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Otto Lilienthal MUSEUM

Machineflight and Birdflight

by Gustav Lilienthal

Birds flight and Machine flight differ far more as many people and even some aeronauter [sic!] believe.

Only the gliding flight is performed after the same rules and laws by the bird and the pilot of a flying machine. Also quadrupedes [Vierbeiner] which are able to make very wide jumps like the flying squirrel and the flying mouse by expanding a skin between their hind and fore legs make a gliding flight. Fig. 1 & 2.

The gliding flight is the most primitive kind of locomotion in the air, it may be called a passive flight. It was this kind of flying that man attempted when at first he longed for to reach the swift way of travelling in the ocean of the air.

In modern times the art of flying took its starting point also from the gliding flight.

My brother and myself were practising gliding between 1893-1896. My brother got an extraordinary skill extending to the length up to 350 yards from a height of 18 yards. Fig 3. When introducing a dirigible horizontal-rudder instead of shifting the point of gravity by altering the position of the legs to keep the balance he went with a deadly accident.

This alteration meant a departure from the way which the bird uses to keep the equilibrium in the longitudinal direction.

I am sorry to say that this departure has been accepted by all modern machine types and has caused a long line of deadly falls. The knowledge of our gliding flights and the receipt of one of our apparatuses which we had delivered to Mr. Chanute gave the first impulse to the brother Wrights to take up our experiments after my brothers death. With real American pluck and genius of the inventor they brought the experiments to perfection by the introduction of the motor driven air screw. The stability and steering was highly improved by the twist of the wings. So they became the inventors of the kite flying systems. The invention of gliding flights seems to be made at a very early date in pre historical times. The tale speaks of Daidalos and Ikaros who attempted to cross the sea from the island Kreta that ended with the fall of Ikaros into the sea called after his name even now. This flight most likely has been made by a glider. Daidalos a celebrate[d] architect and engineer in Athens was obliged to leave his country, having killed his nephew because the young fellow was still more clever as he himself. In consequence of the banishment Daidalos and his son came to Kreta and became the slaves of the cruel king Minos according to the habit of those days. Minos soon made use of Daidalos ability and ordered him to build the labyrinth known as a place of worship of a dragon feed on man.

After this job was finished and the accounts to be controlled some differences likely sprung up, as this sometimes takes place even now a days. Daidalos lost the confidence of the king had to leave

the court and retired to a lonely country house at the sea store.

This coast of Kreta is very steep and in places 3000 feet high. Here the old engineer might have been often planing how to get rid of the burden of slavery. If he only could be able to soar like the birds of the sea to come out of the sight of the store watch and reach a friendly vessel that could wait for him in a far distance. The large sea gulls and sea eagles were excellent patterns to imitate their flight. He commenced to build wings from light willow wood and covered them with feathers of the larger birds. Already the first attempts may have given good results. His sharp eyes had well observed the curved surface of the wings, for we know, that the ancient people were much better observers of nature as we modern.

The wings of the fabulous animals of the Babylonians and Assyrians show the design of the bird wings more accurate than the title figures of some of our aeronautical journals.

The covering of the wings by natural feathers is not bad. I believe we soon will return to this method for reasons I may explain later in a special paper. Only the fixing by wax or asphalt was not solid enough, for poor Ikarus meant his death after the rising sun made the wax soft and the feathers loosened.

When my brother and I were boys of 15 & 16 years building one of our first flight machines we also used feathers to cover the roods but we sewed them to line strips, a hard job that made at least our fingers bleed. Truly Daidalos could not employ fine steel needles so he had to help himself otherwise.

General speaking the construction of a gliding flyer could not have been a serious task for a man like Daidalos who was able to model statues and the delicate ornamentation of the Greek architecture. The escape was an offer of death or live for the prisoners. This will call for the courage to jump down from the steep height. The adventurers would have been able to extend their flight up to twenty mile from the height of their starting point so they could reach a vessel out of sight of the coast guard. Only Daidalos was successful and was brought to Sames from where he sailed to Syrarcuse than a Greek colonie.

There is no reason that no real fact is at the bottom of this tale.

Our modern flying machines the kiteflyers have no representation among birds now a days, but in older times some million years ago, when the mountains of the Alpes and the Jura formed the store of an ocean when the oldest representatives of the birds the “Archaeopteryx” lived, flying was exercised in the way of our modern machines. This system comprises stiff bearing wings driven forward by a special arrangement the motor driven screw.

But how did the antediluvial bird fly? Archaeopteryx was a bird of the size of a fowl with strong legs and wings that had feathers extending only up to the limb

corresponding to our hand. There were no finger feathers or pinions. Instead of them a perfect claw with toes and curved nails were projecting from the wing. s. fig. 4. All flying method require a forward motion to the air. The gliding flight gets the forward motion by the own weight giving up height like a book slipping down a step desk. The kiteflyer is propelled by the screw. The bird beating the wings is driven forward by the oblique position of the finger feathers when striking the air at the down stroke. Fig. 5.

[Folgender Absatz auf dem Rand eingefügt] The breast bone of Archaeopteryx not visible in the imprints of the limestone has been discovered by cutting up the sheet from the back. Here it was found that the breast bone had an angular section whilst the breast bone of our flying bird forms a T-section. As the small figures of fig. 4 shows the breast bone of Archaeopteryx had not space enough to attach the powerful muscles which the modern bird has for the down stroke of the wing. [Ende

Einschub] Archaeopteryx had no finger feathers how could it fly? There´s only one chance left!

After running against a wind or jumping down from a tree which it could climb by means of its claws of the wings the long tail of the bird made wave like motion like the flounder. The tail was splendidly adapted for this purpose consisting of 20 vertebral bones like the tail of a rat. It was covered with very long and brought feathers at both sides forming a surface larger then one wing. Fig. 6.

A comparison of the action of the tail with the action of the screw propeller of modern flying machines is therefore well founded.

Our bird with the exception of the young ostrich and the young of a wild fowl of South America, all modern bird, have only one free finger limb, the thumb which is covered with some strong feathers. This thumb can be spread forward which is always done when the bird intends to sit done. At the same time the legs are hang vertically down creating a strong resistance to the forward motion.

The horizontal curse of the birds flight is altered by the position of the tail similar to the horizontal rudder of the flying machine only the bird is besides able to shift the wing more or less forward and backward. By this action the point of gravity is either brought forward or backward to the centre point of the air resistances giving either a declining or raising direction of the flight. Fig 7.

In this way the bussard or the kormoran striking down on its prey nearly vertically can suddenly turn into the horizontal again or steer upward. Doing this the wings are also lifted a little bringing the body lower down. This creates again a turning moment into the upward direction of the flight. If our flying machine would have similar means at their commands besides the horizontal rudder less accidents would take place when they descend in a gliding flight or just before the landing.

Steering side ways the birds equipment is also better than that of the flying machine. The latter is using the vertical rudder and by keeping the balance by twisting the ends of the wings it creates at the same time a backward pressure that reduces the speed and with this the bearing pressure. The bird when flapping the wings gives a different incline to

the pinion feathers that changes at once the forward pressure of one side or the other, also a longer stroke of one wing will directly increase the lifting pressure which is necessary to keep the proper balance.

Similar to the flight of the machine is also the flight of the flying fish. At my last journey to and from Brazil I had a good chance to study this most interesting little creature. Fig. 8.

The flying fishes swim in shoals near the surface of the water and try to escape when chased by their enemies by rising into the air. They lift at first by a powerful jump, make then some vibrating motions with their two pairs of large fins and than with stretched out fins they glide along mostly against the wind till the forward motion is reduced by the head wind against the body. Then the flight goes downwards and when the water is touched a new action of the tail produces new propulsion and a new lift. In this way I saw fishes fly even 500 yard.

When birds fly with flapping wings their flight is based differently from that of the flying machine. It is a great mistake that the birds wings act after the same principle as the blades of the screw propeller.

The air screw revolving with a certain speed only creates a pressure according to the pitch of the blades.

The wing with its up and downward motion receives the “beating action” which takes place when

the air is acted upon suddenly. The resistance of the air then can be 10 – 15 times larger as it would be when the same wings would revolve permanently in the same velocity as before.

This beating action enables the bird to make flying possible when rising from the starting point especially in calm air.

Quite out of competition is the soaring flight of birds. In this kind of flying the aeronautic sees the highest perfection.

Soaring flight we call the locomotion in the air with camly [calmly] outspread wings in any direction to a wind of sufficient strength blowing not on an incline but over an even plain or the sea.

The brother Wright tried this with a specially built glider and succeeded to keep on a point in the air but this took place when the wind was blowing uphill.

It is known by our measurements that a curved sheet receives only vertical pressure when placed horizontally against the wind. If this pressure would be directed not vertical but only 3 degrees forward soaring would be possible therefore when the wind blew uphill probably, it might

have had changed the direction of the air pressure some degrees forward and gave the appearance of soaring. Real soaring in a wind blowing horizontally requires a superior form of wings which have not been made yet.

The grand sight of so soaring birds have been often described by good observers as by the Americans Lancaster and Chanute and also the great Briton Charles Darwin.

Myself had a very good opportunity to study the soaring of the frigate birds when staying some years at Rio de Janeiro. This bird with wings of 0,5 square yards, has only a weight of 3,6 lbs and is able to soar already in a wind of 3-4 yards per second velocity. Fig. 9 & 10.

Soaring is performed not only in curves but just as well in straight lines to any direction of the wind. Birds that can keep in a certain district and are controlling their hunting ground for pray soar in circles whilst seabirds following the vessels keep up with them in any direction to the wind with motionless wings. To keep the equilibrium when soaring the bird is also lifting the wings more or less in the shoulder and elbow. At strong winds the end of the wings are kept in an angle backwards. I saw the albatross near cape of good hope holding the end of the wings parallel to the body.

The steering side ways is done in the same way when flying with flapping wings only the frigate bird folds its brought long tail to vertical sheet looking from below like a single narrow feather. Fig 8.

Compared the birds flight with the capacity of accommodation to the demand of the wind our flying machines appears to stand still in the children’s shoes: In this regard very little progress is made since the brother Wright produced the first flight to the astonished world. Surely progress will come by and by. Nature took also long time to change the Archaeopteryx to the frigate bird.

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corresponding to our hand. There were no finger feathers or pinions. Instead of them a perfect claw with toes and curved nails were projecting from the wing.

At a gliding flight the forward motion of birds as well of machines is originated by the weight. The wings being placed the fore edge lower than the hind edge and the motion is a gliding in the air on an oblique plain. The position of the wings is guarded by the horizontal rudder of the machines or the tail of the birds. The birds have besides the means to shift the wings forward so that their point of gravity goes backwards from the centre point of the air pressure.