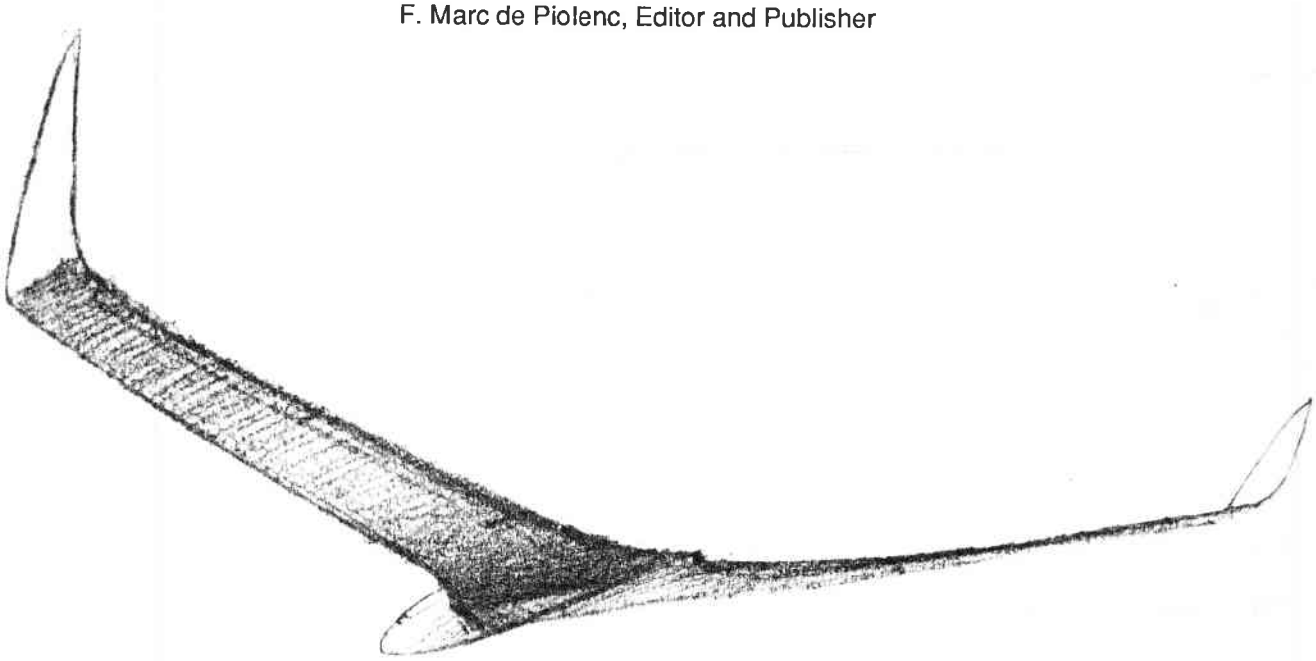
TWITT NEWSLETTER

F. Marc de Piolenc, Editor and Publisher



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

The numbers in the upper right corner of your label indicate the last issue of your current subscription, e.g. 8903 means this is your last issue.

NEXT TWITT MEETING: Saturday, 18 March 1989, beginning at 1330 hours. As always, the location is Hangar A-4, Gillespie Field, El Cajon, California, in the first row of hangars on Joe Crosson Drive.

CONTENTS

ABOUT OUR COVER

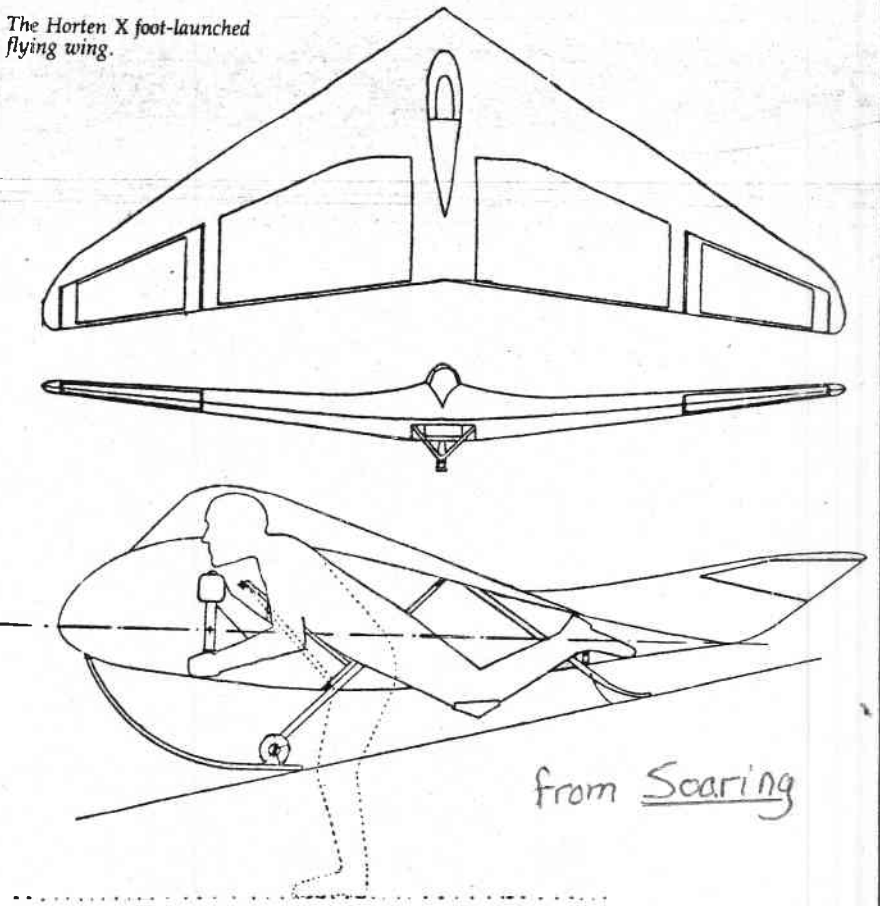
The beautiful pencil sketch of the Akaflieg Braunschweig SB-13 that adorns our cover is the work of Kenneth Carpenter, who seems to be in the habit of providing a masterpiece with every piece of correspondence. Keep writing, please!

MINUTES OF FEBRUARY TWITT MEETING

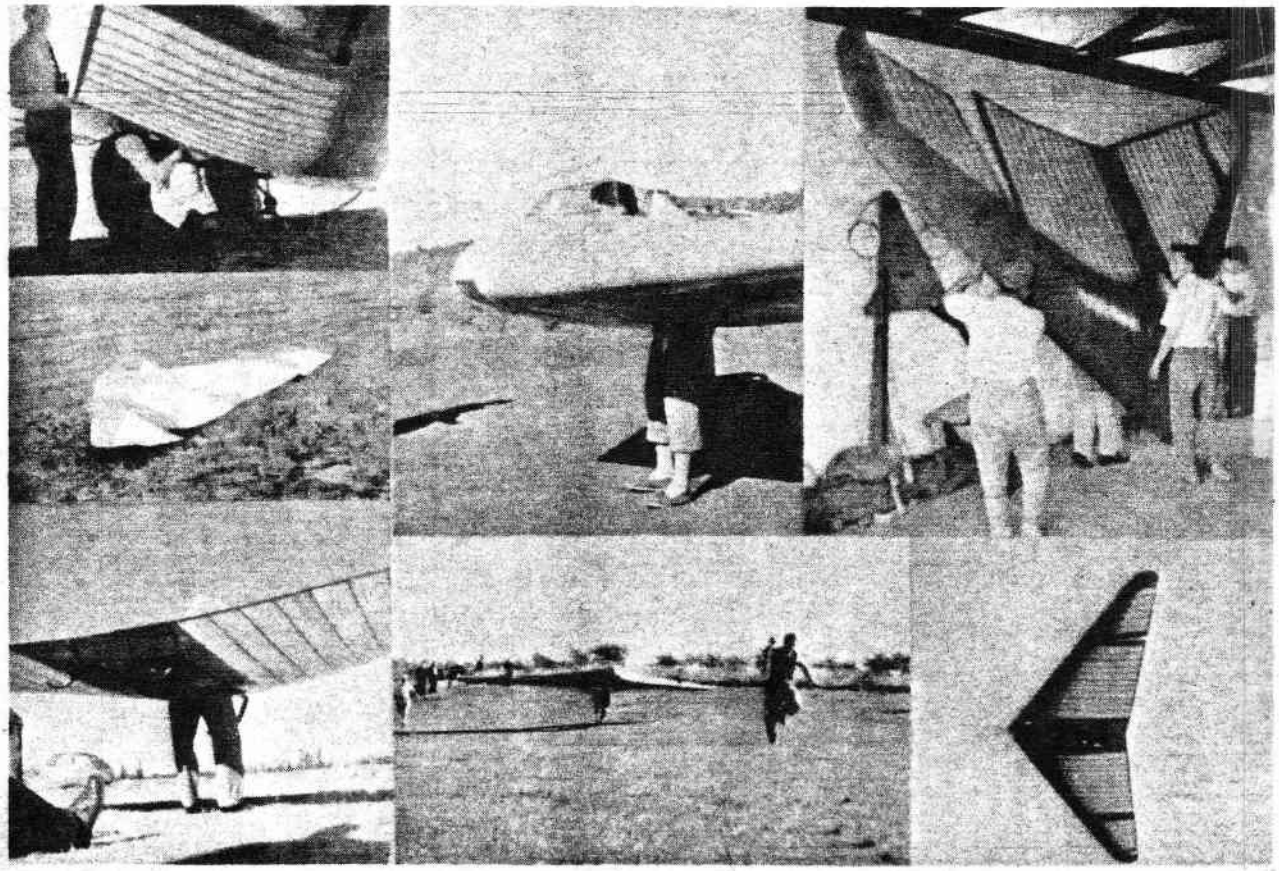
Present were Bob Fronius, June Wiberg, Doug Fronius, Marc de Piolenc, Martin [?] Roy, Harald Buettner, Jack Green, Phillip Burgers, Andy Kecskes, H.J. Pio, Jim Neiswonger, Steve Bennett, Jorge Paullada, Ed Lockhart, Bill McCaffrey, Greg Kendall, Tim Rosauer, Ralph Wilcox, Clarke Templeton and Jorge Paullada, Jr.

Bob Fronius opened the meeting by recalling that on 20 February 1962, Colonel John Glenn made America's first orbital space flight, alone in a Mercury capsule. Bob then thanked Andy Kecskes, who had taken over preparation for the meeting when Bob was unable to do so due to severe complications following abdominal surgery. Bob also reminded those present of the Soaring Society of America convention at the Los Angeles Airport Hilton, 23-25 February. *Faute de mieux,* this month's raffle prize was a year's subscription to the TWITT Newsletter, or a twelve month, free extension of an existing one. The program for the meeting consisted of a videotape of the excellent West German series, "Pioneers in Aviation", followed by featured speaker Phil Burgers. Bob apologized for his inability to answer questions; his hearing aid had been broken during his stay in hospital and would take some time to repair. Doug Fronius was preparing the Leister-Kaufman sailplane for a high-altitude wave flight out of California City. The videotape "Pioneers in Aviation" followed. Bob then asked visitor Clarke Templeton to introduce himself, which he did. Your Editor must now apologize to Mr. Templeton and all TWITTs; Mr. Templeton's remarks are inaudible on the audio tape and yours truly took no notes! Marc de Piolenc then rose to introduce Phil Burgers and his topic, Dr. Reimar Horten and his contributions to flying wing design. Phil began his talk by quickly reviewing the work of the early pioneers of tailless airplane design, notably Etrich (of *Zanonia* fame) and Junkers, who patented a flying wing design in the Twenties. These provided much of the inspiration for the Horten brothers' early entry into the field, first as model builders, then as full-scale aircraft designers. Phil chronicled the Horten machines from the Horten I (poor directional control—burned by the Hortens to keep some pilot with more curiosity than sense from killing himself] to the still little–known *Piernifero* foot-launched glider built in Argentina [Some info on this machine, taken from *Soaring,* issue date unknown, appears on page 3—Ed]. Your Editor concentrated his note taking on the high points of the Hortens' career and on material Phil learned directly from Reimar Horten, not available from sources such as *Nurfluegel.* The Horten IVb, a variant of the highly successful Horten IV, used a laminar airfoil section from a captured North American P-51 fighter. The machine was unsuccessful, largely because the laminar section was used at a Reynolds number far below that for which it was designed and suffered laminar separation at the tips. In all their designs, the Hortens eschewed the use of vertical surfaces, but managed to make machines that were directionally stable nonetheless. The Ho V, a twin-engined machine, could fly safely with one engine out. According to Phil, Dr. Horten discovered the phenomenon of vortex-enhanced lift, used by high-performance delta airplanes to achieve high lift coefficients for landing, as early as 1943 while working with the Horten III. This would give him priority over those who later published observations on the "ram's horn" vortex system associated with high leading edge sweep, deep root chord and high angle of attack. Horten's own delta design had ailerons placed so as to control the core of the leading edge vortex, an advanced feature even now. Phil then explained the thinking behind the bell-shaped spanwise lift distribution curve that has been a hallmark of Horten designs since the Horten II. We will defer discussion of the details to a later issue, when we publish a translation of Dr. Horten's own article for *Delta* on the subject. This part of the discussion stimulated a lot of questions. Phil also discussed the tests of a Horten IV by August "Gus" Raspet's group at Mississippi State University. The MSU researchers found an extensive area of separation over the back of the center-section. Phil noted that the reason for the separation was that the turtle-back section of the pilot pod had had to be repaired—an American GI in Germany had taken a hatchet to it to remove the swastika painted on it. The repair

The existence of a Horten X foot-launched, 7.5 meter, flying wing in Argentina has long intrigued ultralight enthusiasts. But solid information on the craft has been hard to come by in the U.S., despite efforts by the journal to contact designer Reimar Horten. Last Summer, Jan Scott, president of the Vintage Sailplane Association and an avid collector of information on the fabled Horten flying wings of the '30's, attended an "Old Timers" vintage sailplane meeting in France. Reimar's brother Walter was there and the chance meeting opened communications with Argentina. (Jan is fluent in German.) This exchange has made possible the publication of the accompanying photographs of this unusual 7.5-meter design as well as the 3-view drawing. Scott has also made his translation of an article by Reimar Horten available for publication in *Soaring*.



The Horten X foot-launched flying wing.



was not quite to factory standard, hence the separation. That was not the only problem with the tests, however. It seems that the MSU folks calculated the spanwise lift distribution of their ship based on Schrenk's "simplified" theory and Weissinger's correction for sweep, but did not take washout into account! It could go without saying that the results confused them enormously, further proof that even genius has its off days. Phil himself had begun building a Horten IV–like machine in Argentina before his departure for the US, but the project was not pursued after he had left. Phil considers bats the most complex flying wings in nature, pointing out that they have "mission–adaptive" wings, adjustable in camber, chord and thickness as well as sweep and twist! Like birds, bats are statically unstable and rely on active control in flight. The raffle drawing followed the conclusion of Phil's talk. Ralph Wilcox won a twelve month extension of his subscription.

MARCH MEETING PROGRAM

April 1988 speaker Barnaby Wainfan will be in the San Diego area for the EAA and San Diego Aerospace Museum sponsored program, The Great Airfoil Frontier [see announcement elswhere in this issue—Ed]. He has graciously consented to address TWITT again. Barnaby is an airfoil expert, author of the Wind Tunnel column in *Kitplanes* magazine, and an avid model airplane competitor (one of his serious rivals is Madame Wainfan). Saturday, 18 March promises to be a real treat for both flying wing buffs and airfoil nuts. For those of us who fit easily into both categories, plan to make a day of it: rendez-vous at 1330 at hangar A-4, Gillespie Field, and at the Aerospace Museum Theater at 1900 hours. The raffle prize will be two excellent books by "Hannan's Hangar" columnist (and frequent Newsletter contributor) Bill Hannan.

LETTERS

Glider Pilot, Model Builder and Designer

This just in from Charles R. Fox of Davenport, Iowa:

How to start this letter. I hate paper work. 55 ridiculous years of age. Used to live at El Rancho 80 trailer park in El Cajon [California] in about 1958. Glider rating—fly Phoebus C—Iowa's largest collector of non–flying gliders: [Marske] Pioneer II kit, broken Cirrus, taper wing Monerai FX- 170, sold Cheracowa [sic]. Seen B. Carmichael at Eastern Homebuilders in N.Y. few years ago.

Attended Bryon Ohio's [?] seminar last year. Good info on wing tips, *if it is true.* At least I presented it at Madison Wisconsin National Model Symposium. Our team won the Great Race last year by Chicago—40 miles, 2 hrs 15, with a 374 airfoil. My ship with RG-15 [?] I think is better but it was finished, but not profiled then. It is now; what a major difference that makes. We design all our own molds. Would like to compete with a model f. wing if I could come up with a design.

What happened to the flying wing they were building in Germany? I heard of it 3-4 years ago.

Jim Marske's Pioneer II is really flying well now after they went back to their older airfoil 3312 ? or so [how about 23312—Ed]. Bob Michener's ship. He said they may get laminar flow back to 80% on bottom of that airfoil. I hear Marske has somebody working on a laminar airfoil for it. If it works out, I may build mine.

Have also designed 5 different Delta radio control models, 1 stunt pattern ship, 1 Me–163 type—very good ship, 6 or 7 glider f. wing types.

Without knowing, I would bet you are building, if the molds are for a sailplane, a high AR swept Horten like wing?

Under the heading that Flying wings will never amount to anything (I don't believe it) because of low cl and so forth, I built a proof of concept type, where a large % of the wing is the best airfoil available. I used 4061 and a 5010, which is a 4061 with reflex [??]. The worst case for pitching moment.

My theory is that if you have enough of the wing forward of the cg, the lift there compensates for the pitching moments. Also needed is enough sweep to move the cg rearward to achieve this and enough elevator to overcome any pitch problems in case my theory is wrong.

Both the 9 inch [22.5 cm] and the 100 inch [2.5 m] radio control model proved this point. 90°flaps can be lowered with no more pitch change than spoilers. The model was too directionally stable and hard to turn with that high of an A.R. It seemed pitch stable. I remember an earlier model with full span elevons, which turned well until the central fin fell off. I don't think the 4061 airfoil is the best choice, and I don't like the idea of full span ailerons because of the drag, when used. The profile fuselage was used to try to add central area to try to make it turn. It flew well without tip fins, but did not high-start well without them. It towed up very well.

More thought and building may result in good design for a real sailplane. I don't rule out a straight wing w/tapered tips with reflex laminar

wing. I feel a reflex airfoil must not have the high point too close to the reflex portion to be efficient.

Good flying,

Charlie Fox

Actually, the TWITT machine will have variable sweep—near zero for high performance flight in statically unstable mode, aft swept for takeoff and landing. The German f.w. you mentioned is almost certainly the SB-13. It's flying, and I guarantee you will see much more about it in these pages.

Our Man in NASA

Todd Hodges from NASA-Ames writes:

I enjoyed attending your meeting last November so much that I hope I can make your April meeting. It looks like I have another business trip to Southern California, and may be arriving April 28th (Friday) and leaving May 9th. If your meeting is April 29, I can attend. Enclosed are a sample of reports that I donate to your library [see list under Library Donations elsewhere in this issue—Ed.]. As I promised you all in November, one of the reports is on the Langley wing tip shape testing.

Hope to see you in April.

Todd Hodges

P.S. I will keep an eye out for NASA reports that are of interest to TWITT.

TWITT Design Forum in the Works

TWITT Syd Hall, who feels he has received too much attention [!] from this rag and prefers that we not quote him in extenso, has proposed to submit a flying wing design of his for critical appraisal at a forthcoming TWITT meeting. The following are excerpts from two letters:

It is my intent to send you an extremely detailed three-view, when it all gells, on the following condition. The condition is that TWITT assemble and evaluate and criticize, and that, as much as can be caught (on tape?) be fed back to me for a possible improvement of the bird. The objective of us all is to put better "genes" in the genus "tailless", and since I am not near El Cajon, this is the next best bet.

You will get my bird as soon as I get it onto one folio. Right now it exists with many updates, revisions, improvements, etc., and it would be (I fear) confusing. I want it to be clear, and beyond misunderstanding, since I intend to consider *HEAVILY* the comments and observations and suggestions that you might make. (I feel that Hangar A-4 has a lot of smarts that I need. Unfortunately, I live remote. But I still intend to make use of this resource, since I feel strongly that we TWITTs are pushing a cause and we should act as a unit or team to produce the best we can. To put it another way, anything that is less than the best that we can all do reflects upon the concept that we espouse—that of the wing being the thing.)

Syd Hall

Well, that's as much as I felt I could print without violating the spirit of Syd's request that we print only excerpts from his letters. It's a pity, too, because there is much more in there that is—in my editorial judgement—of value to our readers. Modesty is praiseworthy so long as it doesn't stand in the way of progress; I would rather be free to exercise my editorial privilege of selecting and printing material of general interest. C'mon, Syd—change your mind!

Syd's idea for a remotely-piloted technical forum is ingenious and applicable to the majority of TWITTS, who do not inhabit the greater San Diego area. Your Editor is more than a bit embarrassed at not having thought of it himself. This is a very good opportunity for faraway TWITTS to expose their ideas at our meetings, to our mutual benefit. There's no reason why the presentation couldn't become a dialog, with thoughts traveling by audio-cassette, letter or even videotape, and the hot items being published in the Newsletter so that everybody stays in touch. It would do much to restore balance to TWITT activities, which are now centered on the southwestern United States.

Needs German Flying Wing Model Book

Bob Ratliff of Richardson, Texas, writes:

How can I obtain the Library listing and prices? How is the library set up? Do you sell, rent, loan, copy articles or what? I am looking for *Nurfluegel-modelle* by Martin Lichte, published by Verlag fur Technik und Handwerk, GmbH, F.R. of Germany.

Bob Ratliff

Sorry, Bob, but we don't have that book. We will publish the address of the publisher in the next issue of this Newsletter, but if any US TWITTs know of a local source for this book, please contact TWITT so we can publish that information as well. As for the library status, please see my comments in issue # 32 for details, but basically no sortable listing exists. Until one is prepared, the best we can do is solicit requests for flying wing material and search our files for a match. If we find it, we can reproduce it for a modest fee.

Cover Artist Comments on TWITT

Kenneth Carpenter of Providence, RI, sent us the breathtaking sketch that appears on our cover. Here's the note that came with it.

Dear Bob,

I would like to thank you and the members of T.W.I.T.T. for providing wing enthusiasts with an organization positioned on the cutting–edge of flying wing design and data. Enclosed is a check for $17.50; $15.00 for the subscription & $2.25 for any back issues pertaining to the SB-13.

Yours truly,

Kenneth J. Carpenter

*Thank you for those comments. Of course, it's people like you who **put** TWITT on the cutting edge...*

Kuhlmans Strike Again

Just a short note to let you know that this article comes from *Delta* #2. Arrived in our mailbox from Reinhard Werner just a few days ago. Possibly a "translate and print" for TWITT's newsletter?

*This sheet seems to live on a steady diet of coincidence; the excerpt from **Delta** contains two items, one on a Horten II airfoil analysis contributed by Dipl.-Ing. Martin Lichte, whose book on flying wing models Bob Ratliff wants a copy of, the other by Dr. Reimar Horten concerning the bell-shaped lift distribution discussed by last month's TWITT speaker, Philip Burgers. Dr. Horten's article is in a much less formal style than the technical chapter in **Nurfluegel,** hence a better candidate for translation. Look for it in a future issue.*

Another Library Inquiry

Read with interest about TWITT and request you enter my subscription to your Newsletter, check enclosed. I would very much appreciate a list of the materials in the technical library and what is required to obtain photocopies of "publications of interest." I have a 15m flying with sailplane designed in 1971 as an A.E. undergraduate at Georgia Tech. Military service, career and family have taken precedence over getting the design built until now. I would like to update the design study and get a prototype built and flying. Thanks in advance for the help.

Ross Hoffman

See my earlier comments about the library. Send us your want list and we'll see what we can do. For obvious reasons, helping get machines in the air is a high-priority item at TWITT; we'll help if we can. Any chance of our getting a copy of your design study?

Looking for Low AR Flying Wing, WIG Experts

This from Eldon Runkel of Madison, Alabama:

This covers a new subscription and 31 back issues. I would also like the phone numbers of people you feel would be qualified and willing to discuss the design of:

- Low aspect ratio flying wings, such as the Horten X
- Wing–in–ground–effect aircraft

Thanks!

Eldon Runkel
1104 Woodbine
Madison, AL 35758
(205)721-7571 (W)
(205) 461-8752 (H)

*Hmmm...I don't know any WIG experts. As for the other topic, it happens to be my hobby, although I can't be sure that I know anything of value to you. Feel free to contact me at (619) 272-1725. Meanwhile, we will publish your address and 'phone and leave it up to our readers to get in touch if they feel both willing and able. Another thing which you may already know: Kuechemann's **Aerodynamic Design of Aircraft** contains much valuable*

information on low AR, blended wing-body designs and their possible applications.

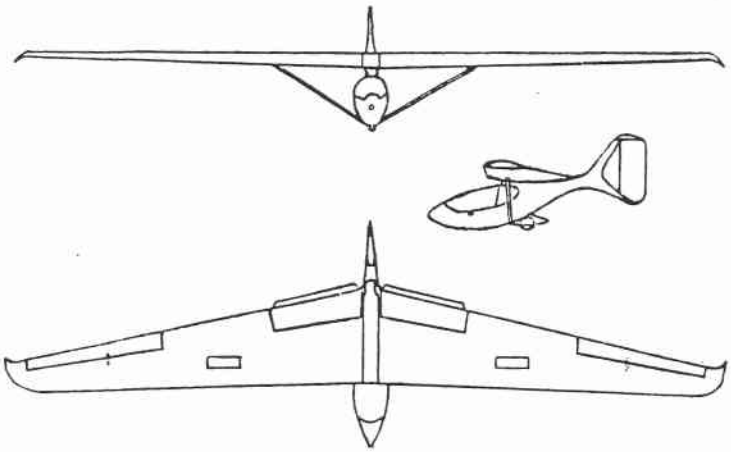
LIBRARY CONTRIBUTIONS

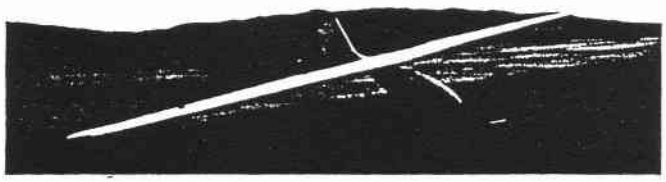
- *Stuttgarter Profilkatalog I.* Contributed by Bob Fronius.

TWITT is grateful to Todd Hodges (see LETTERS) for the following valuable additions to our collection:

- Vijgen, Van Dam and Holmes: "Sheared Wing–Tip Aerodynamics: Wind-Tunnel and Computational Investigations of Induced–Drag Reduction," 5th Applied Aerodynamics Conference, AIAA–87–2481 CP
- Yates and Donaldson: "A Fundamental Study of Drag and an Assessment of Drag–Due–to–Lift Reduction Devices," NASA Contractor Report 4004, September 1986
- OSTIV (Organisation Scientifique et Technique Internationale du Vol a Voile) Publication XVIII: *Summary of the Lectures held during the XIXth Congress of Ostiv in Rieti, Italy, 2 August-10 August 1985, and other Selected Papers originally printed in* ***AERO REVUE*** *or in* ***TECHNICAL SOARING***

SIERRA MONARCH





Span 42 ft.
Area 167 ft.
Aspect ratio 11.3
Empty wt. 270 lbs.
Gross wt. 470 lbs.
Wing loading 2.8 PSF

This is to introduce the Sierra Monarch, a tailless sailplane inspired by Jim Marske's Monarch "C". Although there are similarities this is a completely redesigned aircraft and construction has been changed significantly in this high performance version.

At present, a complete set of construction drawings are being made and plans are to produce a kit; to include molded fiberglass parts, such as fuselage, and all metal fittings prefabricated and welded. Additional materials including canopies will also be available.

By offering a clear and complete set of plans and all the specialized parts, cost can be kept to a minimum. It will however, take the average builder about 400 hrs. to construct. An experienced mechanic with a complete shop about 100 hrs.

However, before plans and parts will be released, the prototype will have completed testing and all modifications noted, projected for January 82. An information pak will be available at that time, which will include; latest test data, a phantom view construction drawing, color pictures, latest schedule and prices.

Look for us in Soaring or write to:

Tim Weakley
P.O. Box 2750
Olympic Valley, Cal 95730

The article that follows originally appeared in Kitplanes, Dec 1988.

Ed.

Let's consider airfoils for flying wings.

BY BARNABY WAINFAN

This month we consider the selection of airfoils for flying wings and tailless airplanes.

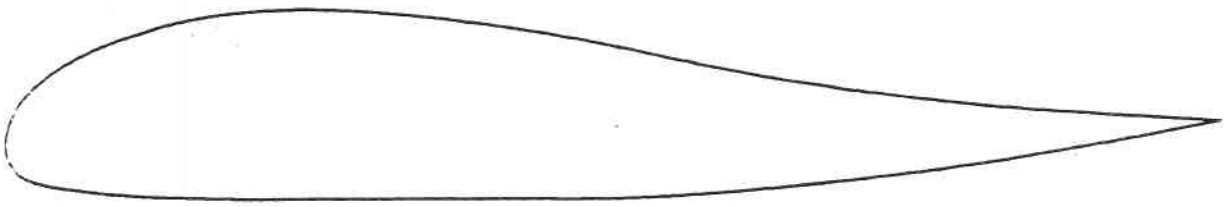
Our letter this month comes from Daniel Haskell of Scottsdale, Arizona.

"My question is about airfoils for flying wings or tailless aircraft. I am curious about the reflexed versus symmetrical profiles."

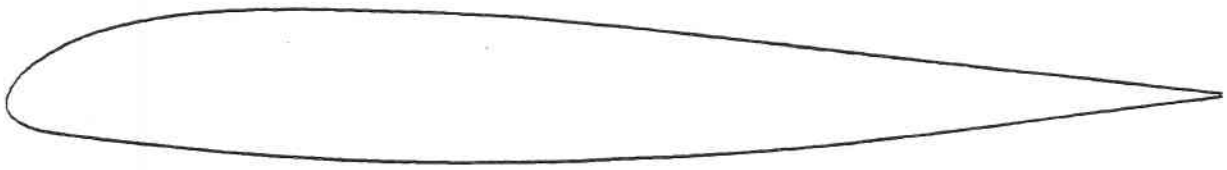
As the old saying goes, the addition of a tail to an airplane hides a multitude of sins. The horizontal tail has enough pitch control power to trim out virtually any pitching moment the wing generates. When we remove the horizontal tail to get a tailless airplane or flying wing, the trimming task once performed by the horizontal tail must now be performed by the wing. The wing must also lift the airplane, of course, so the wing design becomes more difficult because the wing must satisfy more requirements.

Before we get into airfoil selection for tailless airplanes, we should first touch on the very important difference between stability and trim. Many people seek the mythical "stable airfoil" when designing tailless airplanes. They never find it . . . because there is no such thing as a "stable airfoil," or an "unstable airfoil" for that matter. The notion of a stable airfoil stems from the antiquated concept of airfoil "center of pressure." The center of pressure concept is highly misleading and is almost never used in modern aerodynamics.

An airplane is statically stable in pitch if increasing its angle of attack causes the aerodynamic pitching moments generated by its flying sur-



Reflexed airfoil used on Backstron's Plank



Airfoil used on Marke Pioneer has less reflex

faces to change in a negative (nose-down) sense and decreasing the angle of attack causes a positive (nose-up) change in pitching moment. The static pitch stability of an airplane in unstalled flight is dependent solely on the relative positions of the center of gravity of the airplane and its aerodynamic center (AC). If the c.g. is forward of the AC (also called the "neutral point"), then the airplane is statically stable in pitch. If the c.g. is aft of the AC then the airplane is unstable in pitch. This is true regardless of the airfoil used.

The aerodynamic center of all airfoils falls at or near the 25% chord point in subsonic flight. Bodies have a somewhat destabilizing effect so the neutral point of a tailless airplane will typically be between 20% chord and 23% chord. As long as the c.g. is ahead of this point the airplane will be statically stable in pitch.

For the airplane to achieve steady, level flight, it is not sufficient that it be stable; it must also be trimmed. An airplane is trimmed when all of the moments acting on it are in equilibrium. If we add up all of the pitching moments about the center of gravity caused by all of the aerodynamic forces acting on the airplane, the sum will be equal to zero when the airplane is in trim. If the sum is not zero then the nose will either rise or fall depending on the direction of the residual moment and the airplane will not maintain steady flight at a constant angle of attack.

If the airplane is stable, the c.g. will be forward of the aerodynamic center. The lift is therefore acting behind the c.g. and will cause a negative (nose-down) pitching moment. In order for the airplane to be in trim, the flying surfaces must generate a positive (nose-up) pitching moment to counteract the negative moment generated by the lift.

The combined requirement that an airplane must be both stable and in trim makes the design of a wing for a tailless airplane more difficult than the design of the wing of a conventional airplane. Not only must the wing provide lift but, with the tail gone, it must also provide the pitching moment required to trim the airplane.

Effect of Camber on Pitching Moment

One of the major determinants of the pitching moment of a wing is the pitching moment generated by its airfoil. The pitching moment generated by the airfoil is determined almost entirely by the camber of the airfoil. Both the amount of camber and the distribution of camber have an effect.

In general, the more camber an airfoil has, the more negative its pitching moment will be. A symmetric airfoil, which has no camber, has a zero Cm0 and generates no pitching moment at all. An airfoil with negative or inverted camber will generate a positive (nose-up) pitching moment.

The distribution of the camber of an airfoil has a dramatic effect on its pitching moment. Adding the same amount of camber at different points on the airfoil affects the pitching moment more or less depending upon where on the chord the camber is added. The more aft the position of the camber, the larger its effect on C_{m0} will be.

Many of the "advanced airfoils" for general aviation that have appeared in the last 5 or 10 years have featured large amounts of aft camber. This is usually the result of an attempt to increase C_{LMAX} in order to increase wing loading. The unfortunate side effect is, as we have seen, that these airfoils also generate large negative pitching moments. This renders them unsuitable for any form of tailless airplane.

Low-Moment Airfoils

As you may have already inferred, the vast majority of airfoils produce a negative (nose-down) pitching moment. This is not surprising, as airfoils have positive camber. For most types of airplanes, a moderate amount of negative pitching moment is acceptable. The tail or canard can easily generate enough pitching moment to trim the airplane, although canard airplanes can tolerate less

negative pitching moment than aft-tail airplanes.

Unlike other types of airplanes, tailless planes and flying wings do not have separate surfaces such as tails or canards to generate pitching moment to trim the airplane. For a stable airplane to be in trim, the complete airplane configuration must generate a positive aerodynamic pitching moment about the aerodynamic center. If there is no tail or canard, the wing must have a positive pitching moment.

There are two ways to create a positive-pitching-moment wing. The first is to use a combination of sweepback and washout so that at zero total wing lift, the tips are pushing down and the root is lifting up. The second is to use an airfoil that has a positive C_{m_0}. The use of sweep and twist is limited by several factors and cannot produce a very large pitching moment. It can be enough to trim the airplane only if the airfoil has little or no negative pitching moment. Unswept, "flying plank" tailless airplanes must have positive-pitching-moment airfoils in order to trim.

Airfoil Shapes for Low or Positive Pitching Moment

If an airfoil is to have low negative or positive pitching moment, the camber of the airfoil must be different from the camber of "conventional" airfoils.

If zero pitching moment is acceptable, as is the case with a tailless airplane with a swept-back, washed-out wing, one choice is the symmetric airfoil. Symmetric sections were commonly used on early tailless airplanes. The disadvantage of symmetric sections is that they have their minimum drag at zero lift. A lifting wing with a symmetric airfoil will have more drag than it could have if the airfoil were properly cambered to match the cruise lift coefficient of the vehicle.

If a positive-pitching-moment airfoil is required (as is the case with an unswept or "plank" tailless), the problem becomes even more difficult. One way to get a positive pitching moment is to simply turn a normally-cambered airfoil upside down. The result is a negative-camber airfoil with a positive pitching moment. The problem with this approach is, of course, that negative camber does not work very well when the airfoil must generate positive lift. A negative-camber airfoil has its minimum drag at a negative lift coefficient. This is not very useful if one wants to fly upright. The second problem with negative camber is that it causes the maximum lift coefficient to be quite low. All in all, a negative-camber airfoil does not seem to be a very attractive solution to the problem of designing a tailless airplane with good performance.

So far we have seen two ways to produce low-pitching-moment airfoils but both have limited usefulness. Ideally, we would like to retain the lift and drag advantages of a normal, positive-camber airfoil in an airfoil with a positive or zero pitching moment.

Reflex

The goal of a high-performance, positive-pitching-moment airfoil can be achieved by using some facts we discussed earlier. The first of these is that camber near the trailing edge has much more effect on pitching moment than camber near the leading edge. The second important fact was discussed in an earlier article when we looked at the effects of camber on lift. Camber in the forward portion of the airfoil can have a large, positive effect on the maximum lift of an airfoil and can move the minimum drag to a positive lift coefficient.

Using these two concepts we arrive at the proper camber distribution for a high-performance, positive- or zero-pitching-moment airfoil. The airfoil should have positive camber over its forward portion to provide good lift and drag characteristics and negative camber over its aft portion to control its pitching moment. Such an airfoil is shown in the sketch.

Note that the forward portion of the camber line of this airfoil is concave downward while the aft portion of the camber line is concave upward. The mathematical term for a curvature reversal of this type is a *reflex* and so this type of airfoil is said to have reflex camber. Usually, it is just called a reflexed airfoil and the term *reflex* is used to describe the amount of upsweep in the aft portion of the airfoil.

The amount of reflex required is determined by the desired pitching moment and the amount of positive camber in the forward portion of the airfoil. Reflexed airfoils can have positive pitching moments and good lift and drag characteristics. In general, they still tend to have somewhat lower maximum lift coefficients than "conventionally cambered" airfoils, but not so low as to render them unacceptable. For a tailless airplane to reach its maximum performance potential, its airfoils will almost always have some degree of reflex to tailor pitching moment while allowing the forward portion of the airfoil to be positively cambered.

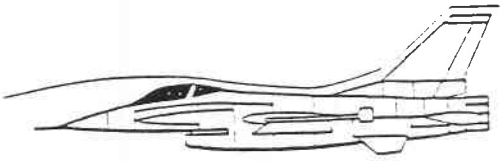
Control Characteristics

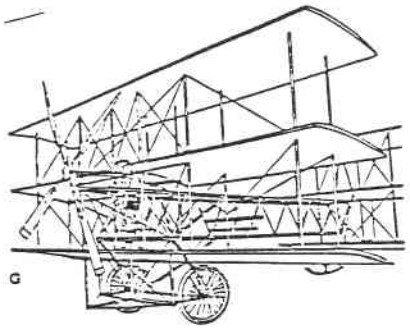
One problem that sometimes arises with reflexed airfoils is control-surface hinge moments. If the airfoil has large amounts of reflex, there will be a download on the aft portion of the airfoil. If a control surface is inset into the wing, it will have a net down force on it and will want to hinge trailing-edge down. If it is an elevon, the pilot will have to pull on the stick to hold the elevators neutral and maintain level flight.

This can be handled in two ways. The first is to use a spring or bungee trim system to help the pilot pull. The second is to tailor the shape of the extreme trailing edge of the airfoil or use trailing-edge trim tabs to eliminate the undesirable hinge moments.

One airfoil that has looked attractive to flying-wing designers over the years is the NACA 8-H-12. This is a zero-pitching-moment, laminar-flow airfoil. It is currently used on the rotor blades of several gyros. Unfortunately, as Al Backstrom found out with his Super Plank sailplane, the 8-H-12 has all of its reflex right near the extreme trailing edge of the airfoil. This caused the elevons to have unpredictable and difficult-to-handle hinge moments, producing unacceptable stick force reversals with angle of attack. Backstrom was never able to solve this problem and the Super Plank was eventually abandoned because of the poor flying qualities caused by the elevon hinge moments. The moral of the story is that the 8-H-12 is a fine airfoil for helicopter blades but it has serious problems when it is used for tailless airplanes.

Not all reflexed airfoils suffer from the problems of the 8-H-12. Several unswept tailless airplanes— notably those designed by Charles Fauvel, Jim Marske and Al Backstrom—have flown successfully and comfortably using properly designed reflexed airfoils. □





The Great Airfoil Frontier

Front loaded airfoils ! Aft loaded loaded airfoils ! Laminar flow, New codes, Vortex lift , etc...

Moderator: REG FINCH

Panelists: 1) Dr. R.H. LIEBECK (McDonnell Douglas- Liebeck airfoils, etc.)

2) Dr. PETER LISSAMAN (Aero Viroment Inc.- Gossamer Condor & Albatross , etc.)

3) BARNABY WAINFAN (" Windtunnel " column in Kitplanes magazine, etc...)

4) " VAN "VAN EVERY (Design Office Head A- 4 , F-4 many major Aerospace Companies, etc...)

Time: 7- 9:30 pm
Date: Saturday March 18, 1989
Place: Aerospace Museum Theatre in Balboa Park - Rear entrance. Park in rear.
Admission : Free
Sponsored by: Experimental Aircraft Association Chapter 14
Information: 435-1075

THE HORTEN IV