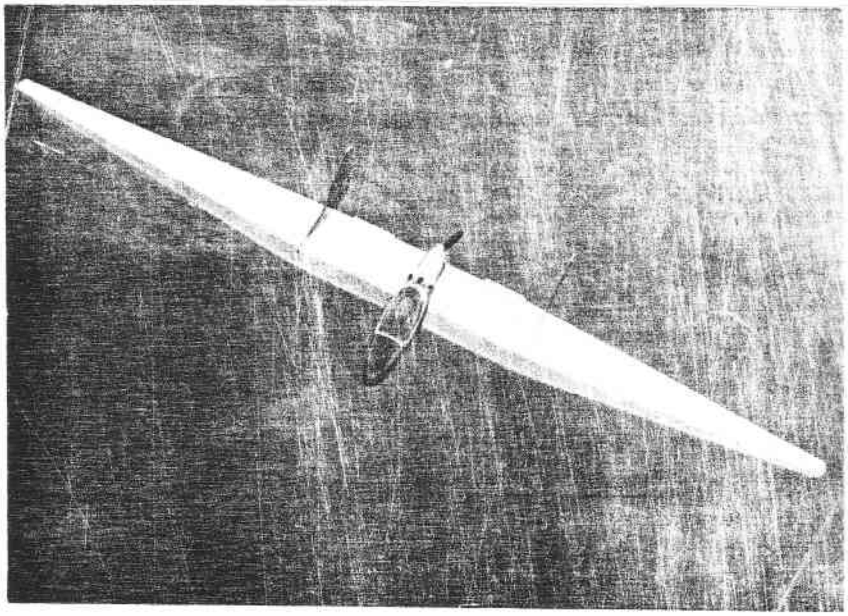
No. 2, July 1986

TWITT



TWITT
(The Wing Is The Thing)
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MINUTES OF THE SECOND MEETING

The second TWITT meeting took place on 26 July 1986 at Gillespie Field. Present were the original TWITTs (minus Hernan Posnansky), plus Pete Girard, Lou Sauve, Reg Finch, Tasso Proppe, Bob Noble, and Robbie Grove. Your editor, Marc de Piolenc, took the minutes. If anyone was left out of the list of participants, it's because your editor ingeniously contrived to lose the sign-in sheet.

Bob Fronius opened the meeting by introducing those who were not present at the first meeting and summarizing the topics discussed so far. TWITT's goal, said Bob, is to build a self-launching, high performance flying wing sailplane. Harald Buettner then demonstrated a mechanism, which he had designed and mocked-up, which he proposed as a replacement for conventional trailing edge control surfaces. The demonstrator was a short section of a fiber-reinforced-plastic wing in which the upper and lower skins were not bonded at the trailing edge. This left them free to flex and to slide against each other from the rear spar to the t.e., producing a smooth change in camber over that region. A torque tube anchored to the rear spar drives a belt bonded at its ends to the upper and lower skins to flex them under the pilot's control. The question of how to adjust the aircraft's c.g. was then discussed, the primary means considered being an adjustable pilot's seat or a movable trim weight. Howie Burr spoke in favor of a movable weight, stating that he had used one in his own sailplane for many years with good results. Lou Sauve brought up the Kasper Bekas, a tailless sailplane designed by Witold Kasper. An argument ensued over how the stability of the Bekas was achieved and what its actual performance was. Phillip Burgers explained the Kasper vortex-control system. Bruce Carmichael pointed out that the Bekas' main advantage over other types resided in its ability to continue flying under the pilot's control with separated flow over the entire wing upper surface; this feature allowed a near-vertical landing approach with easy transition to a more normal flight mode at any time. Bruce doubted, however, that a Kasper wing offered any advantage in max L/D or minimum sink rate. Floyd Fronius mentioned that the Kasper wing design was being used successfully in a popular ultralight airplane. In response to a question, Bob Fronius repeated the performance goals set in the first meeting. A discussion of the variable-stability, variable-sweep scheme set forth by Hernan Posnansky ensued. Discussion of the necessary "black box" (stability augmentation system) was limited by Hernan's absence from the meeting. It was agreed that consideration of the question of whether to build a variable stability machine must await the next meeting, when Hernan would be present to defend his idea. Following the break, a serious effort was made to return to the meeting's agenda by broaching the topic of lift distribution and its effect on stability and performance. Phillip Burgers demonstrated how a backwards-swept wing is conferred longitudinal stability through the use of a bell-shaped spanwise lift distribution instead of the conventional half-ellipse. It was pointed out that stability was achieved at the cost of some span efficiency, since the tip acts in effect as the airplane's tail, producing a down-load--hence a pitch-up moment--at zero lift. The meeting was then adjourned. A request was made for an extension of the meeting for the benefit of the more technically-minded TWITTs. The resulting "post-meeting" expired at about 8 o'clock in the evening.

AGENDA OF MEETING, 23 AUGUST 1986

1. Stability and Control
    - a. Pitch Stability and Damping
    - b. Yaw Stability and Control
    - c. Roll Control
    - d. Handling Qualities
    - e. Unusual Attitudes; Recoveries
        - 1. Vne Control
        - 2. Spins

2. Design and Construction
    - a. CG Range — C.G.
        - 1. Straight wing has narrower range for same AR
    - b. Trimmable CG
        - 1. Internal--Weight Shift
        - 2. External--Control Tabs
    - c. Method of Fabrication
        - 1. Female Molds
        - 2. Foam Core
    - d. Pilot Position

Here are the references that might conceivably--or inconceivably be of use to you:

The Mitchell Sailplane, S-O '53, p. 20
Flying Wing Sailplanes, M-J '48, p.8
Lippisch: The seed that became a tree, M-A '53, p. 3
The performance of sailplanes in circling flight, J-A '51, p. 13
Marske, J: The XM-1 tailless sailplane, D '60, p. 4
Horten I: Interesting gliders, J-F '59, p. 23
Horten III: New German sailplanes, N '38, p.8
Horten IV: (by Raspet), N-D '50
The modified Horten IV of the AHQ BAFO club, N-D '50, p. 9
The EPB Flying Plank: J-A '54, p. 14 and S-O '54, p. 18 and J-F '57, p. 18 and M-J '55, p. 15 and Ja'60, p. 10
Farrar: No listing
FAUVEL: See attached list
Kaspar: No listing
Backstrom: Mar '62, p. 16

LIFT DISTRIBUTION ON FLYING WING AIRCRAFT by Dr. Reimar Horten

The following contains the essence of what was presented to me by Dr. Reimar Horten during my visit to his home in Athos Pampa, Argentina in May 1980. J. Scott

After Dr. von Prandtl [sic] had published his wing theory at Goettingen in 1918, and thereby established a basis for an understanding of the lift distribution spanwise across the wing, as well as the presence of induced drag, it was found that the flat elliptical shape gave uniform air deflection along the entire span, which minimized the induced drag. It was also determined that the relationship between span and lift was constant.

Today one rarely sees a true elliptical wing, as other factors dictate its ideal shape. The straight tapered wing, for instance, is lighter and easier to build, factors which outweigh the advantages of the elliptical wing.

Since lift and weight are equal in straight and level flight, one needs to find out how the weight of the wing on a cantilevered sailplane changes with its shape and taper when the span is constant.

Let's look at the flight characteristics. For good roll control, the airfoil should be thin in the aileron area, while a thick airfoil is needed at the root to obtain an acceptable weight/strength ratio. Since the sailplane will be thermalling near the wing's maximum lift capability, its stall characteristics must be closely studied, both during turns and level flight. If air separation first occurs near one tip, which is likely due to the thin airfoil used there,, the roll will quickly stall additional portions of the wing due to its downward movement, and the asymmetric lift cannot be overcome by the ailerons.

In a swept back flying wing, the conditions are somewhat different. Here the flow separation occurs initially at a point about 1/3 the halfspan, right where the center of pressure and the aircraft's center of gravity are located; thus no upsetting moment is created. Asymmetric lift can be controlled by the ailerons, since these still work in undisturbed airflow. If the separation should occur on one side only, a moment is created about the yaw axis because a stalled wing has a greater increase in parasite drag which slows the wing despite the disappearance of induced drag. When ailerons are used to control the asymmetry, normal--not adverse--yaw should be generated to cancel out the moment, and directional control should be maintained even with rudders of low efficiency.

Now, let's see how we can satisfy all requirements for a fully-controllable stalled flying wing, and thereby avoid involuntary spins. Most pilots will think of stability as the primary requirement. This is not true! What is needed is the proper distribution of moment around all three axes and the ability to fly out of any upset.

Trim about the pitch axis requires that the center of pressure and center of gravity lie on a line at 25% of the wing chord. The conventional elliptical-shaped wing without washout has an elliptically shaped lift distribution curve at all angles of attack, and the center of pressure in the Y-direction on a half-wing can be expressed as Y ell = 0.42(b/2). This lift distribution is not desireable, since the point along the wing where the airflow first separates cannot be determined.

The desired bell-shaped lift distribution curve can be obtained on any wing by the appropriate amount of twist or wash-out. The center of pressure will then be located near 1/3 of the halfspan and moves along the wing with changes in angle of attack. On a flying wing sailplane with built-in wash-out, one can obtain the desired lift distribution simply by moving the wing tip elevators, thus obtaining a C_L corresponding to the best L/D ratio. This distribution should be at or near the desired form at other C_Ls, thereby giving us the same center of pressure in the Y-direction.

The moment about the pitch axis depends therefore on a lift distribution, which at its center of pressure (Y = 1/3 x b/2) also has the largest C_L loading, and, depending on the taper ratio, will determine where airflow separation first occurs in the case of an excessive angle of attack. Thus one can without difficulty determine the fixed wash-out, the wash-out that is variable through elevon deflection and the needed wing taper ratio.

Once the airflow separation point along the span is determined, the balance problem around the roll axis is also solved, since the ailerons remain effective and will overcome any asymmetrical loads. Remaining is the most important problem in a flying wing--how to retain aileron effectiveness at all angles of attack, and to minimize or eliminate adverse yaw.

A sweptback wing has a large skid-roll moment, and it is therefore necessary to prevent any skidding caused by aileron yaw, since the skid will cancel the desired roll moment and aileron response will be zero! To put it simply; one must make coordinated flying of the wing easy for the pilot. This puts one additional requirement on the lift-distribution. While the elliptical lift curve was quite suitable for an conventional aircraft, the swept-back flying wing sailplane was found to require the bell shaped curve in order to give a slight negative angle of attack in the aileron area near the tips. This reverses the forces normally associated with wingtip vortices and actually generates some forward thrust (1)! Adverse yaw is also minimized when the ailerons are deflected, and therefore controllability about all three axes is assured to a degree not possible with conventional aircraft.

The easy flying characteristics are especially beneficial during blind flying, when the absence of adverse yaw makes flying on instruments so easy thet the artificial horizon can be eliminated and the aircraft flown for extended periods on T&B and airspeed only. During the 1938 Rhoen contest, two Ho IIIs climbed to 25,000 feet in a Cu-Nimb cloud using these instruments only (2).

While testing the Ho II in 1935, it was found that the calculated center of pressure and the one found during test flight did not coincide. The swept wing differed from the straight in that a loss of lift was noted where the wing roots were joined. It was found that the angle at which the two leading edges converged reduced the local lift gradient (A. Pope has investigated this problem in a NACA wind tunnel and published a practical correction formula). Theoretically, this problem could be overcome in two ways: one, by incorporating one or more steps in the sweep-back of the leading edge, or secondly by changing the chord in the affected area to maintain the 25% center of pressure line through the center sectin despite its irregular shape. The Ho V uses the first solution, the Ho IV the second (3). On the high-performance Ho VI the 25% line was given a rearward pointed peak at the center through an exaggerated parabolic tail to maintain a lift gradient which compared favorably to a straight wing (4). A high aspect ratio sailplane is an ideal tool for investigating the effect of sweep and dihedral on lift distribution. It must be even along the entire wing, with no irregularities in the curve caused by wing shape or protrusions in order to obtain minimmum induced drag and thereby maximum performance. Any eddy, large or small, in an airflow creates streamlines to which the aircraft must be shaped.

FOOTNOTES

(1) The convex shape of the lift distribution curve induced vertical velocity components which created induced drag. The concave shaped lift curve, combined with positive lift, induces thrust!

(2) Translator's note: The two prototypes, D-12-347 flown by Werner Blech and D-12-348 flown by Heintz Scheidhauer, both entered a thunderstorm along with 16 other sailplanes (!) according to Dr. Horten's brother Walter. It was commmon in such instances for the pilot to undo his safety belt and attach the parachute rip cord to the aircraft structure. Both pilots were tossed from their aircraft. Blech was dead when found; his parachute had functioned normally. Scheidhauer remained aloft hanging from his parachute for nearly two hours and almost froze to death. Both Ho IIIs were destroyed. The altitude was verified by the barograms.

(3) Translator's note: In the mid-fifties, a Ho IV was

acquired by the Mississippi State University for performance testing. In their effort to improve streamlining, the 25% line was apparently lost. Their best L/D was 29:1; the Hortens claim 37:1.

(4) A paper on lift distribution curves as affected by geometric variations on straight and swept wings was published by Multhopp and Weissinger.

OF FORCES AND MOMENTS

During the last TWITT meeting, there was some confusion over terminology, particularly the terms Aerodynamic Center (a.c.) and Center of Pressure (c.p.). The following letter, reprinted from the August 1986 issue of Model Aviation, should shed some light...

Both Correct!

Recent letters concerning airfoils (John Brownlee in the February 1986 issue and Brad Powers in the May 1986 issue) recall a memorable line in a popular film of a few years ago: "What we have here is a failure to communicate." It's a heated argument, but their only difference is one of visualization—how each chooses to understand a rather complex physical phenomenon. Both are right.

I suppose that this is caused by something like a generation gap. From reading his articles, I understand that Brad Powers is, like myself, a retired engineer who probably learned his aerodynamics in the Thirties. Mr. Brownlee, apparently, has also been educated in the same field but perhaps 20 years or so later.

Early NACA (NASA's predecessor) airfoil data always presented "Center of Pressure" (C.P.) rather than "Aerodynamic Center" (A.C.) location. C.P. is defined as pitching moment divided by lift. On cambered airfoils, this quantity varies with angle of attack. But "thin" airfoil theory predicts, and wind tunnel data verifies, that all cambered sections have a constant pitching moment together with a fixed A.C. (center of lift) over their useful angle of attack range. This apparent paradox, a fixed A.C. and a moving C.P., has confused both modelers and full-scale aero engineers for 60 years or more. Possibly for this reason, the NACA changed this early format sometime in the Thirties. All airfoil data is now shown in a lift-drag-pitching moment about the A.C. format (note that there is no moment about the C.P.). A.C. is defined as that point about which the pitching moment is constant. With this convention, lift is assumed to act at the A.C. which is at a fixed position on each section (usually between 23% and 26% chord—thickness has some effect on its location).

How do you resolve this "paradox?" There is no paradox. When you divide a fixed moment by a force that varies with angle of attack, obviously you get a C.P. that varies with the same parameter. Simply remember, you cannot speak of A.C. and C.P. simultaneously; they are two different ways of describing the same thing. If you assume lift acts at the C.P., there is no airfoil-produced pitching moment; if you place it at the A.C., there is a constant (almost) pitching moment due to airfoil camber. But it's immaterial which convention is chosen; both concepts are correct.

Their "Clark Y" wing discussion was similar. Both are right in their own context. Powers is right: a short-nosed fuselage, attached to a wing at a positive incidence angle, will add a nose-up moment. But Brownlee was also right: typically, this will not be enough to trim a useful lift coefficient. But give me a long, noseless fuselage shaped like an inverted airfoil, then . . . ? On the other hand, while it is correct, Powers' statement that "Clark Y" airfoils with upturned elevons are suitable for tailless designs is a weak argument. That's not a "Clark Y" anymore.

Joe Tschirgi
Nanjing, China

With this letter, we'd like to bring this discussion to a close.

[From Bruce Carmichael's collection; translated by Marc de Piolenc]

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Akaflieg Muenster's All-Wing Sailplane

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Based on the realization that the price-fixing policies of the sailplane-building oligarchy have made the popularization of soaring impossible, the Akaflieg Muenster has developed a sailplane for home construction. It is an all-wing machine with a swept-back deep chord wing made of wood. The rectangular, one-piece, single spar wing will use balsa wood for the leading edge and plywood skin for the rest (Eppler 620-624 airfoil section). At the tips, the wing has drag rudders and flaps of altered camber which serve simultaneously as ailerons and elevators. A 2.3 meter long, single seat fuselage built of balsa/glass fiber laminate [?] is permanently attached to the wing. A retractable wheel is installed in the wing root. Large split-flap airbrakes on the aft fuselage serve as landing aids.

Data: Span 13.00 m, Length 2.5 m, Wing Area 9.1 sq.m, Aspect Ratio 12, Empty Weight 120 kg, Gross Weight 230 kg, Best Glide Ratio (at 22 kg/sq.m) 39 at 90 km/h, Minimum Airspeed 64 km/h, Never-Exceed Speed 200 km/h.

B. Herlitzius

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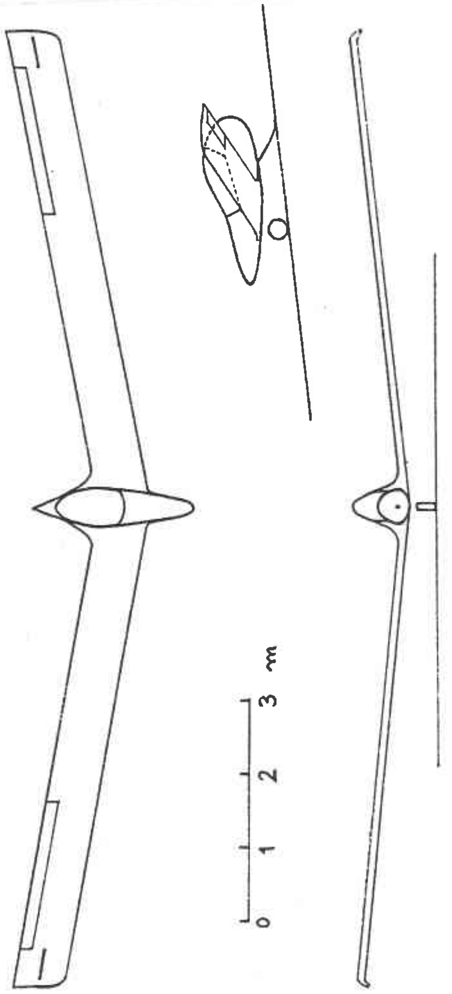
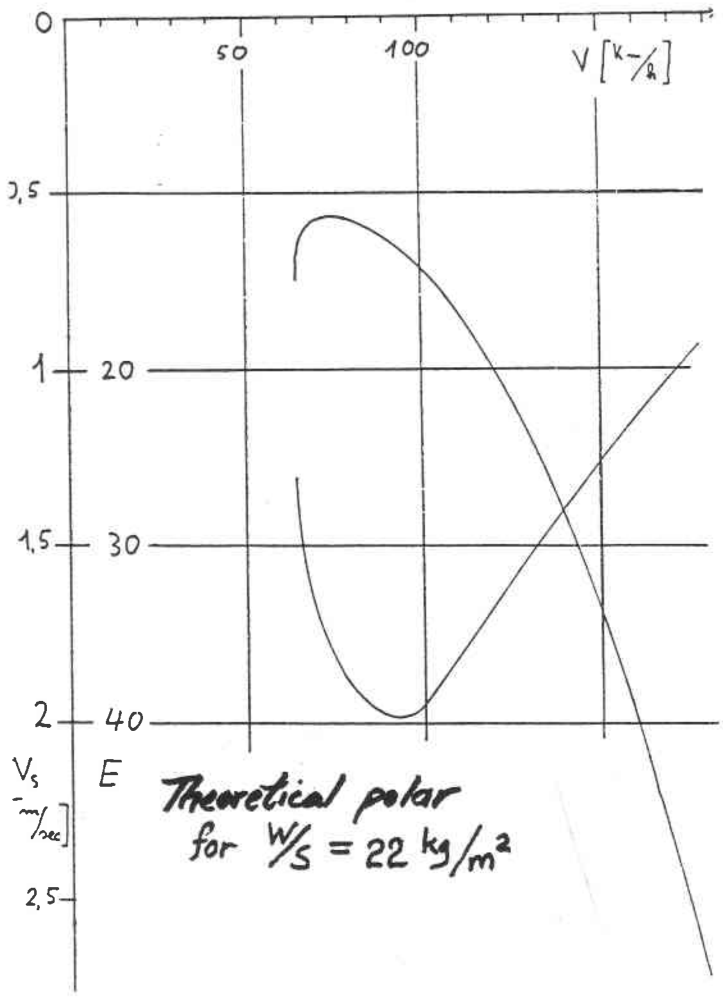


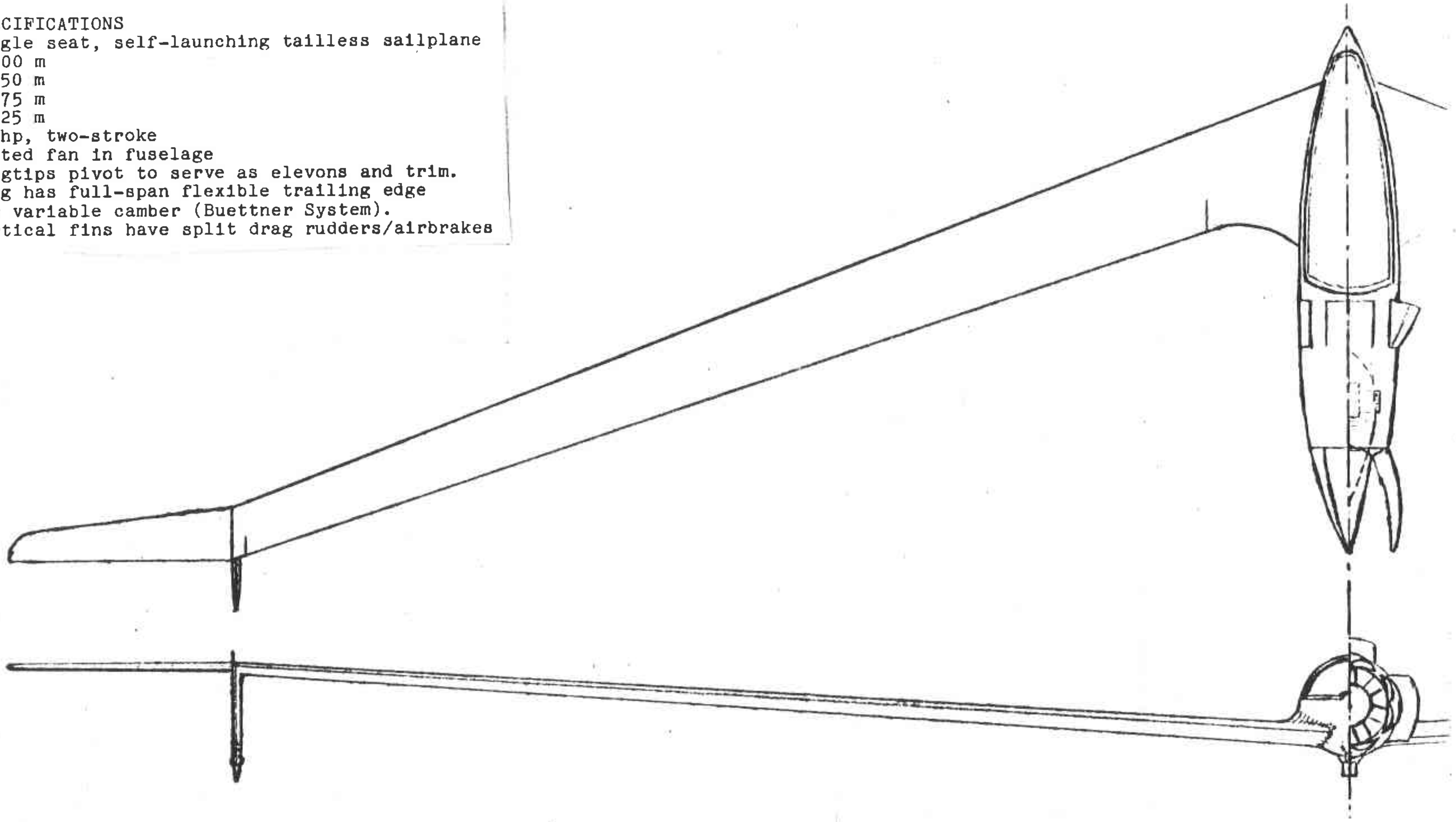


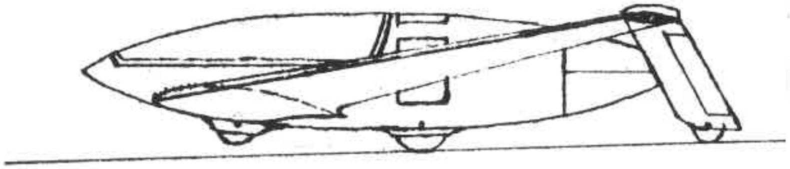
Theoretical polar for W/S = 22 kg/m²

AAR I
A Self-Launching Tailless Sailplane
proposed by Harald Buettner

SPECIFICATIONS

Type:	Single seat, self-launching tailless sailplane
Span:	18.00 m
Length:	3.50 m
Root chord:	0.75 m
Tip chord:	0.25 m
Powerplant:	30 hp, two-stroke
Propulsion:	Ducted fan in fuselage
Controls:	Wingtips pivot to serve as elevons and trim. Wing has full-span flexible trailing edge for variable camber (Buettner System). Vertical fins have split drag rudders/airbrakes





CONTROL DESCRIPTION

Each wingtip (elevon) is controlled by its own stick (this provides absolutely free mixing) and has its own trim lever. Each pedal works one vertical split rudder only; both pedals together act as airbrakes and wheel brakes.

Flaps are controlled by two levers: one controls the inner two thirds of both wing panels, the other controls the outer third of both panels.

Air intakes and exit clamshells are adjustable to three positions: one--closed, two--1/4 open and three--fully open. Position two is used for cooling down the engine after it is shut down in flight.

The pilot's seat is adjustable fore and aft to give correct center of gravity position.

FLYING WING DESIGN FLOWCHART

proposed by F. Marc de Piolenc

1. Choose planform and basic airfoil thickness form (symmetrical section).

2. Calculate optimum mean camber surface based on design conditions:

   straight flight
   design lift coefficient
   design lift distribution
   stability criteria (Horten 1983)

but ignoring:

   control surface design
   fabrication constraints

3. Calculate the aerodynamic efficiency of this reference or "ideal" airplane.

4. Impose fabrication constraints:

   maximum length of foam slabs
   hot-wire cutter limitations
   practical core shapes
   structural limitations

Approximate the ideal camber surface with linear-transition sections.

5. Calculate the actual pressure distribution of a wing with a practical mean camber surface as determined in (4). Calculate its efficiency and stability and compare to reference airplane. Revise design to yield performance as close as possible to the reference machine.

6. Calculate the structure weight including fittings. Revise initial gross weight estimate. Repeat steps 2-5 if revision is significant, say greater than plus or minus 5%.

7. Lay out control surfaces. Calculate the effects of control deflection on stability and efficiency. Compare to reference airplane.

8. Freeze design. Prepare shop drawings and templates.

9. Build!