THE PHOENIX AS A SOLUTION TO OPTIMUM CROSS-COUNTRY SOARING

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In this paper the Phoenix sailplane (reference 1) will be compared in cross-country cruising performance with two other modern flight tested sailplanes, RJ-5 and HP-8. The essential difference in these sailplanes is their wing loading, Phoenix at 3.77, RJ-5 at 5.2 and HP-8 at 7.2 psf.

However, there is another singular distinguishing feature of the Phoenix in that a moderate aspect ratio of 17.83 is used for the wing design, whereas RJ-5 and HP-8 were both of aspect ratio 24.

What Phoenix lacks in aspect ratio is made up by its lower skin friction drag coefficient. This extremely low drag coefficient, however, was not achieved at the expense of lift coefficient.

In fact, the remarkable feature of Phoenix lies in the employment of mathematically derived airfoils which were designed by Dr. Richard Eppler (ref. 2) to possess two laminar buckets, one near best glide ratio and one at high cruising speeds. In this paper we will show that Dr. Eppler actually succeeded in prescribing such double bucket airfoils from boundary layer theory.

What really ensured the attainment of such fine aerodynamics was the excellent structural design of Mr. Hermann Naegele who employed Fiberglas-Polyester resins with balsa as the filler of a pure sandwich structure. But discussion of the finesse of the structures must be deferred at this time in order to concentrate on the theme of this paper.

Since this paper is written as a technical paper we cannot go into a scientific consideration of the Eppler airfoils which were the principal objective in the Phoenix research program conducted at Mississippi State University during the spring of 1959.

Preparation for Phoenix Flight Research

In a preliminary flight in Stuttgart the senior author determined a few of the interesting flight characteristics of the Phoenix (ref. 3). In this flight a maximum lift coefficient of 1.5 was measured. Subsequent airspeed calibrations of the flush pitot-static system confirmed the validity of this measurement.

On arriving at Mississippi State University the contours of the Phoenix airfoils were carefully measured with a wave gauge. In general, waves having a maximum deviation of 0.017″ were found over the entire chord of the wing. Knowing from the work of Pretsch (ref. 4) that waves near the leading edge have a serious destabilizing effect on the laminar boundary layer it was felt that the entire top surface of the airfoils should be smoothed in order to ensure maximum lift coefficient and that one test area on the bottom of the wing should be contoured for profile drag measurements. The accuracy of the contouring on the top surface was such that no area deviated more than 0.002″ On the test area on the bottom surface the maximum deviation was kept below 0.0015″.

The results of this smoothing were two-fold:

1. The maximum lift coefficient was increased from 1.5 to 1.75.

2. The laminar extent on the top surface was carried far beyond the minimum pressure peak.

Performance of Phoenix Compared with RJ-5 and HP-8

On examining the speed polars, fig. 1, the reader will see two outstanding features of the Phoenix:

1. Its very low sinking speed of 1.55 fps.

2. The large extent of usable flight regime between the minimum in sinking speed and the stall. This implies a wide latitude in choosing circling speeds.

In fig. 2 are shown the flight test data plotted as glide ratios versus airspeed. It will be seen that in spite of a much lower aspect ratio Phoenix achieves the same maximum glide ratio as the RJ-5.

The comparison with HP-8 might be more favorable had the HP-8 been flight tested in its final condi-

Fig. 1. Speed polar of Phoenix, RJ-5 and HP-8.

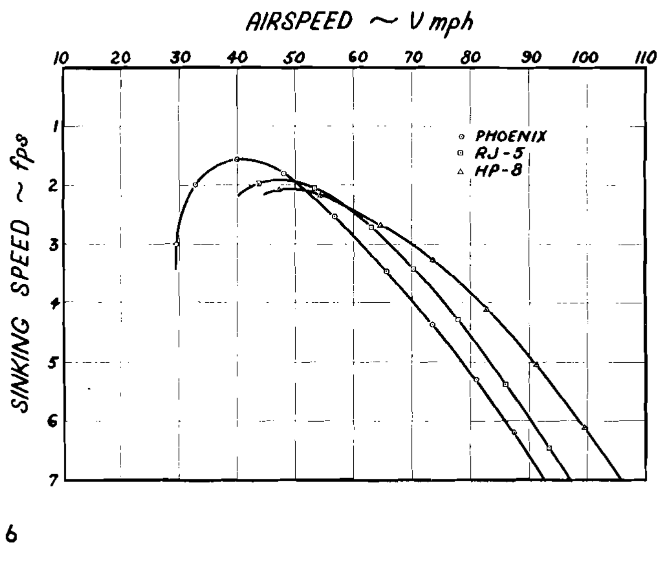

Fig. 2. Glide ratio of Phoenix, RJ-5 and HP-8.