No. 201 MARCH 2003

T.W.I.T.T. NEWSLETTER

Here are two shots of Don Mitchell's original Stealth model. On the left is a picture taken in 1994 during preparation for a flight. On the right is the Stealth in flight. This Mitchell design never was completed in a full size aircraft, although there is a Stealth wing prototype now owned by Norm Castagneto who resides in Temecula, California. These photos apparently came from Don Mitchell's private collection.

T.W.I.T.T.
The Wing Is The Thing
P.O. Box 20430
El Cajon, CA 92021

The number after your name indicates the ending year and month of your current subscription, i.e., **0303** means this is your last issue unless renewed.

Next TWITT meeting: Saturday, March 15, 2003, beginning at 1:30 pm at hanger A-4, Gillespie Field, El Cajon, CA (first hanger row on Joe Crosson Drive - Southeast side of Gillespie).

TWITT

THE WING IS THE THING

THE WING IS THE THING (T.W.I.T.T.)

T.W.I.T.T. is a non-profit organization whose membership seeks to promote the research and development of flying wings and other tailless aircraft by providing a forum for the exchange of ideas and experiences on an international basis. T.W.I.T.T. is affiliated with The Hunsaker Foundation, which is dedicated to furthering education and research in a variety of disciplines.

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60oz/60	50.00	53.00	37.00

Meetings are held on the third Saturday of every other month (beginning with January), at 1:30 PM, at Hanger A-4, Gillespie Field, El Cajon, California (first row of hangers on the south end of Joe Crosson Drive (#1720), east side of Gillespie or Skid Row for those flying in).

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PRESIDENT'S CORNER

First, I need to make a correction to something in last month's newsletter. I mistakenly identified the person giving Bruce Carmichael his Hall of Fame award on page two. Instead of it being Larry Sanderson, it was really Bob Ball, President of the National Soaring Museum Board of Trustees. I apologize for the oversight.

I won't be at the March meeting, which will be one of the few times I have missed one. But, I can't pass up a free Mexican Riviera cruise with my wife and her family while her brother celebrates his fiftieth birthday. This will be the first time since 1995 that a majority of her family has been in one place at the same time and, with my father-in-law having health problems this might be one of the last occasions for this to occur. I am sorry I will miss this special meeting, but Bob and Gavin will handle it just fine.

I guess I really stumped everyone with the two mystery wings. Bob Hoey offered the Bomb designation to the January cover shot based on his observations from years ago at El Mirage. But, so far no one has offered anything on the February cover drawing. I guess I will have to include it in the SHA newsletter and see if anyone there can remember what it was supposed to be.

Just in case someone forgets the user ID and Password to the members only section of the website, I have included it here on the masthead right under the website address.

Bob spent a bunch of time going through all the material we received from Irv Culver and has sorted out the most important flying wing pieces. We will start printing parts of it over the coming months in the newsletter and share some of it with the public through the website. This issue will contain his analysis of flying wings.

Andy

MARCH 15, 2003 PROGRAM

We are very pleased to have **Dr. Paul MacCready** as our speaker for March. The presentation, titled **"Flying Wings From the 247' Helios to 1 oz Toy Fliers"** covers the lack of fins/rudders and stabilizers/elevators on efficient natural fliers, from spans of 1 mm to 10 m, suggesting that often stability and control can be achieved by other methods or compromises. This is explored with our *(Aerovironment)* 247' span Helios, which has maintained level flight two miles higher than any other airplane, a tiny tailless R/C model weighing just over an ounce, and various vehicles in between."

It is very important that we start the meeting right on time, 1:30 P.M., in March. This will allow Paul to make his presentation and leave enough time for him and others to make a trip out to Torrey Pines for the regatta commented on below. So please leave for the meeting a little earlier than normal so you don't miss any part of Paul's talk.

Also occurring on March 15 & 16 is The Classic Mid-Winter Torrey Pines Vintage Sailplane Regatta at the historic cliffs of Torrey Pines. So far they have at least seven vintage gliders lined up for the regatta and more will probably be there as word spreads through the vintage ranks. You can learn more on preparing for the regatta at the link below.

http://www.ssaregion12.org/Torrey.htm

You could also plan on coming down to San Diego early on March 15th to stop by the Torrey Pines event before coming on to the meeting.

LETTERS TO THE EDITOR

TWITT:

I am sending you some pictures of the 16ft RC model of the Stealth wing that Don built. We were going to offer this airplane to the RC model crowd. So Don built two ships based on the full size stealth wing. The one that is flying was the first one. Steve Mahrle helped us out with this one and it was a spectacular flying airplane. Great glide ratio, aerobatic, everything you would want for a large RC craft.

The second model, the one shown in the Feb. '03 newsletter was not flown, but I did finish building it and I do have the airplane in my shop. I installed a weed eater motor with a shortened shaft to put the motor more on the CG. I used a Futaba radio control system.

I will soon be offering kits for the B-10 as well as component kits. So along with the plans, a builder can start making parts and keep the cost down and spread out.

I will upgrade my web site to make this information available to interested Wing builders.

And congratulations to Bruce Carmichael for his induction into the US Soaring Hall of Fame.

Richard Avalon
mitchellwing@earthlink.net
http://home.earthlink.net/~mitchellwing/

(ed. – Thanks for sending along these pictures. There wasn't room on this page to show a couple of them, so readers go to page 9 for a couple of the shots sent along by Richard.)

February 13, 2003

Job Opportunity

Team TWITT:

I have opportunities available in Georgia for Aircraft wind tunnel model builders. I was hoping your team may possibly know individuals currently looking for full time employment. If so please contact me at the information below. Thank you for your assistance.

Sincerely

Marty P. Hill
Onsite Aviation, LLC
marhill@onsite-aviation.com

(ed. – I received this by e-mail but really didn't have any good way to pass it along in a timely manner. If you are interested in such a job, you might contact Marty anyway and see if it is still available. I would think that if he is searching through organizations like ours, that he is having trouble finding a suitable candidate.)

LETTERS AND E-MAILS WITH FLYING WING INFORMATION HAVE REALLY SLOWED UP. PLEASE SEND US YOUR THOUGHTS, STORIES, ETC., SO WE CAN SHARE THEM WITH OTHERS.

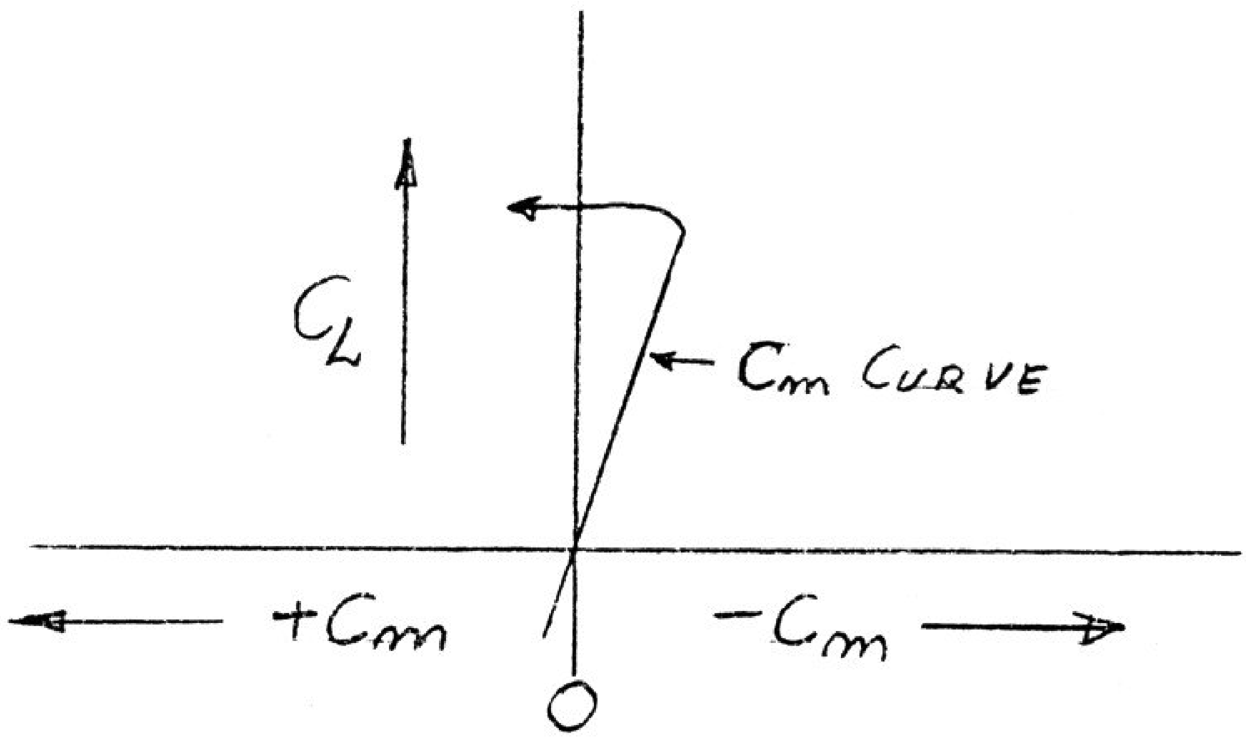
TAILLESS – FLYING WINGS

By Irv Culver
February 1986

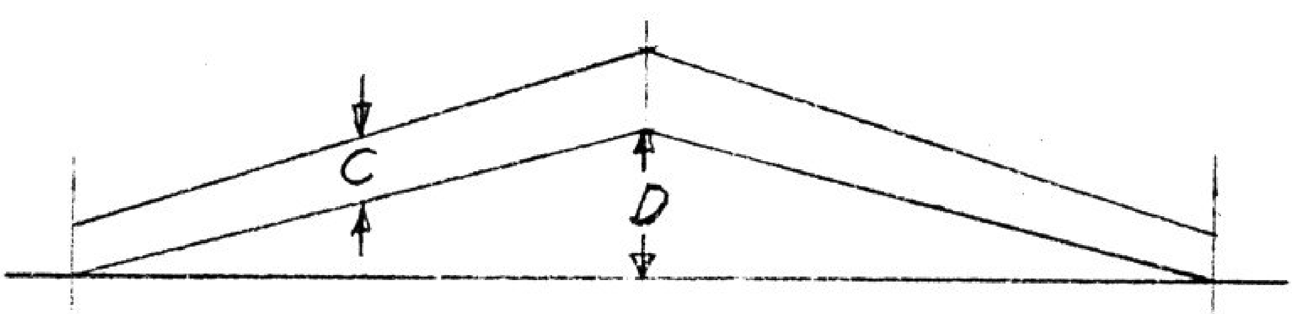
During the past 50 or 60 years the author has observed several tailless designs of airplanes, gliders and sailplanes. The impression received is that little is commonly known abut the aerodynamics, flight dynamics or aerolastics of tailless designs.

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 explanation of this phenomenon is that the pitch damping becomes negative for some designs at high values of Ǿ/V x Chord, where Ǿ = pitch angular velocity and 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.



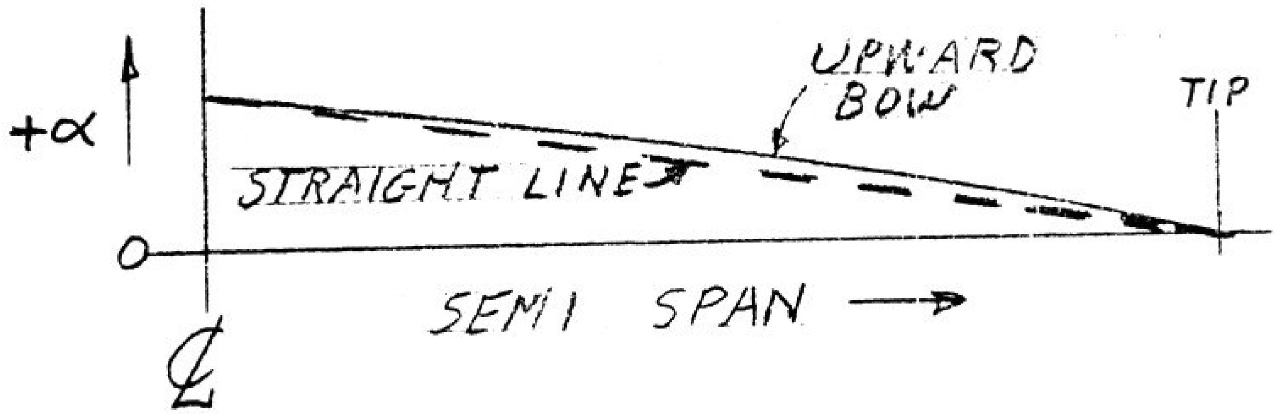
The reason tumbling is a problem is that the machine gets trapped in its own lift circulation or vortex. The tumbling study suggested that a simple criteria for the border line between tumbling and not tumbling, for the case of the CG on the wing chord plane vertically and at 25% of the MAC, was D/C = 2, where C is the average chord and D is the trailing edge crotch dimension.



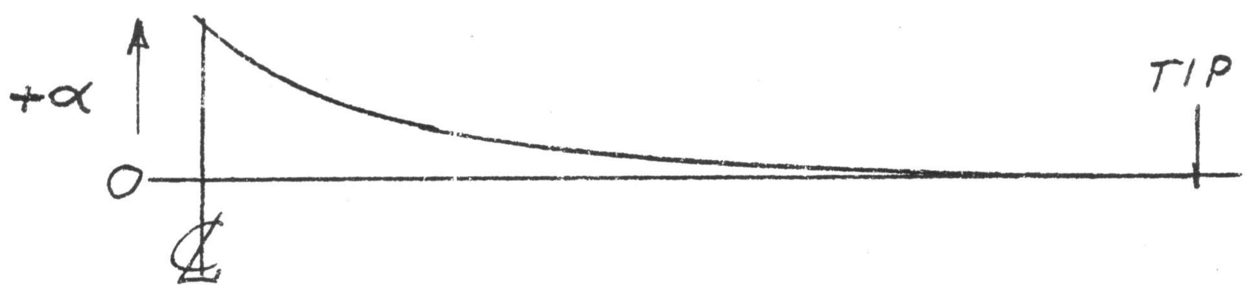
About twenty cardboard models were made to check the theory, with varying values of AR, sweep and taper ratio. These models approximately confirmed the theory. That is, anything less than D/C = 2, could tumble if adequate pitch rate were applied at low speed. Next, the effect of vertical offset of the CG: For CGs of "l" 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.

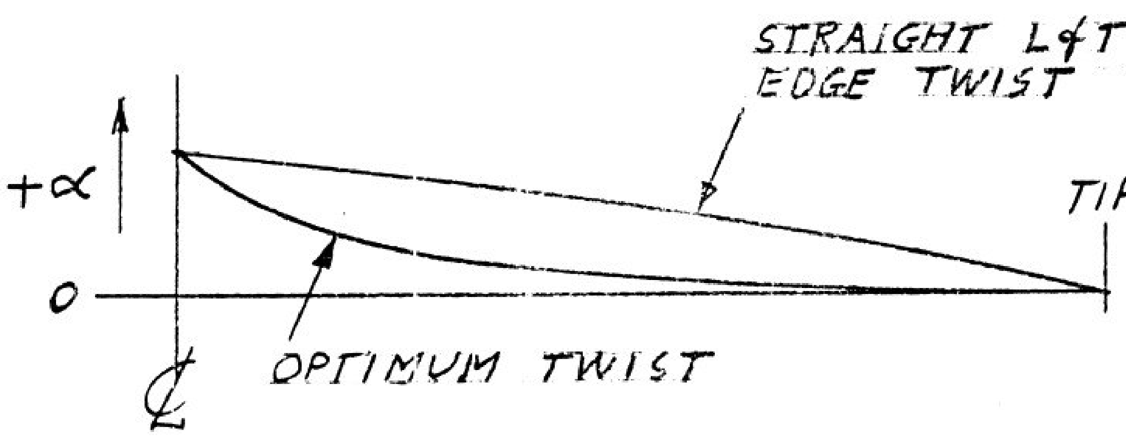
The third Bad is the poor span loading achieved by twisting the wing using straight leading and trailing edges. For a tapered wing this gives a twist distribution that looks like this if you hold the tip at 0 angle.



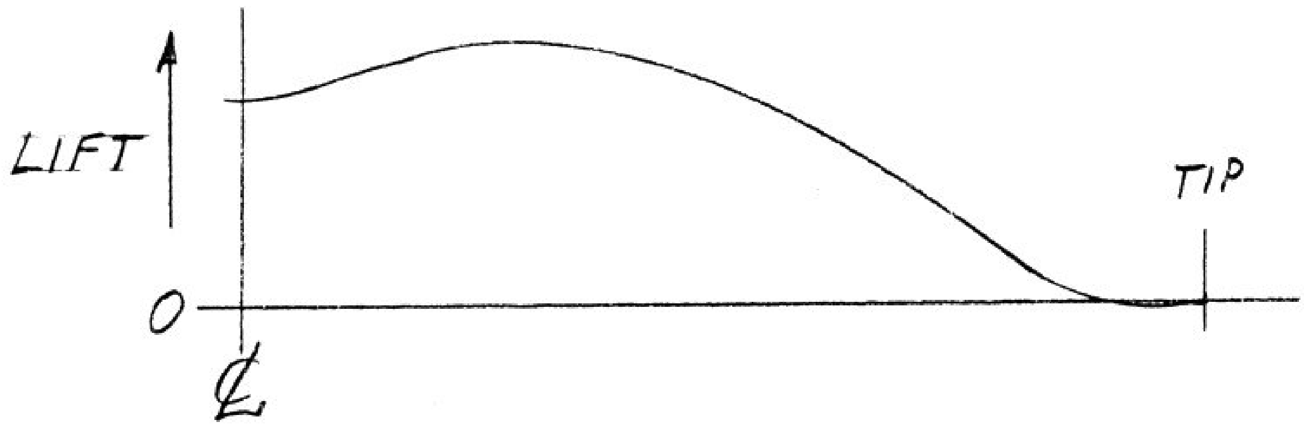
The reason for the upward bow is that for straight leading and trailing edges the vertical offset difference of these edges due to twist is proportional to the span, but to find the twist angle you must divide this local offset by the local chord. Now the optimum twist distribution for a swept back wing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



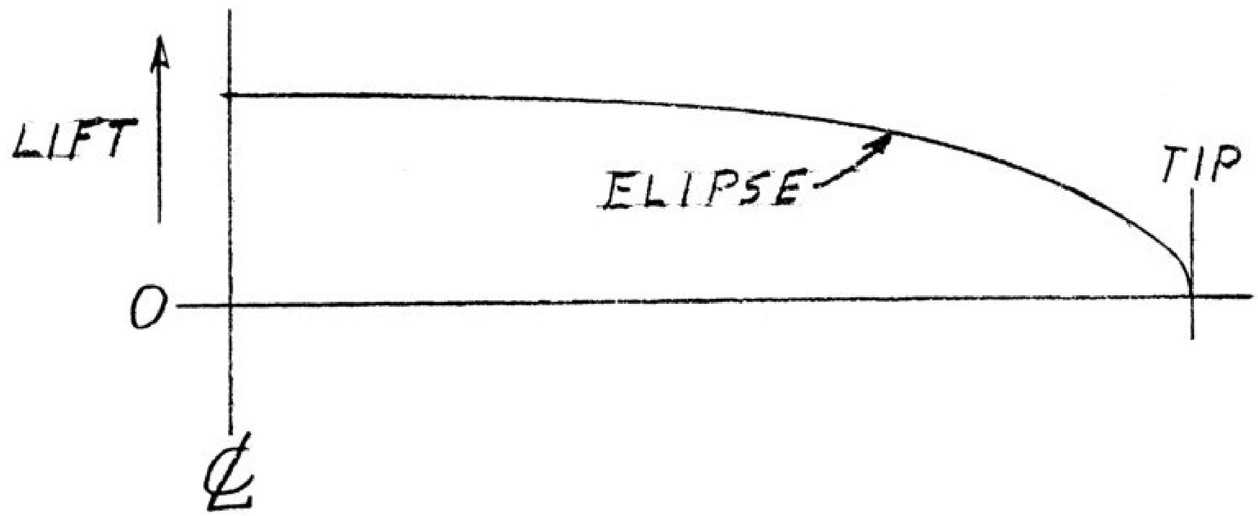
So if you superimpose these two curves you get a picture like this:



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 much push down at the tips to balance the loss of lift at the CL to trim the pitch. Now the minimum C_{Di} (induced drag) corresponds to a span loading that looks like this.

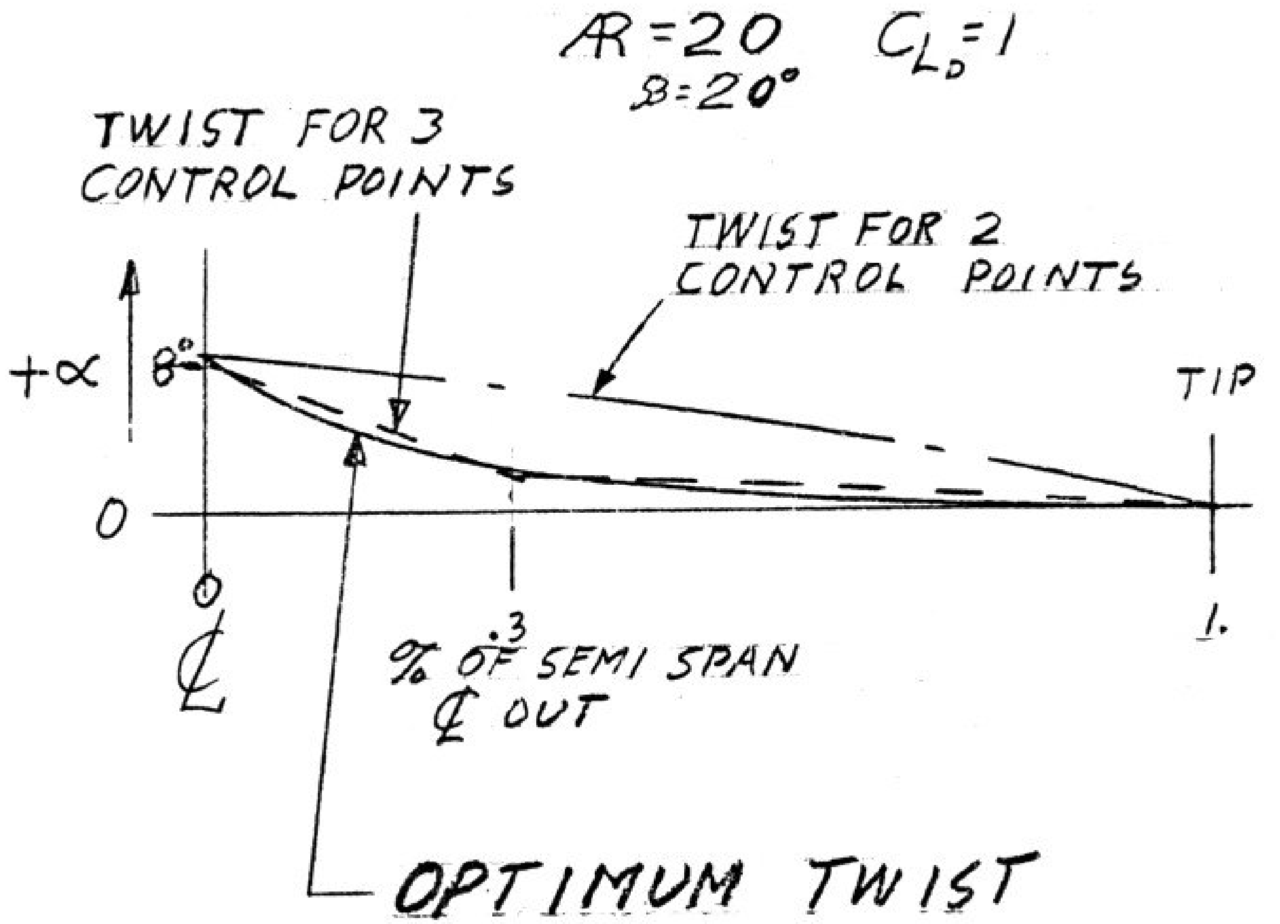


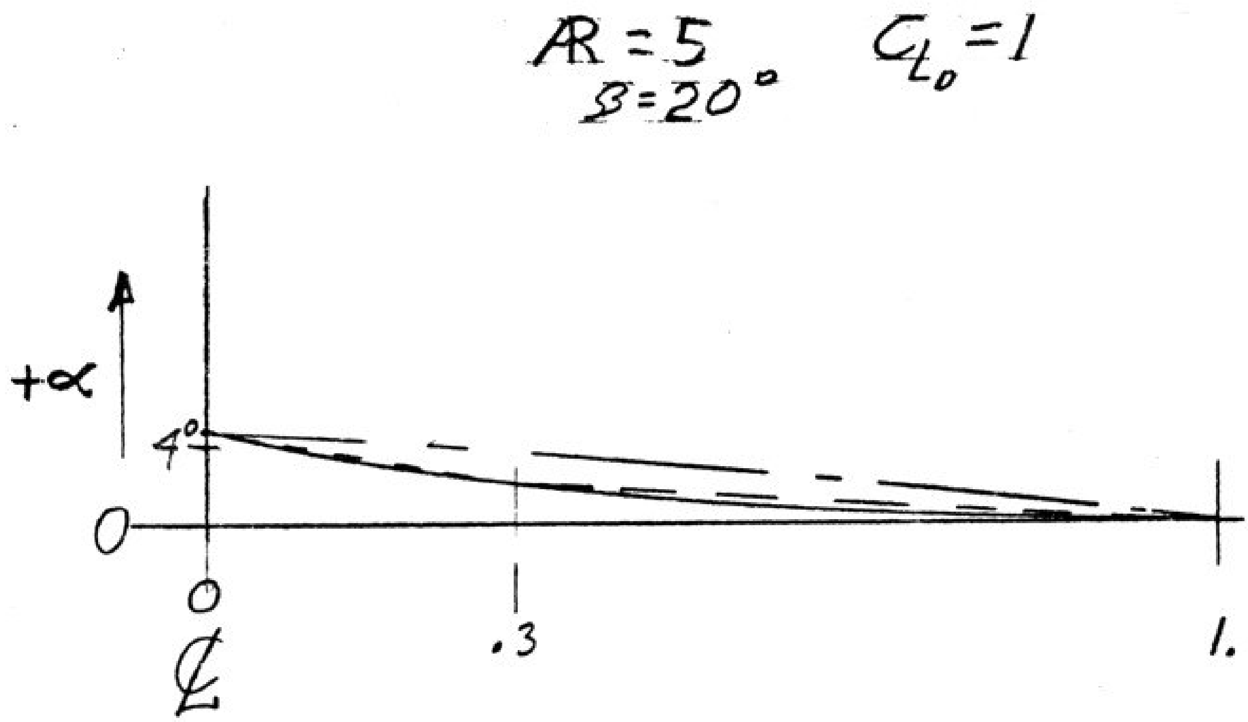
If you restore the lift near the CL you will not have to push down at the tips. So why not twist the wing appropriately to achieve this optimum span loading and reduce the induced drag? The question is: why put span on a machine and then drastically reduce its effect? The answer appears to be that it 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 35% out from CL and twisting around the main spar. This would produce a wing with almost perfect twist distribution without much additional work.

The next page shows optimum twist for two wings of widely different aspect ratios, both for a sweep angle at the 50% chord of 20 degrees 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 larger 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 CL 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_{LD} and, an equation for the distribution of the twist. These equations deal with the twist of the 0 lift lines (∞_{Lo}) of the airfoils. If you are using airfoils from the book you can find (∞_{Lo}) by looking at the characteristics.


AR=20 C_{L_D}=1
ß=20°
TWIST FOR 3
CONTROL POINTS
TWIST FOR 2
CONTROL POINTS
+α
8°
TIP
0
0
.3
1.
℄
% OF SEMI SPAN
℄ OUT
OPTIMUM TWIST


AR=5 C_{L_D}=1
ß=20°
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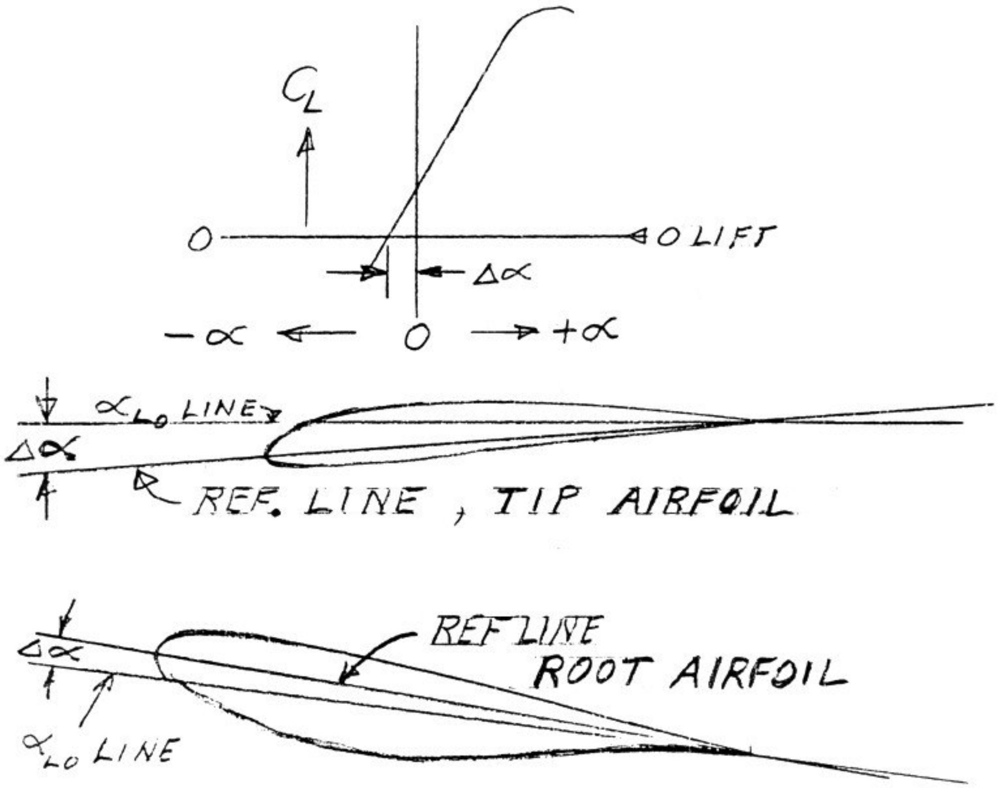
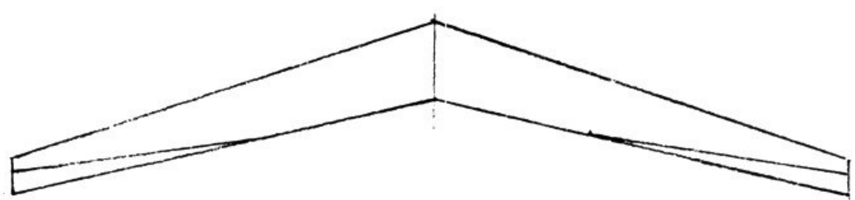


It looks inverted and it is. Don't use any airfoil with a high C_{mo}. The airfoil at approximately 30% of the span out from CL could have a slight forward camber, NOT INVERTED.

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.



Nomenclature:

C_{L_D} = design C_L for twist

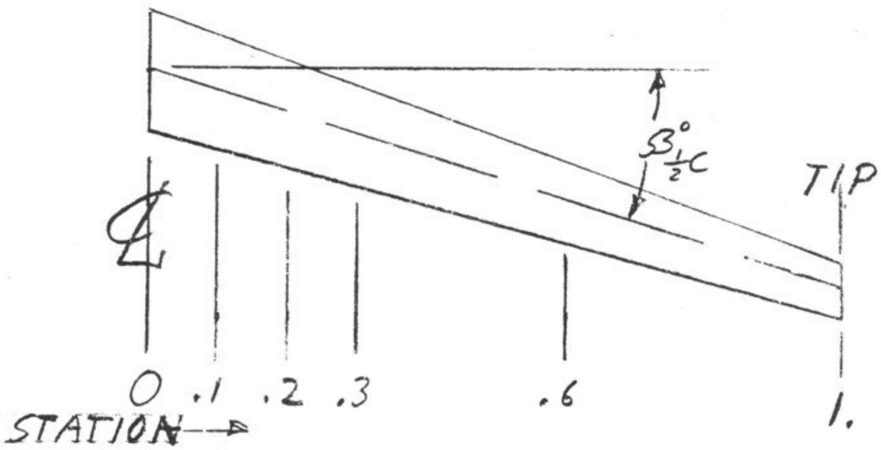
AR = aspect ratio of the complete wing

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

α^o_{RT} = total twist angle of the 0 lift (α_{L0}) lines from root to tip in degrees

α^o_S = angle of the (α_{L0}) line at any station relative to the tip (α_{L0}) in degrees

$\left(1 - \text{station}\right) = 1 - \left(\dfrac{\text{distance out from } \mathrm{C\!\!\!L}}{1/2 \text{ span}}\right)$



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

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

THIS IS THE EXPONENT TO (1-STATION)

The next Bad is aerolastics. As you increase the sweep to improve the handling qualities and reduce the possibility of tumbling you increase the aerolasitc 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 **Φ** in the front view the sweep angle **β** makes the apparent angle **α** of the tip change as seen by the air. First order equation (all angles in radians):

$$\Delta \Phi \beta = \Delta \alpha$$

Where **Δ Φ** is an angle of deflection of the outer wing in bending; **β** is the sweep angle of the ¼ chord, and; **Δ α** is a change in angle of attack due to the elastic deflection angle **Δ Φ.** This effect is not serious unless you want to go fast with large sweep and high aspect ratio thin wings, with glass spar caps.

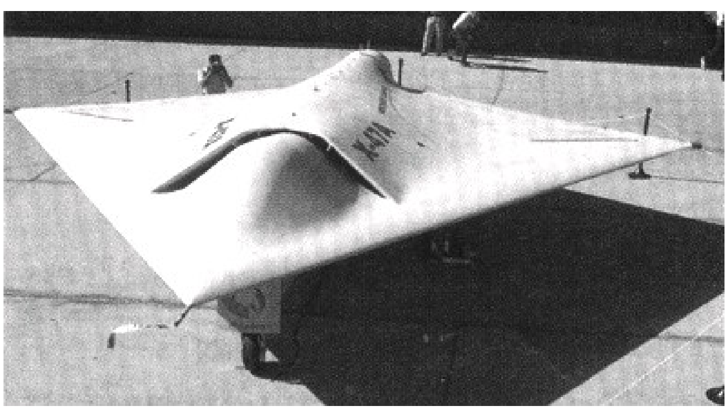
The way to alleviate this problem is mass (dynamic, not static) balance the elevons at the tip only for first mode symmetric flutter. This makes the elevons trailing edge heavy for the static pitch divergence mode, so that positive maneuvering tends to put the trailing edge down, counteracting the nose 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 the bottom wire to the 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. Sweptback 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 degrees. Bent tips of 45 degrees 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 degrees 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.

ABOVE & BELOW: These are a couple of the pictures sent to us by Richard Avalon of the Mitchell Stealth design. The top one gives you a good idea on the size of this model. See a couple of more on the next page.

Above, the Northrop Grumman X-47A Pegasus on its maiden flight for the Naval Air Warfare Center at China Lake, CA. It flew for 12 minutes. (Photo from Northrop Gumman/Associated Press in the San Diego Union Tribune, 2/24/03). **Below** is a look at the actual shape.



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Coming Soon: <u>Tailless Aircraft Bibliography</u> Edition 1-g

Edition 1-f, which is sold out, contained over 5600 annotated tailless aircraft and related listings: reports, papers, books, articles, patents, etc. of 1867 - present, listed chronologically and supported by introductory material, 3 Appendices, and other helpful information. Historical overview. Information on
sources, location and acquisition of material. Alphabetical listing of 370 creators of tailless and related aircraft, including dates and configurations. More. Only a limited number printed. Not cross referenced: 342 pages. It was spiral bound in plain black vinyl. By far the largest ever of its kind - a unique source of hardcore information.

But don't despair, Edition 1-g is in the works and will be bigger and better than ever. It will also include a very extensive listing of the relevant U.S. patents, which may be the most comprehensive one ever put together. A publication date has not been set yet, so check back here once in a while.

Prices: To Be Announced

Serge Krauss, Jr. skrauss@earthlink.net
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<u>Tailless Tale</u>, by Dr. Ing. Ferdinando Gale'

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<u>On The Wing...the book</u>, by Bill and Bunny Kuhlman (B^2) A compilation of their monthly column that appears in RC Soaring Digest magazine. More than 50 articles on a wide range of topics of interest to enthusiasts of tailless configurations. 234 pages of technical and non-technical articles, plus coding for computer programs to determine twist and other design parameters. 250 pp. US$28.00

<u>On the 'Wing...the book, Volume 2</u>, by Bill and Bunny Kuhlman (B^2) Continues where the initial volume left off. Contains more than 50 "On the 'Wing..." articles. Airfoils, designing for stability, control systems, descriptions of full size and model and aircraft. 234 pp. US$28.00

Additional information - sample pages and chapter headings, plus descriptions of other available titles - is available on <http://www.b2streamlines.com>.

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Bruce Carmichael brucecar1@juno.com

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VIDEOS AND AUDIO TAPES

VHS tape containing First Flights "Flying Wings," Discovery Channel's The Wing Will Fly, and ME-163, SWIFT flight footage, Paragliding, and other miscellaneous items (approximately 3½+ hours of material).

Cost: $8.00 postage paid
Add: $2.00 for foreign postage

VHS tape of Al Bowers' September 19, 1998 presentation on "The Horten H X Series: Ultra Light Flying Wing Sailplanes." The package includes Al's 20 pages of slides so you won't have to squint at the TV screen trying to read what he is explaining. This was an excellent presentation covering Horten history and an analysis of bell and elliptical lift distributions.

Cost: $10.00 postage paid
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VHS tape of July 15, 2000 presentation by Stefanie Brochocki on the design history of the BKB-1 (Brochocki,Kasper,Bodek) as related by her father Stefan. The second part of this program was conducted by Henry Jex on the design and flights of the radio controlled Quetzalcoatlus northropi (pterodactyl) used in the Smithsonian IMAX film. This was an Aerovironment project led by Dr. Paul MacCready.

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An Overview of Composite Design Properties, by Alex Kozloff, as presented at the TWITT Meeting 3/19/94. Includes pamphlet of charts and graphs on composite characteristics, and audio cassette tape of Alex's presentation explaining the material.

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VHS of Paul MacCready's presentation on March 21,1998, covering his experiences with flying wings and how flying wings occur in nature. Tape includes Aerovironment's "Doing More With Much Less", and the presentations by Rudy Opitz, Dez George-Falvy and Jim Marske at the 1997 Flying Wing Symposiums at Harris Hill, plus some other miscellaneous "stuff".

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NURFLUGEL

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Tailless Aircraft in Theory and Practice

By Karl Nickel and Michael Wohlfahrt

498 pages, hardback, photos, charts, graphs, illus., references.

Nickel and Wohlfahrt are mathematicians at the University of Freiburg in Germany who have steeped themselves in aerodynamic theory and practice, creating this definitive work explaining the mysteries of tailless aircraft flight. For many years, Nickel was a close associate of the Horten brothers, renowned for their revolutionary tailless designs. The text has been translated from the German Schwanzlose Flugzeuge (1990, Birkhauser Verlag, Basel) by test pilot Captain Eric M. Brown, RN. Alive with enthusiasm and academic precision, this book will appeal to both amateurs and professional aerodynamicists.

Contents: Introduction; Aerodynamic Basic Principles; Stability; Control; Flight Characteristics; Design of Sweptback Flying Wings - Optimization, Fundamentals, and Special Problems; Hanggliders; Flying Models; Fables, Misjudgments and Prejudices, Fairy Tales and Myths, and; Discussion of Representative Tailless Aircraft.

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FLYING WING SALES

BLUEPRINTS – Available for the Mitchell Wing Model U-2 Superwing Experimental motor glider and the B-10 Ultralight motor glider. These two aircraft were designed by Don Mitchell and are considered by many to be the finest flying wing airplanes available. The complete drawings, which include instructions, constructions photos and a flight manual cost $140, postage paid. Add $15 for foreign shipping.

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