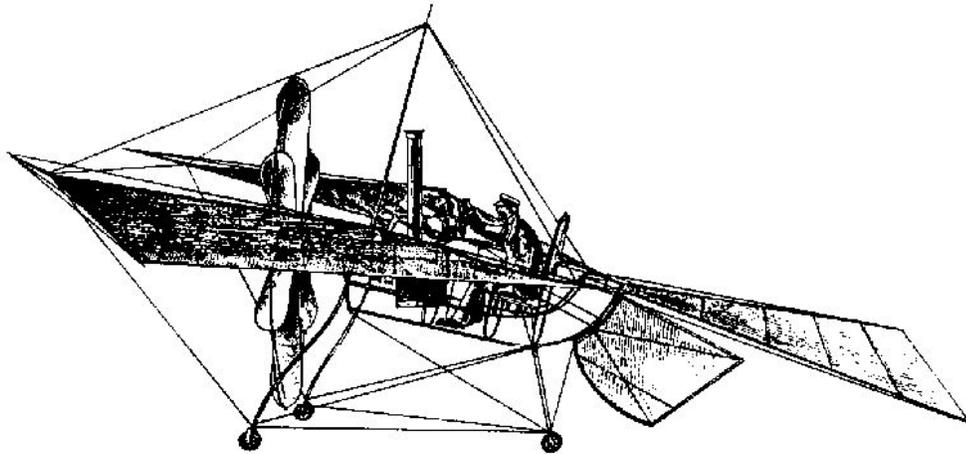
Jan Wnek, Poland — controlled flights 1866 - 1869.

Jan Wnek controlled his glider by twisting the wing's trailing edge via strings attached to stirrups at his feet. Church records only—Kraków Museum unwilling to allow verification.

Goodman Household, South Africa, 1871

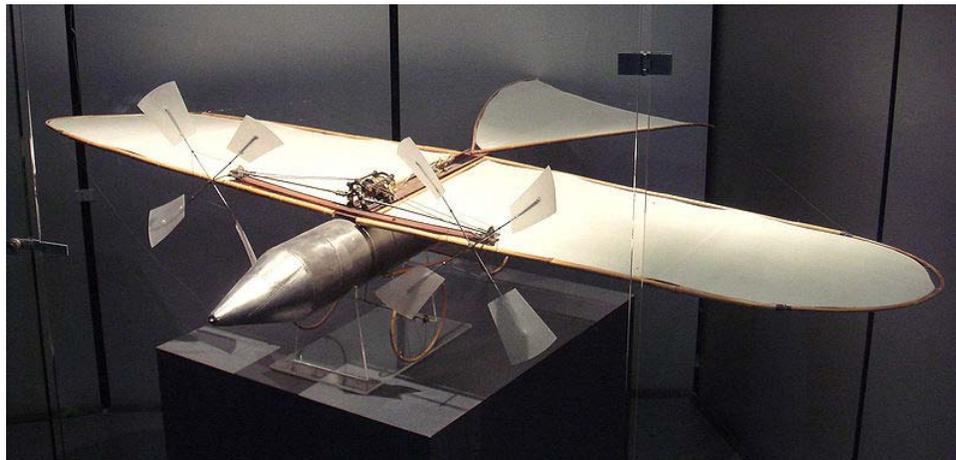
Goodman built and flew his own glider over one hundred meters. The story is that he crashed breaking both glider and a leg. The event took place in the Kwazulu Natal Midlands near Curry's Post in 1871 and is recorded variously in legend and local literature.

Félix du Temple de la Croix, France, 1874



First take-off of a manned and powered aircraft, from a downsloped ramp, resulting in a brief hop a few feet above the ground.

Victor Tatin, France, 1874



First airplane to lift itself under its own power, the *Aeroplane* was an unmanned plane powered by a compressed-air engine.

John Joseph Montgomery, United States of America 1883

First controlled glider flight in the United States, from a hillside near Otay, California.

Alexander Feodorovich Mozhaiski, Russian Empire — 1884

First powered hop by a manned multi-engine (steam) fixed-wing aircraft, 60–100 feet (20-30 meters), from a downsloped ramp.

Clément Ader, France — October 9, 1890



He reportedly made the first manned, powered, heavier-than-air flight of a significant distance (50 m) but insignificant altitude from level ground in his bat-winged, fully self-propelled fixed wing aircraft with a single tractor propeller, the Ader Éole . Seven years later, the Avion III (a different machine) was said to be flown upon 300 metres (in fact just lifted off the ground, and lost control). The event was not publicized until many years later, as it had been a military secret. The events were poorly documented, the aeroplane not suited to have been controlled; there was no further development. Later in life Ader claimed to have flown the Avion II in 1891 for over 200 meters.



Otto Lilienthal, Germany — 1891

The German "Glider King" was a pioneer of human aviation—the first person to make controlled untethered glides repeatedly and the first to be photographed flying a heavier-than-air machine. He made about 2,000 glides until his death August 10, 1896 from injuries in a glider crash the day before.

Chūhachi Ninomiya, Japan - 1894

Japanese inventor who developed several small powered models including an early tailless aircraft.

Lawrence Hargrave, Australia—November 12, 1894

The Australian inventor of the box kite, linked four of his kites together, added a sling seat, and flew 16 feet. By demonstrating to a sceptical public that it was possible to build a safe and stable flying machine, Hargrave opened the door to other inventors and pioneers. Hargrave devoted most of his life to constructing a machine that would fly. He believed passionately in open communication within the scientific community and would not patent his inventions. Instead, he scrupulously published the results of his experiments in order that a mutual interchange of ideas may take place with other inventors working in the same field, so as to expedite joint progress.

Hiram Stevens Maxim, United Kingdom — 1894

The American inventor of the machine gun built a very large 3.5 ton flying machine that ran on a track and was propelled by powerful twin naphtha fueled steam engines. He made several tests in the huge biplane that were well recorded and reported. On July 31, 1894 he made a record breaking speed run at 42 miles per hour (68 km/h). The machine lifted from the 1,800-foot (550 m) track and broke a restraining mechanism, crashing after a short uncontrolled flight just above the ground.

Samuel Pierpont Langley, United States — May 6, 1896

First sustained flight by a heavier-than-air powered, unmanned aircraft: the Number 5 model, driven by a miniature steam engine, flew half a mile in 90 seconds over the Potomac River near Washington, D.C. In November the Number 6 flew more than five thousand feet. Langley's full-size manned powered Aerodrome failed twice in October and December 1903.

Octave Chanute, United States — Summer 1896

Designer of first rectangular wing strut-braced biplane (originally tri-plane) hang glider, a configuration that strongly influenced the Wright brothers. Flown successfully at the Indiana shore of Lake Michigan, U.S. by his proteges, including Augustus Herring, for distances exceeding 100 feet (30 m).

Carl Rickard Nyberg, Sweden — 1897

Managed a few short jumps in his Flugan, a steam powered, manned aircraft

Gustave Whitehead, United States — 1899

Reportedly flew a steam-powered monoplane about half a mile and crashed into a three-story building in Pittsburgh in April or May 1899, according to a witness who gave a statement in 1934, saying he was the passenger.

Percy Pilcher, England — 1899

Pioneer British glider/plane builder and pilot; protege of Lilienthal; killed in 1899 when his fourth glider crashed shortly before the intended public test of his powered triplane. Cranfield University built a replica of the triplane in 2003 from drawings in Philip Jarrett's book "Another Icarus". Test pilot Bill Brooks successfully flew it several times, staying airborne up to 1 minute and 25 seconds.

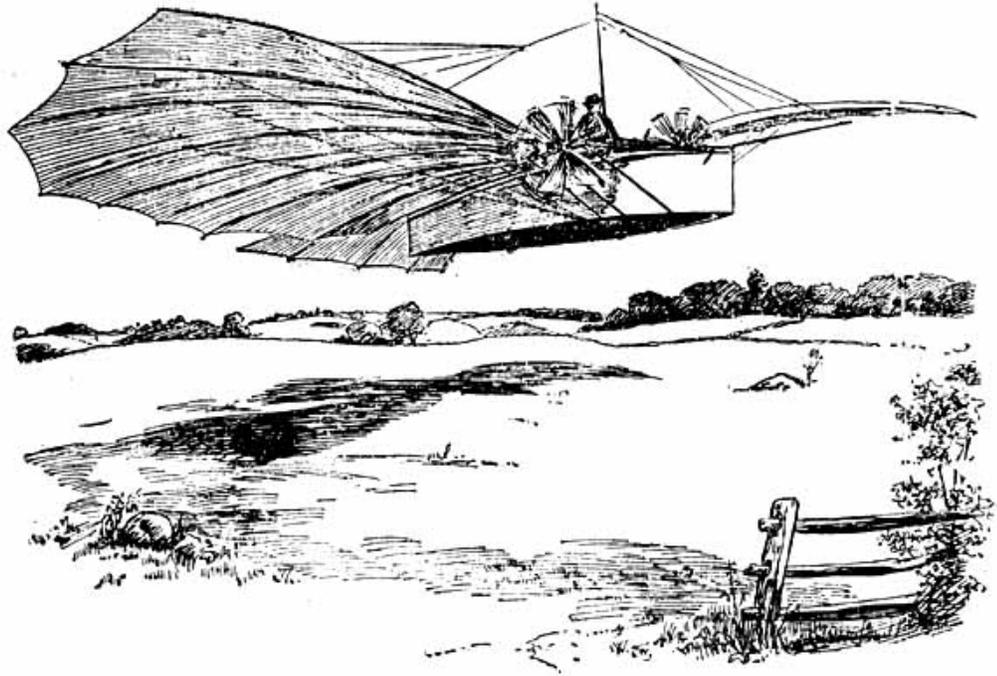
Augustus Moore Herring, United States — 1899

Claimed a flight of 70 feet (21 m) by attaching a compressed air motor to a biplane hang glider. However, he was unable to repeat said flight with anyone present.

20th century

Dr Wilhelm Kress, Austria — 1901

Tested Drachenflieger, tandem monoplane seaplane similar to Samuel Langley, which made brief airborne hops but could not sustain itself.



Gustave Whitehead, United States — August 14, 1901

First publicized account of a flight by an aeroplane heavier than air propelled by its own motor — Whitehead No. 21. Reports were published in the *New York Herald*, and the *Bridgeport (CT) Herald*. The event was reportedly witnessed by several people, one of them a reporter for the *Bridgeport Herald*. Children and youngsters who were present signed affidavits about 30 years later about what they saw. Reports said he started on the wheels from a flat surface, flew 800 meters at 15 meter height, and landed softly on the wheels. Other reports said he never flew.

Lyman Gilmore, United States — May 15, 1902

Gilmore claimed to be the first person to fly a powered aircraft (a steam-powered glider). No witnesses. But he was an able inventor, rotary snow plow, 8-cylinder rotary motor, etc.

Gustave Whitehead, United States — January 17, 1902

Whitehead claimed two spectacular flights on January 17, 1902 in his improved Number 22, with a 40 Horsepower (30 kilowatt) motor instead of the 20 hp (15 kW) in the Number 21 aircraft and aluminium instead of bamboo. In two published letters that he wrote to *American Inventor* magazine, he said the flights took place over Long Island Sound and covered distances of about two miles (3 kilometers) and seven mi (11 km) at heights up to 200 ft (61 m), ending with safe

landings in the water by the boat-like fuselage. Some later affidavits assert he flew, others that he never flew.

Orville & Wilbur Wright, United States — October 1902

Completed development of the three-axis control system with the incorporation of a movable rudder connected to the wing warping control on their 1902 Glider.

They subsequently made several fully controlled heavier than air gliding flights, including one of 622.5 ft (189.7 m) in 26 seconds. The 1902 glider was the basis for their patented control system still used on modern fixed-wing aircraft.

Richard Pearse, New Zealand — March 31, 1903

Several people reportedly witnessed Pearse make powered flights including one on this date of over 100 feet (30 m) in a high-wing, tricycle undercarriage monoplane powered by a 15 hp (11 kW) air-cooled horizontally opposed engine. Flight ended with a crash into a hedgerow. Although the machine had pendulum stability and a three axis control system, incorporating ailerons, Pearse's pitch and yaw controls were ineffectual. (In the mockumentary *Forgotten Silver*, director Peter Jackson recreated this flight, supposedly filmed by New Zealand filmmaker Colin McKenzie. The film was so convincing, Paul Harvey reported it as genuine on his syndicated *News and Comment* program).

Karl Jatho, Germany — August 18, 1903

On August 18, 1903 he flew with his self-made motored gliding aircraft. He had four witnesses for his flight. The plane was equipped with a single-cylinder 10 horsepower (7.5 kW) Buchet engine driving a two-bladed pusher propeller and made hops of up to 200 ft (60 m), flying up to 10 ft (3 m) high.



Orville & Wilbur Wright, United States — December 17, 1903

First recorded controlled, powered, sustained heavier than air flight, in Wright Flyer. In the day's fourth flight, Wilbur Wright flew 279 meters (852 ft) in 59 seconds. First three flights were approximately 120, 175, and 200 ft (61 m),

respectively. The Wrights laid particular stress on fully and accurately describing all the requirements for controlled, powered flight and put them into use in an aircraft which took off without the aid of a catapult from a level launching rail, with the aid of a headwind to achieve sufficient airspeed before reaching the end of the rail.

John Joseph Montgomery and Daniel Maloney, United States 1905

First high altitude flights with Maloney as pilot of a Montgomery tandem-wing glider design. The glider was launched by balloon to heights up to 4,000 feet (1,200 m) with Maloney controlling the aircraft through a series of prescribed maneuvers to a predetermined landing location in front of a large public gathering at Santa Clara, California.

Wilbur Wright, United States — October 5, 1905

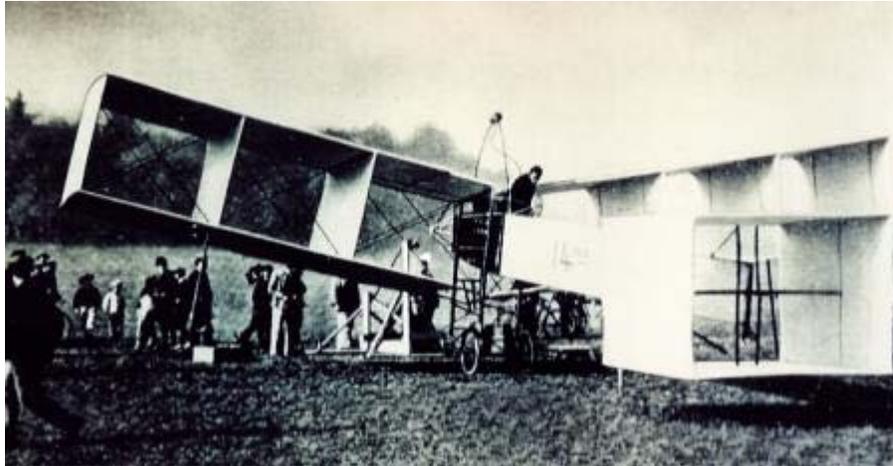
Wilbur Wright pilots Wright Flyer III in a flight of 24 miles (39 km) in 39 minutes (a world record that stood until Orville Wright broke it in 1908) and returns to land the plane at the takeoff site.

Traian Vuia, Romania — March 18, 1906



Fully self-propelled, fixed-wing aircraft using a carbonic acid gas engine and a single tractor propeller. He flew for 12 meters in Paris without the aid of external takeoff mechanisms, such as a catapult, a point emphasized in newspaper reports in France, the U.S., and the UK. The possibility of such unaided heavier-than-air flight was heavily contested by the French Academy of Sciences, which had declined to assist Vuia with funding

Jacob Ellehammer, Denmark — September 12, 1906



Built monoplane, which he tested with a tether on the Danish Lindholm island.

Alberto Santos-Dumont, Brazil — October 23, 1906

The "14 Bis" at Bagatelle field, Paris. The Aero Club of France certified the distance of 60 meters (197 ft); height was about 2–3 meters (6–10 ft). Winner of the Archdeacon Prize for first official flight of more than 25 meters. Described by some scholars as the first "sportsman of the air". As reported in previous years and months by Ader, Whitehead, Pearse, Jatho and Vuia, the 14-Bis biplane flew and landed without a rail, catapult, or the presence of high winds, propelled by an internal combustion engine.

Table of flying machines

Literature, Designs only:

Designer/maker	Nationality	Title or specialty	Year	Status/Description
Roger Bacon	British	<i>Secrets of Art and Nature</i>	c. 1250	ornithopter design
Leonardo da Vinci	Italian	The Ornithopter	c. 1490	design, literature
Emanuel Swedenborg	Swedish	Flying Machine	1714	design, literature
Sir George Cayley	British	On Aerial Navigation	1809-1810	Technical literature. This work laid the ground rules for all later aircraft
Le Comte Ferdinand Charles Honore Phillippe d'Esterno		On The Flight Of Birds (<i>Du Vol des Oiseaux</i>)	1864	technical literature

Louis Pierre Mouillard	French	The Empire Of The Air (<i>L'Empire de L'Air</i>)	1865	literature
Otto Lilienthal	German	Birdflight as the Basis of Aviation (<i>Der Vogelflug als Grundlage der Fliegekunst</i>)	1889	literature
James Means	American	The Problem of Manflight, Aeronautical Annual	1894 - 1897	literature
Octave Chanute	American (born in France)	Progress in Flying Machines	1894	His technical articles collected in a book
Wilbur Wright	American	Some Aeronautical Experiments	1901	Published speech to Western Society of Engineers, Chicago
Martin Wiberg	Swedish	"Luftmaskin"	1903	Received a patent for a design powered by a liquid fuel rocket

More than design or literature

Note overlapping years in several cases, so all items in this list may not be in strict chronological order.

Designer/Maker	Nationality	Machine name/description	Year	Claimed	Achieved
John Childs	American	"Feathered glider"	1757	Three successful flights in two days	Reports suggest that this was a fairground trick, involving sliding down a tethered rope. He had claimed to have performed the same stunt many times

				earlier in Europe
William Samuel Henson	British	Aerial Steam Carriage, "modern"-looking monoplane with "cabin", tail and twin pusher propellers	1842	Models only, publicity illustrations
John Stringfellow	British	The Stringfellow Machines	1848, 1868	Indoor flights by fixed-wing steam-powered models
Sir George Cayley	British	"Governable Parachute"	1849-1853	Child- and man-carrying glides, both towed and free-flying
Rufus Porter	American	The New York to California Aerial Transport	1849	Uncompleted steam-powered dirigible
Jean Marie Le Bris	French	The Artificial Albatross	1857, 1867	Towed gliding flight
Felix and Louis du Temple de la Croix	French	Du Temple Monoplane, aluminum construction, steam-powered	1857-1877	Powered manned hop from ramp
James William Butler, Edmund Edwards		The Steam-Jet Dart	1865	
Francis Herbert Wenham	British	"Aerial Locomotion" (academic paper)	1866	Patented superposed wing design (biplane, mulitplane); invented wind tunnel

Jan Wnęk	Polish	glider	1866-1869	Controlled flights from local church tower
Frederick Marriott		Marriott flying machines	1869	
Alphonse Pénaud	French	Planophore, Pénaud Toy Helicopter	1871	Rubber-powered fixed-wing and helicopter models
Thomas Moy	British	Moy Aerial Steamer, tandem wings, 120 lb (55 kg), 15 ft (4.6 m) wingspan, 3 horsepower, twin fan-type propellers	1875	Lifted 6 inches (0.15 m) from ground at London Crystal Palace
Enrico Forlanini	Italian	Demonstration in Milan, Helicopter, unmanned, steam-powered.	1877	rose to 13 meters (40 feet) for 20 s duration: first heavier than air self-powered machine to fly
Thomas Moy	as above	The Military Kite	1879	
Charles F. Ritchel	American	Ritchel Hand-powered Airship	1878	
Victor Tatin	French	Tatin flying machines	1879	
J. B. Biot	French	The Biot Kite	1880	
Alexandre Goupil	French	Goupi Monoplane, La Locomotion Aérienne	1883	
John Joseph Montgomery	American	Montgomery monoplane, Tandem-wing Gliders	1883-1911	A pre-1900 foot-launched manned glide; balloon-launched after 1900
Aleksandr	Russian	Mozhaiski	1884	Powered

Fyodorovich Mozhaiski		Monoplane, multi-engine, steam		manned hop from ramp
Massia and Biot		Massia-Biot Glider	1887	
Pichancourt		Mechanical Birds	1889	
Lawrence Hargrave	British immigrant to Australia	Hargave flying machines and Box Kites	1889-1893	influential designs
Clément Ader	French	Eole, Avion, bat-wing, steam-driven	1890-1897	Manned, powered hops from level surface
Chuhachi Ninomiya	Japanese	The Tamamushi (model)	1891	
Otto Lilienthal	German	Bat-wing hang gliders, mono- and biplane	1891-1896	2,000 manned glides, dozens photographed
Horatio Frederick Phillips	British	Multiplanes	1893-1907	Multiple-wing test machines; successful flights in 1904 (50 feet) and 1907 (500 feet)
Hiram Stevens Maxim	British (born in America)	Maxim Biplane, a behemoth machine: 145 ft (44.2 m) long, 3.5 tons, 110 ft (33.5 m) wingspan, two 180 hp steam engines driving two propellers.	1894	Broke from restraining rail and made uncontrolled manned flight. Total flying distance, 1,000 ft (305 m) while restrained, 924 ft (282 m) free flight. Total 1,924 ft (586 m)
Pablo Suarez		The Suarez Glider	1895	
Percy Sinclair Pilcher	British	Bat, Beetle, Hawk bat-wing hang	1896-1899	Manned glides; fatal

		gliders			crash before planned public test of powered triplane; modern replica flown
Octave Chanute and Augustus Herring	American (Chanute born in France)	Hang gliders, "modern" biplane wing design	1896		Manned glides
William Paul Butusov, with Chanute group	Russian immigrant to U.S.	Albatross Soaring Machine	1896		unmanned unpowered uncontrolled hop from ramp
Samuel Pierpont Langley	American	Langley Aerodrome, Tandem wings, unmanned, steam-powered.	1896		5,000 ft. (1.7 km), photographed
William Frost	Welsh	Frost Airship Glider	1896	Manned, 500 meters, possibly with balloon assist	
Carl Rickard Nyberg	Swedish	Flugan	1897 and on	Hops on	
Edson Fessenden Gallaudet	American	Gallaudet Wing Warping Kite	1898		
Lyman Wiswell Gilmore, Jr.	American	Gilmore Monoplane, steam driven	1898	Too little info	
Gustave Whitehead	German (Emigrated to U.S.)	Monoplane with pilot and passenger, steam powered	1899	Flew 500 m, crash	
Wilhelm Kress	Austrian	Kress Waterborne Aeroplane	1901	Long hops	
Gustave Whitehead	as above	Whitehead Albatross, glider	1901		
Gustave	as above	No. 21, bat-wing,	1901	800 m, 4	Modern

Whitehead		20 hp motor, twin tractor propellers		flights, body shifting control	replica successfully flown
Gustave Whitehead	as above	No. 22, 40 hp motor, twin tractor propellers	1902	Flew 10 km circle; control by variable propeller speed and "rudder"	
Richard William Pearse	New Zealand	Pearse Monoplane	1903	150 m, believed controllable but unstable -numerous witnesses	
Karl Jatho	German	The Jatho Biplane	1903		70 m powered hop, unstable
Wright Brothers	American	Wright Flyer, level launch rail, headwind for sufficient airspeed	1903		Four flights, longest 852 feet (260 m), 59 s, controlled
Guido Dinelli		Dinelli Glider, Aereoplano	1903	70 m, no motor	
Wilbur Wright	American	Wright Flyer III, catapult launch	1905		24 miles (39 km), circling, max height about 50 feet (15.2 m)
Louis Blériot, Gabriel Voisin	French	Blériot-Voisin floatplane glider, Blériot-Voison biplane	1905		Towed up, 600 m
Alberto Santos-Dumont	Brazilian living in France	14-bis, Hargrave-style box-cell wings, sharp dihedral, pusher propeller, internal combustion. (Demoiselle in 1909, tractor monoplane with	1906		Controlled, rose off flat ground with no external assistance, 200 meters, 21 s, first official European

Jacob Ellehammer	Danish	wing-warping) Monoplane, helicopter	1906, 1912	flight Tethered powered fixed-wing flight
Traian Vuia	Romanian, flight experiments in France	Vuia I, Vuia II monoplanes, Carbonic acid engine on Vuia I, internal combustion engine on Vuia II	1906-1907	Powered manned hops
Glenn H. Curtiss and A.E.A.	American	June Bug, biplane with wingtip ailerons	1908	First official 1 km U.S. flight Crossed the English Channel, France to Britain, 23 miles (37 km)
Louis Blériot	French	Blériot XI monoplane, tractor propeller	1909	First controlled powered flight in Canada
Aerial Experiment Association (A.E.A)	American	Silver Dart	1909	
Edvard Rusjan	Slovenian	EDA 1	1909	
Ivan Sarić	Croatian	Sarić 1	1910	
Duigan Brothers, John and Reginald	Australian	Duigan Pusher Biplane	1910	

Historic records

Inventor	Accomplishment or Claim	Year
Zhuge Liang	Kongming lantern, first hot air balloon	2nd or 3rd century
'Abbas Ibn Firnas	Single flight of manned ornithopter; ended in crash and injury.	875
Eilmer of Malmesbury	Single flight of manned glider.	1010
Unknown	Manned kites are common. Reported by Marco Polo	1290

Chinese		
Lagari Hasan Çelebi	First manned rocket flight	1633
Bartolomeu de Gusmão	First lighter-than-air airship flight	1709
John Childs	Unnamed flying device, flew 700m three times over two days. Documentation suggests that he glided down along a 700m rope and landed where the rope was fixed to the ground.	1757
Montgolfier brothers	Modern hot air balloon	1783
Diego Marín Aguilera	Single flight of manned-glider-wings	1793
William Samuel Henson	Aerial Steam Carriage, flight of model	1842
John Stringfellow	Stringfellow Machines	1848, 1868
Henri Giffard	Non-rigid airship, hydrogen filled envelope for lift, powered by steam engine	1852
Sir George Cayley	Cayley Glider, flight of manned glider. Investigating many theoretical aspects of flight. Many now acknowledge him as the first aeronautical engineer.	1853
Rufus Porter	New York to California Aerial Transport, an early attempt at an airline	1849
Jean Marie Le Bris	Artificial Albatross	1857, 1867
Félix du Temple de la Croix	Monoplane (1874) Maybe first powered manned fixed-wing flight, a short hop, from a downward ramp.	1857 - 1877
James William Butler and Edmund Edwards	Steam-Jet Dart Patented a prophetic design, that of a delta-winged jet-propelled aircraft, derived from a folded paper plane.	1865
Francis Herbert Wenham	Wenham's Aerial Locomotion	1866
Jan Wnęk	Loty glider, many flights	1866
Frederick Marriott	Marriott flying machines, as well as an attempt at an early airline	1869
Alphonse Pénaud	Planophore, Pénaud Toy Helicopter	1871
Thomas Moy	Moy Aerial Steamer,	1875
Thomas Moy	The Military Kite	1879
Charles F. Ritchel	Ritchel Hand-powered Airship	1878
Victor Tatin	Tatin flying machines	1879

Massia and Biot	Massia-Biot Glider	1879? 1887?
Alexandre Goupil	Goupi Monoplane, La Locomotion Aerienne	1883
John J. Montgomery	Montgomery Monoplane and Tandem-Wing Gliders	1883 - 1911
Aleksandr Fyodorovich Mozhaiski	Mozhaiski Monoplane	1884
Charles Renard Arthur Constantin Krebs	The first fully controllable free-flight was made with the La France	1884
Pichancourt	Mechanical Birds	1889
Lawrence Hargrave	Hargrave flying machines and Box kites	1889 - 1893
Clément Ader	Éole, Avion, short, manned and powered, flights	1890 - 1897
Chuhachi Ninomiya	Karasu model, Tamamushi model	1891 ,1895
Otto Lilienthal	Derwitzer Glider, Normal soaring apparatus and others, many flights	1891 - 1896
Horatio Phillips	Phillips Flying Machine	1893, 1906
Hiram Stevens Maxim	Maxim Biplane	1894
Pablo Suarez	Suarez Glider	1895
Octave Chanute and Augustus Herring	Chanute and Herring Gliding Machines	1896
William Paul Butusov	Albatross Soaring Machine	1896
William Frost	Frost Airship Glider	1896
Percy Sinclair Pilcher	Pilcher Hawk Based on the work of his mentor Otto Lilienthal, in 1897 Pilcher built a glider called The Hawk with which he broke the world distance record when he flew 250 m (820 ft)	1897
Samuel Pierpont Langley	Langley Aerodromes	1896 - 1903
Carl Rickard Nyberg	Flugan, very short manned flight	1897
Edson Fessenden Gallaudet	Gallaudet Wing Warping Kite	1898
Gustave	A purported steam engine powered, 500-1000m flight,	1899

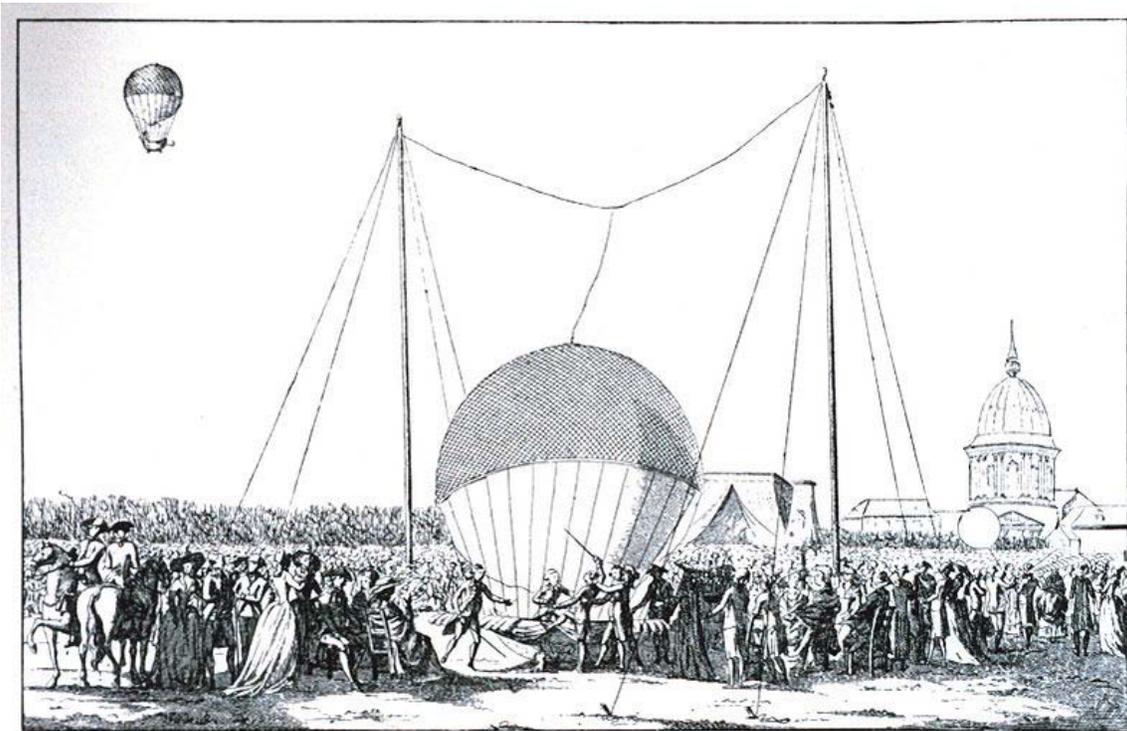
Whitehead	ending in collision with a three-story house, according to affidavit 37 years later by Louis Darvarich, self-described passenger..	
Count Ferdinand von Zeppelin	Zeppelin airship LZ 1. The first Zeppelin flight occurred on July 2, 1900 over the Bodensee, lasted 18 minutes. The second and third flights were in October 1900 and October 24, 1900 respectively, beating the 6 m/s velocity record of the French airship La France by 3 m/s.	1900
Wilhelm Kress	Kress Waterborne Aeroplane hops	1901
Gustave Whitehead	A newspaper reported a manned, powered, controlled 800m flight. Whitehead claimed four flights on the same day in the aircraft, designated Number 21.	1901
Alberto Santos-Dumont	Santos-Dumont gained fame by designing, building, and flying dirigibles. On 19 October 1901, he won the Deutsch de la Meurthe prize of 100,000 francs by taking off from Saint-Cloud, flying his steerable balloon around the Eiffel Tower, and returning.	1901
Gustave Whitehead	He claimed a manned, powered, controlled 10 km flight, a circle over Long Island Sound, one of two flights the same day, landing in the water twice without damage to the plane, designated Number 22.	1902
Lyman Gilmore	Gilmore Monoplane Built a steam-powered airplane and claimed that he flew it on May 15, 1902.	1902
Richard William Pearse	Pearse Monoplane. First flight March 31, 1902 Waitohi, New Zealand. Evidence exists that on 31 March 1903 Pearse made a powered, though poorly controlled, flight of several hundred metres and crashed into a hedge at the end of the field. The aircraft had a tricycle type landing gear and primitive ailerons.	1903-1904
Wright brothers	Completed development of the three-axis control system with the incorporation of a movable rudder connected to the wing warping control on their 1902 Glider. They subsequently made several fully controlled heavier than air gliding flights, including one of 622.5 ft (189.7 m) in 26 seconds.	1902
Karl Jatho	Jatho Biplane 10 hp 70m hops	1903
Guido Dinelli	Dinelli Glider, Aereoplano	1903, 1904
Wright brothers	Wright Flyer I, Successful, manned, powered, controlled and sustained flight, 259m, in 59 seconds, according to the Federation Aeronautique International and Smithsonian Institution. Preceded by three other flights, each less than 200 feet.	1903
Ferdinand Ferber	Archdeacon glider	1904

and Gabriel Voisin		
Wright Brothers	Wright Flyer III Wilbur Wright pilots a flight of 24 miles (39 km) in nearly 39 minutes on Oct. 5, a world record that stood until Orville Wright surpassed it in 1908.	1905
Louis Blériot and Gabriel Voisin	Blériot-Voison floatplane glider, biplane	1905
Traian Vuia	Vuia I, Vuia II, Several short powered flights. August 1906, 24m flight. July 5, 1907, Flew 20m. and crashed.	1906 - 1907
Jacob Ellehammer	Ellehammer monoplane September 12, 1906 became the second European to fly an airplane (after Traian Vuia). He made over 200 flights in the next two years using many different machines. No distance data found.	1906 - 1907
Alberto Santos- Dumont	First official European flight on 23 October 1906 in aircraft designated 14-bis or Oiseau de proie ("bird of prey"). On 12 November 1906, he flew the 14-bis 220 metres in 21.5 seconds. He won the Archdeacon Prize founded by the Frenchman Ernest Archdeacon in July 1906, to be awarded to the first aviator to demonstrate a flight of more than 25 m.	1906
Glenn H. Curtiss	AEA June Bug First official U.S. flight exceeding 1 kilometer (5,360 ft (1,630 m).	1908
Louis Blériot	Blériot V, Blériot XI On July 25, 1909 Louis Blériot successfully crossed the Channel from Calais to Dover in 36.5 minutes, 35 km	1909
Aerial Experiment Association (AEA)	Silver Dart on 10 March 1909, McCurdy flew the aircraft on a circular course over a distance of more than 35 km (20 mi).	1909
Aurel Vlaicu	Vlaicu 1909, Vlaicu I, Vlaicu II, Vlaicu III	1909- 1910
Henri Fabre	Le Canard, First seaplane.	1910
Duigan Brothers	Duigan Pusher Biplane	1910
John William Dunne	With the Dunne D.5 tailless Biplane, the fifth in a series of tailless swept-wing designs, Dunne was among the first to achieved natural stability in flight in the same year.	1910.

Chapter- 2

Claims to First Piloted Flight in Pre-19th Century

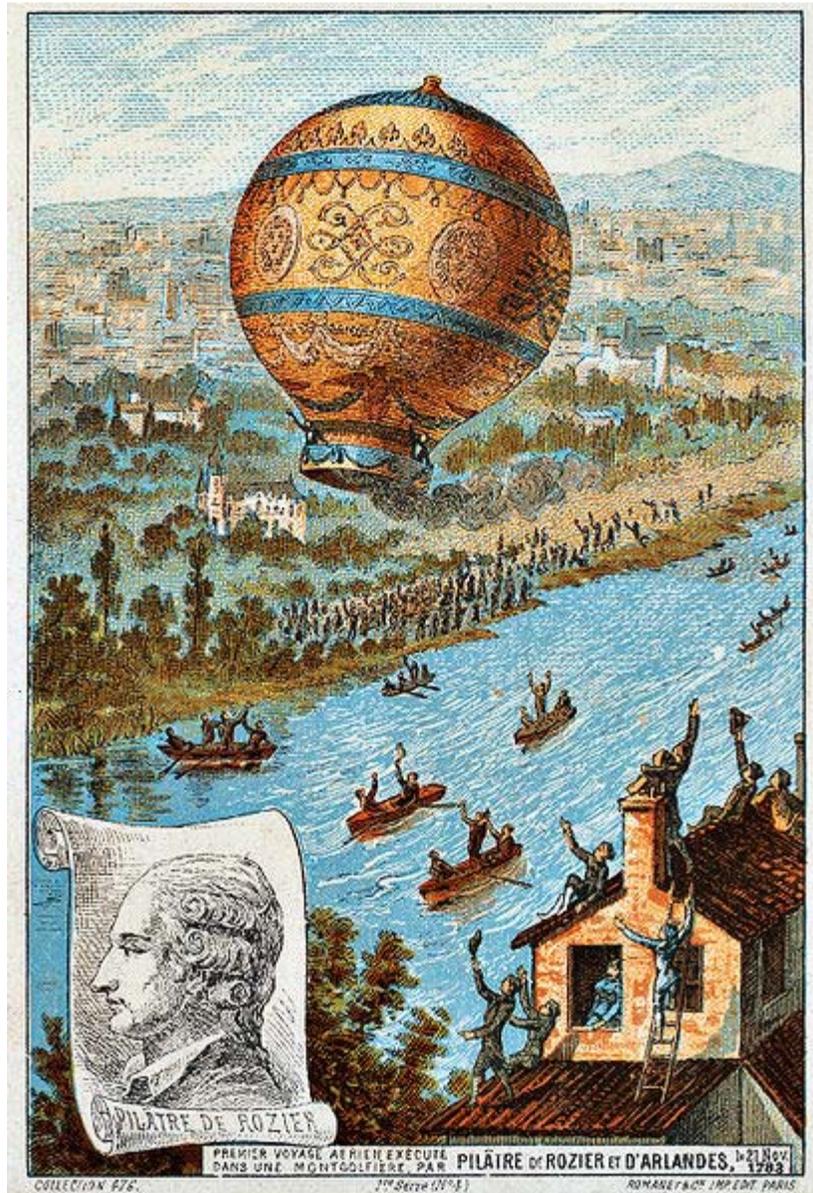
Jean-François Pilâtre de Rozier



The first tethered balloon ascent on 15 October 1783 by Rozier.

In June 1783, he witnessed the first public demonstration of a balloon by the Montgolfier brothers. On 19 September, he assisted with the untethered flight of a sheep, a cockerel and a duck from the front courtyard of the Palace of Versailles. The French King Louis XVI decided that the first manned flight would contain two condemned criminals, but de Rozier enlisted the help of the Duchess de Polignac to support his view that the honour of becoming first balloonists should belong to someone of higher status, and the Marquis d'Arlandes agreed to accompany him. The King was persuaded to permit d'Arlandes and de Rozier to become the first pilots.

After several tethered tests to gain some experience of controlling the balloon, de Rozier and d'Arlandes made their first untethered flight in a Montgolfier hot air balloon on 21 November 1783, taking off at around 2 p.m. from the garden of the Château de la Muette in the Bois de Boulogne, in the presence of the King. Their 25-minute flight travelled slowly about 5½ miles (some 9 km) to the southeast, attaining an altitude of 3,000 feet, before returning to the ground at the Butte-aux-Cailles, then on the outskirts of Paris.

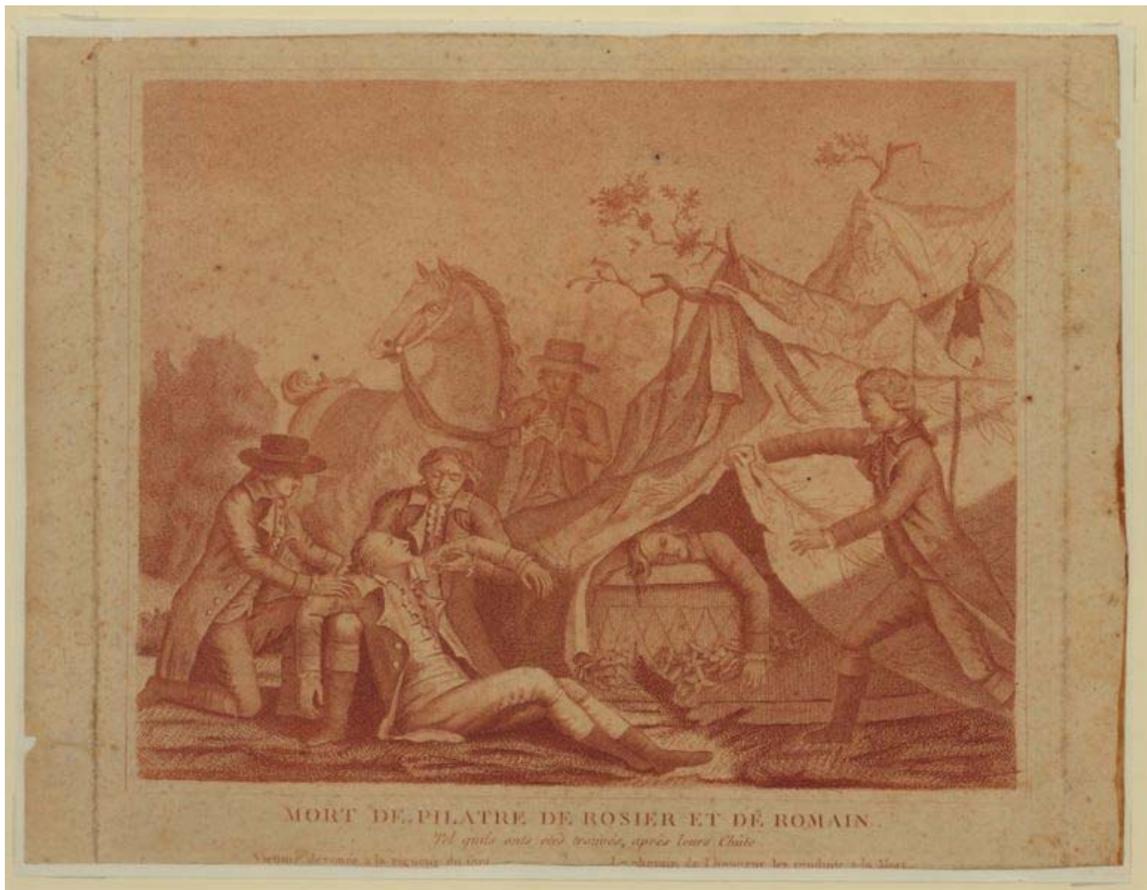


The first untethered balloon flight, by Rozier and the Marquis d'Arlandes on 21 November 1783.

Along with Joseph Montgolfier, he was one of six passengers on a second flight on 19 January 1784, with a huge Montgolfier balloon *Le Flesselles* launched from Lyon. Four French nobles paid for the trip, including a prince. Several difficulties had to be

overcome. The wallpaper used to cover the balloon's envelope became wet because of extreme weather conditions. The top of the balloon was made of sheep- or buckskin. The air was heated by wood in an iron stove: to start, the straw was set on fire with brandy. (In other tests charcoal or potatoes were used). The balloon had a volume of approximately 23,000 m³, over 10 times that of the first flight, but it only flew a short distance. The spectators kneeled down when the balloon came down too quickly. That evening the aeronauts were celebrated after listening to Gluck's opera, *Iphigénie en Tauride*.

Rozier took part in a further flight on 23 June 1784, in a modified version of the Montgolfiers' first balloon christened *La Marie-Antoinette* after the Queen, which took off in front of the King of France and King Gustav III of Sweden. Together with Joseph Proust, the balloon flew north at an altitude of approximately 3,000 metres, above the clouds. They travelled 52 km in 45 minutes before cold and turbulence forced them to descend past Luzarches, between Coye et Orry-la-Ville, near the Chantilly forest. They set records for speed, altitude and distance travelled.



Fatal accident at Wimereux, 15 June 1785

Final flight

De Rozier's next plan was an attempt to cross the English Channel from France to England. A Montgolfier balloon would not be up to the task, requiring large stocks of fuel for the hot air, so his balloon the Rozière balloon was a combination hydrogen and hot air balloon. It was prepared in the autumn of 1784, but the attempt was not launched until after another Frenchman, Jean-Pierre Blanchard, and American companion, Dr John Jeffries, flew across the English Channel in a hydrogen gas balloon on 7 January 1785, from England to France.



Deaths of Rozier and Romain

Despite several attempts, De Rozier and his companion, Pierre Romain, were not able to set off from Boulogne-sur-Mer until 15 June 1785. After making some progress, a change of wind direction pushed them back to land some 5 km from their starting point. The balloon suddenly deflated (without the envelope catching fire) and crashed near Wimereux in the Pas-de-Calais, from an estimated height of 1,500 feet. Both occupants were killed. Eight days later his fiancée died, possibly having committed suicide. A commemorative obelisk was later erected at the site of the crash. The King had a medal struck, and gave his family a pension.

The modern hybrid gas and hot air balloon is named the Rozière balloon after his pioneering design.

Hydrogen balloon flight by Jacques Charles

First hydrogen balloon



The balloon built by Jacques Charles and the Robert brothers is attacked by terrified villagers in Gonesse.

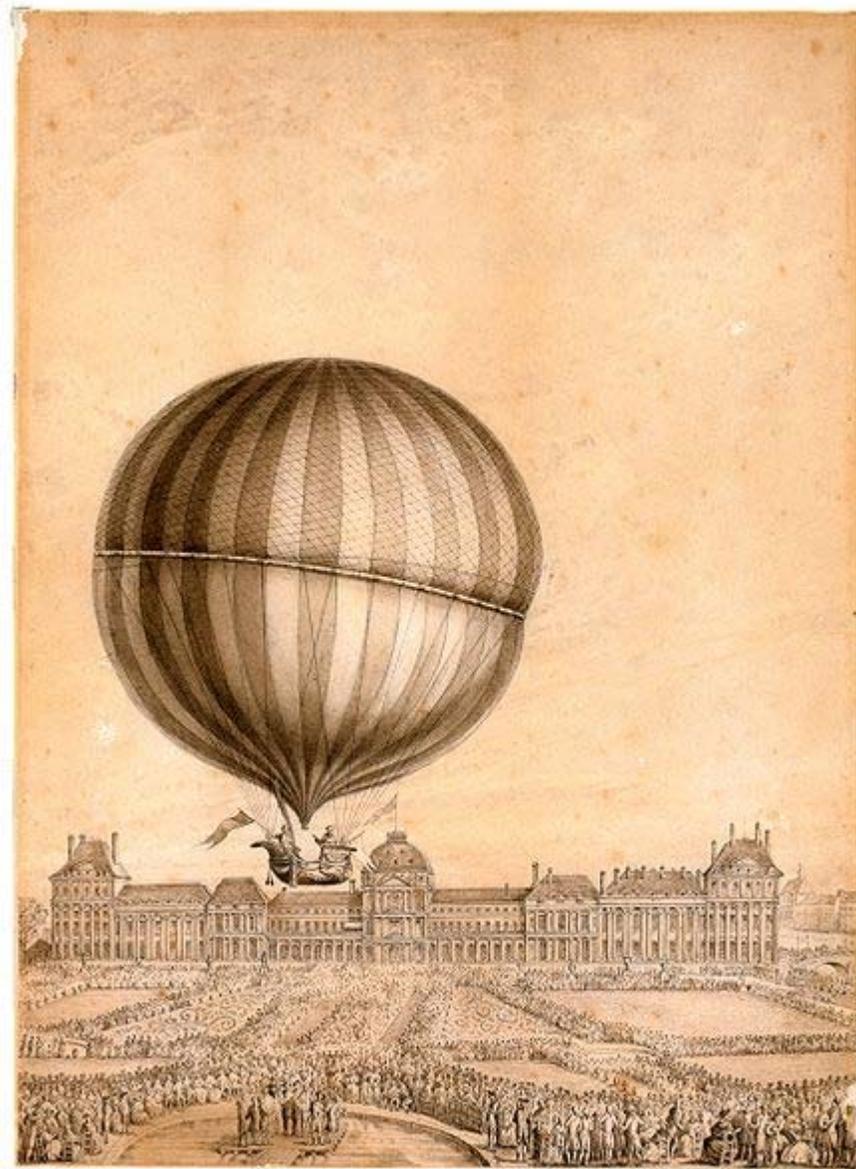
Charles conceived the idea that hydrogen would be a suitable lifting agent for balloons having studied the work of Robert Boyle's *Boyle's Law* which was published 100 years earlier in 1662, and of his contemporaries Henry Cavendish, Joseph Black and Tiberius Cavallo. He designed the craft and then worked in conjunction with the Robert brothers, Anne-Jean and Nicolas-Louis, to build it in their workshop at the *Place des Victoires* in Paris. The brothers invented the methodology for the lightweight, airtight gas bag by dissolving rubber in a solution of turpentine and varnished the sheets of silk that were

stitched together to make the main envelope. They used alternate strips of red and white silk, but the discolouration of the varnishing/rubberising process left a red and yellow result.

Jacques Charles and the Robert brothers launched the world's first hydrogen filled balloon on August 27, 1783, from the Champ de Mars, (now the site of the Eiffel Tower) where Ben Franklin was among the crowd of onlookers. The balloon was comparatively small, a 35 cubic metre sphere of rubberised silk, and only capable of lifting circa 9 kg (20 lb). It was filled with hydrogen that had been made by pouring nearly a quarter of a tonne of sulphuric acid onto a half a tonne of scrap iron. The hydrogen gas was fed into the balloon via lead pipes; but as it was not passed through cold water, great difficulty was experienced in filling the balloon completely (the gas was hot when produced, but as it cooled in the balloon, it contracted). Daily progress bulletins were issued on the inflation; and the crowd was so great that on the 26th the balloon was moved secretly by night to the Champ de Mars, a distance of 4 kilometres.

The balloon flew northwards for 45 minutes, pursued by chasers on horseback, and landed 21 kilometers away in the village of Gonesse where the reportedly terrified local peasants destroyed it with pitchforks or knives. The project was funded by a subscription organised by Barthelemy Faujas de Saint-Fond.

First manned hydrogen balloon flight



Contemporary illustration of the first flight by Prof. Jacques Charles with Nicolas-Louis Robert, December 1, 1783. Viewed from the Place de la Concorde to the Tuileries Palace (destroyed in 1871)

At 13:45 on December 1, 1783 Jacques Charles and the Robert brothers launched a new manned balloon from the Jardin des Tuileries in Paris. Jacques Charles was accompanied by Nicolas-Louis Robert as co-pilot of the 380-cubic-metre, hydrogen-filled balloon. The envelope was fitted with a hydrogen release valve and was covered with a net from which the basket was suspended. Sand ballast was used to control altitude. They ascended to a height of about 1,800 feet (550 m) and landed at sunset in Nesles-la-Vallée after a 2 hour

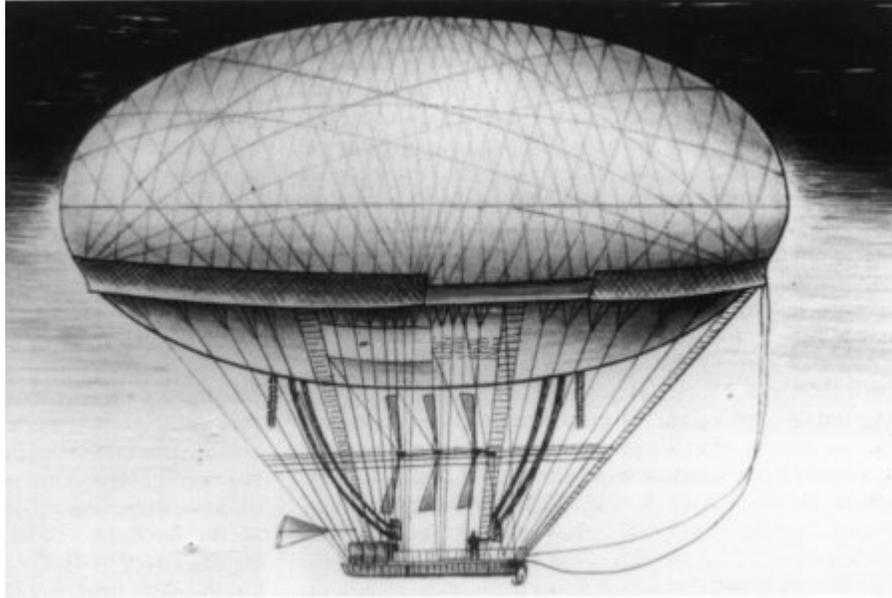
5 minute flight covering 36 km. The chasers on horseback, who were led by the Duc de Chartres, held down the craft while both Charles and Nicolas-Louis alighted.

Jacques Charles then decided to ascend again, but alone this time because the balloon had lost some of its hydrogen. This time it ascended rapidly to an altitude of about 3,000 metres, where he saw the sun again. He began suffering from aching pain in his ears so he 'valved' to release gas, and descended to land gently about 3 km away at Tour du Lay. Unlike the Robert brothers, Charles never flew again, although a hydrogen balloon came to be called a *Charlière* in his honour.

It is reported that 400,000 spectators witnessed the launch, and that hundreds had paid one crown each to help finance the construction and receive access to a 'special enclosure' for a "close-up view" of the take-off. Among the 'special enclosure' crowd was Benjamin Franklin, the diplomatic representative of the United States of America. Also present was Joseph Montgolfier, whom Charles honoured by asking him to release the small, bright green, pilot balloon to assess the wind and weather conditions.

This event took place ten days after the world's first manned balloon flight by Jean-François Pilâtre de Rozier using a Montgolfier brothers hot air balloon. Simon Schama wrote in *Citizens*:

“ *Montgolfier's principal scientific collaborator was M. Charles, ... who had been the first to propose the gas produced by vitriol instead of the burning, dampened straw and wood that he had used in earlier flights. Charles himself was also eager to ascend but had run into a firm veto from the King, who from the earliest reports had been observing the progress of the flights with keen attentiveness. Anxious about the perils of a maiden flight, the King had then proposed that two criminals be sent up in a basket, at which Charles and his colleagues* ”
became indignant.



Meusnier's dirigible

Further ballooning activities

The next project of Jacques Charles and the Robert brothers was to build an elongated, steerable craft that followed Jean Baptiste Meusnier's proposals (1783–85) for a dirigible balloon. The design incorporated Meusnier's internal *ballonnet* (air cells), a rudder and a method of propulsion.

Jacques Charles chose never to fly in this craft, but on July 15, 1784 the brothers flew for 45 minutes from Saint-Cloud to Meudon with M. Collin-Hullin and Louis Philippe II, the Duke of Chartres in *La Caroline*. It was fitted with oars for propulsion and direction, but they proved useless. The absence of a 'gas release valve' meant that the duke had to slash the 'ballonnet' to prevent rupture when they reached an altitude of circa 4,500 metres (14,800 ft).

On September 19, 1784 the Robert brothers and M. Collin-Hullin flew for 6 hours 40 minutes, covering 186 km from Paris to Beuvry near Béthune. This was the first flight over 100 km.

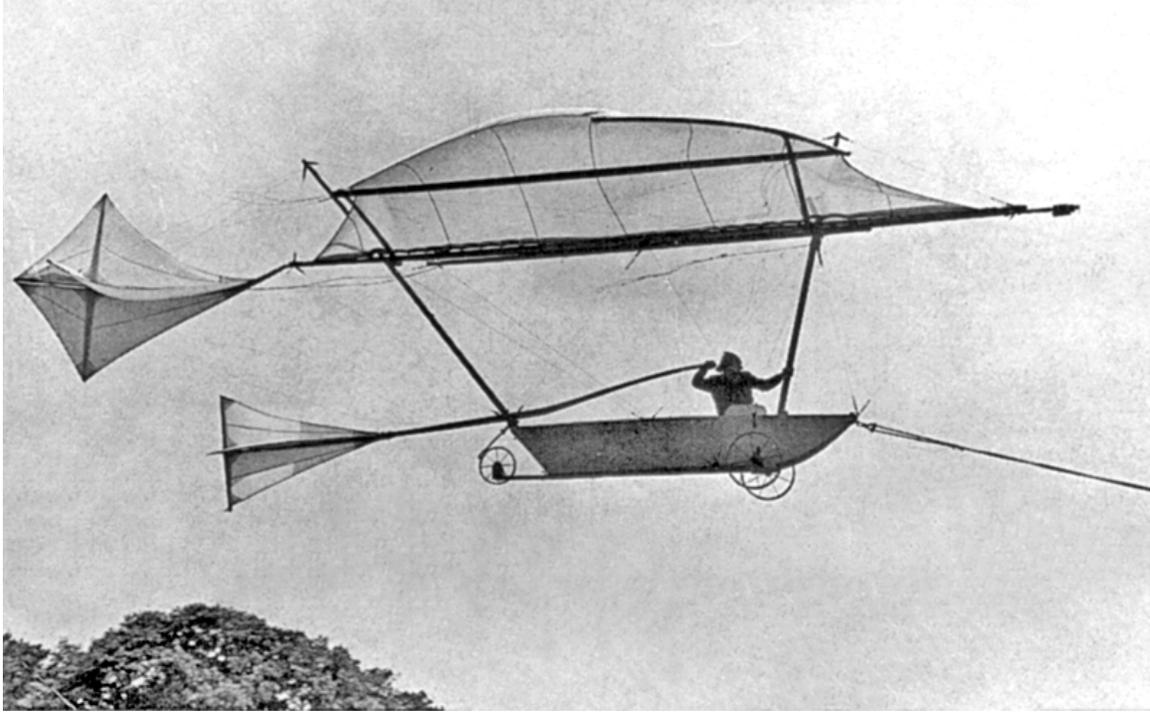
Chapter- 3

Claims to Piloted Flight in 19th Century

Flying Machine by George Cayley, England — 1853

General engineering projects

Cayley, from Brompton-by-Sawdon, near Scarborough in Yorkshire, inherited Brompton Hall and its estates on the death of his father, the 5th baronet. Captured by the optimism of the times, he engaged in a wide variety of engineering projects. Among the many things that he developed are self-righting lifeboats, tension-spoke wheels, the "Universal Railway" (his term for caterpillar tractors), automatic signals for railway crossings, seat belts, small scale helicopters, and a kind of prototypical internal combustion engine fuelled by gunpowder. He also contributed in the fields of prosthetics, air engines, electricity, theatre architecture, ballistics, optics and land reclamation, and held the belief that these advancements should be freely available.



A replica of Cayley's glider being flown by Derek Piggott in 1973

Mechanics' Magazine,

MUSEUM, REGISTER, JOURNAL, AND GAZETTE.

No. 1520.] SATURDAY, SEPTEMBER 25, 1852. [Price 3d., Stamped 4d.
Edited by J. C. Robertson, 166, Fleet street.

SIR GEORGE CAYLEY'S GOVERNABLE PARACHUTES.

Fig. 2.

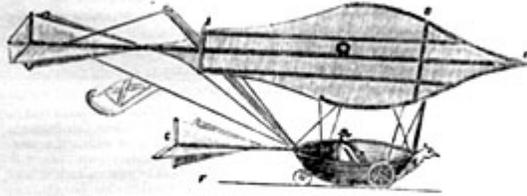
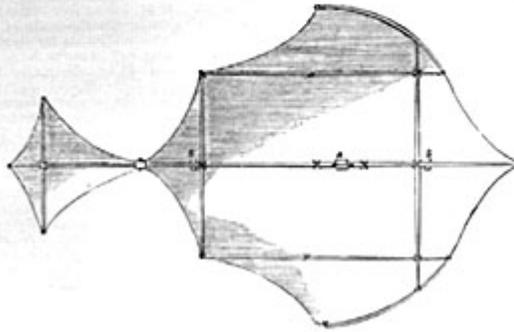


Fig. 1.



VOL. LVII.

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Yorkshire Air Museum

Flying machines

He is mainly remembered, however, for his pioneering studies and experiments with flying machines, including the working, piloted glider that he designed and built. He wrote a landmark three-part treatise titled "On Aerial Navigation" (1809–1810), which was published in Nicholson's *Journal of Natural Philosophy, Chemistry and the Arts*. The recent (2007) discovery of cartoons in Cayley's school notebooks (held in the archive of the Royal Aeronautical Society Library in London, England) reveal that even at school Cayley was developing his ideas on the theories of flight. It has been claimed that these images indicate that Cayley modeled the principles of a lift-generating inclined plane as early as 1792. To measure the drag on objects at different speeds and angles of attack, he later built a "whirling-arm apparatus"—a development of earlier work in ballistics and air resistance. He also experimented with rotating wing sections of various forms in the stairwells at Brompton Hall. These scientific experiments led him to develop an efficient cambered airfoil and to identify the four vector forces that influence an aircraft: *thrust*, *lift*, *drag*, and *gravity*. He discovered the importance of the dihedral angle for lateral stability in flight, and deliberately set the centre of gravity of many of his models well below the wings for this reason; these mechanics influenced the development of hang

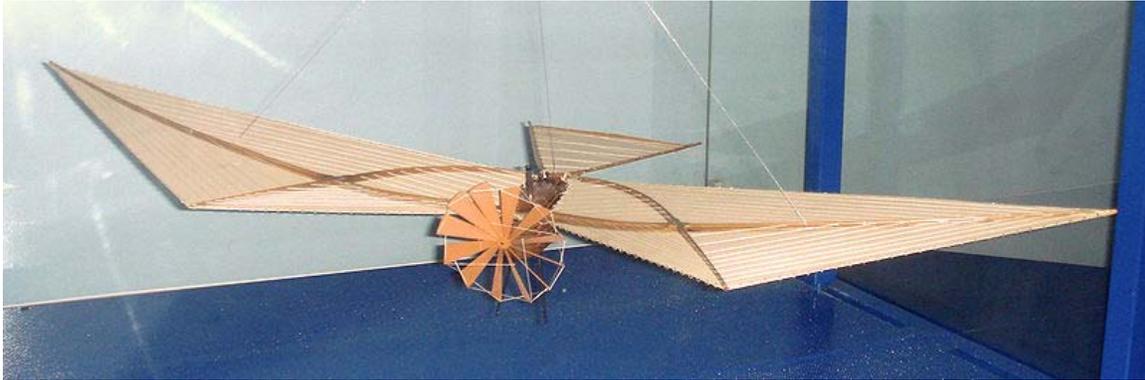
gliders. As a result of his investigations into many other theoretical aspects of flight, many now acknowledge him as the first aeronautical engineer. His emphasis on lightness led him to shift the forces in the landing gear wheel from compression to tension by using string as wires, in effect re-inventing the wheel. This wire wheel principle was (and is) later used by others for bicycles, cars and many other vehicles.

By 1804 his model gliders appeared similar to modern aircraft: a pair of large monoplane wings towards the front, with a smaller tailplane at the back comprising horizontal stabilisers and a vertical fin. Around 1843, he was the first to suggest the idea for a convertiplane, an idea which was published in a paper written that same year. During some point prior to 1849 he designed and built a biplane powered with "flappers" in which an unknown ten-year-old boy flew. Later, with the continued assistance of his grandson George John Cayley and his resident engineer Thomas Vick, he developed a larger scale glider (also probably fitted with "flappers") which flew across Brompton Dale in 1853. The first adult aviator has been claimed to be either Cayley's coachman, footman or butler: one source (Gibbs-Smith) has suggested that it was John Appleby, a Cayley employee—however there is no definitive evidence to fully identify the pilot. An obscure entry in volume IX of the 8th Encyclopædia Britannica of 1855 is the most contemporaneous account with any authority regarding the event. A 2007 biography of Cayley (Richard Dee's *The Man Who Discovered Flight: George Cayley and the First Airplane*) claims the first pilot was Cayley's grandson George John Cayley (1826–1878). Dee's book also reports the re-discovery of a series doodles from Cayley's school exercise book which suggest that Cayley's first designs concerning a lift-generating inclined plane may have been made as early as 1793.

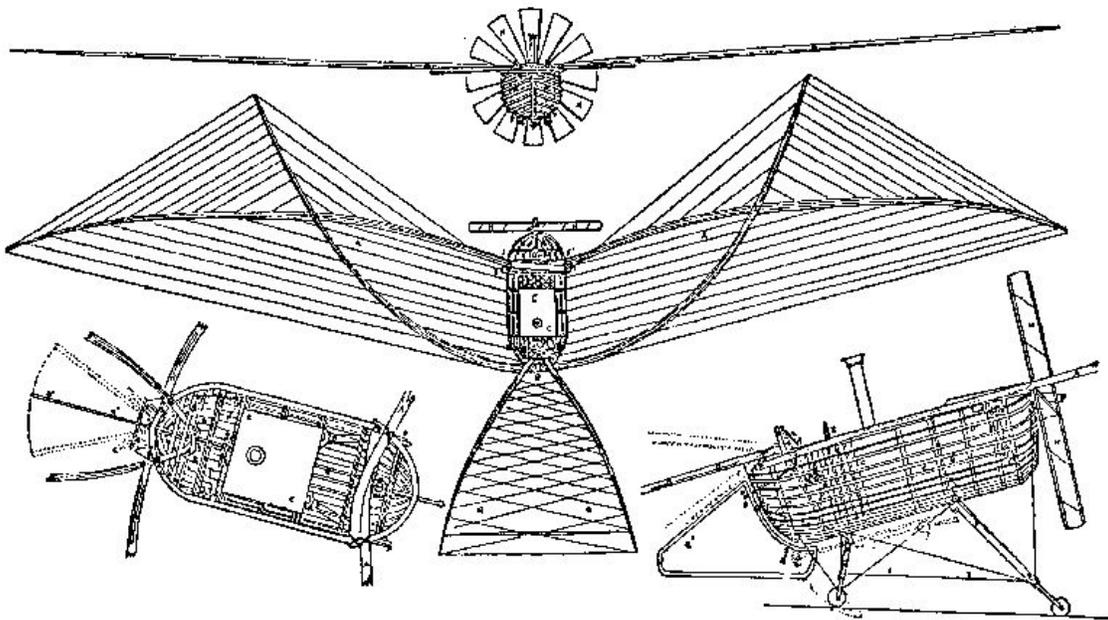
A replica of the 1853 machine was flown at the original site in Brompton Dale by Derek Piggott in 1973 for TV and in the mid-1980s for the IMAX film *On the Wing*. The glider is currently on display at the Yorkshire Air Museum. Another replica, piloted by Allan McWhirter, flew in Salina, Kansas just before Steve Fossett landed the Virgin Atlantic GlobalFlyer there again in March 2003, and later piloted by Richard Branson at Brompton in summer 2003.

Flying Machine by Félix du Temple de la Croix, France, 1874

Flying machine patent



Airplane of Félix du Temple de la Croix, 1857. Musée de l'Air et de l'Espace.



1857 patent drawing of Félix du Temple's flying machine, the "Canot planeur".

Félix du Temple accomplished the first successful flight of a powered aircraft of any sort, a model plane that was able to take-off under its own power, in 1857. There are however

competing claims for the first "assisted" powered flight, with John Stringfellow's experiments in 1848.

Félix du Temple patented the designs for his aerial machine in 1857, which incorporated a retractable wheel landing gear, a propeller, a 6 hp engine and a dihedral wing design, under the title "Locomotion aérienne par imitation du vol des oiseaux" ("Aerial locomotion by imitation of the flight of birds"). He built several large models together with his brother Luis. One of them, weighing 700 grams, was able to fly, first using a clockwork mechanism as an engine, and then using a miniature steam engine. The two brothers managed to make the models take off under their own power, fly a short distance and land safely.

As they tried to build a unit capable of carrying a man, they realized that steam engines lacked power and were too heavy. They developed in 1867 an original "hot air" engine design, which did not prove satisfactory. They also experimented with the new internal combustion gas engine design developed by Lenoir, but which also lacked the necessary power.



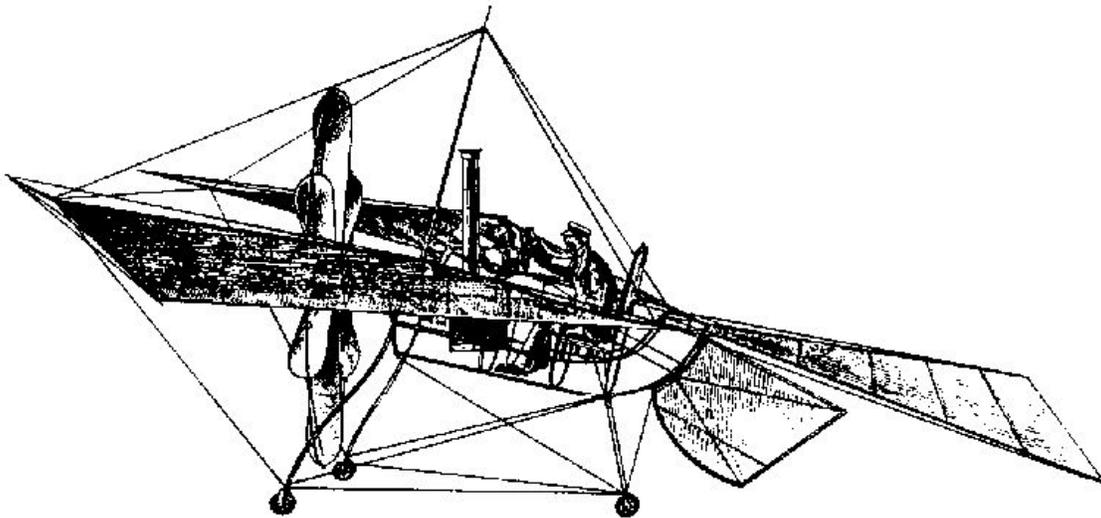
Felix du Temple de la Croix du Temple circa 1870.

Du Temple continued his research and finally succeeded in creating a very compact, high-speed circulation steam engine for which he applied for a patent on 28 April 1876. The engine used very small pipes packed together "to obtain the highest possible contact surface for the smallest possible volume"

"When he began with the aid of his brother, M. Louis du Temple, to experiment on a large scale, the inadequacy of all motors then known became apparent. They first tried steam at very high pressures, then a hot-air engine, and finally built and patented, in 1876 a very light steam boiler weighing from 39 to 44 lb. to the horse power, which appears to have been the prototype of some of the light boilers which have since been constructed. It consisted in a series of very thin tubes less

than 1/8 inches in internal diameter, through which water circulated very rapidly, and was flashed into steam by the surrounding flame." Octave Chanute, *Aeroplanes : Part III*, August 1892

The "Monoplane"



Félix du Temple's 1874 *Monoplane*.

In 1874, the two brothers built the *Monoplane*, a large plane made of aluminium in Brest, France, with a wingspan of 13 meters and a weight of only 80 kilograms (without the pilot). Several trials were made with the plane, and it is generally recognized that it achieved lift off under its own power after a ski-jump run, glided for a short time and returned safely to the ground, possibly making it the first successful powered flight in history, depending on the definition — since the flight was only a short distance and a short time.

The plane was displayed at the 1878 World Fair (Exposition Universelle (1878)) in Paris.

High-circulation steam engine

The plane used a very compact, high-speed circulation steam engine for which Félix du Temple applied for a patent on 28 April 1876. The engine used very small pipes packed together "to obtain the highest possible contact surface for the smallest possible volume".

The original steam engine which had been developed by Félix du Temple was later commercialized by him from a company he established in Cherbourg, "Générateur Du Temple S.A." and became highly successful. The design was adopted by the French Navy for the propulsion of the first French torpedo boats:

"Officers and engineers have now made up their opinion regarding Du Temple's steam engine. Everybody proclaims the superiority of its qualities... orders are pouring in from our commercial harbours and from the French government." *Revue Maritime* 1888 ("L'opinion est faite aujourd'hui sur la chaudière Du Temple parmi les officiers et les ingénieurs. Tout le monde proclame ses qualités supérieures... les commandes affluent de nos ports de commerce et de la part du gouvernement français".)

Industrial legacy

Following his death in 1890, his successors took over the management of the company. "Générateur Du Temple S.A.", acquired the Lesénéchal company in 1905, and by 1918 had several hundred employees when it was absorbed by the shipbuilding company Société Normande de Construction Navale.

Quote

"In general, birds, especially the largest ones, only rise and fly because of an acquired speed: this speed which is necessary to rise is obtained either by running on the ground or on water, or by jumping from a high point. Once arrived at a certain height that allows him to fly horizontally and move forward with just the flap of the wings, he gains speed, spreads his wings and tail so as to form as flat a surface as possible, and thus moves forward without any visible movement of the wings and without falling significantly"

– *Félix du Temple.*

Flying Machine by Clément Ader, France — October 9, 1890

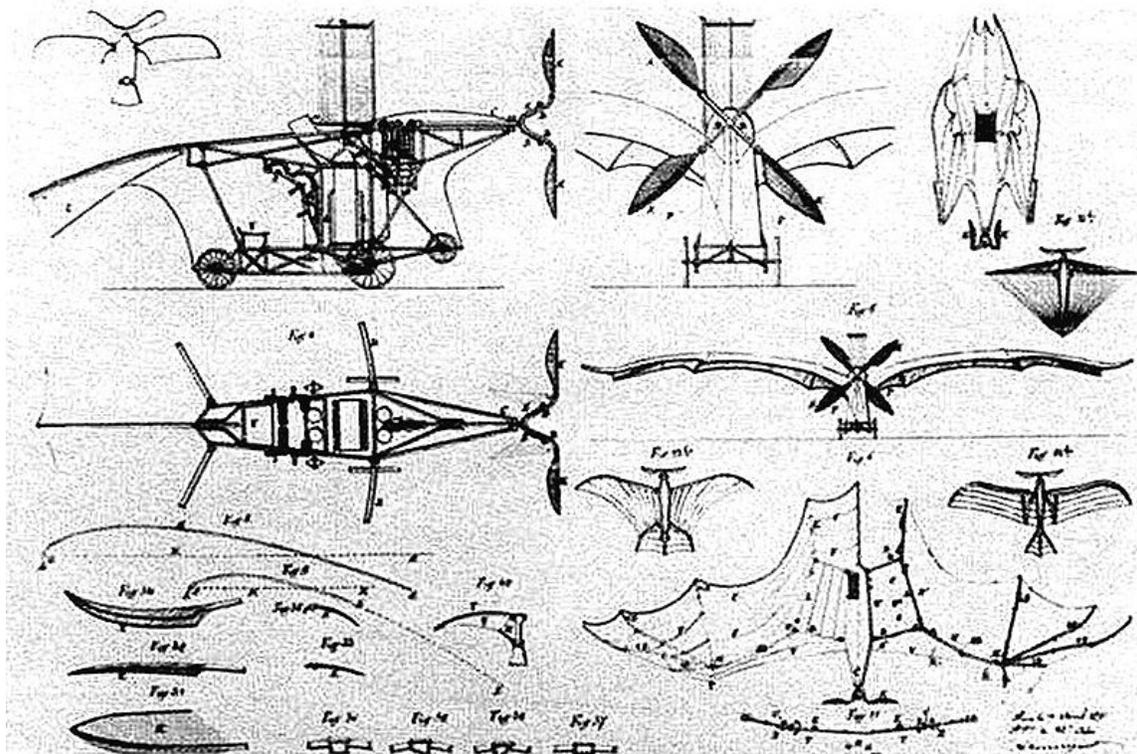
The inventor

Ader innovated in a number of electrical and mechanical engineering fields. He originally studied electrical engineering, and in 1878 improved on the telephone invented by Alexander Graham Bell. After refining the Bell Telephone he established the first such network in Paris in 1880. In 1881, he invented the "théâtrophone", a system of telephonic transmission where listeners received a separate channel for each ear, enabling stereophonic perception of the actors on a set; it was this invention which gave the first stereo transmission of opera spectacles, over a distance of 2 miles (3 km) in 1881. In

1903, he devised a V8 engine for the Paris-Madrid Rally; although three or four were produced, none was sold.

Development of aircraft

Following this, he turned to mechanical flight and concentrated much time and money on it until the end of his life. Using the studies of Louis Pierre Mouillard (1834–1837) on the flight of birds, he constructed his first flying machine in 1886, the *Éole*. It was a bat-like design run by a lightweight steam engine of his own invention (4 cylinders developing 20 horsepower (15 kW)). The weight was no more than 4 g/W (7 pounds per horsepower), and it drove a four-blade propeller. The wings, with a span of 14 metres, were equipped with a system of warping and all together weighed 300 kg (650 pounds). On 9 October 1890, Ader attempted a flight of the *Éole*. Historians say the aircraft evidently took off, reached a height of 20 cm, and flew uncontrolled approximately 50m, 13 years before the Wright Brothers.

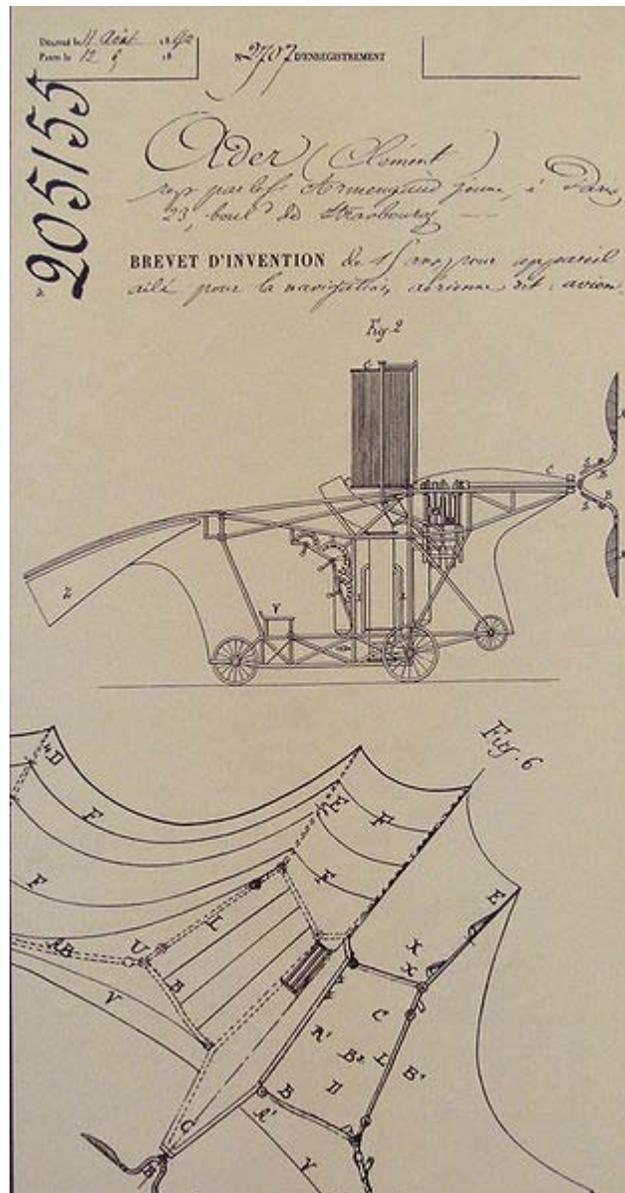


Patent drawings of Clement Ader's *Éole*.



Clement Ader *Avion III* (1897 photograph).

Ader undertook the construction of an aircraft he called the *Avion II* (also referred to as the *Zephyr* or *Éole II*). Most sources agree that work on this aircraft was never completed, and it was abandoned in favour of the *Avion III*. However, Ader claimed in later life that he flew the *Avion II* in August 1892 for a distance of 200 metres in Satory, which was then a military base, and which is still today a military airport near Paris.



Clement Ader's *Eole* French patent 205155, 19 April 1890.

Ader's progress attracted the interest of the minister of war, Charles de Freycinet. With the backing of the French War office, Ader developed and constructed the *Avion III*. It was like an enormous bat made of linen and wood, with a 16-yard (15 m) wingspan, equipped with two puller propellers of four blades, each powered by a steam engine of 30 hp (22 kW). After extensive taxi tests, Ader attempted a flight at Satory on 14 October 1897. Some witnesses contend that the *Avion* rolled, took off and, viewed by the official commission, flew a distance of more than 300 yards (300 m), while others contend that the *Avion III* crashed before even taking off. In any event, the commission was not impressed and withdrew its funding, but kept the results secret. After the Wright brothers made their flight, the commission released reports on Ader's flights, stating that they were successful.

L'Aviation Militaire

Clément Ader remained an active proponent of the development of aviation. He published in 1909 *L'Aviation Militaire*, a very popular book which went through 10 editions in the five years until the beginning of World War I, which is especially famous for its vision of air warfare and its precise description of the concept of the modern aircraft carrier with a flat flight deck, an island superstructure, deck elevators and a hangar bay. His published concept for the aircraft carrier, relayed by the US Naval Attaché in Paris were followed by the first trials in the United States in November 1910.

"An airplane-carrying vessel is indispensable. These vessels will be constructed on a plan very different from what is currently used. First of all the deck will be cleared of all obstacles. It will be flat, as wide as possible without jeopardizing the nautical lines of the hull, and it will look like a landing field."

—Clément Ader, "L'Aviation Militaire", 1909

Assessment



Clément Ader's Avion III at the Musée des Arts et Métiers.



Avion III.

His Avion is still displayed at the museum of the Conservatory of Arts and Industry in Paris. Non-French aviation historians often discredit any claims of priority, since all flight attempts ended in crashes, many were disputed, and Ader greatly exaggerated his achievements in later life. Nonetheless, Ader is still admired for his efforts. In 1938, France issued a postage stamp honoring him, and Airbus named one of its aircraft assembly sites in Toulouse after him.

Flying Machine by Samuel Pierpont Langley, United States — May 6, 1896

Aviation work



Langley's Aërodrome No. 5 in Flight, May 6, 1896
From instantaneous photograph by Alexander Graham Bell

Langley's steam-powered *Aërodrome No. 5* in flight. Photo by Alexander Graham Bell.

Langley attempted to make a working piloted heavier-than-air aircraft. His models flew, but his two attempts at piloted flight were not successful. Langley began experimenting with rubber-band powered models and gliders in 1887. (According to one book, he was not able to reproduce Alphonse Pénaud's time aloft with rubber power but persisted

anyway.) He built a rotating arm (functioning similar to a wind tunnel) and made larger flying models powered by miniature steam engines.

His first success came on May 6, 1896 when his Number 5 unpiloted model flew nearly 3/4 of a mile after a catapult launch from a boat on the Potomac River. The distance was ten times longer than any previous experiment with a heavier-than-air flying machine, demonstrating that stability and sufficient lift could be achieved in such craft. On November 11 that year his Number 6 model flew more than 5000 feet.

In 1898, based on the success of his models, Langley received a War Department grant of \$50,000 and \$20,000 from the Smithsonian to develop a piloted airplane, which he called an "Aerodrome" (coined from Greek words roughly translated as "air runner"). Langley hired Charles M. Manly (1876–1927) as engineer and test pilot. When Langley received word from his friend Octave Chanute of the Wright brothers' success with their 1902 glider, he attempted to meet the Wrights, but they politely evaded his request.

While the full-scale Aerodrome was being designed and built, the internal combustion engine was contracted out to manufacturer Stephen Balzer (1864–1940). When he failed to produce an engine to the power and weight specifications, Manly finished the design. This engine had far more power than did the engine for the Wright brothers' first airplane—50 hp compared to 12 hp. The engine, mostly the technical work of men other than Langley, was probably the project's main contribution to aviation.

The piloted machine had wire-braced tandem wings (one behind the other). It had a Pénauud tail for pitch and yaw control but no roll control, depending instead on the dihedral angle of the wings, as did the models, for maintaining roughly level flight.



Manly with Langley

In contrast to the Wright brothers' design of a controllable airplane that could fly against a strong wind and land on solid ground, Langley sought safety by practicing in calm air over the Potomac River. This required a catapult for launching. The craft had no landing gear, the plan being to descend into the water after demonstrating flight which if successful would entail a partial, if not total, rebuilding of the machine. Langley gave up the project after two crashes on take-off on October 7 and December 8, 1903.

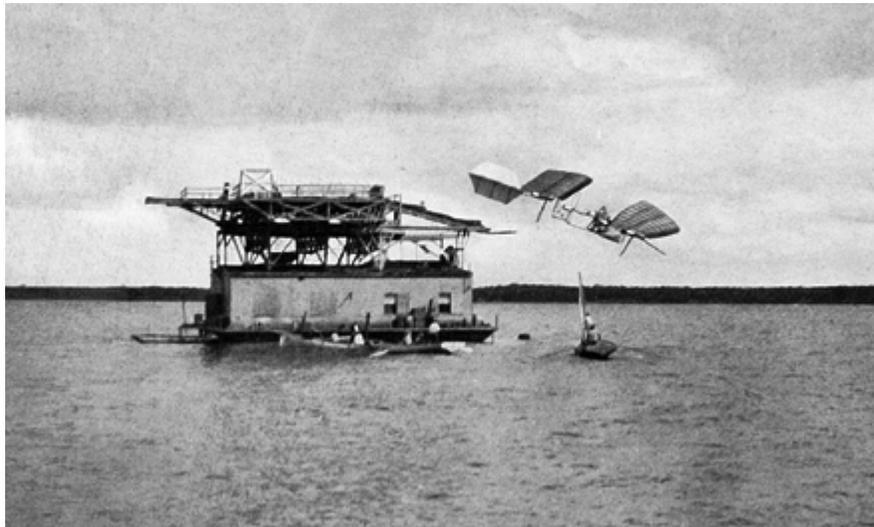
In the first attempt, Langley said the wing clipped part of the catapult, leading to a plunge into the river "like a handful of mortar," according to one reporter. On the second attempt the craft broke up as it left the catapult (Hallion, 2003; Nalty, 2003). Manly was

recovered unhurt from the river both times. Newspapers made great sport of the failures, and some members of Congress strongly criticized the project.

The Aerodrome was heavily modified and flown a few hundred feet by Glenn Curtiss in 1914, as part of his attempt to fight the Wright brothers' patent, and as an effort by the Smithsonian to rescue Langley's aeronautical reputation. Nevertheless, courts upheld the patent. However, the Curtiss flights emboldened the Smithsonian to display the Aerodrome in its museum as "the first man-carrying aeroplane in the history of the world capable of sustained free flight". Fred Howard, extensively documenting the controversy, wrote: "It was a lie pure and simple, but it bore the imprimatur of the venerable Smithsonian and over the years would find its way into magazines, history books, and encyclopedias, much to the annoyance of those familiar with the facts." (Howard, 1987). The Smithsonian's action triggered a decades-long feud with the surviving Wright brother, Orville.

Langley had no effective way of addressing the Wright brothers' central innovation of controlling an airplane too big to be maneuvered by the weight of the pilot's body. So if the Aerodrome had flown stably, as the models did, Manly would have been in considerable danger when the machine descended, uncontrolled, for a landing—especially if it had wandered away from the river and over solid ground.

Air and sea craft, facilities and an award have been named in Langley's honor, including:

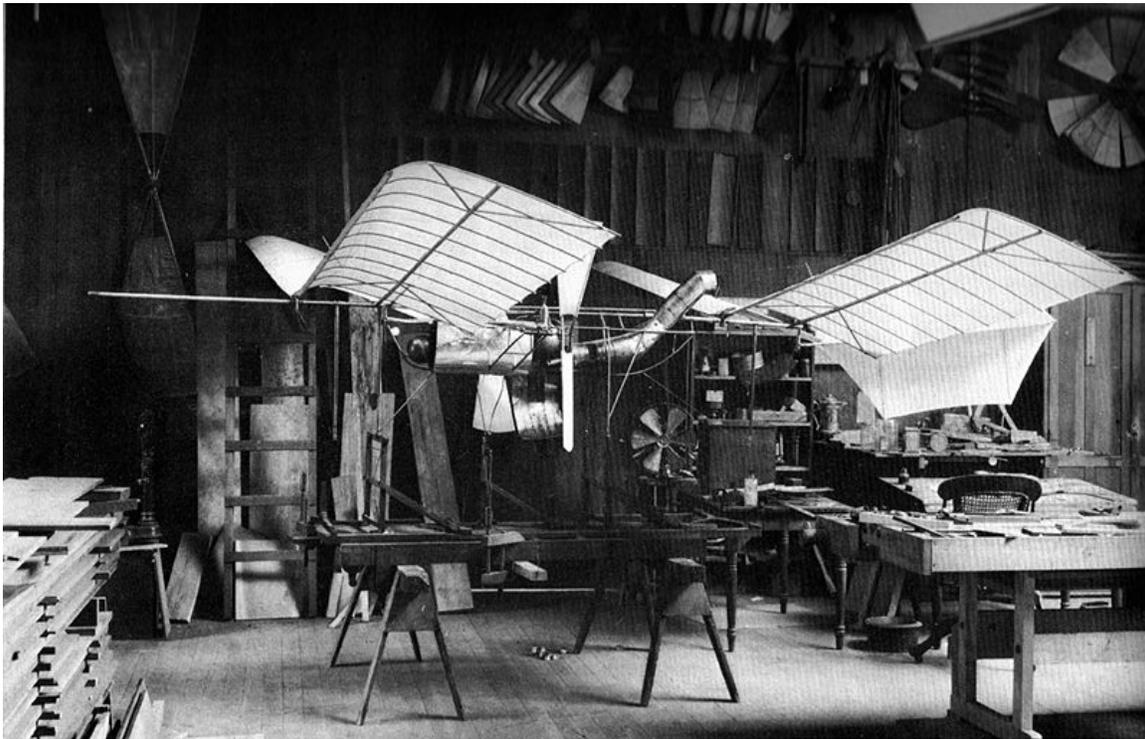


First failure of the manned Aerodrome, Potomac River, Oct. 7, 1903

- Langley medal
- NASA Langley X-43A Hyper-X
- NASA Langley Research Center (NASA LaRC), Hampton, Virginia
- Langley Air Force Base
- Langley Hall at the University of Pittsburgh
- Langley High School in Pittsburgh

- Langley Memorial Aeronautical Laboratory
- Langley unit of solar radiation
- Mount Langley in the Sierra Nevada
- USS *Langley* (CV-1)
- USS *Langley* (DE-131), laid down 10 July 1942 and renamed *Hammann* on 1 August 1942
- USS *Langley* (CVL-27)
- Seadrome Langley, intended as one in a chain of Atlantic aviation way-stations, cancelled due to the Depression
- SS *Samuel P. Langley*, U.S. Liberty Ship

Other work

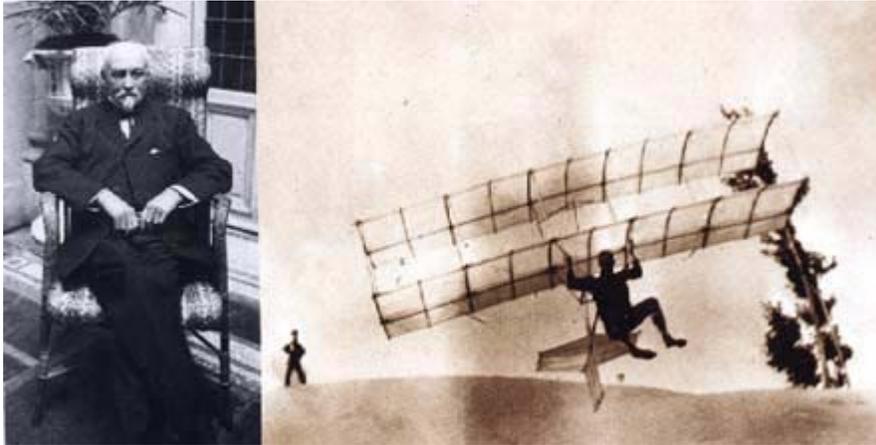


Langley's 1/4-scale model; it flew several hundred yards on August 8, 1903.

Langley invented the bolometer, an instrument for measuring infrared radiation, and used it on astronomical objects. He made one of the first attempts to measure the surface temperature of the Moon, and his measurement of interference of the infrared radiation by carbon dioxide in Earth's atmosphere was used by Svante Arrhenius in 1896 to make the first calculation of how climate would change from a future doubling of carbon dioxide levels.

Flying Machine by Octave Chanute, United States — Summer 1896

Aviation



Octave Chanute's 1896 biplane hang glider, a trailblazing design adapted by the Wright brothers

Chanute first became interested in aviation during a visit to Europe in 1875. When he retired from his engineering business in 1890, he decided to devote his time to furthering the new science of aviation.

Applying his engineering background, Chanute collected all the data that he could find from flight experimenters around the world. He published this as a series of articles in *The Railroad and Engineering Journal* from 1891 to 1893, and collected them together in the influential book *Progress in Flying Machine* in 1894. This was the most systematic global survey of fixed-wing heavier-than-air aviation research published up to that time.

At the World's Columbian Exposition in Chicago in 1893, Chanute organized a highly successful International Conference on Aerial Navigation.

Chanute was too old to attempt to fly himself, and he partnered with younger experimenters, including Augustus Herring and William Avery. In 1896 and 1897 Chanute, Herring and Avery tested hang gliders based on designs by German aviator Otto Lilienthal, as well as hang gliders of their own design, in the sandhills on the shores of Lake Michigan near the town of Miller Beach not far from what would become the city of Gary, Indiana.

These experiments convinced Chanute that the best way to achieve extra lift without a prohibitive increase in weight was to stack several wings one above the other, an idea proposed by British engineer Francis Wenham in 1866 and realized in flight by Lilienthal

in the 1890s. Chanute invented the "strut-wire" braced wing structure that would be used in powered biplanes of the future. He based the design on the Pratt truss which was familiar to him from his bridge-building work. The Wright brothers based their glider designs on the Chanute "double-decker," as they called it.

Chanute corresponded with many aviation pioneers, including Louis Mouillard, Gabriel Voisin, John J. Montgomery, Louis Blériot Ferdinand Ferber, Lawrence Hargrave and Alberto Santos Dumont. In 1897 Chanute started a correspondence with British aviator Percy Pilcher. Following Chanute's ideas, Pilcher built a triplane, but he was killed in a glider crash before he could attempt to fly it.

Chanute was in contact with the Wright brothers from 1900, when Wilbur Wright wrote to him after reading *Progress in Flying Machines*. Chanute helped to publicize the Wright brothers' work, and provided consistent encouragement, visiting their camp near Kitty Hawk in 1901, 1902 and 1903. The Wrights and Chanute exchanged hundreds of letters from 1900 to 1910.

Chanute freely shared his knowledge about aviation with anyone who was interested and expected others to do the same, although he did encourage colleagues to patent their inventions. His open approach led to friction with the Wright brothers, who believed their ideas about aircraft control were unique and refused to share them. Chanute did not believe the Wright flying machine patent, premised on wing-warping, could be enforced and said so publicly. The friendship was still impaired when Chanute died in 1910, although Wilbur Wright delivered the eulogy at Chanute's funeral.

The town of Chanute, Kansas is named after him, as well as the former Chanute Air Force Base near Rantoul, Illinois, which was decommissioned in 1993. The former Base, now turned to peacetime endeavors, includes the Octave Chanute Aerospace Museum, detailing the history of aviation and of Chanute Air Force base.

In 2003, as part of its commemoration of the 100th anniversary of the Wright Brothers' flight, *Aviation Week & Space Technology* named Chanute 38th on its list of the top 100 "most important, most interesting, and most influential people" in the first century of aerospace.

Quotes

"...let us hope that the advent of a successful flying machine, now only dimly foreseen and nevertheless thought to be possible, will bring nothing but good into the world; that it shall abridge distance, make all parts of the globe accessible, bring men into closer relation with each other, advance civilization, and hasten the promised era in which there shall be nothing but peace and good-will among all men."

Flying Machine by Gustave Whitehead, United States — 1899

Flight claims

Pittsburgh 1899

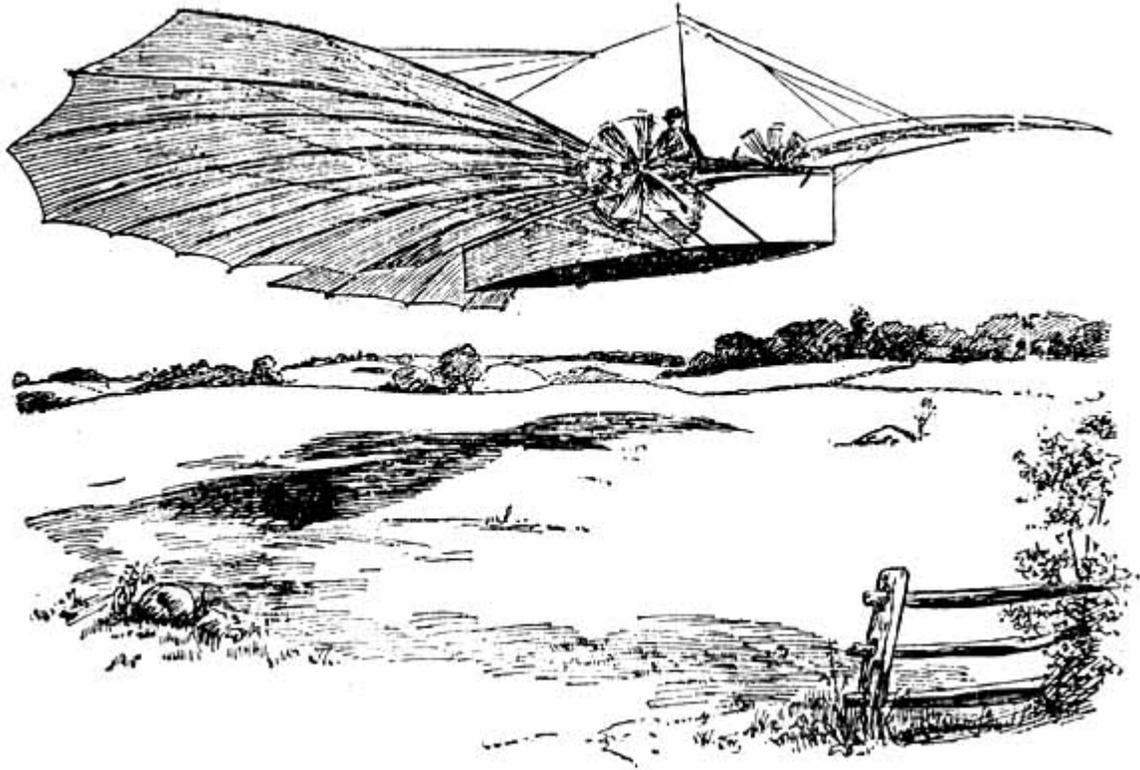
According to an affidavit given in 1934 by Louis Darvarich, a friend of Whitehead, the two men made a motorized flight together of about half a mile in Pittsburgh's Schenley Park in April or May 1899. Darvarich said they flew at a height of 20 to 25 ft (6.1 to 7.6 m) in a steam-powered monoplane aircraft and crashed into a three-story building. Darvarich said he was stoking the boiler aboard the craft and was badly scalded in the accident, requiring several weeks in a hospital. Reportedly, because of this incident, Whitehead was forbidden to do any more flight experiments in Pittsburgh.

Whitehead and Darvarich traveled to Bridgeport, Connecticut to find factory jobs.

Connecticut 1901

The aviation event for which Whitehead is now best-known reportedly took place in Fairfield, Connecticut on August 14, 1901. According to an eyewitness newspaper article widely attributed to journalist Dick Howell of the Bridgeport *Sunday Herald*, Whitehead piloted his Number 21 aircraft in a controlled powered flight for about half a mile up to 50 feet high and landed safely. The feat, if true, preceded the Wright brothers by more than two years and exceeded their best 1903 Kitty Hawk flight, which covered 852 feet at a height of about 10 feet.

The *Sunday Herald* article was published on August 18, 1901. Information from the article was also reprinted in the *New York Herald* and *Boston Transcript*. No photographs were taken, but a drawing of the aircraft flying accompanied the *Sunday Herald* article. Whitehead subsequently claimed he made four "trips" in the airplane on August 14, 1901; and that the longest was one and a half miles.



The drawing which accompanied the article in the August 18, 1901, *Sunday Herald*

The *Sunday Herald* reported that before attempting to pilot the aircraft, Whitehead successfully test flew it unmanned in the pre-dawn hours, using tether ropes and sandbag ballast. When Whitehead was ready to make a manned flight, the article said: "By this time the light was good. Faint traces of the rising sun began to suggest themselves in the east."

The newspaper reported that trees blocked the way after the flight was in progress, and quoted Whitehead as saying, "I knew that I could not clear them by raising higher, and also that I had no means of steering around them by using the machinery." The article said Whitehead quickly thought of a solution to steer around the trees:

"He simply shifted his weight more to one side than the other. This careened the ship to one side. She turned her nose away from the clump of sprouts when within fifty yards of them and took her course around them as prettily as a yacht on the sea avoids a bar. The ability to control the air ship in this manner appeared to give Whitehead confidence, for he was seen to take time to look at the landscape about him. He looked back and waved his hand exclaiming, 'I've got it at last.'"

When Whitehead neared the end of a field, the article said he turned off the motor and the aircraft landed "so lightly that Whitehead was not jarred in the least."

Junius Harworth, who was a boy when he was one of Whitehead's helpers, said Whitehead flew the airplane at another time in the summer of 1901 along the edge of property belonging to the local gas company. Upon landing, Harworth said, the machine was turned around and another hop was made back to the starting point.

During this period Whitehead also reportedly tested an unmanned and unpowered flying machine, towed by men pulling ropes. A witness said the aircraft rose above telephone lines, flew across a road and landed undamaged. The distance covered was later measured out at around 1,000 ft (305 m).

Connecticut 1902

Whitehead claimed two spectacular flights on January 17, 1902 in his improved Number 22, with a 40 Horsepower (30 kilowatt) motor instead of the 20 hp (15 kW) used in the Number 21, and aluminum instead of bamboo for structural components. In two published letters he wrote to *American Inventor* magazine, Whitehead said the flights took place over Long Island Sound. He said the distance of the first flight was about two miles (3 kilometers) and the second was seven miles (11 km) in a circle at heights up to 200 ft (61 m). He said the airplane, which had a boat-like fuselage, landed safely in the water near the shore

For steering, Whitehead said he varied the speed of the two propellers and also used the aircraft rudder. He said the techniques worked well on his second flight and enabled him to fly a big circle back to the shore where his helpers waited. He expressed pride in the accomplishment: "...as I successfully returned to my starting place with a machine hitherto untried and heavier than air, I consider the trip quite a success. To my knowledge it is the first of its kind. This matter has so far never been published."

In his first letter to *American Inventor*, Whitehead stated his claim of flying in the summer of 1901 .¹ He added, "This coming Spring I will have photographs made of Machine No. 22 in the air." He said snapshots, apparently taken during his claimed flights of January 17, 1902 "did not come out right" because of cloudy and rainy weather. The magazine editor replied that he and readers would "await with interest the promised photographs of the machine in the air," but there were no further letters nor any photographs from Whitehead.

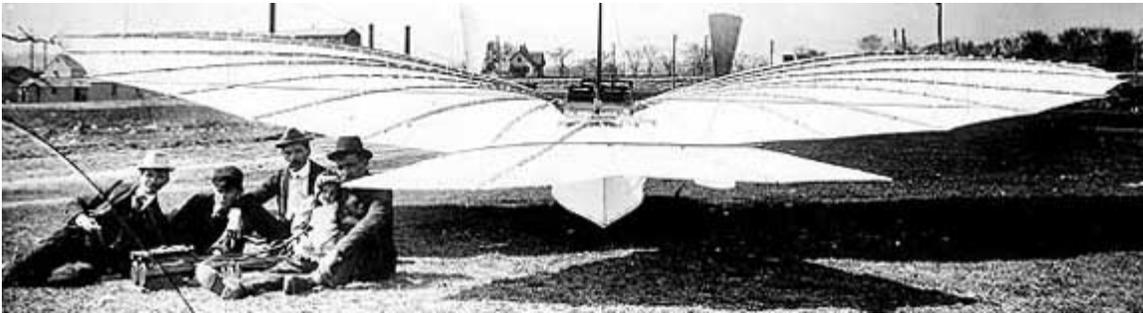
A description of a Whitehead aircraft as remembered 33 years later by his brother John Whitehead gave information related to steering:

"Rudder was a combination of horizontal and vertical fin-like affair, the principle the same as in the up-to-date airplanes. For steering there was a rope from one of the foremost wing tip ribs to the opposite, running over a pulley. In front of the operator was a lever connected to a pulley: the same pulley also controlled the tail rudder at the same time."

John Whitehead arrived in Connecticut from California in April 1902, intending to help his brother. He did not see any of his brother's aircraft in powered flight.

A 1935 article in *Popular Aviation* magazine, which renewed interest in Whitehead, said winter weather ruined the Number 22 airplane after Whitehead placed it unprotected in his yard following his claimed flights of January 1902. The article said Whitehead did not have money to build a shelter for the aircraft because of a quarrel with his financial backer. The article also reported that in early 1903 Whitehead built a 200 horsepower eight-cylinder engine, intended to power a new aircraft. Another financial backer insisted on testing the engine in a boat on Long Island Sound, but lost control and capsized, sending the engine to the bottom.

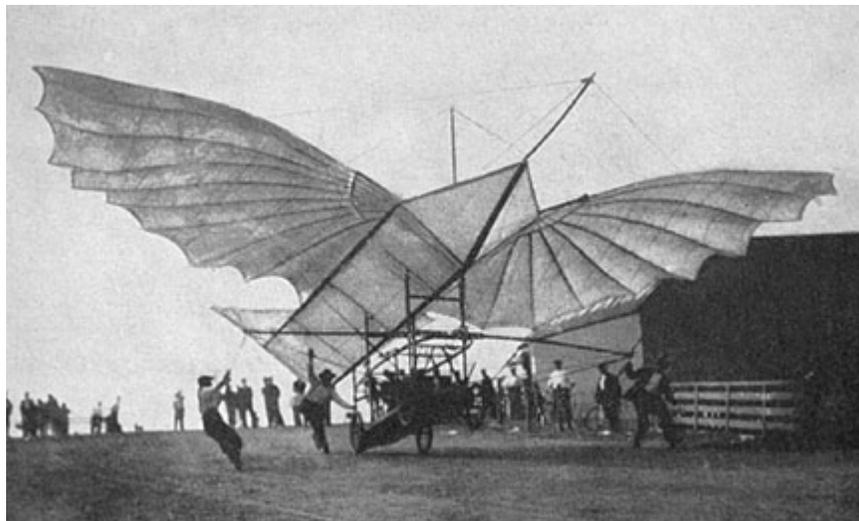
Aerial machines



The No. 21 aircraft. Whitehead sits beside it with daughter Rose in his lap; others in the photo are not identified. A pressure-type engine rests on the ground in front of the group.



Whitehead piloting his glider of 1903



Whitehead's large Albatros-type glider - ca. 1905 - 1906

Whitehead's Number 21 monoplane had a wingspan of 36 ft (11 m). The fabric covered wings were ribbed with bamboo, supported by steel wires and were very similar to the shape of the Lilienthal glider's wings. The arrangement for folding the wings also closely followed the Lilienthal design. The craft was powered by two engines: a ground engine of 10 hp (7.5 kW), intended to propel the front wheels to reach takeoff speed, and a 20 hp (15 kW) acetylene engine powering two propellers, which were designed to counter-rotate for stability.

Whitehead owned and read a copy of Octave Chanute's famed 1894 "Progress in Flying Machines." Chanute detailed D'Esterno's design, along with a top view drawing of the machine, which was not built. The design of Whitehead's No. 21 1899-1901 monoplane shared many important features with the design of Count D'Esterno's 1864 monoplane glider and Penaud and Gauchot's 1876 monoplane.

Whitehead described his No. 22 aircraft and compared some of its features to the No. 21 in a letter he wrote to the editor of *American Inventor* magazine, published April 1, 1902. He said the No. 22 had a five-cylinder 40 hp kerosene motor of his own design, weighing 120 lbs. He said ignition was "accomplished by its own heat and compression." He described the aircraft as 16 feet long, made mostly of steel and aluminum with wing ribs made of steel tubing, rather than bamboo, which was used in the Number 21 aircraft. He explained that the two front wheels were connected to the kerosene motor, and the rear wheels were used for steering while on the ground. He said the wing area was 450 square feet, and the covering was "the best silk obtainable." The propellers were "6 feet in diameter...made of wood...covered with very thin aluminum sheeting." He said the tail and wings could all be "folded up...and laid against the sides of the body."

Whitehead also built gliders until about 1906 and was photographed flying these machines.

Chapter- 4

Flying Machines in 20th Century

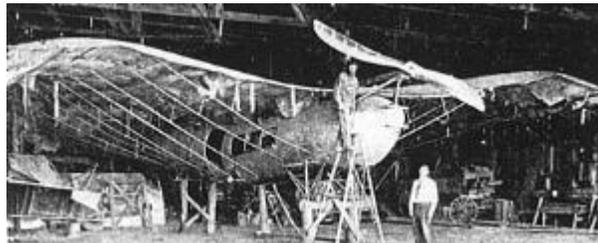
Flying Machine by Lyman Gilmore, United States — May 15, 1902

Work

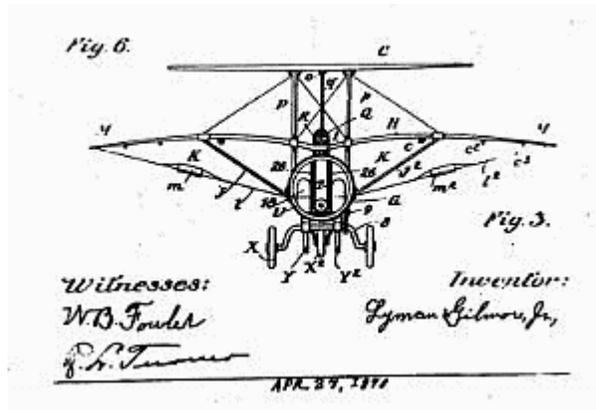
Lyman Gilmore was in contact with other flight pioneers like Samuel Langley and, eventually, the Wright brothers.

In 1902, Gilmore was granted two patents on steam engines, the first of which was granted in 1902. He invented in other areas too, for example a rotary snowplow. On March 15, 1907, Gilmore opened the first commercial airfield, Gilmore Airfield, in Grass Valley. There is now middle school named in his honor on the site of the airfield.

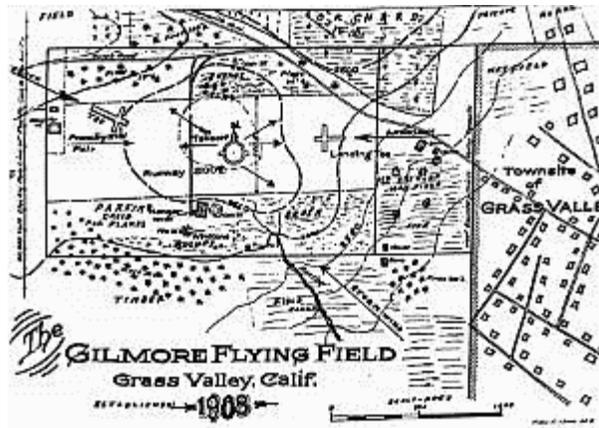
Local legend says Gilmore wore the same long coat for years and was never far from it. It continues to say that when he was involuntarily hospitalized for his last illness the coat and all of his long-worn clothing were burned. While he had never accumulated much money, it was said that all he had was sewn into the lining of that coat and was destroyed with it.



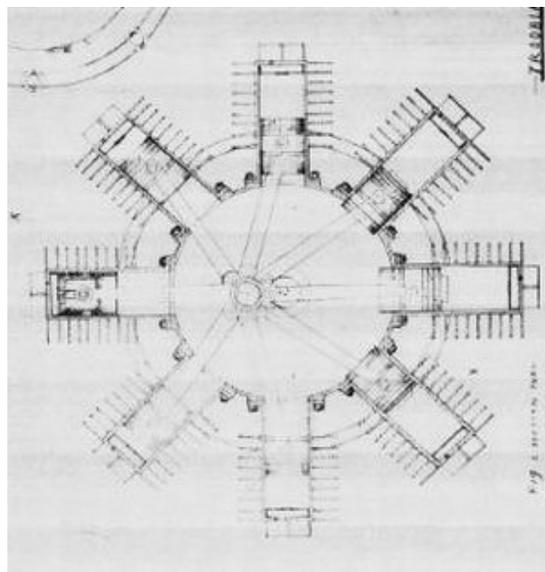
Gilmore's second, larger plane



Drawing of the smaller first plane



Gilmore Flying Field



One of Gilmore's inventions, an 8-cylinder radial engine

After the fire in his hangar, Gilmore began mining for gold and died a poor man in Nevada City, California. His grave can be found in Pine Grove Cemetery, about a half mile outside of town.

Flying Machine by Richard Pearse, New Zealand — March 31, 1903

Flights

Pearse made several attempts to fly in 1902, but due to insufficient engine power he achieved no more than brief hops. The following year he redesigned his engine to incorporate double-ended cylinders with two pistons each. Researchers recovered components of his engine (including cylinders made from cast-iron drainpipes) from rubbish dumps in 1963. Replicas of the 1903 engine suggest that it could produce about 15 horsepower (11 kW).



Richard William Pearse Monument



A silver medal struck by the New Zealand Mint for the New Zealand Museum of Transport and Technology in 1982 to commemorate the *"80th Anniversary Of World 1st Powered Flight"* by Pearse. MOTAT's website gives 1903 as the year of his first flight, not 1902 as indicated on the medal.

Verifiable eyewitnesses describe Pearse crashing into a hedge on two separate occasions during 1903. His monoplane must have risen to a height of at least three metres on each occasion. Good evidence exists that on 31 March 1903 Pearse achieved a powered, though poorly controlled, flight of several hundred metres. Pearse himself said that he had made a powered takeoff, "but at too low a speed for [his] controls to work". However, he remained airborne until he crashed into the hedge at the end of the field.

With a 15 horsepower (11 kW) engine, Pearse's design had an adequate power-to-weight ratio to become airborne (even without an aerofoil). He continued to develop the ability to achieve fully controlled flight. Pearse incorporated effectively located (albeit possibly rather small) "ailerons". The design's low centre-of-gravity provided pendulum stability. However, diagrams and eye-witness recollections agree that Pearse placed controls for pitch and yaw at the trailing edge of the low-aspect ratio kite-type permanently stalled wing. This control placement (located in turbulent air-flow, and close to the centre of gravity) would have had minimal, possibly inadequate, turning moment to control the

pitch or yaw of the aircraft. The principles of his design, however, accord precisely with modern thinking on the subject. The Wright brothers, in comparison, successfully applied the principles of airfoil wing-profile and three-axis control to produce fully controlled flight, although their design, using wing-warping and forward mounted stabilizer, soon became obsolete.

Pearse's work remained poorly documented at the time. No contemporary newspaper record exists. Some photographic records survived, but undated, with some images difficult to interpret. Pearse himself made contradictory statements which for many years led the few who knew of his feats to accept 1904 as the date of flying. Unconcerned about posterity and in remote New Zealand, he received no public credit for his work during his lifetime. The Wrights had considerable difficulty in getting their accomplishment recognised, despite better documentation and witnesses; a "Fliers or Liars?" debate continued for quite some time after Kitty Hawk, and it took highly public demonstrations before the Wright brothers gained wide recognition. Although Pearse patented his design, his innovations — such as ailerons and the lightweight air-cooled engine — did not succeed in influencing others.

List of witnessed flights

- 31 March 1903 - First powered flight. Estimated distance around 350 yards in a straight line, barely controlled.
- March ? 1903 - A distance of only about 150 yards.
- 2 May 1903 - Distance unknown: the aircraft ended up in a gorse hedge 15 ft (4.6 m) off the ground.
- 11 May 1903 - Pearse took off along the side of the Opihi River, turned left to fly over the 30' tall river-bank, then turned right to fly parallel to the middle of the river. After flying nearly 1,000 yards, his engine began to overheat and lost power, thus forcing a landing in the almost dry riverbed.

Later activities

Pearse moved to Milton in Otago in about 1911 and discontinued his flying experiments due to the hillier country there. Much of his experimental equipment got dumped in a farm rubbish-pit. However, he continued experimenting and produced a number of inventions. He subsequently moved to Christchurch in the 1920s, where he built three houses and lived off the rentals.

Throughout the 1930s and 1940s, Pearse continued to work on constructing a tilt-rotor flying-machine for personal use — sometimes described as a cross between a windmill and a rubbish-cart. His design resembled an autogyro or helicopter, but involved a tilting propeller/rotor and monoplane wings, which, along with the tail, could fold to allow storage in a conventional garage. Pearse intended the vehicle for driving on the road (like a car) as well for flying. However he became reclusive and paranoid that foreign spies would discover his work. Committed to Sunnyside Mental Hospital in Christchurch in

1951, Pearse died there two years later. Researchers believe that many of his papers were destroyed at that time.

Claims

On his death, the Public Trustee administered Pearse's estate. Fortunately for posterity, the trust officer given the task of disposing of his personal effects recognised the significance of his aeronautical achievements and brought them to wider attention. As a result, aviation pioneer George Bolt saw Pearse's last flying machine. In 1958, Bolt excavated the South Canterbury dump site and discovered some components, including a propeller. His research in the 1960s (among eyewitnesses, most of them schoolchildren at the time of Pearse's early achievements) produced strong evidence for flight in 1903: people who had left the district by 1904 remembered the events, and recalled a particularly harsh winter with heavy snow.

During filming of a television documentary in the 1970s, crew attached a replica of Pearse's 1902 machine by a rope to a team of horses. When the horses bolted, the machine took to the air and flew, indicating that the design could fly. Unfortunately, this did not get filmed, as the crew had packed away their cameras at the end of the day's shooting. Fate seems to have conspired against any of Pearse's machines achieving recognition.



A replica aeroplane on display at the South Canterbury Museum in Timaru

In the mid 1980s, a MOTAT staff-member expressed the opinion that Pearse himself, having seen that "history had already been written" stated in his later years that though he had in fact flown in March, 1903, he had said "1904" because the Wright brothers at Kittyhawk had become part of history, and that therefore Pearse declined to appear to posterity as a disputatious claimant to the first controlled powered flight. Certainly the opinion expressed makes sense, though the aircraft itself, admittedly "short-coupled" in terms of control, appears to have had the ability of controlled flight. Adding some confusion to the issue, the tilt-propeller aircraft Pearse later worked on bears a very close resemblance to the original aircraft, and the remains at MOTAT, though presented as parts of a single machine, may very well come from three separate machines:

1. the "original" March 1903 machine
2. a later version of the same with a tilt-propeller
3. the original March 1903 motor, in sadly decayed state, along with the motor mounted in the MOTAT replica, which derived from the remains of at least two motors from the Pearse farm "dump site".

Despite close examination, a definitive determination may have become impossible.

The South Canterbury Museum in Timaru includes display material relating to Pearse and to his contribution to early aviation.

Legacy

At the dawn of the 20th century, a number of enthusiasts in several countries advanced towards powered heavier-than-air flight — a fact easily overlooked in the wake of the first practical controlled flights by the Wright brothers, who gained international fame during their public flight demonstrations of 1908. Pearse, as one of several pre-Wright designers, advanced some distance towards controlled flight. However, unlike many of these other pre-Wright aeronauts, Pearse had little influence on his successors, because details of his ideas and experiments went unpublished.

Pearse's designs and achievements remained virtually unknown beyond the few who witnessed them, and they had no impact on his contemporary aviation designers. However, his concepts had much in common with modern aircraft design, and others later implemented these concepts without knowing of Pearse's efforts. As a result some have described Pearse as a man ahead of his time. (So far ahead of his time, in fact, that the second New Zealand flight did not occur until 5 February 1910 when Vivian Walsh flew an aircraft he had built himself.)

Many New Zealanders have made up their minds that Temuka was the site of the world's first powered flight. Wanaka has a line of tiles mounted on the sidewalk by the lake listing important world and New Zealand historic events. The 1903 tile says that the first powered flight in history occurred in Timaru (with some emphasis), and at the bottom of the tile for 1903 the Wright Brothers were listed as having also flown that year.

Much controversy persists around the many competing claims of early aviators.

Flying Machine by Alberto Santos-Dumont, Brazil — October 23, 1906

Balloons and dirigibles



Santos-Dumont #6 rounding the Eiffel Tower in the process of winning the Deutsch Prize. Photo courtesy of the Smithsonian Institution (SI Neg. No. 85-3941)

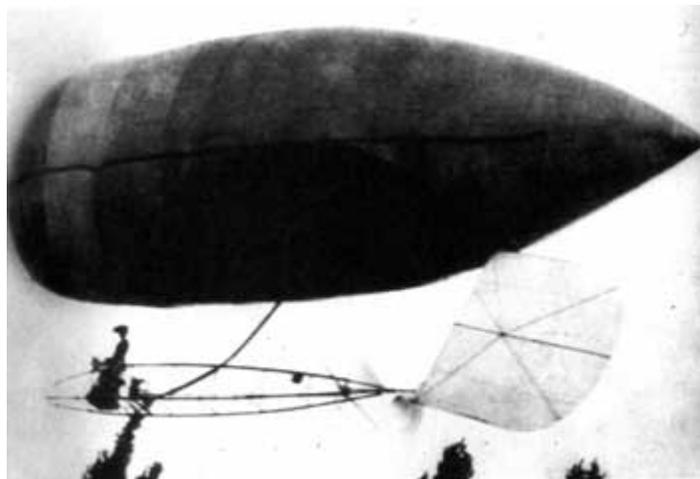
Santos-Dumont described himself as the first "sportsman of the air." He started flying by hiring an experienced balloon pilot and took his first balloon rides as a passenger. He quickly moved on to piloting balloons himself, and shortly thereafter to designing his own balloons. In 1898, Santos-Dumont flew his first balloon design, the *Brésil*.

After numerous balloon flights, he turned to the design of steerable balloons or *dirigible* type balloons that could be propelled through the air rather than drifting along with the breeze.

Between 1898 and 1905, he built and flew 11 dirigibles. With air traffic control restrictions still decades in the future, he would glide along Paris boulevards at rooftop level in one of his airships, commonly landing in front of a fashionable outdoor cafe for lunch. On one occasion he even flew an airship early one morning to his own apartment at No. 9, Rue Washington, just off Avenue des Champs-Élysées, not far from the Arc de Triomphe.

To win the Deutsch de la Meurthe prize Santos-Dumont decided to build a bigger balloon, the dirigible Number 5. On August 8, 1901 during one of his attempts, his dirigible lost hydrogen gas. It started to descend and was unable to clear the roof of the Trocadero Hotel. A large explosion was then heard. Santos-Dumont survived the explosion and was left hanging in a basket from the side of the hotel. With the help of the crowd he climbed to the roof without injury.

The zenith of his lighter-than-air career came when he won the *Deutsch de la Meurthe* prize. The challenge called for flying from the Parc Saint Cloud to the Eiffel Tower and back in less than thirty minutes. The winner of the prize needed to maintain an average ground speed of at least 22 km/h (14 mph) to cover the round trip distance of 11 km (6.8 miles) in the allotted time.



Aida D'Acosta Breckinridge piloted Santos-Dumont's airship in 1903.

On October 19, 1901, after several attempts, Santos-Dumont succeeded in using his dirigible *Number 6*. Immediately after the flight, a controversy broke out around a last minute rule change regarding the precise timing of the flight. There was much public outcry and comment in the press. Finally, after several days of vacillating by the committee of officials, Santos-Dumont was awarded the prize as well as the prize money of 125,000 francs. In a charitable gesture, he donated 75,000 francs of the prize money to the poor of Paris. The balance was given to his workmen as a bonus. An additional matching 125,000 francs was voted to him along with a gold medal by the government of his native Brazil.

Santos-Dumont's aviation feats made him a celebrity in Europe and throughout the world. He won several more prizes and became a friend to millionaires, aviation pioneers, and royalty. In 1903 Aida D'Acosta Breckinridge piloted Santos-Dumont's airship. In 1904, he went to the United States and was invited to the White House to meet U.S. President Theodore Roosevelt.

The public eagerly followed his daring exploits. Parisians affectionately dubbed him *le petit Santos*. The fashionable folk of the day mimicked various aspects of his style of dress from his high collared shirts to singed Panama hat. He was, and remains to this day, a prominent folk hero in his native Brazil.

Heavier than air aircraft



M. SANTOS DUMONT'S FIRST SUCCESS WITH A FLYING MACHINE.

M. Santos Dumont, after several preliminary trials in Paris on November 12th, when his flying machine had flown 75, 128, and 142 yards, decided to return to his starting point by going against the wind. For thirty yards the motor ran along the ground, then suddenly it rose to a height of about five yards, and appearing like a great white bird, it soared half-way down the course. M. Santos Dumont, startled by some spectators in his way, twisted his rudder quickly, and the machine came heavily to the ground, damaging one of its wings. The experiment, however was a triumph, for actual flight was achieved; and it seems as though it were only a matter of time for the conquest of the air to be accomplished. The 235 yards were traversed in twenty-one seconds.

The November 12 flight

Although Santos-Dumont continued to work on dirigibles, his primary interest soon turned to heavier-than-air aircraft. By 1905 he had finished his first airplane design, and also a helicopter. He finally achieved his dream of flying an aircraft on October 23, 1906 by piloting the 14-bis before a large crowd of witnesses for a distance of 60 metres (197 ft) at a height of two to three metres (10 ft). This well-documented event was the first flight verified by the Aéro-Club de France of a powered heavier-than-air machine in Europe and won the Deutsch-Archdeacon Prize for the first officially observed flight further than 25 meters. On November 12, 1906, Santos-Dumont set the first world record recognized by the Federation Aeronautique Internationale by flying 220 metres in 21.5 seconds.

Santos-Dumont made other contributions to the field of aircraft design. He added movable surfaces, the precursor to ailerons, between the wings in an effort to gain more lateral stability than was offered by the *14-bis* wing dihedral. He also pushed for and exploited substantial improvements in engine power-to-weight ratio, and other refinements in aircraft construction techniques.



Alberto Santos-Dumont flying the Demoiselle over Paris

Santos-Dumont's final design was the Demoiselle monoplane (Nos. 19 to 22). This aircraft was employed as Dumont's personal transportation and he willingly let others make use of his design. The fuselage consisted of a specially reinforced bamboo boom, and the pilot sat on a tensionally-held seat between the main wheels of a tricycle landing gear. The Demoiselle was controlled in flight partly by a tail unit that functioned both as elevator and rudder, and by wing warping (No. 20).

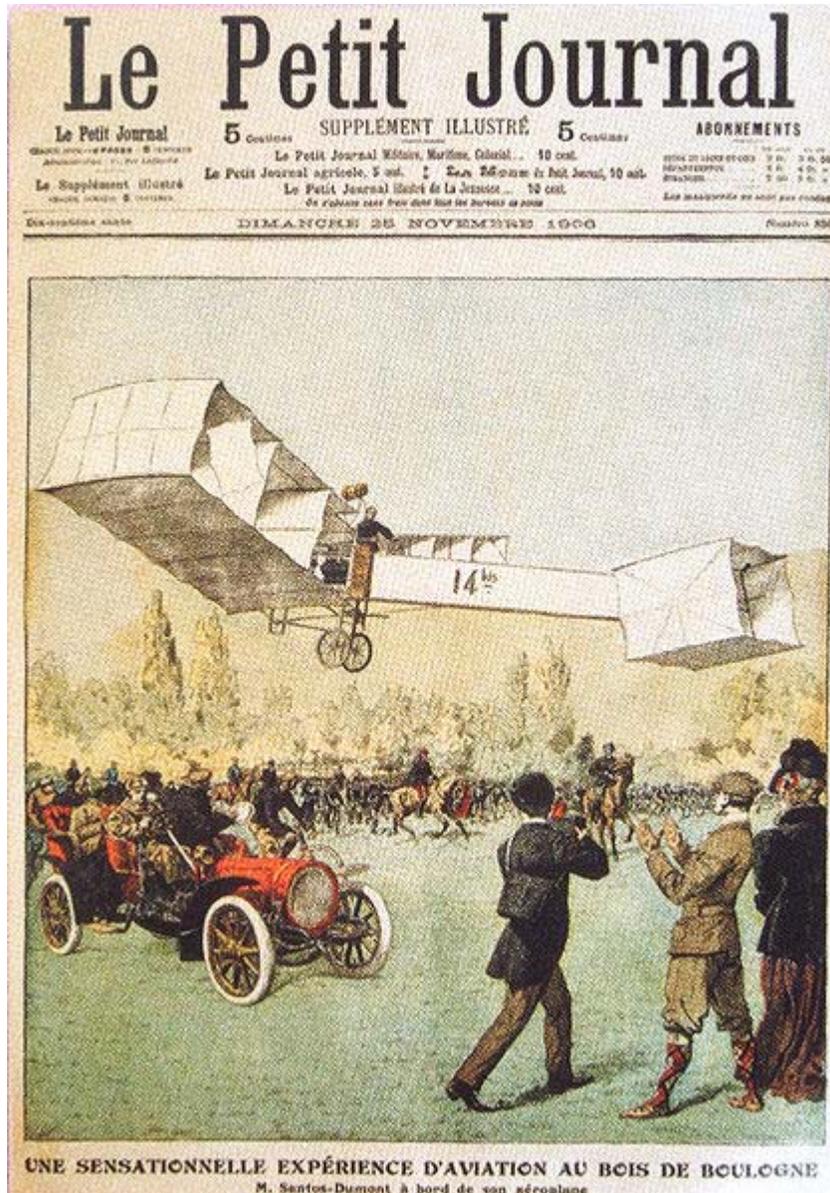
In 1908 Santos-Dumont started working with Adolphe Clément's Clément-Bayard company to build the *Demoiselle No 19*. They planned a production run of 100 units,

built 50 and sold only 15 for 7,500 francs for each airframe. It was the world's first series production aircraft. By 1909 it was offered with a choice of 3 engines, Clement 20 hp; Wright 4-cyl 30 hp (Clement-Bayard had the license to manufacture Wright engines); and Clement-Bayard 40 hp designed by Pierre Clerget. The Demoiselle achieved 120 km/h.

The Demoiselle airplane could be constructed in only 15 days. Possessing outstanding performance, easily covering 200 m of ground during the initial flights and flying at speeds of more than 100 km/h, the Demoiselle was the last aircraft built by Santos-Dumont. The June 1910 edition of the Popular Mechanics magazine published drawings of the Demoiselle and affirmed that "This machine is better than any other which has ever been built, for those who wish to reach results with the least possible expense and with a minimum of experimenting." American companies sold drawings and parts of Demoiselle for several years thereafter. Santos-Dumont was so enthusiastic about aviation that he released the drawings of Demoiselle for free, thinking that aviation would be the mainstream of a new prosperous era for mankind.

The first fixed-wing aircraft: The *14-bis* versus the *Wright Flyers*

Confusion occasionally still arises over whether the Wright 1903 Flyer I, or the 14-Bis was the first true airplane.



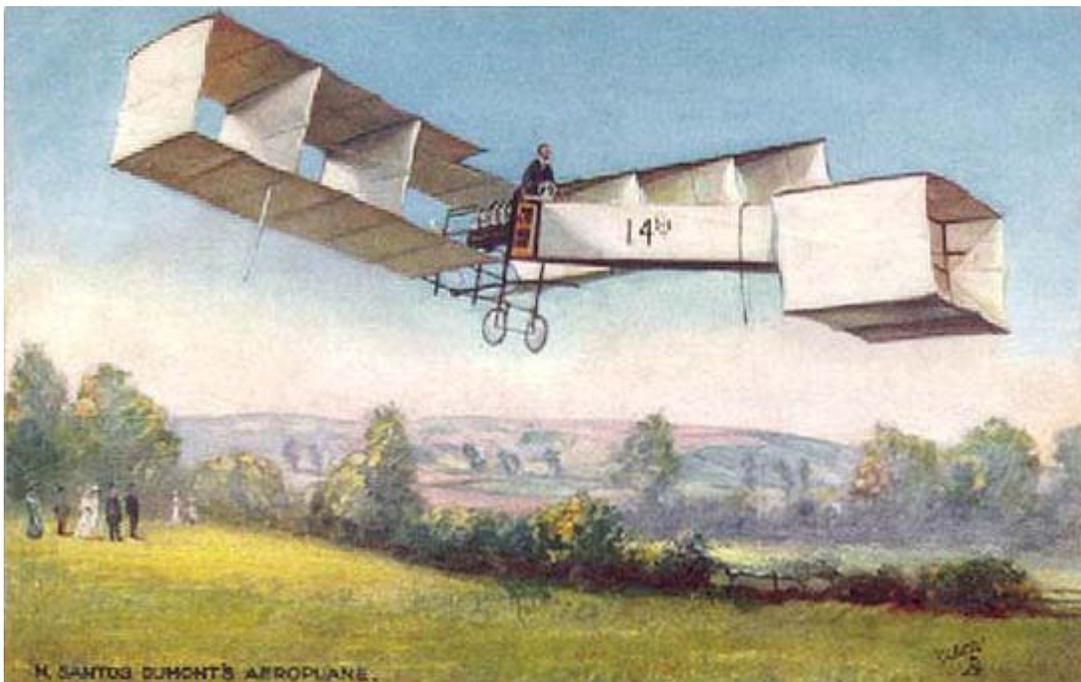
Flight of Santos Dumont, Le Petit Journal, 25 November 1906

While the Wrights later used a launch catapult for their 1904 and 1905 machines, Santos-Dumont and other Europeans used wheels whereas the Wrights stuck with skids for too long, which necessitated the use of a catapult in the absence of significant wind.

The Fédération Aéronautique Internationale, founded in France at the beginning of the century to keep track of aviation records and other aeronautical activities, stated among its rules that an aircraft should be able to take off under its own power in order to qualify for a record. Many Santos-Dumont fans believe this meant the 14-bis was, technically, the first fixed-wing aircraft.

Most points that argue for Santos-Dumont's airplane being the more practical, and thus the first, cite a letter from Wilbur Wright to French Army Captain Ferdinand Ferber, part of which says:

We had already seen by the picture in the New York Herald that the plane rests on three wheels and we deduce from this that Mr. Santos Dumont, in order to effect his take-off, has first to make a run over a long level field. With the aid of the starting-off pillar that we use, Orville and I speedily go right up into the air in a much more practical fashion... We are sure to find a lot in our favor if we come to exhibit in France; but the voyage and the transportation of the machine and the pillar cost much more money than the two poor mechanics can afford to spend; also, dear Captain Ferber, if French experts, under your management, desire to come to Dayton, we will give them a demonstration of the machine in a neighboring field, flying for five minutes in a complete circle and let them have an option of the performance and release of the machine, for \$50,000, cash down.
—W.W.



14-bis on an old postcard

Opinions may vary on whether the Wright Flyer or the 14-bis was the more practical (and thus the "first") heavier-than-air flying machine. Both designs produced aircraft that made free, manned, powered flights. Which one was "first" or "more practical" is a matter of how those words are defined. No one could contest that the Wrights flew first or that Santos-Dumont took off on wheels before the Wrights and earned a variety of prizes and official records in France. Patriotic pride heavily influences opinions of the relative importance and practicality of each aircraft, thus causing debate. U.S. citizens

prefer definitions that make the Wrights the "first" to fly, while Brazilians believe that Santos-Dumont had the first "real", practical aircraft, and that his nationality may have caused his accomplishments to not receive worldwide recognition.

Many other inventors could also claim the title to the first flying machine. From powered, heavier-than-air, but less-than-controllable aircraft, to gliders and balloons, a long series of "flying machines" separately achieved many of the individual criteria that are required of an "aircraft". These achievements, most of them first accomplished in the 1800s, include being able to sustain flight (albeit lighter-than-air flight), using thrust to move wings through the air so as to generate enough lift to rise off the ground (albeit not controllably), and creating a winged vehicle that can stay in the air for more than a few seconds and that can be controlled to turn, dive, climb, etc. (albeit only gliders that required a loss of altitude to "power" them). For example, Frederick Marriott's Avitor was a slightly-heavier-than-air dirigible that was fully controllable. It relied primarily on a large hydrogen gas bag for flight, but it had wings and could only get off the ground by moving forward so that the wings generated the additional lift needed to overcome its weight. Could such a hybrid be "the first heavier-than-air flying machine"? It is only one of many examples of a long history of flying contraptions, so this debate could easily be extended well beyond being about simply the 14-Bis versus the Wright Flyer.

Chapter- 5

Flying Machine by Orville & Wilbur Wright, United States

Flights

Toward flight



Park Ranger Tom White demonstrates a replica of the Wright brothers 1899 box kite at the Wright Brothers Memorial

In July 1899 Wilbur put wing warping to the test by building and flying a five-foot box kite in the approximate shape of a biplane. When the wings were warped, or twisted, one end would receive more lift and rise, starting a turn in the direction of the lower end. Warping was controlled by four lines attached to the kite. The lines led to two sticks held

by the kite flyer, which tilted them in opposite directions to twist the wings and make the kite bank left or right.

In 1900 the brothers journeyed to Kitty Hawk, North Carolina to begin their manned gliding experiments. Wilbur chose the location on the basis of a reply to his first letter to Octave Chanute, whose suggestions included the Atlantic coast for regular breezes and a soft sandy landing surface. Wilbur also requested and scrutinized U.S. Weather Bureau data, and selected Kitty Hawk after writing to the government meteorologist stationed there. The location, although remote, was closer to Dayton than other places Chanute had suggested, including California and Florida. The spot also gave them privacy from reporters, who had turned the 1896 Chanute experiments at Lake Michigan into something of a circus. Chanute visited them in camp each season from 1901 to 1903 and saw gliding experiments, but not the powered flights.

Gliders

The Wrights based the design of their first full-size glider (as well as the 1899 kite) on the work of their recent predecessors, chiefly the Chanute-Herring biplane hang glider ("double-decker", as the Wrights called it), which flew well in the 1896 experiments near Chicago; and aeronautical data on lift that Lilienthal had published. The Wrights designed the wings with camber, a curvature of the top surface. The brothers did not discover this principle, but took advantage of it. The better lift of a cambered surface compared to a flat one was first discussed scientifically by Sir George Cayley. Lilienthal, whose work the Wrights carefully studied, used cambered wings in his gliders, proving in flight the advantage over flat surfaces. The wooden uprights between the wings of the Wright glider were braced by wires in their own adaptation of Chanute's modified "Pratt truss", a bridge-building design he used in his 1896 glider. The Wrights mounted the horizontal elevator in front of the wings rather than behind, apparently believing this feature would help avoid a nosedive and crash like the one that killed Lilienthal. (Later, when the Brazilian aviation pioneer, Santos-Dumont, flew his *14-bis* in Paris in 1906, French newspapers dubbed the tail-first arrangement a "canard", because of the supposed resemblance to a duck in flight.) Wilbur incorrectly believed a tail was not necessary, and their first two gliders did not have one. According to some Wright biographers, Wilbur probably did all the gliding until 1902, perhaps to exercise his authority as older brother and to protect Orville from harm.

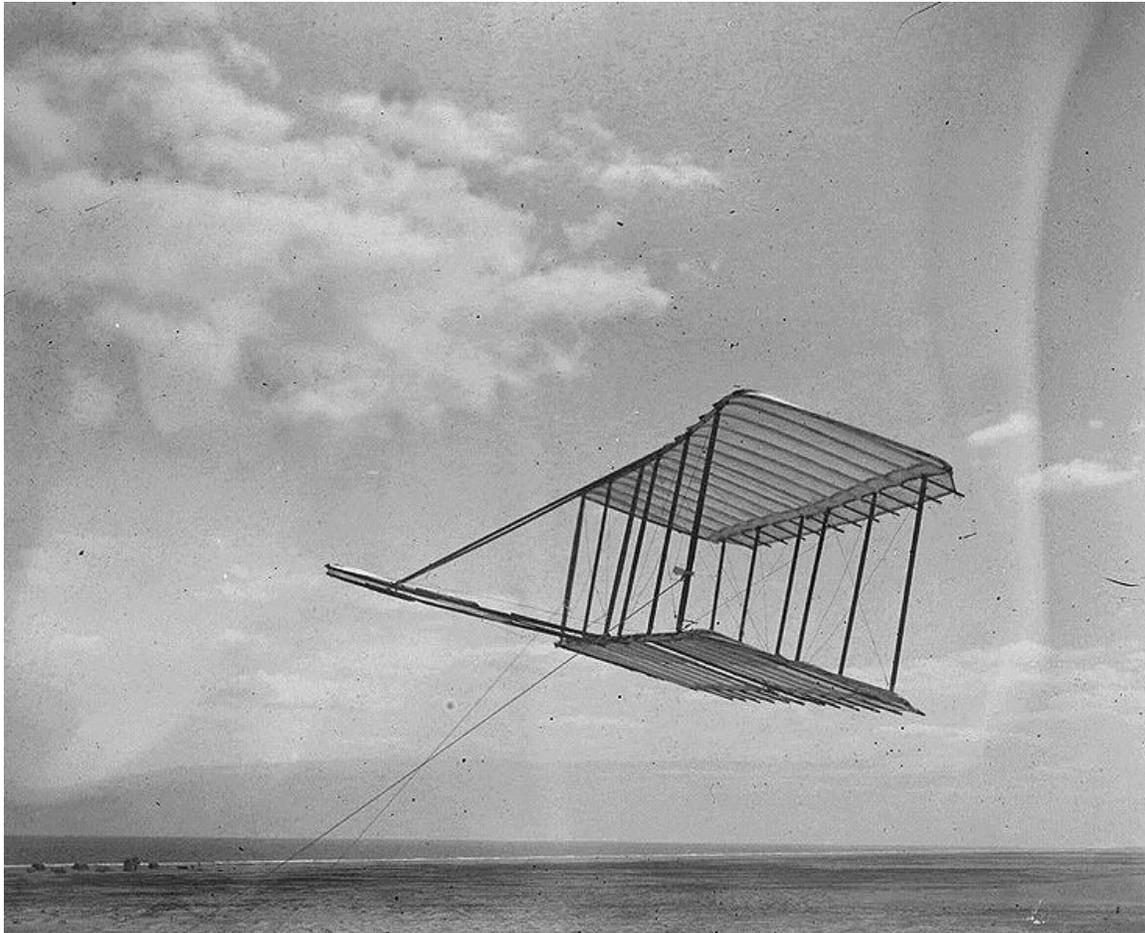
Glider Vital Statistics

	Wingspan	Wing area	Chord	Camber	Aspect ratio	Length	Weight
1900	17 ft 6 in (5.33 m)	165 sq ft (15 m ²)	5 ft (2 m)	1/20	3.5:1	11 ft 6 in (3.51 m)	52 lb (24 kg)
1901	22 ft (7 m)	290 sq ft (27 m ²)	7 ft (2.1 m)	1/12,*1/19	3:1	14 ft (4.3 m)	98 lb (44 kg)
1902	32 ft 1 in (9.78 m)	305 sq ft (28 m ²)	5 ft (1.5 m)	1/20–1/24	6.5:1	17 ft (5.2 m)	112 lb (51 kg)

* (This airfoil caused severe stability problems; the Wrights modified the camber on-site.)

1900 Glider

The brothers flew the glider only a few days in the early autumn of 1900 at Kitty Hawk. In the first tests, probably October 3, Wilbur was aboard while the glider flew as a kite not far above the ground with men below holding tether ropes. Most of the kite tests were unpowered with sandbags or chains (and even a local boy) as onboard ballast.



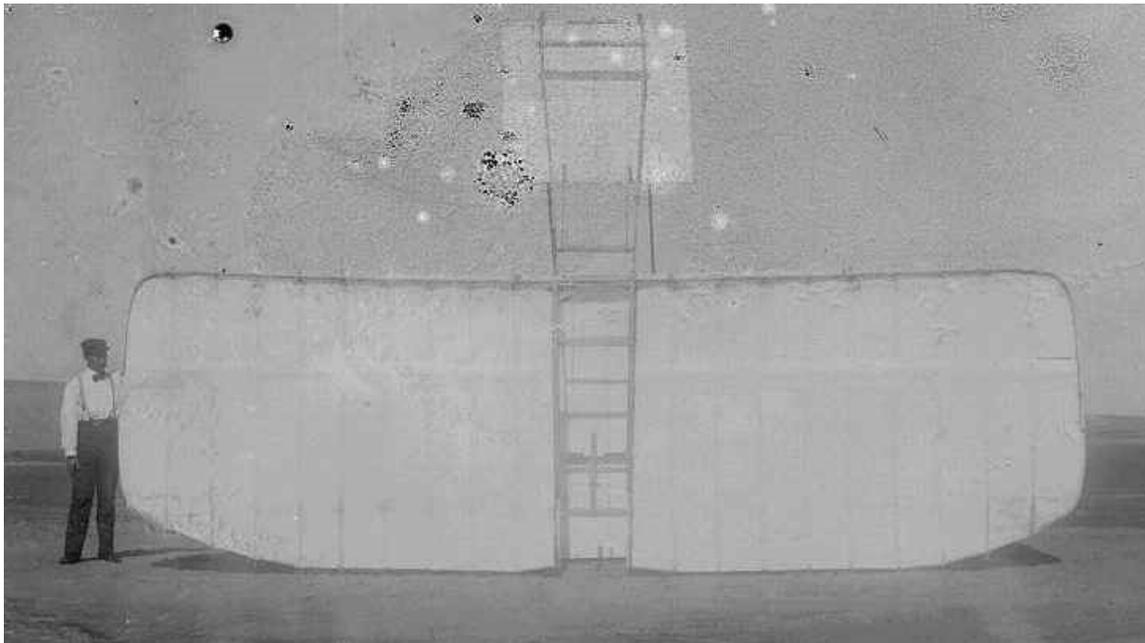
The 1900 glider. No photo was taken with a pilot aboard.

They tested wing-warping using control ropes from the ground. The glider was also tested unmanned while suspended from a small homemade tower. Wilbur (but not Orville) made about a dozen free glides on only a single day. For those tests, the brothers trekked four miles (6 km) south to the Kill Devil Hills, a group of sand dunes up to 100 feet (30 m) high (where they made camp in each of the next three years). Although the glider's lift was less than expected (causing most tests to be unmanned), the brothers were encouraged because the craft's front elevator worked well and they had no

accidents. However, the small number of free glides meant they were not able to give wing-warping a true test.

The pilot lay flat on the lower wing, as planned, to reduce aerodynamic drag. As a glide ended, the pilot was supposed to lower himself to a vertical position through an opening in the wing and land on his feet with his arms wrapped over the framework. Within a few glides, however, they discovered the pilot could remain prone on the wing, headfirst, without undue danger when landing. They made all their flights in that position for the next five years.

1901 Glider



Orville at Kitty Hawk with the 1901 glider, its nose pointed skyward; it had no tail.

Hoping to improve lift, they built the 1901 glider with a much larger wing area and made 50 to 100 flights in July and August for distances of 20 to 400 ft (6 to 122 m). The glider stalled a few times, but the parachute effect of the forward elevator allowed Wilbur to make a safe flat or "pancake" landing, instead of a nose-dive. These incidents wedded the Wrights even more strongly to the *canard* design, which they did not give up until 1910. The glider, however, delivered two major disappointments. It produced only about one-third the lift calculated and sometimes failed to respond properly to wing-warping, turning opposite the direction intended—a problem later known as adverse yaw. On the trip home after their second season, Wilbur, stung with disappointment, remarked to Orville that man would fly, but not in their lifetimes.

The poor lift of the gliders led the Wrights to question the accuracy of Lilienthal's data, as well as the "Smeaton coefficient" of air pressure, which had been in existence for over 100 years and was part of the accepted equation for lift.

The Lift Equation

$$L = k S V^2 C_L$$

L = lift in pounds

k = coefficient of air pressure (Smeaton coefficient)

S = total area of lifting surface in square feet

V = velocity (headwind plus ground speed) in miles per hour

C_L = coefficient of lift (varies with wing shape)



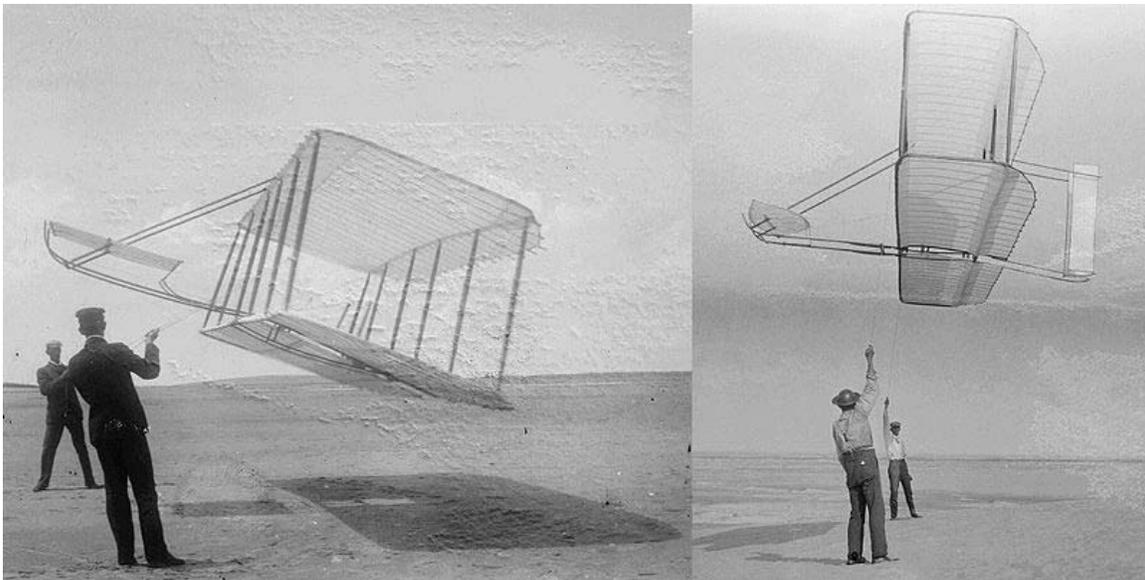
Replica of the Wright brothers' wind tunnel at the Virginia Air and Space Center

The Wrights—and Lilienthal—used the equation to calculate the amount of lift that wings of various sizes would produce. On the basis of measurements of lift and wind during the 1901 glider's kite and free flights, Wilbur believed (correctly, as tests later showed) that the Smeaton number was very close to 0.0033, not the traditionally used 60 percent larger 0.0054, which would exaggerate predicted lift.

Back home, furiously pedaling a strange-looking bicycle on neighborhood streets, they conducted makeshift open-air tests with a miniature Lilienthal airfoil and a counter-acting flat plate, which were both attached to a freely rotating third bicycle wheel mounted

horizontally in front of the handlebars. Because the third wheel rotated against the airfoil instead of remaining motionless as the calculations predicted, the Wrights confirmed their suspicion that published data on lift were unreliable, and they decided to expand their investigation. They also realized that trial-and-error with different wings on full-size gliders was too costly and time-consuming. Putting aside the three-wheel bicycle, they built a six-foot wind tunnel in their shop and conducted systematic tests on miniature wings from October to December 1901. The "balances" they devised and mounted inside the tunnel to hold the wings looked crude, made of bicycle spokes and scrap metal, but were "as critical to the ultimate success of the Wright brothers as were the gliders." The devices allowed the brothers to balance lift against drag and accurately calculate the performance of each wing. They could also see which wings worked well as they looked through the viewing window in the top of the tunnel. Prior to beginning their wind tunnel experiments, Wilbur, at Chanute's invitation, traveled to Chicago to give a speech to the Western Society of Engineers on September 18, 1901. Wilbur's speech consisted of detailed accounts of his and Orville's glider experiments at Kitty Hawk up to the fall of 1901 and was complemented by a lantern slide show of photographs. Wilbur's speech was the first public account of the brothers' experiments.

1902 Glider



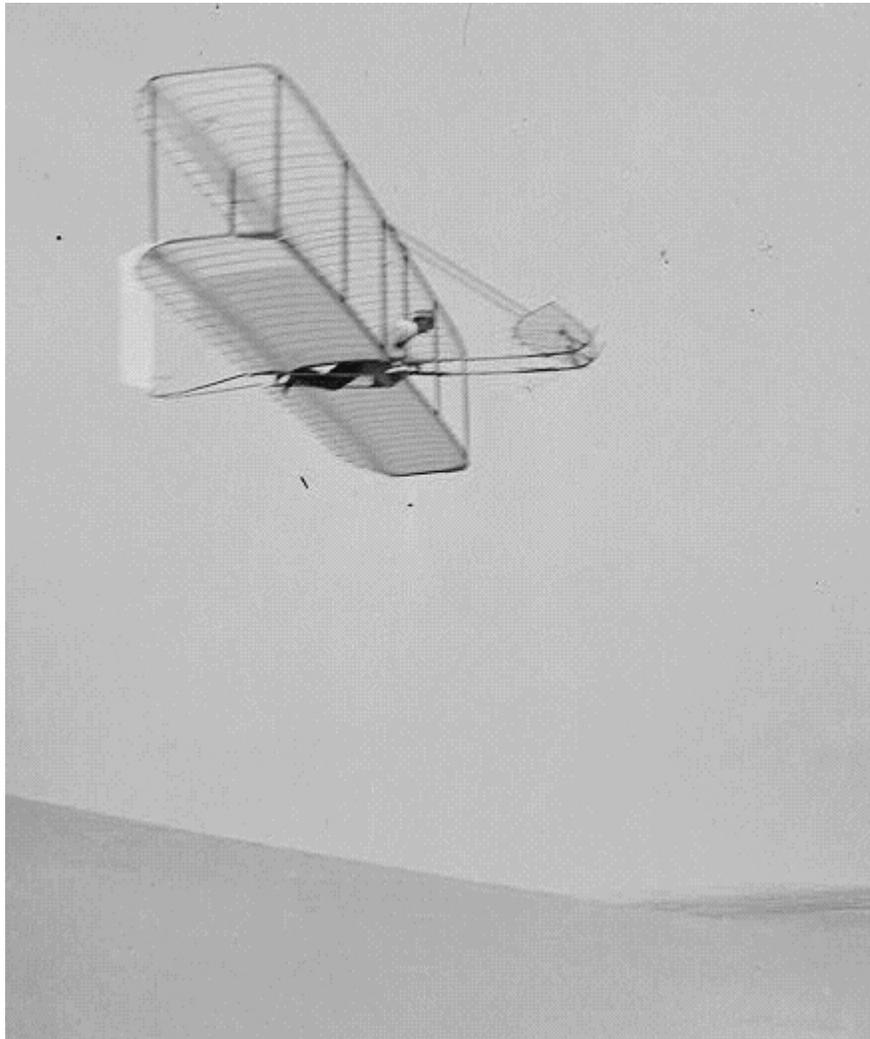
A Big Improvement

At left, 1901 glider flown by Wilbur (left) and Orville. At right, 1902 glider flown by Wilbur (right) and Dan Tate, their helper. Dramatic improvement in performance is apparent. The 1901 glider flies at a steep angle of attack due to poor lift and high drag. In contrast, the 1902 glider flies at a much flatter angle and holds up its tether lines almost vertically, clearly demonstrating a much better lift-to-drag ratio.

Lilienthal had made "whirling arm" tests on only a few wing shapes, and the Wrights mistakenly assumed the data would apply to their wings, which had a different shape. The Wrights took a huge step forward and made basic wind tunnel tests on 200 wings of

many shapes and airfoil curves, followed by detailed tests on 38 of them. The tests, according to biographer Howard, "were the most crucial and fruitful aeronautical experiments ever conducted in so short a time with so few materials and at so little expense". An important discovery was the benefit of longer narrower wings: in aeronautical terms, wings with a larger aspect ratio (wingspan divided by chord—the wing's front-to-back dimension). Such shapes offered much better lift-to-drag ratio than the broader wings the brothers had tried so far.

With this knowledge, and a more accurate Smeaton number, the Wrights designed their 1902 glider. Using another crucial discovery from the wind tunnel, they made the airfoil flatter, reducing the camber (the depth of the wing's curvature divided by its chord). The 1901 wings had significantly greater curvature, a highly inefficient feature the Wrights copied directly from Lilienthal. Fully confident in their new wind tunnel results, the Wrights discarded Lilienthal's data, now basing their designs on their own calculations.



Wilbur Wright pilots the 1902 glider over the Kill Devil Hills, October 10, 1902. The single rear rudder is steerable; it replaced the original fixed double rudder.

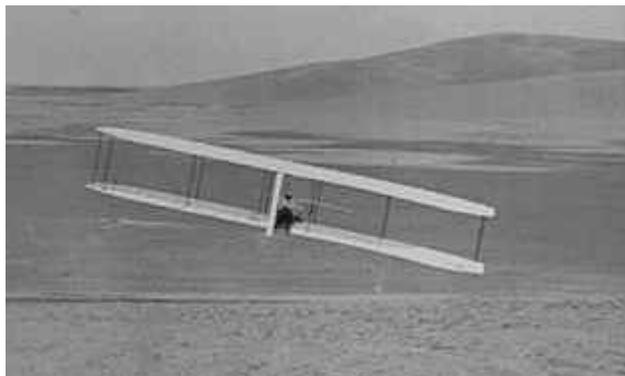
With characteristic caution, the brothers first flew the 1902 glider as an unmanned kite, as they had done with their two previous versions. Rewarding their wind tunnel work, the glider produced the expected lift. It also had a new structural feature: a fixed, rear vertical rudder, which the brothers hoped would eliminate turning problems.

By 1902 they realized that wing-warping created "differential drag" at the wingtips. Greater lift at one end of the wing also increased drag, which slowed that end of the wing, making the aircraft swivel—or "yaw"—so the nose pointed away from the turn. That was how the tailless 1901 glider behaved.

The improved wing design enabled consistently longer glides, and the rear rudder prevented adverse yaw—so effectively that it introduced a new problem. Sometimes when the pilot attempted to level off from a turn, the glider failed to respond to corrective wing-warping and persisted into a tighter turn. The glider would slide toward the lower wing, which hit the ground, spinning the aircraft around. The Wrights called this "well digging".

Orville apparently visualized that the fixed rudder resisted the effect of corrective wing-warping when attempting to level off from a turn. He wrote in his diary that on the night of October 2, "I studied out a new vertical rudder". The brothers then decided to make the rear rudder movable to solve the problem. They hinged the rudder and connected it to the pilot's warping "cradle", so a single movement by the pilot simultaneously controlled wing-warping and rudder deflection. Tests while gliding proved that the trailing edge of the rudder should be turned away from whichever end of the wings had more drag (and lift) due to warping. The opposing pressure produced by turning the rudder enabled corrective wing-warping to reliably restore level flight after a turn or a wind disturbance. Furthermore, when the glider banked into a turn, rudder pressure overcame the effect of differential drag and pointed the nose of the aircraft in the direction of the turn, eliminating adverse yaw.

In short, the Wrights discovered the true purpose of the movable vertical rudder. Its role was not to change the direction of flight, but rather, to aim or align the aircraft correctly during banking turns and when leveling off from turns and wind disturbances. The actual turn—the change in direction—was done with roll control using wing-warping. The principles remained the same when ailerons superseded wing-warping.



Wilbur makes a turn using wing-warping and the movable rudder, October 24, 1902.

With their new method the Wrights achieved true control in turns for the first time on October 8, 1902, a major milestone. During September and October they made between 700 and 1,000 glides, the longest lasting 26 seconds and covering 622.5 feet (189.7 m). Hundreds of well-controlled glides after they made the rudder steerable convinced them they were ready to build a powered flying machine.

Thus did three-axis control evolve: wing-warping for roll (lateral motion), forward elevator for pitch (up and down) and rear rudder for yaw (side to side). On March 23, 1903, the Wrights applied for their famous patent for a "Flying Machine", based on their successful 1902 glider. Some aviation historians believe that applying the system of three-axis flight control on the 1902 glider was equal to, or even more significant, than the addition of power to the 1903 Flyer. Peter Jakab of the Smithsonian asserts that perfection of the 1902 glider essentially represents invention of the airplane.

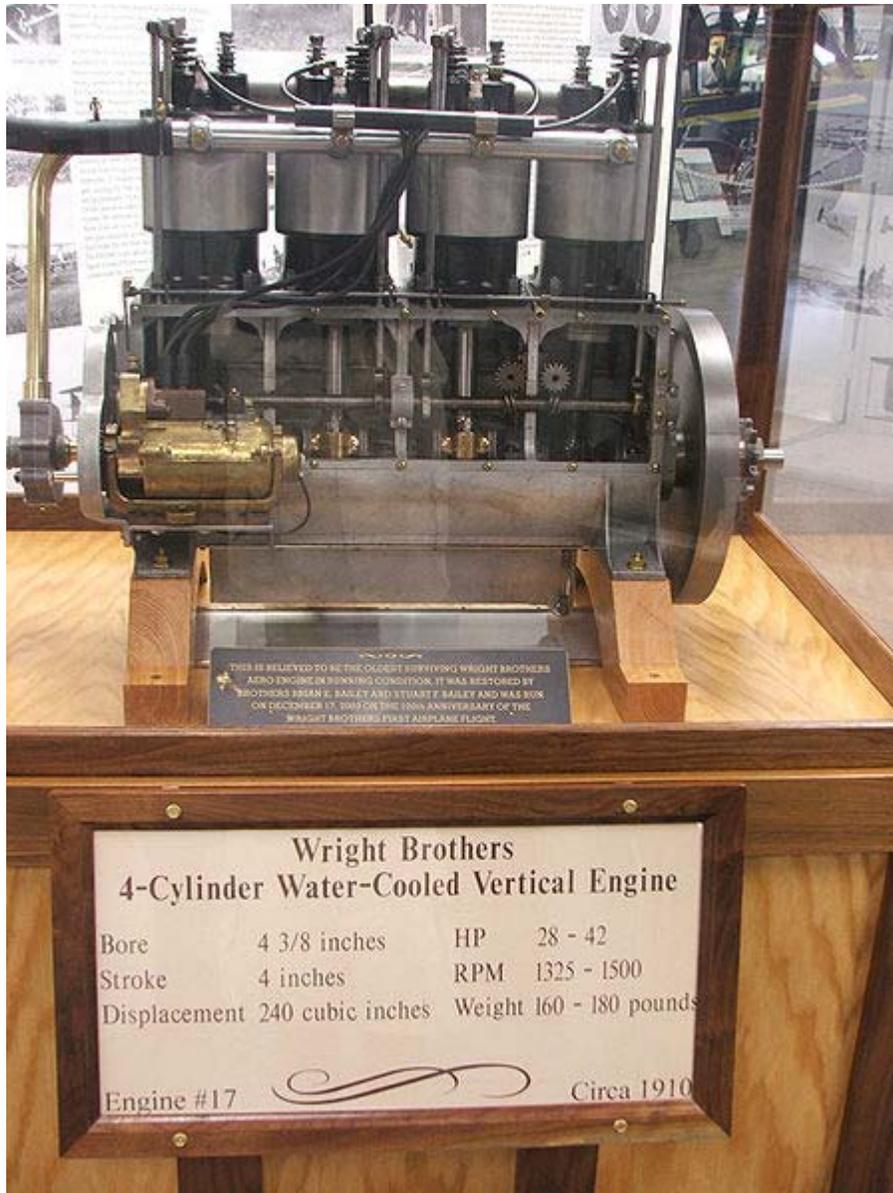
Adding power



First flight of the Wright Flyer I, December 17, 1903, Orville piloting, Wilbur running at wingtip.

In 1903 the brothers built the powered Wright Flyer I, using their preferred material for construction, spruce, a strong and lightweight wood, and Pride of the West muslin for surface coverings. They also designed and carved their own wooden propellers, and had a purpose-built gasoline engine fabricated in their bicycle shop. They thought propeller design would be a simple matter and intended to adapt data from shipbuilding. However, their library research disclosed no established formulas for either marine or air propellers, and they found themselves with no sure starting point. They discussed and argued the question, sometimes heatedly, until they concluded that an aeronautical propeller is essentially a wing rotating in the vertical plane. On that basis, they used data from more wind tunnel tests to design their propellers. The finished blades were just over eight feet long, made of three laminations of glued spruce. The Wrights decided on twin "pusher" propellers (counter-rotating to cancel torque), which would act on a greater quantity of air than a single relatively slow propeller and not disturb airflow over the leading edge of the wings.

Wilbur made a March 1903 entry in his notebook indicating the prototype propeller was 66% efficient. Modern wind tunnel tests on reproduction 1903 propellers show they were more than 75% efficient under the conditions of the first flights, and actually had a peak efficiency of 82%. This is a remarkable achievement, considering that modern wooden propellers have a maximum efficiency of 85%.



A Wright engine, serial number 17, circa 1910, is on display at the New England Air Museum in Windsor Locks, Connecticut.

The Wrights wrote to several engine manufacturers, but none met their need for a sufficiently lightweight powerplant. They turned to their shop mechanic, Charlie Taylor, who built an engine in just six weeks in close consultation with the brothers. To keep the weight low enough, the engine block was cast from aluminum, a rare practice for the time. The Wright/Taylor engine was a primitive version of modern fuel-injection systems, having no carburetor or fuel pump. Gasoline was gravity-fed into the crankcase through a rubber tube from the fuel tank mounted on a wing strut.

The propeller drive chains, resembling those of bicycles, were actually supplied by a manufacturer of heavy-duty automobile chain-drives. The *Flyer* cost less than a thousand

dollars, in contrast to more than \$50,000 in government funds given to Samuel Langley for his man-carrying Great Aerodrome. The Flyer had a wingspan of 40.3 ft (12.3 m), weighed 605 lb (274 kg) and sported a 12 horsepower (8.9 kW) 180 lb (82 kg) engine.

In camp at Kill Devil Hills, they suffered weeks of delays caused by broken propeller shafts during engine tests. After the shafts were replaced (requiring two trips back to Dayton), Wilbur won a coin toss and made a three-second flight attempt on December 14, 1903, stalling after takeoff and causing minor damage to the Flyer. (Because December 13, 1903, was a Sunday, the brothers did not make any attempts that day, even though the weather was good.) In a message to their family, Wilbur referred to the trial as having "only partial success", stating "the power is ample, and but for a trifling error due to lack of experience with this machine and this method of starting, the machine would undoubtedly have flown beautifully." Following repairs, the Wrights finally took to the air on December 17, 1903, making two flights each from level ground into a freezing headwind gusting to 27 miles per hour (43 km/h). The first flight, by Orville, of 120 feet (37 m) in 12 seconds, at a speed of only 6.8 miles per hour (10.9 km/h) over the ground, was recorded in a famous photograph. The next two flights covered approximately 175 feet (53 m) and 200 feet (61 m), by Wilbur and Orville respectively. Their altitude was about 10 feet (3.0 m) above the ground. The following is Orville Wright's account of the final flight of the day:

Wilbur started the fourth and last flight at just about 12 o'clock. The first few hundred feet were up and down, as before, but by the time three hundred ft had been covered, the machine was under much better control. The course for the next four or five hundred feet had but little undulation. However, when out about eight hundred feet the machine began pitching again, and, in one of its darts downward, struck the ground. The distance over the ground was measured to be 852 feet; the time of the flight was 59 seconds. The frame supporting the front rudder was badly broken, but the main part of the machine was not injured at all. We estimated that the machine could be put in condition for flight again in about a day or two.

54.
 fur on the other. As a result the machine would rise suddenly and then as suddenly, on turning the rudder, dart for the ground. A sudden dart when out about 100 feet from the end of the tracks ended the flight. Time about 12 seconds (not known exactly as watch was not promptly stopped). The second flight here for throwing off the engine was broken, and the skid under the rudder cracked. After repairs, at 20 min after 11 o'clock Will made the second trial. The course was about like mine, up and down but a little longer over the ground though about the same in time. Did not measure but about 175 ft. Wind speed not quite so strong. With the aid of the station men present, we picked the machine up and carried it back to the starting ways. At about 20 minutes till 12 o'clock I made the third trial, ^{out} Will about the same distance as Will's, I met with a strong gust from the left which raised the left wing and sidled the machine off to the right in a lively manner. I immediately turned the rudder to bring the machine down and then worked the end control. Much to our surprise, on reaching the ground the left wing struck first, showing the lateral control of this machine much more effective than on any of our former ones. At the time of its sidling it had raised to a height of probably 12 to 14 feet. At just 12 o'clock Will started on the fourth and last trip. The machine started off with its ups and downs as it had before, but by the time he had gone three or four hundred feet he had it under much

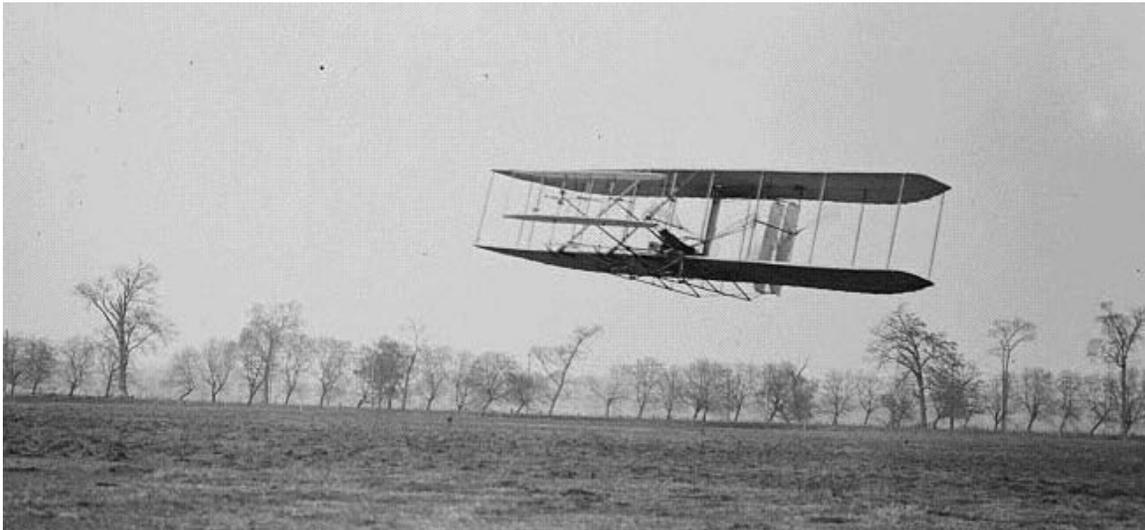
Orville's notebook entry of December 17, 1903

Five people witnessed the flights: Adam Etheridge, John T. Daniels (who snapped the famous "first flight" photo using Orville's pre-positioned camera) and Will Dough, all of the U.S. government coastal lifesaving crew; area businessman W.C. Brinkley; and Johnny Moore, a teenaged boy who lived in the area. After the men hauled the Flyer back from its fourth flight, a powerful gust of wind flipped it over several times, despite the crew's attempt to hold it down. Severely damaged, the airplane never flew again. The brothers shipped it home, and years later Orville restored it, lending it to several U.S. locations for display, then to a British museum, before it was finally installed in the Smithsonian Institution in Washington, D.C. in 1948, its current residence.

The Wrights sent a telegram about the flights to their father, requesting that he "inform press." However, the *Dayton Journal* refused to publish the story, saying the flights were too short to be important. Meanwhile, against the brothers' wishes, a telegraph operator leaked their message to a Virginia newspaper, which concocted a highly inaccurate news article that was reprinted the next day in several newspapers elsewhere, including Dayton. The Wrights issued their own factual statement to the press in January. Nevertheless, the flights did not create public excitement—if people even knew about them—and the news soon faded. (In Paris, however, Aero Club of France members, already stimulated by Chanute's reports of Wright gliding successes, took the news more seriously and increased their efforts to catch up to the brothers.)

Modern analysis by Professor Fred E. C. Culick and Henry R. Jex (in 1985) has demonstrated that the 1903 Wright Flyer was so unstable as to be almost unmanageable by anyone but the Wrights, who had trained themselves in the 1902 glider.

Trouble establishing legitimacy



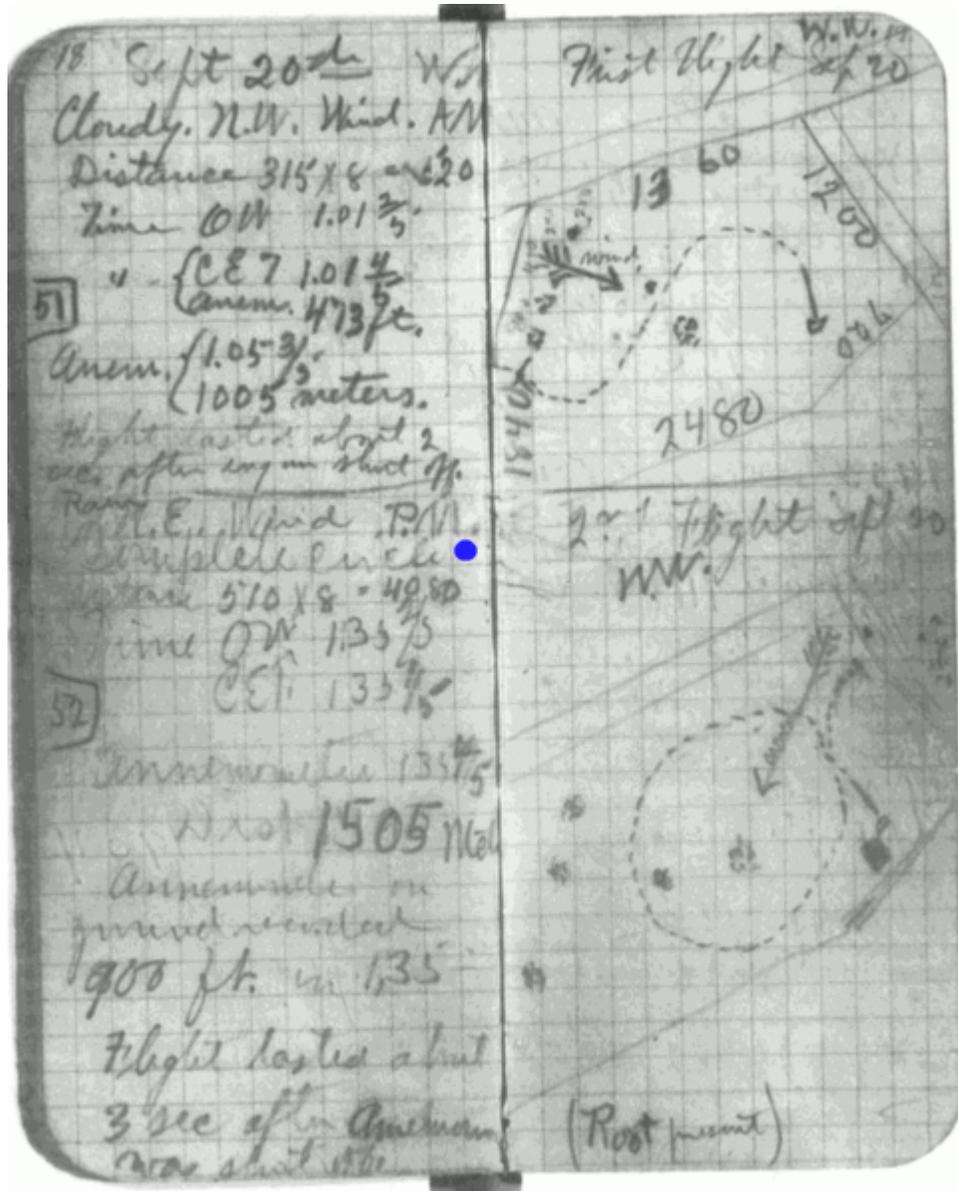
Orville in flight over Huffman Prairie in Wright Flyer II. Flight #85, approximately 1,760 feet (536 m) in 40 1/5 seconds, November 16, 1904.

In 1904 the Wrights built the *Flyer II*. They decided to avoid the expense of travel and bringing supplies to the Outer Banks and set up an airfield at Huffman Prairie, a cow pasture eight miles (13 km) northeast of Dayton. They received permission to use the field rent-free from owner and bank president Torrance Huffman. They invited reporters to their first flight attempt of the year on May 23, on the condition that no photographs be taken. Engine troubles and slack winds prevented any flying, and they could manage only a very short hop a few days later with fewer reporters present. Some scholars of the Wrights speculate the brothers may have intentionally failed to fly in order to disinterest reporters in their experiments. Whether that is true is not known, but after their poor showing local newspapers virtually ignored them for the next year and a half.

The Wrights were glad to be free from the distraction of reporters. The absence of newsmen also reduced the chance of competitors learning their methods. After the Kitty Hawk powered flights, the Wrights made a decision to begin withdrawing from the bicycle business so they could devote themselves to creating and marketing a practical airplane. The decision was financially risky, since they were neither wealthy nor government-funded (unlike other experimenters such as Ader, Maxim, Langley and Santos-Dumont). The Wright brothers did not have the luxury of giving away their invention; it was to be their livelihood. Thus, their secrecy intensified, encouraged by advice from their patent attorney, Henry Toulmin, not to reveal details of their machine.



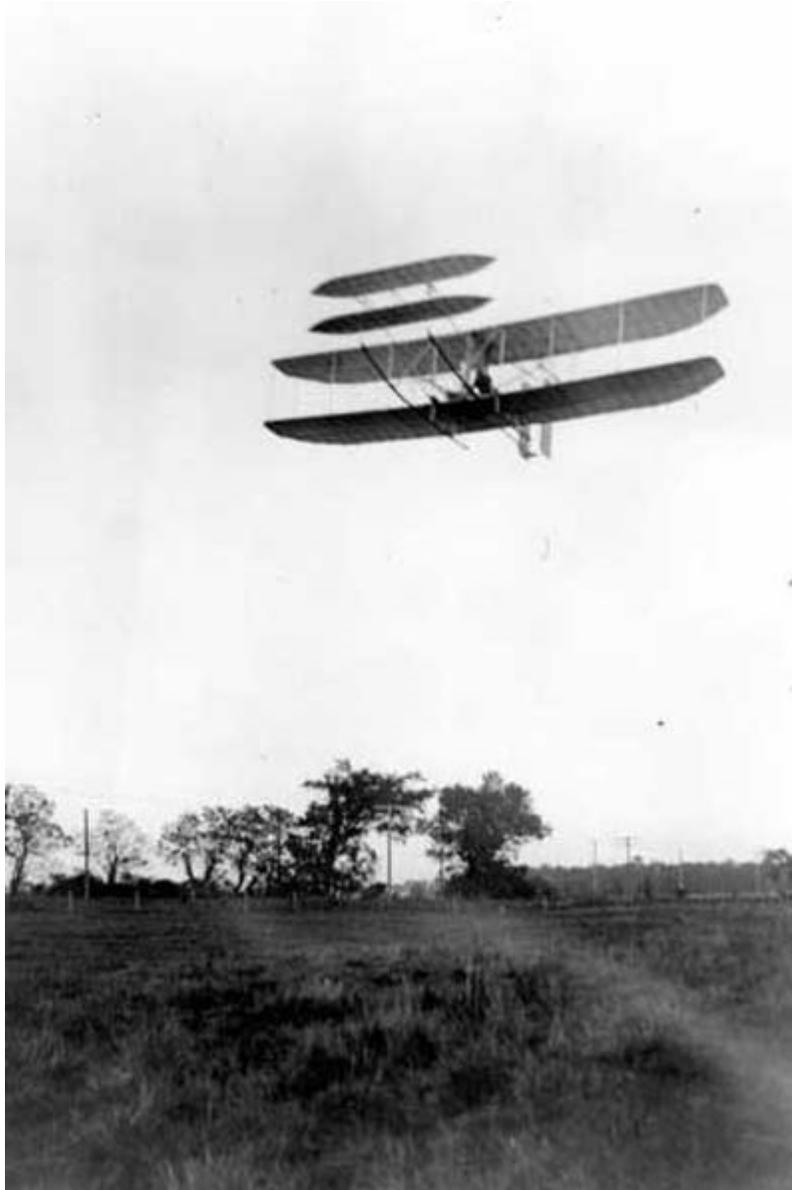
Wilbur flying almost four circles of Huffman Prairie, about 2 and 3/4 miles in 5 minutes 4 seconds; flight #82, November 9, 1904.



Wilbur's logbook showing diagram and data for first circle flight on September 20, 1904

At Huffman Prairie, lighter winds and lower air density than in Kitty Hawk (because of Ohio's higher altitude and higher temperatures) made takeoffs very difficult, and they had to use a much longer starting rail, stretching to hundreds of feet, compared to the 60-foot (18 m) rail at Kitty Hawk. During the spring and summer they suffered many hard landings, real crackups, repeated Flyer damage, and bodily bumps and bruises. On August 13, making an unassisted takeoff, Wilbur finally exceeded their best Kitty Hawk effort with a flight of 1,300 feet (400 m). Then they decided to use a weight-powered catapult to make takeoffs easier and tried it for the first time on September 7. On September 20, 1904, Wilbur flew the first complete circle in history by a manned heavier-than-air powered machine, covering 4,080 feet (1,244 m) in about a minute and a half. Their two best flights were November 9 by Wilbur and December 1 by Orville, each

exceeding five minutes and covering nearly three miles in almost four circles. By the end of the year the brothers had accumulated about 50 minutes in the air in 105 flights over the rather soggy 85-acre (340,000 m²) pasture, which, remarkably, is virtually unchanged today from its original condition and is now part of Dayton Aviation Heritage National Historical Park, adjacent to Wright-Patterson Air Force Base. Despite progress in 1904, the Flyer was still frequently out of control. The Wrights scrapped the battered and much-repaired airplane, but saved the engine, and in 1905 built a new *Flyer III*, which included an important design change. The brothers installed a separate control for the rear rudder instead of linking the rudder to the wing-warping "cradle" as before. Each of the three axes—pitch, roll and yaw—now had its own independent control. Nevertheless, this Flyer offered the same marginal performance as the first two. Its maiden flight was June 23 and the first several flights were no longer than 10 seconds. After Orville suffered a bone-jarring and potentially fatal crash on July 14, they rebuilt the Flyer with the forward elevator and rear rudder both enlarged and placed several feet farther away from the wings. These modifications greatly improved stability and control, setting the stage for a series of six dramatic "long flights" ranging from 17 to 38 minutes and 11 to 24 miles (39 km) around the three-quarter mile course over Huffman Prairie between September 26 and October 5. Wilbur made the last and longest flight, 24.5 miles (39.4 km) in 38 minutes and 3 seconds, ending with a safe landing when the fuel ran out. The flight was seen by a number of people, including several invited friends, their father Milton, and neighboring farmers.



Wright Flyer III piloted by Orville over Huffman Prairie, October 4, 1905. Flight #46, covering 20 and 3/4 miles in 33 minutes 17 seconds; last photographed flight of the year

Reporters showed up the next day (only their second appearance at the field since May the previous year), but the brothers declined to fly. The long flights convinced the Wrights they had achieved their goal of creating a flying machine of "practical utility" which they could offer to sell.

The only photos of the flights of 1904–1905 were taken by the brothers. (A few photos were damaged in the Great Dayton Flood of 1913, but most survived intact.) In 1904 Ohio beekeeping businessman Amos Root, a technology enthusiast, saw a few flights including the first circle. Articles he wrote for his beekeeping magazine were the only published eyewitness reports of the Huffman Prairie flights, except for the unimpressive

early hop local newsmen saw. Root offered a report to *Scientific American* magazine, but the editor turned it down. As a result, the news was not widely known outside of Ohio, and was often met with skepticism. The Paris edition of the Herald Tribune headlined a 1906 article on the Wrights "FLYERS OR LIARS?"

In years to come Dayton newspapers would proudly celebrate the hometown Wright brothers as national heroes, but the local reporters somehow missed one of the most important stories in history as it was happening a few miles from their doorstep. James M. Cox, publisher at that time of the Dayton Daily News (later governor of Ohio and Democratic presidential nominee in 1920), expressed the attitude of newspapermen—and the public—in those days when he admitted years later, "Frankly, none of us believed it."



The *Dayton Daily News* reported the October 5 flight on page 9, with agriculture and business news.

A few newspapers published articles about the long flights, but no reporters or photographers had been there. The lack of splashy eyewitness press coverage was a major reason for disbelief in Washington, D.C. and Europe and in journals like *Scientific American*, whose editors doubted the "alleged experiments" and asked how U.S. newspapers, "alert as they are, allowed these sensational performances to escape their notice."

The Wright brothers were certainly complicit in the lack of attention they received. Fearful of competitors stealing their ideas, and still without a patent, they flew on only one more day after October 5. From then on, they refused to fly anywhere unless they had a firm contract to sell their aircraft. They wrote to the U.S. government, then to Britain, France and Germany with an offer to sell a flying machine, but were rebuffed because they insisted on a signed contract before giving a demonstration. They were unwilling even to show their photographs of the airborne Flyer. The American military, having recently spent \$50,000 on the Langley Aerodrome—a product of the nation's foremost scientist—only to see it plunge twice into the Potomac River "like a handful of mortar", was particularly unreceptive to the claims of two unknown bicycle makers from Ohio. Thus, doubted or scorned, the Wright brothers continued their work in semi-obscurity, while other aviation pioneers like Brazilian Alberto Santos-Dumont, Henri Farman, Leon Delagrange and American Glenn Curtiss entered the limelight.

European skepticism

In 1906, skeptics in the European aviation community had converted the press to an anti-Wright brothers stance. European newspapers, especially in France, were openly derisive, calling them *bluffeurs* (bluffers). Ernest Archdeacon, founder of the Aéro-Club de France, was publicly scornful of the brother's claims in spite of published reports; specifically, he wrote several articles and in 1906, stated that "the French would make the first public demonstration of powered flight".

The Paris edition of the *New York Herald* summed up Europe's opinion of the Wright brothers in an editorial on February 10, 1906:

The Wrights have flown or they have not flown. They possess a machine or they do not possess one. They are in fact either fliers or liars. It is difficult to fly. It's easy to say, 'We have flown.'

Alberto Santos-Dumont's public flight in October 1906 was the first certified by the Aéro-Club de France and the Fédération Aéronautique Internationale (FAI). In 1908, after the Wrights' first flights in France, Archdeacon publicly admitted that he had done them an injustice.

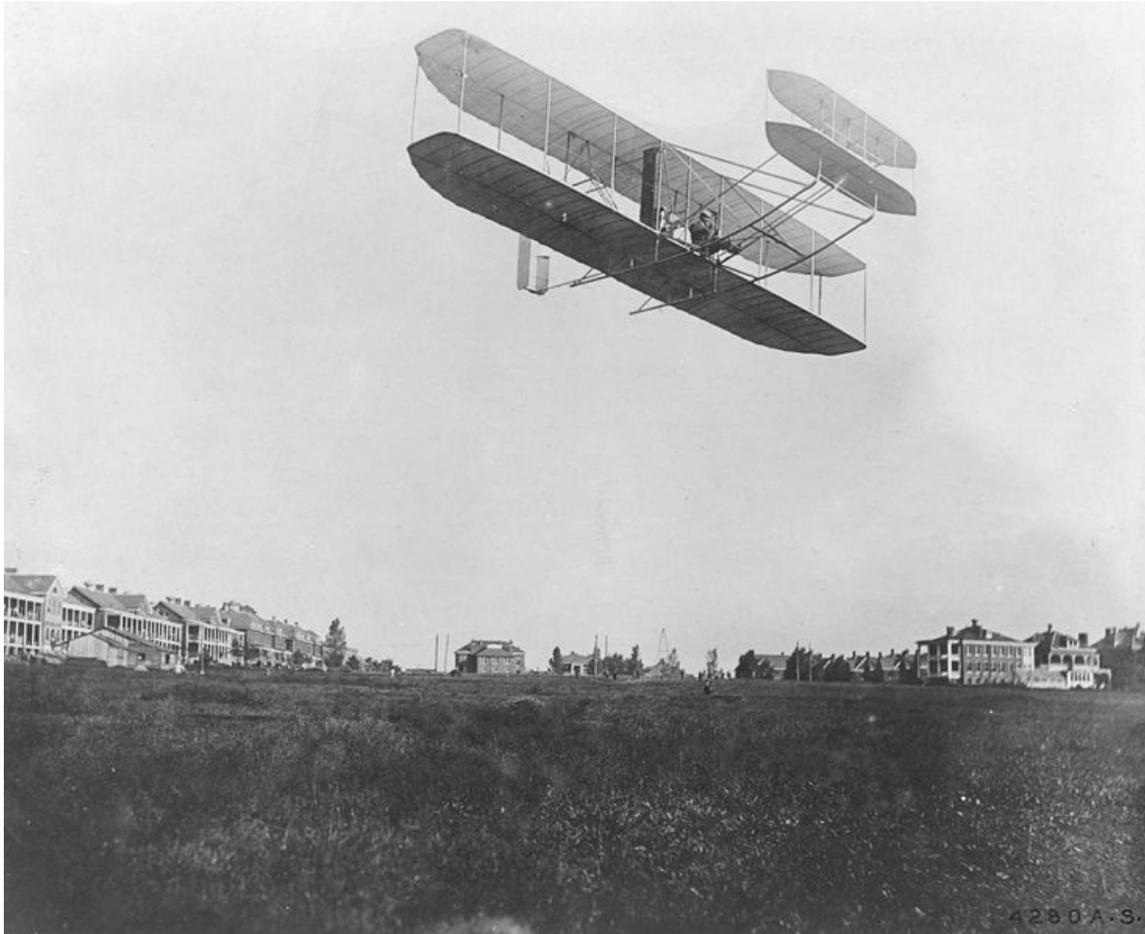
Return to Kitty Hawk May 1908

The Wright brothers made no flights at all in 1906 and 1907 while they pursued fitful negotiations with the U.S. and European governments. While grounded they experimented with a pontoon and engine setup on the Miami River in hopes of flying their airplane from the water. These experiments proved unsuccessful. In May 1906 they were finally granted a patent for their flying machine. In 1907 the brothers journeyed to Europe for the first time for face-to-face talks with government bureaucrats and businessmen. Orville joined his brother two months after Wilbur's departure, but first packed a new Model A Flyer in a crate which was shipped to France and left in storage at Le Havre in anticipation of demonstration flights. In early 1908 the Wrights finally signed contracts with a French company and the U.S. Army. In May they went back to Kitty Hawk with their 1905 Flyer to practice for their all-important demonstration flights. They had not been to the camp in four and a half years and had to rebuild their two sheds, which had been badly damaged by weather and scavengers; the 1902 glider was in a hopeless state of disrepair.

Their American and French contracts required them to be able to carry a passenger. They modified the 1905 Flyer by installing two seats and adding upright control levers. After tests with sandbags in the passenger seat, Charlie Furnas, a helper from Dayton, became the first fixed-wing aircraft passenger on a few short flights May 14. For safety, and as a promise to their father, Wilbur and Orville did not fly together. However, several newspaper accounts at the time mistakenly took Orville's flight with Furnas as both brothers flying together. Later that day after flying solo seven minutes, Wilbur suffered

his worst crash when, still not well-acquainted with the two control levers, he apparently moved one the wrong way and slammed the Flyer into the sand between 40 and 50 miles (80 km) an hour. He emerged with only bruises and a cut nose, but the accident ended the practice flights—and the airplane's flying career.

Public showing



Orville demonstrating the flyer to the U.S. Army, Fort Myer, Virginia September 1908.
Photo: by C.H. Claudy.



Hart O. Berg (left), the Wrights' business agent, and Wilbur at the flying field near Le Mans.

The brothers' contracts with the U.S. Army and a French syndicate depended on successful public flight demonstrations that met certain conditions. The brothers had to divide their efforts. Wilbur sailed for Europe; Orville would fly near Washington, D.C.

Facing a lot of skepticism in the French aeronautical community and outright scorn by some newspapers that called him a "bluffeur," Wilbur began official public demonstrations on August 8, 1908 at the Hunaudières horse racing track near the town of Le Mans, France. His first flight lasted only one minute 45 seconds, but his ability to effortlessly make banking turns and fly a circle amazed and stunned onlookers, including several pioneer French aviators, among them Louis Bleriot. In the following days, Wilbur made a series of technically challenging flights, including figure-eights, demonstrating his skills as a pilot and the capability of his flying machine, which far surpassed those of all other pilot pioneers.

The French public was thrilled by Wilbur's feats and flocked to the field by the thousands. The Wright brothers catapulted to world fame overnight. Former doubters issued apologies and effusive praise. *L'Aérophile* editor Georges Besançon wrote that the flights "have completely dissipated all doubts. Not one of the former detractors of the Wrights dare question, today, the previous experiments of the men who were truly the first to fly...." Leading French aviation promoter Ernest Archdeacon wrote, "For a long time, the Wright brothers have been accused in Europe of bluff... They are today hallowed in France, and I feel an intense pleasure...to make amends."

On October 7, 1908, Edith Berg, the wife of the brothers' European business agent, became the first American woman passenger when she flew with Wilbur—one of many

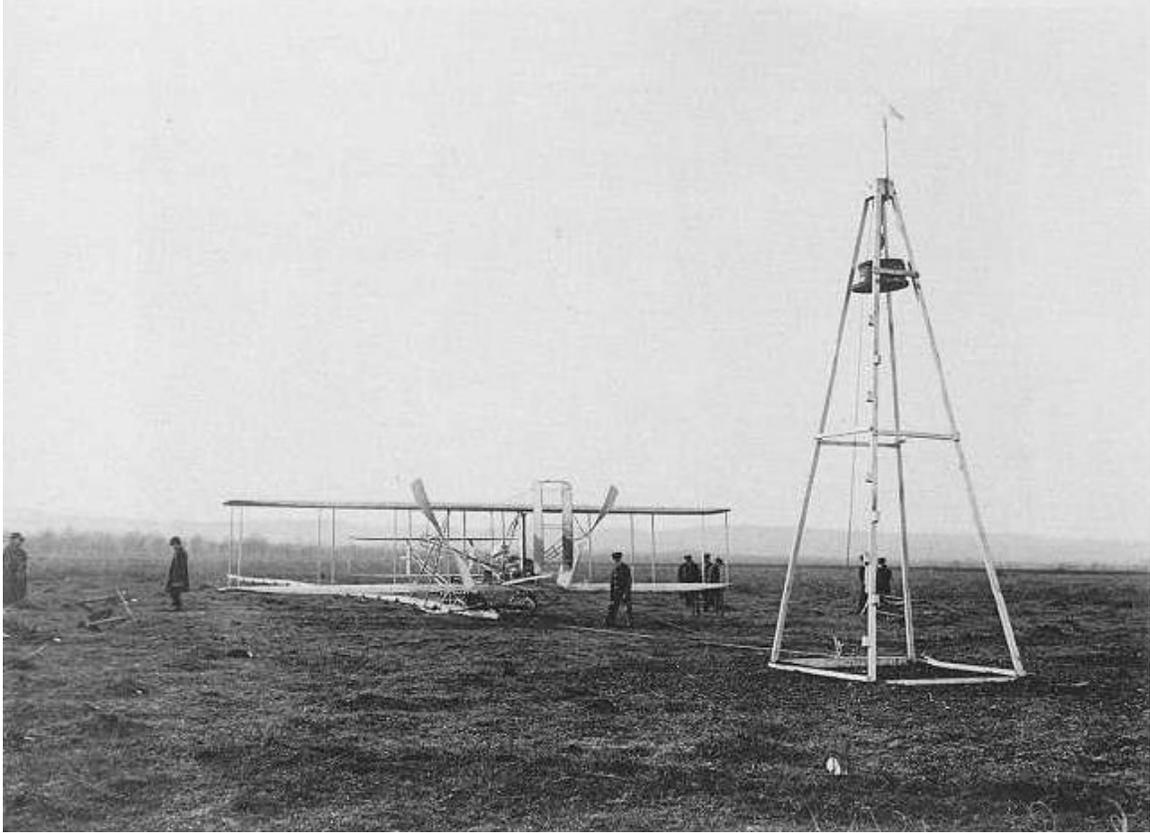
passengers who rode with him that autumn. Wilbur also became acquainted with Léon Bollée and his family. Bollee was the owner of an automobile factory where Wilbur would assemble the Flyer and where he would be provided with hired assistance. Bollee would fly that autumn with Wilbur. Madame Bollee had been in the latter stages of pregnancy when Wilbur arrived in LeMans in June 1908 to assemble the Flyer. Wilbur promised her that he would make his first European flight the day her baby was born which he did, August 8, 1908.

Orville followed his brother's success by demonstrating another nearly identical Flyer to the United States Army at Fort Myer, Virginia, starting on September 3, 1908. On September 9, he made the first hour-long flight, lasting 62 minutes and 15 seconds.



Fort Myer crash. photo by C.H. Claudy

On September 17, Army lieutenant Thomas Selfridge rode along as his passenger, serving as an official observer. A few minutes into the flight at an altitude of about 100 feet (30 m), a propeller split and shattered, sending the aircraft out of control. Selfridge suffered a fractured skull in the crash and died that evening in the nearby Army hospital, becoming the first airplane crash fatality. Orville was badly injured, suffering a broken left leg and four broken ribs. Twelve years later, after he suffered increasingly severe pains, X-rays revealed the accident had also caused three hip bone fractures and a dislocated hip. The brothers' sister Katharine, a school teacher, rushed from Dayton to Virginia and stayed by Orville's side for the seven weeks of his hospitalization. She helped negotiate a one-year extension of the Army contract. A friend visiting Orville in the hospital asked, "Has it got your nerve?" "Nerve?" repeated Orville, slightly puzzled. "Oh, do you mean will I be *afraid* to fly again? The only thing I'm afraid of is that I can't get well soon enough to finish those tests next year." Deeply shocked by the accident, Wilbur determined to make even more impressive flight demonstrations; in the ensuing days and weeks he set new records for altitude and duration. In January 1909 Orville and Katharine joined him in France, and for a time they were the three most famous people in the world, sought after by royalty, the rich, reporters and the public. The kings of England, Spain and Italy came to see Wilbur fly.



Wright Model A Flyer flown by Wilbur 1908–1909 and launching derrick, France, 1909

The Wrights traveled to Pau, in the south of France, where Wilbur made many more public flights, giving rides to a procession of officers, journalists and statesmen—and his sister Katharine on February 15. He trained two French pilots, then transferred the airplane to the French company. In April the Wrights went to Italy where Wilbur assembled another Flyer, giving demonstrations and training more pilots. A cameraman climbed aboard and made the first motion picture from an aircraft.

After their return to the U.S., the brothers and Katharine were invited to the White House where President Taft bestowed awards upon them. Dayton followed up with a lavish two-day homecoming celebration. In July 1909 Orville, with Wilbur assisting, completed the proving flights for the U.S. Army, meeting the requirements of a two-seater able to fly with a passenger for an hour at an average of speed of 40 miles (64 km) an hour (64 km/h) and land undamaged. They sold the aircraft to the Army's Aeronautical Division, U.S. Signal Corps for \$30,000 (which included a \$5,000 bonus for exceeding the speed specification). Wilbur climaxed an extraordinary year in early October when he flew at New York City's Hudson-Fulton celebrations, circling the Statue of Liberty and making a 33-minute flight up and down the Hudson River alongside Manhattan in view of up to one million New Yorkers. These flights solidly established the fame of the Wright brothers in America.

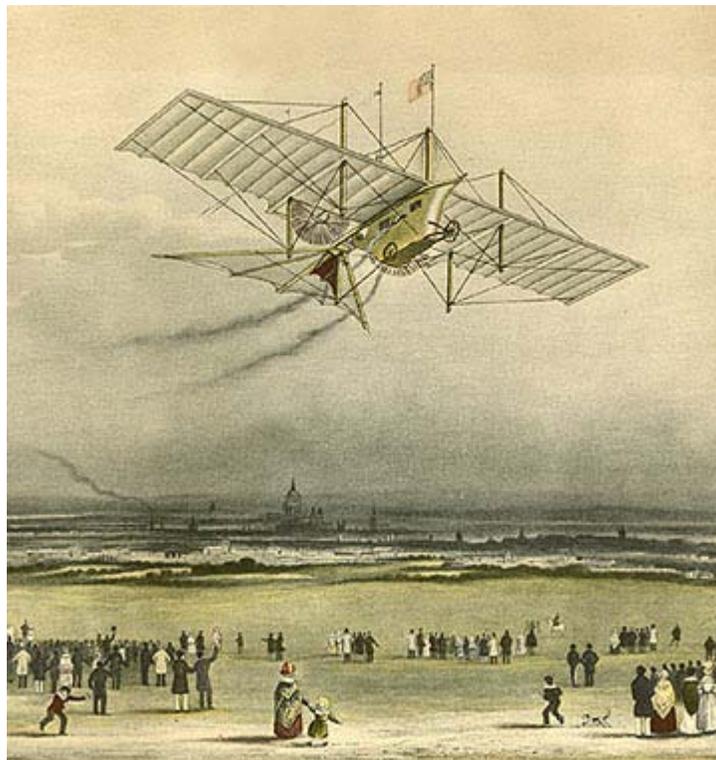
Family flights

On May 25, 1910 back at Huffman Prairie, Orville piloted two unique flights. First, he took off on a six-minute flight with Wilbur as his passenger, the only time the Wright brothers ever flew together. They received permission from their father to make the flight. They had always promised Milton they would never fly together to avoid the chance of a double tragedy and to ensure one brother would remain to continue their experiments. Next, Orville took his 82-year old father on a nearly seven-minute flight, the first and only one of Milton Wright's life. The airplane rose to about 350 feet (107 m) while the elderly Wright called to his son, "Higher, Orville, higher!"

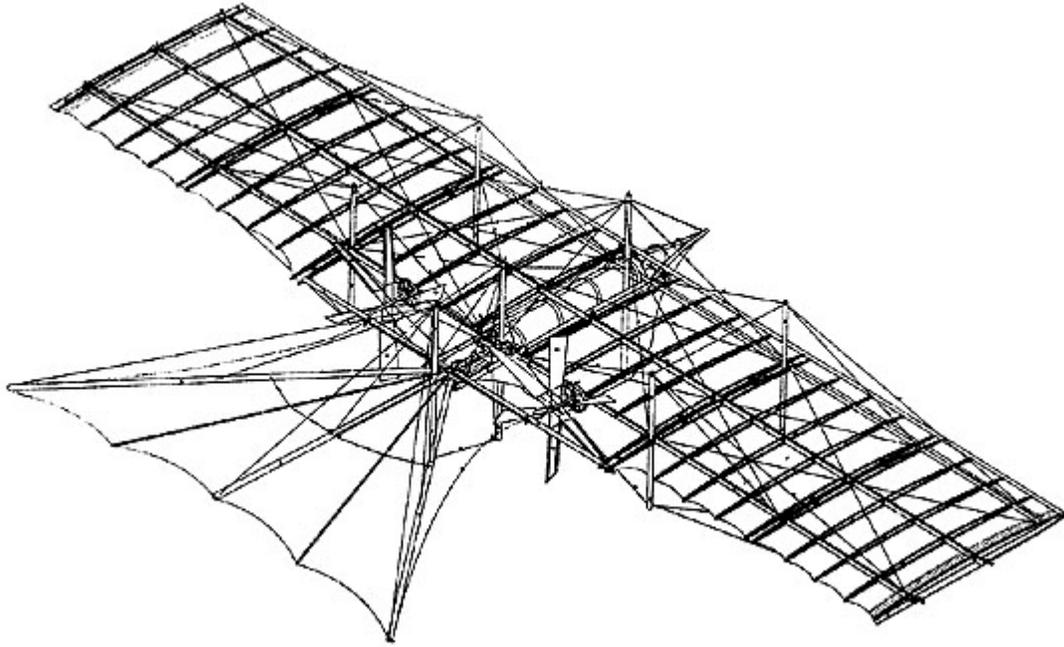
Chapter- 6

Specific Examples of Early Flying Machines

Aerial Steam Carriage



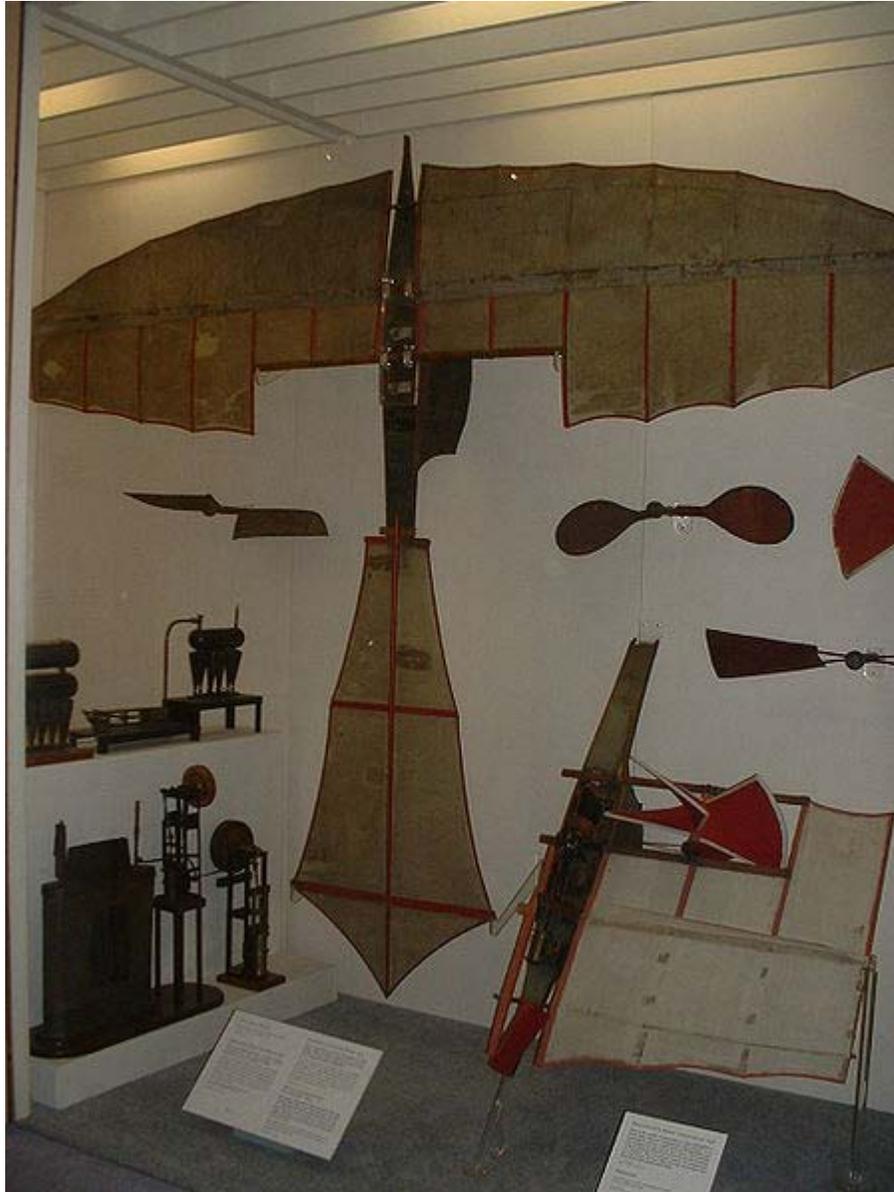
The Henson Aerial Steam Carriage of 1843 (imaginary representation for an advertisement)



Patent drawing for the Henson Aerial Steam Carriage of 1843

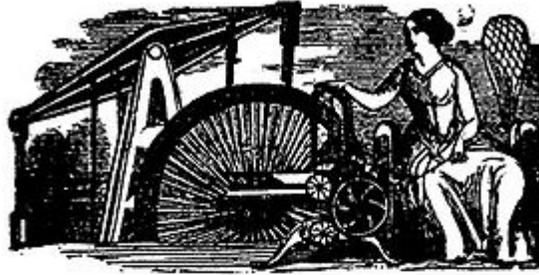


William Samuel Henson (1812-1888)



John Stringfellow's flying machine in the Science Museum, London.

Scientific American.



New Inventions.

An Air Navigator.

A series of experiments have lately been made beneath an immense tent in Cremorne Gardens, London, by a **Mr. Stringfellow**—a fine name for suspension. The inventor marches through the air by a machine which sustains and propels itself through the circumambient fluid. The machine excited considerable attention and surprised all the spectators by its wonderful performance. The next expedition that is fitted out by the British government to explore the Niger and the country through which it winds its sluggish and pestilential way, should employ this Mr. Stringfellow with a number of his machines to make a flying exploration, untrammelled with their heels in mud or water.

Scientific American on September 23, 1848; Volume 4, Issue 1, page 4

The **Aerial Steam Carriage**, also named **Ariel**, was a flying machine patented in 1842 that was supposed to carry passengers into the air. It was, in practice, incapable of flight since it had insufficient power from its heavy steam engine to fly. A more successful model was built in 1848 which was able to fly for small distances within a hangar. The Aerial Steam Carriage was significant because it was a transition from glider experimentation to powered flight experimentation.

Specifications

The Ariel was to be a monoplane with a wing span of 150 feet (46 m), weigh 3,000 lb (1,400 kg) and was to be powered by a specially-designed lightweight steam powered engine producing 50 hp (37 kW). The wing area was to be 4,500 sq ft (420 m²), with the tail another 1500, yielding a very low wing loading. The inventors hoped that the Ariel would achieve a speed of 50 mph, and carry 10-12 passengers up to 1,000 miles (1,600 km). The plan was to launch it from an inclined ramp. The undercarriage was a 3-wheel design.

British patent 9478

William Samuel Henson (1812–1888) and John Stringfellow (1799–1883) received British patent 9478 in 1842.

In order that the description hereafter given be rendered clear, I will first shortly explain the principle on which the machine is constructed. If any light and flat or nearly flat article be projected or thrown edgewise in a slightly inclined position, the same will rise on the air till the force exerted is expended, when the article so thrown or projected will descend; and it will readily be conceived that, if the article so projected or thrown possessed in itself a continuous power or force equal to that used in throwing or projecting it, the article would continue to ascend so long as the forward part of the surface was upwards in respect to the hinder part, and that such article, when the power was stopped, or when the inclination was reversed, would descend by gravity aided by the force of the power contained in the article, if the power be continued, thus imitating the flight of a bird. Now, the first part of my invention consists of an apparatus so constructed as to offer a very extended surface or plane of a light yet strong construction, which will have the same relation to the general machine which the extended wings of a bird have to the body when a bird is skimming in the air; but in place of the movement or power for onward progress being obtained by movement of the extended surface or plane, as is the case with the wings of birds, I apply suitable paddle-wheels or other proper mechanical propellers worked by a steam or other sufficiently light engine, and thus obtain the requisite power for onward movement to the plane or extended surface; and in order to give control as to the upward and downward direction of such a machine I apply a tail to the extended surface which is capable of being inclined or raised, so that when the power is acting to propel the machine, by inclining the tail upwards, the resistance offered by the air will cause the machine to rise on the air; and, on the contrary, when the inclination of the tail is reversed, the machine will immediately be propelled downwards, and pass through a plane more or less inclined to the horizon as the inclination of the tail is greater or less; and in order to guide the machine as to the lateral direction which it shall take, I apply a vertical rudder or second tail, and, according as the same is inclined in one direction or the other, so will be the direction of the machine.

Aerial Transit Company

William Samuel Henson, John Stringfellow, Frederick Marriott, and D.E. Colombine, incorporated as the "Aerial Transit Company" in 1843 in England, with the intention of raising money to construct the flying machine. Henson built a scale model of his design, which made one tentative steam powered "hop" as it lifted or bounced, off its guide wire. Attempts were made to fly the small model, and a larger model with a 20-foot (6.1 m) wing span, between 1844 and 1847, without success.

The company planned "to convey letters, goods and passengers from place to place through the air", according to the patent.

In an attempt to gain investors and support in Parliament, the company engaged in a major publicity campaign using images of the Ariel in exotic locales, but the company failed to gain the needed investment. There was speculation in the press about whether the Ariel was a hoax or fraud.

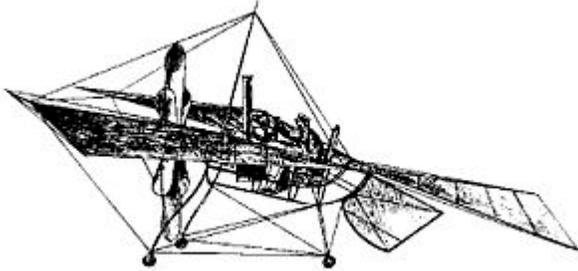
Stringfellow's son wrote the following:

My father had constructed another small model which was finished early in 1848, and having the loan of a long room in a disused lace factory, early in June the small model was moved there for experiments. The room was about 22 yards (20 m) long and from 10 to 12 feet (3.7 m) high. The inclined wire for starting the machine occupied less than half the length of the room and left space at the end for the machine to clear the floor. In the first experiment the tail was set at too high an angle, and the machine rose too rapidly on leaving the wire. After going a few yards it slid back as if coming down an inclined plane, at such an angle that the point of the tail struck the ground and was broken. The tail was repaired and set at a smaller angle. The steam was again got up, and the machine started down the wire, and, upon reaching the point of self-detachment, it gradually rose until it reached the farther end of the room, striking a hole in the canvas placed to stop it. In experiments the machine flew well, when rising as much as one in seven. The late Reverend J. Riste, Esquire, lace manufacturer, Northcote Spicer, Esquire, J. Toms, Esquire, and others witnessed experiments. Mister Marriatt, late of the San Francisco News Letter brought down from London Mister Ellis, the then leasee of Cremorne Gardens, Mister Partridge, and Lieutenant Gale, the aeronaut, to witness experiments. Mister Ellis offered to construct a covered way at Cremorne for experiments. Mr Stringfellow repaired to Cremorne, but not much better accommodations than he had at home were provided, owing to unfulfilled engagement as to room. Mister Stringfellow was preparing for departure when a party of gentlemen unconnected with the Gardens begged to see an experiment, and finding them able to appreciate his endeavours, he got up steam and started the model down the wire. When it arrived at the spot where it should leave the wire it appeared to meet with some obstruction, and threatened to come to the ground, but it soon recovered itself and darted off in as fair a flight as it was possible to make at a distance of about 40 yards (37 m), where it was stopped by the canvas. Having now demonstrated the practicability of making a steam-engine fly, and finding nothing but a pecuniary loss and little honour, this experimenter rested for a long time, satisfied

with what he had effected. The subject, however, had to him special charms, and he still contemplated the renewal of his experiments.

Du Temple Monoplane

Monoplane



The Du Temple Monoplane.

Role	
National origin	France
Manufacturer	Félix du Temple
First flight	1874
Number built	1

The **du Temple Monoplane** was a large aeroplane made of aluminium, built in Brest, France, by naval officer Félix du Temple in 1874.

The plane had a wingspan of 13 m (43 ft) and a weight of only 80 kg/180 lb (without the pilot).

Several trials were made with the plane, and it is generally recognized that it achieved lift-off under its own power after a ski-jump run, glided for a short time and returned safely to the ground, making it the first successful powered flight in history, although the flight was only a short distance and a short time.

The plane was displayed at the 1878 World Fair (Exposition Universelle (1878)) in Paris.

Steam engine

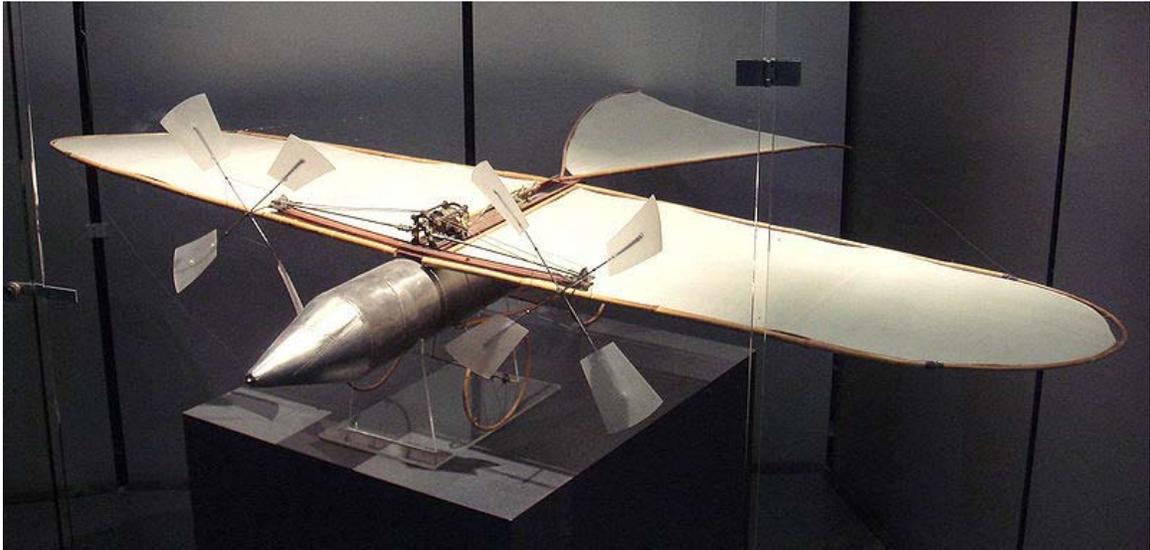
The plane used a very compact, high-speed circulation steam engine for which Félix du Temple applied for a patent on 28 April 1876. The engine used very small pipes packed together "to obtain the highest possible contact surface for the smallest possible volume"

"When he began with the aid of his brother, M. Louis du Temple, to experiment on a large scale, the inadequacy of all motors then known became apparent. They first tried steam at very high pressures, then a hot-air engine, and finally built and patented, in 1876 a very light steam boiler weighing from 39 to 44 lb. to the horse power, which appears to have been the prototype of some of the light boilers which have since been constructed. It consisted in a series of very thin tubes less than 1/8 in. in internal diameter, through which water circulated very rapidly, and was flashed into steam by the surrounding flame." Octave Chanute, *Aeroplanes* : Part III, August 1892

This type of boiler, which boils the water instantly, has come to be known as a flash boiler. The engine design was later adopted by the French Navy for the propulsion of the first French torpedo boats:

"Officers and engineers have now made up their opinion regarding Du Temple's steam engine. Everybody proclaims the superiority of its qualities... orders are pouring in from our commercial harbours and from the French government." *Revue Maritime* 1888 ("L'opinion est faite aujourd'hui sur la chaudière Du Temple parmi les officiers et les ingénieurs. Tout le monde proclame ses qualités supérieures... les commandes affluent de nos ports de commerce et de la part du gouvernement français".)

Victor Tatin



Victor Tatin airplane of 1879. Original craft, at Musée de l'Air et de l'Espace.

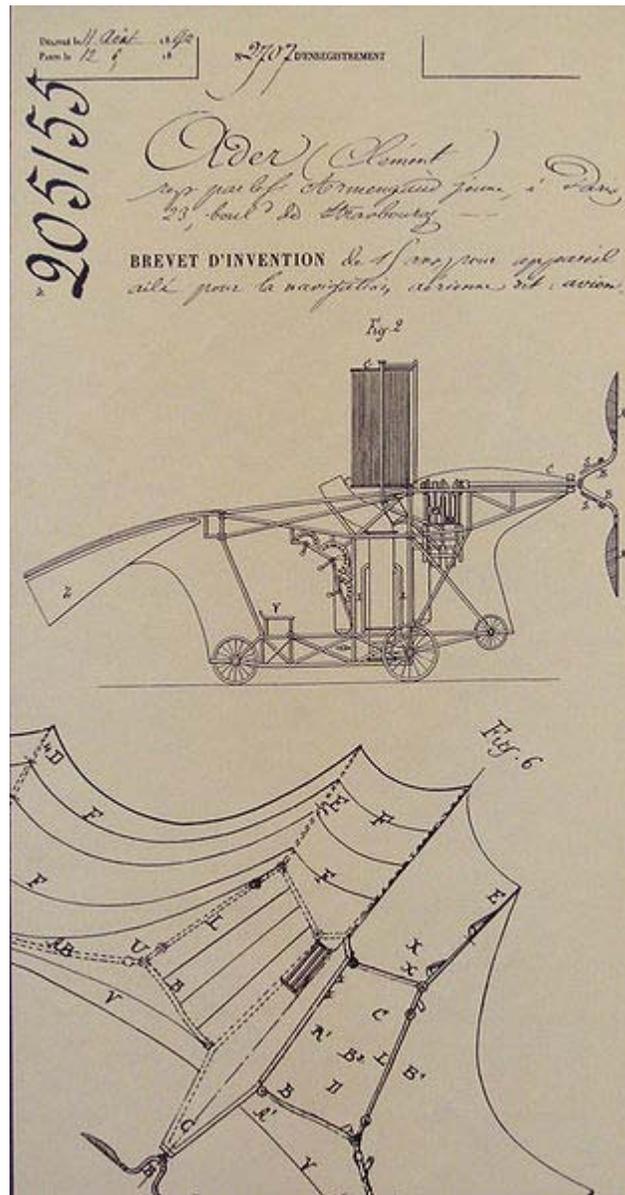
Victor Tatin(1843-1913) was a French inventor, who created an early airplane, the *Aéroplane* in 1879. The craft was the first model aeroplane to lift itself by its own power after a run on the ground.

The plane had a span of 1.90 meters, and weighed 1,8kg. It had two propellers, and was powered by a compressed-air engine. The plane was tried in a circular building at the military facilities of Chalais-Meudon. Tethered to a central pole by a string so that it could rotate, it ran with its own power and took off as it was running at a speed of 8 meters per second.

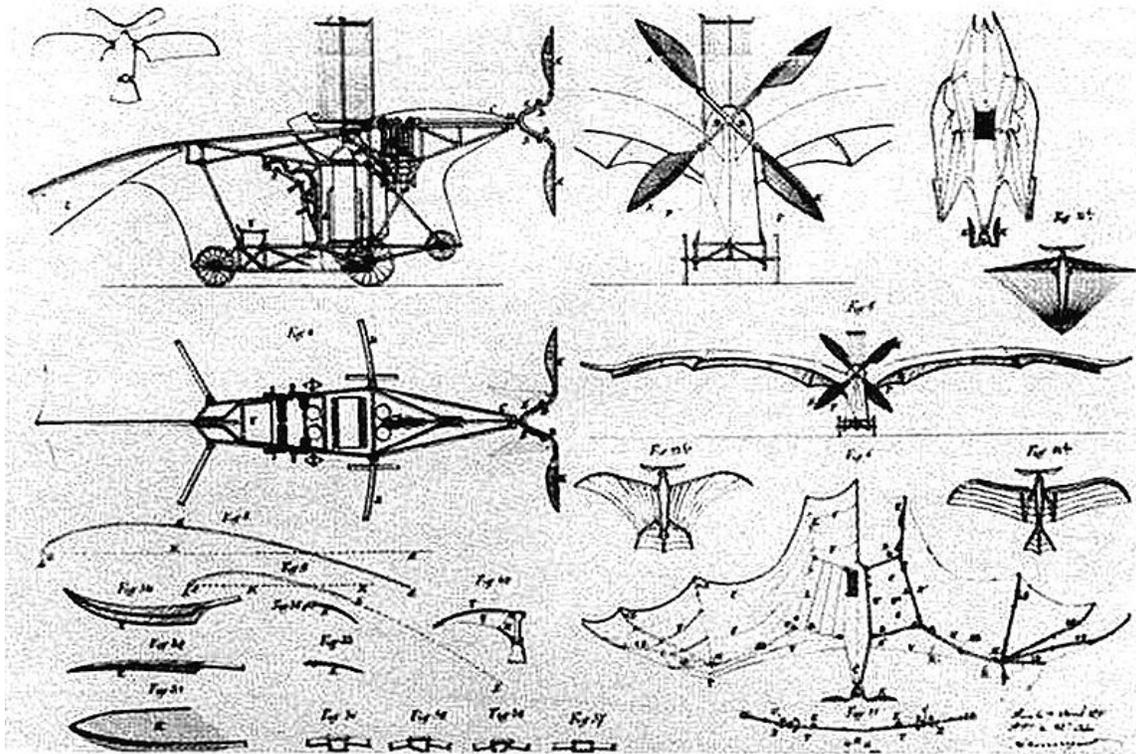
Works

- Victor Tatin, *Elements d'aviation* (Paris: Dunod et Pinet, 1908).

Ader Éole



Clement Ader's *Avion* French patent 205155, 19 April 1890.



Patent drawings of Clement Ader's *Eole*

The *Ader Éole*, also called *Avion*, was an early steam-powered aircraft. The *Éole* was named after the Greco-Roman wind god Aeolus. It was developed by Clément Ader in 1890. Unlike many early flying machines, the *Éole* did not attempt to fly by flapping its wings, but was to rely on the lift generated by its wings (mechanical copies of bat wings). Its steam engine was an unusually light weight design and drove a propeller at the front of the aircraft. The machine lacked means for the pilot to control the direction of flight.

On October 9, 1890, the machine achieved a short flight of around 50 m (164 ft) at the Chateau d'Armainvilliers in Brie. It reached a height of around 20 cm (8 in). The poor power-to-weight ratio of the steam engine and bad weather were felt to limit the flying height achieved. Ader later claimed to have flown the *Éole* again in September 1891, this time to a distance of 100 m (328 ft), but this claim is less substantiated.

The *Éole* is considered by some to be the first true aeroplane, given that it left the ground under its own power and carried a person through the air for a short distance; and therefore consider the event of October 9 to be the first flight. However, the lack of directional control and the dead-end that steam-powered aircraft were doomed to reach weigh against these claims. Ader's proponents have claimed that the Wrights' early airplanes required a catapult to take off; however, the Wrights did not use a catapult for their first flights in 1903, though they did for many flights in 1904 and later.

Modern attempts to recreate and evaluate the craft have met with mixed results. A full-size replica built in 1990 at the *École Centrale Paris* crashed on its first flight, injuring its pilot and leading to the termination of the experiment. Scale models, however, have been successfully flown.

Specifications (Éole)

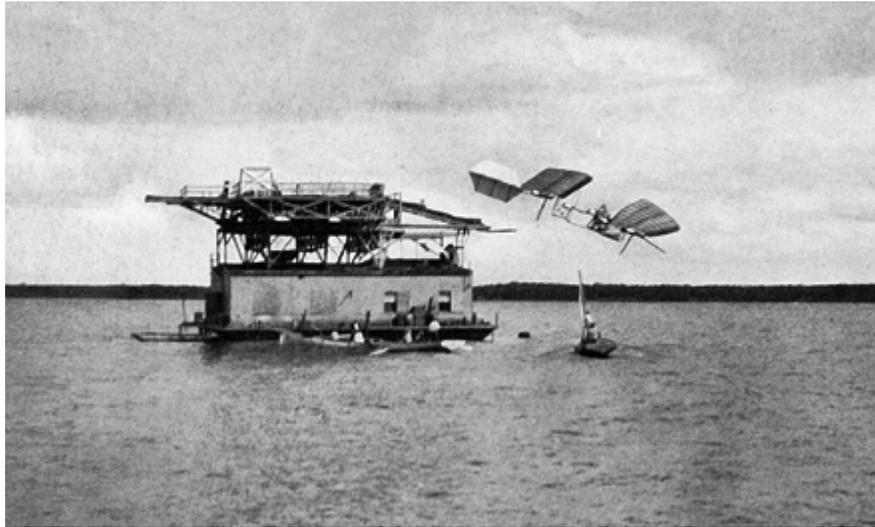
General characteristics

- **Crew:** one, pilot
- **Length:** 6.50 m (21 ft 4 in)
- **Wingspan:** 14 m (45 ft 11 in)
- **Height:** ()
- **Wing area:** 28 m² (301 ft²)
- **Empty weight:** 226 kg (497 lb)
- **Loaded weight:** 330 kg (727 lb)
- **Powerplant:** 1× Ader alcohol-burning steam engine, 15 kW (20 hp)

Performance

- **Maximum speed:** 252 km/h (knots, 158 mph)
- **Range:** 50 m (164 ft)
- **Service ceiling:** 20 cm (8 in)
- **Wing loading:** 8 kg/m² (2.4 lb/ft²)
- **Power/mass:** 0.05 kW/kg (0.03 hp/lb)

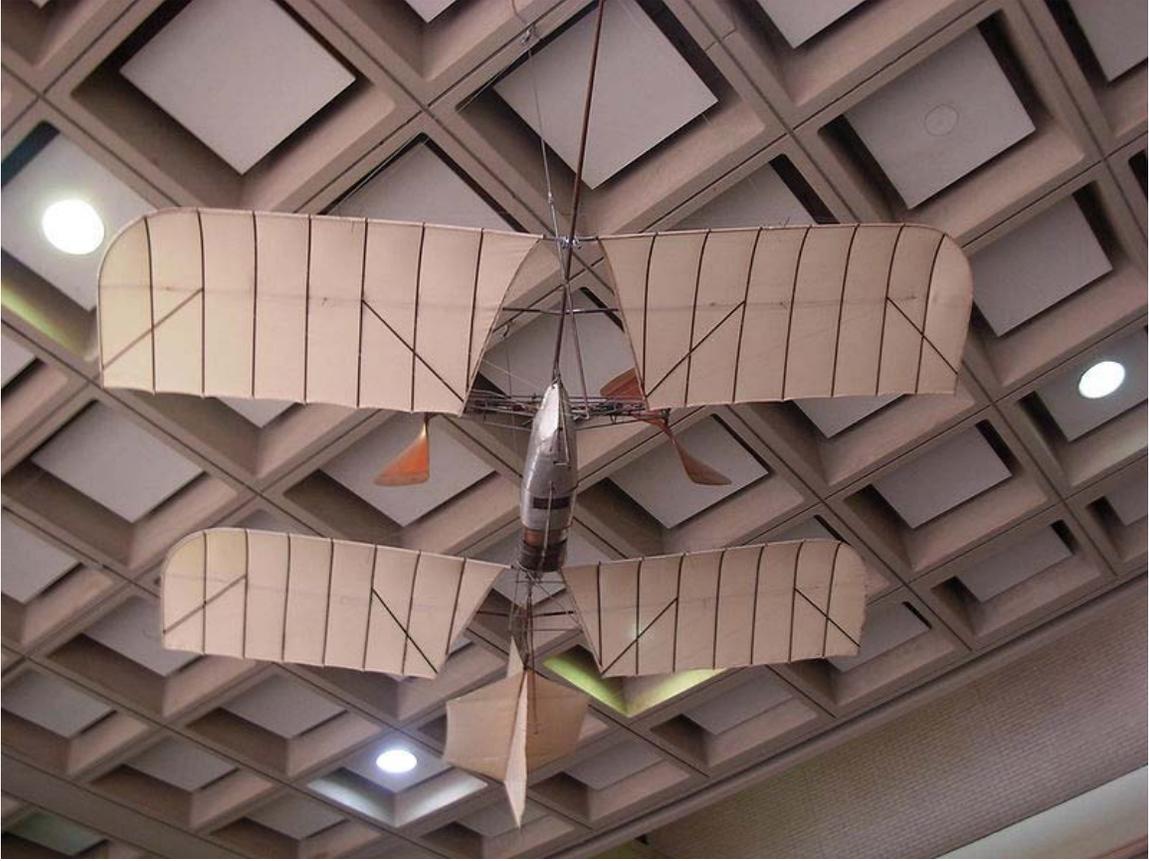
Langley Aerodrome



First failure of the manned Aerodrome, October 7, 1903



The man-carrying Aerodrome as displayed at the National Air and Space Museum's Steven F. Udvar-Hazy Center





Langley Aerodrome No. 6 at Wesley W. Posvar Hall, University of Pittsburgh

The **Langley Aerodrome** was a pioneering but unsuccessful manned powered flying machine designed at the close of the 19th century by Smithsonian Institution Secretary Samuel Langley. The U.S. Army paid \$50,000 for the project in 1898 after Langley's successful flights with small-scale unmanned models two years earlier.

Langley coined the word "Aerodrome" and applied it to a series of engine-driven unmanned and manned tandem wing aircraft that were built under his supervision by Smithsonian staff in the 1890s and early 1900s. The term is derived from Greek words meaning "air runner".

After a series of unsuccessful tests beginning in 1894, Langley's unmanned steam-driven model "number 5" made a successful 90-second flight of over half a mile about 25 miles an hour at a height of 80 to 100 feet on May 6, 1896. In November model "number six" flew more than 5,000 feet. Both aircraft were launched by catapult from a houseboat in the Potomac River near Quantico, Virginia, south of Washington, D.C.

The full-scale Aerodrome, financed by the United States War Department and piloted by Langley's chief assistant Charles M. Manly, was launched the same way on October 7 and December 8, 1903. On both attempts the Aerodrome failed to fly and crashed into the Potomac River seconds after launch. Manly was pulled unhurt from the water each time.

Nine days after the December 8 failure, the Wright Brothers flew into history with their four successful flights near Kitty Hawk, North Carolina. The Aerodrome's internal combustion engine generated 53 horsepower, about four times that of the Wright brothers' gasoline engine of 1903. However, Langley had not properly appreciated the problems of calculating stress on an airframe or controlling an aircraft, and the Aerodrome broke up on launch. Langley made no further tests, and his experiments became the object of scorn in newspapers and the U.S. Congress.

With Smithsonian approval, Glenn Curtiss extensively modified the Aerodrome and made a few short flights in it in 1914, as part of an unsuccessful attempt to bypass the Wright Brothers' patent on aircraft and to vindicate Langley. Based on these flights, the Smithsonian displayed the Aerodrome in its museum as the first heavier-than-air manned, powered aircraft "capable of flight." This action triggered a feud with Orville Wright (Wilbur Wright died in 1912), who accused the Smithsonian of misrepresenting flying machine history. Orville backed up his protest by refusing to donate the original 1903 Kitty Hawk Flyer to the Smithsonian, instead exiling it to Science Museum of London in 1928. The dispute finally ended in 1942 when the Smithsonian published details of the Curtiss modifications to the Aerodrome and recanted its claims for the aircraft.

Two of Langley's scale model Aerodromes survive to this day. Aerodrome No. 5, the first Langley heavier-than-air craft to fly, is on display at the Smithsonian's National Air and Space Museum in Washington, D.C. Aerodrome No. 6 is located at Wesley W. Posvar Hall, University of Pittsburgh, and was restored in part by the Pitt engineering students. Fabric on the wings and tail is the only new material, although the tail and several wing ribs were rebuilt using vintage wood from the same time period provided by the Smithsonian. Langley had been an astronomy professor at the university before he ascended to the Smithsonian's top job.

The man-carrying Aerodrome survived after being rebuilt and tested by Curtiss and was converted back to Langley's original 1903 configuration by Smithsonian staff. It occupied a place of honor in the Smithsonian museum until 1948 when the Institution welcomed home the original 1903 Wright Flyer from Britain. Afterward, the Aerodrome resided out of view of the public for many years at the Paul Garber Facility in Suitland, Maryland. Today it is displayed at the National Air and Space Museum's Steven F. Udvar-Hazy Center in Chantilly, Virginia.