THEORY OF SOARING FLIGHT

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PART 5

This is a part of the revision by Dr. Klemperer of his orignal study of soaring flight, published in 1926 as volume 5 of the Proceedings of the Aerodynamical Institute at the Institute of Technology, Aachen. Part 1 appeared in the March-April 1943 issue of SOARING, *Part 2 in the May-June, Part 3 in the July-August, and Part 4 in the November-December 1943 issues of* SOARING.

NOW it might be of some practical interest to inquire what sort of control technique would be required to execute the maneuvers shown to utilize the Betz effect. The general principle is simply fly at larger than average angle of attack or lift coefficient during the ascending phases of the wind fluctuations and at smaller than average during the descending phases. For the hypothetical case of Betz' simplest assumption of infinite inertia of the sailplane in pitch, the natural correlation between uncontrolled lift coefficient C_L and wind slope β would be given by a displacement of the lift coefficient C_L against the angle of attack α curve as shown in the right side of Fig. 3. The improved prescription is shown as curve $C_L(\beta)$. The difference between the curves for "best" control and "natural" effect gives a clue to how much the aircraft would have to be tilted in unison with the wind wave. This tilting is contrary to one's natural tendency to parry or mitigate the gust effect. The pilot has to pull up during the up gust phase to increase lift still more, and push forward on the stick to decrease lift still more in the down draft phase, but not quite in the same manner. This is a rather complicated and uncomfortable proposition. The quantitative amounts of control required depend on aspect ratio, average lift coefficient and wind amplitude. This type of control is "unstable" in character and difficult to learn, especially in view of the lack of knowledge of the amplitudes and frequencies of vertical pulsations that may be present in the wind at any one place and time. Therefore, efforts to build an automatic device to perform this sort of control are likely to be disappointing. However, that some little benefit is derived from these vertical pulsations without any artificial control just by virtue of whatever inertia in pitch the aircraft may possess, remains worth remembering; on the other hand it must not be forgotten that there is also a penalty to pay for the gain, as was explained in the earlier chapter dealing with the power absorbed in phugoid motion. (SOARING. May-June, 1943).

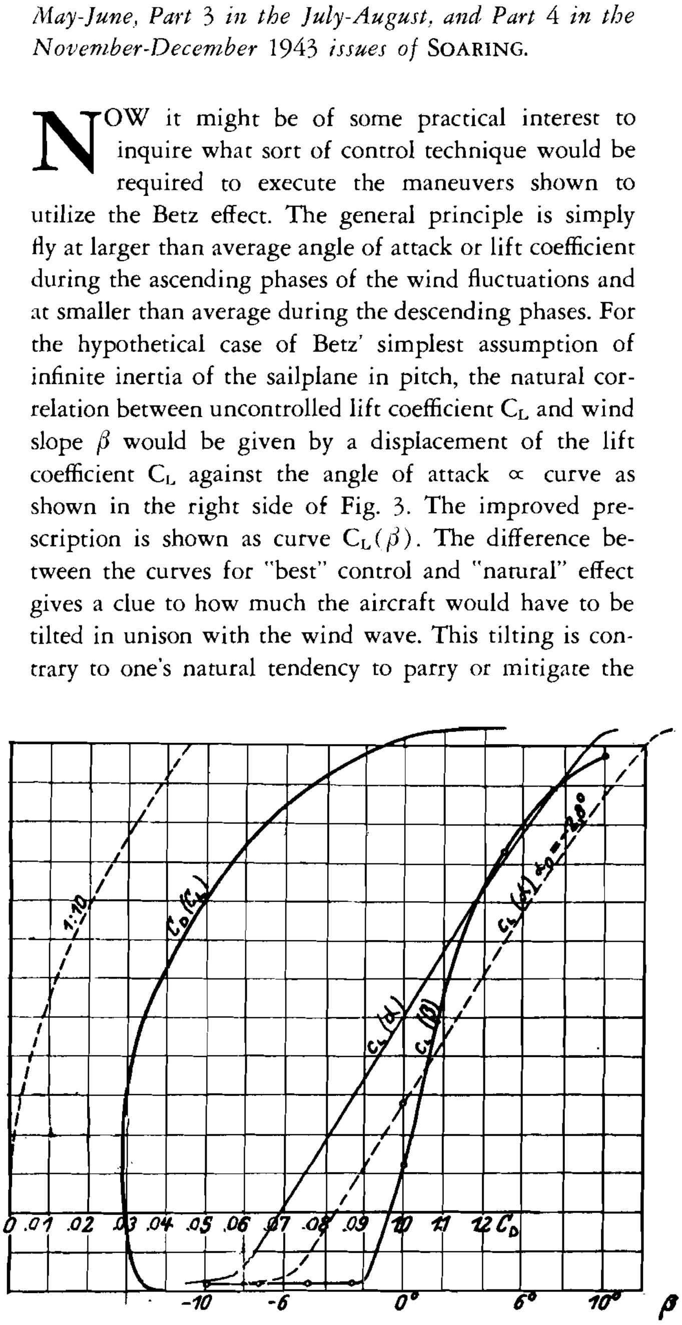

Fig. 3

If the aircraft is endowed with any appreciable longitudinal stability which tends to hold the angle of attack constant, then it will automatically act to oppose the wresting of energy from vertical wind waves and to minimize any gain derived from the Knoller-Betz effect.

Many designers, especially in the period of 1918 to 1928, among those v. Loessl, Harth and Messerschmitt, experimented with variable incidence wings in hopes of increasing with their designs utilization of vertical wind fluctuations. Instead of a conventional elevator they wanted to control the incidence of the wing against the fuselage and leave the tail stabilizer fixed. They hoped thus to give the pilot more "feel." This, however, proved fallacious. It is true that when the average pressure center coincides with the wing pivot point the pilot can distinguish between a vertical up wind component gust and a horizontal head-on gust. Both give extra lift but the former changes the angle of attack and hence the moment and develops a stick force (provided the airfoil is curved of course), while the latter does not. This different reaction it was thought would enable the pilot to react differently to the two types of gusts as he should to make the most of both of them. Unfortunately, as soon as the controls are used this distinction becomes obscured. When pulled back, an up gust is felt like a head-on gust; when pushed forward of the neutral point it feels like a

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