

"THE FLYING MAN."

OTTO LILIENTHAL'S FLYING MACHINE.

BY VERNON.

HERR OTTO LILIENTHAL, of Berlin, who has attained some celebrity as "The Flying Man," was born forty-six years ago in the antiquated little city of Anklam, near the Baltic coast of Pomerania, about sixty miles to the northwest of Stettin. A residence so near the sea afforded him, in early life, many an opportunity of prosecuting his favorite studies and observations. In later years he migrated with his younger brother Gustav, his enthusiastic coadjutor in all his researches in the domain of aviatics, to Berlin, where he established, and is now conducting, a large manufactory of small steam-engines, whose mechanical appliances furnish him with every facility for the construction of his flying apparatus. He is an accomplished mathematician, and a close observer of nature; and is, besides, endowed in large measure with that poetic instinct which nearly always constitutes one side of even the most practical German character.

THE BIRD'S WING LILIENTHAL'S MODEL.

For more than twenty years Herr Lilienthal, with his brother's aid, and

in the intervals of more serious occupations, has been studying the subject of aerial navigation. He has taken the flying bird as his teacher. After many experiments with flat wings or plane surfaces, he became convinced that it was the gentle parabolic curve

of the wing which enables a bird to sustain itself without apparent effort in the air, and even to soar, without a motion of the wings, against the wind. This he has demonstrated not only by experiment, but by an application of the doctrine of the resolution of forces to the action of the wind upon a concave surface. The circling ascents of the carrier-pigeon, as he rises when released, to gain a general view of the landscape, and to take his bearings before starting on his homeward journey,

depend upon this principle. He *flies* with the wind, but he *sails* or *soars* against it. The fins of many fishes, and the web feet of aquatic birds, are strikingly analogous in construction. The sails of a ship assume a similar form. It would be impossible to sail so near the wind in beating, if the instrument of propulsion were a rigid flat surface. It is the effort of the sail to get away from the wind



A handwritten signature of Otto Lilienthal. The signature is written in a cursive, flowing style. It starts with a large, ornate 'O' and ends with a long, sweeping tail that extends to the right. The name 'Lilienthal' is clearly legible in the middle of the signature.

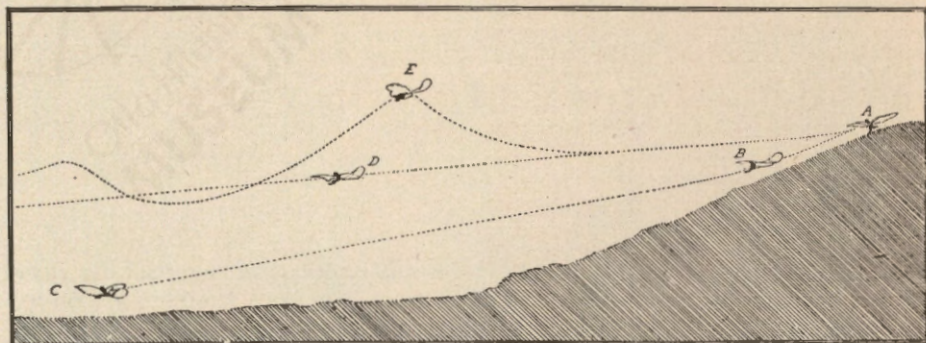


CHART OF A FLIGHT.

A. The start. B. The gliding descent. C. Alighting in still air. D. Course in ten-mile breeze. E. Soaring in a strong breeze.

which it gathers in its ample bosom which drives the boat forward, almost in the very teeth of the breeze.

"There are still prominent investigators who *will not see*," said Herr Lilienthal to me, "that the arched or vaulted wing includes the secret of the art of flight. As we came upon the track of this idea, my brother and I, who were then young and wholly without means, used to spare from our breakfasts, penny by penny, the money to prosecute our investigations; and often the 'struggle for life' compelled us to interrupt them indefinitely. While we were devoting every moment of our spare time to the solution of the prob-

lem, almost every one in Germany regarded the man who would waste his energies in such unproductive labor as a fool. Years ago the most distinguished professor of mathematics in the Berlin Industrial Academy sent me word that of course it could *do no harm* to amuse myself with such pastimes, but warned me earnestly against putting any money into them. A special commission of experts, organized by the state, had, in fact, laid it down as a fundamental principle, once for all, that it was *impossible* for a man to fly. German societies for the promotion of aëronautics did not then exist, and those subsequently formed



PREPARING FOR A START FROM A HILL.

were devoted almost entirely to the interests of ballooning.

"I have always regarded the balloon, and the exclusive attention which it so long attracted, as a hindrance rather than a help to the development of the art of flight. If it had never been invented, it is probable that more serious investigations would have been prosecuted towards other solutions of the

THE WING OF THE BIRD.

The wing of a bird is divided into three parts, corresponding to the shoulder-joint, the fore-arm, and the hand and fingers of the human frame. The two former, composed largely of bones and muscles and tendons, are comparatively heavy, and their rapid movement demands the expenditure of considerable physical force; the last consists almost entirely of "pen-feathers," or pinions, which move to a certain extent automatically. In the larger birds—the "sailers" or "soarers," which alone are to be considered here—the first two members, with their concave under surfaces, furnish the sustaining power; and the last, being at the greatest distance from the shoulder, or axis of motion, the chief propulsive force. The construction of each member is peculiarly adapted to its special purpose, and it is this which Herr Lilienthal has endeavored to imitate.

An oarsman, on his forward stroke, opposes the blade of his oar almost perpendicularly to the resistance of the water; as he lifts it at the beginning of the backward stroke he "feathers" it, or brings it into a nearly horizontal position, so that its

edge cuts the air. The pinions of birds act in precisely the same way. There are other analogies between the wing and the oar. The back stroke of the oar occupies only about half the time of the "pull," and the up stroke of the wing bears about the same relation to the downward beat. Moreover, at certain inclinations of the wing, the upward stroke, while detracting little or nothing from the sustaining power,



A START FROM A HILL.

problem. Since the time of Montgolfier nearly all practical efforts have been directed to the improvement of the balloon. But it has nothing in common with the birds, and it is these that we must take as our model and exemplar. What we are seeking is the means of free motion in the air, in any direction. In this the balloon is of no aid; there is no relation between the two systems."

contributes to the forward movement. As the pinions separate in consequence of the action of the air from above, they present their concave surface obliquely to the resisting medium, and act like an oar in "sculling," which, whether moved to the right or the left, impels the boat forward. It is evident that this must greatly lighten the physical exertions of a bird in rapid flight, for in whichever direction he moves

his wings he gains propulsive force.

To the conviction that concave or vaulted wings were essential to success, Herr Lilienthal was led not only by the examination of a great variety of natural wings, and by theoretical deduction, but by actual experiment. The means adopted for this purpose were ingenious and simple. He fitted up an apparatus in the form of the fly-fans found on the dining tables of clubs and restaurants, with two long arms revolving horizontally, to the ends of which surfaces of different kinds and degrees of curvature could be affixed in any required position. The motive power was furnished by a weight, and could be exactly measured. There was also an adjustment which enabled the observer to measure the lifting force of various surfaces, moving at different angles of inclination through still air. By this means Herr Lilienthal was enabled to reach conclu-



SOARING IN A STRONG BREEZE.

sions which were of great value to him in the construction of his flying machine; and the most important of them was, that the most effective form of wing was that whose convexity, as measured by the versed sine of the arc, should be one-twelfth of the breadth of the wing, or of the length of the chord connecting the opposite edges.

HERR LILIEN-
THAL'S
WINGS.

The flying machine devised and now used by Herr Lilienthal is designed rather for *sailing* than for *flying*, in the proper sense of the term; or, as he says, "for being carried steadily and without danger, under the least possible angle of descent, against a moderate wind, from an elevated point to the plain below." It is made almost entirely of closely woven muslin, washed with collodion to render it impervious to air, and stretched upon a ribbed frame of split willow, which has been found to be the lightest and strongest material for this purpose. Its main elements are the arched wings; a vertical rudder, shaped like a conventional palm-leaf, which acts as a vane in keeping the head always towards the wind; and a flat, horizontal rudder, to prevent sudden changes in the equilibrium.

The operator so adjusts the apparatus to his person that, when in the air, he will be either resting on his elbows

or seated upon a narrow support near the front. With the wings folded behind him, he makes a short run from some elevated point, always against the wind, and, when he has attained sufficient velocity, launches himself into the air by a spring or jump, at the same time spreading the wings, which are at once extended to their full breadth by atmospheric action; whereupon he sails majestically along like a

breeze at an angle of not more than six degrees to the horizon."

The principle is recognized in the umbrella-form universally adopted for the parachute. Try to run with an open umbrella held above the head and slightly inclined backwards, and see what a lifting power it exerts. Mechanical birds have been constructed with flat wings, which, so long as the machinery operated, were able to sus-



DESCENDING IN STILL AIR.

gigantic seagull. In this way Herr Lilienthal has accomplished flights of nearly three hundred yards from the starting point.

"No one," said Herr Lilienthal to me, "can realize how *substantial* the air is, until he feels its supporting power beneath him. It inspires confidence at once. With flat wings it would be almost impossible to guard against a fall. With arched wings it is possible to sail against a moderate

tain themselves moderately well and to fly rapidly; but no one has yet succeeded in making any practical use of them. Their course has no intelligent direction; when the motive power gives out, they fall heavily to the earth. *Soaring*, in the sense of rising against the wind as the birds do, is possible only with dome-shaped wings. The aeroplane, or flat wing, when inclined at a certain angle to the breeze, may rise while its momentum continues;



DESCENDING IN STILL AIR.

but this once overcome, its power is gone, and nothing can restore it.

PROPER DIMENSIONS FOR THE WINGS.

"The curve of a bird's wing," said Herr Lilienthal, "is parabolic; but the simple parabola differs so little from the arc of a circle that I adopted the latter curve as the more practicable, and the wings which I now use are, in the main, segments of a spherical surface. They are so constructed that they can be folded together like the wings of a bat, and require very little storage room when not in use.

"It was only gradually that I arrived at the proper dimensions. One does not easily gain an adequate conception of the materiality of the air, and my apprehensions led me at first to make the wings too large. I found that the varying force of the atmospheric currents, modified as they are by the undulations of the earth's surface, en-

dangered my equilibrium in direct proportion to the spread of the wings. Those which I now employ are never more than twenty-three feet from tip to tip, and I am thus enabled, by a simple change of posture, so to alter the position of the centre of gravity as to restore the equilibrium.

"There are limits also to the *breadth* of the wings, or their extension backwards. The operator must be able in a moment to transfer the centre of gravity so far to the rear as to overcome the action of the air, which might otherwise tend to throw him forward, and precipitate him to the earth. When one feels himself falling, the natural impulse is to stretch out the arms and legs in the direction of the fall; but it is one of the peculiarities of this mode of navigation that the movement must be in the contrary direction, or towards the *upper* side. The centre of gravity is thus shifted to the one side or to the other, forward or backward; and the

pressure of the air, acting with greater force on the lighter and broader surface, soon restores the equilibrium. It is not easy to realize in practice at first, but after a short experience the movement becomes almost involuntary.

"When there is no wind, the apparatus acts simply as a parachute. The pressure of the air is directly from beneath, and is equal on all parts of the under surface. I have more than once found myself in this position, when I have utilized the speed attained in a gradual descent in rising to a greater height, in order to soar over some obstacle like a tree or a crowd of people. Under favorable circumstances it is easy to mount to a height even greater than that of the starting point, but the forward motion is thereby partially or wholly neutralized, and it may happen that one comes to a complete standstill in mid-air. In such cases it is only necessary to throw the centre of gravity so far back that the air shall act more powerfully on the forward surface, and the gradual gliding descent is resumed. So in landing I bend backward, exactly as a crow does when alighting in a field,

and reach the ground without the slightest shock. The worst that is likely to happen in any case is the breaking of the apparatus; there is little danger to life or limb.

"I am far from supposing that my wings, although they afford the means of *sailing*, and even of *soaring*, in the air, possess all the delicate and subtle qualities necessary to the perfection of the art of flight. But my researches show that it is well worth while to prosecute the investigations farther."

THE LILIENTHAL MOTOR.

Having demonstrated the practicability of sailing and soaring, Herr Lilienthal has sought, in his recent experiments, to reach a practical solution of the problems of actual flight. The first difficulty to be overcome was the discovery of a suitable motor, without which all efforts to fly would be hopeless. If we estimate the ordinary weight of a man at one hundred and sixty pounds, and add to that the weight of the flying apparatus, we have a total burden of at least two hundred



A START FROM A WALL.

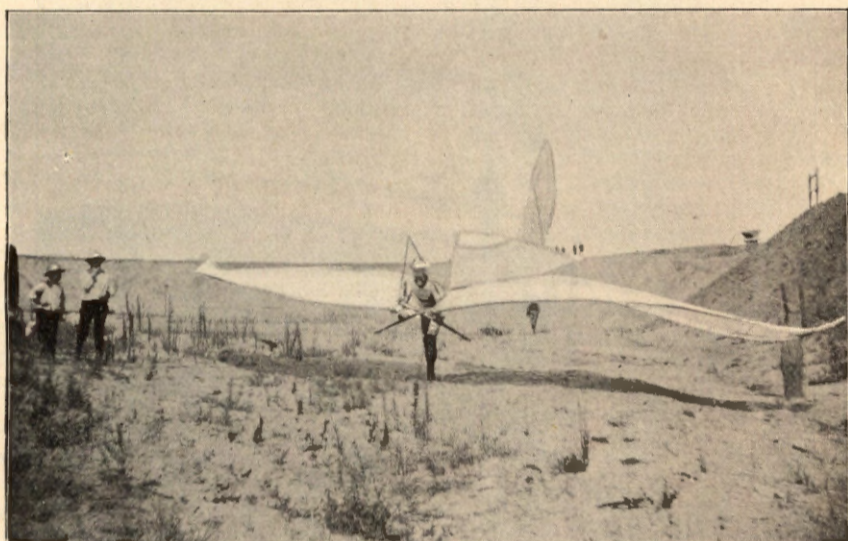
"THE FLYING MAN."



THE DESCENT.

pounds to be raised and supported simply by aërial resistance. It is calculated that to overcome the attraction of gravity in such a case requires a force of one and one quarter horse power, which no man is able to exert for more than a very short time.

With such an apparatus as Herr Lilienthal's, steam engines and electric motors are not readily available; but he conceived the ingenious idea of employing, as a motive force, the vapor of liquid carbonic acid, which, under ordinary atmospheric pressure,



A SAFE LANDING.

boils at a temperature far below that at which mercury freezes. His engine requires no fire, nor boiler, nor steam-chest; only a diminutive cylinder with the requisite valve arrangements, which may be readily worked by hand, and a small reservoir of the liquid acid lying close beside it.

The one first constructed was of two horse-power, with a receiver to contain enough carbonic acid to last for two hours, and was attached to the front of the flying apparatus. The whole contrivance, with the necessary machinery to impart motion to the wings, added less than twenty-five pounds to the weight, and this will probably be reduced in future by the use of some alloy of aluminium, instead of

iron, in the manufacture of the heavier portions. The wings were also fitted with rotatory pinions, constructed on the principles already indicated, and capable of automatic action under the pressure of the air.

The first experiments with this apparatus were rather *too* successful, at least in demonstrating the power of the engine. Unfortunately, the inventor had under-estimated the energy of his motor, which acted with such unexpected vigor that the wings were broken, and the modifications thus shown to be necessary will require some time for their completion. Herr Lilienthal confidently expects, however, eventually to solve the problem in this way.