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The Flying Man

Otto Lilienthal—History, Flights and Photographs

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The Flying Man

Otto Lilienthal—History, Flights and Photographs

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Images that traveled around the world: man can fly! © Otto-Lilienthal-Museum. All Rights Reserved

Preface

Otto Lilienthal was the first person to make well-documented, repeated, successful flights with gliders and became known as the *flying man*. This book is the long-overdue first modern, English-language biography of the German pioneer. In some sections, it follows the great aeronautical biography of Otto Lilienthal, written by Werner Schwipps in 1988 under the title *Der Mensch fliegt* (*Man can fly*). In 1966, Schwipps had published his first biography of Lilienthal. Many others followed, dedicated to specific aspects of Lilienthals lifes work. Schwipps' books have remained standard references for research on Lilienthal to this day.

In 1991, a museum opened in Lilienthal's hometown of Anklam in northern Germany, in which all the flying machines of the aviation pioneer were reconstructed. Its long-time director is one of the authors. The detailed drawings of Lilienthal's flying machines are taken from the estate of Stephan Nitsch, held by the *Otto-Lilienthal-Museum*. After 2016, the occupation of European aviation research with Lilienthal's flight technology attracted world-wide attention. Markus Raffel, the second of the authors, is Professor of Aerodynamics at *Leibniz University of Hanover* and Head of the *Department of Helicopters* at the *Institute of Aerodynamics and Flow Technology* at DLR,

the *German Aerospace Center*. After practicing hang gliding in France and California, he practically flew various authentic replicas of Lilienthals glider constructions.

Göttingen, Germany — Markus Raffel
Anklam, Germany — Bernd Lukasch

Acknowledgments

Many friends and aviation specialists made this book possible. In addition to Werner Schwipps, whose archives are now in the *Otto-Lilienthal-Museum* and the *German Museum of Technology* in Berlin, more recent research has been carried out especially at the *German Museum* in Munich and the *German Aerospace Center* (DLR). The authors would particularly like to thank Prof. Rolf Henke and Prof. Andreas Dillmann from the DLR, Charlotte Holzer from the *German Museum*, Tom Crouch from the *National Air and Space Museum*, Lewis Wyman from the Manuscript Division at the Library of Congress, Andrew Beem of *Winsports* in Los Angeles, the owner of *Kity Hawk Kites*, the hang gliding school on the Outer Banks, John Harris and his team of flight instructors lead by Billy Vaughn.

Special thanks go to Simine Short, author and aviation specialist at the *National Soaring Museum* in Elmira/New York, who has been in close contact with the authors for some time and has checked the manuscript critically. The authors would like to extend their sincere thanks to the editors Hal Brian (EAA), Angela Lahee (Springer), and Johannes Braukmann for their assistance at the final stage of manuscript preparation and for their insightful comments and suggestions.

The chapter *To fly is everything* contains excerpts from Paul Glenshaw's article *More Than a Century Later, Lilienthal and Wright Gliders Fly Together for the First Time at Kitty Hawk* originally appeared in *Air and Space/Smithonian Magazine*, January, 2020, and is used with his permission.

The poem of Otto Lilienthal, missing in the 1911 English edition, was translated by M. Buckow and G. Evans, Greifswald.

The annexes about the wind tunnel and flight tests of the patented monoplane, the large biplane and the experimental monoplane replicas are excerpts from articles published in the *AIAA-Journal of Aircraft* by Markus Raffel and his co-authors Felix Wienke, Pascal Weinhold, Clemens Schwarz, and Andreas Dillmann from DLR.

The reconstruction and detailed drawings of Lilienthal's flying machines are taken from the estate of Stephan Nitsch, held by the *Otto-Lilienthal-Museum*.

About This Book

"*Of all the men who attacked the flying problem in the nineteenth century, Otto Lilienthal was easily the most important. His greatness appeared in every phase of the problem. No one equaled him in power to draw new recruits to the cause; no one equaled him in fullness and dearness of understanding of the principles of flight; no one did so much to convince the world of the advantages of curved wing surfaces; and no one did so much to transfer the problem of human flight to the open air where it belonged.*"

These words were spoken by Wilbur Wright, who successfully accomplished the first powered flight together with his brother Orville in 1903 on the sand dunes of the Outer Banks off the coast of North Carolina.

Lilienthal attracted worldwide attention due to a series of spectacular photographs showing him in flight, images made possible by technology that had only just been developed. This fortuitous union between a pioneer of aviation and the pioneers of so-called "instantaneous photography" is responsible for the immense contemporary popularity of Lilienthal's flights around the globe, the first ever free and successful heavier-than-air flights performed by man. This book traces the life of the German aviation pioneer, focusing on the designs of his many aircraft and the photographic documentation that has survived. The book also concludes with a spectacular research project conducted by one of the authors, right up to and including his own training exercises with exacting replicas of three of Lilienthal's designs. This project

offered new insight into Lilienthal's work, but it also allowed for a spectacular meeting to unfold between replicas of Lilienthal's 1895 biplane and the Wright brothers' 1902 biplane in the air at a historic location on the Outer Banks in North Carolina.

Contents

About the Authors

Markus Raffel (*1962) is Professor of Aerodynamics at *Leibniz University of Hanover* and Head of the Department of Helicopters at the *Institute of Aerodynamics and Flow Technology* at DLR, the *German Aerospace Center*. He started at DLR in 1991, working in the field of experimental aerodynamics. Raffel is the recipient of several science awards from German, French, and US research organizations (e.g., *German Metrology Institute, French National Centre for Scientific Research, American Helicopter Society*). He has published more than 150 journal and conference papers and is the leading author of the widely distributed textbook *Particle Image Velocimetry*, about the most common optical flow diagnostic technique today.

After a short flying course with glider aircraft, he became interested in flying. He obtained his private pilot certificate and flies single engine and light-sport aircraft in Europe and in the USA. However, after practicing hang gliding in France and California, in preparation for flying Otto Lilienthal's monoplane, he admits that, for him, gliding with ultralight aircraft is the most exhilarating way of flying. He continues to enjoy flying whenever he finds time to do so.

Bernd Lukasch (*1954) studied physics at the *Humboldt University* of Berlin and earned his doctorate in 1984 after completing his thesis on *Atomic Collisions in Solid State Physics*. In 1988, he helped found the *Otto-Lilienthal-Museum* in Anklam which opened in 1991. Lukasch took over the management of the museum in 1992 and remained its director until 2019. Under

his leadership, the museum was awarded the title *National Memorial* by the State Minister for Culture and Media of the Federal Republic of Germany and the *European Museum of the Year Award—Special Commendation* by the *European Museum Forum*.

Bernd Lukasch is the author of a biography about both Lilienthal brothers *Erfinderleben* (*inventors' lives*, 2005) and the author/editor of numerous publications in popular and history journals.

The Beginning of an Era

Why are we interested in the past? Why do we study history? If we could, we would undoubtedly try to look into the future also and study what's to come. But, sadly, we don't yet have this power. Historians look back because, as the saying goes, "*the future comes from the past*". We don't know whether today's news, with so much noise and sensationalism, includes even one thing that might still be remembered in 10 years, much less 100. Something that would make people say, "*That's when it started. Nobody knew it at the time, but that's when the world changed*." For subsequent generations, certain names, dates, and events become synonymous with turning points, signposts of the end of one era and the beginning of the next—Archimedes, Galileo, Columbus, Einstein, and many more. The twentieth century has gone down in history as a century of world wars and great social upheaval, but also one of industrial and technological revolutions. Most importantly for our purposes, it was the century that brought us air and space travel.

The "*conquest of the heavens*" began more than 200 years ago with two French brothers named Montgolfier. In 1783, humanity defied gravity when a balloon of the brothers' design carried two people on the first successful manned flight in recorded history. The appeal of flight remains as strong today as it ever was—in Europe, they still call balloons "*Montgolfieres*" and celebrate November 21, the date of the first manned ascent, as "*Montgolfier Day*". Hundreds of years earlier, the Chinese regularly flew man-carrying tethered kites, and largely apocryphal stories abound of those who affixed

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crudely built wings to their arms or backs and took leaps of faith that invariably ended badly.

We all know that date of the dawn of the century of air and space travel—December 17, 1903, when the Wright brothers made the first successful, documented, and controlled powered flight on the sand dunes of Kitty Hawk in North Carolina. But, when you dig deep, world-changing accomplishments are never as simple—nor as uncontested—as history eventually remembers them. People like Smithsonian Secretary Samuel Pierpont Langley in Washington, D.C., and the subsequently controversial Gustave Whitehead of Connecticut, not to mention George Cayley in England, Clement Ader in France, and Richard Pearse in New Zealand had experimented with what notable inventors like Alexander Graham Bell and Thomas Edison called "*the flying machine problem*." But it was Orville and Wilbur Wright who made history, not because they flew 852 feet that cold December day, but because the age of aviation began with them. While the world was initially skeptical—news travelled a lot more slowly back then—once the Wrights began publicly demonstrating their aircraft in the United States and particularly in Europe, starting in France in 1908, their achievements were recognized, and Kitty Hawk and 1903 were enshrined in the history books. Powered and controlled human flight was proven possible, and the ancient myths and superstitions that had surrounded mankind's eternal dream to fly like a bird gave way to the technological history of the airplane.

The Wright brothers worked with remarkable efficiency, discipline, and determination. They analyzed, tested, and expanded on the world's body of aeronautical knowledge in less than a decade. They gleaned information wherever they could, but generally credit three key sources as they studied the nascent sciences of aviation: Octave Chanute of Chicago, editor of the *American Engineer and Railroad Journal*, and its spinoff called *Aeronautics*; Frenchman Louis-Pierre Mouillard, author of the book *The Empire of the Air*; and Germany's Otto Lilienthal who published the book *Birdflight as the Basis of Aviation* in 1889, and had himself been flying a series of pioneering gliders since 1891. The astonishing photos of Lilienthal made news around the world from 1893 on, and the Wright brothers themselves said that his fatal accident in 1896 was the catalyst they needed to turn their attention to flying.

While Lilienthal's book was not translated into English until 1911, the Wrights acquired a German copy, with a few key translated passages provided by Chanute. In 1912, Wilbur Wright wrote the following about Lilienthal:

"Of all the men who attacked the flying problem in the 19th century, Otto Lilienthal was easily the most important. His greatness appeared in every phase of the problem. No one equaled him in power to draw new recruits to the cause; no one equaled him in fullness and dearness of understanding of the principles of flight; no one did so much to convince the world of the advantages of curved wing surfaces; and no one did so much to transfer the problem of human flight to the open air where it belonged.

As a missionary he was wonderful. He presented the cause of human flight to his readers so earnestly, so attractively, and so convincingly that it was difficult for anyone to resist the temptation to make an attempt at it himself, even though his sober judgment and the misfortunes of all predecessors warned him to avoid touching it. If Lilienthal had done nothing more than this he still would have been one of the greatest contributors to the final success. But he was much more than a mere missionary.

As a scientific investigator none of his contemporaries was his equal. He set forth the advantages of arched wings in such convincing manner as to make him the real originator of this feature. [...]

Lilienthal was the real founder of out-of-door experimenting. It is true that attempts at gliding had been made hundreds of years before him, and that in the nineteenth century, Cayley, Spencer, Wenham, Mouillard, and many others were reported to have made feeble attempts to glide, but their failures were so complete that nothing of value resulted.

[… Whatever Lilienthal's] limitations may have been, he was without question the greatest of the precursors, and the world owes to him a great debt."

By the end of the nineteenth century, Lilienthal had successfully flown hundreds of times over distances of up to 800 feet in a series of more than a dozen gliders of his own design. In addition, he'd also manufactured and sold a series of gliders, one of which was purchased in 1896 by legendary publisher William Randolph Hearst for promotional purposes and survives to this day on display at the *Smithsonian Institution's National Air and Space Museum* in Washington, D.C.

Lilienthal was a successful designer and pilot, and had even been experimenting with different types of propulsion and control systems. Does this mean that the Wright brothers' fame is misplaced? In a word, no. Of course not. But it's hard to say how successful they would have been without the groundwork, and, perhaps more importantly, the inspiration provided by Lilienthal.

Lilienthal deciphered the secrets of lift and proved that the wings he designed could carry a person. He studied birds and learned to fly like one,

bringing the ancient myth of Icarus to life. Lilienthal's studies and experimentation led him to make significant contributions to the young science of aerodynamics. But it wasn't science that made him famous—it was art. Ottomar Anschütz, Lilienthal's most prominent photographer, had, like his pioneering contemporaries, embraced the concept of short exposure photography, using new equipment he'd invented himself. These "snapshots" had supplanted the work of portrait painters over the years, with photographs quickly becoming the new standard for documentation. Anschütz inscribed the phrase *Nach dem Leben aufgenommen*, which translates to *captured true to life* on each photo he produced of one of Lilienthal's flights. The message was "man can fly", and it spread rapidly around the world, armed with photographic proof. It was a lucky coincidence that these developments in photography were happening at the same time as Lilienthal's pioneering flights. Without the photographs, it seems unlikely that his book would have ever piqued the Wright brothers' interest.

For those who saw them in person, Lilienthal's flights were an impressive spectacle, but they were seen more as an artistic achievement, as opposed to the dawn of a new technological age. Lilienthal crashed on August 9, 1896 and died the next day. The *flying man* was gone, and a vital chapter in the development of aviation had come to an end. Lilienthal's achievements were largely forgotten until the Wright brothers made their own flights in Germany more than a decade later. By then, Lilienthal's built-up flying hill, runway, and hangar had fallen into disrepair.

It is amazing to reflect on the fact that barely a quarter of a century passed between Lilienthal's gliding tests and the airborne battles of World War I. The technology of aviation has progressed at an almost unimaginable pace, while the idea of flight remains the dream of so many. Lilienthal's efforts, like aviation itself, represent both the romance of man's visceral, age-old yearning to fly, and the science that it took to make it a reality.

When Lilienthal imagined the future of flying, commercial flights and military aviation were not what he had in mind. To him, flying would be a sport (similar to the sport of soaring today), even a cultural institution that existed to bring those ancient dreams to life. He occasionally wrote about these predictions, imagining a future where the ability to fly was so profoundly world-changing that it broke down barriers between people and nations.

> "*I, too, have made it a lifelong task of mine to add a cultural element to my work that should result in uniting countries and reconciling their people. Our experience of today's civilization suffers from the fact that it only happens on the surface of the earth. We have invented barricades between our countries, custom regulations and*

constraints, and complicated traffic laws. These are only possible because we are not in control of the 'kingdom of the air', and not as 'free as a bird'.
Numerous technicians in every nation are doing their utmost to achieve the dream of free, unlimited flight and it is precisely here where changes can be made that would have a radical effect on our whole way of life. The borders between countries would lose their significance because they could not be closed off from each other. Linguistic differences would disappear, as human mobility increased. National defense would cease to devour the best resources of nations as it would become impossible in itself. And the necessity of resolving disagreements among nations in some other way than by bloody battles would, in its turn, lead us to eternal peace. We are getting closer to this goal. When we will reach it, I do not know."

Lilienthal's utopian vision of the benefits of aviation makes it all the more tragic that Germany's collective memory of him and his legacy is so closely tied to the two world wars, not to mention the many ways in which his story was coopted by the *National Socialists* for propaganda purposes. Lilienthal was idolized as a hero by the German air forces, which perhaps explains why no comprehensive biography of the man has been published in English to date, though there are many in German. Lilienthal's legacy and body of work have been studied, and his scientific and technical achievements have been scrutinized and published in biographical form—a selection of these writings is listed in the appendix. Besides the history of aviation itself, several books have also been written about the many-faceted personalities of Otto and his brother Gustav. Werner Schwipps, a scientific journalist from Cologne, has written about Lilienthal from multiple different perspectives for decades. In Germany, he is considered the father of Lilienthal biographers. The latest of his biographies was published in 1988, entitled *Der Mensch fliegt* or *Man Can Fly*—Historic Photographs of Lilienthal's Flight Experiments. Schwipps' book provides the foundations of this one—the first ever comprehensive English-language biography of Lilienthal. Since then, the previously incomplete photographic legacy of Otto Lilienthal has been extensively studied at the *Otto-Lilienthal-Museum* in Lilienthal's birthplace of Anklam, providing another resource for the foundations of this book.

From 2016 to 2019, the *German Aerospace Center* conducted a spectacular research program. At an aerodynamic research institute founded in Göttingen in the early twentieth century, co-author Markus Raffel oversaw a renewed scientific investigation featuring aerodynamic, flight, and mechanical studies of Lilienthal's three basic aircraft designs—his production glider, his large

biplane, and his experimental monoplane performed using modern aeronautical research equipment. This research program attracted interest from around the globe. The final part of this book is devoted to the experiments performed as part of this reverse engineering project, offering new insight that would never have been possible without a practical understanding of Lilienthal's approach to flight.

The Sky Over Pomerania

It might be surprising to learn that the search for the roots of human flight leads us not to a big city, not to some prestigious international university, not to a center of technological progress, but to a small town in the north of Germany near the Stettin Lagoon near the Baltic Sea. Why did it take until nearly the dawn of the atomic age for people to glean the secrets of flight from nature? They really weren't even that much of a secret—for thousands of years, birds have been circling in the sky above the heads of envious men, butterflies have been flapping their colorful wings, and bees have been buzzing from blossom to blossom.

> "*One could almost get the impression that the stork was created specifically to incite the desire to fly in us humans, and to serve as our teacher in this art,*"

is how one book described it, today considered the origin of the physics of wings. The book was printed in Berlin, the booming capital of Germany, in 1889, some 41 years after its author was born in the small Pomeranian town of Anklam, near the Baltic Sea. Otto Lilienthal, the first of eight children born to the cloth merchant Gustav Lilienthal and his wife Caroline, came into the world on May 23, 1848 in the shade of the mighty *St. Nicholas Church*, a typical example of the northern German brick Gothic style with a tower looming 103 m above the wide flatlands into the sky, a testimony to the glory of God and the city's pride and wealth. His brother Gustav was just a year and a half younger. Otto Lilienthal remained close with Gustav

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throughout his whole life, growing up with him, going to school with him, and watching the storks in the floodplains near the city with him. Gustav helped him make a set of artificial wings from goose feathers, as well as a massive, flapping-wing device with a wingspan of six meters, which they built and tested together. He laid with Gustav in the grass, gazing up at the sky, and wondering why the storks that circled above them were able to glide so effortlessly without ever falling, or even needing to flap their wings.

Three decades would pass between the Lilienthal brothers' forays into nature and their childhood and adolescent inventions before the images of Otto the flying man literally travelled around the world. During this time, the brothers lost their father at a young age, Otto served in the Franco-Prussian War, watched as balloons left behind a besieged Paris, and lived in Berlin as a *bed-renter* who had to share a bed with several other tenants. He studied mechanical engineering at the *Berlin Trade Academy*, later the *Technical University of Berlin*, was hired at his first job, and founded a factory to manufacture steam boilers and small wall-mounted steam engines. After several design iterations, Otto Lilienthal's factory became the world's first aircraft manufacturer in 1893. For the first time in history, flying machines were being regularly produced in series. Built from willow wood and cotton fabric, those early gliders, based on his *Normalsegelapparat* (literally, normal soaring apparatus) design were available for purchase in multiple countries for 500 marks. That's the rough equivalent of six months' salary for an average skilled German laborer of the day, though Lilienthal's customers were likely more well-heeled than that. It's believed that Lilienthal sold nine of the gliders, and surviving examples are displayed in London, Moscow, and Washington, D.C. Another model, one that he used himself, is on display in the *Deutsches Museum* in Munich.

Lilienthal built a dozen or so other designs that he used for testing control methods, performance improvements, and even a flapping wing mechanism. One of these test models, the so-called *Sturmflügelapparat* (*Storm Wing Apparatus*), has survived the test of time—today, it can be found in the *Technical Museum* in Vienna. Our understanding of these other designs of Lilienthal's largely comes from an entirely different invention that Lilienthal encountered while studying the wings of the white stork.

In 1884, the photographer Ottomar Anschütz presented a series of photographs of storks in Berlin, which caused quite a sensation. At the time, small photographs called *carte de visite* were popular items to collect and give as gifts. Given the state of camera technology at the time, photographs required extremely long exposure time, which made taking pictures of things like live wild animals virtually impossible. Anschütz had worked on this

Fig. 1 Ottomar Anschütz: *Storks No. 38*, 1884. © Otto-Lilienthal-Museum. All Rights Reserved

problem for quite some time, and razor-sharp images of the birds nesting and flying proved that he had finally succeeded. He kept the technique secret for years, but, in 1888 patented a high-speed camera whose focal plane shutter was located immediately in front of the light-sensitive photographic plate. This innovation provided the basis for all subsequent mechanical exposure systems and enabled him to capture photos at high shutter speeds, compared to seconds or even longer in typical cameras of the day. This invention enabled him to do what photographers had dreamt of for a half century or so—take pictures of objects in motion.

Lilienthal owned some original prints of the stork photographs. Having chosen the white stork as his "teacher", he was undoubtedly delighted at the ability to study these incredibly clear and precise depictions of the birds' wings in flight. In a nice bit of symmetry, just a few years later, Anschütz photographed Otto Lilienthal during flights near his home on the outskirts of Berlin (Fig. 2).

Lilienthal's flights were no secret in Berlin; he could be spotted by the public almost every weekend after 1894. Lilienthal's *Fliegeberg*, literally *Fly Mountain*, an artificial hill he'd built near his home as a place to test his gliders, became a tourist attraction for Berliners. Today, onlookers would simply pull out their mobile phones and effortlessly record every flight as

Fig. 2 Ottomar Anschütz mounted each of his photographs onto a cardboard frame with the inscription "Nach dem Leben aufgenommen von Ottomar Anschütz" [Captured true to life by Ottomar Anschütz]. Otto Lilienthal in flight on August 16, 1894. ("see Fig. 12, page 122").

a high-resolution video. And indeed, besides Anschütz himself, several other photographers watched Lilienthal fly and captured his feats on their new and improved cameras. That small group of photographers was generally centered in Berlin, so it's not surprising that the vast majority of photographs of Lilienthal were taken at the *Fliegeberg*—it was only on two occasions that he was able to entice a photographer to visit his "*high performance flying grounds*" in the Rhinower Mountains, a two-hour, 100-km train ride from Berlin. Only a few photos exist of his 250-m flights that area, the last of which, in 1896, took a fatal turn.

The only photographs relating to his accident are two images that show the damaged flying machine in the courtyard of his factory in Berlin, taken days later, likely as part of the police investigation. The circumstances of his final flight are shrouded in controversial eyewitness accounts and conjectures, some plausible and others less so.

The spectacular and striking photographs of the first flying man not only impressed Lilienthal's immediate successors, but most importantly left their mark on the Wright brothers themselves. Generations of pilots have

viewed themselves as Lilienthal's descendants, and his imposing personality and breakthroughs in flight inspired more than a few to try it for themselves. Some of the most recent successful examples of those following in Lilienthal's footsteps are discussed at the end of this book.

From Poor Student to Excellent Scholar

"Nothing is better for developing a serious outlook on life than seeing your siblings lying cold and pale, robed in white, surrounded by flowers, in a child-sized coffin."

At a very young age, Otto and Gustav Lilienthal lost four sisters and one brother. Their deaths can be attributed to unsanitary living conditions, sleeping in windowless chambers with dry rot underfoot, and a lack of medical care, according to what Otto later wrote in a family history. Three of their siblings died before age one. The fourth, Wilhelmine, was just four when she died. The two boys were very aware of her death, as they had already developed a close personal bond with her. Otto, the eldest sibling, was born in Anklam on May 23, 1848, with Gustav following suit on October 9, 1849. Regarding his relationship with his brother, Otto Lilienthal later wrote:

"*My brother Gustav was and is my second self.*"

This statement is especially powerful given that Otto wrote it at the age of 46.

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> "*Not only did we share all of our joys and sorrows in early childhood, he wrote, we also undertook all of our foolish pranks and sensible ideas together; not only did we share the same nurturing influence of our excellent mother, but we also advanced toward the same worldview in our ongoing self-education. Many of our biggest undertakings were a joint effort.*"

In his brother Gustav, Lilienthal saw a

> "*shining proof that diligence and perseverance in self-improvement provide greater momentum for achieving greatness than early giftedness.*"

Gustav was only a bad student when forced to struggle with ancient languages in high school. Later, at the newly built middle school in Anklam, he would finally find something that captured his interest, and Otto would undoubtedly have described himself in the same way. He also completed high

Fig. 1 The brothers Otto and Gustav Lilienthal, 1862. *Photo* A. Regis.