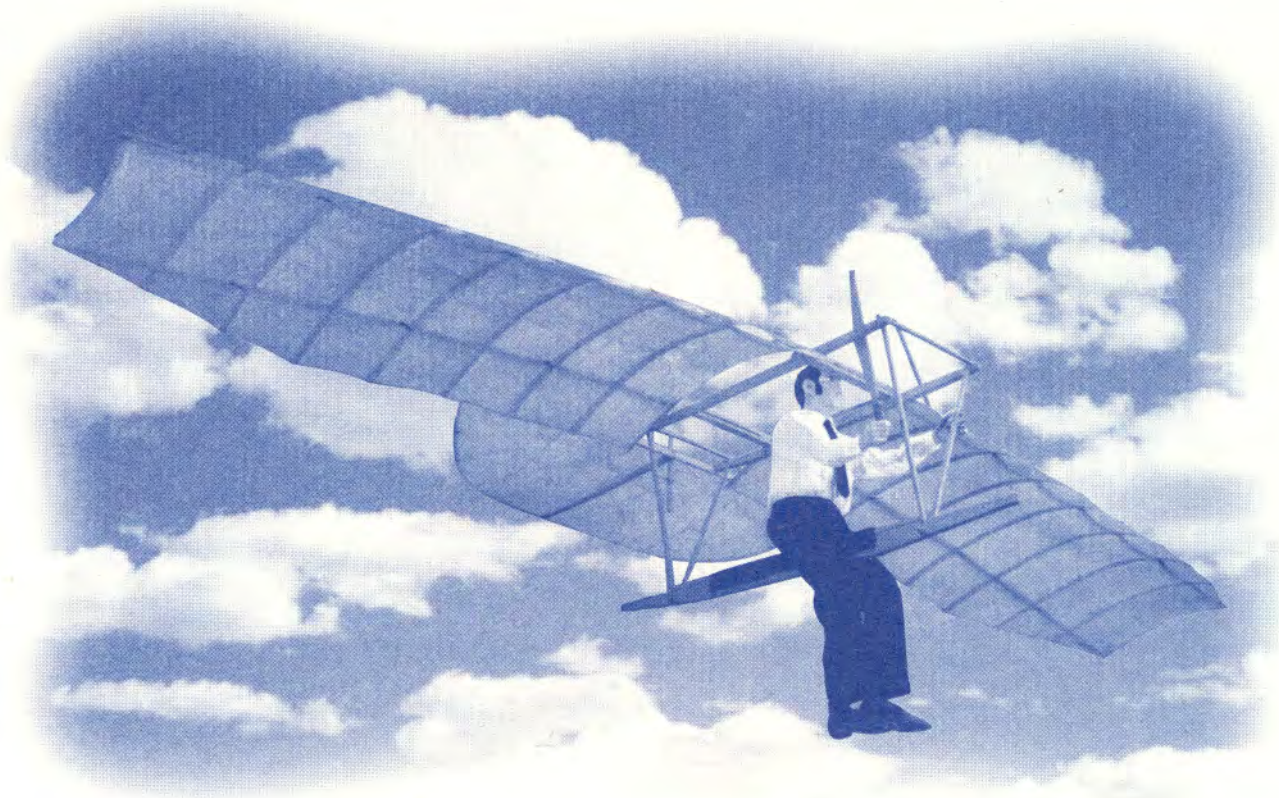


John Joseph Montgomery 1883 Glider



**An International Historic
Mechanical Engineering Landmark**

Designated by



ASME International

The American Society of Mechanical Engineers

May 11, 1996

at

Hiller Aircraft Museum and Santa Clara University

INTERNATIONAL HISTORIC
MECHANICAL ENGINEERING LANDMARK

JOHN J. MONTGOMERY HUMAN-PILOTED GLIDER

1883

THIS REPLICA REPRESENTS THE FIRST HEAVIER-THAN-AIR CRAFT TO ACHIEVE CONTROLLED, PILOTED FLIGHT. THE GLIDER'S DESIGN WAS BASED ON THE PIONEERING AERODYNAMIC THEORIES AND EXPERIMENTAL PROCEDURES OF JOHN JOSEPH MONTGOMERY (1858-1911), WHO DESIGNED, BUILT, AND FLEW IT. THIS GLIDER WAS WAY AHEAD OF ITS TIME, INCORPORATING A SINGLE PARABOLIC, CAMBERED WING, WITH STABILIZING AND CONTROL SURFACES AT THE REAR OF THE FUSELAGE. WITH HIS GLIDER'S SUCCESS, MONTGOMERY DEMONSTRATED AERODYNAMIC PRINCIPLES AND DESIGNS FUNDAMENTAL TO MODERN AIRCRAFT.

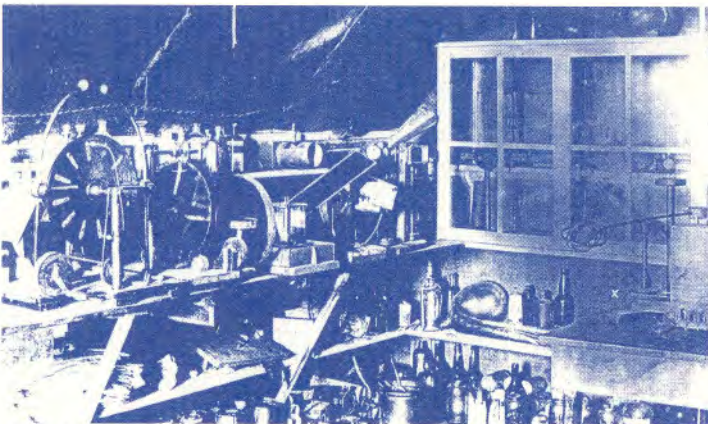
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS 1996

Historical Background

On Aug. 28, 1883, at Otay Mesa near San Diego, a manned glider left the surface of the earth and soared in a stable, controlled flight. At the controls was John Joseph Montgomery, aged 25, who had designed and built the fragile craft. After the launching, John and his brother James, who had helped launch the glider, paced off the distance of the flight as 600 feet. In addition to James, several local ranchers and others in John's family witnessed the construction and flight of the 1883 glider.

This 1883 flight of Montgomery's glider was the first manned, controlled flight of a heavier-than-air machine in history. It preceded by some 10 years the famous glider flights of Otto Lilienthal, and by 20 years the historic powered flights of the Wright brothers.

Since the beginning of recorded history, humankind has dreamed of flying. Most early experimenters focused on mimicking the flight of birds. Birds, however, fly by combining lift, propulsion, structure, stability, and control in one complex mechanism—the articulated, flapping wing. John Montgomery was one of the early investigators to realize that progress was possible only when these requirements were addressed more or less independently. By proceeding scientifically and performing his own experimental and analytical studies, he was able to make fundamental advancements in the areas of lift generation and flight structures, as well as in the interrelated areas of stability and control.



John Montgomery's laboratory at his family's ranch home in Otay Valley, San Diego County (1882–83)

In 1882, Montgomery set up a laboratory in a barn on his family's ranch home at Fruitland in Otay Valley. Before designing the 1883 glider, Montgomery made a comprehensive study of bird flight. He would have his sisters rile up birds, including his grandmother's chickens, to get them to fly overhead while he lay supine so that he could observe them. He also shot birds so that he could measure and weigh them. By these means he began to learn how much wing area could support a given weight, how to shape a wing for high lift, and how the tail contributed to stability and control.

After observing the natural airfoil shape of the birds' wings, he incorporated the wing shape in the 1883 machine. He designed a parabolic wing section with more curvature toward the front of the wing, giving the wing a gull-like wing shape and high lift.

Montgomery was the first to incorporate successfully the wing airfoil parabolic shape in a heavier-than-air man-carrying aircraft. His glider also had its stabilizing and control surfaces at the rear of the aircraft, the placement of which was unique at that time and which anticipated modern aircraft design. (The Wright brothers' 1903 Wright Flyer and later designs placed stabilizing and control surfaces at the front.) The structure Montgomery designed was both lightweight and flight-worthy.



John Montgomery in approximately 1883, at the age of about 25

John and James Montgomery tested the glider from the edge of Wheeler Hill at Otay Mesa. In order to launch, James ran with a rope attached to the glider, and John ran along straddling the keel. James would fall to the ground after John had already leapt onto the glider, which would take him into the air over the valley. Montgomery demonstrated that man could attain controlled flight and land without harm to himself or the aircraft.

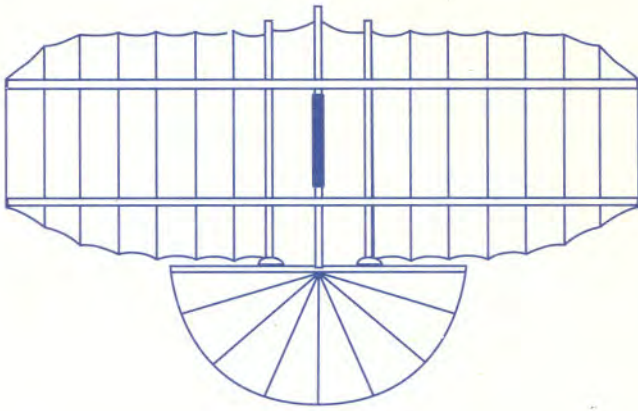
Unfortunately, Montgomery's achievement of 1883 was not immediately recognized widely, for several reasons. First, he was on the West Coast of the United States, and all the publicized aviation experimentation (by Samuel Langley, Octave Chanute, Alexander Graham Bell, and others) was on the East Coast. Second, he was short of money to continue his experiments (he considered filing a patent on the 1883 glider because he "expressed apprehension that someone would get advantage of him in the discovering of aerial navigation and completing the subject," but he could not afford it).

Fate of the Glider

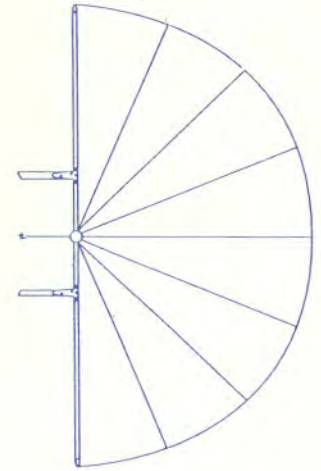
The 1883 glider, as well as several other aircraft prototypes and experimental equipment, remained in the Montgomery barn at Otay Mesa until 1915. In the winter of 1915–16, the Montgomery ranch, including the barn, was washed away when the Otay Dam broke, and all the artifacts were lost.

In 1962, hand-drawn plans of the glider dated 1882 were found in a trunk of Montgomery's early papers preserved by his youngest sister, Jane. Garland Goodwin used the plans to produce engineering drawings of the machine. The drawings were used as the basis of a competition sponsored by the Self-Soar Association to decide whether or not the vehicle was really flyable.

The replica of the 1883 glider on loan to the Hiller Aircraft Museum was built by Ace and Judy Campbell of San Jose as an entrant in the Self-Soar Association's competition. No flight of the replica has ever been attempted.

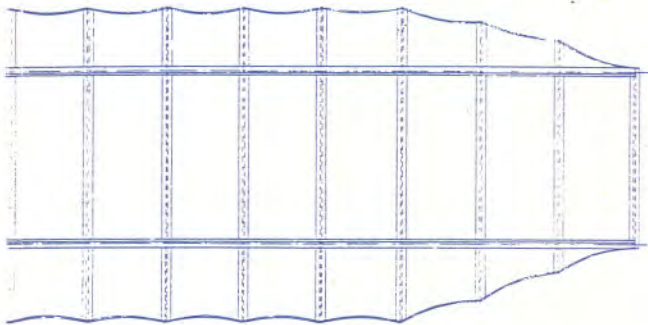


Control in pitch was provided by an all-moving, semicircular, aft-mounted horizontal tail. The tail surface was deflected by a lever controlled by the pilot. Shifting of the pilot's weight augmented pitch control and provided limited roll control. There was no apparent means of yaw control.

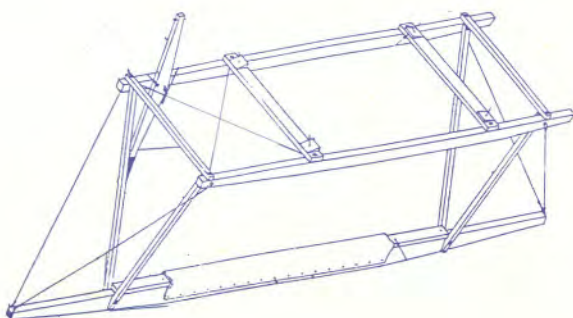


The 1883 Glider

The aircraft, which weighed 40 pounds, was a single-wing glider with a stabilizer at the rear of the fuselage. The wing, which had a span of 20 feet, incorporated a parabolic airfoil. It was constructed of a frame of thin ash ribs of about 4.75 feet long, which were steamed and curved. The wing area was approximately 82.5 square feet, giving a wing loading of about 2.5 pounds per square foot (assuming Montgomery weighed 170 pounds) and an aspect ratio of 4.85. Stretched over the frame was unbleached muslin, sewn by Montgomery's sister Jane. An 0.080-inch-diameter wire was strung along the tips of the ribs to support the leading and trailing edges.



The 8-foot fuselage was constructed of three ash longerons, the upper two placed perpendicular to the two wing spars; the other was below with a padded area for the pilot. The fuselage was nearly 8 feet long and about 4 feet high. Carbon steel wires were used to support the structure.



Post-1883 Accomplishments

Before he started on a new series of gliders, Montgomery decided he needed to learn more about the principles of flight and the relationship between the wing surface and the air. For ten years he repeatedly performed experiments that resulted in the publication of several papers and reinforced his conclusion that the parabolic airfoil shape was the most efficient wing design. Montgomery used a spinning table and a water tunnel to test his theories.

He arrived at three conclusions: First, a wave is produced with crests above the airfoil, causing particles approaching the airfoil to ascend and those leaving to descend. Second, the best shape in an airflow "is one having a gradually increasing curvature from the rear to the front edge." Third, "[how the shape is curved] is dependent on the relation of weight to the surface and the length of the surface to its breadth."

Montgomery also concluded that the aspect of the parabolic shape that makes it so much more efficient than a flat surface is its "low-pressure area," which had helped his 1883 glider stay in the air longer than his other prototypes. This principle would not be recognized by many until 1910. Montgomery understood that the pressure differential was greatest at the leading edge of a parabolic-shaped wing and decreased toward the rear, and he made sure to incorporate it into his next series of gliders, which included the *Santa Clara* and *Evergreen*.

Montgomery presented one of his papers, "Soaring Flight," which summarized his basic laws of aerodynamics, at the historic International Conference on Aerial Navigation in Chicago in 1893. In addition, his experimental results, which he described at the convention at Chicago, were incorporated in a paper published in *Aeronautics* magazine, July 1894. Another paper, "New Principles in Aerial Flight," appeared in *The Scientific American Supplement* on Nov. 22, 1905. The illustration at right illustrates Montgomery's theory of the parabolic airfoil.

Englishman Horatio F. Phillips, often credited with the cambered airfoil in history books, patented his designs in 1884, a year after Montgomery's flight. He did not test his results until

1893, only a year before Montgomery published the results of his flights and the subsequent years of experimentation after its flight.

The European pioneer Otto Lilienthal has been credited by many as building the first successful man-carrying gliders; however, after several failures with flat airfoils, he did not construct his first successful glider until 1894, 11 years after Montgomery's first flight and the same year Montgomery submitted his revolutionary theories of aircraft and airfoils in Chicago.

In 1896 Montgomery worked on a series of model gliders that would eventually lead to the 1905 *Santa Clara*. He concentrated his work on the refinement of the flight characteristics of the aeroplane (Montgomery was the first to refer to the whole aircraft as an *aeroplane*).

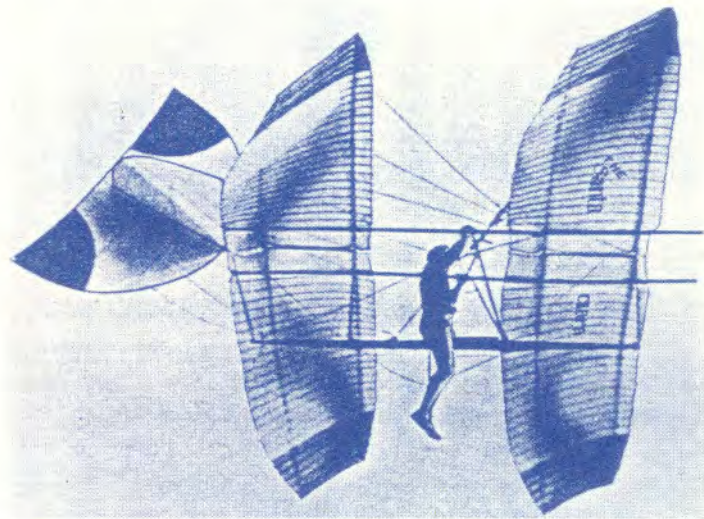
The 1905 *Santa Clara* incorporated wing warping, a predecessor to ailerons, in which lines from the tandem wings to a wooden rod at the feet of the pilot allowed the pilot to control the glider. It also had a vertical and horizontal stabilizer in the rear of the craft that the pilot could manipulate. On March 16, 1905, Daniel John Maloney flew the glider in its first flight, at Aptos, Calif., after it was dropped from a balloon from around 800 feet.

In a historic flight at Santa Clara College, the *Santa Clara* performed several horizontal figure-eights, well-controlled turns, and spirals after being dropped from 4,000 feet by a balloon. The flight, which lasted 15 to 20 minutes, was witnessed by hundreds of people, including members of the press. Octave Chanute, when in New York, confirmed this flight to several people, including Samuel Langley and Alexander Graham Bell. Bell would later say, "All subsequent attempts in aviation must begin with the Montgomery machine." Chanute called the *Santa Clara* flight "the most daring feat ever attempted." Victor



Montgomery (center) and pilot Daniel John Maloney (right) standing beside the 1905 *Santa Clara*

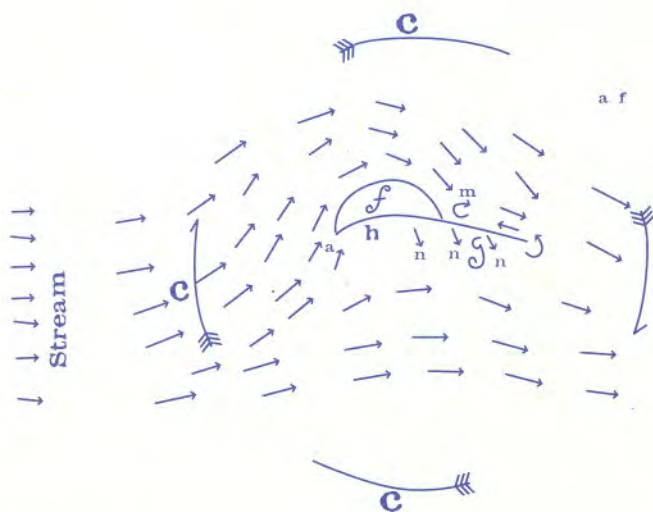
Lougheed (co-founder of the Lockheed Aircraft Co.) commented, "The one great problem of aerial navigation from the beginning had been that of controlled flight and maintained equilibrium, which here, for the first time in history, it was their privilege to witness." These quotes from Bell, Chanute, and Lougheed can be found on an obelisk monument on the campus of Santa Clara University where the *Santa Clara* was raised into the air on April 29, 1905.



Daniel Maloney flying the tandem wing *Santa Clara*

On July 18, 1905, Maloney crashed and died in the *Santa Clara* after tangling the glider in the lift rope of the balloon. The *Santa Clara* was later restored by the Northern California Chapter of the American Aviation Historical Society; it is now on loan to the Hiller Aircraft Museum.

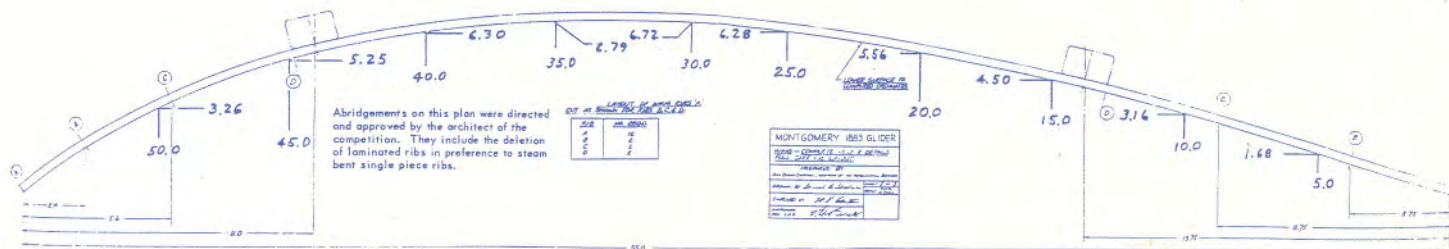
After pursuing nonaeronautical activities for several years, Montgomery returned to his aircraft development and built the 1911 *Evergreen*. This machine had several ingenious elements that set it apart from its contemporaries. The structure was designed to be elastic to endure wind gusts and turbulence. The outer wing sections had an aileron effect, and the inboard trailing section of the wing was designed to have a flap effect. Handstick control, popular at the time, was replaced with a wheel-yoke, the next step in aircraft control. The wheel-yoke,



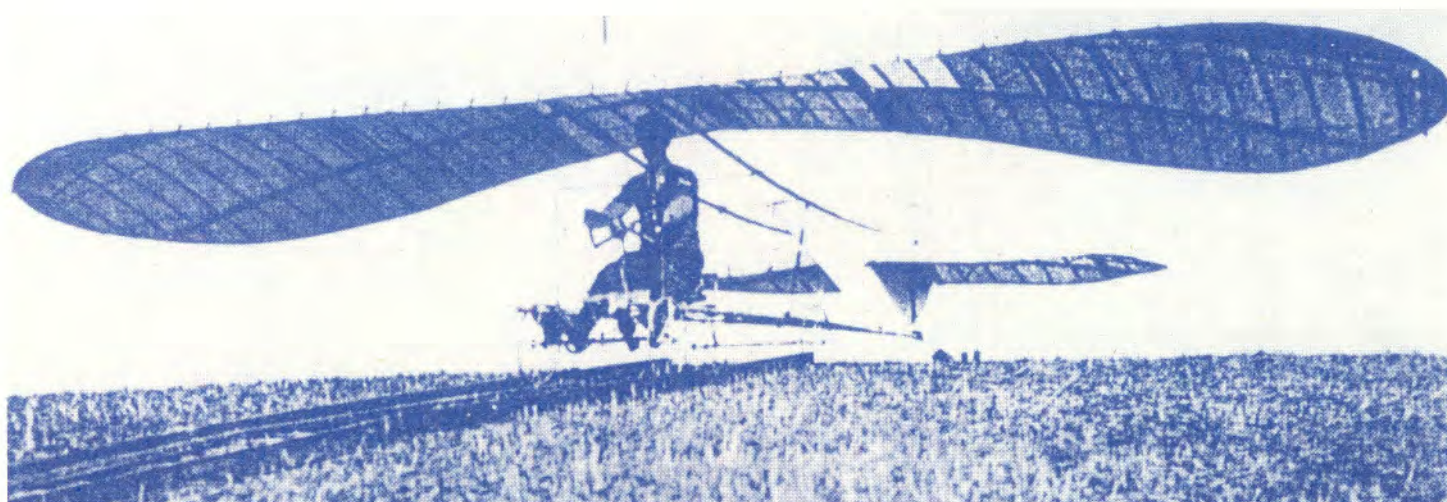
A sketch from Montgomery's article "The Airplane: A Scientific Study," which appeared in *The Redwood*, April–May 1905, Santa Clara University. The figure shows the circulation of air over a parabolic airfoil. Note that there is more curvature toward the front of the airfoil and that there is a region of "leading-edge suction."

designed by Deperdussin, a French designer and pioneer, centralized the control of the aircraft and reduced the labor of the pilot. Montgomery had also refined the control surfaces into a single wing during a time when less-refined multiple-winged aircraft were popular.

There are two 1911 *Evergreen* restorations. The first one was restored by the Smithsonian National Air and Space Museum based on parts donated by Santa Clara University. It is now on display at the San Diego Aerospace Museum. The second, with wheel-yoke control, was restored by eight Lockheed Missiles and Space employees in 1961; it was given back to Santa Clara University and is on display at the Hiller Aircraft Museum.



The airfoil section of the 1883 glider



The 1911 *Evergreen* being launched from a track on a hill in the Evergreen district of San Jose (designated Montgomery Hill in 1961). Note the single-wing, aft-tail layout. Joseph Vierra is the pilot on this occasion.

John Joseph Montgomery

Born on Feb. 15, 1858, in Yuba City, Calif., son of Zachary and Ellen Montgomery, John Montgomery became interested in flight as a child. His family moved in 1864 to Temescal, the central part of Oakland, Calif. At his grandmother's farm near Oakland, he began his life-long study of the flight of birds.

In 1869 at age 11, he attended an exhibit of Frederick Marriott's steam-powered hydrogen semidirigible balloon, *The Aviator*. As soon as he was home, he built a toy replica of the craft. In 1870 Montgomery attended St. Joseph's Academy, and on Aug. 11, 1874, he entered Santa Clara College (now Santa Clara University). In 1875 he attended St. Ignatius College (now University of San Francisco), where he studied physics, receiving his B.S. in 1879 and M.S. in 1880. As a hobby, he closely observed the flights of gulls. At Otay Mesa, Calif., in 1882, with the help of his sister and brother Jane and James, he set up a laboratory and started construction of his first gliders. In 1883 he built and flew the first successful glider with the help of his brother.

After these experiments, Montgomery performed ten years of research to define better the principles of flight that made his 1883 design fly so successfully. The research culminated in his paper "Soaring Flight," which he read at the International Conference on Aerial Navigation in 1893. He met Octave Chanute at the conference and discussed various principles of flight with him. At Chanute's request, Montgomery agreed to keep up a correspondence on his progress in California. (Chanute was also exchanging letters with the Wright brothers; many of these concerned Montgomery's progress and experimentation in California.)



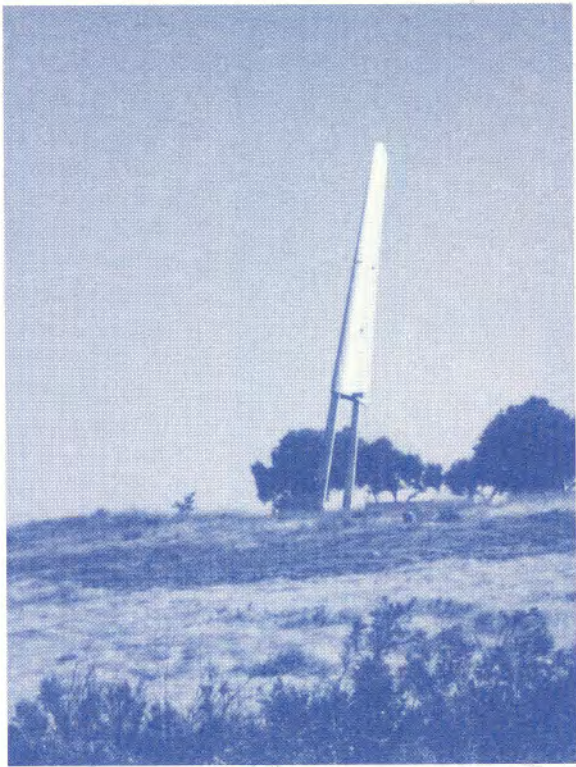
Professor John J. Montgomery (1858–1911)

In 1894 Montgomery joined the faculty of St. Joseph's College in Rohnerville, Calif., where he taught mathematics and continued his aeronautics research. Montgomery moved back to Oakland in 1895. Joining the faculty at Santa Clara College in 1896, he became professor of physics and in 1901 received his Ph.D. He built a wind tunnel on the Santa Clara campus to continue his lab experiments and met John E. Leonard, who suggested that Montgomery perform his flight experiments at Leonard's father's ranch in Aptos, Calif.

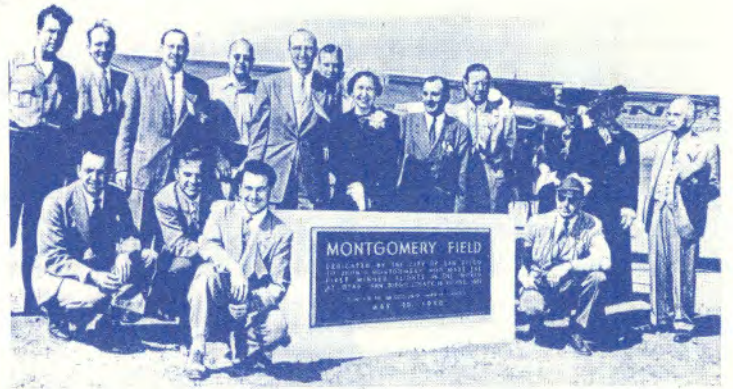
Montgomery experimented with several double mono-plane models, including *The Pink Maiden* and *The Buzzard* from 1896 to 1904, culminating in the design and construction of several gliders of similar designs, one of which was the 1905 *Santa Clara*. The photo at left shows Montgomery at about this time.

In 1906 Montgomery patented his *Santa Clara* design, emphasizing the parabolic airfoil, and tested wing sections on a whirling electric arm. In 1909, assisted by Cornelius Reinhardt (later a mechanic for *The Evergreen*), Montgomery built an electric typewriter and patented an alternating current rectifier. After marrying Regina Clary on June 30, 1910, Montgomery set up a camp in the *Evergreen* area of San Jose. There Montgomery tested his *Evergreen* glider in 55 flights witnessed by his wife, *Evergreen* mechanic Reinhardt, and *Evergreen* mechanic and assistant pilot Joseph Vierra.

After Montgomery made a series of wheel-yoke control alterations on *The Evergreen*, the craft pulled up sharply off its launch rails, stalled, and sideslipped, throwing Montgomery's head against an extending stove-bolt that fastened the fuselage. The bolt punctured his head and brain behind his right ear. After a few hours he died.



90-foot wing monument at Otay Mesa, San Diego County, commemorating the 1883 glider flights (dedicated 1950)



Montgomery Field Airport, San Diego (1950)



Granite obelisk on the campus of Santa Clara University at the spot where the Santa Clara was raised by balloon (1946)



Historical landmark plaque commemorating the Evergreen flights, in the Evergreen district of San Jose (1963), now California Historical Landmark No. 813

The History and Heritage Recognition Program of ASME

The ASME History and Heritage Recognition Program began in September 1971. To implement and achieve its goals, ASME formed the History and Heritage Committee, initially composed of mechanical engineers, historians of technology, and the curator emeritus of mechanical and civil engineering at the Smithsonian Institution. The committee provides a public service by examining, noting, recording, and acknowledging mechanical engineering achievements of particular significance. The History and Heritage Committee is part of the ASME Council on Public Affairs and Board on Public Information.

The Montgomery 1883 glider is the 46th International Historic Mechanical Engineering Landmark to be designated by ASME. Since the ASME History and Heritage Recognition Program began, 173 Historic Mechanical Engineering Landmarks, six Mechanical Engineering Heritage Sites, and six Mechanical Engineering Heritage Collections have been designated. Each reflects its influence on society, either in its immediate locale, nationwide, or throughout the world.

The ASME History and Heritage Recognition Program illuminates our technological heritage and encourages the preservation of the physical remains of historically important works. It provides an annotated roster for engineers, students, educators, historians, and travelers, and helps establish persistent reminders of where we have been and where we are going along the divergent paths of discovery.

For further information, please write to Public Information, the American Society of Mechanical Engineers, 345 E. 47 St., New York, NY, 10017-2392; call 212-705-7740; or fax 212-705-7143.

The American Society of Mechanical Engineers

Daniel T. Koenig, President

Sundaram Krishnamurthy, P.E., Vice President, Region IX

Louis A. Povinelli, Chair, Aerospace Division

George I. Skoda, P.E., History and Heritage Chair, Region IX

John R. Parker, Senior Vice President, Public Affairs

Erwin Fried, P.E., Vice President, Public Information

David L. Belden, P.E., Executive Director

Lynden Davis, Director, Western Regional Office

The ASME History and Heritage Committee

J. Lawrence Lee, P.E., Chair

Robert M. Vogel, Secretary

William DeFotis

Burton Dicht

Robert B. Gaither

R. Michael Hunt, P.E.

William J. Warren, P.E.

Richard S. Hartenberg, P.E., Emeritus

Joseph Van Overseen, P.E., Emeritus

Euan F. C. Somerscales, Emeritus

Diane Kaylor, Staff Liaison

The ASME Santa Clara Valley Section

Ken Youssefi, Ph.D., Chair 1995-96

Lilia A. Sanchez, Ph.D., Chair 1994-95

Julie A. Pollitt, Vice Chair

Sargon Ishya, Secretary

Joseph A. Cassisi, Treasurer

William J. Adams Jr., P.E., Chair, History and Heritage

The ASME Aerospace Division

Louis A. Povinelli, Chair

Barney F. Gorin, Vice Chair

Terrence A. Weisshart, Secretary

Peretz P. Friedmann, Treasurer

Hiller Aircraft Museum

Stanley Hiller Jr.

Henry J. Schumacher, Executive Director

Gordon A. Werne, Curator

Santa Clara University

Paul L. Locatelli, S.J., D.B.A., President

Terry E. Shoup, Ph.D., Dean, School of Engineering

Mark D. Ardema, Ph.D., Chair, Department of Mechanical Engineering

Julia O'Keefe, Archivist

American Aviation Historical Society

Northern California Chapter

Lindy E. Hollingsworth, President

Howard "Ace" Campbell, Secretary and Editor

Owner of the Montgomery 1883 Glider Landmark Replica

Howard "Ace" and Judy Campbell, Builders

References

- Montgomery, John J. "Discussions on the Various Papers on Soaring Flight." *Proceedings of the International Conference on Aerial Navigation*, Chicago, Aug. 1-4, 1893, 246-49.
- Chanute, Octave. *Progress in Flying Machines*. New York: American Engineering and Railroad Journal Press, 1894.
- Montgomery. "The Mechanics Involved in a Bird's Wing in Soaring and Their Relation to Aeronautics," Nov. 9, 1897, address to the Southern California Academy of Sciences, Los Angeles.
- Montgomery. "The Aeroplane," Santa Clara College, *The Redwood* 4, 437-68.
- Montgomery. "Aeroplane" Patent No. 831,173, application filed April 26, 1905, issued Sept. 18, 1906.
- Montgomery. "Principles Involved in the Formation of Winged Surfaces and the Phenomenon of Soaring," presented at the International Aeronautics Congress, New York, Oct. 28-29, 1907.
- Lougheed (Lockheed), Victor, *Vehicles of the Air*. 3rd ed. Reilly and Britton Co., 1909.
- Connick, George P. *John J. Montgomery: His Life in Brief*, The California Pioneers of Santa Clara Valley, June 6, 1959.
- Spearman, Arthur Dunning, S.J. *John J. Montgomery, Father of Basic Flying*. Santa Clara University 1967 and 2nd ed. 1977.

Acknowledgments

Brochure Preparation

Text: Mark D. Ardema and Joseph Mach, SCU School of Engineering; William J. Adams Jr.

Design and Editorial: SCU University Communications Department, Joanne Sanfilippo, Director

Sponsors of the Brochure Printing

BOEING | The Boeing Company
Seattle, Washington, USA

MCDONNELL DOUGLAS  Douglas Aircraft Company
Long Beach, California, USA

Hosts of Landmark Designation Luncheon

ASME Santa Clara Valley Section

ASME Aerospace Division

Santa Clara University

Photographs and film (video) "Gallant Journey"

Courtesy of SCU Archives

