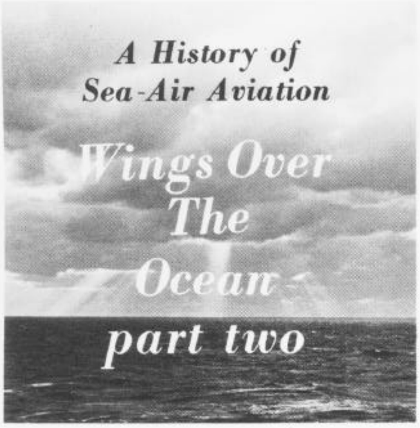
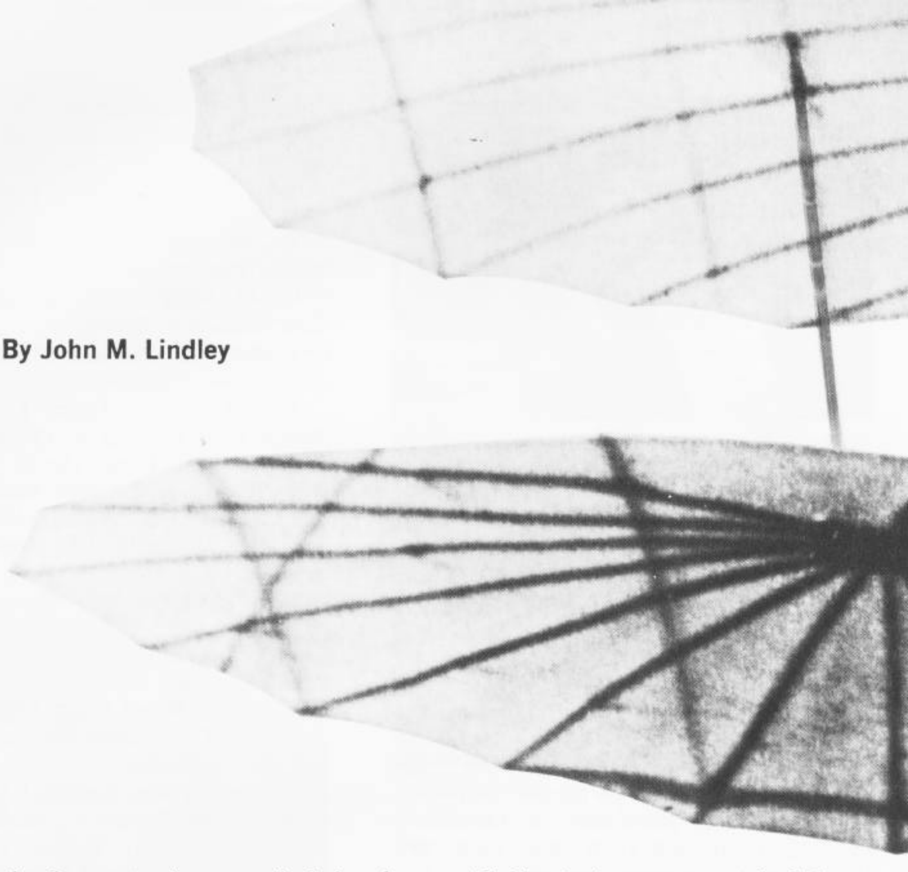


A History of Sea-Air Aviation

Wings Over The Ocean — part two



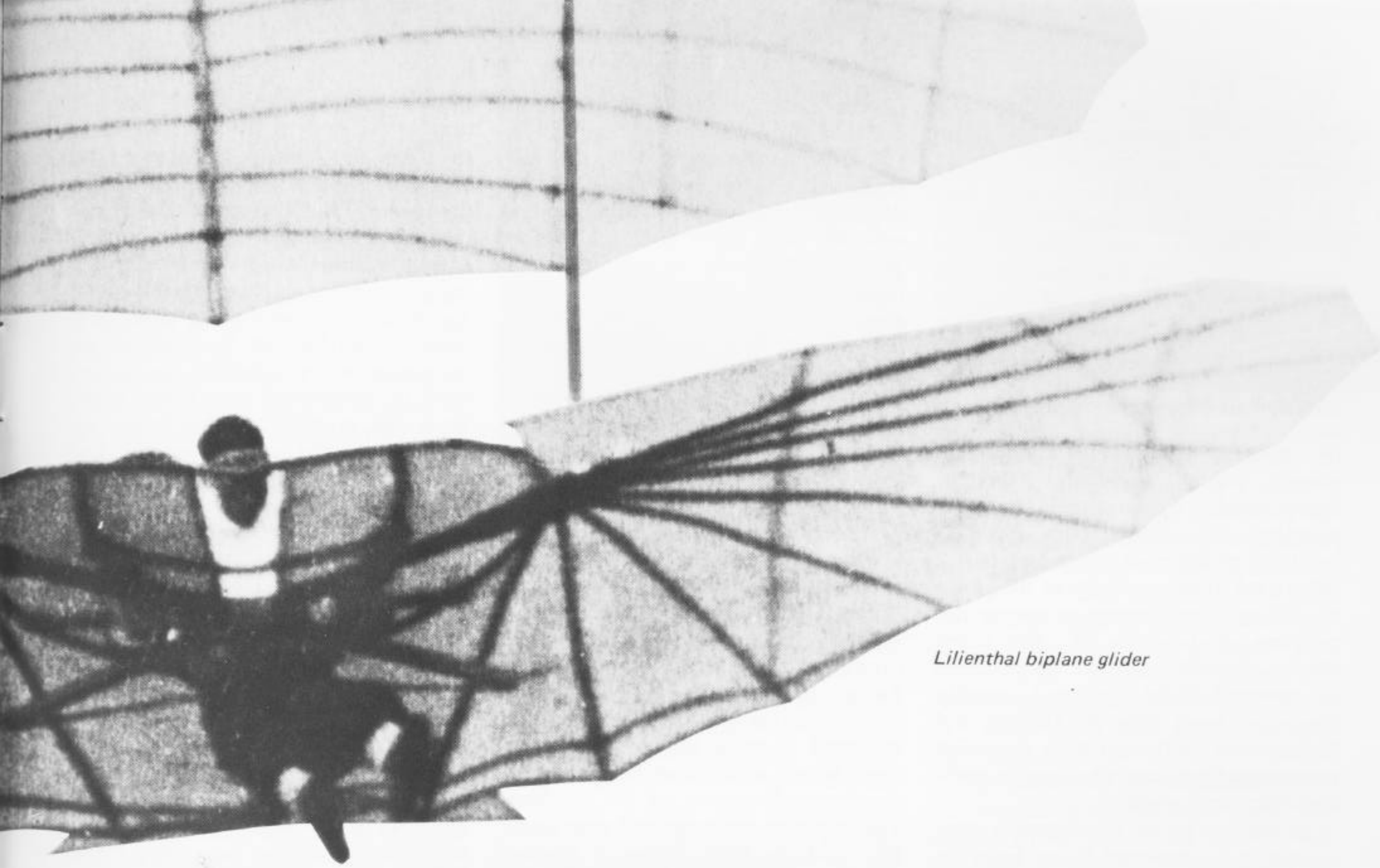
By John M. Lindley

Within a few years after these path-breaking flights by the *Lebaudy*, Count Ferdinand von Zeppelin radically altered the nature of airship travel by building dirigibles much larger than anything previously attempted. His first zeppelin (LZ-1) was a rigid type that was 420 feet long and 38 feet in diameter. It made its first flight from a floating hangar on Lake Constance in Germany on July 2, 1900. Zeppelin was a retired German army officer who visited the United States in 1863 as a military observer of the Civil War. While he was in America, Zeppelin traveled to St. Paul, Minn., where he made his first ascent in a balloon. Zeppelin subsequently reasoned that if he could string a number of balloons in line within a streamlined framework, the resulting dirigible could be both propelled and steered. He subsequently brought this idea to maturity in the LZ-1 which had 24 longitudinal girders and 16 transverse rings made of aluminum. Between each ring was a separate rubberized cloth cell filled with hydrogen. Over the entire framework and series of gas cells was a cotton cloth which served to protect the interior structure and to present a smooth shape to the wind. Beneath the airship, Zeppelin mounted two external cars on a keel-like structure. Each of the cars contained a 16-hp motor geared to two propellers which could drive the dirigible at speeds of nearly 20 miles per hour. Zeppelin achieved vertical control of the LZ-1 with a sliding weight on the keel, and he managed horizontal control with rudders.

Paradoxically, the construction of a practical airship at the turn of the twentieth century occurred almost simultaneously with the Wright Brothers' development of a practical heavier-than-air flying machine between 1903 and 1905. The Wrights' achievement was the more spectacular of the two aviation breakthroughs for several reasons. Although men had been designing or building flying machines, usually along the lines of an ornithopter, for at least 400 years prior to the Wrights' aircraft, by 1900 more was generally known and understood about the flight principles or the science of aerodynamics of lighter-than-air craft than of flying machines that were heavier-than-air — despite the fact that the balloon was not invented until 1783. In addition, the aeronauts of lighter-than-air craft achieved practical control and propulsion of their craft once Benz and Daimler independently built the first gasoline engines. The Wrights and other experimenters in heavier-than-air aviation at the turn of the twentieth century not only depended upon the development of fuel and engine technology, as had their colleagues in airships, but they also depended on the parallel development of the technology of structures and airplane configuration, airscrew (or propeller) design, the science of aerodynamics, and lastly, the principles of flight control.

Unlike their counterparts in lighter-than-air craft who could get their dirigibles into the air and keep them there for a considerable period of time while they experimented with various types of engines and control mechanisms, those who worked with heavier-than-air craft lacked this luxury of substantial time for flight testing. For the pioneer in heavier-than-air craft, air time was measured in seconds. For example, the Wrights' historic first flight on December 17, 1903, lasted only 12 seconds, and the total for all four flights made by the brothers on that day was only 99 seconds. Flight by heavier-than-air craft was, in comparison with balloons or dirigibles, an exceedingly complex problem.

Nevertheless, restless and inquiring minds had struggled with the problem of heavier-than-air flight since the fifteenth century, at least. Leonardo da Vinci, the famous Italian artist and sculptor, investigated the problem of flight, making drawings of flapping-wing machines modeled after birds or bats. He is credited with having invented an aerial screw or propeller, made small helicopters and proposed the concept of the parachute. As one of the greatest intellects of his time, Leonardo refined and



Lilienthal biplane glider

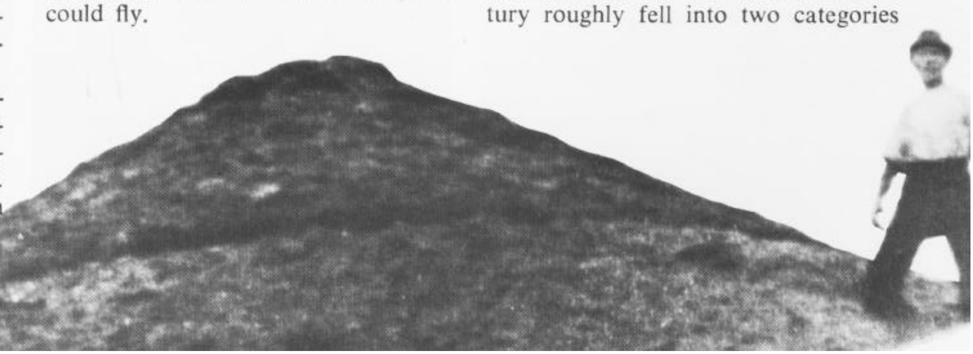
extended the hesitating speculations of his predecessors about the problem of human flight. Yet Leonardo did not do much more than produce a handful of tentative sketches and drawings. He never tried to define the problem of flight.

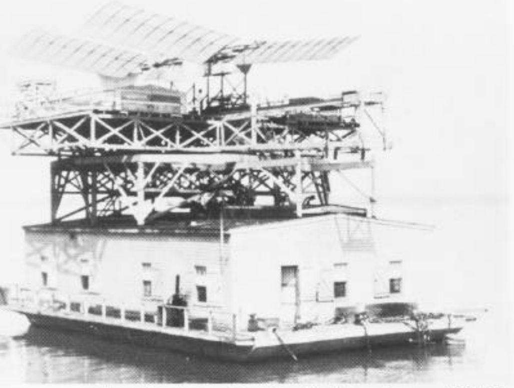
Sir George Cayley made the first guiding definition of the problem of flight. Cayley was a wealthy member of the British aristocracy who had a great passion for science. For nearly 50 years he tried to understand the principles of flying. Although Cayley did make a helicopter in 1796, and he foresaw the possibility of some sort of airship and worked with kites and gliders, his greatest contribution to aviation came in the area of the science of aerodynamics. As a result of his experiments with a "whirling arm" machine which he used to study the resistance of the air to objects in motion, Cayley defined the problem of human flight as the goal of making "a surface support a given weight by the application of power to the resistance of air." Here was the solution to flight in a nutshell!

Unfortunately, others in the primitive field of aviation failed to recognize the importance of Cayley's signposts in aerodynamics until the 1870s. In the meantime, William S. Henson made an airplane called the Aerial Steam Carriage in 1842-43. Henson's craft was a monoplane with a rectangular wing that was to be powered by a steam engine with six double-bladed propellers. It even included a tricycle undercarriage and double-surfaced cambered (curved) wings. John Stringfellow, an engineer who was in the British lace trade with Henson, agreed to build the steam engine for the *Ariel*, as the craft was called. When Henson lost interest in this effort in 1847, Stringfellow carried on with the project. He launched the *Ariel* from an overhead wire the following year, but the craft probably did not fly. What was important about the Henson-Stringfellow collaboration on the *Ariel* was not the success or failure of this flight trial; instead it was the tangible form which the two men gave to the "airplane idea." By improving the design of Henson and Stringfellow, perhaps someday someone might just build a craft which could fly.

Nearly 20 years after the launching of the *Ariel*, Francis Herbert Wenham, a British marine engineer, presented a paper to the Aeronautical Society on the flight of birds titled "Aerial Locomotion." Wenham pointed out that birds' wings are cambered with the thickest portion along the leading edge. From this observation he concluded that "such a wing, at a small angle of incidence, derived most of its lift from the front portion; hence . . . a long narrow wing would be the best type of wing for lifting. . . ." Wenham also reasoned that the greater the number of wings, the greater the total lift. Here was the first formulation of the idea for a biplane. Wenham's 1866 paper had broken new ground in the infant field of aerodynamics and it had also retrieved a line of thought first explored by Cayley, thus serving as a signpost for future pioneers in aviation.

Significant new work in aviation in the last third of the nineteenth century roughly fell into two categories





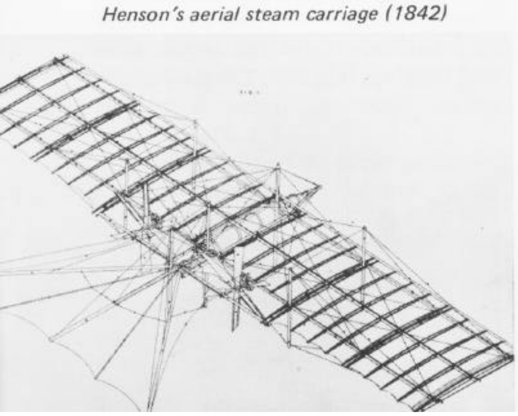
Langley houseboat with Aerodrome (1903)

or streams of development. One stream, which Cayley and Wenham inaugurated, concentrated on the problems of aerodynamics, particularly the problem of wing design and lift. It led quite naturally to the study of gliding in an attempt to master the problem of how to fly. The other stream, the effort to solve the problem of powered flight, followed roughly the initial work done by Henson and Stringfellow (although both men also made significant contributions to aerodynamics and gliding).

In the stream of development concentrating on powered flight, Felix du Temple of France is credited with having made, in 1874, the first successful attempt at powered flight. His steam-powered monoplane machine carried a man as it took off down a ramp, stayed in the air for a few seconds, and then landed safely. The second assisted, powered takeoff came in 1884 when another steam-powered airplane modeled after Henson's *Ariel* took off down a ramp and was airborne for 65 to 100 feet. The craft had been built by A. F. Mozhaiski, a captain in the Imperial Russian Navy.

At the same time that Mozhaiski was working in Russia, a prosperous French electrical engineer named Clement Ader was building heavier-than-air machines in France. In 1890 he tested a bat-formed monoplane powered by an 18-to-20-hp steam engine which drove a tractor propeller. Ader claimed that this machine, which carried a passive human pilot, covered 165 feet. The records concerning this and other subsequent flights are obscure and the results uncertain. It is doubtful that any of Ader's machines actually flew; nevertheless, his work is important because he seemed to have proved to others in aviation that it was possible to get an airframe off the ground if it were fitted with a powerful enough engine.

Henson's aerial steam carriage (1842)



Sir Hiram Maxim, the inventor of a machine gun, built the first heavier-than-air machine that lifted itself off level ground. He had begun by building flying machines in the 1880s and had done some work testing airfoils in a wind tunnel. In 1893 Maxim began to build his final flying machine. When it was completed, the machine weighed more than 2½ tons when carrying fuel and a crew of three. Rather than try his "monster" of a flying machine in a free flight, Maxim mounted it on a track, an arrangement which would also facilitate testing the performance of the machine. The machine made several runs down the track in 1894 before it crashed due to a mechanical failure involving the track. Maxim argued that these tests had shown that the craft developed 10,000 pounds of thrust, a force sufficient to have lifted it into the air had it been free of the track.

While Ader, Maxim and others were trying to hurl a flying machine into the air by mounting a powerful engine on an airframe, Jean Marie Le Bris and Otto Lilienthal were exploring the possibility that flight could be mastered through gliding. Le Bris was a French sea captain whose study of the albatross led him to take up gliding. In 1854 or 1855 Captain Le Bris built a full-sized glider with a 50-foot wingspan which he pulled into a 12-mph wind with the aid of a horse-drawn cart. The glider soared for about 300 feet before coming back to the earth. When Le Bris tried a later takeoff over a quarry, he fell, breaking a leg and smashing the glider.

Otto Lilienthal, a German, subsequently perfected the art of flying a glider. Lilienthal was trained as an engineer and began his aviation studies in the early 1870s. Like so many others in the pioneering stages of aviation, he had become interested in flight while watching the birds near his home. He studied the flight of birds so intensively that he wrote a book, published in 1889, setting forth his ideas about bird flight as the basis for human flight. Convinced that man could fly, Lilienthal devoted his energies to flying fixed-wing gliders. Lilienthal's reason for concentrating on glider flight can be inferred from a comment he once made about balloons: "The balloon has been of no assistance to real aviation; nay it may even be considered as a direct brake upon the progress of this technique, because it split up the energy and directed the investigation which should have been devoted to dynamical flight into wrong channels." In other words, gliders rather than balloons would unlock the secrets of the dynamics of flight and make possible the invention of a true flying machine.

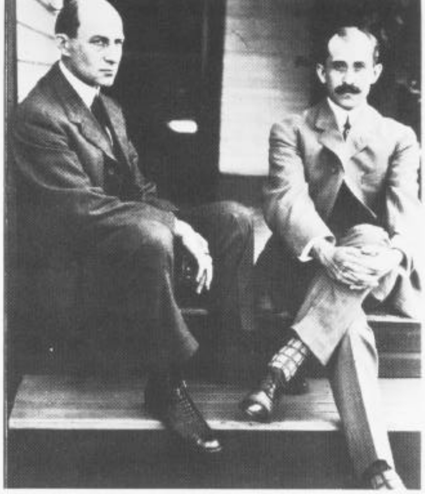
Using the fixed-wing or hang glider from which the pilot hung by his arms and which he controlled by shifting his body, Lilienthal began serious study of "dynamical flight." By 1894 he was making controlled glides of up to about 1,150 feet. He was able to achieve these long flights because he had found through examination of bird wings and plant seeds that a curved wing with a thickened leading edge had superior lifting capacity in comparison with a flat wing. In all, Lilienthal made over 2,000 glider flights, many of them from a 50-foot artificial hill which he had built on the plains near Berlin. One day in 1896 when Lilienthal was making a glide, a gust of wind caused his glider to stall and then to crash. The resulting accident broke Lilienthal's spine and he died the following day, August 10. Despite this tragic and untimely death, Lilienthal and his work in aviation would not be forgotten. The Wright Brothers would refine his glider techniques and bring the study of "dynamical flight" to maturity.

Lilienthal was only one of several contemporaries of the Wrights who were working on the problem of flight. One of these men, the French-born American civil engineer Octave Chanute, directly influenced the brothers from Dayton, Ohio. His fame in the history of aviation is based, in part, on his having been the first great historian of human flight and an influential intermediary and disseminator of aeronautical information between Europe and the United

States. Because he had worked with man-carrying gliders, Chanute could appreciate to some degree the accomplishments of the Wrights in their gliding experiments of 1900-1902. In addition he was a friend and moral supporter who helped the Wrights weather some discouraging setbacks. In addition to his other contributions to aviation, Chanute also introduced the Pratt-truss method of rigging a biplane which the Wrights utilized in their biplane gliders and flying machines.

Unlike Chanute, Samuel P. Langley was known to the Wrights only by reputation. Langley was a distinguished mathematician and astronomer who had become in November 1887 the Secretary of the Smithsonian Institution. The year before he received this appointment, Langley had begun studying aerodynamics by constructing a whirling-arm machine which he used to evaluate the resistance of a plane surface to the air. His experiments convinced him that curved or cambered surfaces were more efficient aerodynamically than flat plates. Armed with this information, Langley proceeded to calculate mathematically that the steam engines then available could, in theory, get a flying machine off the ground.

In 1892-93 Langley began to build model flying machines, called aerodromes, powered with steam engines. After repeated attempts to get one of these models to fly, he succeeded on May 6, 1896, when one aerodrome covered a distance of 3,300 feet. Since Professor Langley conducted these flight tests over water, they were an early tentative step toward flight operations over the ocean. When war broke out with Spain two years later, the U.S. Army accepted Langley's proffered help. They provided him with $50,000 to use in building a man-carrying flying machine. Langley plunged into this project with vigor. He hired Stephen M. Balzer of New York to build a gasoline engine weighing not more than 100 pounds and producing at least 12 horsepower which could supply the necessary power for a full-size flying machine. Balzer was unable to build the engine to Langley's specifications, but Langley's assistant, Charles M. Manly, took over the Balzer engine, redesigned and modified it, and produced an engine that weighed 207.5 pounds and



The Wrights

was capable of producing 52.4 horsepower at 950 revolutions per minute when tested in 1902.

The following year, Langley completed construction of his full-size flying machine which he called *Aerodrome A*. It was a tandem-wing monoplane which together with its pilot weighed about 730 pounds. Langley mounted the aerodrome on an 80-foot catapult atop a houseboat on the Potomac River near Washington, D.C. Manly volunteered to act as the pilot. The first test flight of *Aerodrome A* came on October 7, 1903. The flight of the aerodrome was very brief because after launching it tumbled over the end of the catapult and fell into the Potomac. Langley blamed the failure on the catapult mechanism and hastily prepared for another trial which took place on December 8, 1903. This test was even more disastrous than the first, and Manly almost drowned when the aircraft splashed into the river. Since these trials were held in public, the newspapers hooted and howled over Langley's folly in building a flying machine and then wasting the taxpayers' money when it failed to fly.

Octave Chanute

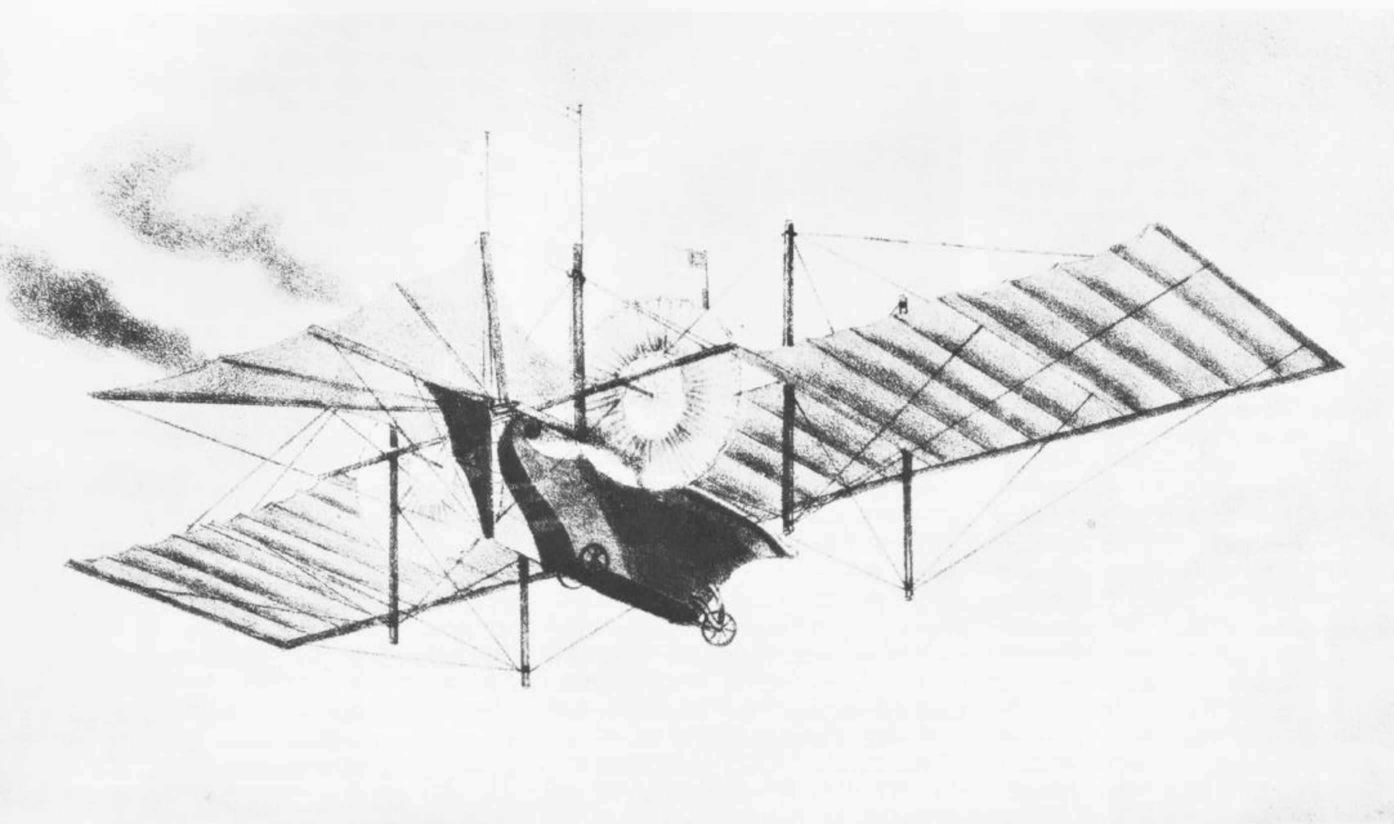
Stung by all the criticism and unable to get his aerodrome to fly, Langley gave up on his flying machine. He died three years later.

Although one historian of aviation has concluded that Langley's "technical influence on aviation was virtually nil," he was important to the Wrights in two respects. First, he was a man of great reputation who took aviation seriously at a time when many felt it was ridiculous. Second, he provided a source of direct competition for the Wrights in 1903. In addition, the launchings of Langley's aerodromes with their disastrous results contrast vividly with the successful flights of the Wrights' machine that year. Contemporaries of Langley and the Wrights probably could not have appreciated the technical and aeronautical distance between the *Aerodrome A* and the Wright *Flyer* of 1903; but it was substantial and significant.

The career and accomplishments of the Wright Brothers have been the subject of a substantial amount of historical literature. A recounting in detail of their work prior to the first successful flights on December 17, 1903, and their subsequent rise to fame has no place in an essay of this length; nevertheless, their work had a profound influence on the subsequent history of sea-air aviation.

Wilbur Wright first learned of Lilienthal's pioneering work with gliders from a magazine article published in 1894. He dated his interest in the problem of flight from the time of Lilienthal's death in 1896. Three years later, Wilbur spent many hours studying the flight of birds in and around his home in Dayton. At the same time he began to read everything he could find on the subject of aviation. Following the lead of Lilienthal, the Wrights decided that they should first build a glider to test their ideas about aeronautical design and to learn how to control their craft while it was airborne, so that they could gradually determine how to fly a powered machine. As Wilbur explained to an audience of engineers in 1901, they spent their time at Kitty Hawk learning to fly gliders because the achievement of stability or flight control "was the *first* instead of the *last* of the great problems in connection with human flight."

To illustrate his point more effec-



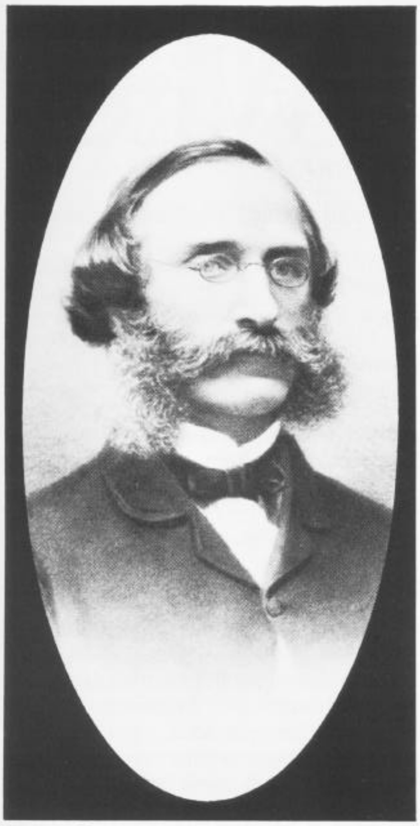
Ariel

tively for the engineers, Wilbur then took a piece of paper, held it out and let it flutter to the floor. Having caught the attention of his audience, he explained: ". . . it will not settle steadily down as a staid, sensible piece of paper ought to do, but it insists on contravening every recognized rule of decorum, turning over and darting hither and thither in the most erratic manner; much after the style of an untrained horse. Yet this is the style of steed that men must learn to manage before flying can become an everyday sport. . . . Now, there are two ways of learning how to ride a fractious horse: one is to get on him and learn by actual practice how each motion and trick may be best met; the other is to sit on a fence and watch the beast awhile, and then retire to the house and at leisure figure out the best way of overcoming his jumps and tricks. The latter system is the safest; but the former, on the whole, turns out the larger proportion of good riders. It is very much the same in learning to ride a flying machine; if you are looking for perfect safety, you will do well to sit on a fence and watch the birds; but if you really wish to learn, you must mount a machine and become acquainted with its tricks by actual trial."

In this homely comparison between learning to ride an untrained horse and learning to handle a flying machine, Wilbur Wright repeated a point that the ancient myth-makers had made long ago: Bellerophon first had to obtain control over Pegasus with the golden bridle.

What, then, was the Wrights' "golden bridle?" It was the principle of "wing warping" or twisting combined with the concept of a movable tail. Lilienthal had attempted to control the flight of his gliders by having the pilot shift the weight of his hanging body which altered the center of gravity of the glider, thereby maintaining the balance of the craft. In contrast, Wilbur Wright discovered that he and Orville could achieve lateral control over their glider by "twisting the wings so as to present their ends to the wind at different angles." The twisting of the wing ends was achieved by means of a series of cords and pulleys fastened to a cradle that the prone pilot moved with his hips. Thus, whenever the pilot of the Wrights' glider felt he was losing lateral balance, he moved his hips in the cradle which twisted the wing tips and presented a changed wing angle.

With the hip cradle providing for wing warping, the pilot had both hands free to manipulate the elevator which gave fore-and-aft control to the glider. Wilbur Wright introduced the idea of a movable vertical tail during the gliding experiments of 1902 as a way to prevent spinning and sliding. Unlike his predecessors, who had used a tail like a ship's rudder for steering their gliders or aircraft, Wilbur used the tilt of the wings resulting from wing warping to effect turning movements. The movable tail served to increase the balance and control of the glider. Initially the Wrights combined the tail control with the hip cradle to avoid having three separate controls, but in 1905 they redesigned their control systems so that the hip cradle controlled wing warping, the right hand operated the rudder and the left hand controlled



William S. Henson

the elevator.

Having found in their glider experiments that wing warping and a movable tail would provide control over the glider, the Wrights knew they had overcome a major obstacle in the development of human flight. Ahead of them lay the problem of finding a suitable engine and of mounting it on a modified glider airframe so that they could try to achieve powered flight. John Evangelist Walsh, the most recent biographer of the Wrights, sums up their work with gliders as follows: ". . . it may be said that, in a way, the day on which man finally conquered the air was . . . Friday, October 10, 1902. For, as Wilbur had insisted from the start, the whole problem of human flight was the achievement of control, not the designing of light motors. An engine and propellers were, so to speak, merely more efficient substitutes for wind and gravity. There was no doubt that a glider which could, under all conditions, be controlled in a descent of a few hundred feet, could with modifications be made to fly on and on, to unpredictable distances, once it carried its own source of power."

This is, of course, exactly what the Wrights did in 1903. With the help of Charles E. Taylor, they built a lightweight 12-hp engine, modified the glider design for mounting an engine and two propellers, and proceeded to test the first Wright *Flyer* successfully on December 17th, just nine days after Langley's aerodrome failed for the second time. By 1905 the Wrights had perfected a practical flying machine. By the end of 1908 they had shown the world, at home and abroad, the superiority of both their *Flyer* and their method of flight control over all the primitive and rudimentary flying machines and methods of their competitors.

What had the Wright Brothers achieved? They were the first men to master glider flight. In fact, the glider never lost its appeal for the Wrights. Almost as a tribute to the teaching and training qualities of the glider, Wilbur Wright returned to gliding in 1911 to make further aerodynamical studies. During this experimental work, he set an endurance record of 9 minutes 45 seconds which lasted until 1921. But the Wrights are not primarily remembered today for their work with gliders. Their place in the history of aviation is secure because they were the first men to make powered, sustained and controlled flights in an aircraft and to land on ground as high as that from which they took off (1903). They had also designed, constructed and flown the first fully practical airplane (1905). This flying machine would take off and land without damaging itself or its pilot. It could fly straight, turn or circle with ease. Lastly, they were the first to construct and fly a practical airplane which could carry passengers (1908).

For the history of sea-air aviation, the Wright Brothers are important for more than what they accomplished in pioneering human flight. As the inventors of the first successful airplane, they belong to the tradition of Daedalus the artificer. Although they had little formal education in engineering, Wilbur and Orville were skilled craftsmen in both wood and metal. In addition, they worked carefully and systematically, testing each glider or *Flyer* piece-by-piece before trying to fly it. Their wind tunnel and other aerodynamical studies were consistent with the most careful experimental methods of science. Their study of the problem of flight control with both gliders and flying machines was also highly systematic. Thus they shared with Daedalus a skill in design and invention second to none. They too, like Daedalus, flew the product of their labors, but instead of flying with feathered wings, they flew with a powered machine.

The Wrights were practical men. They wanted to make a fortune from their invention. Consequently, when they decided to sell their flying machine in 1906, they turned to a buyer whose financial resources were both vast and impeccably sound, the U.S. Government. In choosing to try to sell their invention to the U.S. Army, the Wrights openly acknowledged its potential as a weapon of war. In late 1905 Wilbur had written to an officer of the French army about the sale of the Wright *Flyer*. In this letter he expressed what he foresaw as the military value of their airplane: "With Russia and Austria-Hungary in their present troubled condition and the German emperor in a truculent mood, a spark may produce an explosion at anytime. No government dare take the risk of waiting to develop practical flying machines independently. To be even one year behind other governments might result in losses compared with which the modest amount we ask for our invention would be insignificant."

Wilbur and Orville saw that getting rapidly from one place to another by means of a flying machine was not the only use for their invention. Just as Bellerophon found a formidable weapon in Pegasus which could help him to destroy the Chimaera, so also the Wrights foresaw the potential of the flying machine as a weapon of war. They would have preferred to see their invention used only for peaceful purposes, but they were realistic enough to understand the advantage a flying machine would give to whichever government possessed it. Whether wittingly or not, by the end of 1908 the Wrights had brought together the tradition of Daedalus, the inventor, with the tradition of Bellerophon and Pegasus, the masters of aerial warfare.

To be continued