The Wrights The First Aeronautical Engineers

by Robert B. Johnston

LEGEND HAS IT that the Wright Brothers miraculously created their first airplane, or that they were a couple of bicycle repairmen who were so lucky that they made a successful flying machine on their first attempt. The exact opposite is true. The Wright Brothers were the most careful and meticulous aeronautical experimenters of their day. In addition, they had access through Octave Chanute to much of the published material on manned flight.

Octave Chanute, an experienced engineer, had published a book, *Progress in Flying Machines*, in 1894, and subsequently carried on a wide correspondence with aeronautical experimenters throughout the world. He freely lent this data to any interested investigator and was particularly impressed with the methodical work done by the Wrights.

The brothers, in their original letter to Octave Chanute in May of 1900[1], expounded the belief that successful flying would require much practice, and pointed out that even the great pioneer Lilienthal had flown less than five hours in his five years of experimenting. Hardly sufficient to ride a bicycle well, let alone to fly.

The flights of Lilienthal, Chanute, and others were made in hang gliders in which the principal method of control was achieved by shifting the pilot's weight fore and aft and from side to side. Advanced hang gliders of today are somewhat safer, as they deflect the sail or use control surfaces. It was obvious to the Wrights, especially in view of several fatal accidents that had occurred in this type of glider, that the method of control was inadequate and that very definite size and flight envelope limits were imposed by this crude control system. A practical flying machine could not use such methods.

The brothers therefore selected the "horizontal rudder," or, as it is now called, the elevator, as their means of longitudinal control. This was no innovation. It had been used by several other investigators.

Even before they wrote to Chanute, the Wrights had obtained some papers from the Smithsonian Institution and had experimented with a biplane type of kite. They used this in 1899 to investigate methods of lateral control. The available literature on bird flight expressed the belief that birds maintained their lateral balance by partially retracting one wing or the other, as required. After some observation of the flight of the local pigeons and noting the rapidity of their lateral response, the Wrights concluded that rolling motion was achieved by the air force on twisted wings. They accordingly altered one of their kites so that the horizontal surfaces could be twisted from the ground and were well pleased with the results.

It was this warping of the wings and the subsequent combination of their motion with that of the rudder that formed the basis of the unbreakable Wright patents.

Wilbur and Orville earned their living by owning and operating a bicycle shop. At the turn of the century the bicycle was a major means of transportation and most bicycle shops built much of their own merchandise. As a result, the Wrights had a complete machine shop which they put to good use in building their aircraft.

In the spring of 1900 the Wrights were kept busy producing their bicycles. They spent their spare time searching for a suitable place to test their projected glider where there was usually a steady wind and a few hills. From weather reports and from correspondence with people at various locations throughout the eastern United States and the weather bureau in Washington, they selected the dunes of Kitty Hawk, North Carolina, for their experiments.

Construction of their first glider began in August 1900. It was a canard biplane with a span of 17 feet and chord of five feet. It had no vertical tail. With operator it weighed 190 pounds. The wings had a camber ratio of about 1:22. The ribs were of bent ash and not reinforced, so they lost their curvature with time. Only the upper surface was covered. Tests of this machine were made at Kitty Hawk in September and October of 1900.

It was intended that this machine would be used as a stationary manned kite in winds above 25 miles per hour. In lighter winds it could be flown as an unmanned kite, or, if the control response as a kite appeared to be satisfactory, some gliding flights would be made. The Wrights were happy with the control response and made a total of 12 gliding flights.

As a result of their experiments the brothers reached these conclusions:

1. The horizontal rudder provided ample pitch control.
2. Satisfactory lateral control could be obtained by warping the wings.
3. Lift, and especially drag, were less than would be anticipated from Lilienthal's tables. Lilienthal had made many tests of wings in model gliders and free air measurements; these tests had been published in 1889. (The Wrights later indicated that Lilienthal's tables weren't as far off as they originally thought.)

Most of this information, including the method of obtaining lateral control, was sent to Octave Chanute in a letter dated November 16, 1900[1]. At the brothers' request, Chanute did not reveal to other experimenters the lateral control system.

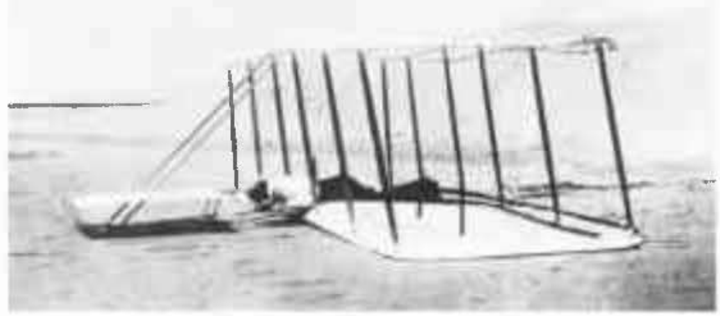
The Wrights were encouraged by the results of the experiments and immediately began to lay plans for a new glider.

They returned to Kitty Hawk with a second glider in July of 1901. This glider, like the first, was to be used as a man-carrying kite. It had a span of 22 feet, with a total area of 290 square feet; the horizontal tail area was enlarged in proportion. Empty it weighed 108 pounds. The camber was increased to 1:12, as this appeared to be more desirable from Lilienthal's tables. Again the glider had no vertical tail. The control system was the same as that of the 1900 aircraft.

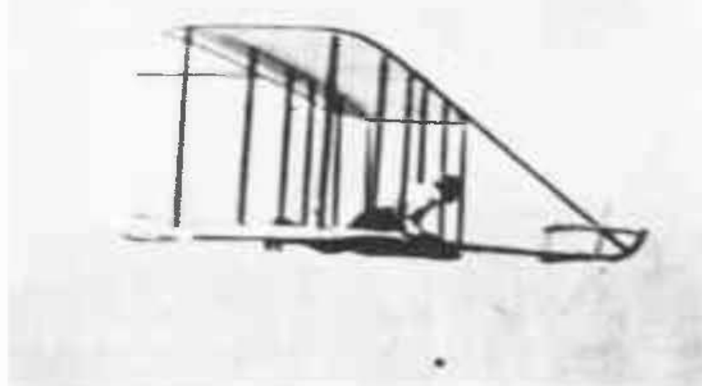
The first flights revealed a longitudinal instability which had not existed on the previous machine. After some consideration the brothers ascribed this to the increased camber. The ribs were trussed down in the center, resulting in a reverse camber in the rear section of the wing. This greatly increased the longitudinal stability, but at the expense of some efficiency.

Lilienthal had pointed out the unstable center of pressure movement that is experienced with highly cambered wings, but had apparently never experienced this effect at the camber values the Wrights were using. As we know, the center of pressure of a cambered wing at zero lift is at minus infinity. As the angle of attack is increased, the center of pressure rapidly

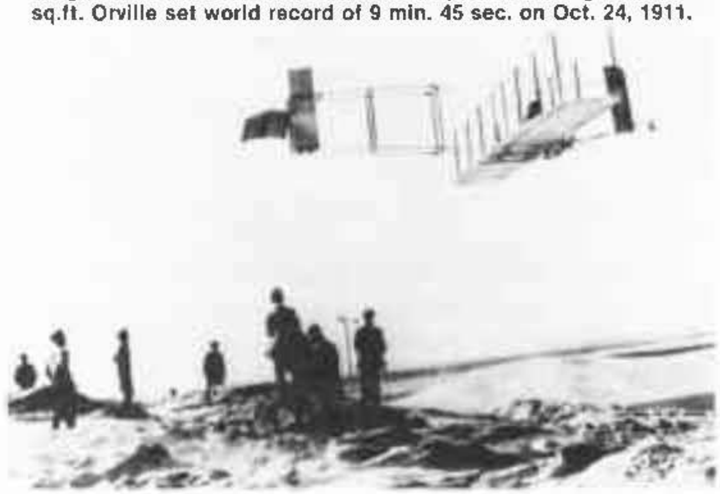
Wright Glider No. 2 (1901).



Wright Glider No. 3 (1902).

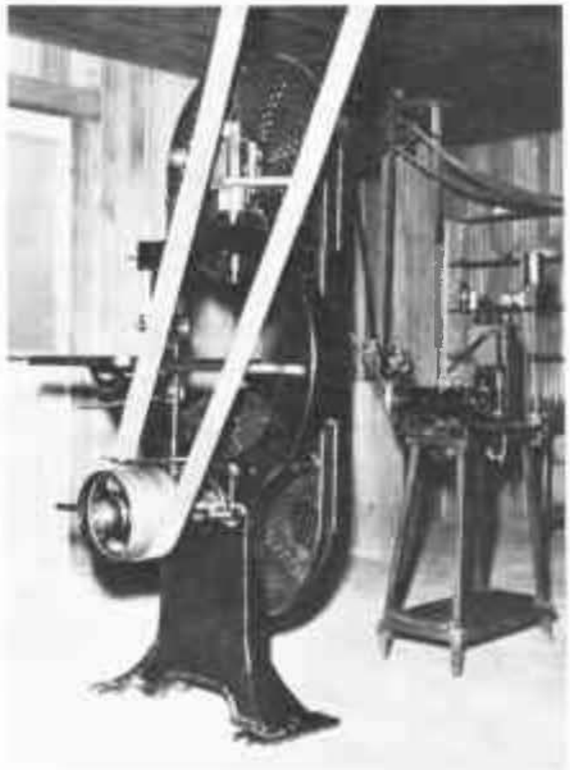


Wright 1911 Glider at Kill Devil Hills. Span 32', Wing area 300 sq.ft. Orville set world record of 9 min. 45 sec. on Oct. 24, 1911.



Results of flight on December 14, 1903. (Collection of Harry Gann)

Wright Brothers' home (L) and bicycle shop (R) at Ford Museum, Dearborn—moved intact from Dayton. (D.W. Carter Collection)



Corner of Wright Brothers' machine shop. Band saw in the foreground, model engine just to right and aft. (D.W. Carter Collection)

moves forward to about 25 to 30 percent of the chord. When the angle of attack increases beyond the stall angle, the center of pressure moves to the rear, reaching the 50 percent chord point at an angle of attack of 90 degrees. This is contrary to the center of pressure movement of a flat plate. On a flat plate the center of pressure is at the leading edge at zero lift and moves gradually rearward to the 50 percent chord point at an angle of attack of 90 degrees.

Several hundred successful gliding flights were made with the second machine, but the altered craft lacked sufficient lifting power to be flown as a man-carrying kite. The lift was much less than that predicted by the available data.

On September 18, 1901, Wilbur Wright presented a paper, "Some Aeronautical Experiments," before the Western Society of Engineers in Chicago. He was introduced by Octave Chanute. In this paper he made some comments on the inaccuracy of the Lilienthal data on wing lift and drag. Orville thought that these comments should be supported by further testing, so the brothers developed a wind tunnel from some old wooden boxes and quickly satisfied themselves that Lilienthal was in error. A second and much improved wind tunnel was then constructed. The ingenuity used in building this tunnel and its associated measuring apparatus was remarkable. Many of today's small wind tunnels could use the balance system to their advantage. The tunnel was of the closed-throat, non-return type with a rectangular cross section. A wind velocity of about 27 miles per hour was reached by driving the 24-inch-diameter, two-bladed fan at about 3000 rpm. The fan was connected to a grinding wheel head which was driven by a belt from their shop line shaft. Power to drive the line shaft was supplied by a two-horsepower gasoline engine of their own design.

It must be realized that the whole principle of relative motion upon which wind tunnel testing is based was not thoroughly understood at that time. The Wrights were often forced to defend the principle that moving the air past a body and measuring the results yields the same information as testing a body moving though the air. Also, there was no known method of accurately measuring the air speed or the dynamic pressure. In order to obtain a consistent pattern of test results it was necessary to use a comparison method.

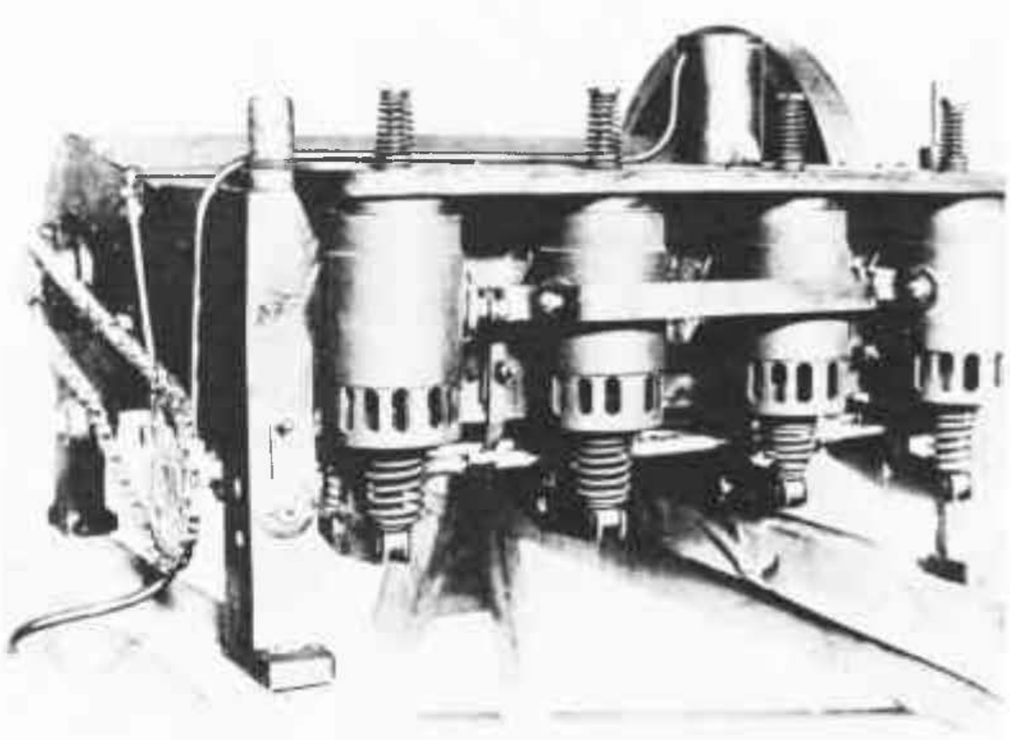
The brothers solved the problem by balancing the lift of a model wing against the drag of a flat plate normal to the wind. The wing model and the flat plate were mounted on separate horizontal cross stream bars, so linked together that the lift on the wing tended to move it across the stream. The drag on the flat plate would tend to resist this movement. When the two were in balance the ratio of wing lift to the drag of the flat plates was indicated by a pointer.

The Wrights later developed a similar system that balanced the wing lift against its drag, resulting in a direct measurement of the lift-drag ratio.

By late May of 1902 the Wrights had more reliable information at their disposal than any previous experimenters. Their wind tunnel experiments included the effects of aspect ratio, wingtip shape, and the penalties of using biplane and triplane configurations. In later years Orville Wright said that the development of this data, which they felt was comprehensive enough so that anyone using it could have developed a successful airplane, was the achievement that pleased them the most.

In late August 1902, the Wrights returned to Kitty Hawk with a third glider. This machine incorporated the lessons that had been learned from the previous year's experiments and the wind

Henry Ford (L), Orville Wright in front of Wright bicycle shop.



Wright Flyer I power plant. (D.W. Carter Collection)

tunnel tests. It had a wing area of 305 square feet and a span of 32 feet, one inch. The wing camber ratio was 1:25 with the point of maximum camber well forward. The forward elevator had an area of 15 square feet. The weight without pilot was 116.5 pounds. It was fitted with a pair of fixed vertical fins of 11⅔ square feet.

The previous glider would sometimes experience what is now called adverse yaw when an attempt was made to lift a wing with the lateral control. The fixed vertical tail was an attempt to overcome this problem. It was intended to assist the glider in flying straight ahead.

First flights showed major improvement over the efforts of the previous year. The elevator control was most satisfactory. However, on some of the flights a new problem arose. The Wrights called the maneuver "well digging," but we now call it spinning. Essentially this is what occurred: one of the wings would drop and the lateral control would be operated to lift that wing. The warping of the wing would increase the angle of attack and therefore the drag on the low wing. If sideslipping had already started, the fixed vertical tail would cause the glider to turn in the direction of the low wing; finally the inside wing would stall, causing a spin to develop. As this only happened about once in 50 flights, it puzzled the brothers greatly.

The problem was finally solved by changing to a movable vertical surface. This surface was coupled to the wing warping control in such a way that the rudder worked with the lateral controls to start the turn.

This was the basic control system which the Wrights covered in Patent No. 821393, granted May 22, 1906; and this patent was the foundation upon which they were able to win all of the suits concerning the development of the airplane.

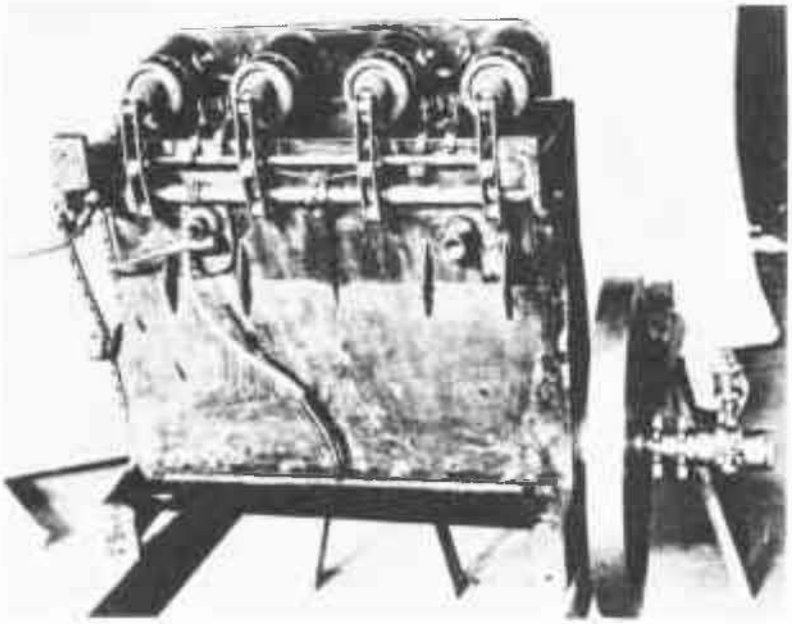
The over 1,000 flights made in the two months spent at Kitty Hawk gave the brothers the greatest confidence in their ability to add an engine and build a successful powered aircraft.

Upon their return to Dayton the brothers wrote to several of the best-known automobile manufacturers in an effort to secure a suitable engine for their airplane. None of the manufacturers was willing to supply such an engine. The Wrights were therefore forced to construct their own.

Their design efforts resulted in a four-cylinder horizontal engine built in accordance with current automobile practice. The bore was four inches, as was the stroke. The cylinders were individual cast-iron units and were fitted into a single-piece cast aluminum crankcase. A camshaft, chain-driven from the crankshaft, operated the exhaust valves and individual breaker points for cylinder firing. The intake valves were opened by natural aspiration and were spring closed. The crankshaft had five main bearings and was machined from a solid sheet of armor plate. The rear of the crankshaft had a 26-pound, 15-inch diameter flywheel, to which was fitted a double sprocket to drive the propeller chains. The connecting rods were tubular. Splash lubrication was used.

The ignition while the engine was running was supplied by a low-tension generator driven by a friction wheel against the flywheel. Four dry-cell batteries and a home-made inductance coil were in a starter box which was not carried in the airplane.

Cooling water was supplied by a long narrow radiator mounted on one of the center section struts. The fuel tank of approximately three-eighths gallon capacity was mounted near the top of another of the center section struts. Fuel was fed to the engine through a rubber hose. There were two valves in the fuel line, the first for metering adjustment and the second for shutting off



Wright Flyer I power plant. (D.W. Carter Collection)

the fuel flow. This was the only method for stopping the engine.

When the Wrights designed the engine they hoped for about eight horsepower but were pleasantly surprised when it developed a little over 12 horsepower at 1025 rpm. Its weight of 160 pounds dry, less generator, made it one of the lightest engines of its power available.

It is perhaps fortunate that the brothers were familiar with bicycles. The use of chain drives enabled them to install rather large diameter, slow-turning propellers which gave them high thrust at low flight speeds. In developing these propellers they searched the marine literature available in the Dayton public library and studied at least one paper furnished them by Chanute, but could find no information on the theory of screw propellers. They were forced to develop their own propeller theory in lieu of making large numbers of propeller tests.

Through the theoretical approach, which occupied many hours of discussion, they designed two eight-foot-diameter propellers which revolved in opposite directions. They were driven at 356 rpm and developed an efficiency of approximately 66 percent, about one-third more than the best achieved by Maxim and Langley, and never approached by any other aeronautical experimenter up to that time.

The airplane into which this motive equipment was placed was considerably larger than anything the Wrights had built before. It had a span of 40 feet, 6 inches, and a total area of about 500 square feet. The front elevators were doubled and incorporated a variable camber with positive camber for nose up and negative camber for nose down. The wings had negative dihedral. All controls were similar to those used on the previous glider. An innovation which the Wrights used for the first time was to cover the top and bottom surfaces of each wing.

Previously the brothers had launched their gliders by picking them up by the wingtips and running with them into the wind. This time the empty weight of 605 pounds prohibited this method. A 60-foot monorail track was therefore prepared. Most of the craft's weight was carried by a jettisonable dolly. A small wheel made from a bicycle wheel hub was permanently attached to the front skid. Unlike later models of the Wright airplane, no catapult was used. The airplane was held in place by a release cable until the pilot was ready to go.

In late September of 1903 the Wrights returned to Kitty Hawk with their new machine. While they completed the assembly of the powered aircraft they made many practice flights in their 1902 glider.

As would be expected, they ran into mechanical difficulties when the engine was started. The propeller shafts failed. These were remade of heavier tubing but after some testing they failed for a second time. Finally, after they had installed some solid steel shafts and overcome some vibration problems, the airplane was ready to fly on the 14th of December.

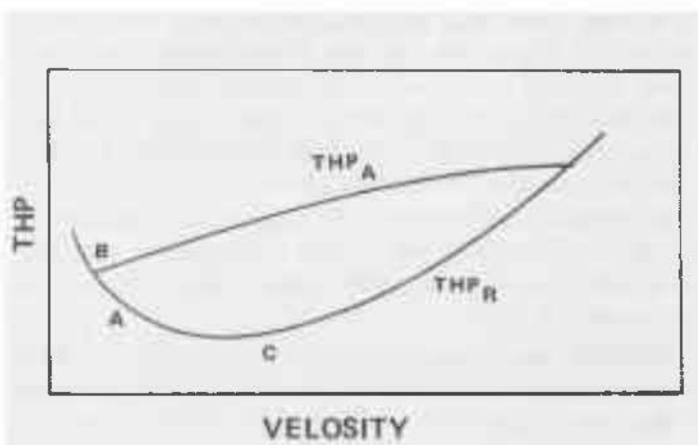
Wilbur was elected to make the first attempt by the toss of a coin, but pulled the airplane up too steeply on the takeoff and dropped back to the ground, breaking the front rudder (elevator).

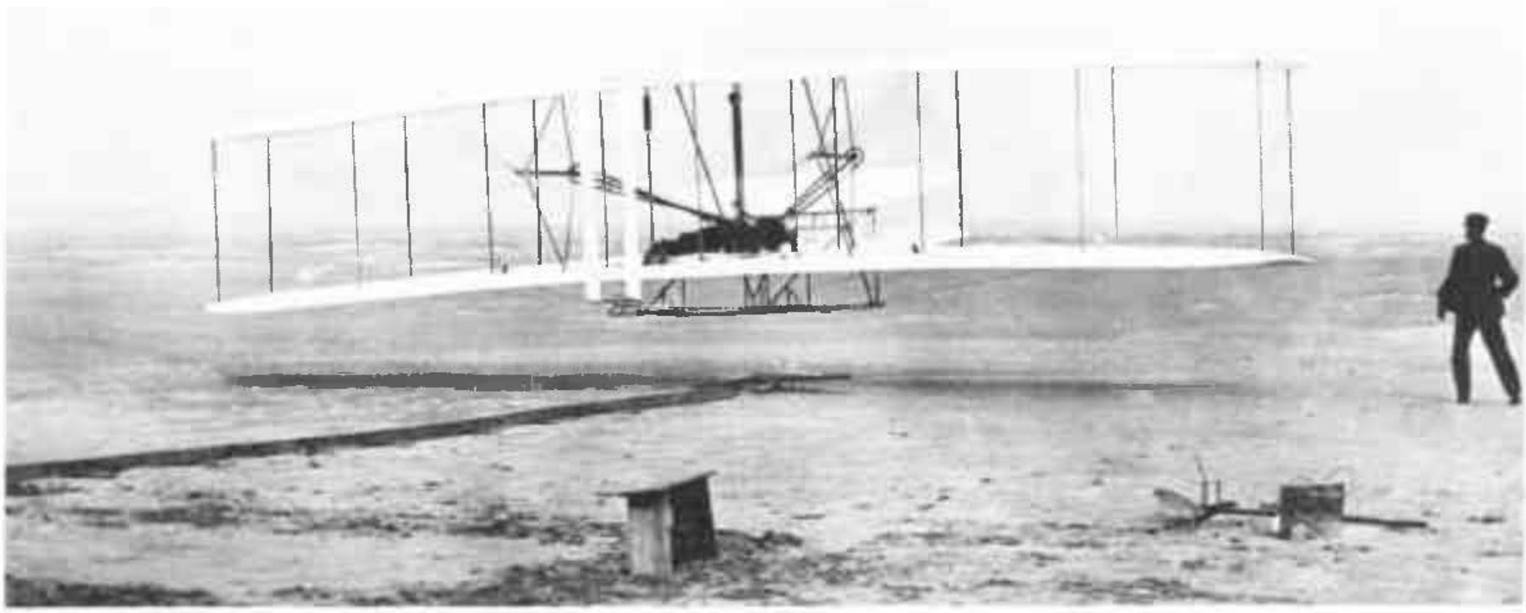
Three days later, on December 17, 1903, with a 20 to 27-mile-per-hour wind blowing, Orville made the first flight, traveling a distance of about 100 feet in approximately 12 seconds. Three other flights were made that day, with Wilbur making the best flight of 852 feet in 59 seconds. Some damage was incurred in the landing from this flight, and while repairs were being made to the damaged parts which had been removed from the machine, a gust of wind overturned the craft, damaging it severely.

This concluded the Wrights' 1903 experiments.

In retrospect it seems fortunate that the brothers were so intent on being home for Christmas that they had the confidence to fly on such a windy day.

When one reads in their diary of their subsequent flights with a new machine starting in May of 1904, one feels it is possible that the wind on December 17, 1903, prevented them from taking off on the back side of the power curve, as they apparently did several times in 1904. To illustrate: Shown is a plot of the thrust horsepower required (THP_R) versus velocity and the thrust horsepower available (THP_A). In his anxiety to take off in a short distance and to climb away from the ground, the pilot may take off at point *A* and pull the nose up to climb, but instead find himself flying at the left hand intersection of THP_R and THP_A (point *B*). He is then caught. If he puts the nose up farther he will not have enough power to maintain level flight and will lose altitude. If he puts the nose down to gain speed he will also lose altitude. If he is just a few feet from the ground, the outcome is obvious.





Kitty Hawk, North Carolina 10:35 AM December 17, 1903; pilot— Orville Wright. (D.W. Carter Collection)

With the strong wind at Kitty Hawk, their takeoff was probably near point *C* and they could move on out to the high speed intersection of THP_R and THP_A, and thus maintain stable flight.

It should be noted that this problem is still with us. It caused the crash of at least one transatlantic attempt in 1927 and some of the takeoff accidents with the De Havilland Comet jet transport. The military services have also had several jet fighter crashes from this effect.

In the flights made on December 17, 1903, the Wrights had difficulty with an extremely sensitive horizontal control system. Orville's diary notes: "I found the control of the front rudder [elevator] quite difficult on account of it being balanced too near the center and thus had a tendency to turn itself when started, so that the rudder was turned too far on one side and then too far on the other."[2]

This story of lateral and directional instability, control surface overbalance, and powerplant vibration difficulties sounds similar to the development problems one encounters today.

The Wrights were anxious to continue their experiments and started out by building three new engines of improved design. One had the same bore and stroke as the original engine but provided better cooling. The second was also four-cylinder but had the bore increased to four and one-eighth inches. This was the engine used in the flights of 1904 and 1905. It was improved from time to time as the brothers tinkered with it.

The 1904 airplane was almost a copy of the 1903 model. It had minor structural improvements and the camber was slightly reduced.

By May 23, 1904, the new airplane, and its engine, was ready for its first flight. The brothers had rented for their experiments a portion of Huffman's farm near Simms Station, a few miles from Dayton, on an electric car line. As with the 1903 machine, the Wrights used a short monorail launching track. The winds were not nearly as strong as those experienced at Kitty Hawk, and the short track made it difficult to take off without some wind.

By late August they were working on a catapult device consisting of a weight which was lifted to some height, and as it fell it pulled a cable attached to the airplane to aid it in takeoff. This was first tried on September 7. On the 20th of September they made their first complete circle in the air. Before the end of 1904 they had completed four circles of the field in one flight lasting a few seconds over five minutes. All of this was done with the rudder interconnected to the wing-warping controls. They had made 105 flight attempts in 1904 and at the end still had a usable airplane. Their total flying time was about 45 minutes.

The 1905 airplane was essentially the same as that used in 1904 except that the camber was again changed. The machine made its first flight on June 24, 1905. Again the necessity of making a living in the bicycle business interfered with their aeronautical endeavors. This airplane suffered from an overbalance of the vertical tail which caused an accident during its eighth flight, on June 30. On the next flight, on July 14, they experienced some longitudinal hunting which resulted in contacting the ground at a considerable angle and caused much damage. In repairing the machine they increased the size of the front rudder (elevator) and put it farther forward. Between repairs and rains they did not fly again until August 24. After increasing the size of the vertical tail they were able to circle well, making four circles on September 6, and on September 8 they attempted a figure eight. Their next-to-last flight of 1905 was made on October 5. Wilbur made 30 circles of the field in about 39 minutes and ran out of fuel. Several of the last few flights were made before a number of witnesses, including a newspaper representative. One more flight was made on October 16, but the engine was not running properly and the airplane flew once around the field and landed.

During some of the flights in 1904 and 1905 the brothers had experienced an inability to pick up the inside wing while turning steeply. After many tests they discovered that they could return to level flight by nosing down. They had, in effect, experienced a mild accelerated stall. Fortunately, in the few cases it occurred before they learned the technique necessary to prevent the stall, they were close enough to the ground to prevent injury, although the machine sometimes suffered damage.

Nineteen hundred and six was a year for negotiation. Wilbur left for Europe in mid-May to negotiate with various governments and private individuals for the rights to the "flyer" they had developed. Orville joined his brother in Paris in early August. They returned to the United States in the fall with the intention of "building half-a-dozen machines for the spring trade."[3]

The U.S. War Department finally, on December 23, 1907, advertised for bids for an airplane. All of the details had been worked out in advance and as the Wrights were the only ones who could meet the specifications, the advertisement was simply made to meet the government's legal requirements. The Wrights' bid for $25,000 was accepted on February 8, 1908.

On March 3, 1908, a contract was signed with a French syndicate for the formation of a company in France.

Both of these contracts required satisfactory demonstration flights. They had not flown since October 1905, but had been inproving both airplane and engine. Their latest engine was much more reliable and would produce about 35 horsepower.

All of their flights had been made lying down on the wing of the airplane. The new airplane was required to carry two people and to be used for training. The brothers decided upon side by side seated positions with dual control levers.

They remodeled their 1905 airplane and installed their latest engine and again went to Kitty Hawk to test the changes and to improve their flying skills. In the four and a half years that had passed, winter winds and shifting sands had taken their toll. They found their camp in ruins and had to build a new one. This took almost a month.

The first test flight was made on May 8, 1908. On May 14 Wilbur and Charles W. Furnas, a mechanic they had brought with them from Dayton, made the first two-person flight. The testing at Kitty Hawk was terminated by an accident that same day.

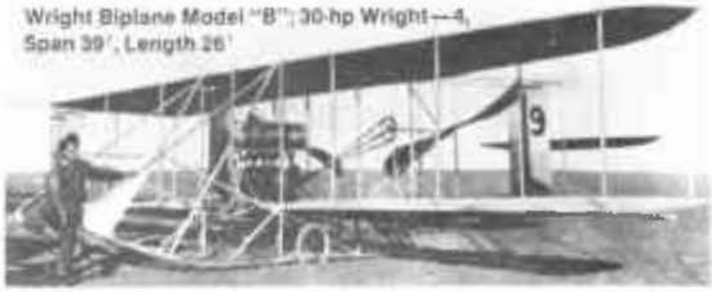
As it was necessary for one of the brothers to go to France in late May to fulfill their contract, Wilbur left for New York City on May 17 and sailed for France on the 20th.

Wilbur selected a field near Le Mans for his flight exhibitions. As might be expected, the airplane shipped by Orville for Wilbur to use in France had suffered much damage in transit. On June 17, Wilbur wrote to Orville, "I opened the boxes yesterday and have been puzzled ever since to know how you could have wasted two whole days packing them. I am sure that with a scoop shovel I could have put things in within two or three minutes and made fully as good a job of it. . . . Did you tell Charley not to separate anything lest it should get lonesome?"[2]

The French newspapers and aeronautical experimenters were very skeptical. After all, Santos-Dumont had made the first public airplane flight in Europe on November 12, 1906. He flew 38 meters. On January 13, 1908, Henri Farman, after several attempts, had completed a circular flight of about one mile. This was the first recorded complete circle by an airplane and was hailed as a great achievement.

Wright Model "A".

Wright Biplane Model "B"; 30-hp Wright—4, Span 39', Length 26'

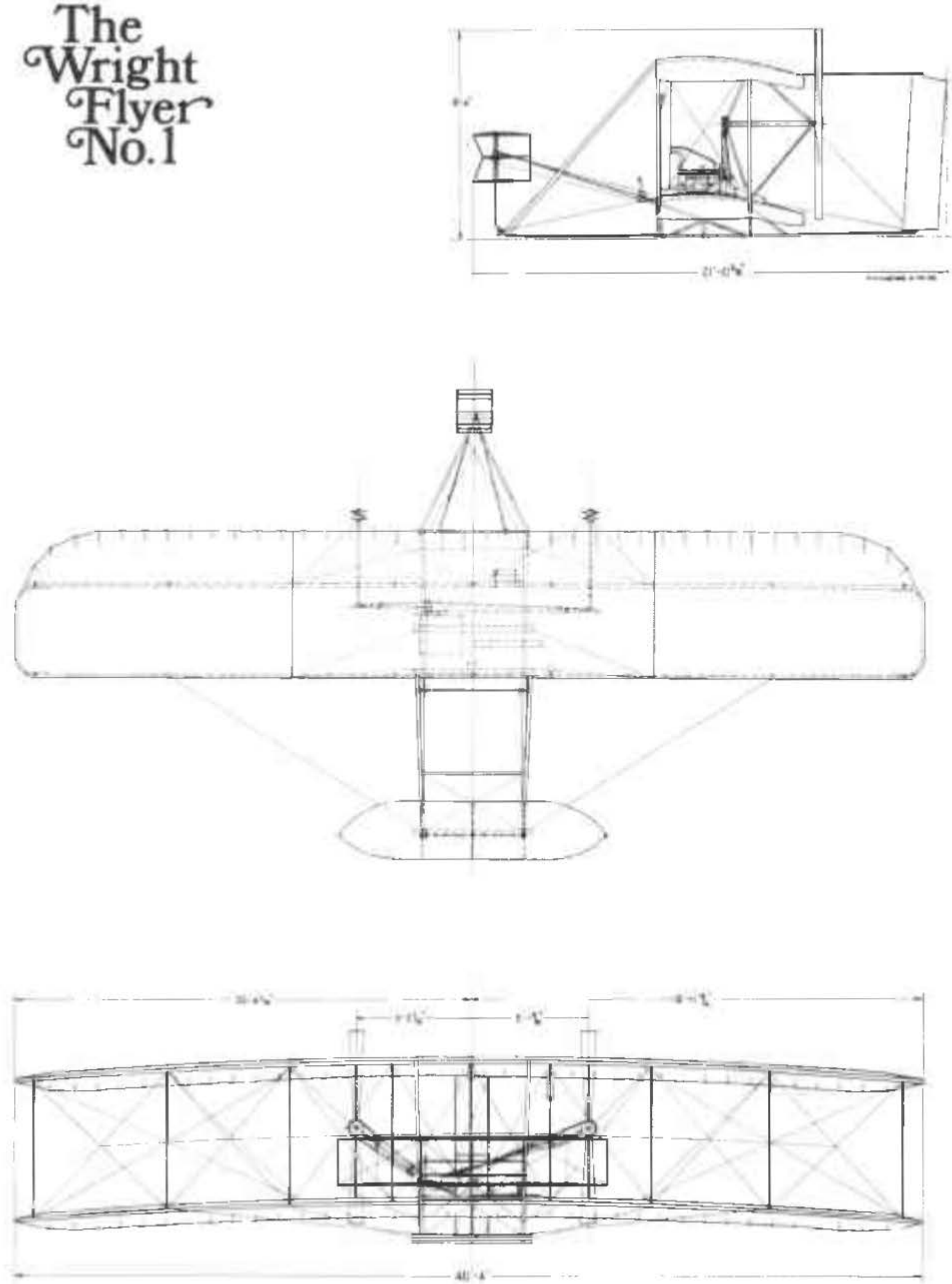


Wright Model "X" with modified controls; 30-hp Wright—4.

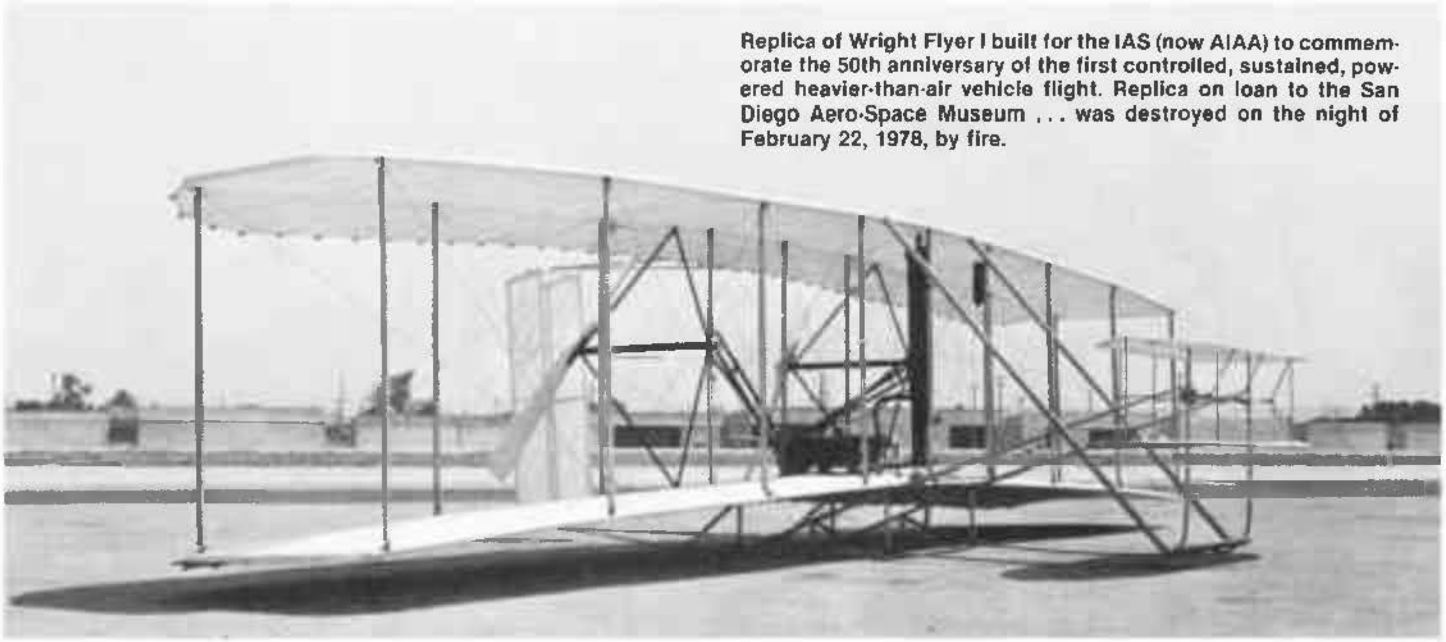
Wright Model "A" at Fort Meyer September 12, 1908. Pilot—Orville Wright; passenger—Major G.O. Squier.

Wright Model "C". Span 38', Length 29', Engine 50-hp Wright 6-60. (D.W. Carter Collection)

The Wright Flyer No.1



Drawing by D. W. Carter



Replica of Wright Flyer I built for the IAS (now AIAA) to commemorate the 50th anniversary of the first controlled, sustained, powered heavier-than-air vehicle flight. Replica on loan to the San Diego Aero-Space Museum . . . was destroyed on the night of February 22, 1978, by fire.

Meanwhile, in the United States, Glenn Curtiss, flying the JUNE BUG, developed by the Aerial Experiment Association, made a public flight of about one mile on July 4, 1908, thus winning the Scientific American Cup. The Curtiss airplane used movable wingtips which acted opposite to each other in a manner similar to ailerons, and the Wrights claimed this violated their patent. By July 10, 1908, the JUNE BUG had made a complete turn, but not in public.

When Wilbur spent the rest of June and all of July without flying his machine, the press became more critical.

After making a preliminary flight on August 8, Wilbur took to the air on August 10, 1908, making a figure eight and landing at the starting point. This so far surpassed anything done by others that the newspapers and the French aviators went wild with excitement. The Wrights were the avowed masters of the air.

Less than a year later, on July 25, 1909, Bleriot crossed the English Channel—the world was catching up. And all of them were using lateral control systems, which the Wrights claimed infringed on their patents. On May 29, 1912, Wilbur Wright died of typhoid fever.

Orville continued as president of the Wright Company that the brothers had started in 1909 until 1915, when he sold his stock in the firm and was retained as a consultant. His active flying days ended about 1914.

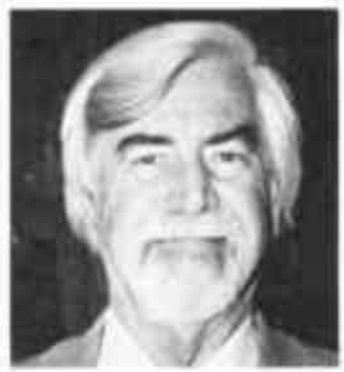
This account has been confined to the achievements of the Wrights. Their straightforward and logical development of the airplane leads one to wonder why others were not able to accomplish similar results. The Wrights were so far ahead of the other aeronautical experimenters that they were able to stop their tests for over a year and no others came close to duplicating their feats.

Many reasons have been advanced for their success, but one of the major factors was the complete equality between the brothers. Each respected the other's opinions and they were able to argue technical matters without animosity. They took turns in flying the gliders and the airplanes. By doing this each had a competent observer on the ground who was well qualified to observe and discuss the experiences of each flight. The pilot is not always the best one to tell what happened. He is too busy trying to control the airplane to remember and understand the sequence of events. This remote type of dual control may well have been one of the underlying reasons for the Wrights' rapid development of powered flight.

REFERENCES

1. *The Papers of Wilbur and Orville Wright*, ed. by Marian W. McFarland. McGraw-Hill Book Co., Inc., 1953.
2. *Ibid.*
3. *Ibid.*
4. *Miracle at Kitty Hawk*, ed. by Fred C. Kelly. Farrar, Straus and Young, Inc., 1951.
5. *Engineering Development of the Wright Airplane*, by Robert B. Johnston. "Aeronautica," July-Dec. 1953, Institute of the Aeronautical Sciences.
6. *Air Dates*, by Air Commodore L.G.S. Payne. Frederick A. Praeger, 1957.
7. *Contact! The Story of the Early Birds*, by Henry Serrano Villard. Thomas Y. Crowell Co., 1968.
8. *Glenn Curtiss: Pioneer of Flight*, by C.R. Roseberry. Doubleday and Co., Inc., 1972.

ABOUT THE AUTHOR



Bob Johnston graduated from CalTech in aeronautics and was a practicing aeronautical engineer for 35 years, working on everything from light airplanes to supersonic transports.

While sometimes helping to make aviation history, he has also been a student of history, trying not to repeat the mistakes of others. Bob is one of the founding members of the A.A.H.S.

His interest in the Wright Brothers was heightened when he assisted in the building of a replica of the 1903 Wright Flyer by the Los Angeles chapter of the Institute of the Aeronautical Sciences for the 50th anniversary of flight. He presented a paper at the dedication of the replica entitled "The Engineering Development of the Wright Brothers' Airplane." Unfortunately this replica was destroyed in the San Diego Aerospace Museum fire.

Bob is now retired from the aerospace industry but continues his interest in aviation history. The present paper is an amplification of the dedication paper and has been altered in some particulars by new information which was not available 25 years ago.