exhibit either a slight lapse rate, an isothermal condition, or an inversion. It is thus possible for the clouds to form immediately above or even within a zone of such characteristics. When formed within a stable layer of this sort, they will usually be of the stratus or alto-stratus type, and hence will generally yield little or no bumpiness.

However, when there is considerable wind shear between the warm air mass and its underlying cold air mass, waves and eddies may be established within the transition zone between them. These disturbances may impart vertical and irregular motions to adjacent layers and thereby impel the clouds to acquire wave or cell patterns. Thus the base of strato-cumulus lying above a warm-front surface of discontinuity may manifest roll formations due to wave action along the surface.

Wherever the wind changes direction rapidly with height between the two air masses, complex cell patterns may be formed in the overlying cloud, which therefore may be of the strato-cumulus or alto-cumulus variety, instead of stratus or alto-stratus. Such patterns are sure indicators of bumpiness.

Under circumstances where the overlying warm air mass is or becomes unstable for saturated air, the clouds undergo vertical development, with the result that alto-cumulus castellatus, towering cumulus, or cumulonimbus clouds arise. These offer positive proof that the turbulence aloft will be quite intense, at least in the growing and active stages of cloud development.

Sometimes, as cumuliform clouds grow vertically, they impinge upon a high inversion layer. Here they spread out somewhat and form turbulent stratiform clouds, but if convection is sufficiently strong they penetrate the inversion, then swell to greater heights. However, if the wind velocity increases rapidly with height aloft, the clouds, instead of developing towers, are shorn by the wind and spread laterally. This condition will manifest intense bumpiness and turbulence.

On some occasions, smooth alto-stratus cloud sheets have been abruptly pierced by cumulus towers growing rapidly from below. This produces a sudden increase in the turbulence above the alto-stratus deck. For this reason the pilot should not fly too close to the upper surface of the cloud sheet when intense convective activity below makes such an occurrence likely. Cumulus heads projecting above alto-stratus clouds indicate this condition clearly.

(To Be Continued)

[1] Harrison, L. P., Atmospheric Turbulence, SOARING, March-April 1942, page 5.
[2] Harrison, L. P., Turbulence Associated with Miscellaneous Types of Clouds, SOARING, Nov.-Dec., 1942, page 9.
[3] Haurwitz, B., "Ueber die Wellenlaenge von Luftwogen," Gerlands Beitraege zur Geophysik, vol. 34, 1931, p. 213.
[4] Taylor, G. I., Proceedings of the Royal Society, Series A, vol. 132, 1931, p. 499.

ON SOARING FLIGHT

by Arthur B. Schultz

I HAVE read with a great deal of interest the series of articles taken from the treatise by E. C. Huffaker and would like to suggest a rational answer to the mystery of these birds soaring at low altitude directly into the wind. I have long forgotten how to carry out the detailed calculations involved but can suggest a method of mathematical analysis which some aerodynamicist member might follow through. Much of this hearkens back to my downwind turn mania [1, 2] but I hope you will pardon my insistence on following this theme.

If an albatross is gliding along in still air there is a circulation about his wing represented by the circulation vector C. This vector can be transposed into two linear vectors $\Delta V/2$ separated by a distance Δh. Now if a gradient in a wind exists (and they do exist) such that at a height differential Δh a velocity differential ΔV occurs, the albatross will be able to maintain altitude without recourse to flapping of wings. If the ΔV is greater than the minimum required the albatross will be able to fly at a higher rate of circulation hence higher speed and actually fly into the wind faster than the wind carries it back.

Data on gradients in the wind are available from studies the electrical transmission engineers have conducted to determine wind forces on power lines.[3] Data on performance characteristics of gulls and albatross must be available from early researches. I feel that if some one would piece these facts together with some modern aerodynamic theory that a very worthwhile contribution to science would be made.

[1] The Downwind Turn, by A. B. Schultz, SOARING, Nov. 1939.
[2] Downwind Turns and Downwind Fight, March-April 1942.
[3] Tests by Detroit Edison Co.