THEORY OF SOARING FLIGHT

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Synopsis

If in observed feats of soaring flight of birds no sign of energy expenditure or consumption is visible, one must conclude that possibly the bird draws energy from the air in which it flies.

Even where there are no vertical wind components the mere existence of different horizontal wind velocities can be utilized by a body.

It is not possible to define the energy available in any dynamic situation because the amount of air "effected" and the power required in calm air depend on the flight "maneuver."

The problem arises what thrust power is actually available at any instant. Any disparity between the power required and that applied will primarily affect the flight velocity and the flight path. In the glider no engine power is available and gravity is the sole source of motive power.

It is of interest to determine the power requirements of maneuvers departing from straight level flight. Horizontal turns in a glider require increased speed because the aerodynamically generated lift must suffice to make up not only for gravity but also for centrifugal force.

At any given instant in the flight path of a complicated maneuver properly executed there is an equilibrium between gravity, inertia forces, and air forces.

We propose to subdivide the soaring effects into three major classes or types which in combination together appear to compose the aggregate of the soaring phenomena.

Static Soaring Flight: When the upward wind component exceeds the minimum sinking speed of the craft in still air then sustained flight or even climb is possible without the expenditure of motive power. To soar in the least vertical wind the craft has to be designed for minimum sinking speed.

It is certain that many of the spectacular soaring flights and records were accomplished essentially, if not wholly, by static soaring in rising currents of air. This fact is an incentive to explore and investigate where and when rising currents are produced in the atmosphere and what vertical velocity components occur in them.

The simplest and most obvious cause for the generation of a rising current is the vertical deflection of the wind by the presence of an extensive obstacle in its path such as a mountain range or an elevated coast.

To stay in the best region the pilot must tack back and forth along the crest across the wind staying to the windward of the top of the ridge.

There also occur steady and gentle ascending currents in the atmosphere and originate from irradiated ground areas. Even though the buoyancy of a heated air mass may be but a small fraction of gravity, yet the vertical velocities attained in such extensive thermals may reach appreciable magnitudes quite sufficient for soaring because the only immediate opposing force is the turbulent friction at the boundaries of the descending currents around.

It is not necessarily a physically extensive obstacle that the wind must encounter to be deflected upward. The mere slowing down of the surface wind where it encounters increasing surface roughness suffices to force the remainder of the wind masses to climb over the slowed down air masses. This effect can be obtained for the idealized case of a wind sweeping over a relatively smooth surface and then suddenly hitting a decidedly rough surface region like a seashore or a forest.

Part IV

IN CONTRAST to the utilization of rising currents by steady or static soaring flight, we may define as Dynamic Soaring Flight the utilization of the internal energy of wind variations which require dynamic maneuvers and evoke inertia reactions. Wind may vary at any one time from place to place (strata) and at any one place from time to time (gusts). Since the aircraft moves it can encounter either kind and feel them as gusts. Various theories have been advanced to explain the mechanism of dynamic soaring flight maneuvers. Observers have greatly differed in their viewpoints and in their opinions about the significance of the various mystifying phases which make up the composite phenomena of dynamic soaring flight. Lanchester, for instance, placed most importance on the longitudinal components of the gusts and discounted the circling of the birds of prey which he was inclined to attribute to their desire to stay within their chosen hunting area. Other observers (particularly Joukovsky, Parseval and Varey) on the contrary were convinced that the circling of these birds is the most effective and the most conspicuous of dynamic soaring maneuvers. (Today we have enough evidence to link the circling of the birds to the thermals, the utilization of which belongs in the category of static rather than dynamic soaring.) Alexandre Sée emphasized the dynamic effect due to the lateral components; he discounted all other dynamic maneuvers as insignificant in comparison. Knoller, Betz and Katzmayr studied the influence of the vertical component of the wind fluctuations. Observation of bird flight from the ground is of course too vague and too uncertain to prove or disprove the predominance or significance of any one such theory.

The random texture of gusts is limited by the boundary conditions imposed by the continuity of the motion between the air and the earth. The relative velocity between aircraft and air is limited between the stalling speed and the terminal speed, but neither the magnitude nor the direction of flight velocity with respect to the ground need stay constant. Hence, while the acceleration component of the wind as measured at any ground station must average out in any particular fixed direction, the same need not be the case when measured