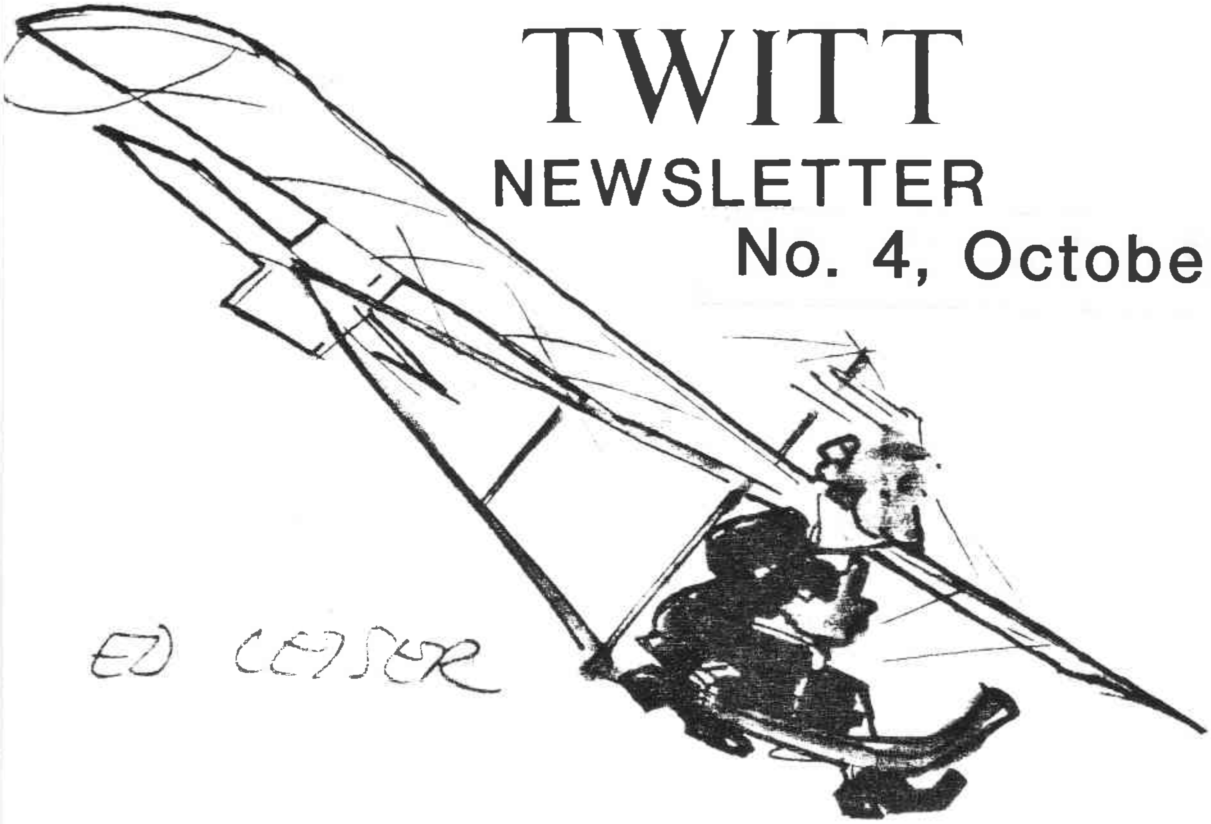
# TWITT

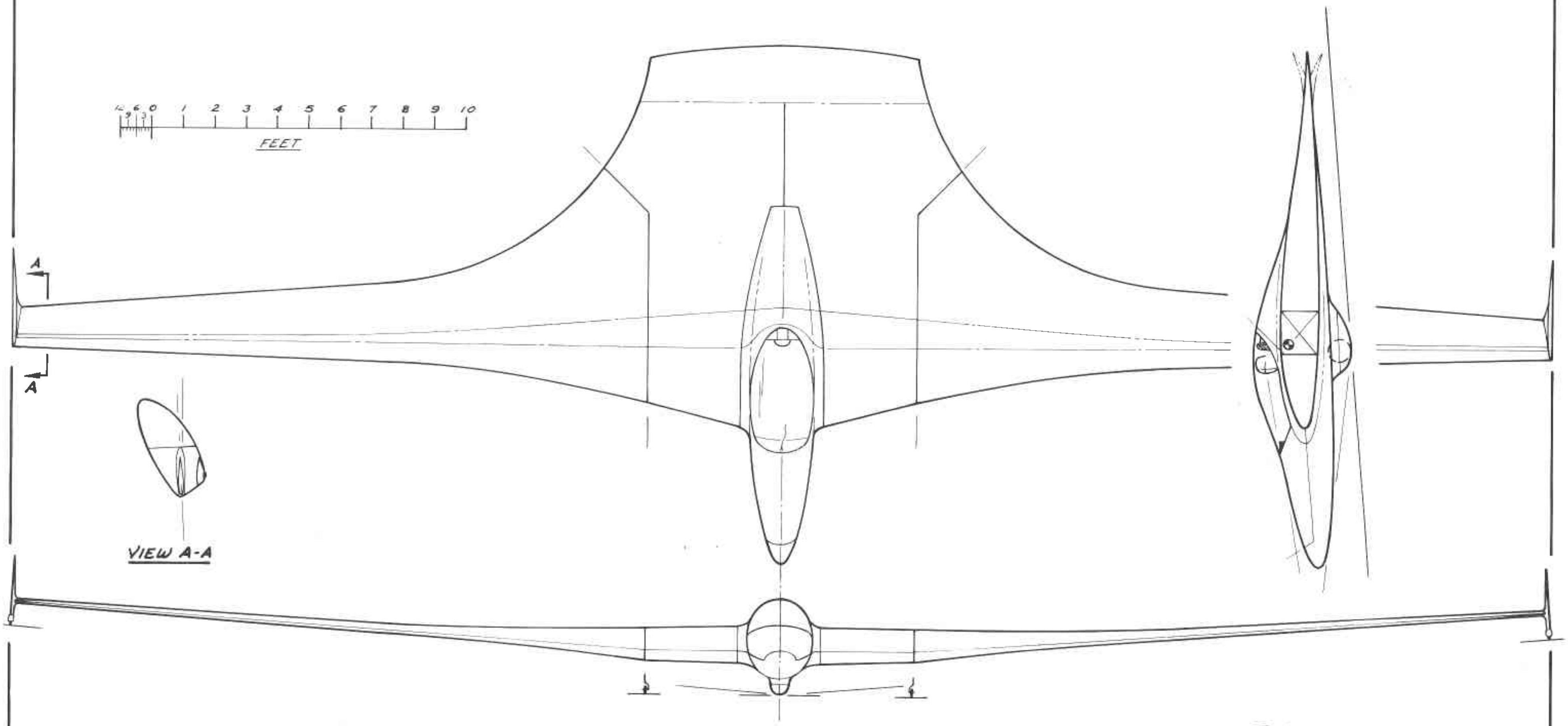
## NEWSLETTER

## No. 4, October 1986



TWITT
(The Wing Is The Thing)
PO Box 20430
El Cajon, CA 92021

Telephone: (619) 224-1497 before 10 AM or after 10 PM



## Manta

BY G. BLUMENTHAL
9/27/86

SPECIFICATIONS:

| | |
|---|---|
| WINGSPAN | 15.0 M (49 FT 2.5 IN) |
| WING AREA | 229.24 SQ FT |
| ASPECT RATIO | 10.56 |
| MAX WING LOADING | 6.63 LB/SQ FT |

REMARKS:

STRUCTURE TO BE GLASS/FOAM OR BALSA SANDWICH • FLEX SKIN ELEVATOR • OUTER QUARTER SPAN TWISTS FOR LATERAL CONTROL • DRAG RUDDERS AT TIPS MOVE OUT ONLY FOR YAW CONTROL • FIXED GEAR WITH COVERS •

# MINUTES OF MEETING, 27 SEPTEMBER 1986

Bob Fronius opened the meeting by introducing guests Klaus SAVIER (sa VEER) and Billy GRAY and passed out copies of drawings of the Jansson tailless glider designs which had been painstakingly enhanced by Harald Buettner. These drawings had appeared in Newsletter No. 3 but had reproduced very poorly due to the poor quality of the originals. Klaus, a native of Germany, tailless airplane devotee, fan and correspondent of Dr. Reimar Horten, then introduced himself and his work. In cooperation with Dr. Horten, who designed the pitch distribution, Klaus has laid out a sport sailplane intended for foot launching. He showed TWITTs a videotape of the (ultimately fatal) flight tests of a quarter-scale RC model of the ship. The model was very fast, giving the camera operator a good bit of trouble. Klaus said it had insufficient sweep and therefore lacked the necessary pitch damping. The model's ultimate crash, however, was not caused by this problem; Klaus simply lost track of the machine's flight attitude. He also showed footage of test flights of his highly modified Mitchell U-2, which is currently undergoing still more modification. Biggest drawback of the U-2 as built is a tendency to tuck at high speed, a result of the wing design philosophy of the designer. Klaus' new mods will include changing the wing and control surface camber lines and introducing aerodynamic twist. The camber line mods should improve pitch stability and the twist should mitigate the strong adverse yaw of the original wing. Klaus also showed off two carved balsa models incorporating Irv Culver's prescriptions for good tailless-aircraft design, plus one incorporating his own. The most obvious difference was that while the Culver gliders incorporated respectively anhedral and dihedral tip fins, Klaus' had straight, Horten-style wingtips. In his talk, Klaus compared the twist distributions according to Horten, which puts most twist near the tips, with that of Culver which puts most of the twist near the root.

Billy Grey suggested that TWITT invite Davis, the designer of the Starship Alfa featured at Oshkosh, to speak to the group. Bob then authorized a fifteen-minute break.

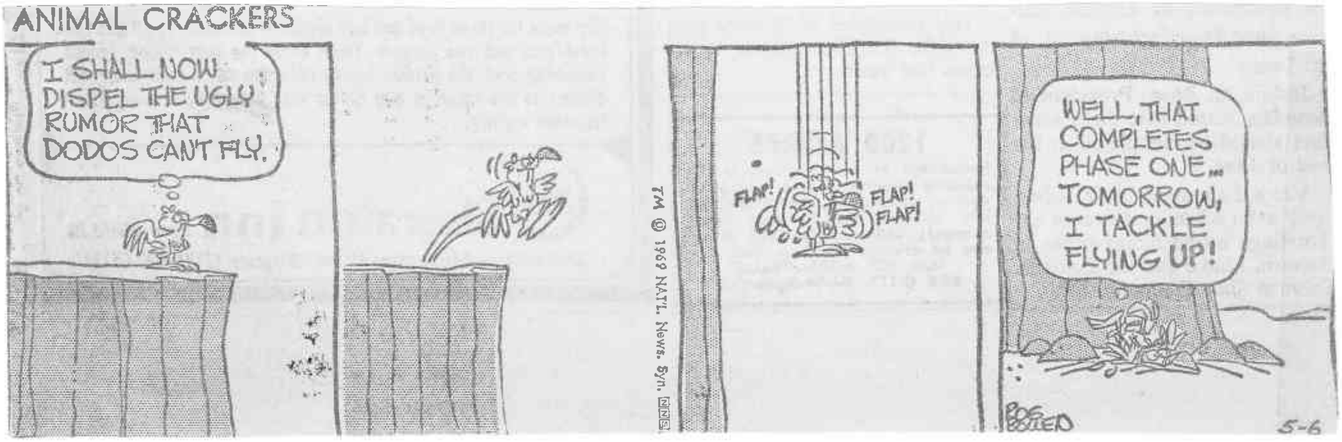
After the break, Reg Finch gave a very-short-notice version of his talk on wing planforms. Despite the lack of preparation and the primitive visual aids used, the talk was well received. In particular, the information on the influence of wing planform on spanwise flow, hence on stall characteristics, was quite useful. Reg said that he was puzzled by the current emphasis on swept-forward wing designs for high-performance airplanes. Phillip Burgers explained that the wing center-section suffers a smaller loss of lift with sweep forward than with sweep back. Reg noted that trailing edge sweep has a greater influence on spanwise flow than the sweep at the quarter-chord line. In his research on wing tip designs, Reg found an optimum toe-out angle of 2.5 degrees for Whitcombe winglets placed above the wing. Jerry Blumenthal mentioned cascade diffuser tips modeled on eagle wing tips. George Wright wondered whether the stiffer structures possible with all-wing aircraft might not give wing performance closer to that predicted by mathematical and wind-tunnel models than is usually the case.

Jerry Blumenthal then rose to discuss his very unusual design which is reproduced in this newsletter. The planform is unswept, primarily to decouple twisting from bending. The center-section chord is drastically extended to provide a moment arm for the elevator. This also provides good spar depth in the center section. Lateral control is achieved by warping the wing tips. Jerry thought that if flutter was a problem in a flexible outer wing panel, it could be damped out aerodynamically with small auxilliary surfaces at the tip. Don Webb accused Jerry of simply hiding the fuselage and tail-boom with a big fillet. Jerry mentioned that he wanted at all costs to avoid any breaks in the wing surface for spoilers and so on and proposed the use of wingtip drag rudders for glide path control. Klaus pointed out that reasonably-sized rudders were not adequate for glide path control in a high-performance machine.

Harald Buettner put up a drawing of yet another spectacular tailless sailplane, this one with a prone pilot and a parabolic planform. The meeting then decayed into random conversation and your Editor stopped taking notes.

## AGENDA OF MEETING, 18 OCTOBER 1986

Mrs. Culver has confirmed Irv Culver's appearance and provided instructions on his care and handling. He needs a large surface on which to write and a good bit of gesticulating room (members are cautioned not to sit too close to the speaker). A large object suspended from the ceiling and droppable at will is useful for ending the presentation when all else fails. As previously mentioned, Irv is no advocate of tailless airplanes, but he still has definite opinions on how to build them. This should be a great meeting.



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dynamics
aerodynamics
structures

Feb. 1986

## TAILLESS - FLYING WINGS

During the past 50 or 60 years the author has observed several tailless designs of airplanes, gliders and sailplanes. The impression received is that little is commonly known about the aerodynamics, flight dynamics or aeroelastics of tailless designs.

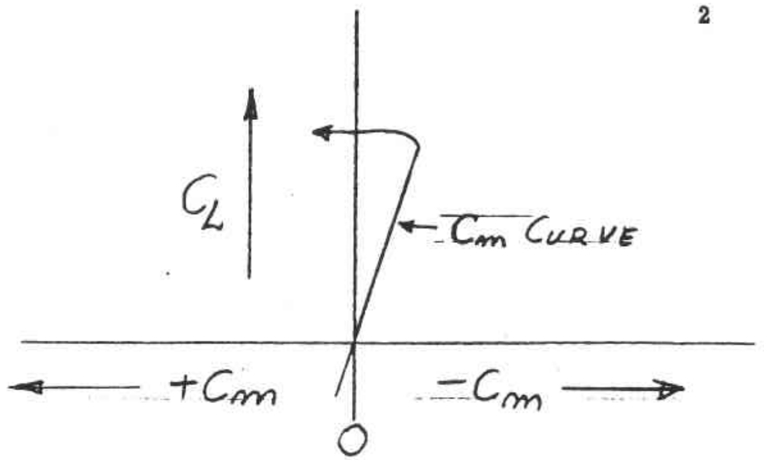
Everything has good and bad. We will discuss only the Bad of tailless designs and how to make Bad Better.

The first Bad is the possibility of tumbling. The author made a theoretical study of tumbling (auto rotation in pitch). The technical explanaation of this phenomenon is that the pitch damping becomes negative for some designs at high values of $\frac{\dot{\theta}}{V} \times \text{CHORD}$

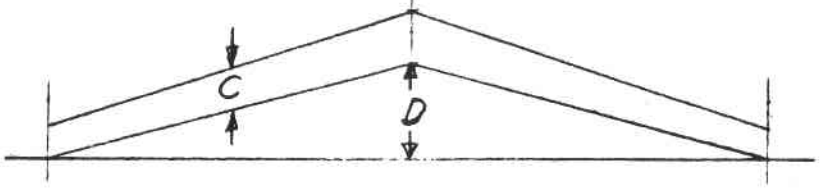
$\dot{\theta}$ = pitch angular velocity

V = forward speed

A lay explanation of this is: for some designs pitch tumbling will occur if rapid nose-up pitch is applied at low speed, or if the design has a nose up hook in the pitching moment curve at high angles of attack.



The reason tumbling is a problem is that the machine gets trapped in its own lift Circulation or vortex. The tumbling study suggested that a simple criteria for the border line between tumbling and not tumbling, for the case of the CG on the wing chord plane vertically and at 25 %of the MAC, was $\frac{D}{C} = 2$



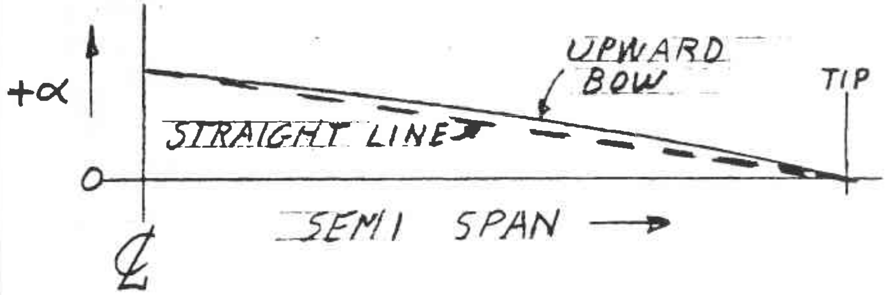
where C is the average chord and D is the trailing edge crotch dimension.

About twenty cardboard models were made to check the theory, with varying values of $\mathcal{R}$, sweep and taper ratio. These models approximately confirmed the theory. That is, anything less that $\frac{D}{C} = 2$ could tumble if adequate pitch rate were applied at low speed.

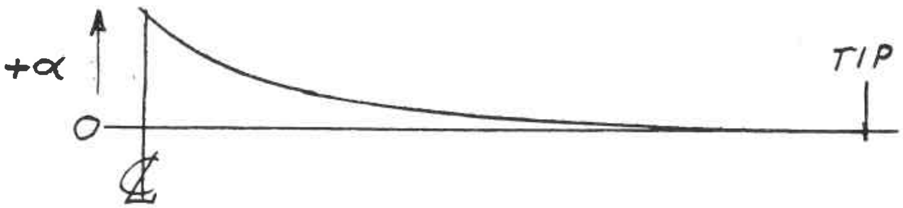
Next, the effect of vertical offset of the CG: For CGs of "1" average chords above or below the chord plane, tumbling if induced would not continue. Further studies of the effect of vertical CG offset may be in order (?).

The second Bad is the lack of pitch and yaw damping from the pilot's point of view. Some pilots (especially helicopter pilots) have no adverse comments to make about the handling qualities of tailless designs, since they are used to machines with "0" or negative damping. However many pilots are prone to PIO when under adverse conditions, like rough air in a machine with low pitch or yaw damping. High sweep angles alleviate this problem.

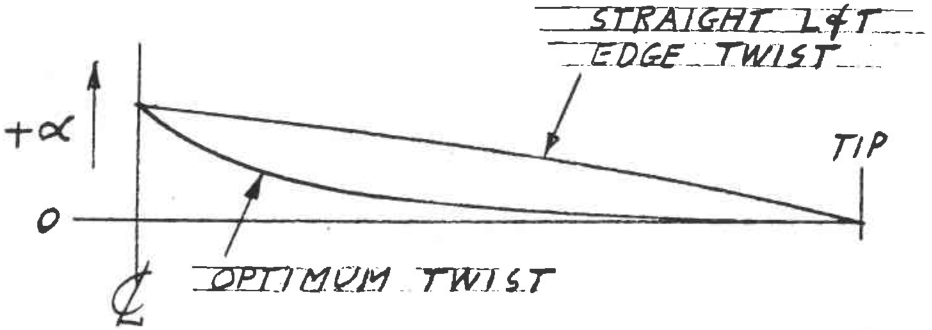
The third Bad is the poor span-loading achieved by twisting the wing using straight leading and trailing edges. For a tapered wing this gives a twist distribution that looks like this if you hold the tip at 0 angle.



The reason for the upward bow is that for straight leading and trailing edges the vertical offset difference of these edges due to twist is proportional to the span, but to find the twist angle you must divide this local offset by the local chord. Now the optimum twist distribution for a swept back wing looks like this:



So if you superimpose these two curves you get a picture like this:



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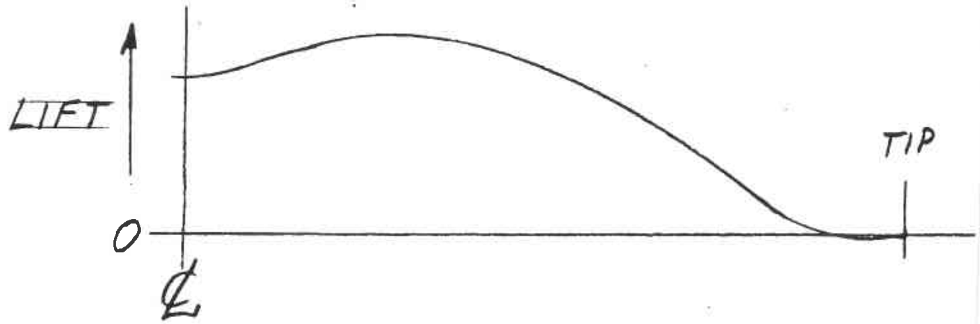
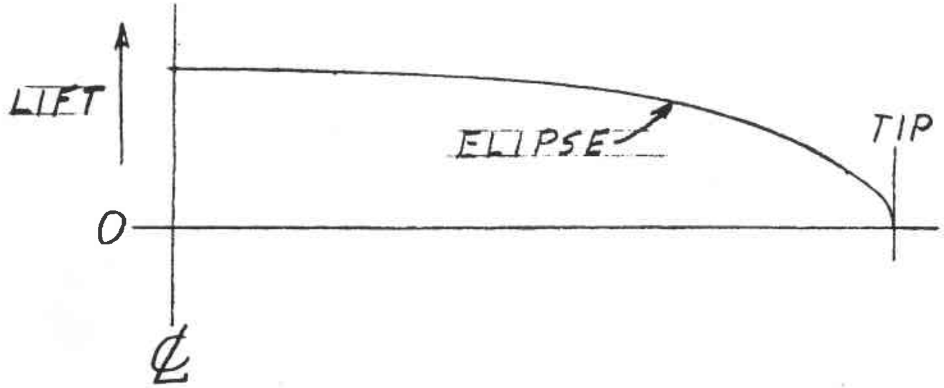
The straight leading and trailing edge twist results in a span loading for a swept back wing that looks like this when trimmed in pitch.



You must push down at the tips to balance the loss of lift at the ℄ to trim in pitch.

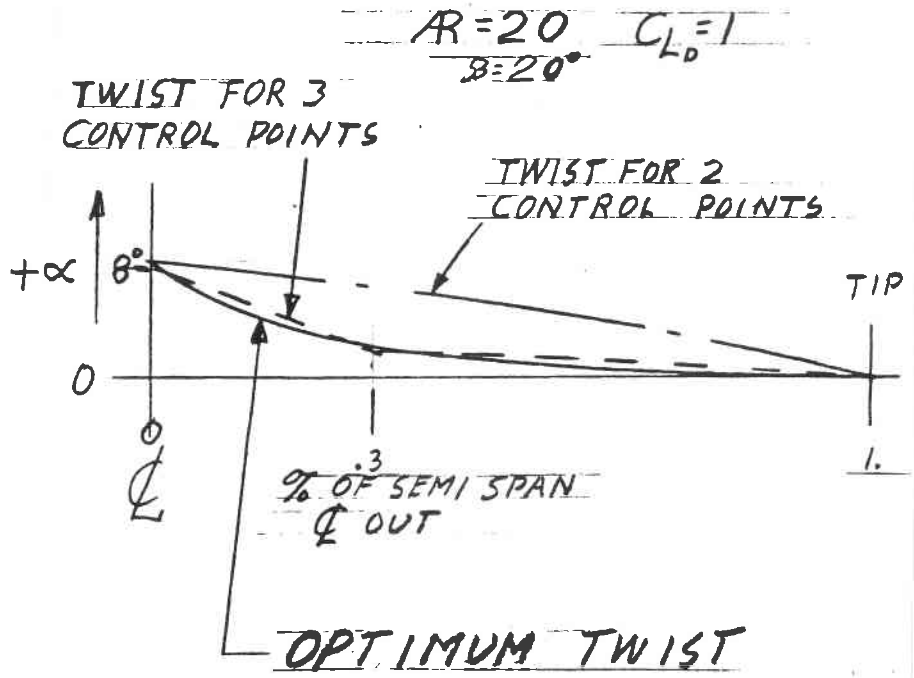
Now the minimum $C_{D_i}$ (induced drag) corresponds to a span loading that looks like this:

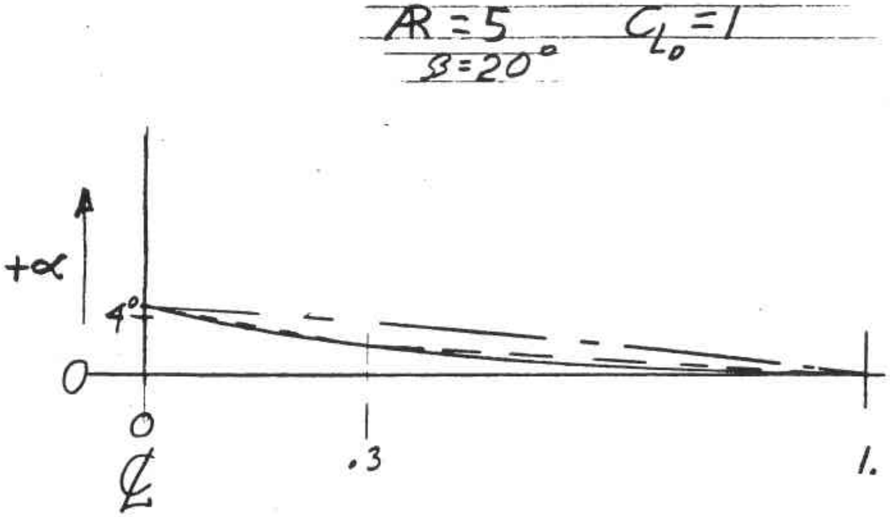


If you restore the lift near the ℄ you will not have to push down at the tips. So why not twist the wing appropriately to achieve this optimum span loading and reduce the induced drag? The question is: why put span on a machine and then drastically reduce its effect? The answer appears to be that it is not simple to build a wing with the optimum twist distribution. A compromise using three control points, like root and tip plus one at 30 % out from ℄ and twisting around the main spar. This would produce a wing with almost perfect twist distribution without much additional work.

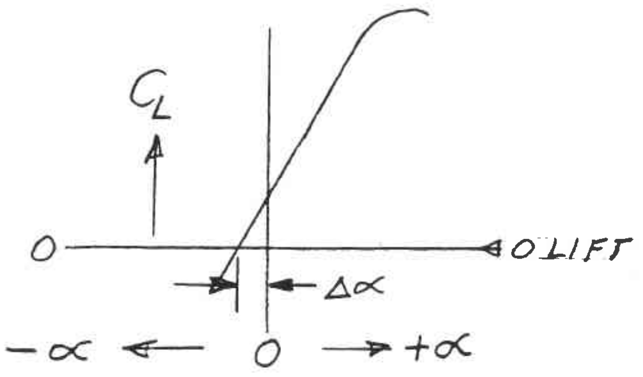
Page 7 shows optimum twist for two wings of widely different aspect ratios, both for a sweep angle at the 50 % chord of 20° and designed to be optimum at a lift coefficient of 1. It is apparent that twisting with 3-control points comes very close to optimum twist distribution, whereas 2-control points gives large errors.

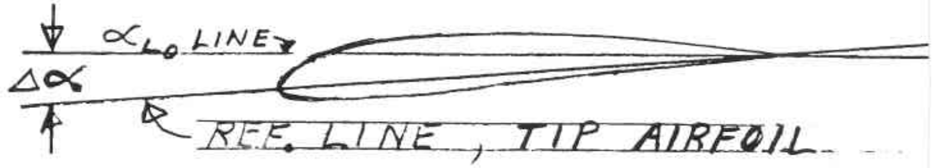
The author wracked his feeble brain to reduce the complicated theory to a practical set of equations for near optimum twist of swept back wings of modest taper ratios (near elliptical chord distribution). The simplified equations do not go to an ∞ angle at the ℄ like the basic theory. Who knows what an infinite angle looks like?

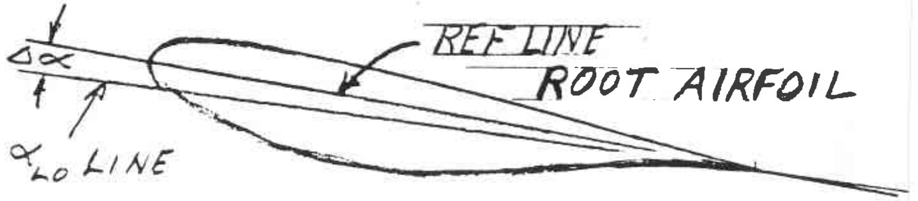




The simplified equations are broken into two parts: total twist root to tip for the chosen design $C_{L_D}$ and an equation for the distribution of the twist. These equations deal with the twist of the 0 lift lines $(\alpha_{L_0})$ of the airfoils. If you are using airfoils from the book you can find $(\alpha_{L_0})$ by looking at the characteristics.







It looks inverted and it is. Don't use any airfoil with a high $C_{m_0}$. The airfoil at approximately 30 % of the span out from ℄ could have a slight forward camber, NOT INVERTED.

The design lift coefficient $C_{LD}$ should be chosen to match the intended use between .8 and 1.4. Use .8 if high speed only is the goal. The author suggests 1 to 1.2 for high performance machines since the penalties are small if tapered elevons are used to trim for high speed.

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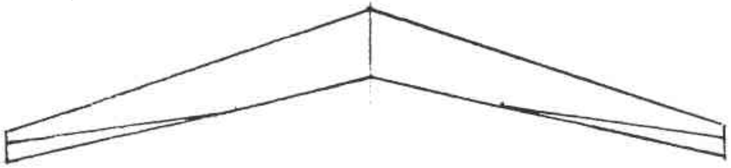


Nomenclature:

$C_{LD}$ = design $C_L$ for twist

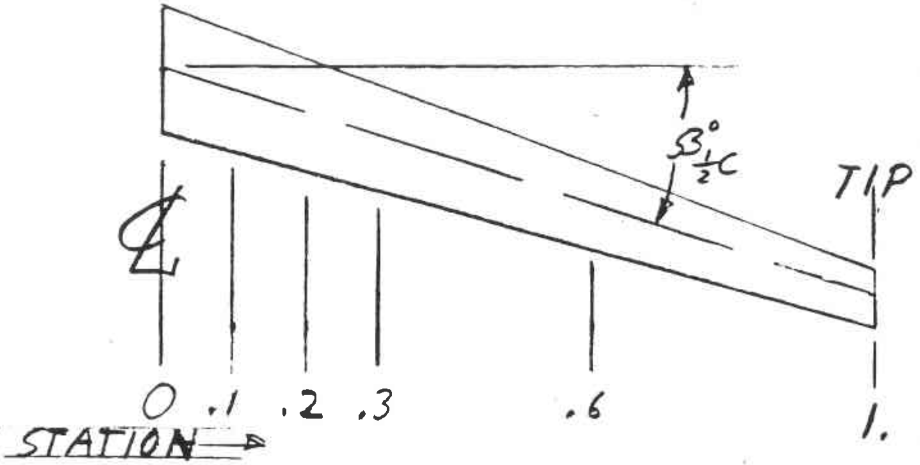
$AR$ = aspect ratio of the complete wing

$\beta^\circ$ = sweep angle of the $\frac{1}{2}$ chord line in degrees

$\alpha^\circ_{RT}$ = total twist angle of the 0 lift $(\alpha_{L0})$ lines from root to tip in degrees

$\alpha^\circ_S$ = angle of the $(\alpha_{L0})$ line at any station relative to the tip $(\alpha_{L0})$ in degrees

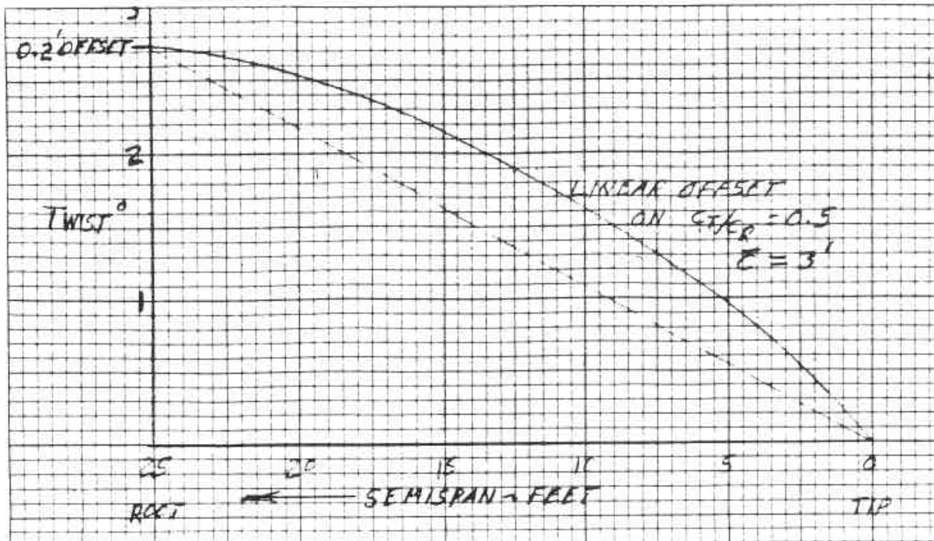
$(1 - \text{station}) = 1 - \left(\frac{\text{distance out from } \mathcal{C}_L}{1/2 \text{ span}}\right)$



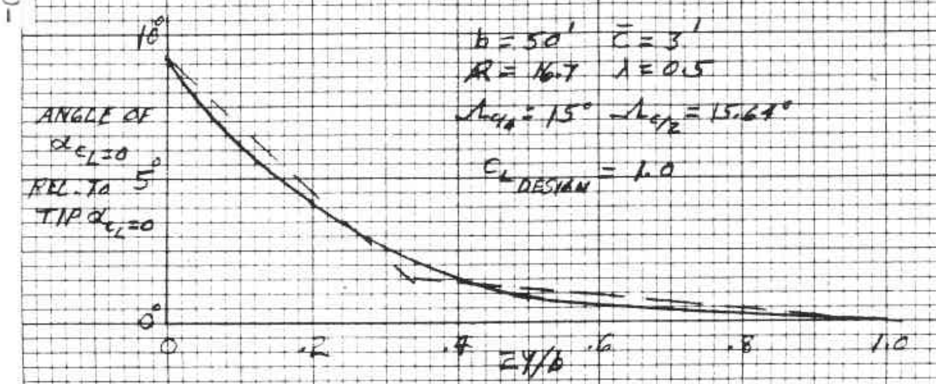
$$\alpha^\circ_{RT} = C_{LD} \times \beta^\circ_{\frac{1}{2}C} \times \pi \times \left(1 - \frac{1}{AR+1}\right) \times \frac{1}{\left(\frac{2\pi}{1+\frac{2}{AR}}\right)}$$

$$\alpha^\circ_S = \alpha^\circ_{RT} \times \left[ (1-\text{STATION})^{\left(\frac{AR+2\pi}{2\pi}\right)} \right]$$

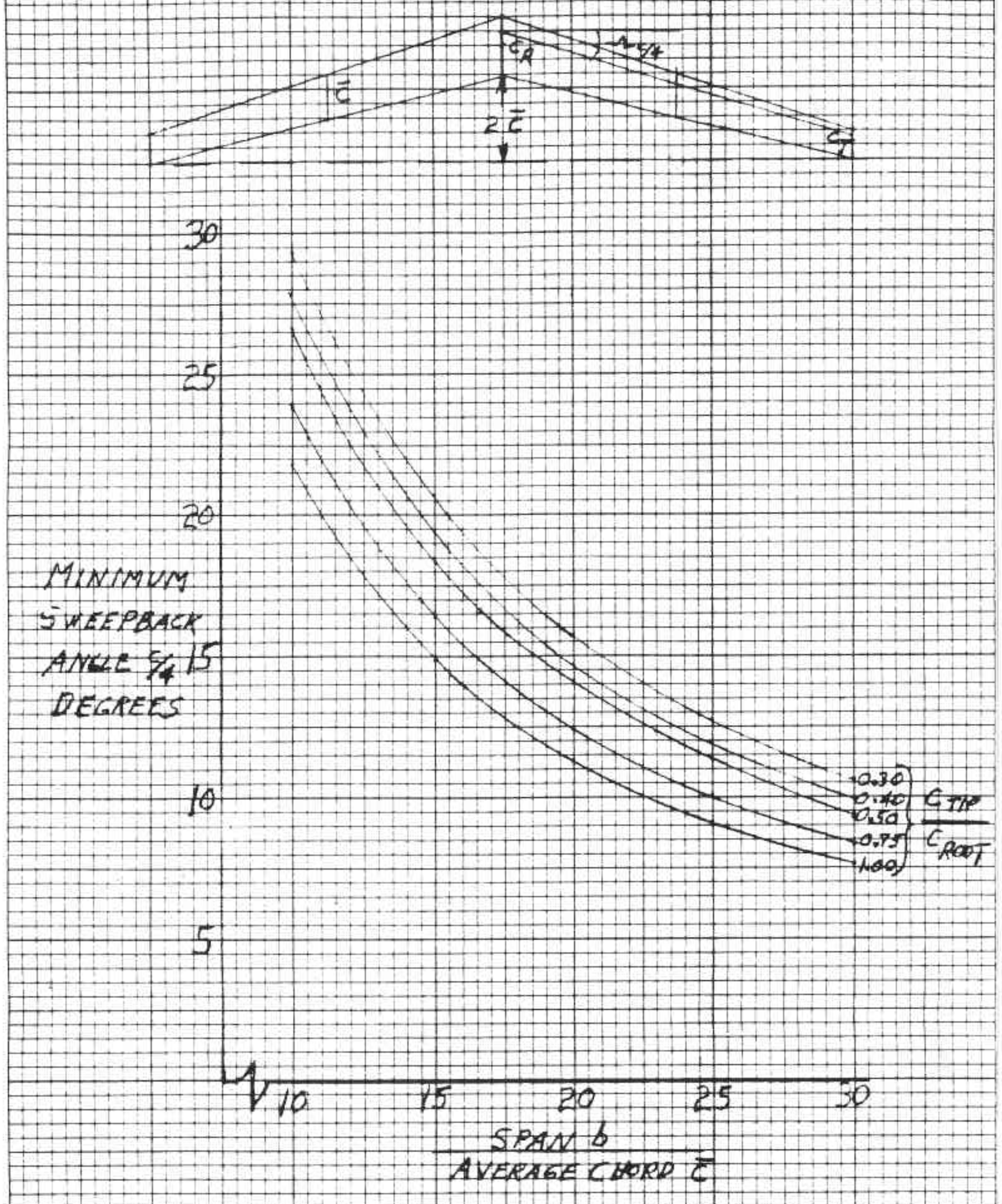
THIS IS THE EXPONENT TO (1-STATION)



TWIST DISTRIBUTION WITH STRAIGHT L.E. & T.E.



OPTIMUM TWIST DISTRIBUTION - IRV CULVER



MINIMUM SWEEPBACK TO AVOID TUMBLING

FROM IRV CULVER FEB 86

The next Bad is aeroelastics. As you increase the sweep to improve the handling qualities and reduce the possibility of tumbling you increase the aeroelastic coupling between wing flap bending and pitch, resulting in reduced pitch static stability at high speed.

An explanation of this is: if the wing tip is bent up at some angle $\phi$ in the front view the sweep angle $\beta$ makes the apparent angle $\alpha$ of the tip change as seen by the air. First order equation (all angles in radians):

$$\Delta\phi\,\beta = \Delta\alpha$$

where $\Delta\phi$ is an angle of deflection of the outer wing in bending;
$\beta$ is the sweep angle of the 1/4 chord, and flexing axis c/3
$\Delta\alpha$ is a change in angle of attack due to the elastic deflection angle $\Delta\phi$.

This effect is not serious unless you want to go fast with large sweep and high aspect ratio thin wings, with glass spar caps.

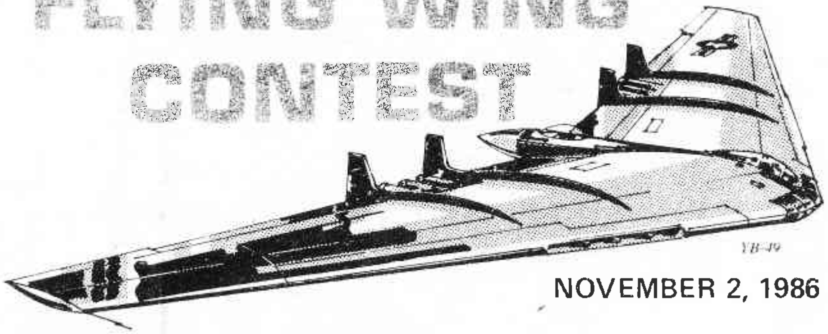
The way to alleviate this problem is mass (dynamic, not static) balance the elevons at the tip only for first mode symmetric flutter. This makes the elevons trailing edge heavy for the static pitch divergence mode, so that positive maneuvering tends to put the trailing edge down, counteracting the nose-up tendency due to the above. Also a bob weight on the stick will help. (Up acceleration results in nose-down stick.) Further, design the control runs in the wing out to the elevons so that up bending causes the trailing edge of the elevons to go down.

An explanation of the above is, if you bend the wing up the top surface of the wing shortens and the bottom lengthens, so if you run wires out the wing to the elevons with the upper wire as close to the top of the wing as practical and the bottom wire close to the bottom, with the top wire going to the top horn on the elevon and bottom to bottom horn, then if you bend the wing up the trailing edge of the elevon will come down, offsetting the effects of the sweep.

Now a few random notes. Swept back wings have excessive roll due to yaw $+C_{l_\beta}$ so I suggest using bent down tips for fins and rudders. These could be at about 45°. Bent tips at 45° are so powerful in producing $-C_{l_\beta}$ that the wing can have some dihedral to give ground clearance, by theory and by paper model tests. Going up with the wing and down at the tip at 45° gave more ground clearance at the tip for the same roll due to yaw than vice versa. More sweep, more CG range, better handling qualities, BETTER PERFORMANCE.

# 20TH ANNUAL

# NORTHROP FLYING WING CONTEST

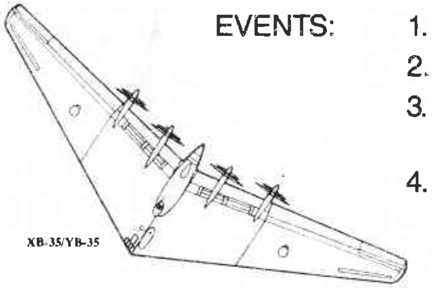


NOVEMBER 2, 1986

- Sponsored By: *MODEL BUILDER* Magazine
  Bill Northrop, Publisher
- AMA Sanction #787 — AMA License reqd.
- Site: Mile Square Park, Fountain Valley, CA
- Time: 8:30 a.m. to 1:00 p.m.
- Jr., Sr., & Open combined in all events
- Entry Fee: $3.00 (Jr. - $2.00) each event

EVENTS:

1. Rubber Power
2. Glider (164 ft. towline)
3. Scale — any power
   (20 sec. official)
4. Gas — 15 sec. eng. run, or
   Electric — 25 sec. motor run
   • combined event •

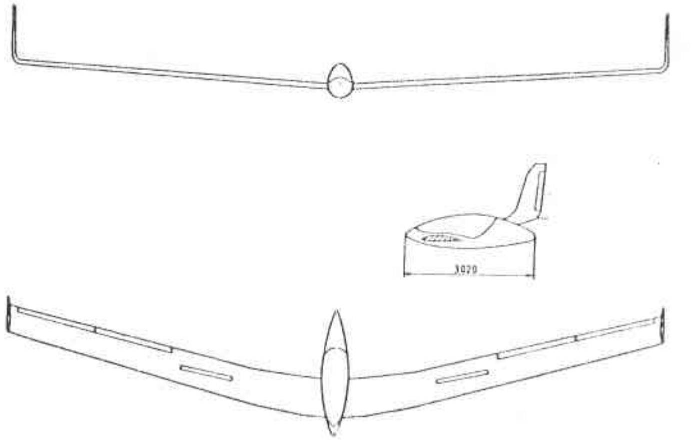


In case of controversy, opinion of Contest Director and Judge will be final.

*Chief CD*
Carl Hatrak
3825 W. 144 St.
Hawthorne, CA 90250

*Scale & Flight Judge*
Bill Stroman

● *NOTE:* Proxy entries encouraged. Send models to flier of your choice, *NOT* to *Model Builder* or CD's.



Here is the first look at Akaflieg Braunschweig's standard class sailplane SB-13, based on the Horten designs. Extensive tests have been performed with a 1/3 scale model. The flutter problems which plagued the high aspect ratio Horten aircraft were present in the SB-13 too, but the designers hope that extensive use of stiff carbon fibers will eliminate the problem.

WRENDEZVOUS
WITH WREN