OBSERVATIONS ON THE FLIGHT OF BIRDS AND THE MECHANICS OF FLIGHT.

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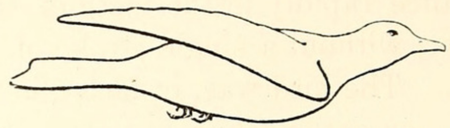
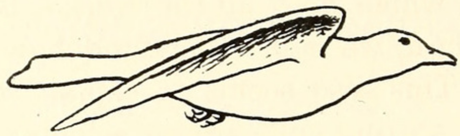
It is only quite lately that the possibility of mechanical flight has been seriously entertained. Within my own memory even scientific men were quite at a loss in attempting to explain the flight of birds. No experiments had been made of the effect of wind upon inclined planes, while the deductions from theory were grossly erroneous. Some experiments made by myself with rough apparatus thirty years ago convinced me of the incorrectness of theory, and at my suggestion the Aeronautical Society of Great Britain, of which I was a member, constructed an apparatus in 1873-74 for ascertaining the effect of wind upon inclined planes, as an indispensable preliminary to the construction of machines for mechanical flight. Since those days many careful and elaborate experiments have been made by Maxim, Professor Langley, and others, and the solution of the problem of mechanical flight seems to be close at hand.

There is still some mystery connected with the flight of birds which calls for explanation; chiefly the extreme ease with which some birds fly, or rather soar. In endeavouring to account for this, let me begin by an elementary description of the action of a bird's wing during flight.

One of the best positions for studying the flight of birds is the deck of a steamer. If we watch a gull following the vessel with quietly beating wings, we notice that the body of the bird scarcely perceptibly drops during the upstroke of the wings, showing that the bird is supported, not only by the downward stroke, but during the upward stroke of the wings; that is to say, the wind strikes the underside of the wing even during the upward stroke. This is effected by the peculiar construction of the bird's wing, in which the muscles are springs tending to pull the after edge of the wing downward to meet the rush of the wind. During the downward stroke the wing bone is at the lower level, and propulsive effect is obtained by the bird thus—

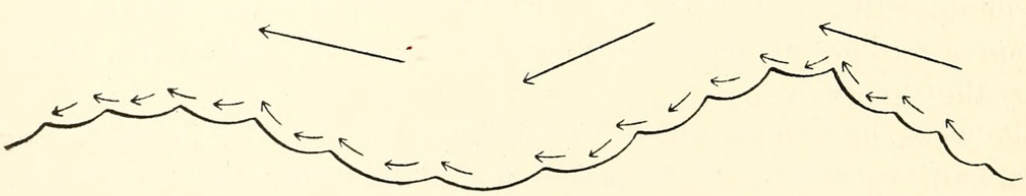


During the upward stroke the wing bone is at the higher level, thus—



the bird being supported by the wind striking the inclined plane of the wing. This seems simple enough, but how are we to explain the flight of the albatross and other sea birds which seldom beat the air with their wings? When and where is the work done which keeps them in motion?

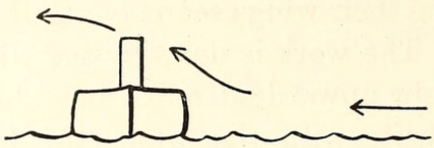
Long observation of the flight of the albatross and other sea birds has convinced me that they are sustained by upward currents of air due to the wind striking the inclined surfaces of the waves. The wind blowing over the sea, and the land, too, to some extent, is a current undulating in a vertical plane chiefly. The wing of the bird is so constructed that the air always impinges on the underside; so that, while supported by the upward current, the bird escapes the reverse action due to the downward current. Again, the upward current, when the wind is strong, is much more violent than the downward, while the velocity of the bird's motion and the elasticity of the wing muscles enable it to derive support from the air even in a current with a downward inclination.



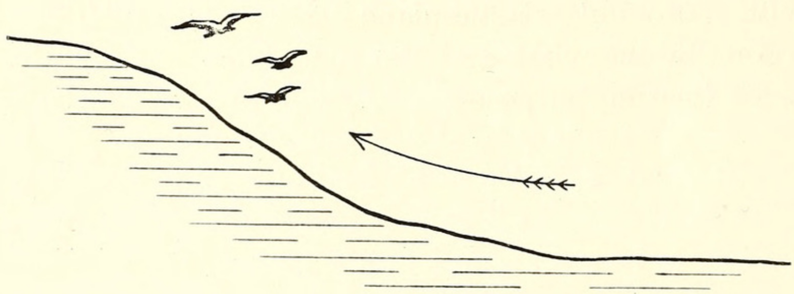
This diagram represents two large waves with a surface of wavelets. The arrows show the direction of the wind glancing upward from the backs of the waves, the larger representing the major currents and the smaller the minor, and the upward currents largely exceeding the downward in force. Two facts seem to me noticeable; one, that the stronger the wind the easier and more rapid the bird's flight; the other, that the bird continually glides downwards as close to the waves as possible, often seeming to stroke the *back* of the wave with the tip of the wing. I have seen large gulls of the albatross kind advance rapidly in the teeth of the wind, close to the surface of the water, without a single stroke of the wing for a hundred yards or more. The bird was, in fact, gliding down an inclined plane. From the momentum thus acquired the bird can lift itself to a considerable height above the waves, from which it descends by an easy slope close to the surface again. The bird merely steers itself in the breeze, which does all the work. So little effort being required from the bird, we can understand how it can keep on the wing for so long. This also seems to explain why it is that albatrosses and similar soaring gulls are so seldom seen to alight upon the water to feed. If severe work were done fuel, in the shape of food, would be constantly needed. Consider now the flight of the gannet. This bird is not a soaring bird; it flaps its wings strongly and raises itself to a considerable height above the waves where it can obtain very little support from upward currents, and remains there until it plunges into the sea for its prey. It then, with great effort, raises itself to the necessary height, and generally, as I have noticed, within five minutes makes another plunge. It is, in fact, feeding, for it must require a good deal of food to enable it to make such violent exertion. As it cannot rest in the air like the albatross, it is frequently to be seen seated on the water.

About the flight of flying-fish there is controversy as to whether the animal beats the air or soars. To ordinary eyesight—at any rate to mine—there appears to be no vibratory motion. Some observers, however, are confident that the wings do vibrate, and argue that failure to observe it is due to the rapidity of the motion. But rapidity of motion results in invisibility, as is the case with the wings of insects and humming birds. It is again urged in favour of the vibratory theory that it is incredible that an animal could jump for one or two hundred yards. This jump, however, is easily explained by the theory of upward currents. Directly the fish springs from the water he commences to soar as an albatross does, and is carried forward by the upward currents, of which he obtains full benefit, being close to the surface of the water during most of his flight. If he touch the top of a wave he sculls with his tail and obtains fresh impetus; and perhaps he might take very much longer flights than he does if he were more independent of salt water.

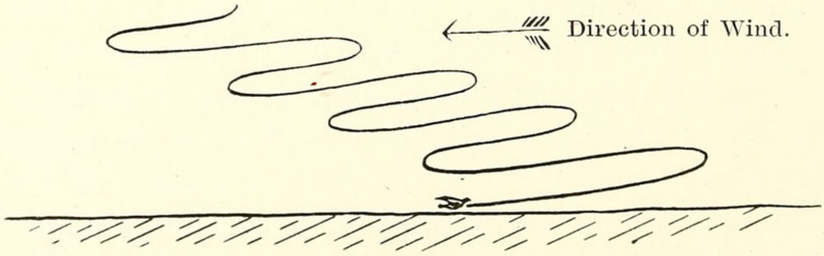
Ordinary gulls, which seldom soar, will do so when conditions are favourable, as when following a vessel they happen to find themselves in the upward current produced by the glancing of the wind from the vessel's side. I have seen gulls resting, without apparent effort, over the vessel going at high speed. The diagram shows how the wind is deflected upwards by the ship's side.



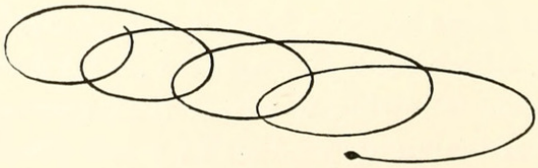
Land birds take advantage of upward currents also. I observed a hawk rise to a height of some three thousand feet, ascending in a spiral without a single flap of its wings. On another occasion I saw a hawk beating a paddock suddenly commence to ascend in spirals. While watching the marvellous performance the dust rose in a whirlwind from an adjacent road, rendering visible the tourbillon of which the bird was taking advantage to get upward. I have seen a



number of vultures poised, stationary as a boy's kite, over the slope of a hill, evidently utilising the upward slant of the wind produced by the hill. Vultures utilise their own inertia to mount.



SIDE ELEVATION OF BIRD'S TRACK IN AIR.



PLAN OF BIRD'S TRACK.

I have observed these birds when disturbed run flapping violently up wind until lifted from the ground, and continuing to beat the air until they got an elevation of from twenty to thirty feet, when they began to wheel, beating their wings scarcely at all. The bird ascends by an inclined spiral. The work is done by the wind, which lifts the bird, partly by the slight upward currents, but chiefly by the inertia of the bird, which drifts with the wind, the horizontal distance drifted being the mechanical equivalent of the same distance advanced in still air. The diagram shows the bird's course in air in side elevation and plan.

The small expenditure of power required to carry the albatross for hours over the sea seems to prove that mechanical flight is practicable, at any rate over the surface of the sea. The important point is to imitate the elasticity of the bird's wing. This seems to have been overlooked hitherto. Many machines have been made with supporting planes, but, so far as I know, they were all too rigid. With thoroughly elastic planes the greater part of the work would be done by the wind, and the motive power would chiefly be necessary for steering purposes.