HISTORICAL NOTE

Albrecht Ludwig Berblinger – Inventor of the Spring-Prosthesis and Hang-Glider (1811)

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Albrecht Ludwig Berblinger (1770–1829), known as the "Flying Tailor of Ulm," started with flight experiments in Ulm, Germany, in the early 19th century. He gained experience in downhill gliding with a maneuverable airworthy semi-rigid hang glider and then attempted to cross the Danube River at Ulm's Eagle's Bastion on the 31st of May 1811. The tricky local winds caused him to crash and he was rescued by fishermen, making him the first survivor of a water immersion accident of a heavier-than-air manned "flight machine." Though he failed in his attempt to be the first man to fly, Berblinger can be regarded as one of the significant aviation pioneers who applied the "heavier than air" principle and paved the way for the more effective glide-flights of Otto Lilienthal (1891) and the Wright Brothers (1902). Less known are Berblinger's significant contributions to the construction of artificial limbs for medical use, as well as the spring-application in aviation. His invention of a special mechanical joint was also used for the juncture of the wings of his "flying machine." Because of his worthwhile contributions to medicine and flight, in 1993 the German Academy of Aviation Medicine named an annual award for young scientists in the field of aerospace medicine in his honor.

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ALBRECHT LUDWIG BERBLINGER (1770–1829), known as the "Flying Tailor of Ulm," was born in Ulm on the June 24, 1770, as the seventh son of a bootmaker and servant of the city's arsenal and a farmer's daughter from Temmenhausen. Only one day later his christening ceremony took place in the city's cathedral. After his father's untimely death in 1783, he was taken, along with his two younger brothers, to the city's orphanage where he stayed for about a year. By the age of 21, the dexterous Berblinger had become a master tailor. A year later, he married Anna Scheiffelin, the daughter of a boatman, and they had six children.

Berblinger was not satisfied with his successful tailor business, and the interests of this gifted worker became focused more and more on mechanical engineering, where he achieved significant results (6).

Berblinger's Contributions to the Field of Orthopedic Mechanics

After Napoleon's Army defeated the Austrian troops in front of the Ulm city walls in 1805, Berblinger "detested the horrible look of the stilts and crutches of people with amputated feet" (9). In addition, other traumatic foot and leg amputations thereafter made him realize the need for a better treatment (6). Berblinger constructed an artificial leg with a special spring device in the knee. While Ambroise Pare (1510–1590), a French Army barber-surgeon, made the most significant contributions to early amputation surgery and prosthesis development, he had no known influence on Berblinger, who is credited with designing a modern flexible mechanical joint (**Fig. 1**) (11). Design, structure, and materials for prosthesis remained largely the same in Germany until the middle of the 20th century. An irony of history is that decades later, after World War II, at the USAAF Aeromedical Center in Heidelberg, located near Ulm, the German Drs. Ulrich Henschke and Hans Mauch developed a hydraulically controlled artificial leg (1). The practicality of Berblinger's prosthesis was recognized by the physicians Buerhlen and Palm from the Ulm Royal Hospital in 1808, as they explicitly acknowledged the "new idea" and the function of Berblinger's artificial leg. Palm's son, Johannes, later wrote his medical thesis "De pedibus artificialibus" (About Artificial Feet) (6).

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In a letter to the King, Berblinger requested the right to make advertisements for his invention (6):

> The humble signatory has, from early youth, had a special inclination toward mechanics, however the early death of his parents and poverty resulted in his being brought up in an orphanage and after leaving this there was the necessity of learning a suitable trade, namely tailoring. Meanwhile, in his free time, he could not avoid satisfying his favorite inclination. In the city of Ulm where he has been established for several years, there occurred, one after the other, amputations of feet due to accidents; the gruesome picture of the wooden-legs and crutches which caused abhorrence – especially in pregnant persons – made him think of manufacturing a machine which would allow the victim to walk as with a natural foot.

Berblinger put an attestation by the local police to his request dated March 1, 1809, which was addressed to the King. The certificate testified that Berblinger had repeatedly manufactured leg prostheses which met the

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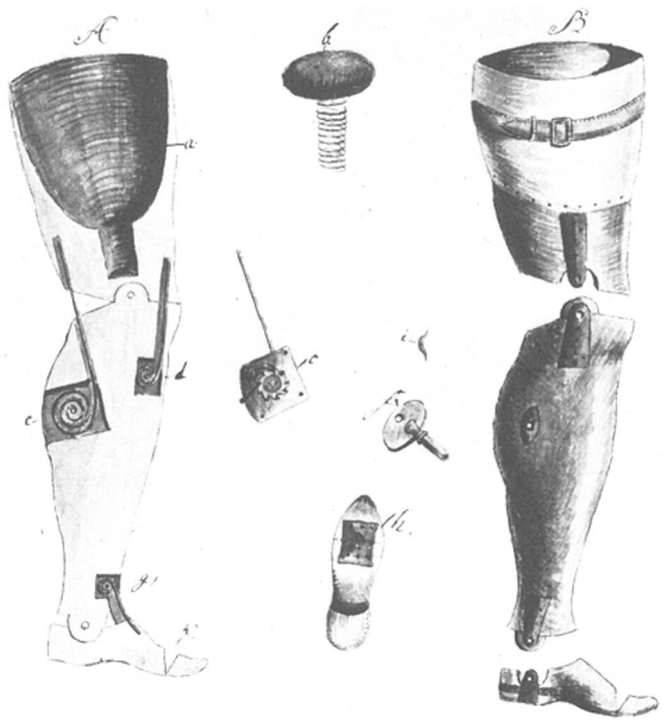

Fig. 1. Albrecht L. Berblinger's "leg machine" after his original drawing. From the Ulm city archives. A) The complete artificial foot as a longitudinal cross-section in order to show the chambers housing the springs. B) The whole machine showing the dissection and hinging.

expectations and demands of the expert authorities. Though Berblinger's invention was regarded as a significant progress in medicine, the right advertising for it was denied by the Minister of State, Baron von Montgelas, on the 29th of the same month with no explanation of why (6).

Berblinger's Contributions to the Glide-Flying

Berblinger's applied his engineering skills related to the orthopedic domains to the field aviation. Berblinger's mechanical straightening joints allowed movements of the knee and ankle joints by means of springs, which could be adjusted by a tool in the center of the joint. When applied to glider design, this mechanism allowed the angle of the two wings to be changed to a slightly aerodynamically advantageous v-form, protecting them from collapsing from strain in flight (3).

In 1810 or 1811 Berblinger manufactured, with reference to the flying apparatus of the Austrian watch maker Jakob Degen (1760–1848), a semi-rigid hang glider. Berblinger used most of the same materials (wood, whalebone, silk, silk cord and glue), the form of the wings, as well as their stringing and covering, and did away with the wing flaps and the entire lever mechanism. By economizing on Degen's motorized mechanism to drive the movable wings, he lightened the weight and gained leg freedom for the run up and landing. Additionally, he shifted the center of gravity of his flyer forward, contributing to an acceptable glide path of his construction. Its braced stability and upwardly vaulted wings connected by semi-rigid joints and a tail already featuring simple aerodynamic elements enabled him to repeat gliding hops (3,5).

Since Berblinger did not provide a technical painting of his flyer, it remains unclear what exactly was the mechanism of the wing connection. **Fig. 2** does not make it any clearer, as by the clothing (garment, scarf, and forelock) and technical details it seems to be a close copy of the Degen painting. However, it seems certain that Berblinger constructed wing connections with a very small vertical backlash. The wings were tied to each other behind the flyer's back with a mechanical straightening mechanism like those of his leg-prostheses. The suspenders shown seem to be a relic of the Degen flyer, with no obvious function in Berlinger's flyer (3). F2

The Degen flyer from 1807 weighed 25 lb and used the flap-valve principle: about 3500 flaps opened during the upstroke and closed during the downstroke. The movement was induced by the power of the arm and leg muscles (5–7,10). Up to this time, most deliberations, plans, models, and lifesize constructions were designed as flying machines with movable, flapping wings to be moved by muscular power (6,10). Interestingly enough, 150 yr earlier, this principle was also given up by Robert Hooke (1635–1709) in Westminster, England. Hooke was interested in the "art of flying" and tried to invent machines operated by human muscle power. However, by his own experiments and deskwork calculations, he realized that human muscles were not sufficient for flying machines heavier than air (12). Realizing this, Degen adapted his idea by attaching a hydrogen balloon, providing his "flying machine" the necessary uplift (6). Berblinger brought his "flying machine" back to the origins following the principle of "heavier than air." He abandoned the hope of getting airborne with it, rather using it as the first-ever glider, intending to sail downward like the "crows from the tower of Ulm cathedral." Like Otto Lilienthal, honored as the first man

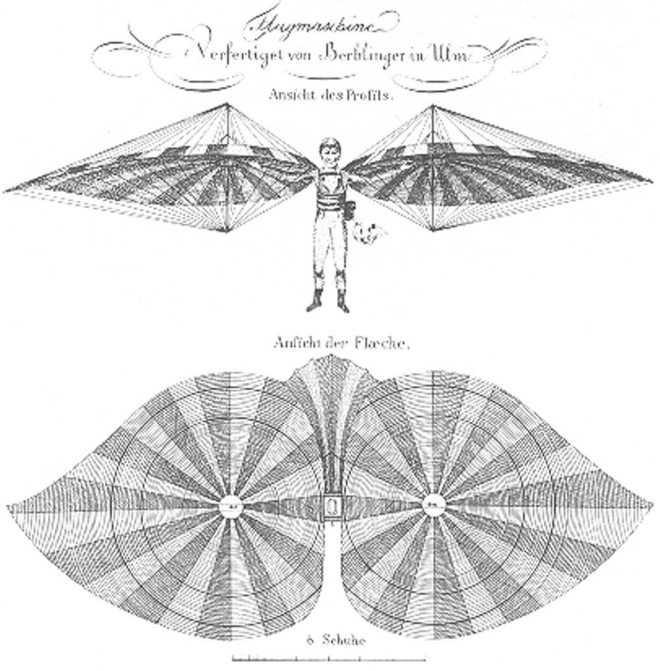

Fig. 2. Flight apparatus of Ludwig A. Berblinger. Copperplate by Johannes Hans. From the Ulm city archives.

to fly, Berblinger observed carefully how birds flew in order to apply it to hang-gliding (4).

It is likely that Berblinger was assisted by his journeyman tailors in the manufacturing of the flyer and on his secret test flights. This, however, could not be kept totally confidential and the experiments were observed by some fellow citizens. One of them, Eduard Leube, remembered having seen Berblinger jumping on the Michelsberg from one summer house downhill to another, which was witnessed and verified also in several poems, and by a father and his son in a report from a local newspaper (5,6). Thereafter his flying apparatus was presented at the Golden Cross Inn (Gasthof zum goldenen Kreuz). The flight demonstration from the Eagle's Bastion was announced in the local newspaper "Schwaebischer Merkur" on April 24, 1811 (6,9).

> After unspeakable efforts over a period of many months, the sacrifice of a very large sum of money and with the complete application of the study of mechanics, the undersigned has succeeded in inventing a flying-machine with which he will make his first attempt here in Ulm in a few days time, for the success of which, being reinforced by the opinions of many with artistic expertise, he does not have the slightest doubt. From today until the day of the attempt which, together with the exact timing, will be announced in this newspaper, the machine is displayed for public viewing and examination in the rooms of the Golden Cross Inn. Berblinger.

One month later, Berblinger announced in the same newspaper (Schwaebischer Merkur, May 27, 1811) his flight demonstration for the afternoon of the 4th of June if the weather was favorable. However, he brought his demonstration forward to the 30th of May as the main attraction for the forthcoming visit of the King of Wuerttemberg. The committee organizing this event—it was, by the way, led by its chairman Count Zeppelin, the grandfather of the later famous airship constuctor—shied away from requiring the King to move up to the Michelsberg located at a 30-min distance. The demonstration for King Friedrich the First, his company, and many spectators was scheduled to take place, for convenience reasons, within the town. Berblinger was instructed to fly across the, at that time 40-m wide, Danube River, starting from the Eagle Bastion (5,6).

By his glide hops, Berblinger achieved about 4 m of glide path after jumping from the 2-m buildings, meaning a glide ratio of about 1:2 (Otto Lilientahl's advanced hang gliders had a glide ratio of 1: 8). Berblinger, who was a complete autodidact and intuitive experimentalist, did not know much about aerodynamics or thermal currents and he knew even less about the ever-present turbulence and downdrafts in the area around the Eagle Bastion. However, from experience on the Michelsberg, he did see a need to raise the starting point of the ca. 13-m high Eagle Bastion by another 6 to 7 m by means of a wooden rack (10).

Due to a broken wing, the demonstration was postponed to the next day. As the spectators had already paid their fee, Berblinger needed protection by the King from the furious crowd. The master weaver Christian Wachter wrote that the King ordered him to repeat the demonstration the following late afternoon (6). Though the weather conditions at the Eagle Bastion were not favorable for a glide flight, due to turbulent tailwind conditions with suddenly occurring downwind drafts, Berblinger was under obligation to undertake his previously announced dangerous flight attempt. He failed and crashed into the Danube River. Luckily enough, he was rescued by fishermen, making Berblinger the first survivor of a water immersion accident of a heavier-than-air manned "flight machine" (6).

Due to this historic failure, Berblinger's was exposed to continuous general mockery and his economic decline and fate were sealed. Jobs with the city's army as a tailor of the K. Cheveaulegers-Regiment No. 1 did not change his social decline, rather they prolonged his martyrdom. A couple of years later, the social status of Berblinger reached its nadir and he died in 1829, ostensibly of consumption in the Ulm poorhouse (6).

It was not only Berblinger's flying appartus that went down in the Danube River, but also his reputation and the idea of glide flight. It took another 80 yr until the flight pioneer Otto Lilienthal (1848–1896) from Anklam restarted the glide idea. However, by methodical and technical superiority, Lilienthal was the first man to fly (glide) in 1891, followed by the Wright Brothers in 1902. In 1895 Lilienthal stated: "Artificial flight may be defined as that form of aviation in which a man flies at will in any direction, by means of an apparatus attached to his body, the use of which requires dexterity of the user" (www.lilienthal-museum.de). By this definition, Berblinger in part pioneered the glide flight idea.

Max Eyth's historical novel about Berblinger was a bestseller in the early 1920s of the 20th century, the pioneer years of aviation. The 1923 edition sold 86,000 copies. The story of a man born 200 yr too early [as stated in the subtitle of this 800-pg book, a poem is presented stating that the idea of flying will outlast the unsuccessful attempts, as first happened with Ikarus (Therefore do not mock him so, O man [O man], when once again an Ikarus arises)] (2). But since then caricature postcards, poems, and plays have appeared that do not take into account Berblinger's courage and visionary contributions to medicine and aviation.

The Berblinger apparatus met the basic requirements for an airworthy glider: nose-heaviness; low weight and sufficient strength and stiffness; and enough ground clearance to ensure a safe takeoff run and landing (5). During recent years rebuilds have turned out to be flyable (10). The Berblinger-flyer was rebuilt 140 yr later by the Hirth-Werke and flight tested by Manfred Herter (8,10). This glider is exhibited today at Ulm Town Hall, demonstrating the advanced wingform of the glider (**Fig. 3**). In 1986, 175 yr after Berblinger's failure, the city F3
of Ulm organized its first flight competition with the goal of crossing the Danube. A Berblinger award was founded 2 yr later to support innovative flight construction. In 1996 a solar-energy-driven single-seater won this award. In 2006, the Berblinger award was again advertised with the goal of sponsoring a project to be presented at the next flight competition in the year 2011, the 200-yr anniversary (www.berblinger.ulm.de). In addition, since 1993 the German Academy of Aviation Medicine has recognized Berblinger's contribution to

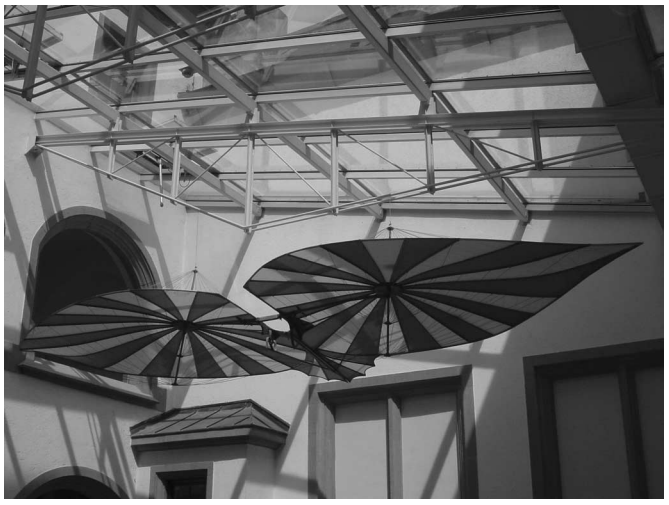

Fig. 3. Replica of Berblinger-glider with its advanced wingform at Ulm Town Hall. Photo by J. Kriebel.

aviation by sponsoring a yearly award named after him for young scientists in the field of aerospace medicine (www.flugmed.org).

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