THEORY OF SOARING FLIGHT

by Wolfgang B. Klemperer

During the war, we will have to content ourselves with theoretical soaring. It is in this field that this original study by Dr. Klemperer is an outstanding contribution. This treatise together with those by Huffaker and Woodcock which were printed in previous issues are landmarks in soaring literature. We only hope that the time lag between the theory and practice of dynamic soaring will not be as long as in the case of thermal soaring (1897-1932).

Preface

THE following is an abstract of a treatise of the Theory of Soaring Flight by the author which was published in German as volume 5 of the Proceedings of the Aerodynamical Institute at the Institute of Technology, Aachen, edited by Professor Th. von Karman who wrote a preface to it. The treatise was completed in 1923 but the publication actually appeared in 1926. The subject matter is divided into the following Chapters:

A. Observational facts
B. The energy sources of Soaring Flight
C. The power requirements without Soaring
D. Soaring effects, their mechanism and their power balance
E. Summary
Bibliography.

A. *Observational Facts*

Certain observations pertaining to the flight of birds and airplanes appear difficult to reconcile with the orthodox theories of aerodynamics and of power required to sustain flight. Phenomena of this sort observed in the flight of birds are usually comprised in the so-called effortless soaring flight. A great deal of mystery has shrouded the explanation of these observations for a long time although some scientists, among them particularly S. P. Langley have devoted a great deal of study to them and written fundamental explanations of them. Naturalists have reported on the amazing soaring feats of the albatross, sea gulls, frigate birds, eagles, vultures, condors, storks, swallows and swifts. All agree that wind is required for soaring. Soaring maneuvers are of great variety and some of them bear a definite relationship to the topography of wind obstacles.

Before the advent of power propelled airplanes it was recognized that imitation of the soaring flight of birds by man would have been a reasonable approach to the solution of mankind's age-old desire to fly. Otto Lilienthal and some of his successors who gathered their first flying experience in crude gliders took a keen interest in this possibility. Only the advent of light motors pushed soaring into the background until it was resumed as a scientific sport after the World War, particularly in Germany where almost all other aeronautical activities were restricted by the victorious Allies. The new movement culminated in Soaring Contests in which previously unbelievable records were achieved. To weigh and interpret these successes is one of the aims of the present investigation.

Soaring effects have also been observed on power propelled airplanes inasmuch as their performance appears to be occasionally influenced by meteorological conditions and, allegedly, by piloting technique. An analysis of such influences in the light of a theory of soaring flight is also intended.

B. *The Energy Sources of Soaring Flight*

Heavier-than-air craft flies by impelling some air masses downward and utilizing the reaction to carry their weight. For reasons of continuity, however, just as much air as is forced down must go up somewhere else. The complex of the air movement thus creared is a system of vortices which has to be continuously expanded. Its decay absorbs the kinetic energy and transforms it finally into heat.

The power required per unit weight to be borne, is a quantity having the dimension of a velocity, can theoretically be made the smaller the greater the mass of air per unit of time impelled downward and the smaller hence its disturbance velocity. The soaring birds have much smaller wing loading than conventional airplanes.

According to the circulation theory of wing lift, the aspect ratio, the span-wise distribution of lift and the mutual influence of a plurality of wings in close proximity have a definite bearing on the "induced" drag which inevitably accompanies the generation of lift. The energy spent in overcoming this induced drag is vested in the vortices which are shed at the trailing edge towards the wing tips. The induced drag (aside from the additional frictional or parasite drag) is expressed in conventional