Birth of American Soaring Flight: A New Technology

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Introduction

SOARING provides man his closest approach to the capabilities of the birds. For some 4000 years,[1] men looked at soaring birds, longing to imitate them, to fly without the use of an engine or muscular power. In the prehistory of aviation, when no engines were available to sustain an aircraft in the air, soaring was the means for heavier-than-air experimenters to keep their planes in the air for a prolonged period of time.

So, where and when did soaring start?

Historians[2] and aeronautical engineers[3] tend to agree that Otto Lilienthal of Germany should receive credit for being the first pilot to recognize,[4] attempt and achieve soaring flight (Fig. 1), but who can take credit for this in the United States?

Background: What Is Soaring?

Today, soaring is generally defined as the art of keeping a motorless aircraft, a glider or sailplane, airborne—or sustained in flight beyond simply sinking in still air—using only the rising air currents that occur in the atmosphere. Since 1930, the C-Badge, created by the Fédération Aéronautique Internationale (FAI), has been recognized worldwide as the first step for a soaring pilot. The requirement, then and now, is to remain airborne for 5 min above the point of release or after being launched.

According to the laws of the mechanics of flight,[5] two sources of energy are available for soaring flight. One is air currents having an upward trend, "static soaring," and the other is irregularities in the natural wind, "dynamic soaring."

Static soaring flight started out as slope soaring above the windward slopes of hills, mountain ranges, and coasts. It might have been recognized in prehistory, but it was first described in the literature and utilized in the 1890s (Fig. 2). The next most basic form of soaring was thermal soaring, recognized in the late 1920s (Fig. 3), which opened up a vast realm of cross-country soaring.[6] If the atmospheric conditions are right, other areas of lift are created in the lee of a mountain. This lift is part of a large scale deflection of air mass, which is known as "lee wave" lift, first recognized in the 1930s and explored scientifically in the early 1950s.

In dynamic soaring, which is still not completely understood, the soaring pilot and his craft utilize the varying velocities and directions of the wind, being able to remain airborne in horizontal or even descending air currents. Some birds, such as the sea gull and the albatross, do practice it at times, and so do some modern sailplane pilots.

Soaring in the 20th Century

In October 1911, Orville Wright went with family members and a friend to Kitty Hawk, North Carolina, taking along the newly designed glider No. 5. The general public was told that this new glider could soar like a bird, but at the same time Wright also wanted to experiment with an "automatic stabilizer," a device that the brothers had submitted for patent[7] in 1908. On 24 October, Orville Wright wrote in his diary[8]: "Sunshine & Wind. Made about 20 glides, ranging from one minute to 9 minutes 45 seconds. [The flights] Measured a space of about 40 yards over which the machine seemed to glide without any loss of speed at angle 6°." For almost 10 years, this soaring duration flight remained an unbroken record throughout the world (Fig. 4).

The first World War brought a tremendous impulse to flying, which resulted in spectacular improvements of design and engineering of the airplane, and at the same time improved performance and piloting skills.[9]

After World War I, the Treaty of Versailles[10] prohibited new airplanes from being manufactured in or imported into Germany. Two aeronautical engineering students from Dresden, Wolfgang Klemperer and Erich Meyer, inquired whether motorless flight was also included in the Treaty—it was not. With the help of Oscar Ursinus, editor and publisher of "Flugsport," gliding and soaring was brought back,[11] and with scientific thoroughness the motorless airplane performance was raised to levels theretofore undreamed of. The "Schwarzer Teufel" (Black Devil) was the first modern sailplane, with a performance not significantly better than that of the Wright 1911 glider. It was designed by Klemperer and fellow members of the Academic Flying Group Aachen.

The scientific explanation of soaring flight seemed too complicated for the layman, and so journalistic visitors regaled their readers with accounts of first-rate miracles. Excitement and enthusiasm spread apace.[12] The slopes of the 3000-ft-high Wasserkuppe Mountain, the site of the first German National Glider Meet, had not been known to many Germans before. Now the Wasserkuppe became crowded with thousands of spectators from near and far for the annual glider meets.

The 1920s are considered the beginning of the sport of soaring as we know it today. In the years to follow the sport was introduced not only to other countries in Europe and North Africa, but also to the United States and the rest of the world.

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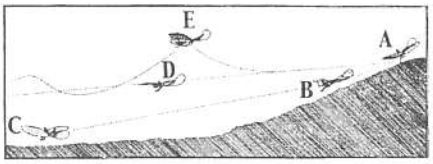

Fig. 1 Otto Lilienthal's chart of a flight: A, start; B, gliding descent; C, alighting in still air; D, course in 10-mile breeze; and E, soaring in a strong breeze. From "The Flying Man, Otto Lilienthal's Flying Machine," *McClure's Magazine*, Sept. 1894.

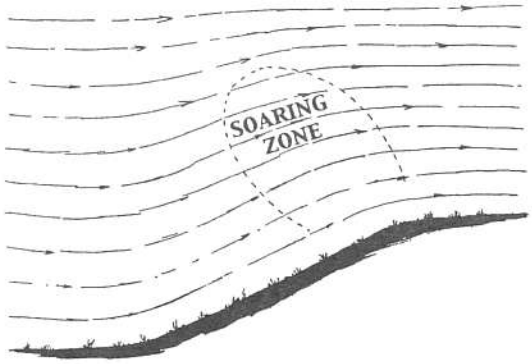

Fig. 2 Airflow over a hill, used in slope soaring. From R. S. Barnaby, "Gliders and Gliding."

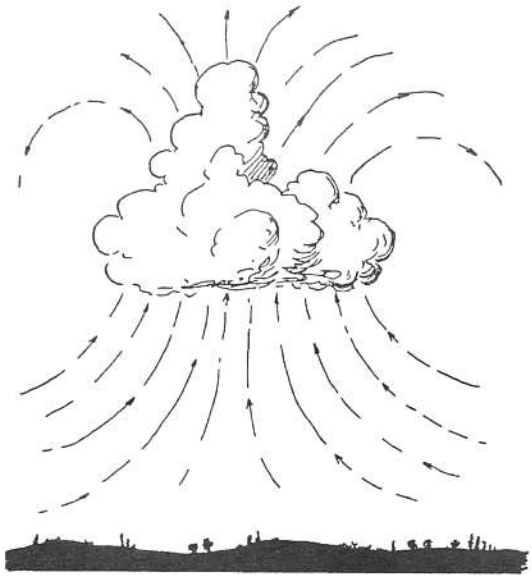

Fig. 3 Rising currents under a cumulus cloud, used in thermal soaring. From R. S. Barnaby, "Gliders and Gliding."

In the mid- to late 1920s, soaring was defined "as powerless flight in which the aircraft was able to maintain angles of glide flatter than its normal glide, and even rise to higher altitudes than those attained in the launching."[13]

A *New York Times* editorial of 1927 (Ref. 14) discussed motorless flight: "... How is it possible for a man without an engine, with nothing but a pair of stiffly outstretched, motionless wings, to remain aloft for hours and attain an altitude of over half a mile? The moving air is his engine. . . ."

In 1929, Captain Ralph S. Barnaby soared a "Prüfling" glider (Fig. 5) for 15 min 6 s along the sand dunes at Cape Cod, Massachusetts, setting a new American duration record. However, it should be mentioned that a few weeks earlier, a German glider pilot flew along the same sand dunes with a higher performance sailplane, staying aloft for over two hours! Today, soaring is regularly practiced by more than 200,000 pilots around the world. Five-

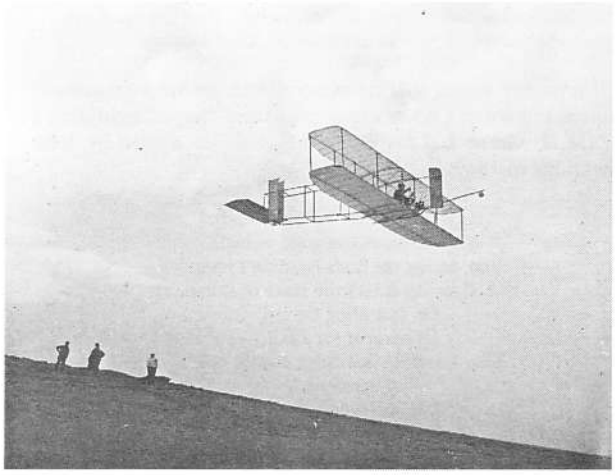

Fig. 4 Wright No. 5 glider soaring along dunes of Kitty Hawk, North Carolina, Oct. 1911, Wright Brother Papers, Library of Congress, Washington, DC (digital file LC-DIG-00692).

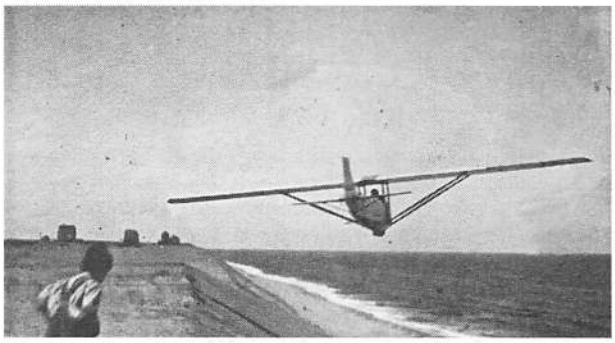

Fig. 5 Barnaby in "Prüfling" sailplane at Cape Cod, Massachusetts, in 1929. From National Soaring Museum, Elmira, New York.

hundred-kilometer flights are commonly achieved. The current distance record stands at 3000 km, and the current altitude record is almost 50,000 ft. As the performance of the sailplane improves, so will the records.

"Soaring": Usage of the Word in Early Literature

To determine who might have been the first pilot to recognize and then attempt soaring flight, prior to Orville Wright's 1911 flight, we need to verify the meaning of the word "soaring." Was the soaring reported in the literature by aviators in the 19th century "sustained" flight? Or were these flights just "glides"? Has the meaning of the word changed?

One of the first usages of the word "soar" can be found in Gefferey Chaucer's dream poem, "The Hous of Fame," written in the 1380s. Here, inspired by Dante's "Divine Comedy," he introduced the eagle in his dream and wrote[15]:

> Thoo was I war, lo! At the laste,
> That faste be the sonne, as hye
> As kenne myght I with myn yë.
> Me thoughte I sawgh an egle sore,
> But that hit seemed moche more
> Then I had any egle seyn.

Or in today's language, very freely translated: ". . as high as my eye can see, I thought I saw an eagle soar, flying much higher than I had seen any eagle fly before."

In 1575, George Turbervile published "The Book of Faulconrie or Hauking, for the onely delight and pleasure of all Noblemen and Gentlemen."[16] In this handbook for the sport of falconry, he describes not only the different hawks being used for hunting, but also the different diseases and cures for the birds. The description of the sparrow-hawk is especially interesting:

> . . . They are called Soarehawkes, bicause when they have forsaken the wood, and beginne to pray for themselves, they flee up aloft upon pleasure, which with us Falconers is called *soaring*.

In the 1800s, the words soaring or soaring flight were frequently used in the literature. One example is the very popular children's poem "Darius Green and his Flying Machine,"[17] written by John T. Trowbridge in 1869:

> If ever there lived a Yankee lad,
> Wise or otherwise, good or bad,
> Who, seeing the birds fly, didn't jump
> With flapping arms from stake or stump,
> Or, spreading the tail
> Of his coat for a sail,
> Take a soaring leap from post or rail,
> And wonder why
> He couldn't fly.

This is clearly an example in which the word "soaring" could have been gliding or jumping gracefully. The question is now, did Trowbridge know the difference between gliding and soaring? Probably not. But as long as he wanted to relay the "leaping high and higher" part in his poem, the usage of the word soaring is appropriate.

Looking at these examples, it is apparent that the general meaning of the words to "soar" or "soaring" has not changed greatly in the past millennium.

"Soaring Flight" as the Beginning of Aviation

During the 19th century fascinating trips through the air were reported by balloon pilots, and imaginary flying machines were envisioned. Most ideas were using avian creatures. It was known that the air furnishes a vast amount of power for the use of mankind, but how could this energy be used to propel a flying machine? Looking at the aeronautical patents,[18] accepted in the mid- to late 1800s, it is quite apparent that many inventors did not comprehend what was needed to invent a successful flying machine.

At the annual meeting of the American Association for the Advancement of Science, in Buffalo, New York, in August 1886, a recently retired civil engineer, Octave Chanute, chaired the Mechanical Science and Engineering Section. As vice president of this Section D, his address "Scientific Invention"[19] discussed progress in mechanical science in general, but he also expressed hope that with the invention of new motive powers perhaps will also come the solution of the last transportation problems, conquering the atmosphere and the possibilities of aerial navigation.

As a follow-up, he asked Israel Lancaster, a well known ornithologist, to give a paper on his research "The Mechanics of Soaring."[20] Here, Lancaster presented some of the most significant facts exhibited by soaring birds. He also offered an explanation of the phenomenon and tried to examine the problem of artificial flight. He defined a "soaring bird" as one that habitually travels the air on motionless wings.

The reactions of fellow engineers and scientists were negative and disappointing. Science Supplement[21] had this to report:

> . . . As a set-off to the papers of more certain value, and perhaps for purposes of recreation, the section listened to a paper, detailing observations and experiments, mixed up with some remarkable theories upon the flight of birds. An abstract will explain the supposed peculiar action of gravity in favor of soaring birds. But the section no doubt needed recreation.

As a result of this Buffalo meeting, the subject of aeronautics was given a certain prestigious status. At least one engineer, Octave Chanute, and one scientist, Samuel Pierpont Langley, decided to become deeper involved with the problem of artificial flight.[22] What were the principal difficulties that had to be overcome? What were the basic aerodynamic requirements? How can air flow over or under a support surface? What lift and drag forces act on surfaces as they cut through the atmosphere?

The *American Engineer and Railroad Journal*, one of the most widely read monthly magazines in engineering circles, was purchased by Matthias Nace Forney from Boston at about the same time as the Buffalo meeting. Chanute, who had worked with Forney on the feasibility study for the New York Elevated Railroad system, had offered help as any friend would.[23] Naturally, Forney was interested in increasing his subscription circle; to him, the future of transportation, including aeronautics, was a fascinating topic that would be of interest to his paying readers. Now Forney proposed to first research and then publish papers on aeronautics of the past and possibly the future. This project seemed challenging to Chanute as he started his retirement life. The first aeronautical article was published in April 1889, discussing "The latest rapid transit scheme."[24] Reuben Jasper Spalding's patent "Flying Machine"[25] (Fig. 6) had just been accepted by the U.S. Patent Office. One of Spalding's claims was that the wings would operate with practically the same effect as the wings of an eagle. Chanute added his editorial comment "..which might be a dangerous admission, were the eagle in a position to file objections in the Patent Office."

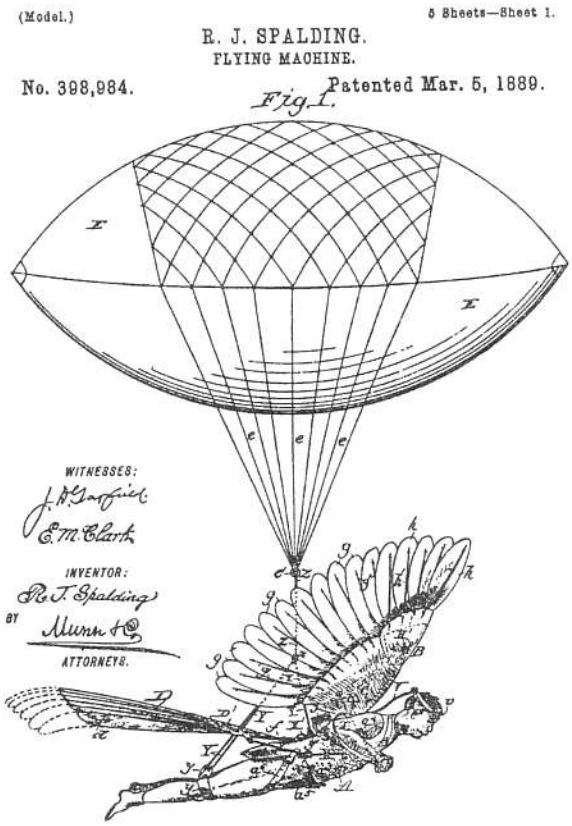

Fig. 6 Reuben Jasper Spalding's "Flying Machine" patent of 1889.

Starting in October 1891 (Ref. 26) Chanute systematically wrote every month for Forney's journal about a different aspect in the "Progress in Flying Machines." Worldwide failures and successes of heavier-than-air flying machines were discussed and evaluated.

Chicago succeeded to host the World Columbian Exposition in 1893. The overall goal of this World's Fair was to present and illustrate progress in arts, inventions and industries worldwide, including transportation on land, water and through the air. The foremost men and women in every department were invited to attend and speak. After the meeting, the papers of each of the conventions were to be published as proceedings and distributed worldwide.

Albert F. Zahm, professor of mechanical engineering at Notre Dame University, Notre Dame, Indiana, and Octave Chanute, who had recently moved with his family to Chicago, cochaired the first International Conference on Aerial Navigation, as part of the World's Fair. This four-day conference was divided into three sessions: scientific principles, aviation (heavier-than-air), and ballooning (lighter-than-air). There were 45 invited papers, and the reading of each of these papers was followed by lively and enthusiastic discussion. About half of the papers discussed soaring as a way to achieve prolonged flight.[27]

There was at least one person in attendance who was not officially invited. He had planned to attend the Electrical Congress in the middle of August when he heard about the Aeronautical Congress. John J. Montgomery of San Diego, California, was quite surprised that "learned men" were discussing flight, something he had tried almost 10 years earlier.[28]

He participated in the discussions,[29] but he also described his 1884 attempt to fly. Montgomery told the audience that he constructed a soaring apparatus, consisting of two arched wings, united by a framework, with a seat. His experiments were first reported in Chanute's book *Progress in Flying Machines*, published the following year. "Mr. Montgomery took this apparatus to the top of a hill. He faced the sea breeze steadily blowing, and gave a jump into the air without previous running. He found himself at once launched upon the wind, and glided gently forward." A second attempt reportedly resulted in a smashed glider.[30] There is much controversy about Montgomery and his claim of having flown. Reading the description of his "takeoff," one wonders whether he really achieved a gliding flight. Most aeronautical engineers are highly skeptical and wonder if he was just lifted of the ground by the sea breeze.

In the conclusion of *Progress in Flying Machines*, Chanute theorized that eventually there will be two types of machines, the "soaring type" which will carry but a single operator, mostly relying on the wind for energy, and the "journeying type," to carry several passengers and with a motor, also utilizing the wind at times.[31]

There were no clear thoughts among the many inventors working the problem of what would be needed to get a flying machine into the air. Was artificial power the required force? How could stability and equilibrium be achieved? If the birds can travel or soar for longer distances, why could men not use the same energies and principles? Could aerial up-currents be used to extend or prolong the flights of their flying machines? Soaring, using either the slopes of the dunes or wind eddies, would allow longer flights to test and gain experience.

Prolonged or Soaring Flight in the 1890s

The first successful steps in the evolution process to invent a flying machine came through the scientific methods of Otto Lilienthal, in Berlin, Germany. He believed that the most important thing to be accomplished was to learn how to handle the machine in the air, to meet its whirls and turmoil. He practiced gliding flight, sliding down on the air from the top of a hill.[32] During the six years prior to his death in 1896, he built machine after machine, honing his flying skills and improving his glider designs, making gradual improvements with each new design.[33] More than once, he also experienced sailing or soaring flight, prolonging his flights by several seconds. His glider—in the German language—was in fact called a "Segelapparat" or sailing apparatus.

News of Lilienthal and his glider flying experiments reached the general public in the United States as well. In his publications he not only described his experiments[34] but he also assured the reader that there was no mystery about sailing flight (Fig. 7). He wanted everyone to know that experimenters needed not to be afraid to work with soaring machines and that they would not be considered lunatics, thus encouraging others to try this new sport and to improve on his design of a flying machine. Lilienthal's publications were[35] eagerly read with amazement. Newspaper reports even elaborated on them resulting in fantastic tales about this "flying man."

After spending almost 10 years researching, lecturing and writing, Chanute was fully aware of the many remaining unknowns. In his article "The Present Status of Aerial Navigation,"[36] he advised those seeking a solution of the problem of flight to turn their attention to experiments in the direction of soaring flight, with a full-size apparatus carrying a man, as the quickest, cheapest, and surest way of ascertaining the exact conditions, which must be met in practical flight. And "we may try to imitate the soaring birds, who derive from the wind all the power required for flight when once they have gotten well under way."

Chanute decided that he, too, had to start actual gliding experiments to find answers. He believed that "automatic stability" was one of the main problems in the invention of a flying machine. Being

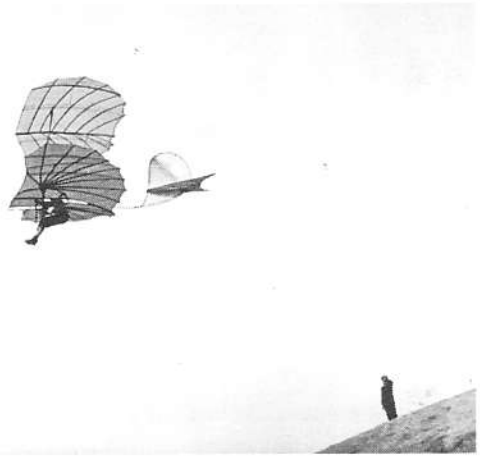

Fig. 7 Otto Lilienthal soaring in 1895 from his man-made hill in Berlin, Germany. From Otto Lilienthal Museum, Anklam, Germany (digital file F126RE).

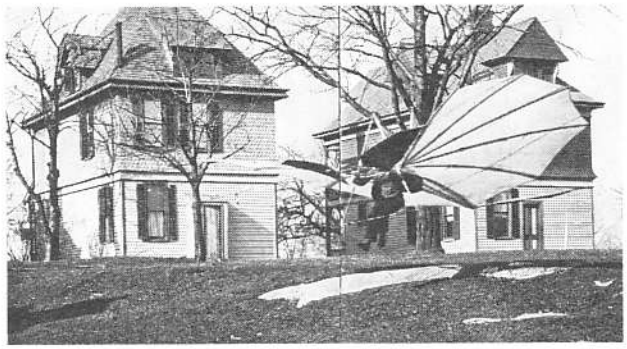

Fig. 8 Augustus Moore Herring flew his Lilienthal-type soaring machine in 1894 in Freeport, Long Island. From Otto Lilienthal Museum, Anklam, Germany (digital file F918).

fully aware of his advanced age, he hired two people in the winter of 1895/1896. William Avery, whose father owned a workshop near the Chanute family residence in the northern part of Chicago, was to build the glider. Augustus Moore Herring, who had built himself a Lilienthal-type "soaring machine" and had flown it for about 50 ft a couple years earlier[37] in the New York City area (Fig. 8), was quite eager to be part of these flying experiments. He agreed to bring along his old machine and share his knowledge.

Glider Flying Experiments in 1896

Several different glider designs were envisioned by Chanute's team. Herring's old Lilienthal type was rebuilt first because the general consensus of each team member was to begin the practical experiments with a known design before venturing into the unknown.

On 22 June 1896, the party of five went into camp in the desert sand hills along the southern shore of Lake Michigan, just north of the railroad station of Miller,[38] now an eastern suburb of Gary, Indiana. It was a colorful group alighting from the morning train, including the older gentleman, Chanute, wearing a suit-coat, his son Charles, the two dogs, Rags and Tatters, Avery, Herring, and William Paul Butusov, a Russian sailor who told everyone that he had built himself a flying machine and had soared in Kentucky for 45 min several years earlier. Each person carried a substantial amount of odd looking luggage, which included kites and the disassembled gliders as well as camping gear and whatever was needed for their daily needs for the next two weeks.

Herring's old Lilienthal machine was assembled and tried first. Even though it proved from the outset an awkward machine to fly, about 100 glides were made.[39] Its operation was a constant struggle with the wind, and not at all what they had expected. After one more

Fig. 9 ***Chicago Record*** **newspaper of 29 June 1896 shows Mr. Herring's flight with the improved Lilienthal soaring machine, landing in front of spectators, including the two dogs, Rags and Tatters.**

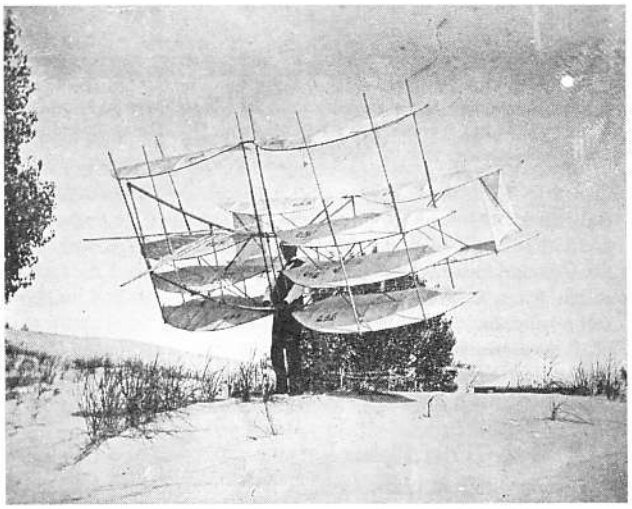

Fig. 10 Octave Chanute, "getting the feel for it!" Note numbering of each wing of "Katydid" multiple wing glider. From ***Octave Chanute Papers*****, Library of Congress, Washington, DC.**

rough landing, it was discarded. "Glad to be rid of it," Chanute wrote in his diary.[40]

Much to the annoyance of Chanute, Chicago newspaper reporters were on site and ready to publish each and every step in their daily papers as soon as they arrived in Miller (Fig. 9). "Nothing embarrasses those engaged in scientific experiment so much as to have the newspapers constantly printing the details of the work and perhaps claiming more for the machines than the experimenters themselves," Chanute told the *Tribune* reporter.[41]

The multiwing glider, "Katydid," with six sets of wings attached so that they could pivot and adjust with each breeze of the wind, was the second design. Each wing was clearly identified to be recorded, positioned and readjusted for the next experiment (Fig. 10). "The grouping of the wings was gradually changed, through six permutations, each being guided by gliding flights and by releasing bits of featherdown in front of the machine, and watching the paths of the air currents which swept past the wings."[42] Some decent gliding flights were made, and every one felt that they were on the right track.

After two weeks of experimenting, evaluating, and especially getting acquainted with this new endeavor, the group returned home. It was a good experience, because much was learned about the weather and the wind, the updrafts along the dunes, and the practical aspects of flight—how to control an aircraft and how to prolong a flight.

Back in Chicago, two additional machines were designed and built. Butusov received funds from Chanute to build his "Albatross" soaring machine and submit the design to the U.S. Patent Office.[43]

The final design for a gliding machine was a triplane, with fixed wings and a flexible tail. It was hoped that this tail, as suggested by Herring, would not only assist in making the craft more stable, but would also help control the glider in flight. The wings were rigidly trussed together. Chanute knew from past experience in the bridge building business that the Pratt truss design gave the most rigid, flexible and lightweight structure.[44] This novel aircraft was again built in Avery's workshop.

Late in August everything was ready for the second trip to the dunes. To avoid publicity, a boat, owned by Chanute's partner in the railroad tie preservation business, was used, which was beached about five miles farther east of Miller, just north of the Dune Park Station. Chanute had high hopes that no reporter would walk through almost three miles of duneland and swamp or along the beach to check them out.

The triplane was assembled and tested first: it was awkward to handle, and the bottom wing frequently got caught in the sand. In typical engineering fashion, with each team member participating, the bottom wing was removed on Avery's advice, and the flexible tail was repositioned on Herring's advice. The simple biplane emerged. It proved to be a key step in the evolution process of the flying machine.

On 5 September 1896, many nice glides were made in calm weather with almost no winds. But on 11 September, the winds increased to 25–30 mph, and several outstanding, prolonged flights were attempted and achieved (Fig. 11). Chanute recorded in his notes[45] that the angle of descent was now much more shallow than in the glides with no wind. "On many occasions the machine and man were raised higher than the starting point."[46] A visiting *Chicago Tribune* reporter had this to say:

Fig. 11 The Chanute-type biplane in flight. Photo probably taken on 11 September 1896. From National Air and Space Museum (NASM negative no. 1A-20359).

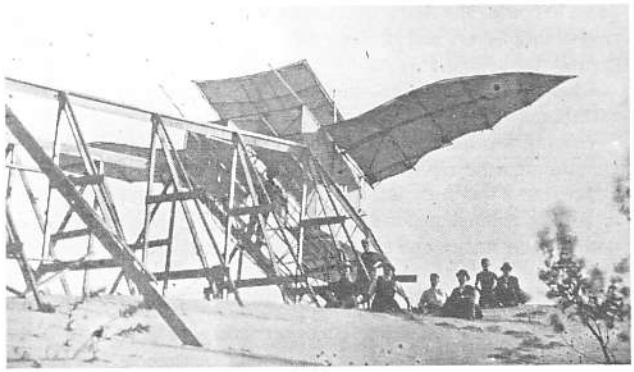

Fig. 12 Butusov's Albatross glider on launching ramp. Takeoff was possible only with strong northerly winds. From *Octave Chanute Papers*, Library of Congress, Washington, DC.

> With the high wind the practice was full of excitement for beholders. One wholly new freak of the air was experienced by Mr. Herring when his machine rose with a sudden gust forty feet higher than the starting point, then coming to a sudden poise, balancing like a bird, swooping at a right angle, travelled a long journey, and alighted gracefully upon a hillside. It was seen that Mr. Herring's flight with the wind alone caught and held the machine and then let it descend gradually.[47]

For the observed record, Avery had the longest distance flight of 10.2 s, flying 256 ft, whereas Herring's longest flight was 10.3 s, but he traveled only 235 ft (Ref. 48).

Herring, who had more flying time in gliders than anyone else in the United States, seemed disappointed that his flights were not significantly better than anyone else's. He always felt that the biplane was "his" design and "his" machine. So, the next day, he took the biplane to experiment by himself. He did not want any one to watch. Returning back to camp late in the afternoon, he reported that his best flight was 14 s covering a distance of 359 ft. Chanute took his word and recorded these values in the performance table of the day.

While the biplane was so successful, Butusov's "Albatross" brought its fair share of problems. A large launching ramp had to be built to assist with the takeoff (Fig. 12). After three unsuccessful attempts to launch it, everyone gave up. It would not soar. It would not even get airborne.

The last sentences in Chanute's diary[49] summed up his personal feelings:

> . . . If the man [Butusov] had been in the machine, he would have not been hurt, but this trial determines clearly that the machine will not perform soaring flight, that it will glide downward only, probably at a maximum angle of 1 in 4 as shown by calculation, and that the head resistance (or drag) & drift must be reduced so as to give a descent of 1 in 10 (6°) before it can be hoped to raise on the wind higher than the starting point. This has not been accomplished with any of the 3 machines.

Chanute was disappointed that sustained flight over a longer distance and for a longer duration had not been achieved. He realized that the biplane, "as then proportioned, glided at too steep an angle to perform soaring flight."[50] But some progress was made toward solving the problem of "artificial flight."

Herring, who had left the team shortly after his 12 September flight, reported a few months later that he built himself a new triplane glider and flew it in October 1896 (Fig. 13), making "flights up to 927 feet in length, all while 'quartering' on the wind. In a few of the flights it was found quite safe to turn the apparatus and it would have been possible to land on a higher point than the starting one."[51] Even though most historians are highly skeptical about such an achievement by Herring, the fact is that he could have been "quartering" or "crabbing" over a distance of 927 ft—for 48 s. He could have made partial turns if the wind would have been strong enough.[52] Because he clearly describes these three possibilities to prolong his flights that could only be achieved in soaring flight, he apparently understood the principles because he experienced them the month prior.

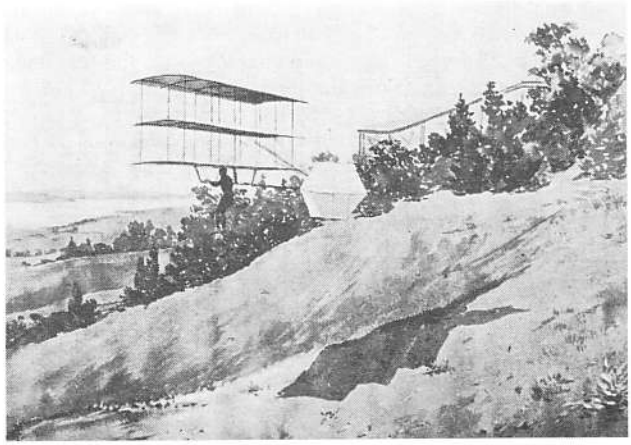

Fig. 13 Herring and his triplane. Painting from Herring's paper, *Aeronautical Annual*, 1897.

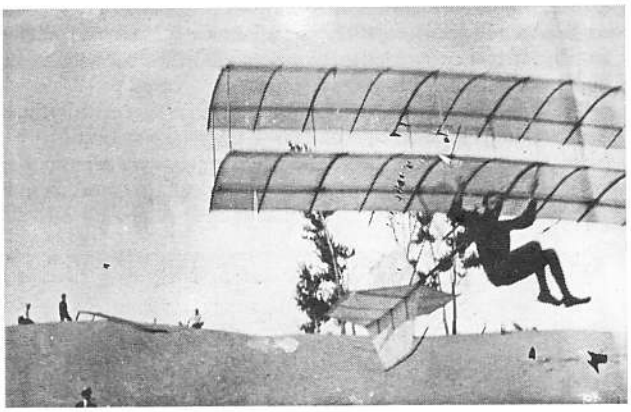

Fig. 14 Glider flying is fun. Many enthusiasts tried this new sport in September 1897. From *Octave Chanute Papers*, Library of Congress, Washington, DC.

Glider Flying Experiments in 1897

During the winter months, Chanute advertised to build and sell any of his gliders for $300 each. Matthias Arnot, a banker from Elmira, New York, ordered a biplane glider. Chanute gave the order to Herring. The ship was again built in Avery's shop, and engineering improvements in the 1896 design were made as they went along. Early in September 1897 the machine was ready.

Herring sent telegrams to the major Chicago newspapers, inviting reporters to come and see for themselves what this new sport is all about. Several enthusiastic reports were published as a result. Arnot had agreed to pay for one week of experimenting; however, it is not clear if he actually did come to the Indiana Dunes to participate and fly the glider. Chanute agreed to pay for the second week, even though he was convinced that nothing new could be learned. He invited fellow members of the Western Society of Engineers from Chicago, and several of the younger men came to try "coasting on the air." Looking at the photos taken by several people, it looks like a good time was had by all (Fig. 14).

Chanute also wrote to his friend James Means, "As you expressed a desire to see a machine in action, I invite you to come out at once."[53] Means came. He spent two days at "Camp Chanute" and was quite impressed by the performance of the biplane. Means, a retired industrialist from Boston who—just like Chanute—was determined to spread as much information about mechanical flight as possible. His vehicle for doing so was a series of volumes of the *Aeronautical Annual*, published between 1895 and 1897.

Knowing that the dunes were about 100 ft (or less) high, with the waters of Lake Michigan not too far away from the foot of the dunes,

one wonders how these relatively long flights of 11–14 s could have been achieved. A flight in a 23-lb biplane glider with a 16-ft wing span and a 135-ft^2 wing area,[54] just gliding down a dune in calm air, took significantly less time. But gliding in strong 25–30 miles per hour wind from Lake Michigan against the steep sand dunes made a difference. Chanute realized why the flights in calm air had a much steeper descending angle than the ones against a strong wind.[55]

> If we had a long straight ridge, bare of trees at the summit, and a suitable wind blowing at right angles thereto, we would have attempted to have sailed horizontally along the top of the ridge, transversely to the ascending current. This manoeuvre is frequently and easily performed by the soaring birds.[56]

In October 1897, a month later, Chanute presented a talk with lantern slides to the Western Society of Engineers on his experiments.[57] At this time he described to the audience the "quartering" flights, a phenomenon well known in nautical circles.

Both, Herring and Chanute described "... 'quartering' or at an angle with the wind in order to make use of the ascending current over the slope which furnished both support and propulsion. The machine faces north, but is advancing west of northwest in a wind coming from the northeast." Figure 15 shows a photo taken in 1897, and Fig. 16 is an assembled graphic illustrating how these quartering flights occurred.

The primitive biplane, which was flown so successfully in the Northern Indiana dunes by members of Chanute's team and by people with no knowledge and experience, newspaper reporters and engineers, became the starting point for many experimenters in the years to come. The flying experience was invaluable, and at this period of time Avery and Herring were the most experienced heavier-than-air pilots in the world.

Chanute's gliding and soaring experiments had provided a practical laboratory for learning about aircraft design and flying technique.

Herring was quite eager to protect what he felt were "his" ideas. He submitted the triplane "Flying Machine" design to the U.S. Patent Office, but it was rejected. He then asked Chanute for help, and the motorized triplane and the biplane glider design were submitted in both of their names and subsequently patented in England.[58]

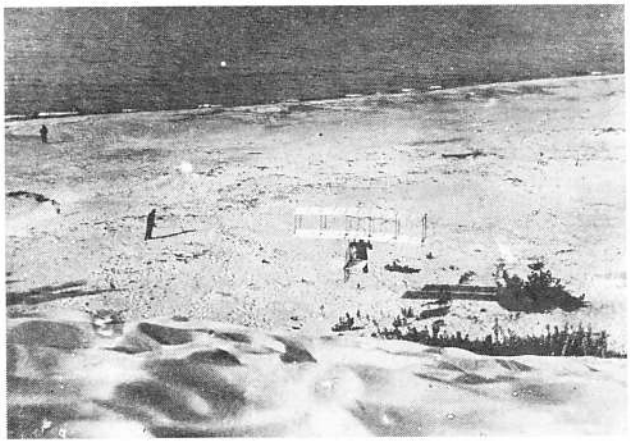

Fig. 15 Chanute-type biplane glider, September 1897. From National Air and Space Museum (NASM negative no. 7A-09329).

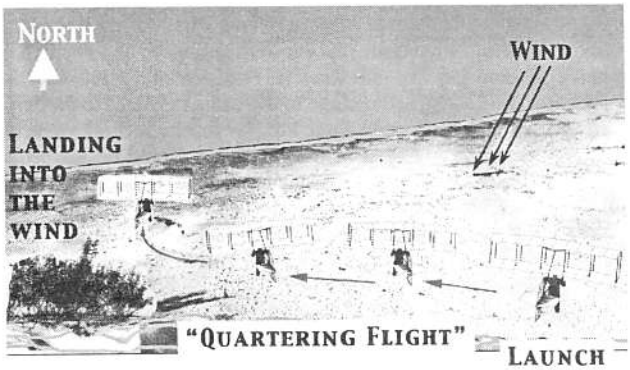

Fig. 16 "Quartering Flights," along the sand dunes of Lake Michigan, or flying at an angle with the wind in order to remain in the ascending current over the slope to sustain flight. The machine faces north, but advances west of northwest in a wind coming from the northeast. After coming to an obstacle (a tree), the glider turns into the wind and glides away from the dune to land on the beach.

Soaring Flight at the Beginning of the 20th Century

Chanute continued to publish papers and give talks in the United States and Europe about his glider flying experiments, but also distributed information on the achievements of other enthusiasts. He became a clearinghouse for aeronautical information and accomplishment worldwide. At the same time, he also invited those who were similarly minded to improve on his work.

Everywhere men were laboring, in different ways, with independent methods, on the problem of artificial flight. Chanute's correspondence[59] reveals that anyone interested in aviation normally contacted him, sometimes sending drawings, and at times asking for money to help build a flying machine. His answers were generally supportive, but he also critiqued—positive and negative, gave advice, shared his knowledge, and helped calculate data to possibly come up with a better design.

May 1900 was a busy month. Not only did Chanute's growing railroad tie preservation business require his fullest attention, but he also received quite a few letters from people who wanted to become more involved with aeronautics. One of these was a five-page letter from Wilbur Wright,[60] bicycle maker, from Dayton, who intended to build a biplane similar to the Chanute-type of 1896/1897.

A fascinating letter exchange between the Wrights and Chanute followed. Sometimes letters were written daily. Frequently, Wilbur tried to explain what he was envisioning or was planning to do; Chanute's answers seemed at times evasive, almost as if he was trying to be a good mentor making his student think harder to come up with a better understanding and solution.

The Wrights were quite certain that their glider, now in the second year of development, would be a success. They wrote to Chanute, "it is scarcely necessary to say that it would give us the greatest pleasure to have you visit us while in camp if you should find it possible to do so."[61] And he did go to Kitty Hawk for one week. Two of his associates, Edward Chalmers Huffaker from Tennessee and George Spratt from Pennsylvania, however, spent almost a month at the Wright camp.[62] The Wrights envisioned that their three-axis control by utilizing a canard (or horizontal "rudder") for pitch control, and warping the wings for lateral control, would be the breakthrough to a controllable aircraft (Fig. 17). Even though the use of wing warping to effect lateral control worked, it did not work the way the Wrights intended when first tried in their full-size machine. It failed to make the airplane roll into the intended turn. The machine experienced significant adverse yaw that resulted in opposite direction turns from the wing warping input.[63]

In frustration the Wrights wondered whether man would ever fly.

Chanute, as a good mentor, asked Wilbur Wright to present a lantern slide talk to the Western Society of Engineers. For the past

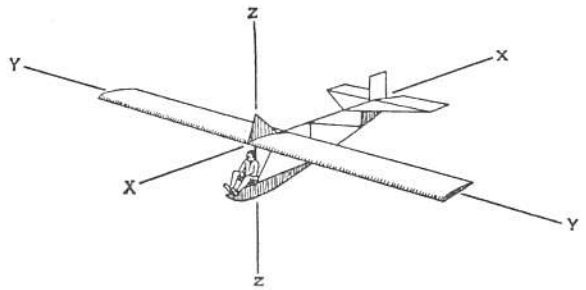

Fig. 17 Three-axis control in a primary glider: x, roll (longitudinal axis); y, pitch (lateral axis); and z, yaw (vertical axis).

40 years this group was one of the most prestigious engineering societies of the United States, with members from all parts of the country coming to Chicago for the biweekly meetings.

Wright was not so sure whether he should accept the invitation to "perform." Katharine Wright wrote to their father about the preparations.[64] She was convinced that it was good for her brother "to get acquainted with some scientific men." Reluctantly, Wilbur agreed. Chanute helped by assembling some of his lantern slides, and "Orv offered all his clothes so off went 'Ullam' arrayed in Orv's shirt, collars, cuffs, cufflinks and overcoat. We discovered that to some extent 'cloth do make the man,' for you never saw Will so 'swell'" when he left for the big city.

The subject of the talk was, of course, the gliding experiments of the past two years at Kitty Hawk.[65] But Wright also discussed soaring, which was still not quite understood:

> I refer to soaring flight, by which the machine is permanently sustained in the air by the same means that are employed by soaring birds. What sustains them is not definitely known, though it is almost certain that it is a rising current of air. But whether it is rising current or something else, it is as well able to support a flying machine as a bird. . . In gliding experiments it is known that the duration of the flight is greatly prolonged, if a strong wind blows up the face of the hill parallel to its surface.

Updrafts would help them achieve some measure of sustained flight and prolong their time in the air to better understand the principles of artificial flight. The talk further described the reasons for soaring flight and the process how to achieve it. About 55 members and guests were present at the 18 September 1901 "special meeting" of the Society. The preparations for the talk on their gliding experiments and the resulting comments from the engineers before and after the meeting were a turning point in the career development of the Wrights. They decided now to approach the subject systematically, as engineers.

Glider Flying Experiments in 1902/1903

In the months that followed, the Wrights checked and rechecked their own data, but they also verified data from other researchers. They built themselves a wind tunnel to test every part of their machine with a simple, well-thought through set of scales. All of their findings were incorporated into the 1902 glider design, which—with the added vertical surface or tail now becoming a movable rudder and by coupling the rudder deflection with the wing warping—had a working three-axis control system.[66] This new machine weighed 102 lb, had a wingspan of 32 ft, and a wing area of 305 ft^2, a significant step up from the 1900 glider with a 17-ft wing span and the 1901 glider with a 22-ft wing span.

Success came in October 1902 when they made a soaring flight of 26 s in duration, covering a distance of 622.5 ft. Wilbur wrote proudly to his sister[67] that they "made the longest distance glides, had the longest time in the air, the smallest angle of descent, and all of this in the highest winds" (~30 miles per hour) (Fig. 18). This glider with its now functioning control mechanism became the basis for their patent.[68]

The relative ability of the early Chanute and Wright gliders to soar is indicated in Fig. 19 showing the sink speed and the velocity of the aircraft. As we know, "lift" is the force perpendicular or at right angles to the direction of the airflow, and "drag" is the force parallel to the direction of the airflow. The designer of an aircraft usually is interested in maximizing lift and minimizing drag. Above the speed design range, the drag will become excessive, and the gliding angle will suffer.[69] The 1896 Chanute-type and the 1902 Wright glider exhibit a similar sinking speed of about 5 ft/s, even though the Wrights calculated the lift to drag or gliding ratio (L/D) of their glider as 7 to 1 (Ref. 70). The graph shows that the Chanute-type glider, with its maximum lift to drag ratio of almost 5, and a sinking speed of 5 ft/s, was capable of soaring under the right weather and terrain conditions, while the Wright 1902 glider, with its maximum lift to drag ratio of almost 6, was a step forward. To put this comparison chart into a modern perspective, two well-known hang-gliders of similar performance are included: the low aspect

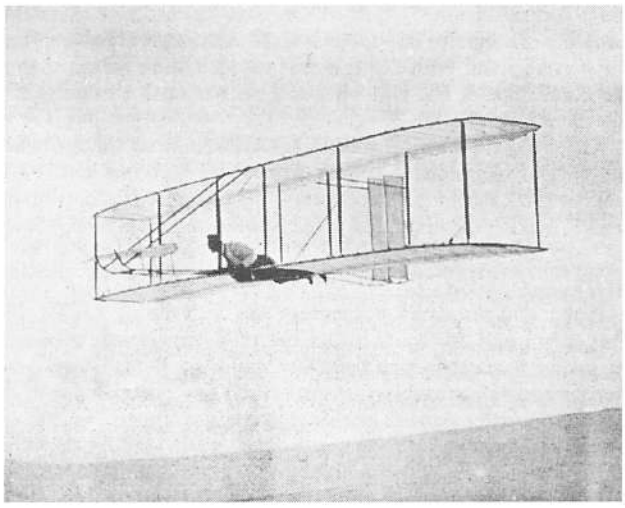

Fig. 18 2 October 1902: Wright glider soaring from north slope of Big Hill. From *Octave Chanute Papers*, Library of Congress, Washington, DC (digital file sc006911).

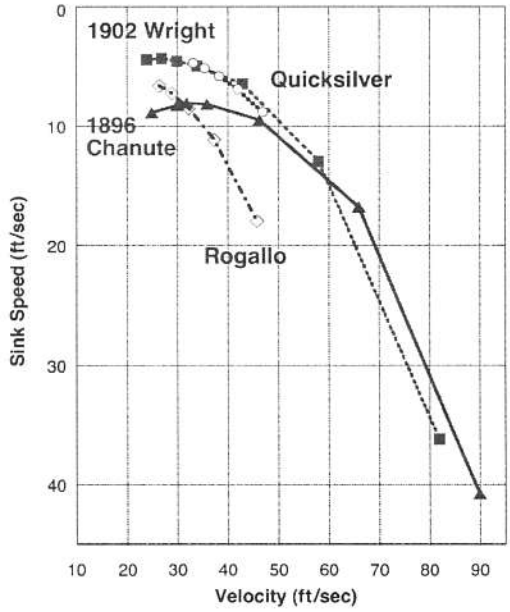

Fig. 19 Performance data comparison of the 1896 Chanute-type (▲) and the 1902 Wright (■) glider, compared with the 1970s Rogallo (□) and Quicksilver (○) hang-gliders. Data calculation by Albion H. Bowers.

ratio Rogallo (maximum lift to drag ratio of 5) and the rigid wing Quicksilver (maximum lift to drag ratio of 7). Both hang gliders were flown in the 1970s. Both machines clearly demonstrated soaring flight giving credence to the claim that the Chanute type of 1896 was soaring as well.

The Wrights spent most of 1903 designing, building and evaluating the powerplant, the engine and the propeller, for their next design, the powered "Flyer" or the "whopper flying machine" as they called it. Back in Kitty Hawk, they continued to polish their flying skills "by gliding and soaring the old machine (i.e., the 1902 glider) and constantly making alterations causing it to respond to control much more quickly and to do things with entire safety."[71] They also bettered their times in the air by soaring for more than one minute and flying a shorter distance. "We are now able to remain practically stationary in the air when a suitable wind blows up a good slope. This is something former experimenters were entirely unable to accomplish." These hovering (or stationary over the ground) soaring flights were achieved when the speed of the aircraft

was equal to the speed of the wind. On 1 October, Wilbur Wright wrote to Chanute[72] that "We did some practicing at soaring and found it easier than we expected. Once we succeeded in remaining almost in one spot for $26\frac{2}{3}$ seconds and finally landed fifty feet from the starting point. With a little more practice I think we can soar on the north slope of Big Hill whenever the wind has a velocity of 9 meters or more."

All of the engineering and flying skills came to fruition when the Wrights succeeded in getting their "Flyer" airborne. On 17 December 1903, the first sustained, controlled, powered flights became reality, making the first flight made by man under artificial power.

What Next?

A two-day aeronautical congress was held during the World's Fair in St. Louis, Missouri, in October 1904. Papers were presented by several researchers, but there was also a kite flying contest, and balloon and flying machine competitions. To compete for one of the prizes for heavier-than-air machines, Avery and Chanute built a new glider, based on the 1896 design. As there was no hill for takeoff, a launching device was designed where Avery, standing on a trolley and holding the glider, was pulled aloft by a 10-hp motor,[73] similar to what is known as a winch launch in today's soaring community.[74] At a height of about 30 ft (the length of the rope), he released (Fig. 20), at times attempting turns and then gliding back to earth, covering distances of up to 300–350 ft. The rope was later extended to more than 100 ft, allowing higher and longer flights.

The next International Aeronautical Congress in the United States was held in October 1907 in New York City.[75] An impressive slate of aero-minded people presented papers, including several on soaring flight. The possibility of aeroplane flight without motor was discussed by Elias E. Ries who had been experimenting toward this end. Chanute's paper on "Soaring Flight" was read on the first day as well. The next day, John J. Montgomery's paper "Principles Involved in the Formation of Wing Surfaces and the Phenomenon of Soaring"[76] was read, followed by a paper by Israel Lancaster on "Observations and Tests of Marvelous Soaring Power of Birds in Calm and Storm."[77]

Because powered machines were significantly more complex, would-be pilots came back to the simpler sport of gliding. It almost seemed that the philosophy of the "School of Lilienthal" made a comeback: "You will be a better pilot if you master the art of gliding and soaring in a motorless aircraft." And "Even when man produces a perfect flying machine he must acquire the skill to use it. The key to success is to practice, practice, practice."[78] Intimate knowledge of the air and its currents, the workings of the controls of the craft, the ability to react correctly, all of this was required to master a glider and the more complicated, powered machines.

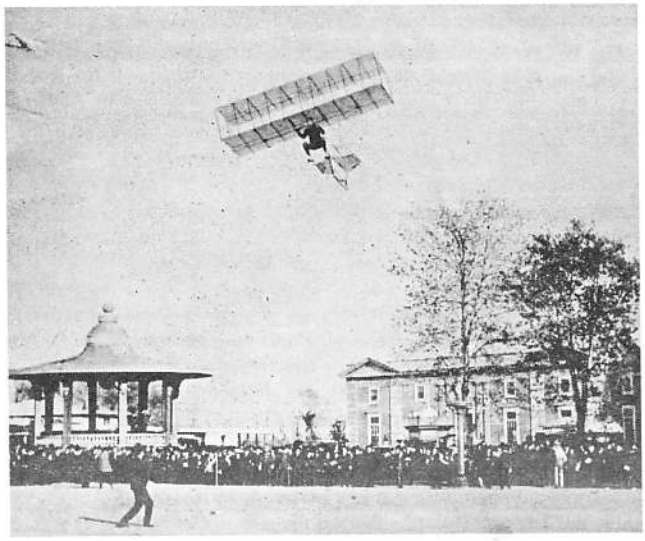

Fig. 20 William Avery performing a winch launch with the Chanute glider at the St. Louis World's Fair, October 1904. From *Octave Chanute Papers*, Library of Congress, Washington, DC.

The *American Magazine for Aeronautics* had called for money prizes for "gasless" machines to stimulate interest in motorless flight. For the first exhibition and tournament by the Aeronautic Society at Morris Park Race Track, New York, in the fall of 1908, Chanute established two silver trophies for the longest glides in any type of apparatus.

Glider Flying in 1909

In 1908, the Wrights made their first public powered flights in France, after having applied for patents on their machine in several European countries. Now pilots wanted to own one of these new fancy machines! But when the Wrights tried to sell their airplanes in England in 1909, they encountered problems. The French manufacturer Leon Bolle could not supply engines on a timely basis.

Their British patent was accepted in April 1909 (Ref. 79). One month later, Orville, Wilbur, and Katharine Wright went to London. In private discussions they strongly recommended to at least two future customers that they should learn the basics of flight in a glider, which would include their three-axis control and a seat, while waiting for their powered machine to be delivered. The Short Brothers built at least one glider, the one for Charles S. Rolls,[80] while T. W. K. Clarke built a glider for Ted Searight and his partner Alec Ogilvie. The drawings of the new British patent, but also from a recent article in *L'Aerophile*, were used as guidelines to make the glider as similar to the big machine as possible[81] especially with the controls and the seat (Fig. 21). Ogilvie made some good glides (Fig. 22) in the fall of 1909 (Ref. 82).

The general public was, again, awakening to the fact that man could fly. One could purchase a glider for $100, or build one by themselves, and enjoy the sensation of flight. Plans for the much simpler Chanute-type biplane glider with control by weight shifting and no concerns about litigations, were widely distributed in magazines, newspapers and booklets. Many early aviation pioneers built themselves a glider, using either the Wrights three-axis control system or the weight shifting control or some variation between the two designs.

Flying, either powered or motorless, was exciting and was discussed in scientific as well as popular magazines. The soaring or

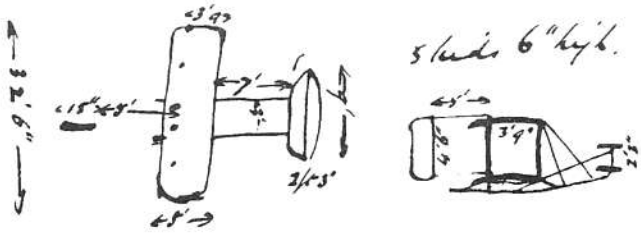

Fig. 21 Alec Ogilvie took the Wright's advice and had a glider built. *Wright Brother Papers*, from Library of Congress, Washington, DC (digital file 1909 Ogilvie 004).

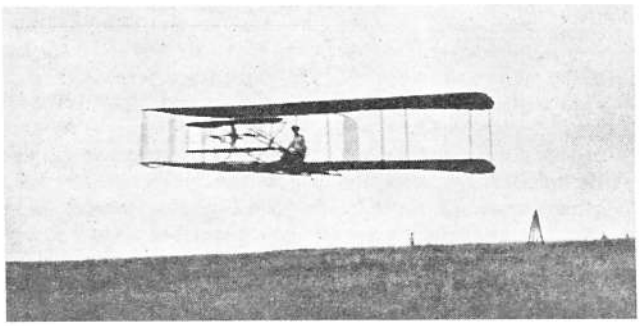

Fig. 22 T. W. K. Clarke built the Wright-type glider for Alec Ogilvie and T.P. Searight. Note the warping of the wings to begin a turn and the launching device in the background. *FLIGHT* (London), 25 September 1909.

sailing flight of certain varieties of large birds was still not thoroughly understood, Chanute wrote in 1909 in his paper "Soaring Flight and How to Perform it[83]: "... How could they transport themselves on rigid, unflapping, wings in any desired direction, how could they circle, rise, advance, return and remain aloft for hours without a beat of the wing in winds of 6 to 20 miles per hour? They appear to obtain from wind alone all the necessary energy, even to advancing dead against that wind." In closing, he writes: "It is hoped, therefore,... [any aviator] will carry the conviction that soaring flight is not inaccessible to man, as it promises great economies of motive power in favorable localities of rising wind."

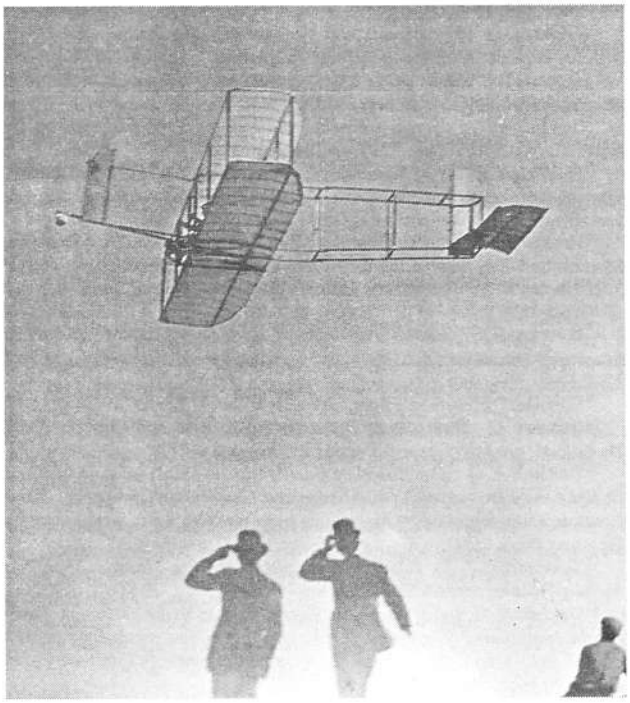

Fig. 23 Orville Wright soaring in strong winds with spectators looking at the 1911 glider. From *Wright Brother Papers* Library of Congress, Washington, DC (digital file LC-DIG-00708).

Glider Flying in 1911

Talks about soaring like the birds continued. Orville Wright announced that they designed a new machine to achieve this. "The buzzard is able to glide without using his wings," he said to members of the Aero Club of St. Louis,[84] "We are trying to make a machine which will approximate that. In other words, we have returned to our original experiments in gliding." In October 1911, he, several family members, and British racing pilot and friend Alec Ogilvie went to Kitty Hawk to experiment with this new "soaring wing" glider. Initially there were a few mishaps, but no one was seriously injured. During the next two weeks, the glider was constantly redesigned. Soon it was configured almost like one of the newer European aircraft. Originally, Wright stated that the goal of the glider flying experiments was to improve the mechanical stability, and to test some new ideas "which can best be experimented with on a glider rather than a power driven aeroplane."[85] In the end, control of the glider (or was it now a sailplane?) was much improved, it showed higher performance and was relatively stable in the air. Many good gliding and soaring flights were made, culminating in Orville Wright's 9 min 45 s soaring flight (Fig. 23) on 24 October.

Table 1 Technical comparison of the earliest soaring planes

Characteristic	1896 Chanute[a]	1902 Wright[b]	1911 Wright[c]
Wing area (total)	135 ft^2	305 ft^2	~ 300 ft^2
Cord	4 ft 3 in.	Upper: 5 ft Lower: 4 ft 11.75 in.	~ 5 ft
Camber	~1/10	1/24 to 1/30	1/20 (?)
Wing span	16 ft	32 ft 1 in.	32 ft
Gap between surfaces	4 ft 3 in.	4 ft 7 in.	~5 ft
Weight	23 lb	112 lb	170 lb
Length	13 ft 2 in.	16 ft 1 in.	~28 ft
Elevator and fixed tail	19 ft^2	21 ft^2	15.5 ft^2
Front rudder	——	15 ft^2	17 ft^2
Glide ratio	5:1	<6:1	<7:1
Aspect ratio	3.8	6.4	6.4

[a]Chanute, O., "Recent Experiments in Gliding Flight," *Aeronautical Annual*, 1897.
[b]McFarland, M. W., "The Papers of Wilbur and Orville Wright, including the Chanute-Wright Letters and Other Papers of Octave Chanute."
[c]Wright, O., "October 1911 Diary," and Keimel, R., "100 Jahre Motorflug der Brüder Wright."

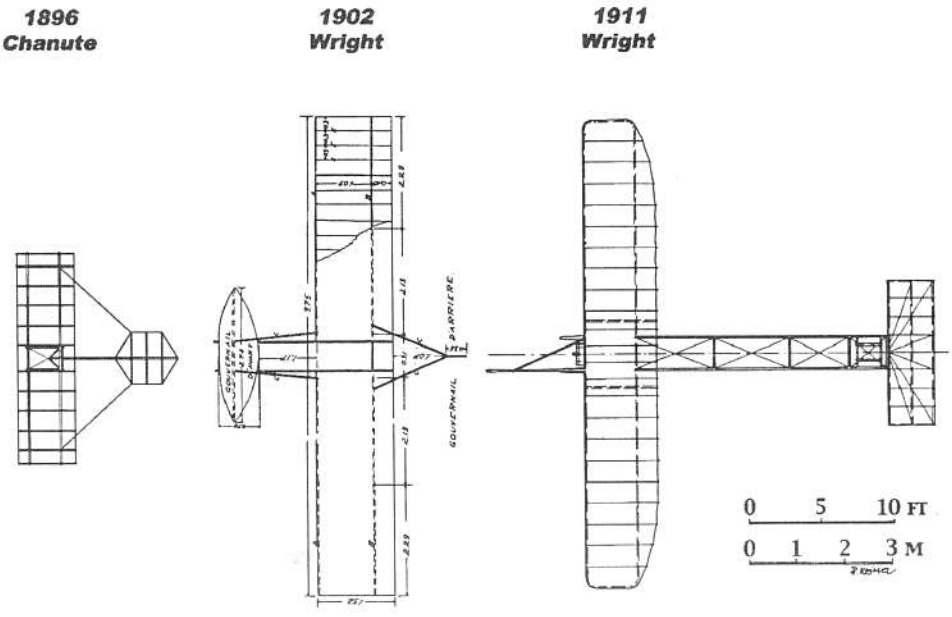

Fig. 24 Size and shape comparison: top view of the 1896 Chanute-type and the 1902 and 1911 Wright gliders.

Looking at the photos of the glider, one can see the design changes toward making the machine more stable and controllable. So, one asks, was it really an automatic stabilizer they were looking for? Or was the goal to find a more stable and controllable design for the aircraft which could then be incorporated into their next powered airplane to make it sell better?

A few weeks later, Orville Wright wrote to J. A. Heringa "... It is possible to use the power of the upward trend of air, and thus dispense with all artificial power. A better knowledge of these air currents, so that one could keep the machine constantly in the rising trends, would enable one to remain aloft without power much longer than has yet been done."[86]

The 15 years, between 1896 and 1911, brought significant improvements in the design of a successful aircraft. This development is documented in Fig. 24, showing the top views of the 1896 Chanute-type, the Wright 1902 (Ref. 87) and 1911 gliders (Ref. 88), and Table 1 gives the technical specifications for these three earliest soaring machines in a comparison.

Conclusions

1) The technology and practice of soaring flight and the emulation of the feats of the birds has been demonstrated and has become a fact during the past century. As with every field of technological achievement, the evolution of powerless flying is a continuing process.

2) Contemporary literature and photos indicate that William Avery and Augustus Moore Herring, associates of Octave Chanute, were airborne and extending otherwise shorter gliding flights to soaring flights of just over 10 s in September 1896. Possible, but not proven conclusively, was Herring's 48 s soaring flight in October 1896. For them, every second of prolonged flight gave extra time to learn about the mechanics of flight and the art of flying. The first glider flying experiments by the Wright Brothers, prior to December 1903, were a continuation of this evolution process. They succeeded to stretch their flying time to more than one minute with a more manageable glider, which enabled controlled turns. The extra flying time helped them learn how to fly the planes they designed.

3) The Wrights continued their research, improving their aircraft design for better stability and control. As part of these experiments, Orville Wright achieved the 9 min 45 s soaring flight with their 1911 glider.

4) Since then, many devices related to stability and control were first discovered or introduced using gliders. By using motorless craft, stability and control problems can be investigated simply, uninfluenced by turbulence and the effects of power. Methods to improved aerodynamic performance have been particularly studied and explored with and on sailplanes with good results, especially in the increase of aerodynamic efficiency. Sailplanes continue to be used as a practical laboratory tool for low-speed aerodynamic research.

5) In addition to its technological usefulness, the experimenters in gliding and soaring, as early as 1896, recognized the sporting attraction of soaring flight.

Acknowledgments

The author gratefully acknowledges the help and support of her husband Jim, a glider pilot, who is just as interested in the history of the sport as in the sport itself. Special thanks are also given Albion H. Bowers, NASA Dryden Flight Research Center, Edwards, California; Leonard Bruno, Manuscript Division, Library of Congress, Washington, DC; Tom D. Crouch, National Air and Space Museum, Washington, DC; Paul Dees, Boeing Commercial Airplanes, Seattle, Washington; Reinhard Keimel, Technisches Museum, Vienna, Austria; Urszula Kerkhoven, John Crerar Library, University of Chicago, Chicago, Illinois; Kevin Kochersberger, Rochester Institute of Technology, Rochester, New York; and Curt Lewis, Chicagoland Glider Council, Chicago, Illinois.

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[7]Wright, O., and Wright, W., "Flying-Machine," U.S. Patent No. 1,075,533, 1913.

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