Aviation & Aerospace
From the Wright Brothers to the Moon

America's Astronaut Factory

Ohio has had an important role in populating the United States astronaut corps -- the birthplace of two dozen astronauts, more than any other state.

The National Aeronautics and Space Administration (NASA) selected the first group of astronauts in 1959. From 500 candidates having the required military jet aircraft flight experience and engineering training as well as height below 5 feet 11 inches, 7 military men became the Nation's first astronauts. The second and third groups chosen included civilians who had extensive flying experience. By 1964, requirements had changed, and emphasis was placed on academic qualifications; in 1965, six scientist astronauts were selected from a group of 400 applicants who had a Doctorate or equivalent experience in the natural sciences, medicine, or engineering. NASA is continually involved in promoting educational programs that encourage all students to study science, math, and engineering, and to consider careers in aerospace.

Many Astronauts graduated from Ohio universities including: Baldwin-Wallace College, Case Western Reserve University, Kent State University, Marietta College, The Ohio State University, Muskingum College, Wright State University, and the Air Force Institute of Technology. Astronauts born in Ohio include:

- Neil Armstrong
- Charles Bassett
- Kenneth Cameron
- Donn Eisele
- Michael Foreman
- Michael Gernhardt
- John Glenn
- Michael Good
- Gregory Harbaugh
- Karl Henize
- Terence Henricks
- James Lovell
- G. David Low
- Robert Overmyer
- Judith Resnik
- Ronald Sega
- Donald Thomas
- Carl Walz
- Mary Weber
- Sunita Williams

ARMSTRONG, Neil A., Civilian
Born August 5, 1930, in Wapakoneta, Ohio.
Bachelor of Science in aeronautical engineering from Purdue University;
Master of Science in aerospace engineering from the University of Southern California.
Flew on Gemini 8 and Apollo 11.
Cumulative hours of space flight are more than 205.
Cumulative EVA time is more than 2 hours.

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BASSETT, Charles A., II, Captain, U.S. Air Force
Born December 30, 1931, in Dayton, Ohio.
Bachelor of Science in electrical engineering from the Texas Technological College.
Died February 28, 1966, in St. Louis, Missouri, in the crash of a T-38 jet.

CAMERON, Kenneth D., Colonel, U.S. Marine Corps (Retired)
Born November 29, 1949, in Cleveland, Ohio.
Bachelor and Master of Science in aeronautics and astronautics from the Massachusetts Institute of Technology.
Flew on STS-37, STS-56 and STS-74.
Cumulative hours of space flight are more than 562.

EISELE, Donn F., Colonel, U.S. Air Force (Retired)
Born June 23, 1930, in Columbus, Ohio.
Bachelor of Science in astronautics from the U.S. Naval Academy; Master of Science in astronautics from the U.S. Air Force Institute of Technology.
Flew on Apollo 7.
Cumulative hours of space flight are more than 260.
Died December 2, 1987, in Tokyo, Japan, of a heart attack.

FOREMAN, Michael J., Captain, U.S. Navy Mission Specialist
Born March 29, 1957, in Columbus, Ohio. Hometown, Wadsworth, Ohio.
Bachelor of Science in aerospace engineering from the U.S. Naval Academy; Master of Science in aeronautical engineering from the Naval Postgraduate School.

GERNHARDT, Michael L., Civilian
Mission Specialist.
Born May 4, 1956, in Mansfield, Ohio.
Bachelor of Science in physics from Vanderbilt University; Master of Science and Doctor of Philosophy in bioengineering from the University of Pennsylvania.
Flew on STS-69, STS-83, STS-94 and STS-104.
Cumulative hours of space flight are more than 1,037.
Cumulative EVA time is more than 22 hours.

GLENN, John H., Jr., Colonel, U.S. Marine Corps (Retired)
Born July 18, 1921, in Cambridge, Ohio.
Bachelor of Science in engineering from Muskingum College.
Flew on Mercury 6, and STS-95.
Cumulative hours of space flight are more than 217.

GOOD, Michael T., Lieutenant Colonel, U.S. Air Force
Mission Specialist.
Born October 13, 1962, in Parma, Ohio.
Bachelor and Master of Science in aerospace engineering from the University of Notre Dame.

HARBAUGH, Gregory J., Civilian
Born April 15, 1956, in Cleveland, Ohio. Hometown, Willoughby, Ohio.
Bachelor of Science in aeronautical and astronautical engineering from Purdue University; Master of Science in physical science from the University of Houston-Clear Lake.
Flew on STS-39, STS-54, STS-71 and STS-82.
Cumulative hours of space flight are more than 817.
Cumulative EVA time is more than 18 hours.

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HENIZE, Karl G., Civilian
Born October 17, 1926, in Cincinnati, Ohio.
Bachelor of Arts in mathematics from the University of Virginia; Master of Arts in astronomy from the University of Virginia; Doctor of Philosophy in astronomy from the University of
Michigan.
Flew on STS 51-F.
Cumulative hours of space flight are more than 190.
Died October 5, 1993, of respiratory and heart failure during a climb of Mount Everest.

HENRICKS, Terence T. "Tom", Colonel, U.S. Air Force (Retired)
Born July 5, 1952, in Bryan, Ohio. Hometown, Woodville, Ohio.
Bachelor of Science in civil engineering from the U.S. Air Force Academy; Master of Arts in public administration from Golden Gate University.
Flew on STS-44, STS-55, STS-70 and STS-78.
Cumulative hours of space flight are more than 1,026.

LOVELL, James A., Jr., Captain, U.S. Navy (Retired)
Born March 25, 1928, in Cleveland, Ohio.
Bachelor of Science from the U.S. Naval Academy; Advanced Management Program, Harvard Business School.
Flew on Gemini 7, Gemini 12, Apollo 8, and Apollo 13.
Cumulative hours of space flight are more than 715.

LOW, G. David, Civilian
Born February 19, 1956, in Cleveland, Ohio.
Bachelor of Science in physics-engineering from Washington and Lee University, and in mechanical engineering from Cornell University; Master of Science in aeronautics and astronautics from Stanford University.
Flew on STS-32, STS-43 and STS-57.
Cumulative hours of space flight are more than 714.
Cumulative EVA time is more than 5 hours.

OVERMYER, Robert F., Colonel, U.S. Marine Corps (Retired)
Born July 14, 1936, in Lorain, Ohio.
Bachelor of Science in physics from Baldwin Wallace College; Master of Science in aeronautics from the U.S. Naval Postgraduate School.
Flew on STS-5 and STS 51-B.
Cumulative hours of space flight are more than 290.
Died March 22, 1996, in the crash of a light aircraft he was testing.

RESNIK, Judith A., Civilian
Born April 5, 1949, in Akron, Ohio.
Bachelor of Science in electrical engineering from Carnegie-Mellon University; Doctor of Philosophy in electrical engineering from the University of Maryland.
Flew on STS 41-D.
Cumulative hours of space flight are more than 144.
Died January 28, 1986, in the STS 51-L Challenger accident.

SEGA, Ronald M., Civilian Colonel, U.S. Air Force Reserve
Born December 4, 1952, in Cleveland, Ohio. Hometowns, Northfield, Ohio, and Colorado Springs, Colorado.
Bachelor of Science in physics and math from the U.S. Air Force Academy; Master of Science in physics from Ohio State University; Doctor of Philosophy in electrical engineering from the University of Colorado.
Flew on STS-60 and STS-76.
Cumulative hours of space flight are more than 420.

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THOMAS, Donald A., Civilian
Mission Specialist.
Born May 6, 1955, in Cleveland, Ohio.
Bachelor of Science in physics from Case Western Reserve University; Master of Science and Doctor of Philosophy in materials science from Cornell University.
Flew on STS-65, STS-70, STS-83 and STS-94.
Cumulative hours of space flight are more than 1,040.

WALZ, Carl E., Colonel, U.S. Air Force
Born September 6, 1955, in Cleveland, Ohio.
Bachelor of Science in physics from Kent State University; Master of Science in solid state physics from John Carroll University.
Flew on STS-51, STS-65, STS-79 and STS-108(up)/Exp 4/STS-111(down).
Cumulative hours of space flight are more than 5,532.
Cumulative EVA time is more than 18 hours.

WEBER, Mary E., Civilian
Born August 24, 1962, in Cleveland, Ohio. Hometown, Bedford Heights, Ohio.
Bachelor of Science in chemical engineering from Purdue University; Doctor of Philosophy in physical chemistry from the University of California at Berkeley.
Flew on STS-70 and STS-101.
Cumulative hours of space flight are more than 450.

WILLIAMS, Sunita L., Lieutenant Commander, U.S. Navy
Mission Specialist.
Born September 19, 1965, in Euclid, Ohio. Hometown, Needham, Massachusetts.
Bachelor of Science in physical science from the U.S. Naval Academy; Master of Science in engineering management from the Florida Institute of Technology.

(Note: STS = Space Shuttle)

Find out more...

- NASA Astronaut Fact Book
  (http://history.nasa.gov/nautfb.pdf)

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Electricity for Deep Space Missions

John H. Birden and Kenneth C. Jordan in 1955 developed the electric power generator used on most United States deep-space missions. At the time, they worked at the Monsanto Research Laboratory in Miamisburg, Ohio. They called their invention the "Thermo-Electric Generator." Since that time, Radio isotope thermoelectric generators have gone through many design changes, but they have been incorporated in most U.S. planetary probes. In fact, in the past three decades, the U.S. has launched 25 missions involving 44 RTGs (Radioisotope Thermoelectric Generators).

As seen on the photo to the right of Saturn (Voyager 2 photo), the invention was critical to our ability to explore space, especially areas beyond Mars. Once a spacecraft reaches Mars, the sun's light is not strong enough to allow solar panels too convert the light into electricity. Without power, space exploration is not possible. The RTG generates electrical power by converting heat to power using thermoelectric couples.

Radioisotope Thermoelectric Generators can provide continuous power for over twenty years -- very important for long term space missions. The Apollo missions to the moon; the Viking missions to Mars; and the Pioneer, Voyager, Ulysses, Galileo, and Cassini missions to the outer Solar System have all incorporated RTGs. At the moment, NASA and the U.S. Department of Energy are working on a new RTG that will operate on planetary bodies as well as in the vacuum of space.

How Radioisotope Thermoelectric Generators Work

Radioisotope thermoelectric generators (RTGs), are used when spacecraft must operate at significant distances from the sun (usually beyond the orbit of Mars), or where the availability of sunlight and therefore the use of solar arrays is otherwise infeasible.

RTGs, as currently designed for space missions, contain several kilograms of an isotopic mixture of the radioactive element Plutonium (Pu) in the form of an oxide, pressed into a ceramic pellet. The pellets are arranged in a converter housing and function as a heat source to generate the electricity provided by the RTG.

Jim Irwin (Apollo 15). The large black object at the bottom is the Radioisotope Thermoelectric Generator (RTG).

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The radioactive decay of the plutonium produces heat, some of which is converted into electricity by an array of thermocouples made of silicon germanium junctions. Waste heat is radiated into space from an array of metal fins. Plutonium -- like all radioactive materials and many non-radioactive materials -- can be a health hazard under certain circumstances and in sufficient quantity. RTGs are therefore designed with the goal of surviving a crash without releasing any plutonium.

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Giant Hangar

The Goodyear Zeppelin Airdock was completed in Akron in 1929, and at the time it was built was the largest building in the world without interior supports. The original designs for the structure were developed by the Wilbur Watson Engineering Company of Cleveland, Ohio. The project cost $2.2 million to complete and provided a huge structure in which "lighter than air" ships -- later known as dirigibles -- could be constructed. Among the first large airship to be constructed here were the Akron (1931) and the Macon4 (1934).

The building itself was unique in shape, and was described as "half a silkworm's cocoon, cut in half the long way." The Goodyear Airdock is 1,175 feet long, 325 feet wide, and 211 feet high. At each end of the building are huge doors that weigh about 600 tons. The doors roll on forty wheels on specially designed curved railroad-type tracks.

The Airdock is such a huge structure that temperature changes within could be very different from that on the outside. To accommodate these fluctuations which could potentially cause structural damage, windows were installed, and the entire structure is mounted on rollers to compensate for expansion or contraction resulting from temperature changes.

Dirigibles were last built in the Airdock in the 1950s. In 1987, Loral Corporation purchased Goodyear Aerospace Corporation and the Goodyear Airdock. It was then acquired by the Lockheed Martin Corporation in 1996. The Goodyear Airdock is located at 1210 Massillion Road in Akron, Ohio. While not open to the public, it can be seen by those traveling on U.S. Rt. 224 east of downtown Akron.

Did you know?

The maiden flight of the American-built rigid airship, the U.S.S. Shenandoah, was on September 4, 1923. On September 3, 1925, she was lost in a storm near Caldwell in southeastern Ohio. Fourteen crew members did including the captain, Lieutenant Commander Zachary Lansdowne. However, one of the ship's officers, Charles Rosendahl, survived by ballooning down in the detached bow section along with a number of other survivors until the bow came to rest on the ground.

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Find out more...

- Goodyear Blimp
  (www.goodyearblimp.com/)
- Goodyear Blimp History
  (www.goodyearblimp.com/history/index.html)
- Building a Blimp
  (www.goodyearblimp.com/archive/ph_building.html)
- A Brief History of the Wingfoot Lake Airship Base
  (www.goodyearblimp.com/history/wingfoot.html)
- National Park Service Bulletin
  (www.cr.nps.gov/nr/publications/bulletins/aviation/nrb_aviation_IV.htm)

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First Successful Helicopter

George de Bothezat, a Russian-born engineer who emigrated to the U.S., developed the first successful American experimental helicopter in Dayton in 1922. It was a four-rotor machine that was powered by a 180 horsepower rotary engine. The U.S. Army sponsored the project.

De Bothezat flew his helicopter for the first time at McCook Field near Dayton, Ohio, in October, 1922. While the flight lasted only about 90 seconds, it proved the principal of helicopter flight. During a series of more than 100 flights during the next two years, De Bothezat and his team fine-tuned controls and operating techniques. One of the flights had three "passengers" hanging onto the airframe. While the Army was encouraged by results, they ultimately abandoned the project which cost about $200,000, reportedly due to the complexity of the machine and perhaps personal differences with de Bothezat, who some claimed was difficult to work with. The original contract with de Bothezat called for a 300 ft hover, but the highest the helicopter reached was about 15 feet. After the project was cancelled, de Bothezat launched a company that designed and manufactured industrial fans. In 1937, however, he returned to helicopter design and founded the Helicopter Corporation of America.

The helicopter launched a new era in civilian and military aviation. Today it is the mainstay of news stations, weather reporters, emergency rescue teams, and others. In the military, helicopters with their ability to both fly and hover became gunships, troop transports, and evacuation ambulances for the injured.

Find out more...

- U.S. Centennial of Flight's "Helicopter Development in the Early Twentieth Century" (http://www.1903to2003.gov/essay/Rotary/early_20th_century/HE2.htm)
- A History of Helicopter Flight (http://www.enae.umd.edu/AGRC/Aero/history.html)
- Evolution of Helicopter Flight (http://www.flight100.org/history/helicopter.html)
- Helicopter History (http://www.helis.com/pioneers/)

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The Modern Parachute

Floyd Smith and Leslie L. Irvin, working with a research team at what then was McCook Field in Dayton, developed the dominant parachute of the twentieth century. The device received a patent on May 18, 1920 and became the basis for parachutes used throughout the rest of the Century. The Ohioans' invention not only saved the lives of thousands of aviators forced to abandon doomed aircraft; it changed military history. The Smith-Irvin designed parachute led to formation of paratrooper corps, elite troops who typically have launched the first assaults in warfare.

Like most technological achievements, the history of parachutes is complex. We know that parachutes existed in the human imagination for centuries before the team began work at McCook, now Wright Field, at the U.S. Air Force's Wright-Patterson Air Force Base. Sebastien Lenormand, of France, usually gets credit for inventing the first practical parachute in 1783.

The United States military launched its research and development program after Germany equipped its World War I pilots with parachutes. Existing parachutes relied on a cord attached to the aircraft. When the aviator jumped, the cord coiled out until the slack was gone. Then the cord yanked out the folded parachute, which billowed open. Everyone thought the attached cord was essential. Humans, they felt, could not survive a free fall through the air. If aviators did survive, they would be in no condition to deploy manually the parachute themselves.

The attached-cord parachute, however, created problems. It deployed relatively close to the aircraft. That was dangerous when the airplane was in flames or exploded right after bailout. Aviators had little chance to get a safe distance away from the aircraft.

Packing it in

Smith and Irvin realized that the existing "static-line actuated" parachutes, attached to the interior frame of the aircraft, were

Fun Factoids

Bailing Out In History

1000 AD -- Chinese send condemned prisoners over cliffs with like-like device.

1495 - Leonardo Da Vinci sketched designs for a parachute.

1783 -- Sebastien Lenormand invented the modern parachute.

1793 -- Jean Pierre Blanchard first used a parachute in an emergency, escaping from an exploded hot air balloon.

1837 -- Robert Cocking became the first person to die from a parachute accident.

1887 -- Thomas Baldwin safely parachuted to the ground from a balloon 5,000 feet above San Francisco's Golden Gate Park.

1919 – Col. Billy Mitchell suggested using parachutes for a new corps of assault troops who would be dropping from airplanes.

1928 -- Six of Gen. Mitchell's troops jump from a bomber, and set up a machine gun, demonstrating that parachute forces are practical.

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unsuitable. They developed a revolutionary new 'chute with canopy and lines packed into a container worn on a body harness.

Aviators activated it manually, with a ripcord yanked while falling freely through the air with no attachment to the aircraft. It had a 28-foot diameter silk canopy with silk suspension lines, folded into a backpack container. A yank on the ripcord opened flaps on the backpack, and deployed a small pilot-chute and then the main parachute.

On April 28, 1919, a member of the design team named Leslie L. Irvin, wearing a prototype of called Model A, jumped from a USD-9 airplane piloted by Smith. Irwin became the first person to make a free-fall parachute jump from an aircraft with the device that would be the 'chute of the future.

Smith received U. S. Patent No.1,340,423 on the parachute, which he manufactured and sold at the Floyd Smith Aerial Equipment Co. in San Diego, California. Brigadier General William ("Billy") Mitchell first conceived the idea of parachuting troops into combat during World War I. Eventually, under the leadership of Major William Lee at Fort Benning, Georgia, members of the Parachute Test Platoon pioneered methods of combat jumping in 1940.

Modern parachutes are best characterized as parawings and parafoils, some with separate, controllable panels.

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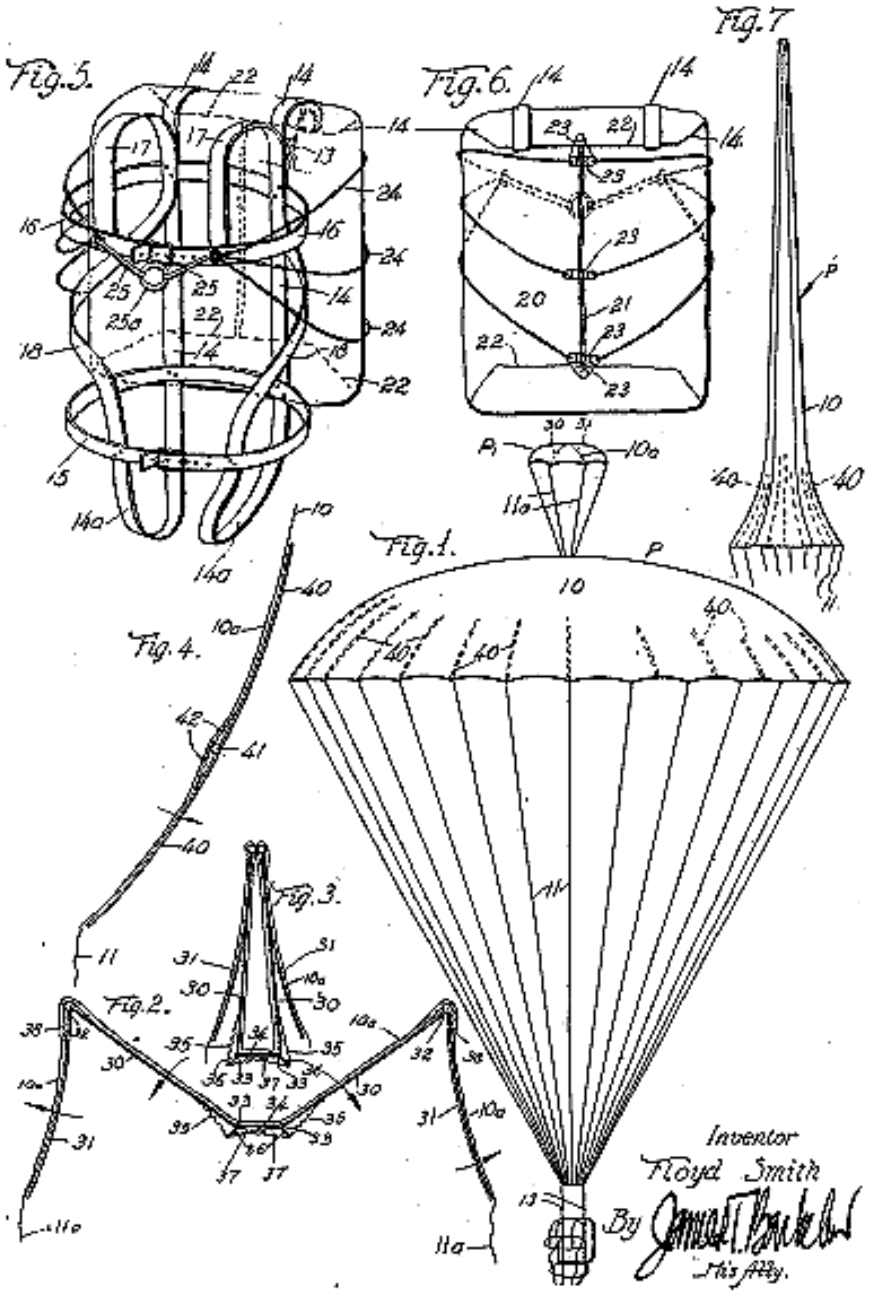
F. SMITH.

PARACHUTE.

APPLICATION FILED JULY 27, 1910.

1,340,423. Patented May 18, 1920.



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Amazing Propeller Advances

Frank W. Caldwell (1889-1974), born in Tennessee, was an Ohio engineer who made landmark advances in the design of aircraft propellers in the 1920s and 1930s. He pioneered a new propeller design that used detachable blades. Caldwell's essential breakthrough was perfecting the use of a hydraulic rather than a mechanical system to change the angle of the propeller blade. The blade allowed for pitch adjustments -- a feature that made Charles Lindbergh's 1927 solo transatlantic flight possible in 1927.

A propeller is an "air screw" that generates forward thrust, or in the case of a reversible propeller, generates reverse thrust to slow an aircraft rapidly for landing on short runways. The greater the pitch -- angle of the blades -- the more pulling power at a specific spinning speed. Take-offs and landings require coarse pitch; whereas, steady speed for the long haul requires fine pitch, in part to save fuel. The first propellers, carved from wood, were fixed pitch, thus a compromise between maximum thrust and fuel efficiency. Initially variable-pitch propellers required pilots to have great physical strength to move the purely mechanical controls and overcome the so-called centrifugal -- outward (Latin for "center fleeing") -- force of a rapidly spinning propeller.

Later, in 1929, while working at the Hamilton Standard Propeller Corporation, Caldwell developed a hydraulic, two-position propeller that improved takeoff and landing efficiency. In 1933, the Collier Trophy -- awarded in recognition of significant achievements in the advancement of aviation -- was awarded to Hamilton Standard, with particular credit to Frank Caldwell, Chief Engineer, for the development and demonstration of a controllable pitch propeller.

Although work in Great Britain and Germany on the concept of a variable pitch propeller preceded Caldwell's efforts, he perfected a hydraulic rather than mechanical means to change the blade's angle. This new propeller design was incorporated into most planes used in World War II. Using Caldwell's design, Hamilton Standard produced 500,000 propellers for World War II aircraft.

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Variable pitch propellers saved many lives during WW II. By minimizing or maximizing the pitch, not only did Caldwell-designed propellers improve aircraft take-offs and landings on short fields, but also most importantly they enabled pilots to "feather" the blades to reduce drag from a disabled engine on a two or four engine aircraft, thus saving valuable fuel and helping to control the craft.

Caldwell also developed a "propeller whirl test" to test his designs for efficiency. The test process called for mounting a propeller to a stand with instruments that measured thrust, endurance, performance, and speed. He later designed whirl-testing facilities for the U.S. government at McCook Field and Wright Field, in Dayton, OH. Caldwell's revolutionary propeller designs brought U.S. flight to a new era of efficiency and safety.

Did you know?

- In 1914, Orville Wright moved to Oakwood, Ohio and encouraged a neighbor's son to enter the propeller business. Robert Hartzell began constructing propellers as part of his father's wood products business. His company, Hartzell Propeller, Inc. responded to the need for propeller manufacture in World War I, and is still a thriving Ohio business today. Hartzell now has four facilities in the Piqua, Ohio area.

Key Facts

- Caldwell earned a mechanical engineering degree from Massachusetts Institute of Technology (MIT) in 1912.
- Many aircraft of the Allied Forces in WWII used Caldwell propellers. Caldwell was responsible for the research, design, and testing of all aircraft propellers used by the U.S. army and navy during WWII.
- In 1990 the American Society of Mechanical Engineers named the Caldwell-designed Hamilton Standard Hydromatic Propeller an International Historic Mechanical Engineering Landmark.

Find out more...

- Hamilton Standard Company History (http://www.hamiltonsundstrandcorp.com/details_printable/1,4291,CLI1_DIV22_ETI3212_LID,00.html)
- Hartzell Propeller Company History (http://www.hartzellprop.com/history/index_history.htm)
- How Stuff Works - The Propeller (http://travel.howstuffworks.com/airplane18.htm)
- The Collier Trophy (http://www.aerofiles.com/collier-trophy.html)
- Patent Link for one of Caldwell's designs: Variable-pitch or Reversible Propeller Hydraulic Propeller Pat. No. 1,893,612; Filed: May 25, 1929; Issued: January 10, 1933 (http://patimg1.uspto.gov/.piw?Docid=01893612&idkey=NONE)

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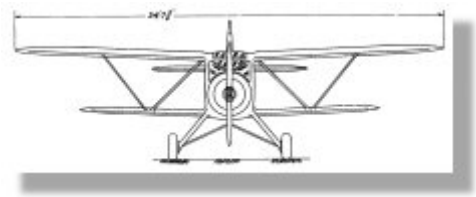
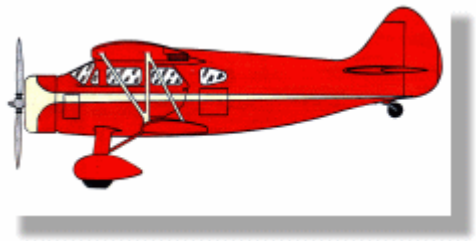
WACO Barnstorms the World

The Weaver Aircraft Company (WACO) of Troy, OH, produced many of the leading biplanes and gliders for the world's military and civilian markets. Between 1919 and 1946, the company manufactured a variety of cabin and open-cockpit biplanes. They also developed several combat gliders that were used in World War II. WACO designed and built primary trainers and both cargo and troop carrying gliders.



WACO aircraft were renowned for their excellent design and outstanding performance. IWACO led the way and was recognized as the leading American manufacturer of civilian aircraft in the late 1920s and early 1930s. The company itself changed names and restructured several times during this period, but the WACO aircraft design remained in production into the 1930's.



WACO also pioneered the "executive plane" market, creating comfortable, personal transportation for wealthy, time-conscious people. Today's Learjets, Gulfstreams, and King Airs were inspired by the early WACO Model 10 and WACO Taperwing.

Did you Know?

The WACO troop-carrying gliders (for example the CG-4 "Hadrian") had a great impact in World War II. Just under 14,000 were built between 1942 and 1947, and they participated in the Allied invasions of Sicily (1943), Normandy, Southern France, and Holland (all 1944), as well as the crossing of the Rhine in 1945. Glider-borne infantry went into battle like paratroopers (often behind enemy lines), but were far less well-known. They were initially denied "hazardous duty pay" on the dubious grounds that crash-landing behind enemy lines in a wood-and-canvas airplane with no engines wasn't unduly "hazardous."

Find out more...

- WACO Historical Society (www.wacoairmuseum.org/society/society.htm)

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Model Modern Wind Tunnel

The Wright Brothers pioneered wind tunnel research in Ohio. From 1900-1902 they tested various unpowered aircraft to develop their knowledge of how flight control systems work. A wind tunnel at Wright Field in Dayton, completed in 1921, was the prototype for other modern aircraft testing facilities around the world. To simulate flight conditions, Wilbur and Orville tested small model wings in a wind tunnel they had built. The wind tunnel was a box with a fan at one end that blew a steady stream of air over model wings mounted on a special "balance" inside the tunnel. Using this device, the brothers were able to gather information that could be used to design the wings of the gliders and powered aircraft that would carry them into the air. The wind tunnel provided them with information on the most satisfactory wing shape. It also enabled them to calculate the size of wing that would be required to lift them into the air, the performance of their propellers, and the amount of power that their engine would have to produce.

How Wind Tunnels Work

Sometimes scientists create a model to help them explain how or why something works the way it does. In aeronautics, researchers and engineers use models to design and modify airplanes. Aeronautical researchers can make a scale model and mount it in a wind tunnel. A wind tunnel is a tube or tunnel through which air is blown. So, instead of an airplane flying through the air, a scale model of the airplane is mounted in a wind tunnel and air is blown around it.

Some wind tunnels are very large and can hold models that are the size of the real airplane. Some wind tunnels are very small and can only hold very tiny scale models of the airplane, or maybe a scale model of a part of the airplane. Some very small wind tunnels can blow air only at very high speeds, which can exceed 3,000 miles per hour (mph). Some of the largest tunnels blow air at less than 150 mph. It may sound slow, but many airplanes take off and land at that speed. Big, slow wind tunnels thus are very useful. Over the years, NASA's Ames Research Center in California has operated more than 20 wind tunnels of varying sizes and purposes.

Technology has come a long way since the Wright brothers' early methods, but NASA engineers still use models and wind tunnels to improve the flight control of sophisticated aircraft. The world's first refrigerated icing wind tunnel went into operation near Cleveland in 1944, and remains the world's largest. The NASA Glenn Icing Research Tunnel (IRT) was built at the end of

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World War II, and was instrumental in developing and testing ice protection systems for piston- and propeller-driven aircraft. Since that time, the IRT has been updated with a larger fan motor, improved fan blades, computerized tunnel controls, and electronic data acquisition, storage, and processing.

Find out more...

- Building 19: 5-Foot Wind Tunnel (http://www.ascho.wpafb.af.mil/BUILDINGS/bldg19.HTML)
- Lift and Drift (http://www.batterson.net/wright_wind_tunnel.htm)
- Wright Brothers Facility (MIT) (http://web.mit.edu/aeroastro/www/labs/WBWT/wbwtlong.html)
- Student's Introduction to the Wright Brothers Wind Tunnel at MIT (http://web.mit.edu/aeroastro/www/labs/WBWT/student_wt_guide.pdf)
- Virtual Tour of the NASA Glenn Icing Research Tunnel (http://www.grc.nasa.gov/WWW/K-12/IRT/)
- NASA Glenn Icing Research Program (http://icebox.grc.nasa.gov/)

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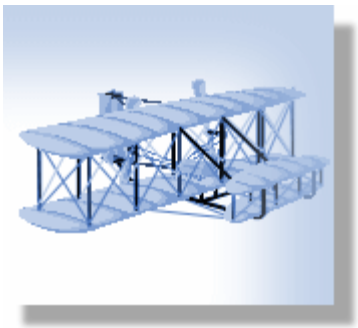
Aviation & Aerospace
From the Wright Brothers to the Moon

The Wright Brothers

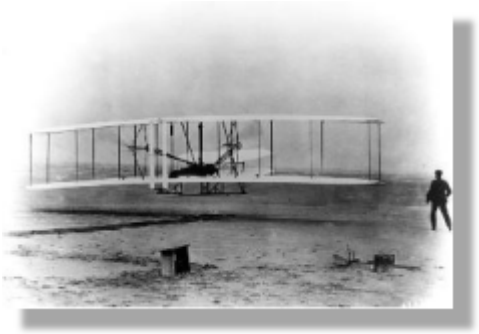


Wilbur and Orville Wright began studying aeronautics in 1896 while building bicycles in Dayton, and built their first "flying machine" in 1903, after years of extensive study, research, and planning. Their dedication allowed them to solve one of the most complex technological problems of their day.

Wilbur was born in Indiana in 1867, and Orville was a native Ohioan, born in 1871 in Dayton. Their childhood home encouraged education and reading. Orville once explained that the two brothers "were lucky enough to grow up in a home environment where there was always much encouragement to children to pursue intellectual interests; to investigate whatever aroused their curiosity." While education was a priority, Orville and Wilbur were actually the only members of their family who did not receive a high school diploma or attend college.

Love of flight began at an early age for the Wright brothers. Their father traveled frequently on business and in 1878 was said to have brought home a rubber band powered toy helicopter for the boys. Apparently the boys enjoyed taking it part, redesigning it, and rebuilding. This would have been the first powered aircraft that they built as a team.

In 1900, the team began carefully designing their first full scale aircraft, designed to carry a man. When the model was complete, they contacted the U.S. Weather Bureau for advice on a good location to build and test their aircraft. Based on feedback, they chose Kitty Hawk, on the Outer Banks of North Carolina. The wind tunnel was developed when their Kittyhawk tests showed them that available airfoil theory was incorrect, and they had to develop their own. It took several years for the brothers to rework their design for success.



On December 17, 1903, they reached their goal of controlled, powered flight. It was a chilly day with winds gusting at 22-27 miles per hour. They delayed their flight a bit due to the high winds and then decided to go for it, but with a goal of staying reasonably close to the ground. That first flight lasted only 12 seconds. They had flown a distance of 120 feet with a ground speed of 6.8 miles per hour and an airspeed of 30 miles per hour. Orville perhaps describes it best: "This flight lasted only 12 seconds, but it was nevertheless the first in the history of the world in which a machine carrying a man had raised itself by its own power into the air in

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full flight, had sailed forward without reduction of speed, and had finally landed at a point as high as that from which it started." After a few repairs, three more flights were accomplished on that first day of air travel. The fourth flight damaged the plane significantly, and it was never flown again. But the efforts of the Wright brothers helped found the U.S. aviation industry.

Did you know?

- Some believe the Wright Brother's greatest contribution to flight was the development of flight controls.
- Orville sold the U.S. Army its first airplane and trained the first well-known pilots to work in America.

Find out more...

- Wright Brothers Aeroplane Company and Museum of Pioneer Aviation (www.first-to-fly.com/)
- To Fly is Everything - a virtual museum of flight (invention.psychology.msstate.edu/air_main.shtml)
- Franklin Institute Flights of Inspiration (www.fi.edu/flights)
- NASA: The Wilbur and Orville Wright Story (www1.jsc.nasa.gov/er/seh/Wright1.html)

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