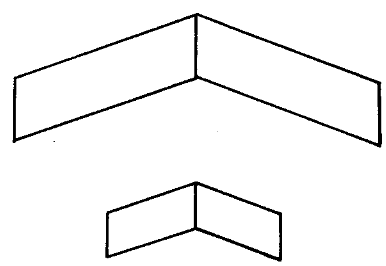
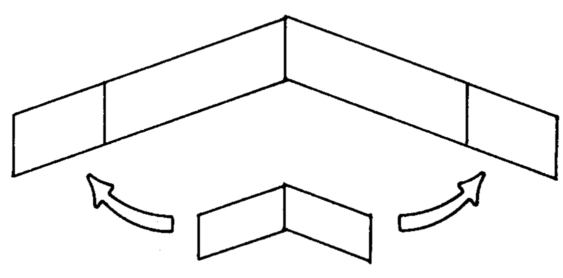
HOW SWEPT 'WINGS FLY

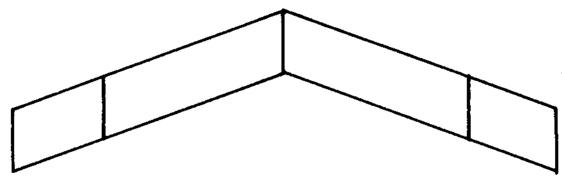
There are at least two formulae available to assist in determining the geometric twist required for swept 'wing pitch stability. A basic knowledge of how swept 'wing pitch stability is achieved is helpful in understanding the workings of these formulae.

It is probably best to think of a swept 'wing as a highly modified conventional tailed aircraft. A conventional sailplane requires a horizontal stabilizer of a particular size, given the pitching moment of the wing airfoil and the moment arm. By increasing the stabilizer's area we can move it closer to the wing while keeping the incidence angles constant.



By simply moving the horizontal stabilizer halves to the wing tips we come up with a tailless planform.





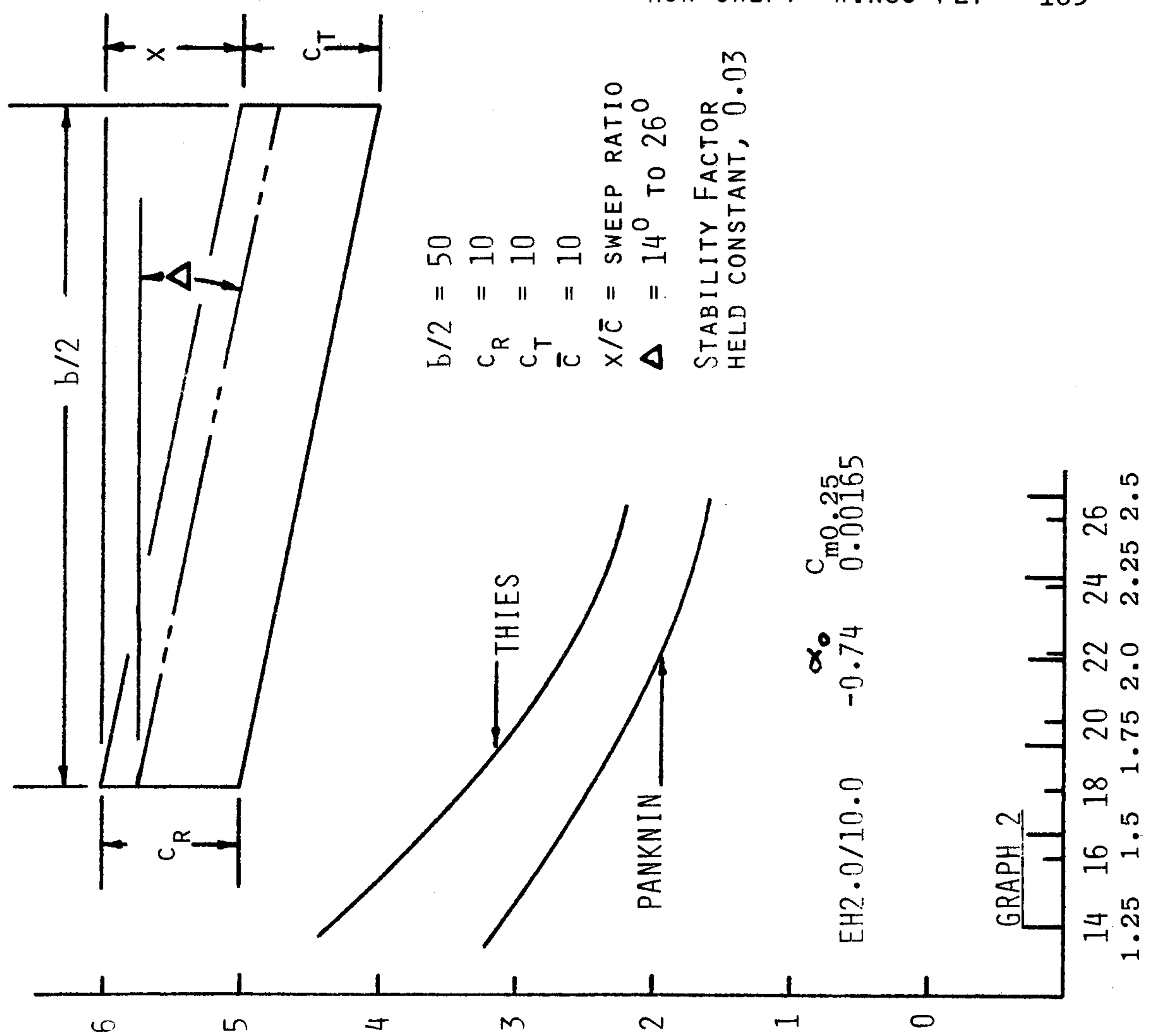
What's nice about this design is there is no downwash to adversely affect the stabilizer. On the negative side, however, the size of the "horizontal stabilizer" had to be increased due to the shorter moment arm.

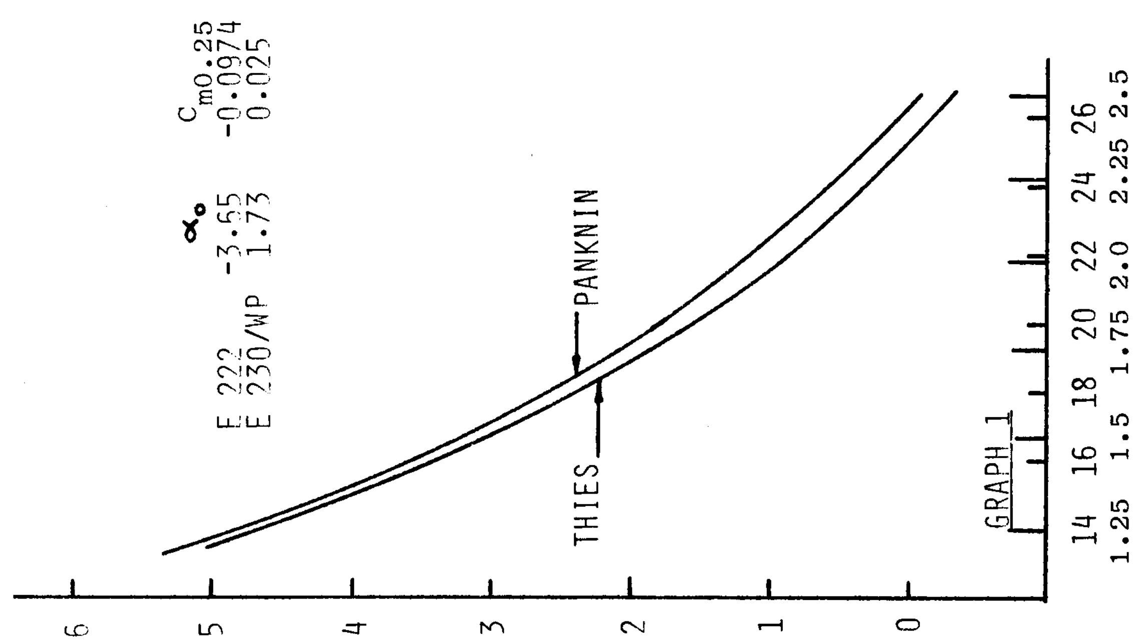
For a conventional sailplane, there are four ways of compensating for a larger negative pitching moment. A more negative angle can be applied to the horizontal stabilizer, the airfoil of the stabilizer can be changed to produce more of a down force, the stabilizer can be made larger, or the tail moment can be increased.

Projecting to swept 'wings, we would again anticipate finding that as the pitching moment of the root section became more negative a larger downforce would need to be applied at the wing tips.

Such is exactly the case, and four things can be done. First, we can retain the same tip section and build in more washout (trailing edge up) to obtain a larger down force; second, we can keep the twist the same but change the tip section to one more capable of producing the required down force; third, if the wing is highly tapered, we can reduce the taper and thus effectively increase the area of the stabilizing wing tips; fourth, we can increase the sweep angle, and hence the moment, while maintaining both the washout and original wingtip airfoil section. The trick is to pick the method which increases drag the least.

The graphs on the next page depict data for two swept wings of variable geometry. Graph 1 shows the twist required for various sweep angles when using the Eppler 222 as the root section and the Eppler 230 for the tip. Graph 2 shows the twist required for various sweep angles when using the EH2.0/10 for both root


b/2
X
C_T
C_R
Δ
b/2 = 50
C_R = 10
C_T = 10
$\bar{C}$ = 10
$X/\bar{C}$ = SWEEP RATIO
Δ = 14^0 TO 26^0
STABILITY FACTOR
HELD CONSTANT, 0.03
THIES
PANKNIN
EH2.0/10.0
α_o
-0.74
$C_{m0.25}$
0.00165
GRAPH 2
6
5
4
3
2
1
0
14 16 18 20 22 24 26
1.25 1.5 1.75 2.0 2.25 2.5


E 222
E 230/WP
α_o
-3.65
1.73
$C_{m0.25}$
-0.0974
0.025
PANKNIN
THIES
GRAPH 1
6
5
4
3
2
1
0
14 16 18 20 22 24 26
1.25 1.5 1.75 2.0 2.25 2.5

and tip. The graphs include curves for the two popular means of determining the twist required: the Thies method and the Panknin method. Both methods have been mentioned in this column previously.

The goal when designing a swept 'wing is to reduce the twist required to about one degree. More twist, while offering greater stability, will reduce performance due to the forward CG required and the increased drag created. As well, it's very easy to create a situation where the lower surface of the wingtip is stalled. But too little twist courts full span stalling, a very dangerous occurrence.

While it may be tempting to utilize a reflexed section across the entire span, the experiences of others show this not to be a viable alternative. Best to stay with the E 222 - E 230 planform, or use an airfoil with a pitching moment very close to zero across the span. For the latter, try one of the EH series sections.

Suggestions for further reading:

Gale', Dr. Ing. Ferdinando; "Aerodynamic Design of Radioguided Sailplanes." One chapter devoted to the aerodynamics of tailless designs. Text is in both Italian and English.

Lichte, Dipl. Ing. Martin; "Nurflugel-modelle." German text devoted to tailless sailplanes and electrics. A twist formula mathematically identical to Thies' is presented.

Panknin, Dr. Walter; "Flying Rainbows." Text of Walter's presentation at the 1989 MARCS Symposium, complete with diagrams and formulae for computation of required twist. Available as part of MARCS Symposium Proceedings.

Thies, Werner; "Pfeilung - ja - aber wie gross?" Four page article explaining use of Thies' twist formula. Diagrams and graphs, step by step directions included. German text originally printed in FMT, February 1984.