a number of points in common: three part single spar wing with rectangular center section and elliptical outer sections, and oval section fuselage with very small, built-in fixed fin and stabilizer.

In 1928 the Kakadu (Figure 9) appeared, designed by Dr. Kupper of Munich University. It was also a cantilever sailplane of large span, but differed from the Darmstadt pattern in wing plan form section and spar design. The spar was a thin walled, rectangular, box with plywood webs, a form that had become popular in metal aircraft. As so little was known of the buckling properties of plywood this scheme was not generally approved until some years later.

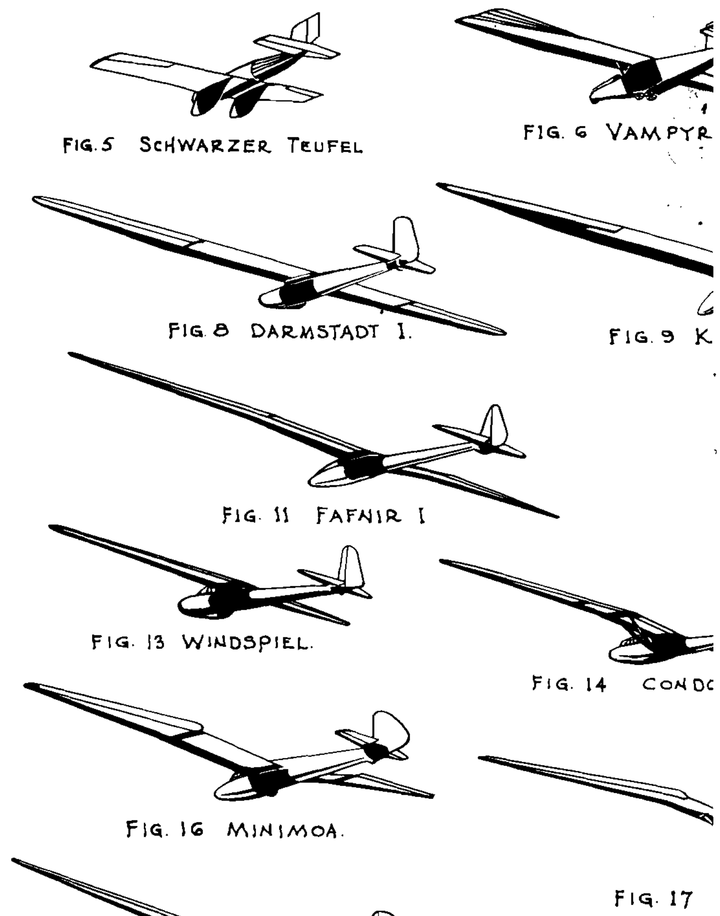
In 1929 the average span of the best sailplanes was about 60 feet, and the limit of development of the cantilever type seemed to have been reached. In designing the Wien (Figure 10), which was flown so successfully by Robert Kronfeld, Alexander Lippisch reverted to short V struts. The Wien was really a development of the training sailplanes that Lippisch had designed in the preceding years at the research establishment of the Rhön Rossiten Gesellschaft on the Wasserkuppe, near Gersfeld. It had a thin wing of high aspect ratio placed well above the fuselage to clear pilot's head and to permit an efficient angle for struts. The drag of the struts was offset by the lower drag of the thin wing.

Flying the Wien equipped with a variometer, the sensitive rate of climb instrument developed for sailplanes, Kronfeld discovered the strong vertical currents under cumulus clouds. Wolf Hirth later found that these currents were due to unequal reflection of heat from different areas on the ground, and were often present even when the air was too dry for cloud to develop. These discoveries opened up new possibilities for soaring over the plains, and led to the development of winch and airplane towed launches.

The discovery of these thermal currents also had a profound influence on sailplane design. Hitherto sailplanes had lacked rolling and yawing maneuverability, principally due to their great span. When steeply banked turns were attempted, the slow recovery resulted in considerable loss of height, and therefore all pilots used very wide, flat turns. As continuous tight spiralling was required to remain within the narrow funnel of warm rising air that characterizes a "thermal," Lippisch designed the Fafnir (Figure 11), a sailplane of greatly increased maneuverability.

Rolling maneuverability was improved by tapering the wings sharply and mounting them directly on the fuselage, thus reducing the rolling moment of inertia; by providing a large aerodynamic washout (about 12°) in order to ensure aileron control right up to the stall; and by increasing the chord of the aileron at the tips and reducing it at the inboard ends. The lower wing position necessitated dihedral to provide ground clearance at the tips, and a gull wing was chosen in the hope that rolling maneuverability and directional stability would benefit.

Yawing maneuverability was improved by increasing the tail arm and by reducing the fuselage depth to a minimum, concentrating the lateral area in the fin and rudder. The pitching maneuverability of sailplanes had always been good owing to the concentration of weight near the pitching axis, and this required no special attention.



Figures 5 to 24 by Jacobs

The low position of the wing placed the leading edge right behind the pilot's head, and to reduce interference the cockpit was totally enclosed and the wing-fuselage juncture carefully faired. The cockpit en-