THE FREE FLIGHT AUTO-PILOT -

BLUNT LEADING EDGE AND ADVANCED HIGH POINT TAILPLANE AIRFOILS

Gerd Wöbbeking

I. THE GLIDER STORY

In 1982, with my first modern circle tow F1A, weak points of the Lepp-influenced design became obvious. Not equipped with VIT, the model was difficult to tow, losing too much height in tight circles. Good zoom launches were not easy too when by accident the model dived instead of gaining height, with late recovery.

I suspected the problem might be the tailplane section. It was the second or third tailplane with "Clark Y 60%" and an AR of 6.6 after experiments with an aspect ratio 4, following trends of these years. The low AR combined with Mylar covering had led to a miserable performance in typical weather conditions of Northern Germany and had already been abandoned.

The problems seemed to be:

1. Too much lift when tightening the circles (while towing with tailplane locked down).
2. Too much lift during zoom launches, sometimes.
3. Even with a normal AR (6,6), poor stability in rough weather conditions.

Problem 1) occurred because of a lift slope of the profile in question being too steep at low angles of attack. The additional lift of the circle airflow during tow generated too much nose down effect. A flatter lift slope – the idea – would make towing more comfortable.

Problem 2) had been identified being a question of Reynolds Number. Acceleration during the launch changes the airflow and a Re-sensitive profile may increase the lift more than desirable. This extra lift produces the dive.

Problem 3) demands a tailplane that lifts strongly at high degrees (10° plus). In rough weather stalls can be watched with really big movements of the angles of attack. This requirement opposed problem 1) and a lift slope not very steep.

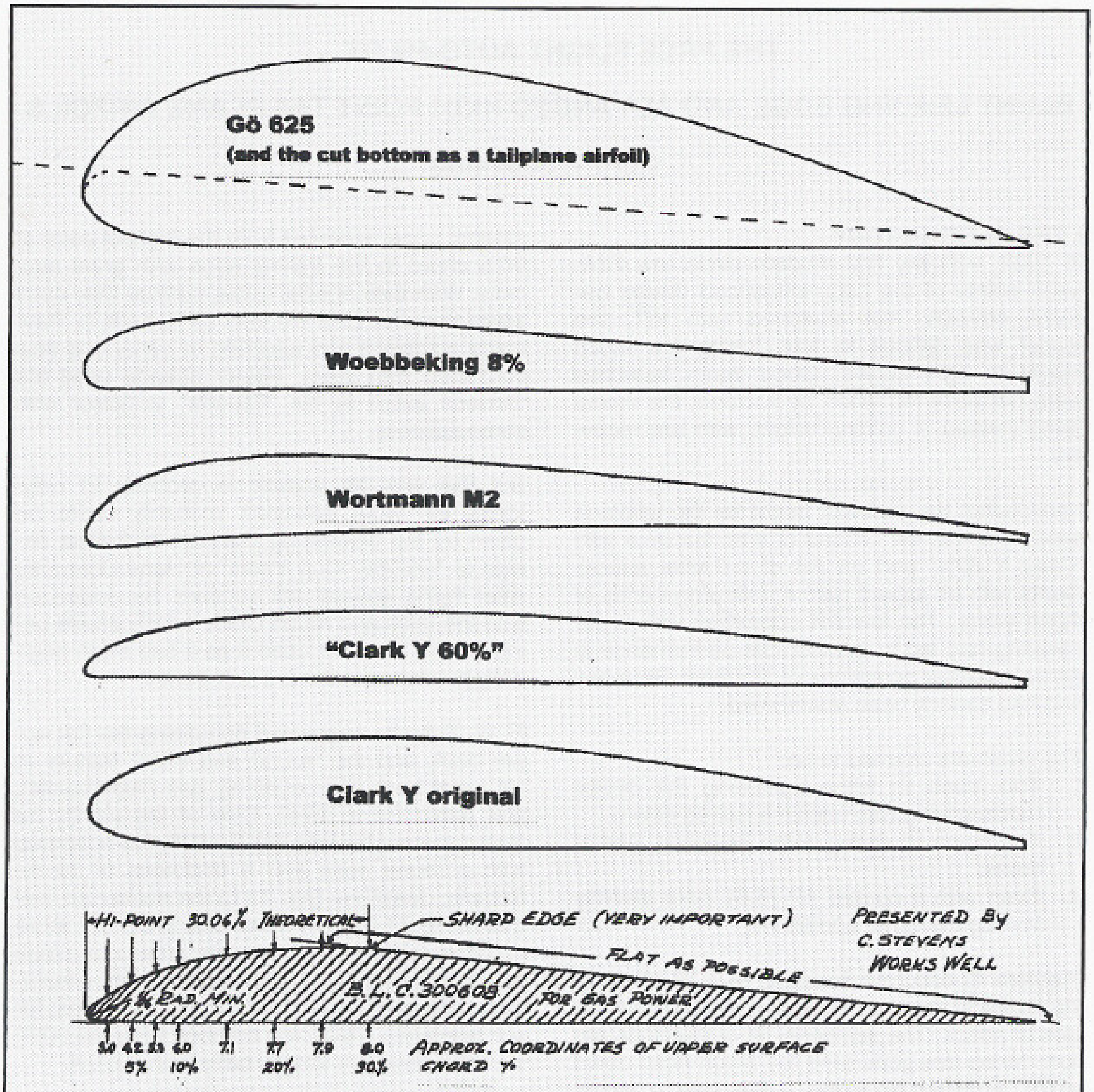
Discussing the problem with Reiner Hofsäss I got some advice. Since Curtis Stevens published his airfoil in 1957, wings of hand launched gliders had been equipped with straight upper surfaces from the highest point at 30% chord to the trailing edge with great success. With their special upper surface they don't seem to suffer from different air speeds (= Reynolds numbers) and attached or separated flow combined with them. Reiner already used the Stevens airfoil in his "Espada" stabiliser with some success.

But this was an answer to problem 2) only. Ideas for more solutions probably could be given by the pioneering German Wakefield design of 1957/58 "Quo Vadis" of Hans Dörmann. After trying several tail sections he ended up with the thick and round Clark Y 12% profile being far the best. He used it as it had been originally published in the pre-war period.

F. W. Schmitz suggested combining the flat upper back and the "round and thick" feature in his great book "Aerodynamik des Flugmodells", first published in 1942. One of the airfoils he tested thoroughly was the Gö 625, flat-bottomed with a round nose and a thickness of 20 %. Schmitz describes (pg. 73 f.) the noticeable fact that at Re 21,000 the lower side produces more negative lift at the comparable angles of attack (up to 8°) than the upper side lift. My conclusion: The blunt nose does the job quite well; for our tailplanes (Reynolds number about 20.000!) we don't need the draggy belly further back.

The other characteristics of "round" and "thick" meet the requirements as well. The lift slopes of the tested airfoils Gö 625 and N 60 (equivalent to the Clark Y) are less steep than those of the curved plate Gö 417 a (pg. 103) but continue noticeably up to 20° and 25° angles of attack respectively (pgs. 147 and 154)! Again the belly in the back could not be blamed for producing high lift at severe stalls. The round nose does it. It seemed to be crucial.

A ruler splitting the Gö 625 left its bottom as an airfoil which would do the job. But I did not dare using a high point at 10 % of the chord. Highest point at 20% chord and 8 % thickness looked not that extreme and seemed to be a good compromise. (In the meanwhile experts like Alexander Andruikov show that high points even more advanced work pretty well too!)

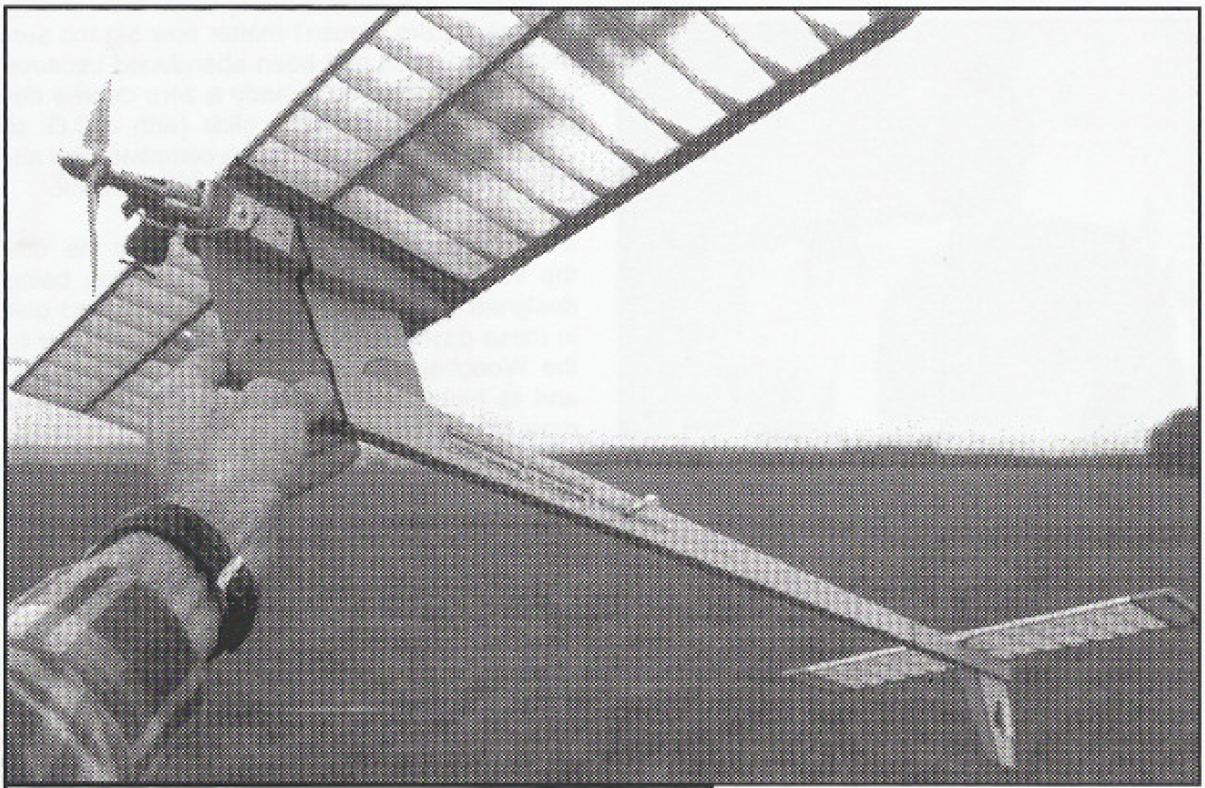


Curt Stevens H.L. Glider Airfoil
(Model Aeronautic Year Book 1957-58 by Frank Zaic)

To make a long story short: 1983 my gliders did much better with this new section. Towing improved, and recovering from small disturbance was smooth with a typical step up in rough thermals. One time I wrote Andres Lepp about my experience. He changed the tailplanes of his short models and was particularly satisfied with the improved reliability of the zoom launch, underlining that sensitivity to Reynolds numbers had been reduced. Andres won the World Champs 1989 and the Euro Champs 1990 (F1A). Why Alexander Adriukov tried the so-called "Woebbeking 8%" on his Wakefields he did not tell me. Designing the profile I never had a VIT equipped F1B in mind. But he claimed in Spring 1992 that this change improved the performance of his models so much that he was able to win World Cup and World Champs within one year (1991).

TAILPLANE SECTION FOR SLOW OPEN POWER MODELS

To introduce the successful British Power Class to Germany I designed a simple high thrust model which could easily be built in several sizes. The wing airfoil with 5% mean camber had been taken from V. Horcicka's "Big Boy", World Champion 1973 from Austria. In combination with a 9% thick tailplane of 25% volume of the wing surface some really good flying models had



Gerd Wöbbeking's Schlosser diesel-powered high thrustline model.

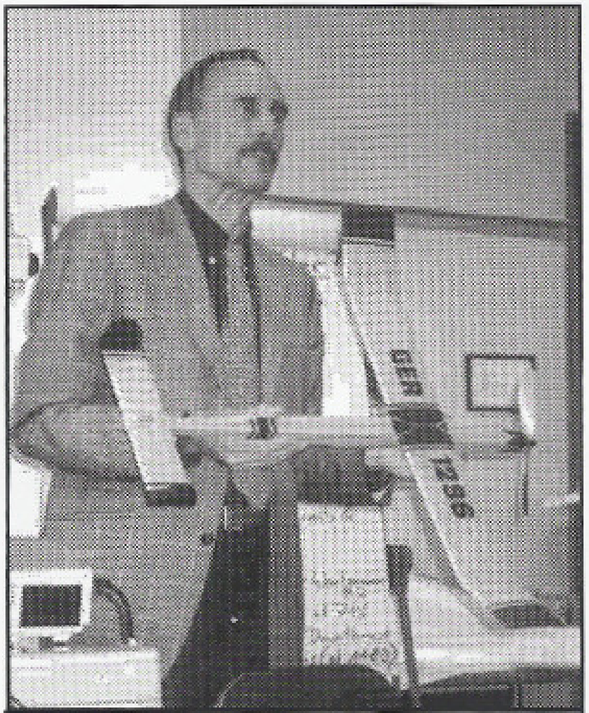
been built with the reliable but slow Schlosser diesel in the front. A few degrees of down thrust worked satisfactorily in fighting the looping tendencies and providing a stable spiral climb.

The peace won't last. Switching to the more powerful Norvel and OS Max FP motors Frank Seja and I ended up with 11° down thrust and a nerve-wrecking unforeseeable flight pattern. After several evenings trying to tame the beasts I thought it over. The tailplane was wrong, again.

Even on the slower models it could be seen that the tilted tailplane in the very last phase of the climb started to work to the opposite side, overriding the trim tab of the rudder. To trim the transition to the glide properly it was necessary to reduce its tilting angle to rely more on the rudder tab. A tilted tailplane works "wrong" when it does not provide lift, but negative lift. This was obviously a matter of speed. With a speed high enough for zero or negative lift at the stabiliser right from the launch the newer models missed the aerodynamic force of the tailplane during the climb nearly at all.

Solution 1) could have been enlarging the stabiliser from 25% to 35% of the wing volume. Solution 2) was thought to be moving back the CG to increase the angle of attack of the tail. Solution 3) was a new more lifting profile in the elevator.

Gerd launches his 'F1C-X' beginner's power model with no moving surfaces.



Gerd at the Free Flight Forum in November 2003 with the P-30 model used for some of the tests.

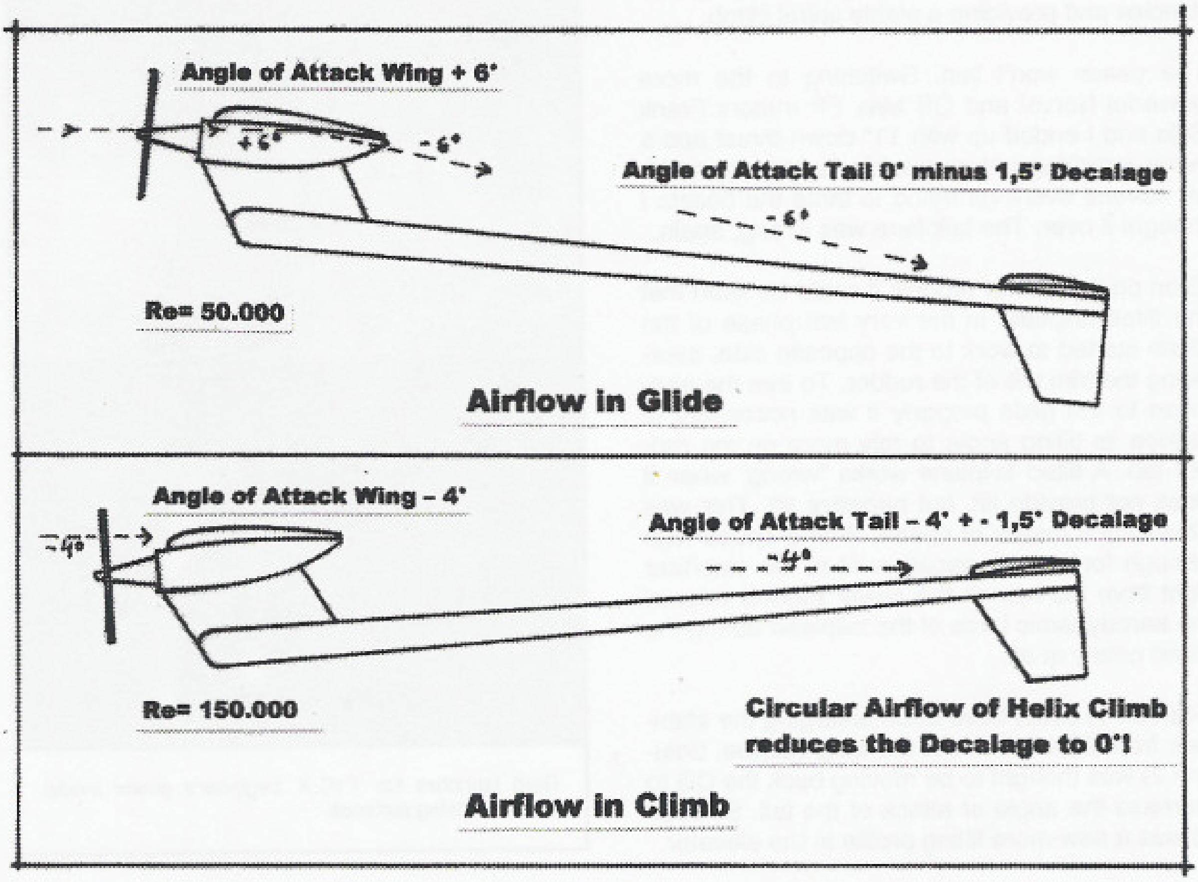
Solutions 1) and 2) had never been tried. Lack of lifting force to increase by enlarging the surface is not a good idea. Zero lift multiplied with Surface = Zero, doesn't matter how big the surface. Solution 2) had been abandoned because a close look showed already a zero degree decalage after trimming the glide (with a C.G. at 71%). Therefore I looked for a complete new airfoil providing more lift at low angles of attack.

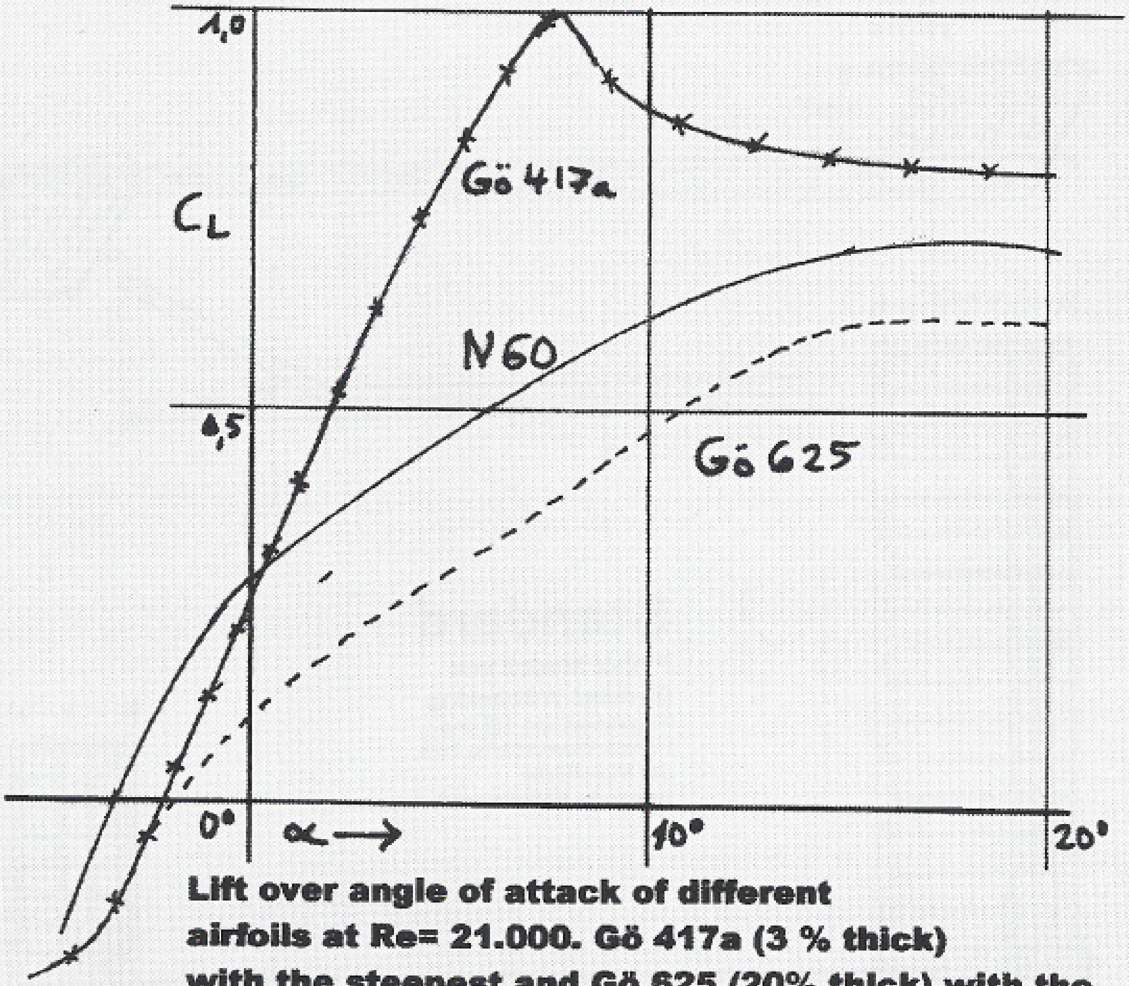
It was not necessary to invent one. In the '60s the Wortmann M2 got some reputation being designed "with a computer" (yes, they had one in these days). Its main features were similar to the Woebbeking 8% but with its undercamber and its higher mean camber of 5% it promised more lift.

The model on which the new tailplane had first been tried had to be completely re-trimmed. With the C.G. remaining at 71%, the decalage for a proper glide increased from 0° to 1,5°. No downthrust of the OS Max FP 10 was needed to fight the looping tendencies! Just the normal helix climb did it and remained necessary for a good transition. With its conduct to fly nice and safe I claimed it being in an "aerodynamic balance".

III. AND WHY NOT WITH RUBBER?

The flight of a Slow Open Power Model divides just in two phases with a short transition. A rubber model flies through four phases: power burst, climb, cruise, and glide. Successful de-





Lift over angle of attack of different airfoils at Re= 21.000. Gö 417a (3 % thick) with the steepest and Gö 625 (20% thick) with the flattest lift slope, N 60 (12 % thick) in between

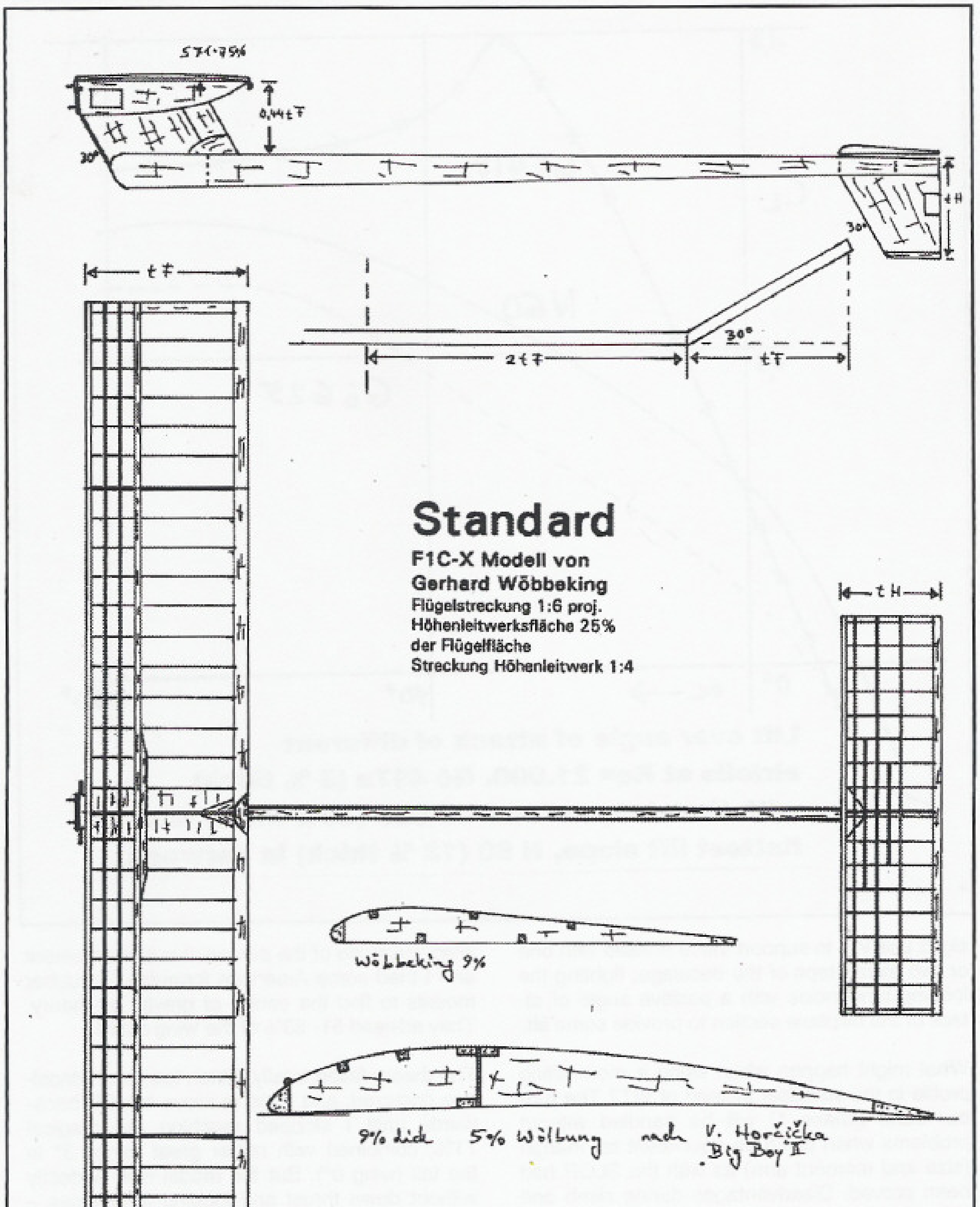
signs use VIT to support these phases with one or two extra steps of the decalage, fighting the looping tendencies with a positive angle of attack of the tailplane section to provide some lift.

What might happen when using a more lifting profile in the stabiliser instead of VIT? The rubber burst (phase 1) will be handled without problems when using an equivalent tail margin (size and moment arm) as with the SLOP had been proved. Disadvantages during climb and cruise? Theoretically the wing adjusts to the speed of the system in an adequate way with the tailplane steering – if the decalage is not too great or not too small.

To test the configuration I built a P-30 model. Its standard performance is well known because of the lot of designs published especially by the US free flight community. My model was of a rather mean layout, but with the Wortmann M2 in the tailplane which measures 25% of the wing. Because of the perspective short moment arm I tried some American formulae for rubber models to find the centre of gravity by theory. They advised 51- 53% of the wing chord.

The theory failed totally. Much too much decalage occurred, and I had to move the CG backwards until I stopped reaching the magical 71%, combined with rather great minus 3° in the tail (wing 0°). But the model flew perfectly without down thrust and looping tendencies – easily reaching 180 sec in still air with 90% of the full turns of seven strands of 3mm FAI Super Sport and – on paper – outperforming O'Dwyer and Kamla by half a minute.

I am sure the Wortmann M2 profile has some future in tailplanes of rubber power models too.


Standard
F1C-X Modell von
Gerhard Wöbbeking
Flügelstreckung 1:6 proj.
Höhenleitwerksfläche 25%
der Flügelfläche
Streckung Höhenleitwerk 1:4
0,44 tF
30°
tH
tF
2tF
Wöbbeking 9%
9% dick 5% Wölbung nach V. Horčička
Big Boy II