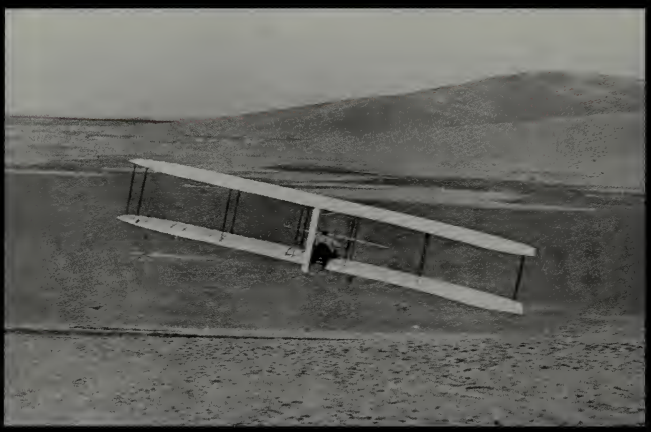
First Flight

The Wright Brothers and the Invention of the Airplane



Top: *Reconstructed 1905 hangar at Huffman Prairie Flying Field, Dayton Aviation Heritage National Historical Park*
Bottom: *Wilbur Wright gliding towards Big Kill Devil Hill in 1902*
Back cover, top: *Monument at Wright Brothers National Memorial, Kill Devil Hills, North Carolina*
Back cover, bottom: *1905 Wright Flyer III in Wright Brothers Aviation Center at Carillon Historical Park, Dayton, Ohio*

First Flight

The Wright Brothers and the Invention of the Airplane

Tom D. Crouch
Foreword by John Glenn

Dayton Aviation Heritage
National Historical Park
Ohio

Wright Brothers National Memorial
North Carolina

Produced by the
Division of Publications
Harpers Ferry Center
National Park Service

U.S. Department of the Interior
Washington, D.C.

National Park Handbooks support management programs and promote the understanding and enjoyment of the more than 380 parks in the National Park System. The National Park Service cares for these special places saved by the American people so that all may enjoy our heritage. Handbooks are sold at parks and can be purchased by mail from the Superintendent of Documents, U.S. Government Printing Office, Stop SSOP, Washington, DC 20402-0001, or through the Internet at http://bookstore.gpo.gov. This is handbook number 159.

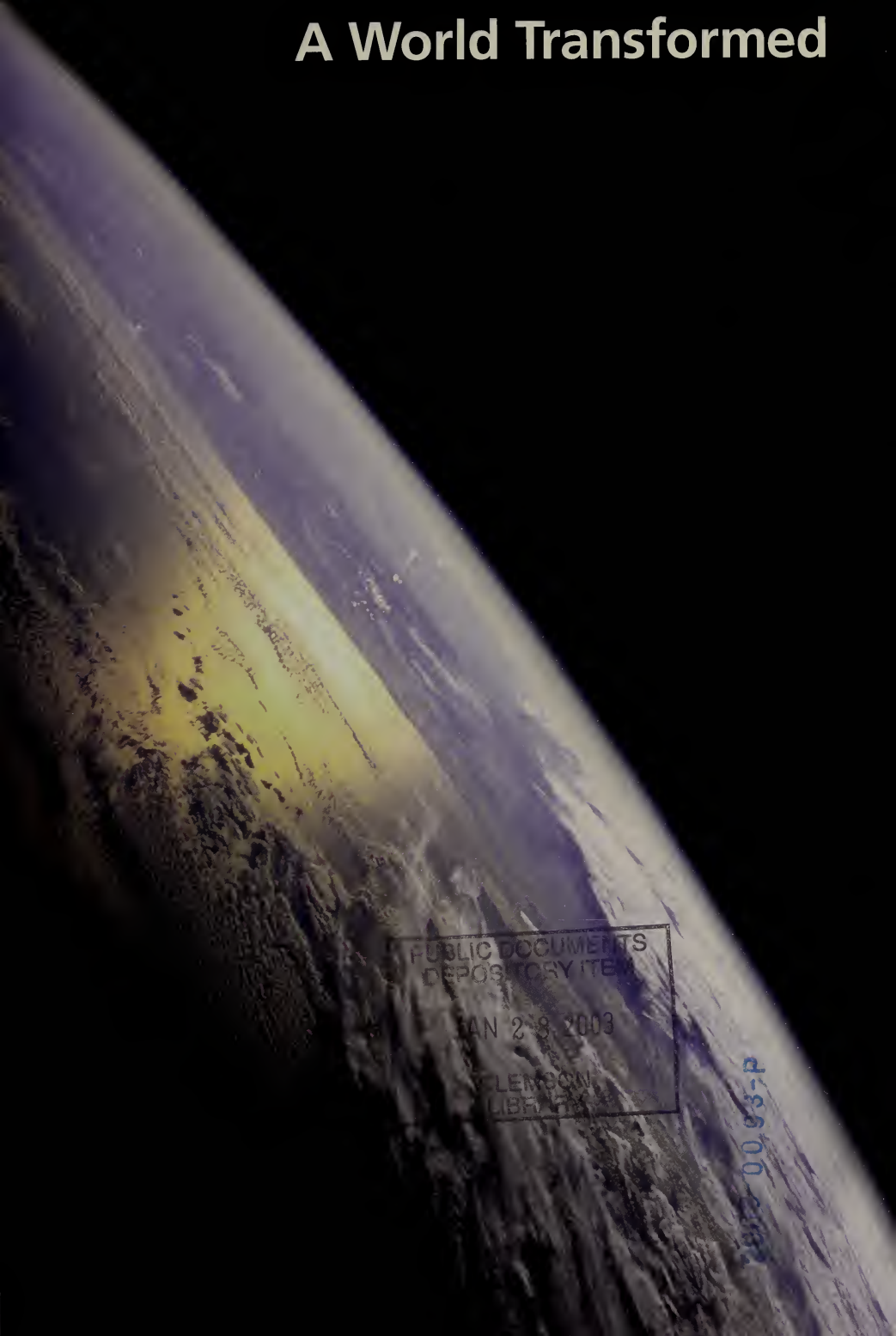
"Oh, that view is tremendous!" On looking back at Earth as I orbited 100 miles above its surface, I was elated, awestruck. The full spectrum of colors was visible in the sunrises and sunsets shining through the atmosphere's prism. They were spectacular in a way that film can't capture. But more than that, my new perspective on our home forever changed the way I thought about it. The human-made problems of our troubled world seemed out of keeping with an Earth that appeared peaceful and beautiful in the darkness of space. On the horizon glowed a very thin film—the air that sustains us—and I was struck by its fragility.

My privileged view of our planet in 1962 can be traced directly back to Orville and Wilbur Wright, who just 59 years earlier made the world's first powered, controlled flight in a heavier-than-air machine. For an aviator a visit to the places where they invented flight is a powerful experience. Wright Brothers National Memorial preserves the sites where they conducted their gliding experiments and made their powered flights in 1903. Dayton Aviation Heritage National Historical Park preserves Huffman Prairie Flying Field, where they developed a practical airplane—the 1905 Wright Flyer III—and learned to fully control it in sustained flight. The park also preserves the Flyer itself and sites associated with the brothers' early years.

The Wrights were the first astronauts. Their initial short flight opened our quest to reach beyond the world we know. They were the first test pilots. Combining science with design intuition, they sought to go "faster, higher, farther," and after them the world would never be the same. Aviation was the defining technology of the 20th century, altering international relations, quickening commerce, changing the face of war. When I fly on an airliner, I am covering a distance in seconds that would have taken a day by horse and wagon. And I still try to get a window seat, because I have never lost my sense of wonder at looking down at our world from above.

John Glenn

A World Transformed



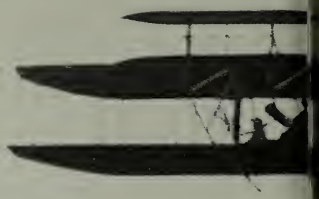
At Home in the Air

They always waved. In photographs of the Wright brothers' first public flights in 1908 and 1909, men and women look up and wave their handkerchiefs, wave their hats, at the pilot of the great noisy machine flying overhead. They wanted their fellow human being, having made his way into the sky, to catch sight of them below. These were not passive watchers; they took part in the event, bearing witness to one of the moments on which history turns.

How astounding it must have been. "Exhilaration," "elation"—these were the words people used in recalling their reaction. Some had seen flight by other experimenters, but it was ragged, tentative, basically extended hops with the pilot hanging on to an alien thing always on the brink of disaster. This graceful machine, though, was at home in the air. It flew smoothly, banking effortlessly into turns, wonderfully responsive to the will of the pilot.

Until then most people had considered the idea of human flight slightly ridiculous, on a level with the quest for a perpetual motion machine, or worse, a prideful ambition to intrude on a realm reserved for birds and gods. But after seeing the Wrights fly, they felt liberated—the human experience had been given a new dimension.

In the infancy of human flight, the Wrights' genius was to understand two things that no one else did. They had to teach themselves to be superb *pilots*, to control an inherently unstable machine in much the same way that a child learns to ride a bicycle. And they had to build a machine that could be controlled. They knew that rudder and elevator alone were not enough; something was needed to allow the pilot to roll the aircraft's wings. Their solution was simple, elegant, and revolutionary, a wing-warping system—the forerunner of ailerons. Airplanes now of course look very different from that first Flyer, but their pilots control them in essentially the same way.



French spectators hail Wilbur Wright as he flies over a racetrack near Le Mans, France, in 1908.

Dayton, Ohio, and North Carolina's Outer Banks are the settings for the Wright story, vividly recounted by noted aeronautical historian and Wright biographer Tom D. Crouch. Dayton, hometown to the two bicycle shop owners, was the supportive environment needed for research, building components of the gliders and powered flyers, and in 1904–05 perfecting the flyers in flights over nearby Huffman Prairie. On the Outer Banks they assembled the components and launched the gliders again and again off the dunes called Kill Devil Hills, tuning the machines, learning to fly, and finally making the first powered flight in 1903. Their achievement linked disciplined immersion in theoretical and mechanical problems with pure adventure—lying down on a wing to sail over the bright sand, the Atlantic breakers ahead, riding the wind with the gulls.

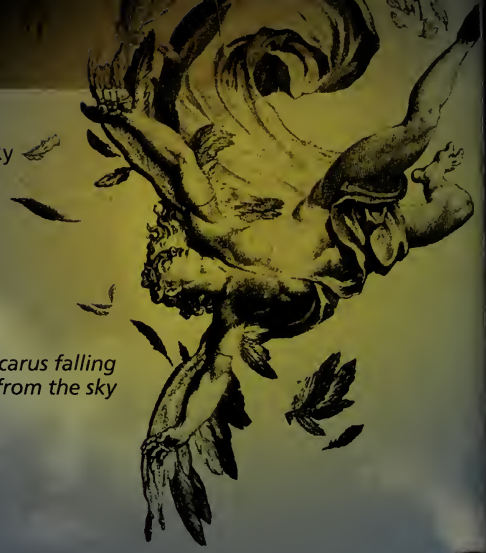
It is a measure of human ingenuity that just 24 years after the first flight, Charles Lindbergh could cross the Atlantic. To this heroic man the Wrights were heroes. He said of them: "Their intellects and senses worked in mutual support. They represented man in balance. And from that balance came wings to lift a world."

Break me my bounds, and let me fly
To regions vast of boundless sky

—Paul Laurence Dunbar

Dreams of Flying

From mythic quests to follow birds into the sky to the first human footsteps on the moon, we have always reached higher, always sought to escape gravity's bounds.



Icarus falling from the sky

1000 B.C.E. First known kite, in China (*early Chinese kite shown above*).

1232 Chinese military rockets.

1250 Roger Bacon theorizes about human-propelled flight. He assumes the pilot must flap the wings.

1485–1500 Leonardo da Vinci designs flying machines (*below*).

1499 Giovanni Battista Danti attempts to fly with a set of wings from a tower. He fails.

1648 John Wilkins theorizes about fixed-wing flight.

1680 Giovanni Borelli concludes that human muscle power is inadequate for flight.

1783 Montgolfier brothers send aloft a hot-air balloon with a passenger—the first human aerial voyage (*right*).

1799 George Cayley theorizes about fixed-wing aircraft with control surfaces in a tail unit, the first modern configuration *(above)*.

1809–10 Cayley publishes papers, *On Aerial Navigation*; lays foundation for modern aerodynamics.

1847 William S. Henson's "Aerial Steam Carriage" model—the first propeller-driven heavier-than-air aircraft design—fails to sustain flight.

1849 10-year-old boy makes short hops on Cayley's glider. This is the first unpowered aircraft design to be inherently stable.

1857 Steam-powered model designed by Félix du Temple makes a brief hop into the air.

1871 Alphonse Pénaud flies first powered inherently stable model aircraft.

1890 Clément Ader makes a short powered hop into the air with his *Éole*, but the flight is neither controlled nor sustained.

1891–96 Otto Lilienthal makes a series of piloted glider flights *(glider reproduction above)*; he dies from injuries sustained in an 1896 crash.

1894 Hiram Maxim's aircraft lifts off slightly from restraining rails but does not fly.

1894 Octave Chanute publishes *Progress in Flying Machines*, a widely-studied history of aviation.

1896 Chanute successfully tests a manned glider. Its biplane design and trussing system are adopted by the Wright brothers.

1896 Samuel P. Langley's steam-powered model *Aerodrome #5* achieves the first truly sustained flight. (His 1903 tests of a full-sized aircraft *[above]* would end in failure.)

A Century of Flight

1903 Orville and Wilbur Wright make the first free, powered, sustained, controlled flights in a heavier-than-air machine *(above)*.

1904–05 Wrights develop the first practical airplane.

1909 First air crossing of the English Channel, by Louis Blériot.

1910–11 First takeoff from a ship (an adapted naval cruiser); first landing on a ship.

1914–18 Aircraft used for reconnaissance and bombing in WWI; DeHavilland DH-4 *(below)* is mass-produced by Dayton-Wright Airplane Co.

1918 World's first regular air mail service. William Hopson *(below)* flew early mail routes.

1919 First crossing of the Atlantic; initiation of regular passenger service in Germany.

1921–22 Gen. Billy Mitchell proves vulnerability of battleships to aerial bombing; USS *Langley* is commissioned as first aircraft carrier.

1924 Two U.S. Army Air Service planes complete first round-the-world flight.

1927 Charles Lindbergh is first to fly solo across the Atlantic.

1932 Amelia Earhart is first woman to fly solo across the Atlantic.

1939 First flight of aircraft powered by a jet engine.

1939–45 Airpower is a dominant force in WWII. Paratroopers are used heavily by Germany and by the Allies in the 1944 invasions of France.

1945 U.S. drops atomic bombs on Hiroshima and Nagasaki.

1947 Charles Yeager breaks the sound barrier in the rocket-powered X-1.

1960 Scott Crossfield reaches Mach 3 in the rocket-powered X-15 *(above)*; he is the first human to fly three times the speed of sound.

1961 Russian cosmonaut Yuri Gagarin is the first human to make an orbital space flight.

1961 U.S. astronaut Alan Shepard is the first American launched into space. He rides in the Mercury capsule *(below)*.

Orion Nebula

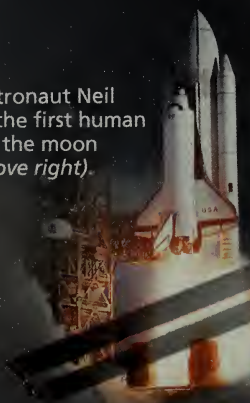
1962 U.S. astronaut John Glenn is the first American to make an orbital space flight.

1965 U.S. astronaut Edward White is the first human to walk in space.

1986 Launch of Russian space station *Mir*, which remains in orbit until 2001.

2000 Russian cosmonauts Sergei Krikalev and Yuri Gidzenko and U.S. astronaut Bill Shepherd board the International Space Station *Alpha* *(below)*.

1969 U.S. astronaut Neil Armstrong is the first human to set foot on the moon *(bootprint above right)*.



1981 Launch of *Columbia*, first flight of the U.S. space shuttle program *(above)*.

From the time we were little children my brother Orville and myself lived together, played together, worked together and, in fact, thought together.

—Wilbur Wright, 1912

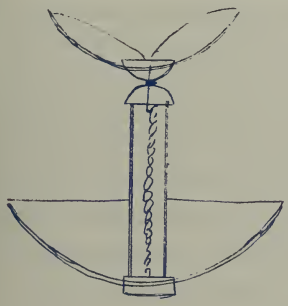
Orville (left) *and Wilbur Wright*

Opening the Skies

Tom D. Crouch
Senior Curator, Aeronautics
National Air and Space Museum

The Wright Family of Dayton

Wilbur (left) *and Orville Wright at ages nine and four. Orville was born in the house on Hawthorne Street in 1871. Wilbur died here in 1912. The drawing, done by Orville from memory in 1929, is of the Pénaud toy brought to the boys by their father more than 50 years earlier.*



"Our first interest began when we were children," Orville Wright once explained when asked how he and his brother Wilbur had become fascinated by flight. "Father brought home to us a small toy actuated by a rubber spring which would lift itself into the air." The year was 1878. Their father Milton Wright had been elected a bishop in the Church of the United Brethren in Christ just a year before, with responsibility for far-flung congregations scattered from the Mississippi River to the Rocky Mountains.

The long weeks on the road were difficult for a loving husband and father. Bishop Wright dispatched a steady stream of entertaining letters to his children, recounting his adventures in the far West only two years after George Armstrong Custer and his troopers met their fate on the banks of the Little Big Horn. Moreover, his children knew that they could expect a pleasant surprise when their father returned.

Hand-launched helicopter toys had delighted and inspired children since the time of Leonardo da Vinci. During the 18th and 19th centuries, the traditional string-pull versions gave way to new designs, powered by bowstring mechanisms or twisted rubber strands. The toy that Milton Wright brought to his sons had been developed by the French aeronautical pioneer Alphonse Pénaud. It was a marvel, capable of climbing as high as 50 feet and remaining in the air for as long as 25 seconds, almost certainly the contemporary world record time aloft for a powered flying machine.

Rather than pouting and moving on to something else when the fragile helicopter inevitably broke, 11-year-old Wilbur and seven-year-old Orville began to build and fly their own copies of the little "bats," as they called them. "But when we undertook to build the toy on a much larger scale," Orville explained, "it failed to work so well." They were still at it a quarter of a century later, making " . . . helicopters out of bamboo, paper, corks, and rubber bands," as their nephew Milton recalled, "and allowing us to run after them when they flew them."

Milton Wright, born in Indiana in 1828, knew from age 15 that the church would be his career. Quiet, well-educated Susan Catherine Koerner Wright, born in Virginia in 1831, married him in 1859. They had three other children (opposite) *besides Wilbur and Orville. (Twins born in 1870 did not survive infancy.)*

Wilbur (April 16, 1867–May 30, 1912) and Orville (August 19, 1871–January 30, 1948) were the third and sixth children born to Milton (1828–1917) and Susan Catherine Koerner Wright (1831–1889). They were seventh-generation Americans on their father's side, direct descendants of Samuel Wright, a Puritan minister who arrived in Massachusetts as early as 1637. Their great-grandfather fought with the patriot army at Saratoga and at Bemis Heights during the Revolution, and they could take pride in paternal relatives who had pioneered the Ohio Valley and settled the Indiana frontier, where their father was born.

Their mother's family represented a very different side of the American story. A native of Loudoun County, Virginia, Susan Wright was the daughter of John Gottlieb Koerner, a skilled wheelwright who had fled Germany to escape conscription, and Catherine Fry, a native-born American of Swiss extraction. In 1832 the Koerners moved to Indiana, where Susan had the run of her father's workshop and learned to use tools at an early age. A very well-educated woman for her time and place, she met Milton Wright at Hartsville College, a church school where she was a student and he was a young minister supervising instruction in the preparatory department. They were married on November 24, 1859, following Milton's return from extended missionary work in Oregon.

Milton was an extraordinary man with an iron will, an unshakable faith in his own judgment, and a determination to walk the path of virtue, whatever the cost. As early as 1869 he began to emerge as a leader of a "radical" church faction opposed to change in traditional doctrines. The controversy would grow over the next 16 years, culminating in a national schism in the church. In 1885 Bishop Wright and his radical colleagues established an "Old Constitution" minority branch of the Church of the United Brethren in Christ.

As both a church bishop and supervisor of litigation for the Old Constitution congregations, Milton Wright

orchestrated a series of lawsuits for possession of church property between 1893 and 1900. He lost every suit but one. During the five years following the court suits, Bishop Wright became involved in yet another major controversy in the church that would continue until his retirement in 1905.

Together, Milton and Susan Wright created a home that was a refuge from the Bishop's church troubles and a bulwark against the temptations and evils that beset honest men and women in the harsh world beyond the family doorstep. The Wrights were an insular, tightly knit, and loving family in which the five surviving children were taught to value their own opinions and judgments, to be ready to stand up for them, and to place absolute reliance on one another.

The oldest Wright boys, Reuchlin (1861–1920) and Lorin (1862–1939), were natives of Indiana, as was Wilbur, who was born on a farm near Millville in 1867. His father joked that as a young boy Wilbur had a forehead "two stories tall." "At fifteen months," Milton remarked, "when turned into a room he seemed to see all of the mischief available at a glance, and always found the greatest first."

The growing family moved to Dayton, Ohio, in 1869, where Milton took up new duties as the editor of the *Religious Telescope*, the principal newspaper of his church. The Wrights initially lived in a rented house, where Susan gave birth to twins, Ida and Otis, both of whom died shortly after birth. Orville was born two years later in a house that Milton Wright had purchased on the West Side of Dayton, across the Great Miami River. Katharine (1874-1929) was born in the same room of the same house, three years to the day after Orville. This was 7 Hawthorne Street—the house that all of them would think of as home.

Elected a bishop in 1877, Milton Wright rented out the Hawthorne Street house the following year and moved the family to Cedar Rapids, Iowa, closer to his new responsibilities. The two oldest boys enrolled in a church college for a time before setting out on their

Katharine Wright

Reuchlin Wright

Lorin Wright

[We] . . . were lucky enough to grow up in an environment where there was always much encouragement to children to pursue intellectual interests; to investigate whatever aroused curiosity.

—Orville Wright, 1943

own. Reuchlin would settle into the life of a Kansas farmer. Lorin went west as well, but returned to Dayton, where he married and bought a house two blocks from his father's home. Neither Wilbur nor Orville would ever marry, but their nieces and nephews were never far from the center of their lives.

The brothers exhibited a decided curiosity about the world around them and a capacity to solve problems through experimentation from a very young age. The earliest letter to have survived from either brother describes just such an experiment. "The other day I took a machine can and filled it with water . . . ," nine-year-old Orville explained to his absent father, "then I put it on the stove [and] I waited and the water came squirting out of the top about a foot . . . . "

The Wright children were always careful to recognize their debt to a father who worked hard to spark his children's curiosity, and to a patient and understanding mother who encouraged her son to conduct an experiment guaranteed to make a mess in her kitchen. Bishop Wright sought to mold his children's character. Their mother taught them the use of tools and crafted some of their toys, including a much-beloved sled.

"[We] . . . were lucky enough to grow up in an environment where there was always much encouragement to children to pursue intellectual interests; to investigate whatever aroused curiosity," Orville once explained. "In a different kind of environment our curiosity might have been nipped long before it could have borne fruit." His sister Katharine agreed. "I wish you could know what Father and Mother were like," she recalled. "They were so independent in the way they ran the family . . . . No family ever had a happier childhood than ours had. I was always in a hurry to get home after I had been away half a day."

Wilbur and Orville were good students and typical boys. Milton Wright remarked that "enthusiasm" always made Orville "a leader among boys." He led armies of youngsters into mock combat, organized

neighborhood circuses, and earned local fame for the flying qualities of the kites he designed, built, and sold. Wilbur played baseball, rode a high-wheeled bicycle he had purchased himself, and excelled at gymnastics—"an expert on the turning pole," according to his father. He was mechanically inclined, designing and building a machine to fold copies of the church newspaper his father published and helping Orville construct a treadle-powered wood lathe.

Wilbur and Orville grew closer as they grew older. "From the time we were little children," Wilbur remarked, "my brother Orville and myself lived together, played together, worked together and, in fact, thought together. We usually owned all of our toys in common, talked over our thoughts and aspirations so that nearly everything that was done in our lives has been the result of conversations, suggestions and discussions between us."

The family moved back to Indiana in 1881 and finally came home to Dayton to stay in 1884. Having completed his high school courses in Indiana, Wilbur was to graduate soon after the return to Dayton. With plans to enter Yale and study for the ministry, he enrolled in college preparation courses at Dayton's Central High School, where he played football and was one of the fastest runners in school.

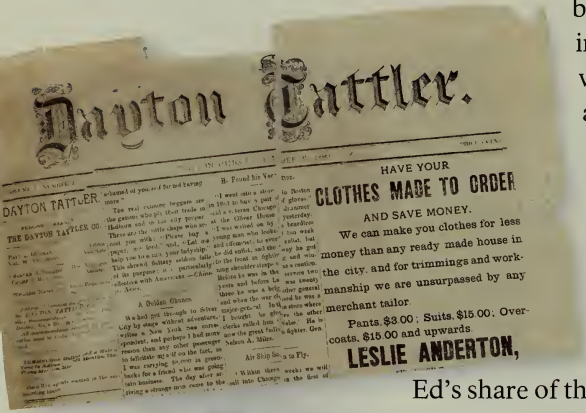
All of that changed during the winter of 1885-86. Wilbur was playing "shinny," a sort of free-form ice hockey, when a loose stick struck him in the mouth. The injury, which seemed minor at first, led to complications and, apparently, depression. All thoughts of college disappeared. Wilbur spent three years as a semi-invalid. He took care of the house, spent long hours reading in his father's extensive library, and nursed his mother, who was dying of tuberculosis. The young man played an important role at a time when the church controversy was approaching a crisis and Milton Wright spent long weeks on the road.

The year 1889 was filled with turmoil and change for the Wright family. In addition to caring for his mother

By the time Wilbur (top) *and Orville were 12 and 8, they were beginning to exhibit the intellectual play that sparked their later achievements. They were lucky in having parents who believed deeply in education and who kept plenty of books around.*

and keeping house for his younger brother and sister, Wilbur had written, and Orville printed, an important tract supporting their father's position in the church controversy. It was distributed at a conference that resulted in the final schism of Milton's denomination. The Bishop returned from the conference to find his wife close to death. Susan Wright died on July 4, 1889.

Orville, who had finished the eleventh grade that spring, decided to set himself up as a printer. He had become interested in printing while living in Indiana, and pursued the hobby with his childhood friend Ed Sines after returning to Dayton. They published one issue of *The Midget*, a small newspaper for school friends, and accepted contracts for calling cards and other printed items. In high school Orville spent two summers honing his printing skills by working for Dayton printers. After he bought Ed's share of the operation, he convinced Wilbur to join him in a printing business. In addition to normal printing services, the brothers edited and published two short-lived local newspapers, *The West Side News* (March 1889–April 1890) and *The Evening Item* (April–August 1890).



Dayton Tattler.

DAYTON TATTLER

THE DAYTON TATTLER CO.

HAVE YOUR

CLOTHES MADE TO ORDER

AND SAVE MONEY.

We can make you clothes for less money than any ready made house in the city, and for trimmings and workmanship we are unsurpassed by any merchant tailor.

Pants, $3.00; Suits, $15.00; Overcoats, $15.00 and upwards.

LESLIE ANDERTON,

Late in 1890 they provided printing services for Orville's friend Paul Laurence Dunbar (1872–1906). The only black member of his class at Central High School, Dunbar launched the *Dayton Tattler*, a paper aimed at the city's African-American community. He also served as editor of the school newspaper, *The High School Times*, and headed its literary group, The Philomatheon Society. While visiting the Wright print shop in the Hoover Block near Hawthorne Street, Dunbar scrawled a bit of light verse on the wall:

Orville Wright is out of sight
In the printing business.
No other mind is half as bright
As his'n is.

While the young Wrights are usually associated with their bicycle shop, their first business enterprise was printing. From 1889 to 1899 they operated a print shop, for the last seven of those years also running the bike shop. From 1890 to 1895 the business was in the Hoover Block (top) *near their home. Besides doing job work for others, Wright & Wright published its own newspapers—a weekly,* The West Side News, *for a little over a year, and a daily,* The Evening Item, *for a few months. The brothers printed the* Dayton Tattler, *a weekly for Dayton's African-American community published by Orville's friend and high school classmate Paul Laurence Dunbar* (bottom). *Dunbar would go on to become a celebrated poet.*

Dunbar's notion of a newspaper for the black community was almost certainly tied to the fact that he had a friend in the printing business. His finances were limited, however. "We published it as long as . . . financial resources permitted of it," Orville later remarked, "which was not very long!" The *Dayton Tattler* lasted for just three issues. With the end of the project Dunbar moved on to a career as a distinguished poet—the first African-American writer to achieve national and international stature.

A more lasting publication was the Wrights' *Snap-Shots At Current Events*, a weekly paper for cyclists that also contained ads for The Wright Cycle Company and other cycle shops. The brothers continued to offer a full range of printing services. On the local scene, however, they were best known for the quality of the presses they built for themselves and for at least one other printer. Orville had established a reputation for the unusual press he constructed from tombstones, folding buggy tops, and other spare parts. After inspecting the press, a visiting Chicago printer walked away impressed, commenting: "Well, it works, but I certainly don't see how it works." Ten years before their serious involvement with the airplane, the Wright brothers were already demonstrating their extraordinary ability to imagine a complex machine and envision how such a machine might function.

The Wrights remained in the printing business for another decade, although after 1892 Ed Sines, Orville's original partner, managed the bulk of the operation. When a lame knee forced Sines to seek other employment in 1899, the brothers finally sold their business and equipment to another Dayton printer.

By 1892 the bicycle craze was sweeping Dayton. The "merry wheel" had begun to capture the American imagination after the safety bicycle replaced the risky high-wheeler in 1887. With its two wheels of equal size, sturdy triangular frame, and trustworthy chain drive system, the safety enabled an entire nation to taste the freedom of the road. The sheer exhilaration

The Bicycle Business

Those who know little else about the Wright brothers can tell you they were bicycle shop owners who went on to invent the airplane. The connection between these two chapters of their story is crucial. The Wrights are a superb example of how, in the right hands, a simple technology can help pave the way for one vastly more complex.

They operated a bicycle sales and repair business from 1892 to 1907, designing their own models starting in 1895. Working in the tradition of 19th-century artisans, they produced custom bikes to order. They were serious about their work and kept abreast of the latest bicycle technology. Wilbur's celebrated 1899 inspiration as he twisted an inner-tube box *(see page 34)* is a good example, as inner-tubes had been on the market barely a year.

The technology and engineering techniques they employed were carried over to their aircraft construction—something easy to spot in the sprockets, chains, and tubing in their flyers. But more important were the parallels the Wrights drew regarding control. A bicycle is unstable. Gyroscopic action alone won't keep it upright; the skill of the rider in making small adjustments is also required. The brothers understood that, as with a bicycle, control of an aircraft depended not on inherent stability—something other aeronautical experimenters sought—but on actively maintaining balance. The Wrights approached the invention of the airplane knowing two things: The machine would have to be controllable and, like a child learning to ride a bike, they would have to teach themselves to fly it.

Below: *The Van Cleve was one of three models designed and built by the Wrights.* Above right: *Orville and employee Ed Sines filing frames in the cycle shop in 1897.* Right: *Wilbur works at the shop lathe in 1897.*

of cycling captivated a generation of young Americans accustomed to high collars, ankle length skirts, and corsets. Nothing in their experience could compare with the thrill of racing downhill into the wind, and the newfound sense of personal independence was irresistible.

The bicycle also bridged the gap between the age of the horse and that of the automobile. It marked the first convergence of technologies crucial to automobile production, ranging from electrical welding to experience with chain-and-shaft transmission systems, metal-stamping technology, and the manufacture of rubber tires.

The Wright brothers were enthusiastic cyclists who earned a reputation as expert cycle repairmen. In 1892 they established their first shop at 1005 West Third Street, where, in addition to providing repair services, they sold bicycles and accessories. In 1896, the year in which they began offering their own bicycles for sale, they were located at 22 South Williams Street.

The Wright Cycle Company, just around the corner from their home on Hawthorne Street, was equipped as a light machine shop, with a lathe, drill press, and tube-cutting equipment driven by a single-cylinder natural-gas engine. The Wrights' own bicycle designs bore the trade names Wright Special, Van Cleve, and St. Clair, the last two honoring Benjamin Van Cleve, a Wright relative and founder of Dayton, and Arthur St. Clair, a Revolutionary War hero.

As with the printing operation, bicycle manufacture provided an opportunity for the Wrights to exercise their talents for mechanical innovation. They devised an electric welding apparatus for building frames and designed their own coaster brakes and oil-retaining hubs. Bicycle design was also critical in shaping their approach to aircraft design.

In the late 19th century a surprising number of observers recognized a link between bicycling and aviation. In June 1896 the editor of the *Binghamton* [New York] *Republican* made an astounding prediction that

Wheeling is just like flying! . . . To learn to wheel one must learn to balance . . . . To learn to fly one must learn to balance.

—James Howard Means, editor of *The Aeronautical Annual*, on the relationship between cycling and flying, 1896.

the invention of a successful heavier-than-air flying machine might well be the work of bicycle makers. "The flying machine will not be in the same shape, or at all in the style of the numerous kinds of cycles," he explained, "but the study to produce a light, swift machine is likely to lead to an evolution in which wings will play a conspicuous part."

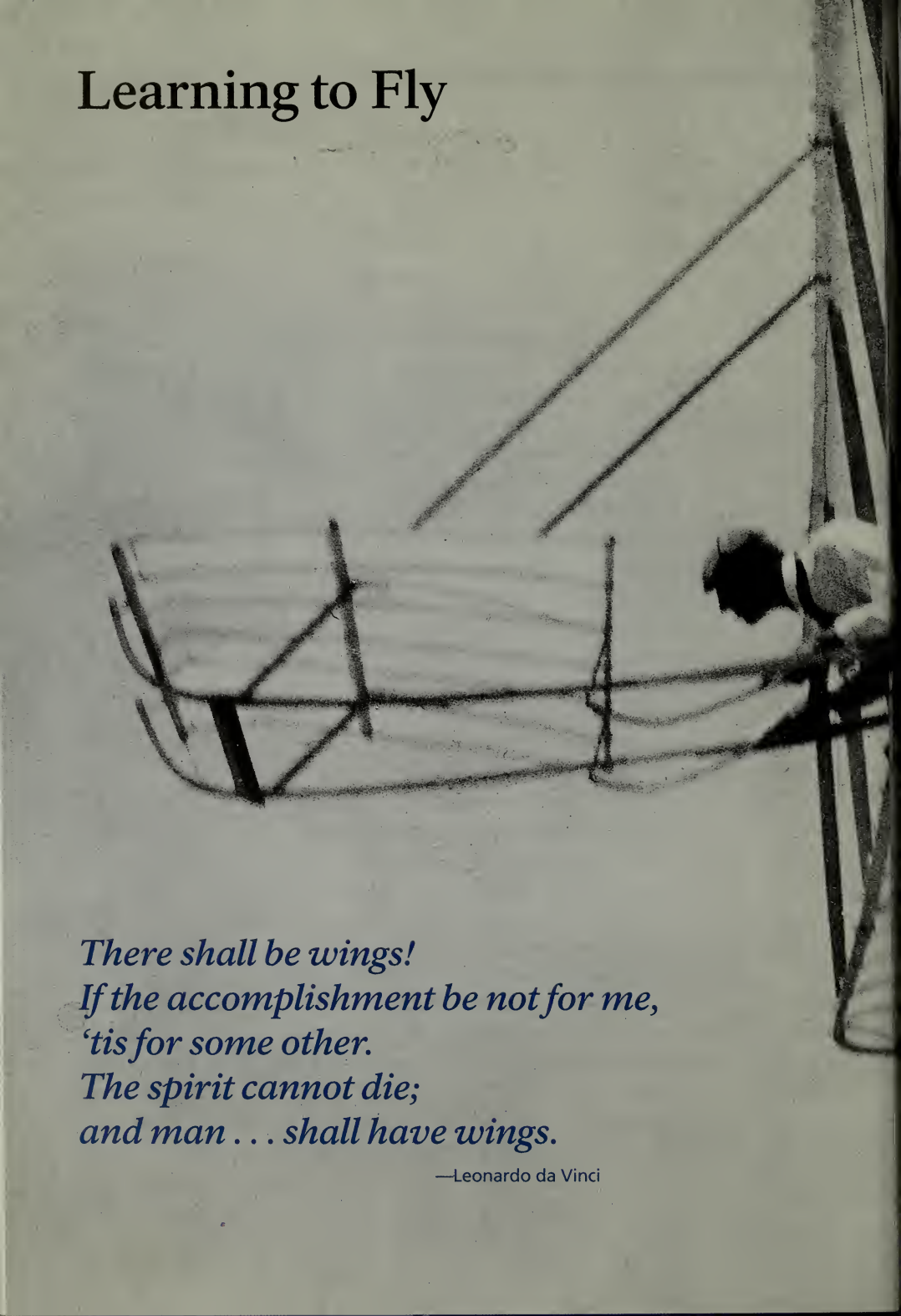
James Howard Means, editor of the influential but short-lived journal, *The Aeronautical Annual*, agreed that the bicycle and the flying machine were linked. "To learn to wheel one must learn to balance," he noted. "To learn to fly one must learn to balance." Otto Lilienthal, the German gliding pioneer, complimented Means on his insight. "I think that your consideration on the development between the flying machine & the bicycle and the analogy between . . . [their] development, is excellent," he wrote. "I am sure the flying apparatus will have a similar development."

The success of Wilbur and Orville Wright validated the prophets. Building bicycles, light-weight structures composed of precision-crafted wood and metal pieces, was ideal preparation for building aircraft structures. The brothers incorporated bicycle parts, including wheel hubs, chain, sprockets, spoke wire, and tubing, into their early powered aircraft designs.

Less apparent, but no less important, is the extent to which their experience as cyclists and cycle makers shaped their thinking with regard to the control of flying machines. The Wrights recognized that, as difficult as riding a bicycle at first seems to a person who has not mastered the art of simultaneously pedaling, balancing, and operating the handlebars, it soon becomes second nature. In the same way, a pilot would internalize the complex motions required to control a flying machine in the air. With this insight they joined the small band of visionaries who were catching glimpses of the path to flight. Through genius, skill, and conviction, it was the Wrights who would light that path.

In the Wrights' fourth bicycle shop, at 22 South Williams Street, they began manufacturing their own brands, among them the Van Cleve. A Van Cleve catalog is pictured below.

Learning to Fly



There shall be wings!
If the accomplishment be not for me,
'tis for some other.
The spirit cannot die;
and man . . . shall have wings.

—Leonardo da Vinci

Wilbur piloting the 1901 glider. Here the aircraft advances very slowly into a stiff breeze.

Had you lived on Hawthorne Street, on the West Side of Dayton, Ohio, in the spring of 1899, you would probably have regarded Wilbur and Orville Wright as honest, hard-working small businessmen, devoted members of a closely knit family, and the best of neighbors. There would have been no question that these fellows were mechanically inclined. They were locally famous for having designed and built everything from printing presses to bicycles. Still, you would certainly not have regarded them as serious candidates for immortal fame as the inventors of the airplane.

The world would come to regard them as a corporate entity—the Wright Brothers. Their ability to mesh as a smoothly functioning team was indeed one of the major factors in their success. At the same time, however, the brothers were able to take advantage of their very different personalities. Each was prepared to rely on the other's strengths to compensate for his own weaknesses.

Wilbur Wright, 32 years old in the spring of 1899, had overcome the doubts and uncertainties of late adolescence to become a cool, self-confident, and very determined adult. His high domed forehead, lean face, and strong features would make him the delight of European caricaturists during his flight demonstrations. His father remarked that Wilbur was "... never rattled in thought or temper." He was a clear and articulate writer and an entertaining and compelling public speaker. Very well read, he had an extraordinary capacity to focus his attention, separate the essentials from the extraneous, and cut straight to the heart of a technical problem.

Unlike his older brother, Orville absolutely refused to speak in public. He would outlive Wilbur by more than 35 years and attend hundreds of banquets and award ceremonies, yet he refused to speak so much as a word into a microphone. On public occasions, a friend explained, "words simply failed him." If Wilbur was the public spokesman, however, Orville wrote

George Cayley (1773–1857) is recognized as the father of aerodynamics. Like the Wrights, he closely observed bird flight. Decades ahead of his time in the study of lift, propulsion, and control, he understood that separate systems would control these functions. The horizontal and vertical control surfaces he designed anticipated those of today.

clear, concise, and effective prose. His efforts in that regard ranged from preparing some of the clearest published statements of what he and his brother had accomplished, to his warm and entertaining letters to family and friends.

Orville would turn 28 on August 19, 1899. The younger brother sported a mustache and an easy grin. His father described him as "exciteable," a man whose thoughts were "quick." Orville was a born inventor, who found his fullest expression in solving technical problems, great and small. He was always careful about his appearance. A favorite niece remarked that she did not believe ". . . there was ever a man who could do the work he did in all kinds of dirt, oil and grime and come out of it looking immaculate." Wilbur, far less concerned about such things, gave the most important speech of his life in Chicago in the fall of 1901 dressed in his brother's top coat, shirt, collar, cuffs, and cuff links.

At the moment of their entry into aeronautics, the Wright brothers seemed to be the most ordinary of young men. The proprietors of two small businesses, they were still living in their father's house. They were restless, anxious to exercise their talents and make their mark on the world. Wilbur, in particular, seems to have been looking for a challenge against which to measure himself and through which he could demonstrate his value to the world. He would find it in the airplane.

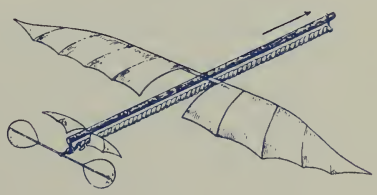
By 1899 Americans were living in an age of change like no other in human history. When their grandparents were young, people, goods, and messages had moved at the speed of the fastest horse. Now travelers could board a train and travel to distant places at speeds unimaginable a lifetime before. Even more astounding was the fact that news and personal messages traveled at the speed of light over telegraph lines, while the telephone enabled people on opposite ends of the continent to converse as if they were in the same room.

The winds of change had swept across Dayton, altering the way people lived their lives. City water had arrived in the early 1870s, followed by sewers and the telephone (1879), the first electric street lights (1882), and paved streets (1889). The Dayton, Springfield, and Urbana, an electric interurban railroad that would link Dayton into a network of cities all over the Midwest, was chartered in 1895. The following year Cordy Ruse, a friend of the Wrights, went clattering down the freshly paved streets of West Dayton in the first automobile ever seen in the city. For all of the change they had witnessed, however, most Americans still regarded the notion of a heavier-than-air flying machine as something close to the definition of the impossible.

Alphonse Pénaud (1850–80) did pioneering work with the concept of inherent stability. His wing configuration and movable tail assembly allowed his model "planaphore" (below) *to steady itself after being hit by a gust of wind. He was the first to use a twisted rubber band as a power source, and he designed the flying toy given to the Wrights by their father.*

The Wright brothers had never forgotten the Pénaud helicopter toy their father had given them in 1878. They paid special attention to the newspaper and magazine articles on aeronautics that came to their attention. They were particularly interested in Otto Lilienthal, the German flying machine experimenter who had published an important book on the basic principles of aeronautics in 1889. He completed some 2,000 flights in 18 different glider designs between 1890 and the time of his death in a glider crash in 1896. He was the one man in history who had repeatedly flown on wings of his own design.

"My own active interest in aeronautical problems dates back to the death of Lilienthal in 1896," Wilbur explained in 1901. "The brief notice of his death that appeared in the telegraphic news at that time aroused a passive interest which had existed from my childhood . . . " Orville was ill with typhoid when Wilbur read a news account of Lilienthal's death. As Orville recovered, Wilbur brought him up to date. They discussed the issue at length and searched their father's library and the shelves of the public library for books on the subject. They found information on the flight of birds, but nothing that offered much insight into the design of heavier-than-air flying machines.



"As our interest at that time was mere curiosity as to what had been done," Wilbur recalled, "we did not pursue the subject further when we failed to find books relating to human flight." But the spark of serious interest had been struck. "From the date of the death of Lilienthal in 1896," Orville remarked, "we were so interested [in aeronautics] that we discussed matters in this line almost daily."

Their interest in flight smoldered for the next three years, until fanned into a flame as a result of reading yet another book on ornithology. "Our own growing belief that men might . . . learn to fly," Wilbur explained, "was based on the idea that while thousands of creatures of the most dissimilar bodily structures, such as insects, fishes, reptiles, birds and mammals, were every day flying through the air at pleasure, it was reasonable to suppose that men might also fly."

This time they moved beyond the resources of the local library in search of information on the design of heavier-than-air flying machines. Wilbur wrote to Washington, D.C., on May 30, 1899, requesting "such papers as the Smithsonian Institution has published on this subject, and if possible a list of other works in print in the English language." Samuel Pierpont Langley, secretary of the Smithsonian, was one of the best known and most successful aeronautical experimenters of the day, having developed steam-powered flying models with wingspans of up to 15 feet—"aerodromes" that had made flights of three quarters of a mile in the spring and fall of 1896.

Richard Rathbun, a Smithsonian official, replied to Wilbur just three days after receiving his letter, enclosing reprints of four articles on aeronautics from Smithsonian publications and some suggestions for additional reading. During the second week in June 1899, the brothers spent a total of $5.50 for additional "books on flying" that Rathbun had recommended.

Having digested the experience of others, the Wrights demonstrated one of the keys to their ultimate success, an extraordinary ability to analyze a

Heavier-than-air flying machines are impossible.

—Lord Kelvin, British mathematician and physicist, 1892.

problem. The invention of the airplane, they concluded, would require solutions to problems in three areas. Such a craft would require wings developing sufficient lift to support the weight of the machine and pilot; an engine powerful enough to propel the craft to flying speed; and a means of controlling the machine in the air.

The brothers reasoned that a great deal was known about the problems of wing design and propulsion. Otto Lilienthal had taken to the air some 2,000 times, while Samuel Langley's tandem-winged aerodromes had established a world record for time aloft by a powered flying machine of one minute and 20 seconds. Experiments with internal combustion engines for horseless carriages were underway in the United States and Europe. That left the problem of control. "We reached the conclusion," Wilbur explained, "that . . . the problem of equilibrium had been the real stumbling block in all serious attempts to solve the problem of human flight, and that this problem of equilibrium in reality constituted the problem of flight itself."

Most aeronautical experimenters assumed that controlling an aircraft in flight would be very difficult, and sought to develop inherently stable machines that would automatically fly straight and level until the pilot initiated a change in course or altitude. In considering the problems of control, the Wright brothers demonstrated another of the gifts that was to set them apart from other experimenters—an extraordinary capacity to apply the lessons learned in one technology to a new situation. As cyclists they knew that an experienced rider could operate an inherently unstable vehicle moving at relatively high speed with few difficulties. Their goal was to develop an airplane that could be controlled with the precision and ease of a bicycle.

How were they to accomplish that goal? An aircraft had to be controlled in three axes—roll, pitch, and yaw *(see pages 66–67)*. The most difficult task was to

It was not until the news of the sad death of Lilienthal reached America in the summer of 1896 that we again gave more than passing attention to the subject of flying.

—Wilbur and Orville Wright, in *Century Magazine*, 1908, on the inspiration they drew from German experimenter Otto Lilienthal, killed in a gliding accident.

Fellow Visionaries

On May 30, 1899, Wilbur Wright wrote to the Smithsonian Institution in Washington, D.C. Affirming his belief that human flight was possible, he declared his intention to "begin a systematic study of the subject in preparation for practical work." Among publications the Smithsonian sent him was Octave Chanute's *Progress in Flying Machines* (1894), a compendium of virtually everything that had been done with heavier-than-air flying machines up to that time.

Chanute became the Wrights' closest colleague in the aeronautical community. After building a national reputation as a civil engineer, he emerged in the 1880s and 1890s as the clearinghouse of information regarding aeronautics. He also supervised the construction and testing of a number of glider designs of his own. The biplane configuration of one of these significantly influenced the Wright brothers' designs.

Famed German glider pioneer Otto Lilienthal was another pivotal figure for the Wrights. Before he died of injuries sustained in a flying accident in 1896, Lilienthal had conducted extensive aerodynamic research, tested his results with a series of successful full-size, piloted gliders, and published a landmark book, *Birdflight as the Basis of Aviation* (1889). Of particular importance was a table of air pressure data on a curved wing surface that became a starting point for aerodynamic research for all serious experimenters. Wilbur would later refer to him as "the greatest of the precursors."

Samuel P. Langley, secretary of the Smithsonian Institution, was celebrated for the successful flight of his *Aerodrome #5* in 1896. It was the first large-scale, unpiloted heavier-than-air flying machine to fly. Langley's credibility was severely compromised, however, with two dramatic and very public failures of a full-size, piloted version of his *Aerodrome* in 1903, the second just nine days before the Wright brothers' triumph at Kitty Hawk. That someone of Langley's stature was experimenting in a field still viewed with skepticism by many instilled confidence in the brothers that aeronautics was a serious endeavor.

—Peter L. Jakab, Curator, National Air and Space Museum

Otto Lilienthal (1848–96) and his biplane glider.

Samuel Langley (1834–1906) and his 1896 powered Aerodrome *model.*

Octave Chanute (1832–1910) and his 1896 glider.

control it in the roll axis (lateral control), balancing the wingtips to maintain level flight, or banking the wings for a turn.

Wilbur was working late in the bicycle shop one evening in July 1899, chatting with a customer, when he began idly fingering a long, slender, inner-tube box. When he held the ends of the box and twisted his hands gently in opposite directions, a helical twist moved back and forth across the box. If the horizontal faces of the box were the two wings of a biplane, and the vertical faces were the struts supporting and separating the wings, he reasoned, a twist in either direction would increase the angle of attack (the upward tilt of the wing relative to the airflow), and thus the lift, on one side and decrease it on the opposite side. The pilot of such an aircraft, provided with suitable controls, could balance the wings with ease, or bank for a turn. It was the technique that would come to be known as wing-warping—the precursor of ailerons on today's aircraft—and it was one of the Wrights' most brilliant and original contributions to aeronautics.

Wilbur explained the idea to Orville, and immediately constructed "... a little model made out of bamboo having lateral spars and upright standards connecting them, the whole being braced by truss threads." The skeletal model was an even clearer demonstration of the warping principle, and provided the brothers with some notion of how they might design the structure of a wing-warping flying machine.

Wilbur then proceeded to build and test their first real aircraft, a biplane kite with a wingspan of five feet and a small rectangular rear elevator. He adapted the Pratt truss—originally crossed bracing used by railroad bridge builders—employing diagonal wires to tie the two wings and six upright struts into a single sturdy yet flexible structure. With lines leading to a pair of sticks held in the operator's hands, a helical twist could be imparted to the wings in either direction to roll the little craft to the right or left. The kite

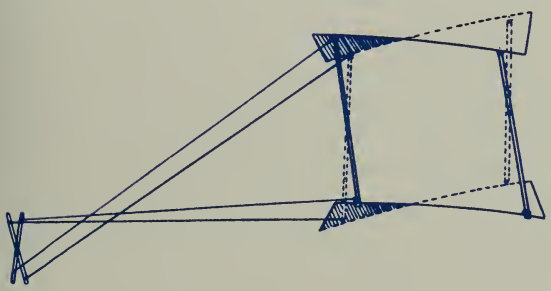
The Wrights wanted their envisioned aircraft to mimic the wing-twisting they had observed in large birds as a means of control, but they didn't know how to achieve this. Twisting the ends of an inner-tube box, Wilbur saw its warped top and bottom as the wings of a biplane glider. The brothers first put the principle into practice with a kite (opposite), *warping the wings from the ground. The system grew more sophisticated in their gliders.*

We reached the conclusion that . . . this problem of equilibrium in reality constituted the problem of flight itself.

—Wilbur Wright, 1899

was constructed so that the top wing could be shifted forward or backward relative to the bottom wing, to pitch the craft up or down.

Wilbur flew the kite for the first time in late July on the grounds of Union Seminary, eight or ten blocks from home. He encountered a dozen or so young boys along the way who had the privilege of helping to launch the first flying machine of any kind to operate under complete control—or almost complete control. When Wilbur allowed the lines to go slack, the kite dove out of control, scattering the youngsters, two of whom stopped by the shop several days later to tell Orville all about it. By that time, Wilbur had already briefed his brother on the successful performance of the kite, and they had decided to take the next step.



Having determined that the wing-warping control system worked in practice, the brothers planned to design and build a kite/glider large enough to carry one of them aloft. With their machine tethered to the top of a 150-foot derrick, they hoped to fly "for hours at a time," growing accustomed to the sensation of flight and "getting in this way a maximum of practice with a minimum of effort."

Anxious to discuss their plan with an authority in the field, Wilbur wrote to Octave Chanute on May 13, 1900. "For some years," he began, "I have been afflicted with the belief that flight is possible to man." Chanute was accustomed to receiving such letters. At 68 he was one of the most distinguished civil engineers in America and a leading authority on the history of aeronautical experimentation.

For more than two decades Chanute had gathered information on flight, organized meetings on aeronautics, and corresponded with aviation pioneers around the globe. He published the results of his research in a

Wilbur Wright
Orville Wright

Established in 1892.

Manufacturers of Bicycles — Van Cleve — St. Clair

Wright Cycle Company

1127 West Third Street.

DAYTON, OHIO. May 13, 1900

Mr. Octave Chanute, Esq.,
Chicago, Ill.

Dear Sir;

For some years I have been afflicted with the belief that flight is possible to man. My disease has increased in severity and I feel that it will soon cost me an increased amount of money if not my life. I have been trying to arrange my affairs in such a way that I can devote my entire time for a few months to experiment in this field.

My general ideas of the subject are similar those held by most practical experimenters, to wit: that what is chiefly needed is skill rather than machinery. The flight of the buzzards and similar sailors is a convincing demonstration of the value of skill, and the partial needlessness of motors. It is possible to fly without motors, but not without knowledge & skill. This I conceive to be fortunate for man, can by reason of his greater intellect, can more reasonably hope to equal birds in knowledge, than to equal nature in the perfection of her machinery.

Assuming then that Lilienthal was correct in his ideas of the principles on which man should proceed, I conceive that his failure was due chiefly to the inadequacy of his method, and of his apparatus. Due to his method, the fact that in five years time he spent only about five hours, altogether, in actual flight is sufficient to show that his method was inadequate. Even the simplest intellectual or acrobatic feats could never be so learned here

would depend on many hours of [illegible] per week without rain or too inclement weather. I am certain that such localities are very

I have your "Progress in Flying Machines" and your articles in the "Annuals" of '95, '96 & '97 as also your recent articles in the "Independent." If you can give me information as to where an account of Pilchers experiments can be obtained I would greatly appreciate your kindness.

Yours truly
Wilbur Wright.

classic book, *Progress in Flying Machines* (1894). Two years later he led a group of young engineers into the sand dunes ringing the southern shore of Lake Michigan, east of Chicago, where they tested a series of gliders, including a successful biplane with which the Wright brothers were especially impressed.

Having introduced himself to Chanute, Wilbur briefly described the brothers' plan, invited comments from the older engineer, and asked for advice as to potential test sites. It was the first of the hundreds of letters, notes, and telegrams that would pass back and forth between them over the next decade. The older engineer would become the closest friend and confidant that the Wrights had in aeronautics.

Familiar with Octave Chanute's respected work on the state of aeronautics, Progress in Flying Machines *(1894), Wilbur Wright wrote him in May 1900 for advice on his upcoming experiments. The letter was the beginning of a close relationship based on mutual esteem and a shared belief in the possibility of flight.*

Neither of the Wrights had attended college or received any formal engineering training. Nevertheless, they would prove themselves to be practical and intuitive engineers of genius. From the outset they were determined to calculate the performance of a glider before it was constructed. Chanute had published a table, based on the work of Otto Lilienthal, that provided precise mathematical values for the amount of lift and drag (the retarding force exerted on the wing by air) on a particular wing shape at varying angles of attack. When used in conjunction with a relatively simple equation, the data enabled the Wrights to calculate the amount of wing area required to lift the estimated weight of a glider, flying at an efficient angle of attack in a wind of given velocity.

The calculations showed that the only hope of getting into the air with a glider of reasonable size was to fly in a headwind of 15 to 20 miles per hour. In addition to such strong and steady winds, the ideal test site would offer gently sloping sand dunes for long flights and soft landings. Dayton did not have any of those advantages.

In response to an inquiry from the Wrights regarding winds in the Chicago area, where Chanute and his associates had flown in 1896, a U.S. Weather Bureau official provided issues of the *Monthly Weather Bulletin*,

which included a table of average wind speeds at each of the 120 field stations maintained by the Bureau. Chicago was indeed the windiest city on the list, but the brothers decided to select a more remote site where they could pursue their experiments without attracting the attention of the public or the press.

The sixth-windiest weather station on the list was located at Kitty Hawk, an isolated village on the Outer Banks of North Carolina. A letter requesting information on local conditions resulted in a short note from Joseph J. Dosher, the only Weather Bureau employee at Kitty Hawk, and a longer letter from his friend William J. Tate, a local notary and Currituck County Commissioner. Tate assured the Wrights that the area was perfect for kite flying, with wide flat beaches, tall sand hills with few trees, and strong, steady winds. "If you decide to try your machine here . . . ," he promised, "I will take pleasure in doing all I can for your convenience & success & pleasure." Tate closed his letter with an assurance that " . . . you will find a hospitable people when you come among us."

The Wrights decided to accept this warm invitation to visit a place that seemed to offer ideal conditions for their experiments. Over the next four years they would conduct their aeronautical work in two places, designing and building their machines in Dayton, testing them in the wind and sand of the Outer Banks.

Wilbur would pioneer the route to Kitty Hawk *(see map, page 43)*, with Orville following a week or so later if he could find someone to manage the bicycle shop. The journey began on September 3, 1900, when Wilbur boarded a train bound for Old Point Comfort, at the tip of the Virginia Peninsula, where he crossed historic Hampton Roads on a steamer and arrived in Norfolk late the next evening.

The trip cannot have been easy for Wilbur. He was traveling with a trunk that contained his personal belongings as well as the prefabricated parts of the 1900 kite/glider. The 18-foot-long pieces of spruce that would serve as main wing spars were too cumbersome

I will take pleasure in doing all I can for your convenience & success & pleasure . . . . you will find a hospitable people when you come among us.

—William Tate, Kitty Hawk resident and local official, in letter to Wilbur, 1900.

to ship, however. Having decided to purchase them en route, Wilbur set out in the 100°F heat of a Norfolk day in search of a lumber yard. Unable to find spruce of the appropriate length, he was forced to settle for white pine spars two feet shorter than planned.

The final leg of the journey began with a short train ride south through the Dismal Swamp to Elizabeth City, North Carolina, where he wandered the dock area for three days in search of a boat to carry him down the Pasquotank River and across Albemarle Sound to Kitty Hawk Bay on the Outer Banks. Unfortunately, as Wilbur explained in a letter to his family, "no one seemed to know anything about the place, or how to get there." Finally, on September 11, he met Israel Perry, who offered him passage to Kitty Hawk aboard a flat-bottomed fishing schooner.

With all of his gear and lumber loaded into a leaky skiff, Wilbur, accompanied by Perry and two others, traveled three miles down the Pasquotank to the schooner, which proved to be in even worse condition than the skiff. "The sails were rotten, the ropes badly worn, and the rudderpost half rotted off," Wilbur noted, "and the cabin so dirty and vermin-infested that I kept out of it from first to last."

Things went from bad to worse when the schooner ran into a storm as it moved east down the sound, pitching, rolling, and taking on water as it went. "In a severe gust the foresail was blown loose from the boom and fluttered to leeward with a terrible roar," Wilbur recalled. "The boy and I finally succeeded in bringing it in though it was rather dangerous work in the dark and with the boat rolling so badly." Captain Perry finally succeeded in tucking his boat behind a point, where they remained safely sheltered from the storm. The adventure was particularly trying for the Captain. "Israel had been so long a stranger to the touch of water upon his skin," Wilbur reported, "that it affected him very much."

The voyage resumed after repairs were complete the following afternoon. They finally tied up at the little

In a severe gust the foresail was blown loose from the boom and fluttered to leeward with a terrible roar. The boy and I finally succeeded in bringing it in though it was rather dangerous work in the dark and with the boat rolling so badly.

—Wilbur Wright, in a letter describing his first trip to the Outer Banks in 1900.

Because their 1900 glider didn't provide enough lift to carry a man when flown as a kite, the Wrights asked young Tom Tate (right), *nephew of their hosts Bill and Addie Tate* (inset), *to ride while they tested the control system from the ground. Avid photographers, the Wrights documented every step of their experiments. They used this 5x7 glass-plate camera after 1901 and with it produced the famous image of the first flight* (pages 64-65).

dock at Kitty Hawk that night. Nine full days after leaving Dayton, Wilbur Wright had arrived at his destination. A young boy who wandered by the dock the next morning volunteered to guide the visitor up a sandy path through the trees to the home of William and Amanda "Addie" Tate. They lived on the western edge of Kitty Hawk, a village of a few dozen buildings scattered through the maritime forest ringing Kitty Hawk Bay.

Tate's welcome was just as warm as he had promised. Wilbur agreed to room with the family, at least until Orville arrived. He would assemble the first full-scale Wright kite/glider in a tent pitched in the Tates' front yard. Mrs. Tate volunteered to help him alter the fabric that had been pre-sewn in Dayton so that it would fit the shorter wings constructed using the new spars.

When complete, the 1900 Wright aircraft was a biplane with a wingspan of 17 feet and a chord (a line between the leading and trailing edges of the wing) of five feet. The total weight without the pilot was just under 50 pounds. The wings were constructed of the pine spars purchased in Norfolk and ash ribs that had been steam-bent to shape in Dayton. The pilot would lie prone in a cut-out section on the lower wing, with his hands grasping the control that flexed the rear edge of the forward elevator up or down to control the aircraft in pitch. His feet rested on a bar that operated the wing-warping system for lateral control.

"The covering of the machine was French sateen [a closely woven cotton]," Wilbur noted, "and it was put on bias, so that no wire stays were needed to brace the surfaces diagonally." Applied on the bias (diagonally), the fabric became a key element of the structure, holding the ribs and spars in place and distributing flight loads across the wing. The result was a tough, easily repaired, flexible wing capable of absorbing punishment that would probably break a more rigid wire-braced structure. The design typified the practical engineering genius of the Wright brothers.

1900

Kitty Hawk, North Carolina

Living on the Outer Banks

For four years, from 1900 to 1903, the Wrights came to the Kitty Hawk area of North Carolina's Outer Banks, seeking the right conditions for their flight experiments. The Outer Banks are a narrow chain of barrier islands stretching more than 175 miles from North Carolina's border with Virginia to below Cape Lookout. Separated from the mainland by sounds up to 30 miles wide, the islands are exposed to prolonged storms, whose high winds have over the years formed dunes up to 100 feet high. The dunes named Kill Devil Hills provided the Wrights with a perfect flight laboratory.

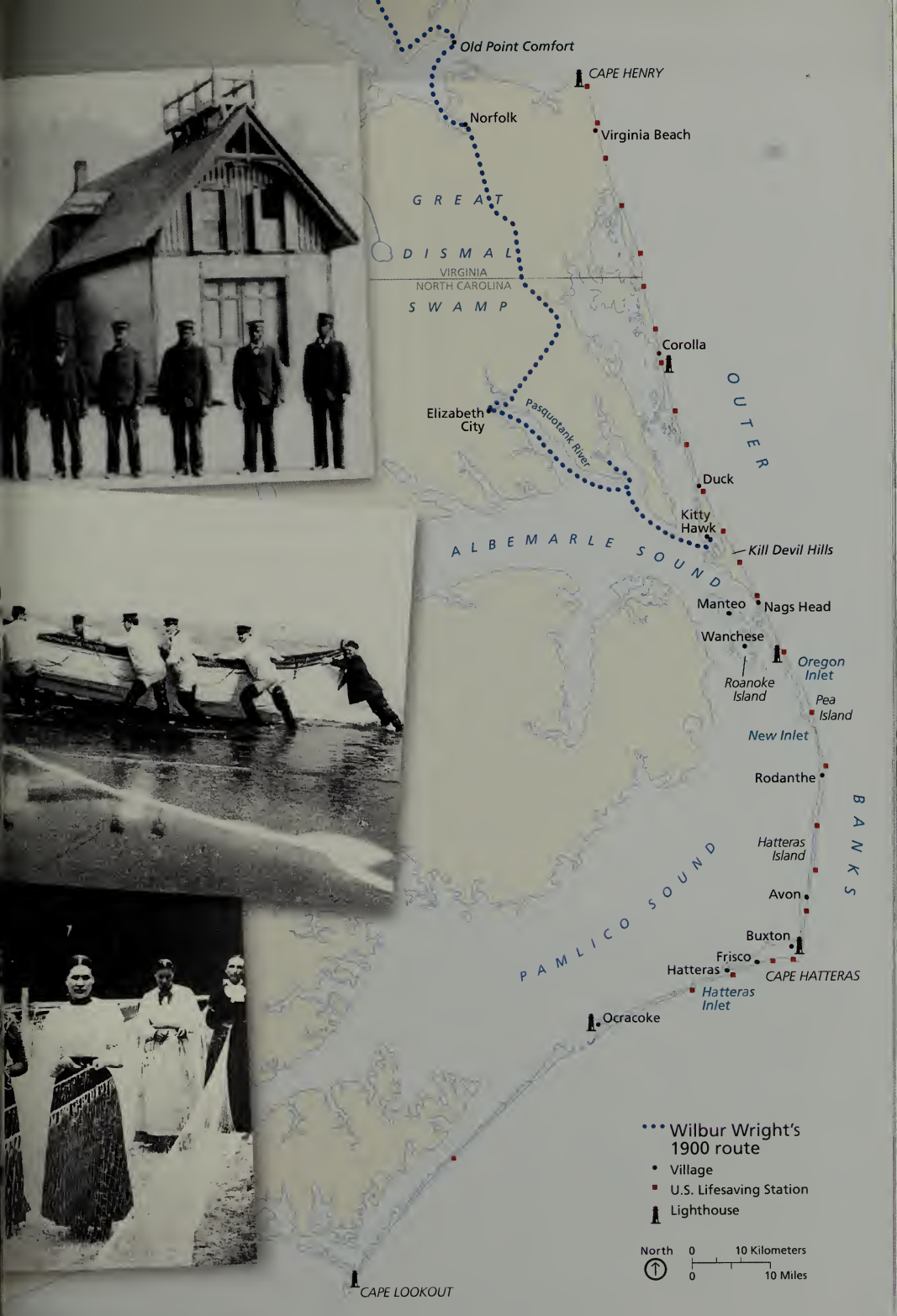
The Outer Banks were geographically isolated, but they were far from deserted. Mainlanders had been vacationing there for decades before the Wrights arrived. From the earliest settlement in the late 17th century the lives of the islands' inhabitants had revolved around the sea: fishing, piloting, lifesaving, and lightering—moving goods from a larger ship to smaller boats for transport through the sounds and tricky inlets. Most Bankers likely practiced a combination of these activities along with subsistence farming.

Fishing had been a primary occupation for more than two centuries. Following the Civil War large commercial fisheries moved into the area, eroding the traditions of independent fishermen. In the late 19th century, men, women, and children went to work for wages in the commercial enterprises.

The treacherous nature of the sea off the Outer Banks created the need for an organized approach to rescuing shipwreck victims. Generally operated and manned by locals, the lifesaving stations built by the U.S. Lifesaving Service appeared on the islands as early as 1874. The station at Pea Island employed an all African-American crew—the only one in the country. Eventually the Lifesaving Service built a total of 29 stations along the Outer Banks. A few of the crew members at the nearby Kill Devil Hills station lent an enthusiastic hand with the Wrights' experiments.

—Jill Hanson, former National Park Service historian

From top: *Crew from the U.S. Lifesaving Station, Pea Island, about 1896; Lifesaving crew hauling their boat from the sea, 1905; Mending fishing nets on Roanoke Island, about 1900.*


Old Point Comfort
CAPE HENRY
Norfolk
Virginia Beach
GREAT
DISMAL
VIRGINIA
NORTH CAROLINA
SWAMP
Corolla
OUTER
Elizabeth City
Pasquotank River
Duck
Kitty Hawk
Kill Devil Hills
ALBEMARLE SOUND
Manteo
Nags Head
Wanchese
Oregon Inlet
Roanoke Island
Pea Island
New Inlet
Rodanthe
BANKS
Hatteras Island
PAMLICO SOUND
Avon
Buxton
Frisco
Hatteras
CAPE HATTERAS
Hatteras Inlet
Ocracoke
Wilbur Wright's 1900 route
Village
U.S. Lifesaving Station
Lighthouse
North
0
10 Kilometers
0
10 Miles
CAPE LOOKOUT

"A Steady Wind and a Free Sweep"

As with everything they did concerning their aeronautical experiments, the Wrights' choice of a place to fly was based on patient research. Their study of U.S. Weather Bureau records and correspondence with William Tate, resident of Kitty Hawk on North Carolina's Outer Banks, indicated that this area offered the best combination of strong and steady winds, hills for gliding, unobstructed space, sand for soft landings, and isolation from the press.

But the very things that made flying conditions ideal made living conditions difficult. In the four flying seasons the Wrights spent on the Outer Banks—usually in the Fall—the letters describe an ongoing battle against the elements. "Trying to camp down here reminds me constantly of those poor arctic explorers," wrote Orville. Blowing sand was a daily fact of life. The infamous Outer Banks nor'easters would have them holding down their tent in the middle of the night. In the latter part of the season, temperatures could be bitter cold. In 1902 they built quarters to replace the tent and in 1903 fashioned a stove, but it was so smoky they had to sit on the floor, "with tears streaming down our cheeks enjoying its kindly rays of heat."

Early in the season they were plagued by a "mighty cloud" of mosquitoes. "Lumps began swelling up all over my body like hen's eggs," wrote Orville to his sister Katharine. For protection they would wrap themselves in blankets. When they could bear the heat no longer and uncovered themselves, the mosquitoes pressed the attack. After a few "desperate and vain slaps," they hid again in the stifling blankets. "Misery!" groaned Orville.

Yet it was worth it. The brothers looked back on their seasons on the Outer Banks with fondness. These were highly creative years—slow, steady experimentation punctuated with technological breakthroughs and satisfying progress in their development as pilots. They were willing to endure great discomfort, discouragement, and the very real threat of injury as they moved towards their goal—to fly.

The Wrights' 1900 tent, pitched by the dunes near Kitty Hawk, accommodated the brothers and their glider.

[It was] like the Sahara, or what I imagine the Sahara to be.

—Orville Wright, remembering Kill Devil Hills, 1943.

A lot of folks thought the Wrights were a little touched, you know . . . they would imitate the way birds flew . . . turn their arms like wings and run through the dunes while watching the gulls.

—Mellie Daniels, Kitty Hawk resident.

Wilbur was close to completing work on the aircraft when Orville arrived in Kitty Hawk on September 28. Soon thereafter the brothers moved into a tent pitched 100 yards or so south of the Tate home, where the maritime forest gave way to sand flats, rolling dunes, and sand hills that stretched from the edge of the sound to the Atlantic surf.

The active career of the first full-scale Wright aircraft lasted less than two weeks, October 5–18, 1900. After testing the new machine as a kite for some time on the first day, Wilbur could no longer resist the urge to venture aloft. This first attempt at tethered flight was frightening, and less than satisfactory. It was apparent from the outset that the wings developed far less lift than the calculations based on the Lilienthal tables had predicted. The dream of remaining aloft for hours at a time was quickly dashed. After one or two tries, the notion of tethering the kite to a tower was also abandoned.

Since prevailing winds were almost never high enough to lift the weight of a pilot, virtually all of the 1900 tests were conducted flying the machine as an empty kite, or carrying a load of sand or chain. The brothers turned the situation to their advantage, measuring the actual performance of their glider, collecting data that could be used to create accurate aerodynamic tables. "So far as we knew," Wilbur remarked, "this had never previously been done with any full scale machine."

They attached a grocer's scale to the kite line to measure the combined lift-and-drag force on the machine, used an anemometer to record wind speed, and measured the angle of the kite line to the horizontal. With that information in hand, they calculated that their wings were generating only two-thirds of the lift predicted by the Lilienthal table. They offered young Tom Tate, Bill Tate's lightweight nephew, some thrilling rides on their kite, an activity that enabled them to calculate the resistance of someone sitting upright on the machine. They were also able to dem-

onstrate the effectiveness of their control system with separate lines running to an operator on the ground.

Satisfied that they had gathered as much data as possible, the Wrights decided to attempt free glides. They carried the aircraft to the highest elevation in the area, a group of four dunes known locally as the Kill Devil Hills, some four miles south of Kitty Hawk. Having lugged the glider part of the way up the slope of the tallest hill (100 feet), they found the wind gusting to 25 miles per hour. "As we had . . . no experience at all in gliding," Wilbur explained, "we deemed it unsafe to attempt to leave the ground." Returning the next day when conditions were a bit less daunting, Wilbur (who would do all the flying until 1902) made a dozen free glides totaling about two minutes in the air.

The Wrights flew their 1900 glider mostly as a kite. Their wing-warping worked as they had hoped, but they found the elevator response unpredictable—and difficult to work simultaneously with the wing-warping controls. However, when they took the machine to the Kill Devil Hills and Wilbur made a dozen free glides with the wing-warping controls tied off, he was able to precisely control the pitch and make soft landings.

They returned to Kitty Hawk alone at the end of the day, having abandoned the machine that first carried them into the sky on the spot where it made its last landing. After asking permission of the brothers, Mrs. Tate salvaged the fabric to make dresses for her two daughters. Several local women later remarked on what a shame it had been to waste such fine fabric on a kite.

On October 19 the Wrights headed back to Dayton and the routine of the bicycle shop, but flight was never far from their minds. The key to their approach to technical innovation involved learning from mistakes as well as successes, and incorporating the lessons learned with each machine into the design of the next. They moved toward the development of a practical airplane through an evolutionary chain of seven aircraft: one kite (1899), three gliders (1900, 1901, 1902), and three powered machines (1903, 1904, 1905). Each of those aircraft was a distillation of the lessons learned with its predecessors.

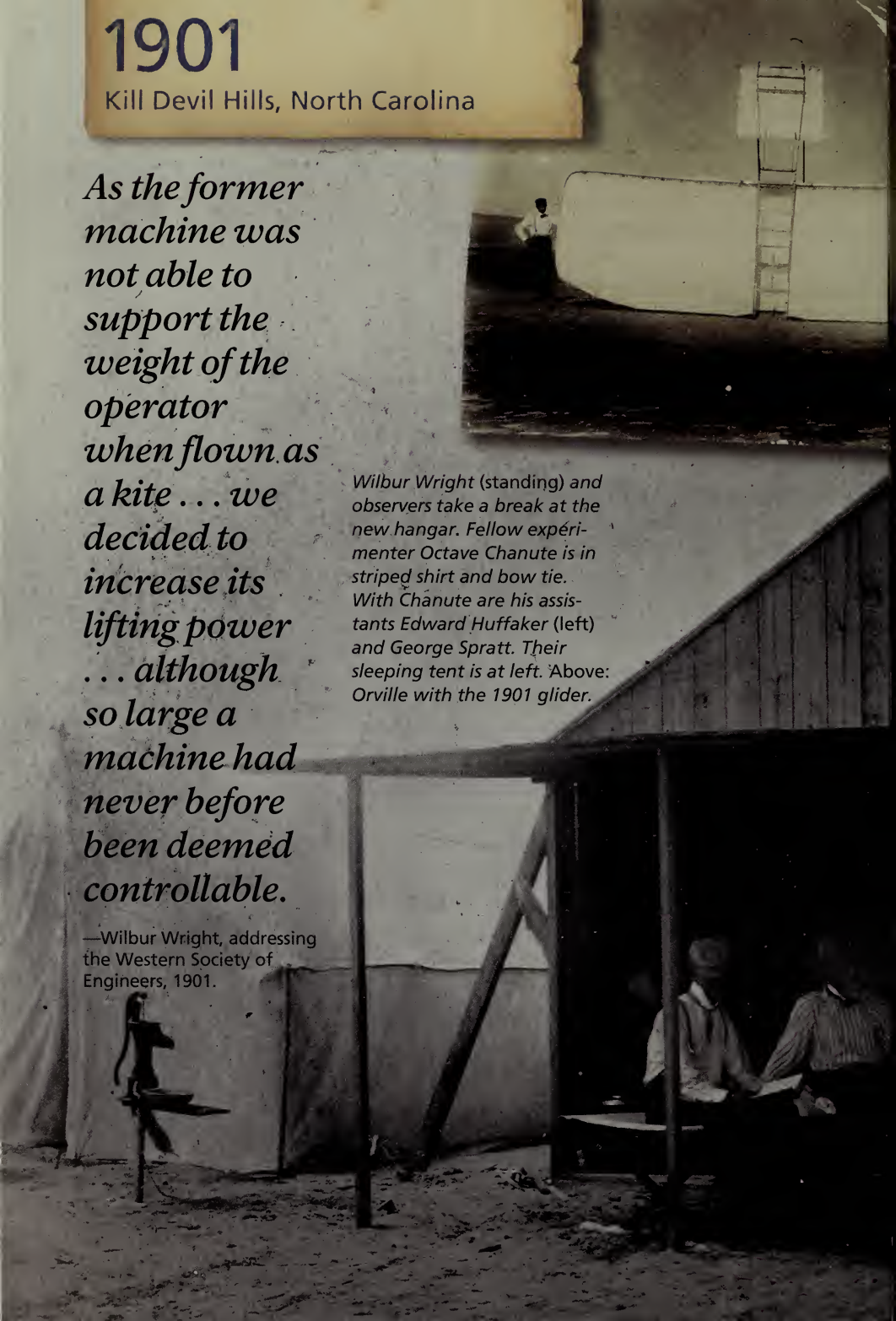
They used a three-pronged attack in the design of their next glider to improve the inadequate lift of the 1900 aircraft: using a less porous muslin wing covering; increasing the camber (curvature) of the airfoil to match that on which Lilienthal had based his table;

1901

Kill Devil Hills, North Carolina

As the former machine was not able to support the weight of the operator when flown as a kite . . . we decided to increase its lifting power . . . although so large a machine had never before been deemed controllable.

—Wilbur Wright, addressing the Western Society of Engineers, 1901.



Wilbur Wright (standing) *and observers take a break at the new hangar. Fellow experimenter Octave Chanute is in striped shirt and bow tie. With Chanute are his assistants Edward Huffaker* (left) *and George Spratt. Their sleeping tent is at left.* Above: *Orville with the 1901 glider.*

Putting Theory to the Test

The 1901 season of experiments was the most trying of all. The larger glider was less responsive to the elevator: pitching up and down, climbing into stalls—"precisely the fix Lilienthal got into when he was killed," Orville wrote his sister Katharine. Worse, the wing-warping control was producing the opposite of the desired effect—adverse yaw. When, for example, the pilot tried to raise the left wing by warping its tip, the wing instead "fell behind." The glider skidded to the left and spun into the sand; the Wrights called it "well-digging." Discouraged, Wilbur wrote that the problem of stability was "seemingly untouched."

If you are looking for perfect safety, you will do well to sit on a fence and watch the birds; but if you wish to learn, you must mount a machine and become acquainted with its tricks . . .

—Wilbur Wright, addressing the Western Society of Engineers, 1901.

and enlarging the wing area from the 165 square feet of 1900 to 290 square feet. The wings of the new glider spanned 22 feet, with a seven-foot chord. The pilot now warped the wings with a hip cradle he moved toward the high wing to restore balance. At 98 pounds the 1901 machine weighed almost twice as much as its predecessor. It was the largest glider anyone had flown to date.

The Wrights returned to the Outer Banks in July 1901. They drove a well on the sand flats at the base of Big Kill Devil Hill, from which they had launched their glider the year before, and, with the help of Bill Tate's brother Dan, put up a large wooden shed. The brothers would assemble and store their new glider under a solid roof, while they lived in a large tent pitched next to the hangar. This season they would share their limited quarters with guests. Octave Chanute spent some time in camp, along with Edward Huffaker and George Spratt, two young experimenters he had hired to conduct aeronautical tests for him.

The Wrights made 50 to 100 free glides and kite tests (the exact number is unknown) with their new machine between July 27 and August 17. There were problems from the outset. On Wilbur's first attempt to glide, the machine nosed sharply into the sand after flying only a few yards. After a series of additional trials in which he kept moving farther to the rear, he was finally able to complete "an undulating flight" of a little more than 300 feet. "It was apparent," Wilbur admitted, "that something was radically wrong."

The cause of the problem was clear. The relatively thin ribs spanned almost five feet between the spars, and were so flexible that under pressure they bowed up at the midpoint, nosing the aircraft into the ground. The brothers devised a complex means of reducing the flexibility by trussing down the ribs of both the upper and lower wings. When testing resumed, flights in excess of 350 feet, lasting as long as 17 seconds, were the order of the day.

While the flights grew longer, it was apparent that the new machine, like its predecessor, developed signifi-

cantly less lift than had been predicted by performance calculations. Moreover, the brothers now encountered a new and quite unexpected problem with the lateral control system. To control the aircraft with wing-warping, the pilot increased the angle of attack on the wingtip that had begun to drop, at the same time decreasing the angle on the opposite tip. It became apparent that the wing on which the angle was increased would sometimes lose speed and drop even more, rather than rising. It was the first step in a frightening sequence of events that led to the aircraft spinning into the sand. "Well-digging," the Wrights called it. "When we left Kitty Hawk at the end of 1901," Wilbur later recalled, "... we doubted that we would ever resume our experiments."

"Although we had broken the record for distance in gliding," he said, "and although Mr. Chanute, who was present at the time, assured us that our results were better than had ever before been attained, yet when we looked at the time and money which we had expended, and considered the progress made and the distance yet to go, we considered our experiments a failure. At the time I made the prediction that men would sometime fly, but that it would not be within our lifetime." Orville remembered a blunter phrase. On the train going home to Dayton, he recalled, Wilbur had remarked that "Not within a thousand years would man ever fly."

"The boys walked in unexpectedly on Thursday," their sister Katharine wrote to their father on August 26, 1901. "[They] haven't had much to say about flying." Small wonder. But if their second glider had been something of a disappointment, it had also taught them a great deal about the aerodynamic forces operating on a wing; underscored the need for a wing structure that would not deform under flight loads; confirmed that there was a problem with the data used to calculate performance; and revealed a dangerous flaw in the control system. In short, while the experience of flying the 1901 glider had been

We doubted that we would ever resume our experiments .... I made the prediction that men would sometime fly, but that it would not be within our lifetime.

—Wilbur Wright, 1912, recalling the brothers' discouragement after the 1901 flying season.

With this homemade apparatus the Wrights determined that the standard tables of lift and drag were inaccurate.

discouraging and a bit frightening, it was also enormously instructive.

The Wrights did not brood for long. Wilbur accepted Chanute's invitation to address the Western Society of Engineers in September of that year, in Chicago. His remarks, entitled "Some Aeronautical Experiments," offered both a brilliant analysis of the current state of aeronautics and a masterful summation of the Wright brothers' work to date.

Determined to come to grips with the central problem of inaccurate performance calculations, the Wrights designed a bicycle-mounted testing device. This confirmed that there were critical inaccuracies in Lilienthal's tables of lift and drag data. To overcome the problem, the brothers designed and built a wind tunnel and a pair of aerodynamic balances with which to gather their own accurate information.

During the fall of 1901 they used their tunnel to gather useful data on lift and drag acting on 48 model airfoils or wings. In addition to testing models with various cambers through a full range of angles of attack, they studied the most efficient wingspan-to-chord ratios; the impact of varying wingtip shapes on performance; and the ideal gap between the wings of a biplane.

The 1902 Wright glider was the product of two years of flight testing and a few weeks' worth of priceless wind tunnel data gathered in the back room of a bicycle shop in Dayton, Ohio. With a span of 32 feet and a chord of five feet, its wings were not only more efficient, but more elongated—more elegant—than those of its predecessors.

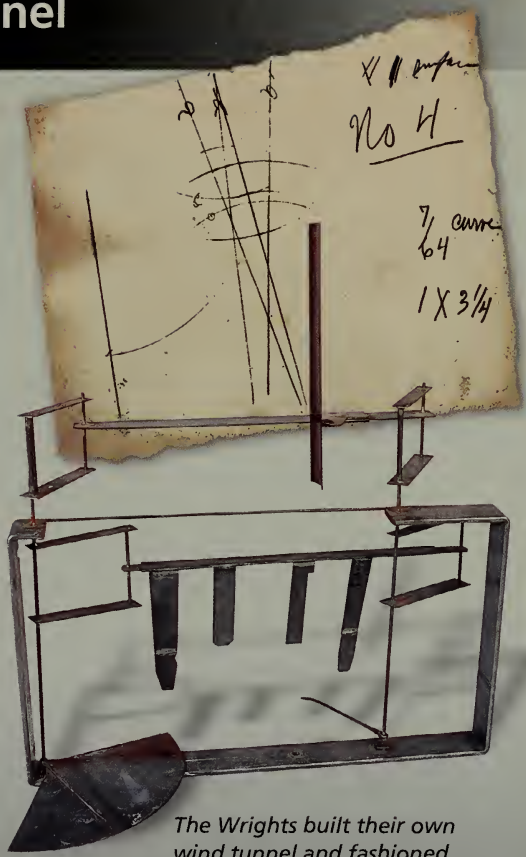
This machine was also the first Wright glider to sport a rudder. The Wrights recognized that the "well-digging" problem was the result of adverse yaw—an increase in drag on an upwarped wingtip that caused the wing to "fall behind" rather than rise. They reasoned that a fixed vertical rudder at the rear of the craft would counteract the adverse yaw and keep the aircraft moving straight forward.

The Wright Wind Tunnel

When their early gliders did not produce the amount of lift predicted by the standard tables, the Wrights built a small wind tunnel in their cycle shop to gather their own data. Balances inside were constructed so that all of the factors other than the one being measured dropped out of the readings. After conducting many preliminary tests in the fall of 1901, they mounted 48 model wing shapes on the balances and amassed an enormous body of very accurate aerodynamic data on lift and drag.

The Wright wind tunnel was not the first ever built, but it was the first used to collect specific aerodynamic data that was then incorporated into the design of an aircraft. Although the equations are more complex and the equipment more sophisticated, modern aircraft engineers fundamentally approach their work as did the Wrights.

—Peter L. Jakab, Curator, National Air and Space Museum



The Wrights built their own wind tunnel and fashioned finely balanced measuring instruments for it (replica above)*. Model airfoils mounted on the balances provided precise lift and drag data. For the preliminary measurements they used rougher instruments and recorded data on wallpaper scraps.*

1902

Kill Devil Hills, North Carolina

We now hold all the records! . . . the longest time in the air, the smallest angle of descent, and the highest wind!!!

—Orville Wright in a letter to his sister Katharine, 1902.

The Joy of Flying

In 1902 the experiences of 1900–01 bore fruit: the countless glides, the bangs and bruises, the long work in Dayton creating new lift tables; and the Wrights' characteristic genius—the ability to argue through a problem, sometimes hotly, until they found a solution. The new machine flew significantly better than its predecessors, generating the expected lift. When the fixed rudder they added to counter adverse yaw didn't solve the problem, they made the rudder movable, then linked its movement to the wing-warping mechanism. That was it. They had a glider that was a joy to fly, one capable of routine, controlled flights of more than 600 feet. It was ready for an engine.

From the height of nearly thirty feet the machine sailed diagonally backward till it struck the ground. The unlucky aeronaut had time for one hasty glance behind him and the next instant found himself the center of a mass of fluttering wreck.

—Wilbur Wright, in a 1903 address to the Western Society of Engineers, describing Orville's accident during the 1902 season.

The Wrights left Dayton on August 25, 1902, for their third experimental season on the Outer Banks. This year the brothers resolved to be more comfortable during their stay at Kill Devil Hills, extending the rear of the hangar to provide living quarters. They installed their beds over the rafters and used the additional floor space for a kitchen and dining area.

They completed 700 to 1,000 glides with their new machine between September 19 and October 24. Though the machine was a distinct improvement, the Wrights were still plagued with adverse yaw. After a number of glides, they reasoned that the rudder would be more effective if it could be turned, and more effective yet if linked to the wing-warping system so that it automatically turned in the appropriate direction. With the new design, the pilot could make smooth, precise adjustments to maintain control.

The 1902 glider was a complete success, marking the end of their original quest for an efficient flying machine operating under the control of the pilot. It embodied their core invention, a complete system of flight control. The system would require additional development, and the brothers would need to sharpen their skills as pilots. Still, the 1902 glider represented a stunning breakthrough. That was so much the case that when the time came to patent their invention, the brothers patented their 1902 glider, picturing the central elements of its flight control system, rather than a powered flying machine.

Back in Dayton that fall the Wrights were now confident that they would be the inventors of the airplane. The next step was to add a propulsion system. When a letter outlining their requirements failed to elicit a response from engine manufacturers, the brothers designed their own power plant and asked Charles Taylor, their bicycle shop machinist, to build it for them.

The cast aluminum engine that powered the 1903 Wright Flyer was a water-cooled, four-cylinder, horizontal in-line model with a four-inch bore and four-

inch stroke. Ignition was provided by a magneto, friction-driven by the large flywheel that smoothed the operation of the engine. There was a spark-retarding lever for use on the ground, but the engine could not be throttled in flight. When complete with a full radiator, gasoline, oil, and accessories, it weighed some 200 pounds. The engine was far from perfect. During the second test run the valve box overheated and cracked the block. Charlie had to return to the foundry for a new casting and begin again. The Wrights had calculated that the engine would have to produce at least eight horsepower to get the airplane into the air. The finished product developed just over 12 horsepower after a few seconds of operation. It would be enough.

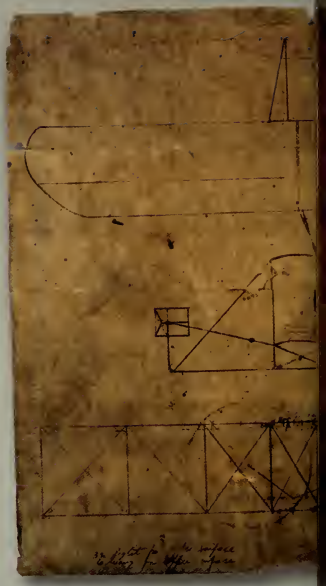
The kinds of tools the Wrights used at their Kill Devil Hills camp are shown above. In 1902, tired of tent living, the Wrights moved in with their glider. Below is Wilbur in the "kitchen."

The design of effective propellers presented a far greater challenge. The Wrights, who had initially hoped to learn from experience with ship propellers, discovered that little thought had been given to basic theory in this area. In another of their brilliant flashes of insight, the brothers reasoned that a propeller could be regarded as a rotary wing in which the lift being generated becomes the thrust that moves the aircraft forward. Knowing the number of revolutions per minute at which the propeller would be turning, they calculated the speed at which the blade would be moving at any point along its length and selected an appropriate airfoil from the tables developed during their wind tunnel tests. It sounds simple enough, but as Orville explained, "on further consideration it is hard to find even a point from which to make a start, for nothing about a propeller, or the medium in which it acts, stands still for a moment."

The engine, mounted on the lower wing of the flyer, drove twin counter-rotating propellers through a chain-drive transmission. The pilot lay prone next to the engine, with his hips in the cradle that operated the wing-warping system. A hand lever operated the forward two-surface elevator. As with the 1902 glider, the sturdy, two-surface rudder was linked to the wing-warping system.

1903

Kill Devil Hills, North Carolina



A Machine that Flies

By 1903 the Wrights believed they had solved the problems of flight: they could control their glider, they had built their own gasoline engine, and they had designed the first true airplane propellers. Now the careful, graduated experiments were over, and the goal was before them. But 1903 was not to be an easy year. They weren't sure the engine would produce enough power to lift the heavier-than-expected flyer—almost five times as heavy as the 1902 glider. Twice the tubular propeller shafts cracked during tests. They were first repaired in Dayton, then replaced with solid shafts made in Dayton. The brothers used the time to improve their flying skills with dozens of glides on the 1902 glider. A final test lifted their spirits. They mounted the flyer on a track and connected it by pulley to a 50-pound box of sand. If it could lift the weight, the engine and propellers should generate enough thrust to get the flyer airborne. The test was successful and the Wrights were now confident that their machine would be the first in history to fly.

Above left: *The Wrights' three-view sketch of their 1903 powered flyer drawn on wrapping paper.* Above: *Orville, in foreground, and Wilbur assemble the flyer.* Below: *The 1903 camp; hangar is at left, living quarters at right.*

Isn't it astonishing that all of these secrets have been preserved for so many years just so that we could discover them!!

—Orville Wright, 1903 letter to fellow experimenter George Spratt

In 1903 the Wrights converted the old hangar building into their living quarters. Shown here is their "living room," with a heating stove crafted from an empty carbide can, a rug hung to help hold in the heat, and a copy of Scientific American.

With a wing area of 510 square feet, a span of 40 feet, four inches, and an empty weight of 605 pounds, the new airplane was the largest machine that the brothers had built to date. It could no longer be launched by running into the wind with the assistance of helpers on each wingtip. Nor would wheels be of any value in the blowing sand of the Kill Devil Hills. Instead, the aircraft would achieve flying speed by riding down a 60-foot wooden monorail on a dolley with two modified bicycle hubs and another hub attached to the front of the machine.

The Wrights arrived back on the Outer Banks with their new machine on September 26, 1903. The first order of business was to repair the old building, which had been blown off its foundation by storms. This year they would put up a new building to house the airplane, and convert all of the old structure into living quarters, complete with a stove crafted from an empty carbide can and a well-stocked pantry that was the envy of every housewife in Kitty Hawk. Wilbur explained to Katharine that the old building was now known as "the summer house," while the new structure had been dubbed the "hand car . . . a corruption of the French 'hangar' used by foreign airship men."

They were soon at work on the 1902 glider stored in the old building, installing a twin-vaned rudder linked to the wing-warping system. They made 180 to 210 flights between September 28 and November 7 while assembling and pre-flight-testing the powered flyer. The record distance was in excess of 610 feet. On October 26 they remained in the air for one minute, 11.8 seconds, the longest glide anyone had achieved.

The Wrights invited Octave Chanute and George Spratt back for another season, although neither visitor was able to remain long enough to witness the flight tests of the powered machine. With some assistance from Spratt, the brothers had almost finished assembling the 1903 airplane before the end of the first week of November, and had engine and transmission tests underway. From the outset engine vibration cre-

ated serious problems with the tubular propeller shafts. Damaged during a test on November 5, the shafts had to be shipped back to Dayton for repair and would not be returned until November 20. When one of the shafts cracked a second time just eight days later, Orville hand-carried them back to Dayton, returning to the Outer Banks on December 11 with a pair of larger, stronger shafts made of solid spring steel.

While the Wright brothers had completely escaped the attention of the press, another aeronautical experimenter was front page news from coast-to-coast. With the outbreak of the Spanish-American War in 1898, the U.S. Government had offered Samuel Langley, secretary of the Smithsonian Institution, $50,000 to design, build, and test a full-scale, piloted version of the steam-powered model "aerodromes" that he had flown two years before. Designed to be launched from a catapult mounted on the roof of a houseboat anchored in the Potomac River, the craft was powered by a very advanced 52-horsepower radial engine and would be piloted by Charles Manly, Langley's chief aeronautical assistant. First tested on October 7, 1903, the machine dropped straight into the water, in the words of one Washington reporter, "... like a handful of mortar."

Manly, who had escaped injury, was game for another test of the repaired craft on December 8. On that occasion the rear wings of the machine began to fold even before it reached the end of the rail. It nosed straight up into the air, flipped onto its back and fell into the water. Manly was rescued from the icy river for a second time, but the aeronautical career of Samuel Langley was at an end.

At Big Kill Devil Hill, it took only a day to install the new propeller shafts. The next day, December 12, the Wrights ran the airplane down 40 feet of the track at full speed, damaging the rudder in the process. The next day was Sunday, and the brothers had too much respect for their father to work on the Sabbath. The repairs were complete by 1:30 the following afternoon.

He seems to think we are pursued by a blind fate from which we are unable to escape . . . .

—Orville Wright, miffed by what the brothers see as Octave Chanute's slighting of the scientific nature of their work, in a 1903 letter home.

After a while they shook hands, and we couldn't help notice how they held on to each other's hand, sort of like two folks parting who weren't sure they'd ever see each other again.

—Member of the U.S. Lifesaving Service recalling in 1927 the moments before Orville's first powered flight on December 17, 1903.

With assistance from local residents, the Wrights carried the airplane to the head of a rail that had been laid down the lower slope of the hill. Wilbur, who had won a coin toss for the honor of making the first attempt, lifted the airplane from the rail at too sharp an angle, and it immediately slammed back to earth, damaging the forward elevator.

They worked on the airplane over the next two days and waited for the wind to return. Conditions were perfect on the morning of December 17, 1903. The winds were blowing at 20–27 miles per hour, and the temperature was close to freezing, 34°F. The cold air, combined with the fact that they were operating at sea level, produced what engineers refer to as a "low density altitude," increasing the effectiveness of the wings and the propellers. The high winds prevailing that morning further increased their chances of success.

The Wrights hung a signal on the side of the "summer house" to let the fellows down at the U.S. Lifesaving Service station know that they needed a hand. John T. Daniels, A. D. Ethridge, and W. S. Dough came trudging up the beach. In addition, W. C. Brinkley, a lumber dealer from Manteo, on nearby Roanoke Island, and Johnny Moore, a neighborhood teenager, walked into camp.

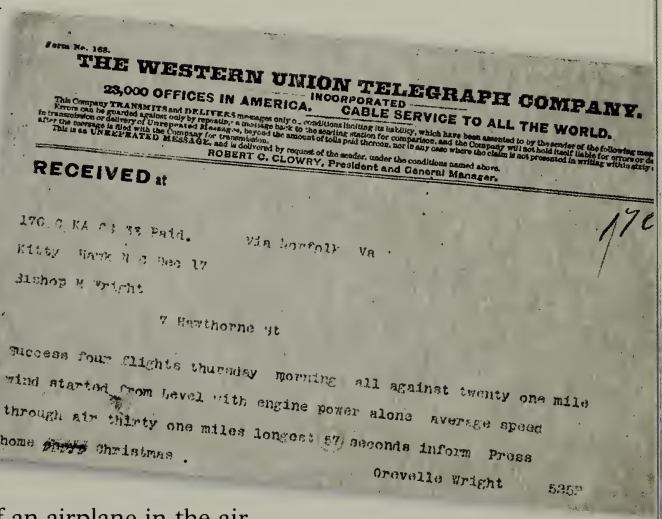
This time the Wrights had staked out the launch rail on the level sand flats near the camp, wanting the lift-off to be unassisted by gravity. Preparations were complete by 10:30 a.m. Orville had set up the camera, aimed at the spot where he thought the airplane might rise into the air, and asked John Daniels to squeeze the bulb if anything interesting happened. The propellers were pulled through to draw fuel into the cylinders, after which the dry battery coil box was carried onto the lower wing to start the engine. With Wilbur steadying the right wingtip, Orville climbed into the pilot's position next to the roaring engine and released the restraining wire that held the machine in place.

Slowly gaining speed against the cold headwind, the airplane clattered down the rail and into the air, flying

120 feet and touching the sand some 12 seconds after takeoff. The brothers and their helpers carried the 605-pound machine back to the starting point and warmed their hands in the shed for a few minutes. Then Wilbur took his position on the lower wing at 11:20 a.m. and made a flight of 175 feet in 12 seconds. Twenty minutes later, Orville flew 200 feet in 15 seconds. Just at noon Wilbur took his second turn, travelling 852 feet through the air in 59 seconds. On a lonely North Carolina beach, before a handful of witnesses, two men had made sustained controlled flights aboard a heavier-than-air machine. Humans had flown.

After removing the front elevator and lugging the machine back to camp, the group was discussing the events of the morning when a gust of wind slowly tumbled the airplane backward. The cast aluminum feet that attached the engine to the airframe snapped. The crankcase shattered when it struck the sand, the chain guides and propeller supports were twisted and smashed, and the ends of virtually all of the ribs were broken off. John Daniels, who held on too long, was carried right along with the machine. He would later comment that he had not only taken the first photo of an airplane in the air that morning, but he had also been the first victim of an accident with a powered flying machine.

The active career of the 1903 Wright airplane was at an end. After lunch the brothers walked four miles up the beach to Kitty Hawk, where they visited friends and sent their father one of the world's most famous telegrams.



Form No. 163.

THE WESTERN UNION TELEGRAPH COMPANY.

INCORPORATED

23,000 OFFICES IN AMERICA. CABLE SERVICE TO ALL THE WORLD.

This Company TRANSMITS and DELIVERS messages only on conditions limiting its liability, which have been assented to by the sender of the following message. Errors can be guarded against only by repeating a message back to the sending station for comparison, and the Company will not hold itself liable for errors or delays in transmission or delivery of Unrepeated Messages, beyond the amount of tolls paid thereon, nor in any case where the claim is not presented in writing within sixty days after the message is filed with the Company for transmission.

This is an UNREPEATED MESSAGE, and is delivered by request of the sender, under the conditions named above.

ROBERT C. CLOWRY, President and General Manager.

RECEIVED at

170 C KA CS 33 Paid. Via Norfolk Va

Kitty Hawk N C Dec 17

Bishop M Wright

7 Hawthorne St

Success four flights thursday morning all against twenty one mile wind started from level with engine power alone average speed through air thirty one miles longest fifty seconds inform Press home Christmas.

Orevelle Wright 525P

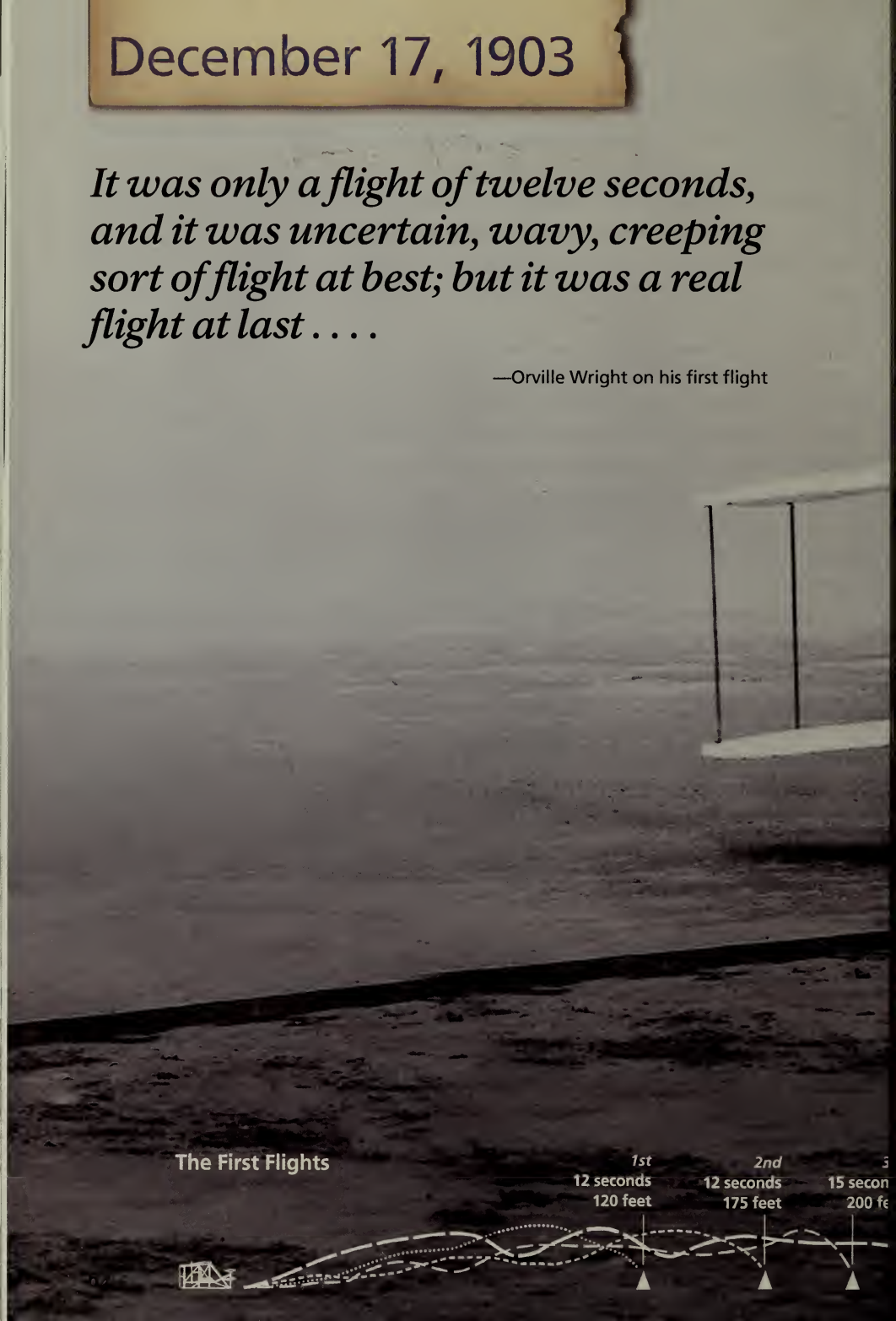
170

Hours after the Wrights' successful flights at Big Kill Devil Hill, Orville sent this telegram to their father. Their initial report understated the longest flight duration by two seconds.

December 17, 1903

It was only a flight of twelve seconds, and it was uncertain, wavy, creeping sort of flight at best; but it was a real flight at last . . . .

—Orville Wright on his first flight



An icy wind gusted up to 27 miles per hour. The season was advancing, so the Wrights decided: this was it. With the aid of workers from the nearby U.S. Lifesaving Station, they placed the starting rail on level ground to ensure that it would be true flight.

Orville lay down in the clattering machine. As it moved slowly along the rail into the wind, Wilbur steadied the wing, then let go as the flyer lifted off. Twelve seconds later, years of work had culminated in the world's first powered, heavier-than-air flight.

Solving the Problems of Flight: The 1903 Wright Flyer

When the Wrights began doing serious aeronautical research in 1899, they were not working in a vacuum. Other experimenters had taken crucial first steps *(pages 32–33)*, but most were groping in the dark, making false assumptions or using inaccurate data. On one thing they agreed: The three major problems of flight involved creating lift, propelling the aircraft, and maintaining control. A common mistake was to rely on a huge expanse of wing area and brute power to lift a machine into the air. Another was to see turning as a two-dimensional operation, as in the steering of a boat. Many approached the control problem by trying to make an inherently stable machine. The Wrights did significant, innovative work in the areas of lift and propulsion, but it was their ability to think about turning and control in an utterly new way that set them apart from everyone else.

Vital Statistics

Length: 21 feet, 1 inch

Wingspan: 40 feet, 4 inches

Chord: 6 feet, 6 inches

Wing area: 510 square feet

Surfaces: ash frame covered with muslin

Weight: 605 pounds

The chains and sprockets used to transmit engine power to the propellers and move the elevator were standard bicycle technology, as were some engine parts. Bicycle tubing protected the transmission chains. During take-off the Flyer rolled along the starting rail on bicycle hubs.

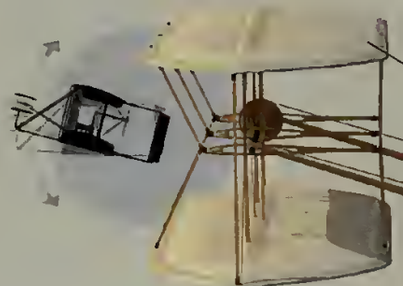
Control

The Wrights understood that flight required not only a working machine, but a skillful pilot who could *fly* it and not simply hang on for the ride. So instead of relying solely on automatic stability, they designed an aircraft that could be—indeed, had to be—controlled in three dimensions: **Roll**—movement around the longitudinal axis through the length of the aircraft; **Pitch**—movement around the lateral axis through the wingspan; and **Yaw**—movement around the vertical axis.

Wing-warping–roll

Roll

Having observed that a soaring turkey vulture steadied itself or turned by twisting up a wingtip to roll its body, the Wrights designed a wing-warping system for their gliders and the Flyer. Moving the hip cradle warped the trailing edge of one wing up and the other down, rolling the aircraft to control it. By combining roll with yaw produced by the rudder they could initiate a turn.



Elevator–pitch

Cooling water trough

Engine

Strut

Wing-warping cradle

Wing spar

Rib

Pitch

The early Wright gliders and powered flyers had the elevator mounted forward of the wings. By tilting the elevator the pilot could pitch the machine up or down to increase or decrease altitude and angle of attack. The added lift of the elevator also helped prevent a nose-dive into the sand after a stall.

Modern Control Surfaces

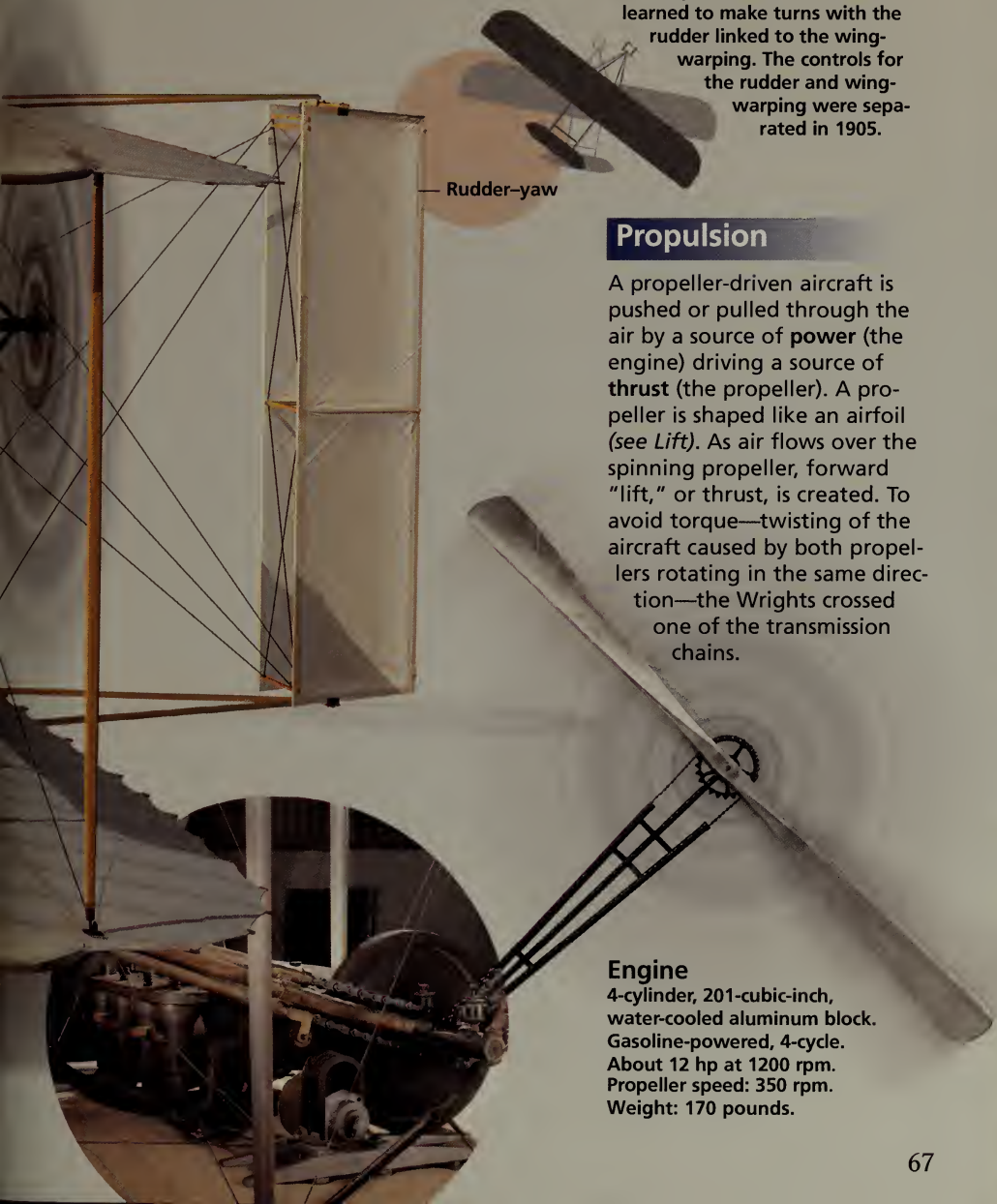
On a contemporary airplane the elevator is in the rear and ailerons have replaced wing-warping, but the aircraft is controlled in essentially the same way as the 1903 Wright Flyer.

Lift

Air moving over the **cambered** (arched) top of an airfoil, or wing, must travel farther than air beneath. It thus moves faster, making the air pressure drop relative to that beneath the wing and creating lift. The **chord**-to-wingspan ratio, degree of camber, airspeed over the wing, and **angle of attack**—the angle at which the wing meets the air—all affect lift. Too great an angle of attack results in a **stall**—loss of lift.

Yaw

A modern pilot swings the nose of an aircraft to the right or left with the rudder. The Wrights first added a rudder to their basic design in 1902 to compensate for the increased drag on one side when the wing was warped. With experience the brothers learned to make turns with the rudder linked to the wing-warping. The controls for the rudder and wing-warping were separated in 1905.



Propulsion

A propeller-driven aircraft is pushed or pulled through the air by a source of **power** (the engine) driving a source of **thrust** (the propeller). A propeller is shaped like an airfoil *(see Lift)*. As air flows over the spinning propeller, forward "lift," or thrust, is created. To avoid torque—twisting of the aircraft caused by both propellers rotating in the same direction—the Wrights crossed one of the transmission chains.

Engine

4-cylinder, 201-cubic-inch, water-cooled aluminum block. Gasoline-powered, 4-cycle. About 12 hp at 1200 rpm. Propeller speed: 350 rpm. Weight: 170 pounds.

To Remember the First Flight

People envisioning a memorial appropriate to the Wrights' achievement at Big Kill Devil Hill went to work in the 1920s, more than two decades after the brothers' experiments at the site. On December 17, 1926, Rep. Lindsay Warren of North Carolina introduced a bill in the U.S. House of Representatives for the creation of a monument to the Wright brothers, to be managed by the War Department. Sen. Hiram Bingham of Connecticut introduced a similar bill in the U.S. Senate. Outer Banks landowners Frank Stick, Allen Heuth, and Charles Baker donated the land where the flight experiments took place.

The act created a memorial commission to select a site and oversee the construction of a large monument. An independent group of local and national supporters, the Kill Devil Hills Memorial Association, attracted to its membership such celebrities as Charles Lindbergh, Cecil B. DeMille, and Joseph Pulitzer, who helped secure the funds to construct a bridge from the mainland.

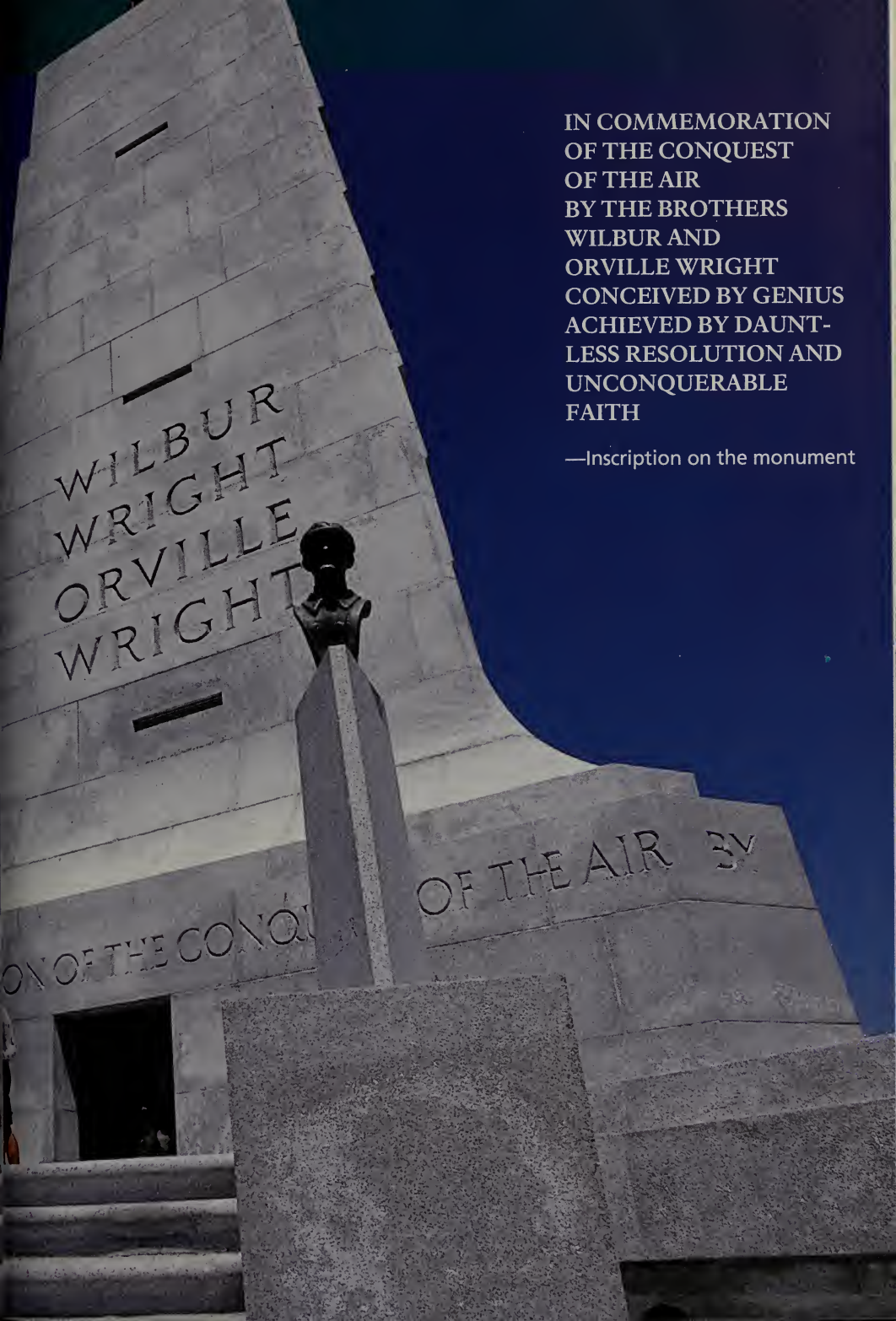
Local residents stabilized Big Kill Devil Hill for the monument with shrub and grass plantings. The design competition was won by the New York architectural firm of Rodgers and Poor, whose design called for a 60-foot-high masonry shaft resting on a star-shaped platform. Its faces were relief-sculpted with wings in the Art Deco style, and a large electric beacon topped the shaft. The structure was completed in 1932; a year later the National Park Service assumed management of the memorial from the War Department.

Twenty-five years of shifting sand dunes hindered the identification of the 1903 powered liftoff point. Three of the four surviving witnesses to the flight gathered at the site in November 1928 and, using Orville Wright's written accounts of the first flights, managed to locate the approximate point of the liftoff. On December 17, 1928, representatives from the National Aeronautics Association placed a granite marker at the site. The six-foot-high marker bore a bronze tablet with the inscription:

The first successful flight of an airplane was made from this spot by Orville Wright December 17, 1903 in a machine designed and built by Wilbur and Orville Wright.

A second monument was placed at the home of William and Addie Tate, where the Wrights stayed when they first came to Kitty Hawk.

—Jill Hanson, former National Park Service historian



IN COMMEMORATION
OF THE CONQUEST
OF THE AIR
BY THE BROTHERS
WILBUR AND
ORVILLE WRIGHT
CONCEIVED BY GENIUS
ACHIEVED BY DAUNT-
LESS RESOLUTION AND
UNCONQUERABLE
FAITH

—Inscription on the monument

Visiting Wright Brothers National Memorial

The Kill Devil Hills area of North Carolina's Outer Banks has undergone a profound transformation since the Wright brothers came here a century ago to put their theories of flight to the test. But there is much at Wright Brothers National Memorial to help the visitor understand their experiences here. Climb to the top of Kill Devil Hill, from which they made hundreds of glides, and you can feel the steady breezes they needed for their gliding experiments.

The reconstructed 1903 camp buildings, the fruit of the brothers' hard-won experience on the Outer Banks, provide a glimpse into the Wrights' domestic and working arrangements. Walking off the distances between the stone marking the takeoff point of the first four flights and the smaller stones marking the landing points—knowing that none of the flights ever rose more than 12 feet above the ground—brings home their physical reality in a way that reading about them cannot do.

In the visitor center there are exhibits on the Wrights, their glider experiments, and the first powered flyer, including full-scale replicas of the 1903 Flyer and the 1902 glider. The architecturally interesting visitor center, designed by the Philadelphia firm of Mitchell/Giurgola Architects and completed in 1960, was named a National Historic Landmark in 2001. During the summer there are a number of programs on the Wrights, aviation history, and the Outer Banks.

More Information
Cape Hatteras Group
1401 National Park Drive
Manteo, NC 27954
252-473-2111
E-mail: CAHA_Interpretation@nps.gov
Internet: www.nps.gov/wrbr

When the Wrights returned to Kill Devil Hills for the 1903 flying season they built a new hangar (reconstruction at left) *for the larger powered aircraft and converted their old 1902 hangar* (reconstruction at right) *into more comfortable living quarters.*

Based on photographs taken by the Wrights, the reconstructed kitchen area of their 1903 quarters shows a well-stocked larder. At center is their gasoline cooking stove and oven.

Perfecting the Airplane

The story broke on December 18, 1903. "The [Cincinnati] Enquirer contained flaming headlines on the Wrights' flying," Bishop Wright noted in his diary that evening. He wrote later that reporters were "... calling and asking for pictures of the boys." The excitement reached even to the remote sands of Kill Devil Hills, where the brothers were packing for the return to Dayton. Boats docking at Kitty Hawk Bay brought offers from the *New York World* to purchase exclusive rights to the story and serious inquiries from magazines as diverse as *Scientific American* and *The Women's Home Companion*.

The Wrights had instructed their brother Lorin to deliver a straightforward press release to the Dayton newspapers when they telegraphed news of a flight, but in Norfolk a telegrapher and a reporter concocted a wildly inaccurate account. The Dayton wire service reporter to whom Lorin took the story failed to recognize its significance, commenting that if the Wrights had flown for fifty-nine *minutes*, "it might have been a story." Instead, the tall tale spun in Norfolk was picked up by a wire service and distributed nationally. After their return home, the Wrights issued a second press release to correct the misinformation being spread coast-to-coast, but the damage had been done.

In spite of the advantages of Kitty Hawk, the brothers had decided to continue their experiments in the Dayton area, where they could live at home, keep an eye on the bicycle shop, and fly from early spring to late fall at minimum expense. They selected Huffman Prairie, an 84-acre pasture some eight miles east of their home, as their new flying field. Although conveniently located near a stop on the interurban line out of Dayton, the field was several miles from the nearest village and as isolated a spot as one could find in the area. Just as important, it was free. The owner, Dayton banker Torrence Huffman, allowed the brothers to use the field at no cost, asking only that they chase the livestock pastured there into the safety of an adjacent area before they attempted any flying.

They done it! They done it! Damn'd if they ain't flew!

—Johnny Moore, a young witness to the world's first powered airplane flight, breaking the news to fellow Kitty Hawkers.

Wilbur measures wind speed with an anemometer, like the one shown above, before making a flight at Pau, France, in 1909. Orville is still using a cane five months after his terrible crash at Fort Myer, Virginia.

1904

Huffman Prairie, Dayton, Ohio

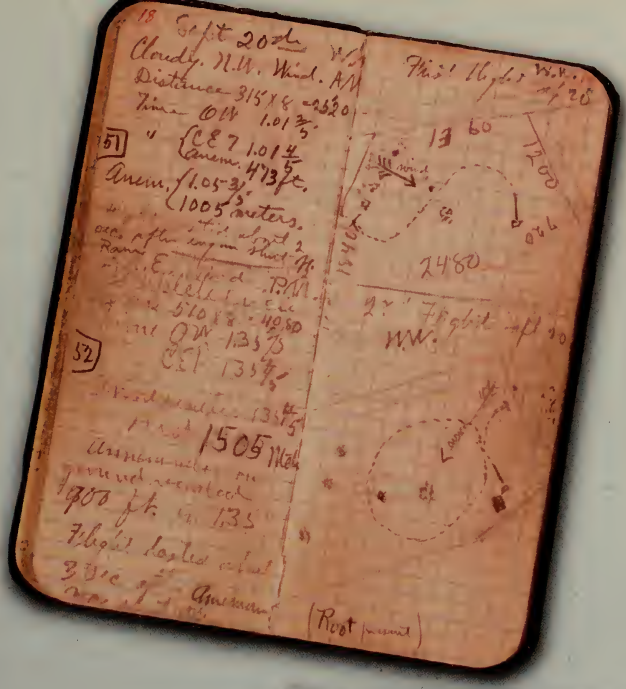
Mastering Flight at Huffman Prairie

If the machine the Wrights had flown in 1903 was to be a practical airplane, it would have to be capable of more than short, straight-line hops. It would have to make turns and operate over less forgiving terrain than the sandy open spaces at Kill Devil Hills. To increase their opportunities for experiment and practice, and to avoid the tedious journey to the Outer Banks, the brothers obtained permission to use a local cow pasture outside Dayton known as Huffman Prairie. Addressing problems with pitch instability and an overly sensitive elevator, the Wrights added increasing amounts of weight to the front of the aircraft to shift the center of gravity forward and mounted the elevator further ahead of the wings. With these modifications the aircraft could be flown with reasonable control for indefinite periods. Improvement came slowly, however. After a frustrating summer of limited success, the brothers finally made their first complete circle on September 20, 1904 *(notebook entry at right)*.

—Peter L. Jakab, Curator National Air and Space Museum

When we had familiarized ourselves with the operation of the machine in more or less straight flights, we decided to try a complete circle.

—Wilbur Wright, *Summary of Experiments of 1904.*



I sort of felt sorry for them. They seemed like well-meaning decent young men . . . neglecting their business to waste their time . . . on that ridiculous flying machine.

—Luther Beard, managing editor of the Dayton *Journal*, 1904.

The Wrights built an almost exact copy of their first powered flyer for the 1904 season. They unveiled their new machine on May 23, 1904. Rather than trying to hide from the press, they invited the public to come watch them fly. Some 40 spectators were on hand, including a dozen or so newsmen, but the wind refused to blow. Wilbur ran the machine right off the end of the launch rail without rising into the air. The crowd was smaller three days later, when Orville kept the machine in the air for all of 25 feet. The reporters went away unimpressed and happy enough to leave the Wright brothers alone for the foreseeable future.

Struggling to get off the ground in the light winds that prevailed in the area, the Wrights used launch rails as long as 240 feet in an effort to achieve flying speed. Still, they couldn't exceed the longest flight of 1903 until August 13, 1904. The brothers improved their propellers during this period and changed the balance of the flyer by adding weight at the front. Most importantly, they began catapulting their machine into the air by launching it down the rail using a 1,600-pound weight dropped from a large derrick. On September 20, just two weeks after they had begun using the catapult, Wilbur flew their first complete circle in the machine, and bettered their time and distance marks in the process: 4,080 feet in just over one minute 35 seconds. The flight was witnessed by a visitor, Amos I. Root. "When it turned that circle, and came near the starting-point, I was right in front of it," Root recalled, "and . . . it was . . . the grandest sight of my life."

A beekeeper and proprietor of an apiary supply house, Amos Root had heard rumors that the Wrights were flying in a field near Dayton and came to see for himself. He was boarding with farmers who were more impressed that Root had driven 175 miles in an automobile than by what was going on in the air over the neighboring field every day. Root described his astonishment to the readers of his journal, *Gleanings in Bee Culture*.

"Imagine a locomotive that has left its track, and is climbing up in the air right toward you—a locomotive without any wheels . . . but with white wings instead . . . a locomotive made of aluminum. Well now, imagine that locomotive with wings that spread 20 feet each way, coming right toward you with a tremendous flap of propellers, and you have something like what I saw . . . . I tell you friends, the sensation that one feels in such a crisis is something hard to describe." Root would return to Huffman Prairie several times over the next two years, ensuring that the beekeepers of America were better informed with regard to the story of the century than were the readers of the *New York Times*.

Wilbur and Orville continued to fly until December 9, 1904. Accidents were fairly common as longer flights enabled the brothers to begin the serious business of mastering their machine, while at the same time identifying and correcting some remaining problems with stability and control.

They began the 1905 season with a third powered airplane. Its wingspan and chord were the same as the 1903 and 1904 aircraft, but it was longer than its predecessors and stood a bit taller. The rudder and elevator were larger, the propellers were improved, and a pair of semi-circular vanes, or "blinkers," were positioned between the two surfaces of the elevator to prevent side slips of the sort that had been a problem the year before. Most importantly, they disconnected the rudder from the wing-warping system and operated it with a separate hand control.

The control problems continued until the brothers increased the size of the elevator and moved it farther forward of the wings. Back in the air in August, they found a dramatic improvement in performance, and their progress that fall was breathtaking. Within a week Orville had flown four times around the field. By September flights of two to five minutes were common. Wilbur flew for more than 18 minutes on September 26. By the first week in October their record had climbed to more than 33 minutes in the air. Their

They're fools.

—Torrence Huffman, owner of Huffman Prairie, 1904.

1905

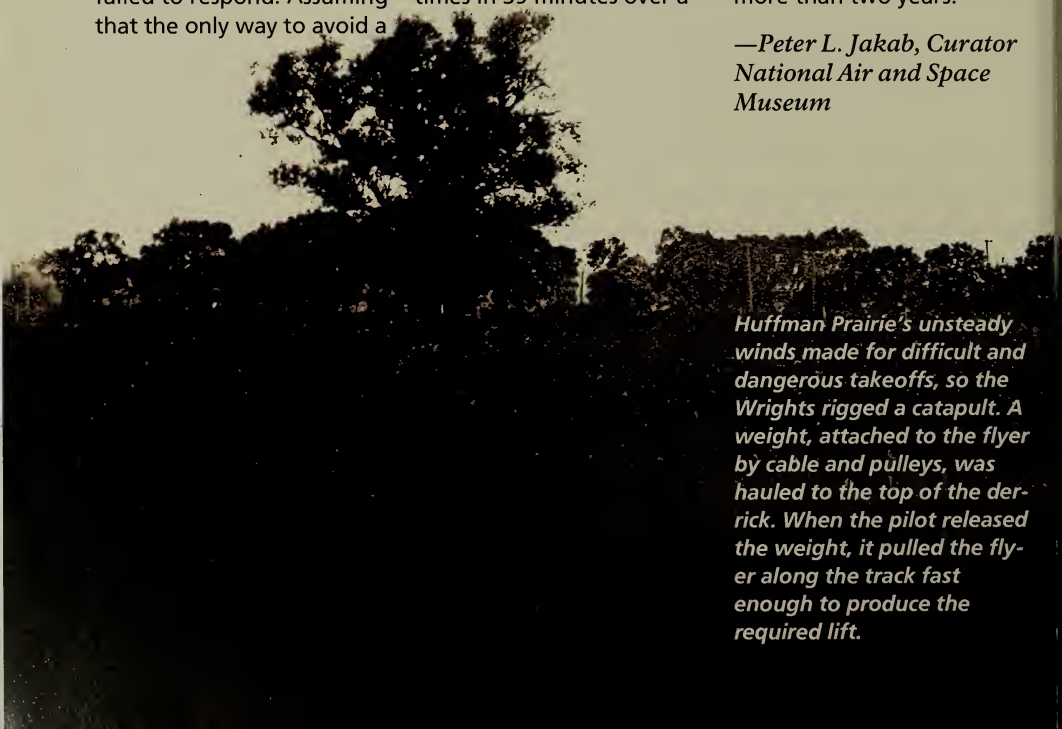
Huffman Prairie, Dayton, Ohio

A Practical Airplane

A near-catastrophe helped the Wrights solve a problem that had plagued them since Kill Devil Hills: restoring lateral balance after turning or banking. During a flight in September 1905, Orville neared a locust tree that served as the western turning point on the oval flying field at Huffman Prairie. As he neared the tree, Orville banked to the left to turn, but realized he was headed straight for the thorn-covered tree. Attempting to avoid the tree by turning right, Orville shifted his hips in the wing-warping cradle, but the flyer failed to respond. Assuming that the only way to avoid a collision was to land, Orville lowered the elevator. Surprisingly, the left wing rose and the machine turned to the right, barely missing the tree. The solution to the persistent problem had been revealed: Lowering the nose with the elevator let gravity supply the extra speed needed to increase lift and maintain control.

With this breakthrough in piloting technique they were now routinely making flights of several minutes. On October 5, 1905, Wilbur made a spectacular flight in which he circled the field 30 times in 39 minutes over a distance of 24 miles. The 1905 airplane remained tricky to fly, but in the hands of a skilled pilot it could maneuver responsively and stay aloft as long as the fuel supply lasted. By any definition the Wright brothers now possessed a practical flying machine. The experimental phase of their aeronautical work was completed. They were ready to share their creation with the world, but wary of revealing their technology before they had patent protection and a contract in hand, the Wrights did not fly at all for more than two years.

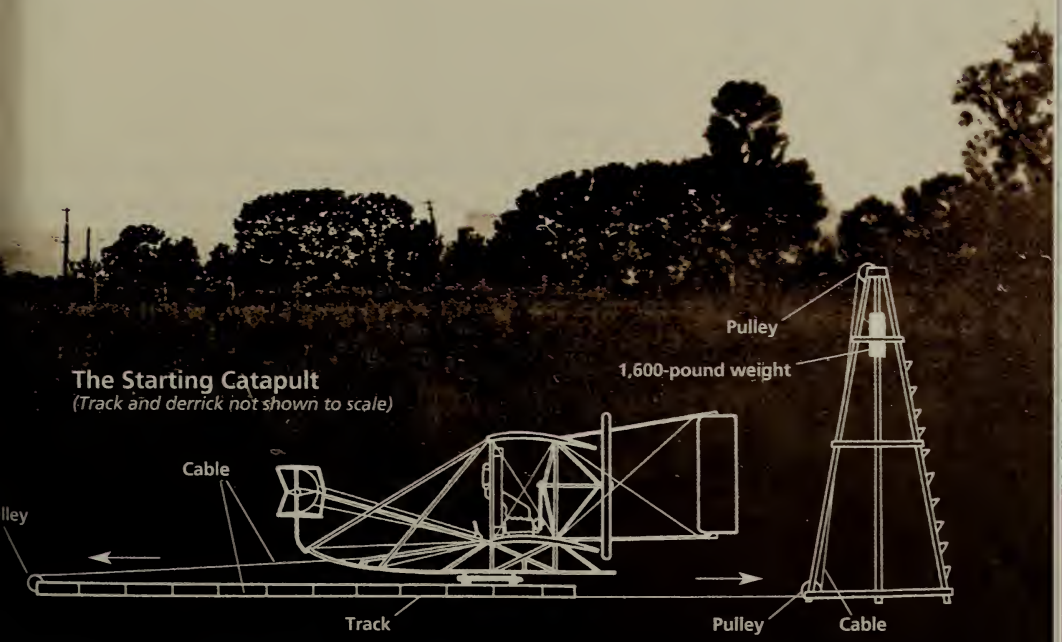
—Peter L. Jakab, Curator National Air and Space Museum



Huffman Prairie's unsteady winds made for difficult and dangerous takeoffs, so the Wrights rigged a catapult. A weight, attached to the flyer by cable and pulleys, was hauled to the top of the derrick. When the pilot released the weight, it pulled the flyer along the track fast enough to produce the required lift.

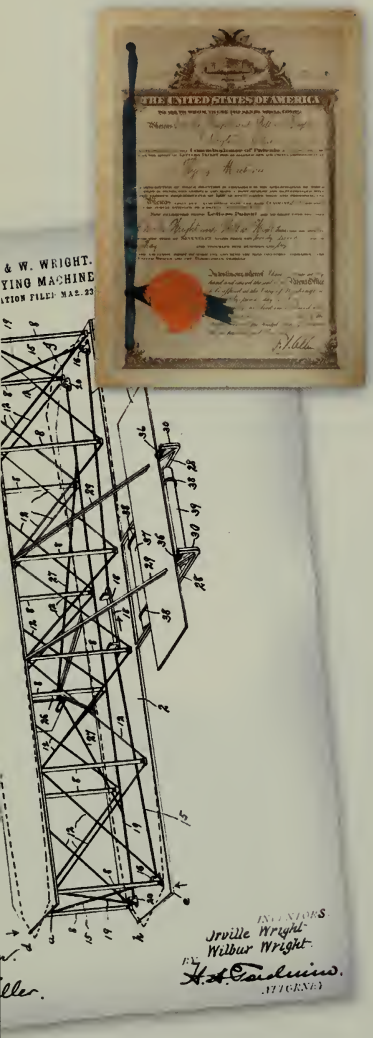
He seemed to think we possessed a . . . wonderful elixir . . . sufficient to overcome the force of gravity and allow the machine to soar aloft.

—Wilbur Wright, describing a newsman's misconceptions about the 1905 flights at Huffman Prairie.



The Starting Catapult
(Track and derrick not shown to scale)

When the Wrights applied for a patent on their invention in 1903, the engine was not part of it. They knew that it was their control system—especially wing-warping—that was revolutionary. The patent was granted in 1906.



best flight of the season, almost 25 miles in a little more than 39 minutes, came on October 5.

For the first time, crowds began to gather along the fence to watch. The growing excitement lured newsmen back to Huffman Prairie. One Dayton reporter offered a neighboring farmer $50 for the date of the next flight. Worried that rivals would copy their machine before they had the protection of a patent or a contract for the sale of their airplane, the brothers simply decided to stop flying. Wilbur landed after a single circuit of the field on October 16, 1905. They would not fly again for the next 31 months.

All too often people assume that the invention of the airplane was complete with the four flights made at Big Kill Devil Hill on December 17, 1903. In fact, that was only the beginning. Huffman Prairie, a humble Ohio cow pasture, deserves to be remembered as the spot where the Wrights transformed the 1903 Flyer—capable of marginal flight—into the practical airplane of 1905. Struggling to overcome conditions of wind and landscape much less favorable than those on the Outer Banks, the brothers here solved the final problems and in the process taught themselves to fly.

The Wrights filed their original patent on March 23, 1903, and were promptly rejected by an official who advised them to "employ an attorney skilled in patent proceedings." It was good advice. Henry A. Toulmin, a patent attorney in Springfield, Ohio, transformed the brothers' achievement into the masterfully crafted patent that was granted on May 22, 1906.

The Wrights had begun the difficult business of trying to sell their invention long before they received a patent. Their challenge was to convince potential buyers that they could supply a practical flying machine, while at the same time protecting their invention by restricting the release of additional photographs or other information that might enable rivals to copy Wright technology. The task was made even more difficult because the brothers had been so successful in masking the details of their achievement from the

press and because they refused to fly until a potential customer signed a contract.

In January 1905 the brothers attempted to contact officials in the War Department through their Congressman. It soon became apparent, however, that the Army officers and administrators who had funded the Langley Aerodrome project *(see pages 32–33)*, and who had been embarrassed and even threatened with political disaster by the failure of that venture, were not about to run such a risk again. After talks with European governments also failed, the Wrights accepted the offer of Flint & Company to assist them in contacting potential customers. A firm specializing in the sale of arms and new technology to the governments of the world, Flint & Company arranged for the Wrights to visit Europe in 1907. They met with military and political authorities in France and Germany but were unable to strike an immediate bargain.

Everything began to change early in January 1908, when the brothers submitted a bid for an airplane that would meet the specifications established by the U.S. Army Signal Corps. Two months later, the Wrights signed a second contract for the sale of an airplane to a French syndicate, which would have the right to produce and sell Wright aircraft under license.

First they would have to brush up their flying skills. They rebuilt their 1905 machine, adding seats for the pilot and a passenger and an upright control system. So they could gain experience with the new controls in relative secrecy, they traveled back to Kitty Hawk in the spring. They made 22 flights in May, including their first flight with a passenger, mechanic Charles Furnas. Wilbur then left directly for France, while Orville traveled back to Dayton by way of Fort Myer, Virginia, where he was scheduled to demonstrate a second airplane for U.S. Army officials in a few months.

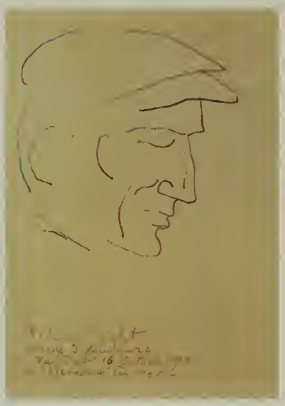
During the years when they refused to fly, public opinion had become divided on the question of what the two brothers from Dayton had actually achieved. Some important journals, including *Scientific American*

The Wrights have flown or they have not flown . . . . They are in fact either fliers or liars. It is difficult to fly. It is easy to say, "We have flown."

—Editorial in the Paris edition of the *New York Herald*, February 1906, during the period when the Wrights refused to demonstrate their flyer.

Il vole! Il vole!

—"He flies!" Shouted by French boys after witnessing Wilbur Wright's first flight at Le Mans in 1908. The words inspired a popular song in France.



While in France for his 1908–09 demonstration flights, Wilbur was a favorite subject for illustrators and caricaturists. His newsboy cap became a popular item of apparel among Frenchmen.

and *Cosmopolitan Magazine*, supported the brothers' claims to have made repeated flights between 1903 and 1905, as did well-known organizations such as the Aero Club of America. Others, including most of the leading French aeronautical experimenters, doubted that the Wrights had accomplished what they claimed.

The brothers were no longer alone in the air. Energized and inspired by an incomplete understanding of Wright technology, a handful of European and American enthusiasts took the external features of the Wright gliders as their starting point and set out in pursuit of the American brothers during the years after 1903. While they did not grasp the essential elements of the Wright control system, European experimenters began to make short hops into the air in 1906 and 1907. In July 1908 the American motorcycle and engine builder Glenn Curtiss, a member of Alexander Graham Bell's Aerial Experiment Association, won the Scientific American Trophy with a straight-line flight of 5,090 feet at a speed of 39 m.p.h.

Wilbur Wright silenced the doubters forever and demonstrated just how far ahead of potential rivals he and his brother were on August 8, 1908, when he made his first public flight from the Hunaudières race track, near Le Mans, France. European aviators, who held their breath during their own wide, skidding turns, watched in stunned admiration as Wilbur banked and maneuvered his machine through tight circles with precision and confidence. "Who can now doubt that the Wrights have done all that they claimed," pronounced one French aviator. "My enthusiasm is unbounded." Another remarked, "Mr. Wright has us all in his hands. What he does not know is not worth knowing." The *London Times* summed the matter up, noting that the flights at Hunaudières "... proved over and over again that Wilbur and Orville Wright have long mastered the art of artificial flight .... and [the flights] give them first place in the history of flying machines."

Now it was time to convince American skeptics. Orville made his first flight at Fort Myer, Virginia, on September 3, 1908. Six days later, with Congressional leaders and three cabinet secretaries watching, he set a new world duration record, shattered it on his next flight, then set a new world record for time aloft with a passenger. He would continue to raise the world duration mark on each of the next three days.

Tragedy ended the Fort Myer flights. On September 17 Orville was flying with Lt. Thomas Selfridge, an aeronautical enthusiast and a member of the Aerial Experiment Association. A cracked propeller resulted in a catastrophic crash that killed Selfridge, the first person to die in a powered airplane accident. Orville was hospitalized with back injuries that would plague him for the rest of his life.

Orville was still recuperating from the accident in early 1909 when he and the Wrights' sister Katharine joined Wilbur at Pau, in the South of France. In August 1908 Wilbur had transferred his operations from Hunaudières to a large artillery field near Le Mans, Camp d'Auvours. He then moved in January 1909 to the warmer weather of Pau. There he completed approximately 64 flights by March, when the Wrights moved to Centocelle, a flying field near Rome.

Besides fulfilling the terms of the contract with the French syndicate, Wilbur taught a small number of European aviators to fly. Everywhere he, Orville, and Katharine went, they were applauded by kings, queens, presidents, prime ministers, and millionaires. Alfonso XIII of Spain came with his camera, anxious to snap his own photos of the three Americans. King Edward VII of England watched two flights, including one on which Katharine flew as a passenger. Some of the most distinguished members of European society lined up for the honor of helping to pull the 1,600-pound launch weight back to the top of the catapult derrick for the next flight.

The Wrights were greeted with a round of celebrations, honors, and awards when they returned to the

They paid no attention to anyone else . . . . They talked only to each other, as though they were on a desert island miles from civilization.

—U.S. Army officer observing Orville and his mechanics at the 1908 Fort Myer demonstration.

Silencing the Skeptics

During the years when the Wrights refused to fly until they had a contract for the Wright Flyer, Europeans took to the air themselves. Boosted by knowledge of Wright technology, French aviators had flown a complete circle, stayed aloft for 20 minutes, carried passengers—all in public demonstrations. Many were dubious of the Wrights' claims, the French most of all, so it was appropriate that France was the setting of the Wrights' first European demonstrations. Wilbur made preparations at a race course near Le Mans, but things did not go smoothly: The Flyer was damaged in transit and Wilbur was burned badly by a ruptured radiator hose. Finally, on August 8, 1908, he took to the air before stunned observers. Over the next few days, before growing crowds, he remained aloft longer and longer, flying smooth banked circles and figure eights with an ease undreamed of by French aviators. All doubts were left in the Flyer's wake. The Wrights were acclaimed as *Les Premiers Hommes-oiseaux*—the first birdmen.

Who can now doubt that the Wrights have done all that they claimed . . . . We are as children compared with the Wrights.

—French aviator after seeing Wilbur Wright's 1908 flights at Le Mans.


Le Petit Journal

SUPPLÉMENT ILLUSTRÉ

DIMANCHE 30 AOUT 1908

L'AÉROPLANE DE WILBUR WRIGHT EN PLEIN VOL

Success and Tragedy at Fort Myer

The U.S. Army Signal Corps was interested in the Wright Flyer, but only if it could stay in the air for an hour with a passenger. To earn the full contract price, it had to average at least 40 mph over a 10-mile course. During the 1908 trials at Fort Myer, Virginia, a split propeller caused the Flyer to crash, badly injuring Orville and killing his passenger, Lt. Thomas Selfridge—the first aviation fatality. Orville returned in 1909, flew with a passenger for well over an hour, averaged more than 42 mph in the speed trial, and won the contract.

United States in May 1909. They were treated to testimonial dinners in New York and Washington, and President Taft invited them to the White House to receive a gold medal awarded by the Aero Club of America. At the Wright Brothers' Home Days Celebration in Dayton on June 18, they received the Congressional Gold Medal from Gen. James Allen, Chief Signal Officer of the Army; a State of Ohio gold medal from Gov. Judson Harmon; and a City of Dayton medal from Mayor Burkhardt. It was just 10 years since Wilbur had flown their original wing-warping kite.

The brothers went back to Fort Myer with a new airplane in June 1909. Orville did all of the flying required to meet the terms of the Army contract, completing the task with a 10-mile flight from Fort Myer to Alexandria, Virginia, and back with Lt. Benjamin D. Foulois in the passenger seat. Averaging two miles per hour faster than the required 40 miles per hour, the Wrights earned a $5,000 bonus in addition to the $25,000 that the Army had agreed to pay for an airplane.

After their demonstrations the Wrights' lives were forever changed; now they were on the world stage. Orville and Katharine left for Germany in August, where Orville made demonstration flights and continued the negotiations begun by Wilbur in 1908 for the sale of an aircraft to the Kaiser's government. In late September Wilbur made a crowd-pleasing flight up the Hudson River from Governors Island past the Statue of Liberty to Grant's Tomb and back.

In College Park, Maryland, he completed the terms of the Army contract by teaching Lts. Frederick Humphries, Frank Lahm, and Benjamin Foulois to fly. Foulois, who arrived late for his training, had yet to solo when Wilbur had to leave College Park for another engagement. Ordered to travel to Fort Sam Houston, Texas, Foulois soloed and gained further experience on his own, writing to the Wrights when problems arose. He would rise to command the U.S. Army Air Corps before World War II, and took great pride in having "learned to fly via correspondence course."

The great diversion . . . was to go over to Fort Myer to see the Wrights fly. When the machine actually left the ground and circled the field . . . it gave us a thrill that no one in this generation will ever have.

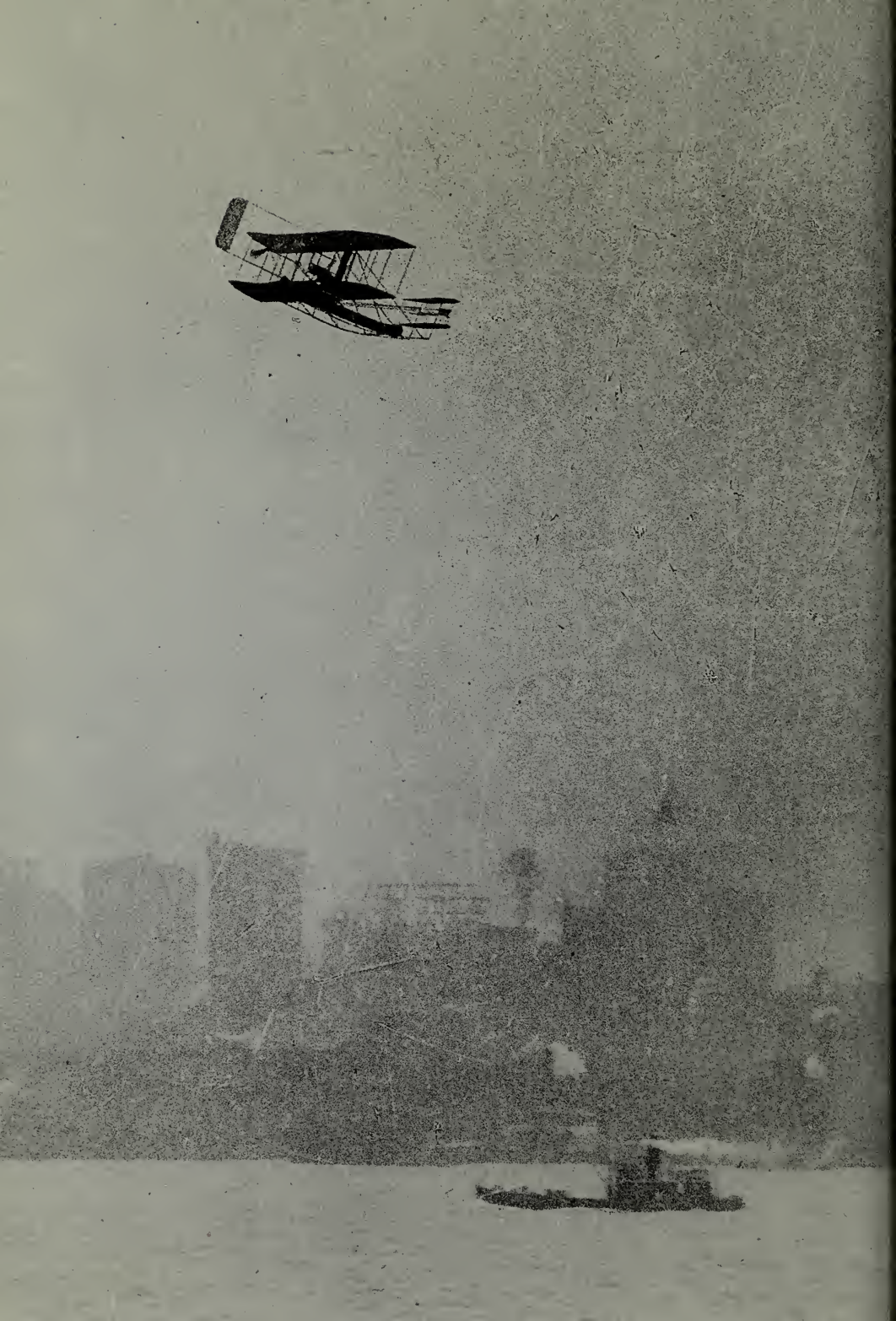
—Alice Roosevelt Longworth, in her autobiography, *Crowded Hours*, 1933.

A Heroes' Welcome in Dayton

The Wrights normally avoided pomp and ceremony, but they understood how Dayton would want to celebrate the achievement of its native sons. On their arrival home they were met by thousands of their fellow citizens, ecstatic over the Wrights' European triumph, then celebrated in grand fashion during the Wright Brothers' Home Days Celebration in June 1909. There were parades, including the one on Main Street shown here, speeches, fireworks, and concerts. At the culminating ceremony, Wilbur and Orville each received medals from the City of Dayton, State of Ohio, and U.S. Congress.


ORVILLE WRIGHT
WILBUR WRIGHT
RESOLUTION OF CONGRESS MARCH 4 1909
IN RECOGNITION AND APPRECIATION OF THEIR ABILITY COURAGE AND SUCCESS IN NAVIGATING THE AIR


THE NATION, STATE and CITY
WELCOME THE
WORLD'S GREATEST AVIATORS
DAYTON, OHIO.
JUNE 17-18-1909.



Awestruck New Yorkers

The Wrights' ongoing competition with Glenn Curtiss, a well-known aviator of the day, led to one of their most celebrated public flights. As a part of events honoring Robert Fulton and Henry Hudson, Wilbur was asked to make a flight around New York City of at least 10 miles or one hour; Curtiss was to fly up the Hudson River to Grant's Tomb and back. Because he would spend so much time over water, Wilbur strapped a sealed canoe between the Wright Flyer's skids to provide flotation. After testing the reconfigured aircraft by circling Governors Island, he flew around the Statue of Liberty, much to the delight of spectators. When Curtiss cancelled his planned flight up the Hudson, Wilbur leapt at the chance to eclipse his rival by making the 20-mile round trip himself. An estimated one million people saw Wilbur's 33-minute flight along the river. Even for worldly New Yorkers, the sight of a winged machine flying over their city became a powerful memory that would never fade.

Katharine Wright, who played such an important supporting role for her brothers during their years of experimentation, joined them in Europe in 1909 and quickly became a popular figure, called by King Alfonso XIII of Spain "the ideal American."

The brothers established The Wright Company in November 1909 to build and sell airplanes, Wilbur serving as president and Orville as vice-president. The board of directors included Cornelius Vanderbilt, August Belmont, Jr., and other leading figures in business and finance. The corporate offices of the new firm were in New York, but the heart of the operation, the factory and flying school, were in Dayton, where the brothers could retain personal control.

The aircraft that the brothers had built since 1907 were known as Model A machines. The first aircraft produced by the new factory was the Model B. Powered by a 40-horsepower engine, it was fitted with wheels and a rear elevator, and no longer required a catapult launch. By 1910 the sight and sound of airplanes in the air was once again familiar to the farmers around Huffman Prairie, where the Wrights established their flying school. Graduates of the Wright School of Aviation included Henry H. "Hap" Arnold, who became a five-star general and commanded the U.S. Army Air Forces in World War II, and pioneer naval aviator Lt. John Rodgers and his cousin Calbraith Perry Rodgers, former motorcycle racer and the first man to fly across the continent.

In addition to building and selling airplanes and offering flight instruction, the Wright brothers established an exhibition team of pilots who would earn money for the company, and themselves, by delighting millions of ticket holders at flying meets across the nation. The Wrights were not enthusiastic about embarking on careers as aerial showmen, but the experience of the Hudson River flight had convinced them that there was considerable money to be made in exhibition flying.

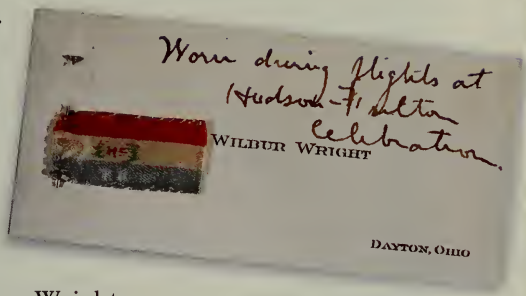
Training of the six pilots who made up the original exhibition team began in March 1910, first in Montgomery, Alabama, while the weather was still bad in Dayton, then at Huffman Prairie in early May. Orville made more than 100 training flights before the end of the month. The Wright aviators (Walter Brookins,

Arthur Welsh, Duval La Chapelle, Frank Coffyn, Ralph Johnstone, and Arch Hoxsey) flew in public for the first time at an Indianapolis meet in June 1910.

The Wright exhibition team faced stiff competition. Others were building airplanes, including Glenn Curtiss. Already locked in a patent battle with the Wrights, Curtiss organized a group of pilots who toured the nation demonstrating his aircraft. The Moisant International Aviators put leading European and American fliers on the exhibition circuit. Some of the most famous aviators, pilots like Lincoln Beachey, operated as independents. From Dominguez Field in Los Angeles to Belmont Park on Long Island, millions of Americans were thrilled by the sight of their fellows racing one another across the sky.

It was, in truth, the poetry of motion, and its appeal to the imagination was evident in every upturned face.

—Writer for the *Chicago Record Herald*, on people watching a Wright airplane fly overhead in 1910.



For the daring aviators of the pioneer period, flying was a dangerous business. Beachey, famed for looping his airplane, died in a 1915 crash in San Francisco. John Moisant, the first American to fly the English Channel, was killed at a New Orleans meet. The first licensed American female pilot, Harriet Quimby, lost her life in a Boston crash. The loss of two Wright pilots, Ralph Johnstone and Arch Hoxsey, helped prompt the brothers to retire from exhibition flying in November 1911.

The Wright Company produced 12 distinct aircraft designs from 1910 to 1915. Orville estimated that the firm produced perhaps 100 machines while he and his brother were in charge, with the Models B and C built in the largest numbers. Other notable models produced by the company included the EX (dubbed the *Vin Fiz*), which Calbraith Perry Rodgers flew from coast to coast; the Model R, designed for racing; the Model F, a U.S. Army aircraft and the first Wright model with a fuselage; and the Model G flying boat.

The brothers remained active flight experimenters. Orville returned to Kill Devil Hills to test a new glider design in October 1911. On one flight he was able to

Seeds of an Industry

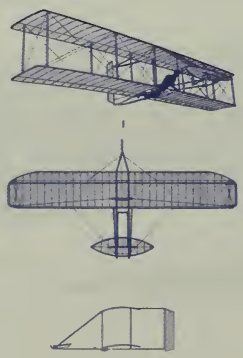
The Wrights received a patent on their control system in 1906, but had to wait three years before they could profit from their invention. Capitalized by financiers like Cornelius Vanderbilt, The Wright Company was incorporated in November 1909. To keep up with European innovations, the brothers quickly designed a new aircraft—the Model B—with wheels and a rear elevator. The company would ultimately design at least 11 more models and sell approximately 100 aircraft, built in a factory in Dayton *(top and center)*. Calbraith Rodgers made the first coast-to-coast flight *(upper left)* in a Wright EX.

Slow early sales, however, spurred the Wrights' entry into a business they had scorned—exhibitions. Two of their exhibition pilots pictured at upper right died in crashes, and the Wrights stayed in the business only two years. Already training U.S. and French military pilots, the Wrights also trained the exhibition team members. The Wright School of Aviation took on civilians who could afford it, such as 18-year-old Marjorie Stinson *(at bottom in 1914)*. At that time the youngest woman to earn a license, she became an air mail pilot and barnstormer.

1900

Gliders to Powered Aircraft *From their first full-scale glider in 1900 to the flyers they used to demonstrate powered flight to the world in 1908 and 1909, the Wrights designed and built eight aircraft. (The 1901 glider, the 1904 Wright Flyer II, and the 1909 Army Signal Corps Flyer flown at Fort Myer are not shown.) The aircraft are drawn to scale; the largest—the 1908-09 Flyer—had a wingspan of 41 feet; the 1900 glider's wingspan was 17.5 feet; the 1902 glider's wings spanned 32 feet.*

1902



soar (climbing higher than his takeoff point) for the first time in history, remaining in the air for almost 10 minutes. It was a record that would stand for 10 years. Orville continued to explore the problems of aircraft stability and control, winning the 1913 Collier Trophy when he demonstrated his automatic stabilizer on a Model E at Huffman Prairie Flying Field.

During the years after 1910, however, the brothers, particularly Wilbur, expended a great deal of time and energy pursuing a series of international law suits against aircraft builders, aviators, and exhibitors who seemed to be profiting by infringing on the Wright patents. Wilbur filed the first of their major law suits against Glenn Curtiss and the Herring-Curtiss Company in January 1910. Though all of the court's decisions were in the Wrights' favor, the Curtiss lawyers were able to keep the case alive until 1917. The matter was finally resolved by the creation of a government-sponsored patent pool that purchased all of the Wright and Curtiss patents.

The Wrights also brought suits against infringers in France and Germany. The German courts ruled against the brothers, arguing that the major elements of the invention had been revealed in the press prior to the grant of the patent. The brothers took action against some of the most famous aircraft builders in France in a complex suit that was still pending in the courts when the Wright patent lapsed in 1917.

Exhausted and weakened by the demands of business and the patent cases, Wilbur Wright contracted typhoid fever and died at the age of 45 on May 30, 1912. "A short life, full of consequences," Milton Wright wrote in his diary that evening. "An unfailing intellect, imperturbable temper, great self-reliance and as great modesty, seeing the right clearly, pursuing it steadfastly, he lived and died." A few days later he added, "Probably Orville and Katharine felt the loss most. They say little."

Orville stepped into his brother's role as president of The Wright Company and was soon named chairman

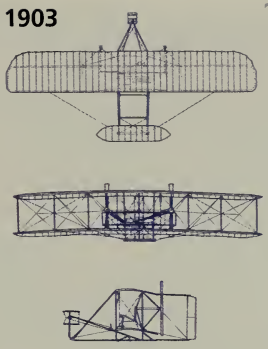
of the newly organized British Wright Company as well. He continued as an active business leader until 1915, when he sold his interest in the company that bore his name. He did not retire from aviation, however. He worked as a consulting engineer for the Dayton-Wright company during World War I, helping to plan for the production of an American version of the DH-4, a light British bomber. He was also quite interested in a pilotless flying bomb being developed by his friend Charles Kettering.

Orville, Katharine, and Bishop Wright settled down to life at Hawthorn Hill, the mansion they had built in the Dayton suburb of Oakwood. Orville built a laboratory, complete with a wind tunnel, in the heart of the old West Dayton neighborhood. He also purchased an island in Canada's Georgian Bay, where the family vacationed for more than a decade.

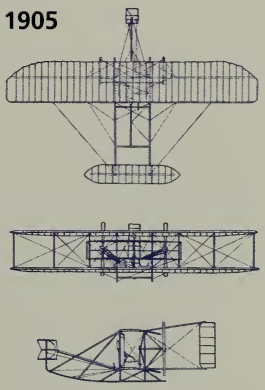
As the surviving member of the brothers who had introduced the airplane to the world, Orville Wright was one of the most celebrated men of his time. Warm and talkative among family and friends, he was shy and uncomfortable with large groups of strangers. Wilbur had been the public speaker; Orville refused to speak in public under any circumstances. He continued to play a public role in aeronautics, however. In 1920 President Woodrow Wilson appointed him to the National Advisory Committee on Aeronautics (NACA), forerunner of the National Aeronautics and Space Administration (NASA). Created to aid the infant U.S. aviation industry by conducting research and development in aeronautics, NACA had a profound impact on the history of American flight technology. Orville took the work of NACA very seriously, and remained a member longer than any other individual.

During the years after World War I, the Wright story was being enshrined as one of the great events in American history. Work on the great monument on Big Kill Devil Hill, the first national monument dedicated to a living American, was completed in 1932. The French had already erected a monument at Le Mans, and Day-

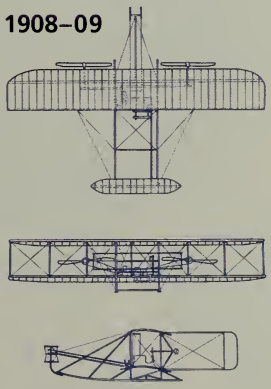
1903



1905



1908–09



The World Embraces Flight

In the years following the Wrights' demonstrations in France and at Fort Myer, Virginia, the world could not get enough of this still barely comprehensible phenomenon—human flight. For many, the first time they believed it had actually happened was when they saw it with their own eyes, and when they did, it engaged their imagination as few other things have in history.

Some flights had great symbolic meaning. When Louis Blériot *(top left and top center)* flew across the English Channel on July 25, 1909, from Calais to Dover, H. G. Wells said that England would never again be the easily defended island it had always been. But mostly flight was a matter of pure joy for pilot and spectator alike. Hundreds of air meets were held around the world. The word "daredevil" took on a whole new meaning, as men and women pulled off incredible—and incredibly dangerous—stunts. In this 1924 photo, Auggy Redlax prepares to grab a hat while hanging from a low-flying Curtiss JN-4 Jenny.

So overwhelmed was I at the wonder of the thing . . . so supremely superior to any other emotion that I had ever experienced.

—Journalist Ida Tarbell, reporting on her first flight in 1913.

ton would follow with a granite shaft overlooking Huffman Prairie in 1940. Henry Ford purchased the old house at No. 7 Hawthorne Street and the bicycle shop in which the brothers had constructed the first airplane and moved them in 1936 to the historic village he was building in Dearborn, Michigan. The states of Indiana and Virginia marked the sites where various family members had been born. Perhaps no other Americans of the 20th century have been as memorialized as the Wright brothers.

But if he and his brother were honored, Orville also struggled to defend their achievement. His long-running quarrel with the Smithsonian Institution was front page news for almost four decades. The problem began in 1914, when the Smithsonian loaned the remnants of the unsuccessful 1903 Langley *Aerodrome* to Glenn Curtiss. Curtiss rebuilt the old machine, making a significant number of fundamental changes, including alterations to the size and shape of the wings and bracing system. He then succeeded in making several short flights from the surface of a lake with the airplane mounted on floats.

Returned once more to its 1903 configuration, the *Aerodrome* was exhibited in the Smithsonian's Arts and Industries Building in Washington, D.C., with a label stating that it was the first machine "capable of flight." Within a few years the claim was being presented as the truth in textbooks and general histories of flight. Orville made repeated attempts to discuss the matter, but Smithsonian officials ignored his appeals for fair play. So in 1928 Orville sent the 1903 airplane to the Science Museum of London, where he said it would remain until the Smithsonian offered the public an honest account of the critically important changes made to the *Aerodrome* before it had flown.

Finally, in 1942 Secretary C. G. Abbott, who had been Langley's chief assistant in astrophysics, published an article outlining the changes and admitting that the 1914 flights were not proof that the *Aerodrome* had been capable of flight. The world's first airplane

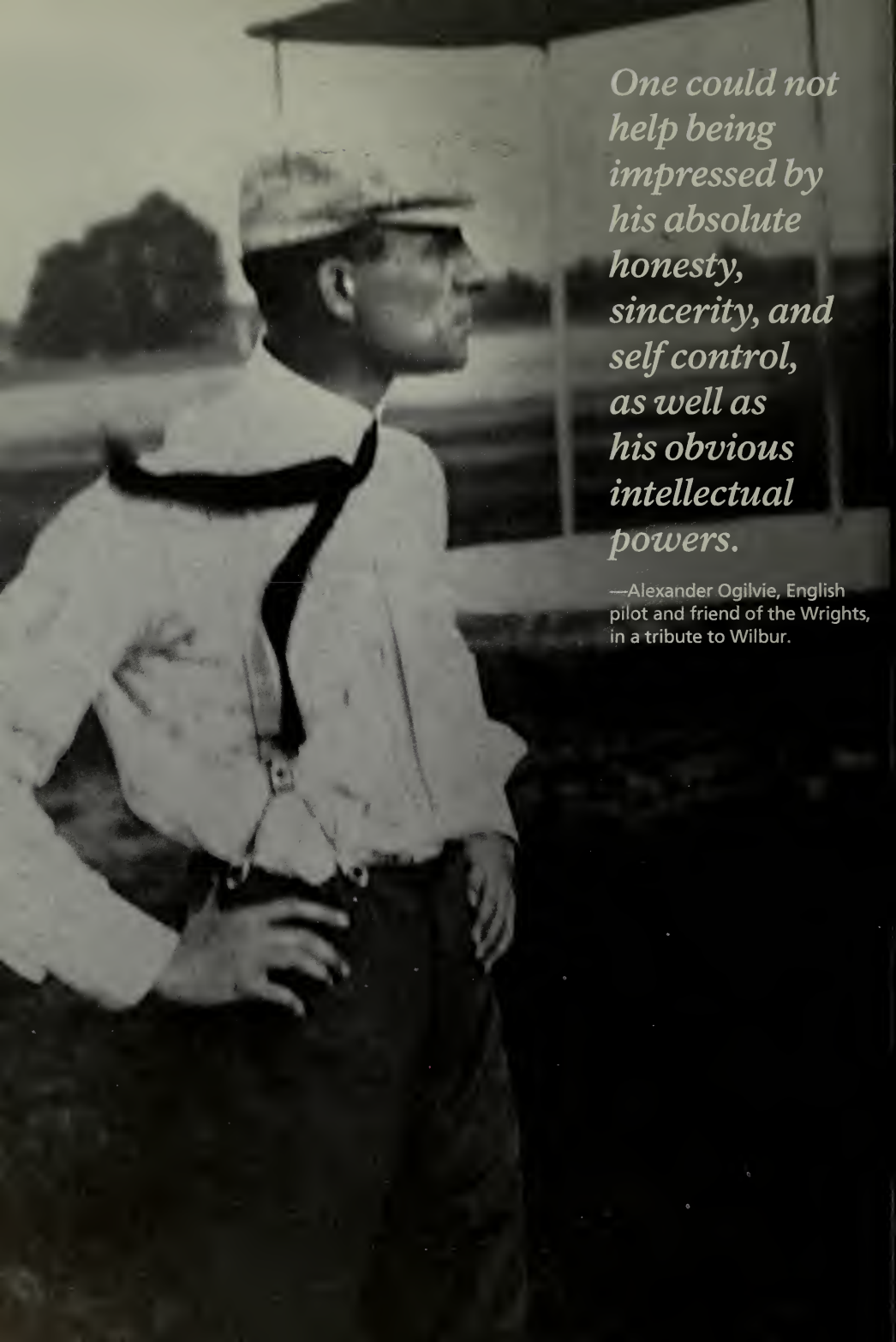
was unveiled in the rotunda of the Smithsonian's Arts and Industries Building on December 17, 1948.

Orville did not live to attend that ceremony. He spent the final months of his life planning for the restoration of the machine he and his brother had flown at Huffman Prairie in 1905—the Wright Flyer III. Considered by Orville to be the world's first practical aircraft, it was placed on display at Deeds Carillon Park, now called Carillon Historical Park, in Dayton.

Following a series of heart attacks, Orville died in Dayton on January 30, 1948, having outlived all the members of his family closest to him. Bishop Wright had died at Hawthorn Hill in 1917 at the age of 88. Katharine had married Henry Haskell, editor of the *Kansas City Star* and an old college friend, in 1927. She died of pneumonia at her home in Kansas City less than two years later. Orville was buried in Dayton's Woodland Cemetery along with his mother, father, Wilbur, and Katharine.

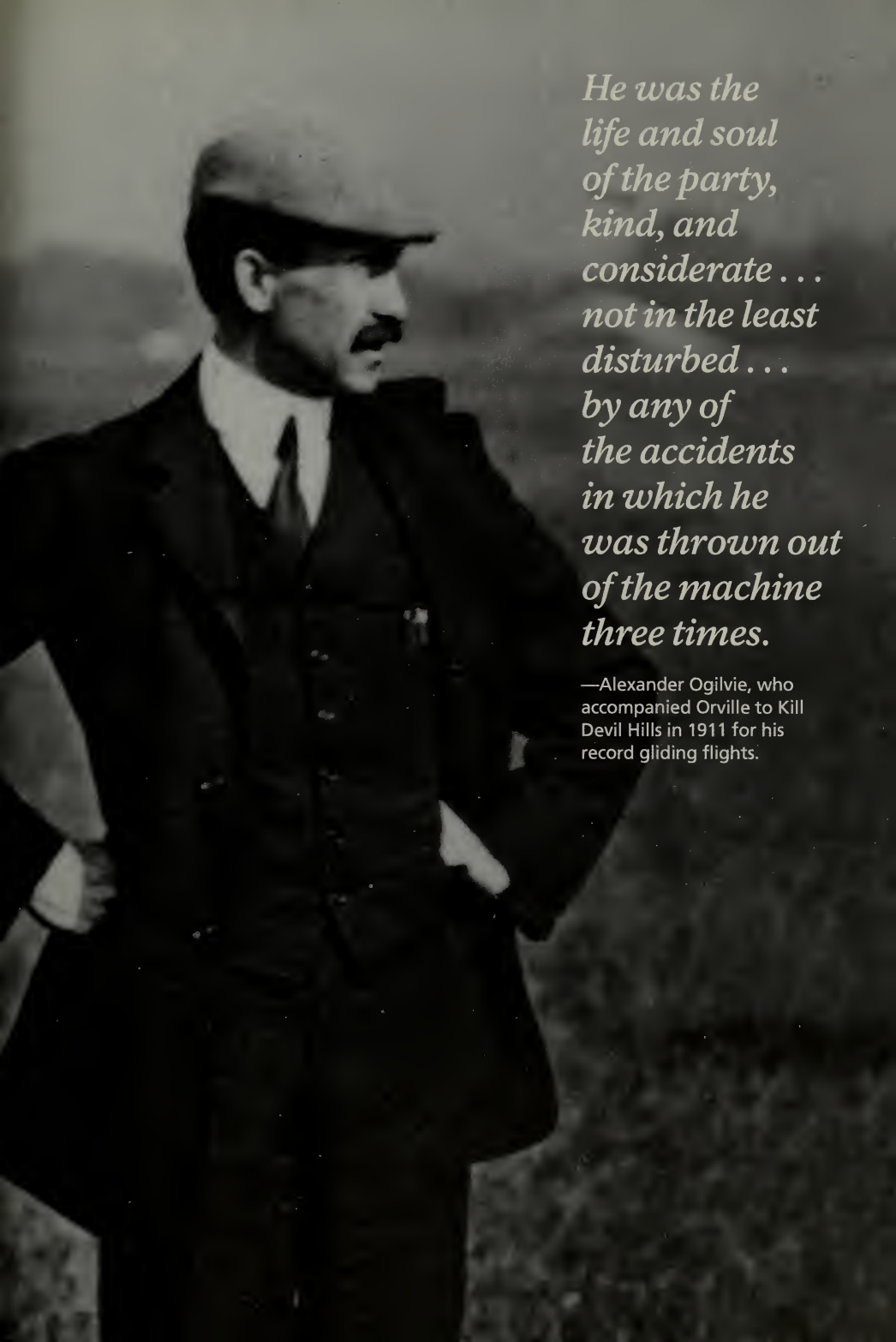
The inventor of the airplane had lived long enough to see jet airplanes fly, to learn that humans had flown faster than the speed of sound, and to know that German V-2 rockets had brushed the edge of space. Perhaps the finest epitaph that he and his brother could have hoped for are the closing words of the label displayed with the world's first airplane at the Smithsonian Institution:

BY ORIGINAL RESEARCH THE WRIGHT BROTHERS DISCOVERED THE PRINCIPLES OF HUMAN FLIGHT AS INVENTORS, BUILDERS, AND FLYERS THEY FURTHER DEVELOPED THE AEROPLANE, TAUGHT MAN TO FLY, AND OPENED THE ERA OF AVIATION



One could not help being impressed by his absolute honesty, sincerity, and self control, as well as his obvious intellectual powers.

—Alexander Ogilvie, English pilot and friend of the Wrights, in a tribute to Wilbur.



He was the life and soul of the party, kind, and considerate . . . not in the least disturbed . . . by any of the accidents in which he was thrown out of the machine three times.

—Alexander Ogilvie, who accompanied Orville to Kill Devil Hills in 1911 for his record gliding flights.

Dayton: A Lifelong Home

When the Wright family moved to Dayton in 1869, they chose to live in West Dayton *(shown below to left of bridge)*, a streetcar suburb west of the center of town and across the Great Miami River. The city of Dayton was easily accessible from West Dayton—recently annexed to the city—but most of the residents stayed within their community for work, shopping, and entertainment. West Dayton developed into a successful section of the city, mirroring its growth and prosperity.

The rapidly growing city, however, still had to deal with such issues as poor sanitary conditions, muddy streets, and inadequate communications lines. By 1880, with the population close to 39,000 people, most of these problems had been solved.

In order to improve their city and establish and improve their businesses, residents of Dayton turned to inventions. In 1870 the U.S. Patent Office listed Dayton fifth in the number of patents granted relative to its population; by 1900 the city ranked first. Some of the best-known inventions credited to Dayton citizens during this period were the cash register, the electric starter for automobiles, and a stock market ticker. The city in which the Wrights came of age proved to be a creative place from which they drew both practical mechanical skills and inspiration.

—Ann Honious, Dayton Aviation Heritage National Historical Park

Above: *Orville is in back row, fourth from left, in his 1889 class picture. His friend Paul Laurence Dunbar is at left in back row.* Right: *From 1890 to 1895 the Wrights' print shop was in the Hoover Block, the building with the awning at far right in this photo of West Third Street.* Below: *Dayton and the Great Miami River in 1912.*

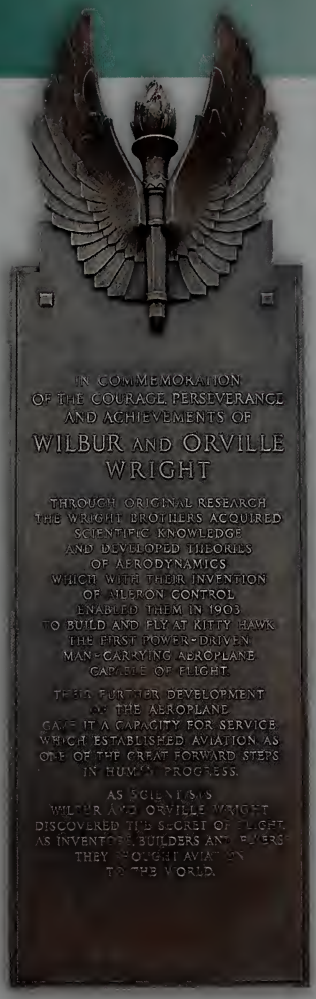
Dayton Remembers

After the Wrights' demonstration flights in France and the United States in 1908 and 1909, Daytonians embraced the Wright brothers and their success. Anxious to honor their famous residents, the city held a homecoming celebration for the brothers in June 1909. For the two-day celebration, the city constructed a Court of Honor as the focal point for the festivities, which included parades, fireworks, and presentations of awards.

After Wilbur's death in 1912, the citizens of Dayton began discussing a memorial to the Wrights, but at first nothing came of it. Ideas that never bore fruit included a memorial science museum and two large Greek columns at Huffman Prairie Flying Field. The Wright Memorial *(memorial plaque at right; also see pg. 111)*, on a hill overlooking Huffman Prairie Flying Field, was finally dedicated on Orville's birthday in 1940.

Out of a proposal to promote tourism in the region through its unique aviation heritage was born the nonprofit Aviation Trail, Inc. (ATI) in 1981. ATI purchased the Hoover Block, location of the Wrights' print shop, and The Wright Cycle Company building, which it opened as a museum in 1988. The following year ATI started a grassroots campaign for a national park that could manage these buildings. As the result of years of hard work by many Daytonians, Congress passed the Dayton Aviation Heritage Preservation Act in 1992, creating Dayton Aviation Heritage National Historical Park. So, after decades of tentative efforts to memorialize the Wrights' lives and legacy, a national park was created through the efforts of interested and enthusiastic citizens.

—Ann Honious, Dayton Aviation Heritage National Historical Park



Wright memorabilia reflect the world's response to their epochal achievement.

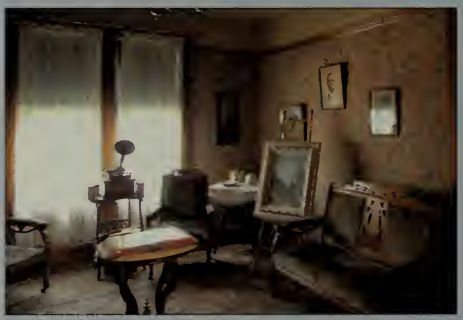
Visiting Dayton Aviation Heritage National H

The story of Orville and Wilbur Wright and their invention of the airplane is a complex one, with a large cast of characters and a number of settings. With several locations illuminating different facets of the story, Dayton Aviation Heritage National Historical Park is a good place to get closer to the Wrights, their times, and their achievement.

The Wright Cycle Company (in business from 1895 to 1897), one of several bicycle shops the brothers operated in Dayton, is the one in which they began seriously theorizing about the possibilities of flight. Nearby is the Wright-Dunbar Interpretive Center *(see architect's rendering at top)*, housed in the old Hoover Block, where they had their printing business from 1890 to 1895. An exhibit on that business is one of many in the center dealing with the Wrights and their friend Paul Laurence Dunbar. This National Park Service museum is integrated with the Aviation Trail Visitor Center next door, under the direction of Aviation Trail, Inc., which offers exhibits on the Wrights and on aviation history in the Dayton Area.

Paul Laurence Dunbar (1872–1906) was the first African-American writer to gain national and international recognition. The house that is now the Paul Laurence Dunbar State Memorial *(second and third from top)* was purchased by Dunbar for his mother in 1904, and is the place where he spent the final months of his life. His mother kept his bedroom and study just as they were when he died. Today it is owned and managed by the Ohio Historical Society.

In the Wright Brothers Aviation Center at Carillon Historical Park, exhibits include the 1905 Wright Flyer III and the camera the Wrights used to record the historic 1903 flights. The center also features a replica of the last bicycle shop the Wrights operated in Dayton (1897 to 1908)—the one in which they designed and built their gliders and powered flyers.



Huffman Prairie Flying Field
Parking
Marl Rd
Pylon Rd
Hebble Creek Rd
Gate 16A
Kauffman Rd
National Rd
Glenn Highway
Colonel
To 70
Exit 15
Huffman Prairie Flying Field Interpretive Center
Wright Memorial
United States Air Force Museum
National Aviation Hall of Fame
WRIGHT-PATTERSON AIR FORCE BASE
Harshman Rd
Woodman Dr
Mad River
Springfield St
Airway Rd
Stillwater River
Great Miami River
Third St
Main St
Patterson Blvd
Edwin C. Moses Blvd
Linden Ave
Stewart St
James H McGee Rd
Exit 53A
See detail below
DAYTON
WEST DAYTON
Carillon Blvd
CARILLON HISTORICAL PARK
Wright Brothers Aviation Center
Dayton Aviation Heritage National Historical Park sites are shown in green
North
0 0.5 1 Kilometer
0 0.5 1 Mile
To 75

Sites in West Dayton

Paul Laurence Dunbar State Memorial
Edison St
First St
Second St
Third St
Fourth St
Fifth St
Paul Laurence Dunbar St
Broadway
Williams St
Wolf Creek
Edwin C. Moses Blvd
Wright-Dunbar Interpretive Center
Aviation Trail Visitor Center
The Wright Cycle Company
0 0.1 Km
0 0.1 Mi

The Wright Cycle Company at 22 South Williams Street.

Huffman Prairie Flying Field, where the Wright brothers developed the practical airplane in 1904 and 1905, was the seed from which grew several other sites related to the Wrights and to aviation history. The original 84-acre plot of land and some 2,000 additional acres were purchased by the U.S. Army Signal Corps in 1917 and became Wilbur Wright Field. After a number of other military installations were located there over the years, Wright-Patterson Air Force Base was established in 1948.

On a hill near Huffman Prairie is the Huffman Prairie Flying Field Interpretive Center, with exhibits on Huffman Prairie, the aeronautical advances made there by the Wrights, and the businesses they operated there, such as the Wright Exhibition Company and the Wright School of Aviation, both established in 1910. The center also examines the part played by Wright-Patterson Air Force Base in modern aeronautical development. Close by is the memorial to the Wrights established in 1940 *(see page 107)*. The people who learned to fly at Huffman Prairie Flying Field are listed on a memorial plaque.

More Information
Dayton Aviation Heritage
National Historical Park
P.O. Box 9280
Wright Brothers Station
Dayton, OH 45409
937-225-7705
E-mail:
DAAV_Resource_Management@nps.gov
Internet: www.nps.gov/daav

During the 1905 season at Huffman Prairie Flying Field, the Wright brothers flew the Wright Flyer III, considered the world's first practical airplane. Restored under the supervision of Orville Wright, it was installed in 1950 at Deeds Carillon Park, now Carillon Historical Park, and is the centerpiece of the Wright Brothers Aviation Center (right) *in the park. The hangar* (bottom right) *at Huffman Prairie Flying Field is a replica of the structure used during the 1905 season.*

The Wright Memorial on Wright Hill (right) *is a quiet place to reflect on the achievement of the Wrights. From atop the hill, one overlooks Huffman Prairie and Wright-Patterson Air Force Base, the modern installation that grew from the field where the Wrights learned to fly. Below is the Huffman Prairie Flying Field Interpretive Center on Wright Hill.*

Aviation Trail, Inc., Dayton, Ohio Dedicated to the preservation of Dayton's aviation heritage, the group saved The Wright Cycle Company building, now part of Dayton Aviation Heritage National Historical Park. The self-guiding Aviation Trail highlights more than 45 aviation landmarks in the Dayton area.

College Park Aviation Museum, College Park, Maryland Houses aircraft and artifacts associated with College Park Airport's history and the early days of aviation. The airport was established in 1909 when the Wrights taught the first three Army pilots.

Dayton and Montgomery County Public Library, Dayton, Ohio The library has a large collection of photographs, programs, postcards, posters, scrapbooks, memorabilia, and journals related to the Wright brothers. Its holdings also include rare books, images, and correspondence illuminating the life of Paul Laurence Dunbar.

Hawthorn Hill, Dayton, Ohio Orville took the lead in planning this house; Wilbur did not live to see its completion in 1914. Their sister Katharine and their father Milton also lived here. It was Orville's home until his death in 1948. *Not open to the public.*

International Women's Air and Space Museum, Cleveland, Ohio Documents women's achievements in aviation. An exhibit on the Wrights' sister Katharine Wright highlights her supportive role.

Hawthorn Hill, Dayton, Ohio

Jockey's Ridge State Park, North Carolina

Jockey's Ridge State Park, Nags Head, North Carolina Site of the tallest sand dune on the East Coast, this is the environment in which the Wright brothers conducted their flying experiments.

National Air and Space Museum, Washington, D.C. The museum holds the world's largest collection of aircraft and spacecraft, including the 1903 Wright Flyer.

National Aviation Hall of Fame, Dayton, Ohio Located at the U.S. Air Force Museum, the exhibit honors pioneers of air and space—scientists, pilots, educators, leaders, engineers, and inventors.

United States Air Force Museum, Wright-Patterson Air Force Base, Dayton, Ohio The oldest and largest military aviation museum in the world includes a replica of the 1909 Wright Military Flyer, the first military heavier-than-air flying machine.

Woodland Cemetery and Arboretum, Dayton, Ohio The Wright brothers, with sister Katharine and parents Milton and Susan, are buried here. The grave of Paul Laurence Dunbar is nearby.

Wright State University, Dayton, Ohio The extensive Wright Brothers Collection includes books, documents, artifacts, and some 4,000 photographs. WSU also provides online works by Paul Laurence Dunbar (www.libraries.wright.edu/dunbar) and holds rare editions of his poetry.

The Wright brothers have long proved an attractive subject for historians of aviation and technology. Here are a few of the best sources for more information.

Chaikin, Andrew. *Air and Space: The National Air and Space Museum Story of Flight.* Bulfinch Press, 1997.

Combs, Harry, with Martin Caidin. *Kill Devil Hill: Discovering the Secret of the Wright Brothers.* Houghton Mifflin, 1979.

Crouch, Tom D. *The Bishop's Boys: A Life of Wilbur and Orville Wright.* W.W. Norton and Company, 1989.

Crouch, Tom D. *A Dream of Wings: Americans and the Airplane 1875–1905.* W.W. Norton and Company, 1981.

Freedman, Russell. *The Wright Brothers: How They Invented the Airplane* (young adult). 1991 (Holiday House, 1994).

Gibbs-Smith, Charles Harvard. *The Wright Brothers: Aviation Pioneers and Their Work 1899-1911.* National Museum of Science and Industry, 2002.

Deines, Ann. *Wilbur and Orville Wright: A Handbook of Facts.* Eastern National, 2001.

Howard, Fred. *Wilbur and Orville: A Biography of the Wright Brothers.* 1987 (Dover, 1998).

Jakab, Peter L. and Rick Young, eds. *The Published Writings of Wilbur and Orville Wright.* Smithsonian Institution Press, 2000.

Jakab, Peter L. *Visions of a Flying Machine: The Wright Brothers and the Process of Invention.* Smithsonian Institution Press, 1990.

Johnson, Mary Ann. *A Field Guide To Flight: On the Aviation Trail in Dayton, Ohio.* 1986 (Landfall Press, 1996).

Kelly, Fred C., ed. *Miracle at Kitty Hawk: The Letters of Wilbur and Orville Wright.* 1951 (De Capo Press, 1996).

Kelly, Fred C. *The Wright Brothers: A Biography Authorized by Orville Wright.* 1943 (Dover Publications, Inc., 1989).

Kirk, Stephen. *First in Flight: The Wright Brothers in North Carolina.* John F. Blair Publisher, 1995.

McFarland, Marvin W., ed. *The Papers of Wilbur and Orville Wright, Including the Chanute-Wright Letters and Other Papers of Octave Chanute. Volume One: 1899–1905; Volume Two: 1906–1948.* 1953 (Ayer Company, 1990).

Moolman, Valerie. *The Road to Kitty Hawk.* Time-Life Books, 1980.

Parramore, Thomas C. *First to Fly: North Carolina and the Beginnings of Aviation.* The University of North Carolina Press, 2002.

Parramore, Thomas C. *Triumph at Kitty Hawk: The Wright Brothers and Powered Flight.* North Carolina Department of Cultural Resources, 1993.

Walsh, John Evangelist. *One Day at Kitty Hawk: The Untold Story of the Wright Brothers and the Airplane.* Thomas Y. Crowell Company, 1975.

Wescott, Lynanne and Paula Degen. *Wind and Sand: The Story of the Wright Brothers at Kitty Hawk* (excellent reproductions of the Wrights' photographs on the Outer Banks and in Dayton). Eastern Acorn Press, 1983.

Wright, Orville. *How We Invented the Airplane: An Illustrated History* (written in 1920 in connection with a patent infringement case). 1953, ed. Fred C. Kelly (Dover Publications, Inc., 1988).

Index

Numbers in italics refer to photographs, illustrations, or maps.

☆GPO:2002—491-280/40004

Images not credited are from the files of the National Park Service. Many of the other images may not be reproduced without permission of the owners.
Abbreviations:
DMCPL: Dayton and Montgomery County Public Library
LC: Library of Congress
MAE: Musée de l'Air et de l'Espace
NASA: National Aeronautics and Space Administration
NASM: National Air and Space Museum, Smithsonian Institution
W-PAFB: Wright-Patterson Air Force Base
WSU: Special Collections and Archives, Wright State University Libraries

Front cover Age Fotostock America, Inc.; Inside front cover Huffman Prairie/hangar Henry Narducci, W-PAFB; Inside front cover 1902 glider WSU; 4-5 NASA; 6-7 NASM; 8 kite NASM; 8 Icarus NASM; 8 balloon Bibliotheque Nationale; 8 Leonardo da Vinci NASM; 9 Cayley drawing NASM; 9 Lilienthal glider Michael Freeman; 9 Langley *Aerodrome* NASM; 8-9 background PhotoDisc; 10 first flight NASM; 10 paratroopers Air Force History Office; 10 German airplane MAE; 10 X-15 NASA; 10 Earhart Corbis Images; 10 stamp NASM; 10 pilot National Archives; 10 WWI bombers Imperial War Museum, London; 10 Lindbergh button NASM; 10 *Spirit of St. Louis* NASM; 11 space walker National Geographic Society; 11 all others NASA; 13 WSU; 14 WSU; 14–15 portraits DMCPL; 15 toy LC; 16 both WSU; 17 all WSU; 19 both WSU; 20 *Tattler* DMCPL; 20 Dunbar Ohio Historical Society; 23 both WSU; 25 catalog Carillon Historical Park; 26-27 LC; 28 National Portrait Gallery, London; 29 Pénaud MAE; 29 model NASM; 32 both LC; 33 all NASM; 35 LC; 36 LC; 41 LC; 42 family WSU; 42 net-mending Outer Banks History Center, Manteo, N.C.; 43 boat North Carolina Office of Archives and History; 44-45 LC; 47 LC; 48-49 WSU; 49 glider LC; 53 diagram LC; 53 wind tunnel WSU; 54-55 both WSU; 57 tools Connie Toops; 57 Wilbur in quarters LC; 58-59 NASM; 59 drawing The Franklin Institute, Inc.; 59 Wrights in hangar WSU; 60 WSU; 63 LC; 64-65 NASM; 67 photo of engine Dan Patterson; 68-69 Mike Booher; 70 NASM; 71 both by Doug Stover, Wright Brothers National Memorial; 72 WSU; 73 NASM; 74-75 WSU; 75 notebook LC; 78-79 WSU; 79 diagram W-PAFB; 80 patent certificate United States Air Force Museum; 80 patent drawing National Archives; 82 MAE; 84-85 NASM; 85 *Petit Journal* MAE; 86 Ft. Myer flight LC; 86 accident WSU; 88-89 DMCPL; 88 medal WSU; 89 medals WSU; 89 poster Allen Airways Flying Museum; 90-91 Brown Brothers; 92 NASM; 93 WSU; 94-95 all WSU; 96 kite LC; 96-97 diagrams NASM; 98-99 stunt Corbis Images; 98 Blériot Culver Pictures, Inc.; 98 Blériot taking off NASM; 99 Heliopolis poster Allen Airways Flying Museum; 99 Aviation Meet poster Seaver Center for Western History Research, Los Angeles County Museum of Natural History; 99 Nice poster MAE; 101 NASM; 103 WSU; 104-105 The NCR Archive at The Montgomery County Historical Society; 105 class WSU; 105 street scene Marvin Christian Photography; 106 artifacts WSU; 106 photograph Dan Patterson; 108 Dunbar House interior Andy Snow; 110 W-PAFB; 111 memorial W-PAFB; 111 Huffman Prairie/hangar Henry Narducci, W-PAFB; 112 Jockey's Ridge State Park Doug Stover, Wright Brothers National Memorial; 112 Hawthorn Hill Bob Petersen, Dayton Aviation Heritage National Historical Park; Back cover Wright Brothers Monument Russell Munson.

Acknowledgements

The National Park Service thanks all those who took part in the preparation and production of this book. We are grateful for the generous financial support of Dayton Aviation Heritage National Historical Park and Eastern National. This handbook could not have been produced without the valuable assistance of Larry Blake and Ann Honious of Dayton Aviation Heritage National Historical Park and Darrell Collins and Fentrice Davis of Wright Brothers National Memorial. The book was produced by the staff of the Division of Publications, Harpers Ferry Center, National Park Service: Megan Kealy and Tom Patterson, cartographers; Melissa Cronyn, art director; Angie Faulkner and Linda Meyers, production assistance; Bill Gordon, editor and writer. Kirilloff Design designed the book. Chris Casady produced the illustrations on pages 66-67. NPS photographer Steve Ruth produced the photographs on pages 22, 40, 52, 53 (center), 107, 108 (second and fourth from top), 109, 111 (top), and back cover (bottom). Tom D. Crouch and Peter L. Jakab, of the National Air and Space Museum, generously provided assistance and technical reviews. Tom Patterson produced the illustration on page 34; Nick Engler and Phil Scott of Dayton, Ohio, provided research for the illustration.

The mission of the Department of the Interior is to protect and provide access to our nation's natural and cultural heritage and to honor our trust responsibilities to tribes. The National Park Service preserves this heritage unimpaired in the National Park System for the enjoyment, education, and inspiration of this and future generations. The National Park Service cooperates with partners to extend the benefits of conservation and outdoor recreation throughout this country and the world. Visit www.nps.gov to learn more about parks and National Park Service programs in America's communities.

Library of Congress Cataloging-in-Publication Data

Crouch, Tom D.
First flight : the Wright Brothers and the invention of the airplane /
Tom D. Crouch ; foreword by John Glenn.
p. cm. — (Handbook ; 159)
Includes bibliographical references and index.
"Dayton Aviation Heritage National Historical Park, Ohio, Wright Brothers National Memorial, North Carolina."
ISBN 0-912627-71-9 (pbk. : alk. paper)
1. Wright, Orville, 1871-1948. 2. Wright, Wilbur, 1867-1912. 3. Aeronautics—United States—History. I. Title. II. Handbook (United States. National Park Service. Division of Publications) ; 159.
TL540.W7 C78 2002
629.13'092'273--dc21
2002009145

National Park Service
U.S. Department of the Interior

Dayton Aviation Heritage National Historical Park
Wright Brothers National Memorial

In the century since its invention by Wilbur and Orville Wright, the airplane has profoundly changed the world and become an emblem of our time. Noted Wright biographer Tom D. Crouch underscores the importance of the Wrights' family, their distinct personalities, and the roles of North Carolina's Outer Banks and Dayton, Ohio, as laboratories of flight. Illustrated features tracing the Wrights' progress, maps, and a fold-out chart depicting the 1903 Wright Flyer and the principles of flight make this an indispensable guide to the Wright brothers' story. A foreword by astronaut John Glenn deepens our sense of their place in the history of flight.