No. 120 JUNE 1996

T.W.I.T.T. NEWSLETTER

This is the surface velocity chart for Phil Barnes' pmc-Z15 math modeled airfoil. He suggests that it could be used in an aircraft such as the German SB-13 shown in 3-view below.

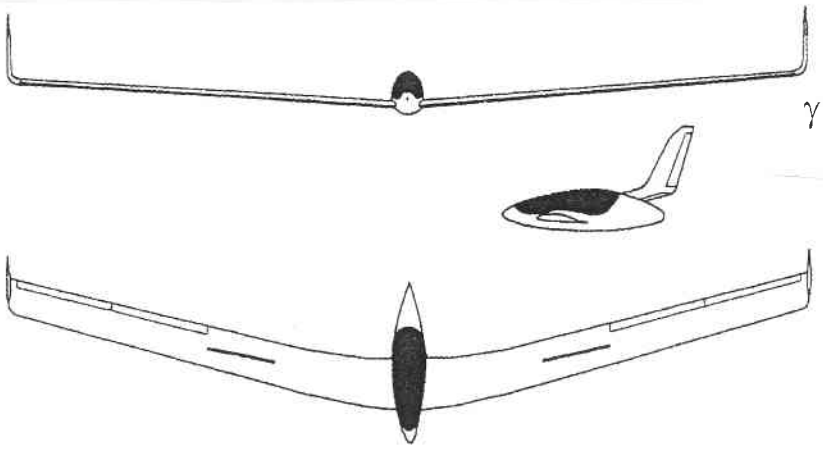
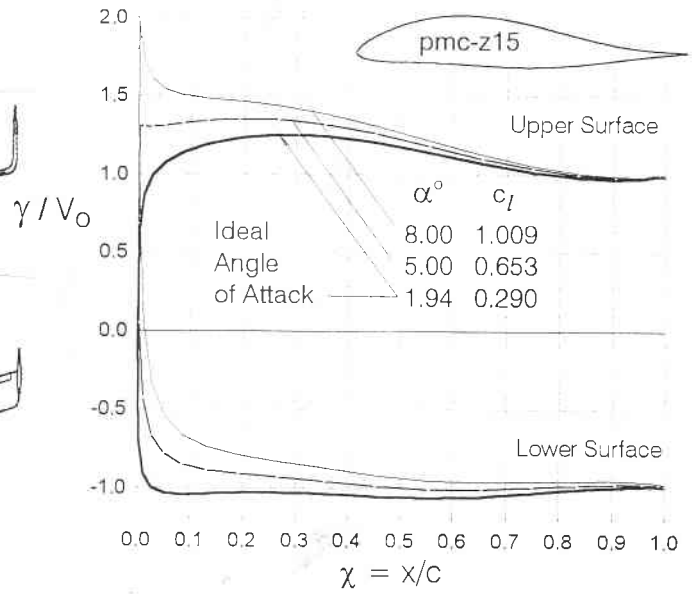


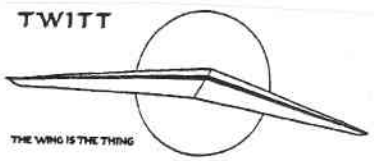
Figure 6.5
pmc-z15 Airfoil Surface Velocity
Theodorsen's Method



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

The number to the right of your name indicates the last issue of your current subscription, e.g., **9606** means this is your last issue unless renewed.

Next TWITT meeting: Saturday, July 20, 1996, beginning at 1330 hrs at hanger A-4, Gillespie Field, El Cajon, CA (first hanger row on Joe Crosson Drive - East side of Gillespie).



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.

T.W.I.T.T. Officers:

President: Andy Kecskes	**(619) 589-1898**
Vice Pres: Bob Chase	**(818) 336-5485**
Secretary: Phillip Burgers	**(619) 563-5465**
Treasurer: Bob Fronius	**(619) 224-1497**
Editor: Andy Kecskes	

The T.W.I.T.T. office is located at:
Hanger A-4, Gillespie Field, El Cajon, California.
Mailing address: P.O. Box 20430
El Cajon, CA 92021

(619) 596-2518 (10am-5:30pm, PST)
(619) 224-1497 (after 7pm, PST)
E-Mail: NBKP63A@prodigy.com

Subscription Rates: $18 per year (US)
$22 per year (Foreign)

Information Packages: $2.50 ($3 foreign)
(includes one newsletter)

Single Issues of Newsletter: $1 each (US) PP
Multiple Back Issues of the newsletter:
$0.75 ea + bulk postage

Foreign mailings: $0.75 each plus postage

Wt/#Issues	FRG	AUSTRALIA	AFRICA
1oz/1	1.00	1.00	1.00
12oz/12	5.00	6.75	5.00
24oz/24	9.00	12.25	9.00
36oz/36	14.00	19.50	14.00
48oz/48	16.75	23.00	16.75
60oz/60	21.75	30.25	21.75

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, east side of Gillespie).

TABLE OF CONTENTS

PRESIDENT'S CORNER

This month I was again shy of much material for the newsletter so used as much of Phil Barnes viewgraphs as necessary to fill in the blank pages. I know some of our members are not quite this technically minded, but it will preserve the information for future generations of TWITT members. Also these additions of the newsletter will eventually find their way into the Library of Congress for the use of a more diverse audience.

Please keep your third Saturday in July open to attend the meeting since it will be very special. I would like to have a good showing for Bruce Hinds, especially since he will be coming down from Palmdale at his own expense. This is a rare opportunity to have contact with someone involved in the leading edge technology of flying wings and should not be missed.

Also, don't forget to mark your calendars for Labor Day weekend to spend at least one day at the Sailplane Homebuilders Association gathering at Tehachapi. Saturday and Sunday will be filled with various workshops and symposiums on subjects near and dear to the amateur builder's heart. There is usually a crowd of about 50-60 builders who have a wide variety of interests, so it is a good opportunity to share ideas, theories, etc., with others who think like you about aviation. We will publish a more detailed schedule of events as they are finalized by Bruce Carmichael and his committee.

Bob got some shots of the N9M while it was at Gillespie, but we didn't get the half-tones done in time for use in the newletter. We'll put some in next month.

Several of you have been asking about the library listing and newsletter index, and rightfully so since it has been a while in completing. I don't have all the answers right now, but will get a better estimate of when either or both of these items will become available. I do know there have been some extenuating circumstances delaying the library list, but it is getting back on track. More on these next month.

This is our Tenth Anniversery issue (No. 120) in case no one noticed. We will have a little celebration at the July meeting so be there for the fun.

Andy

JULY 20, 1996 PROGRAM

As of publication date we have confirmed that our speaker will be **Bruce Hinds**, one of the Northrop B-2 test pilots, who will be coming down from Palmdale and give us some insight on the Air Force's newest flying wing.

His presentation will include an overview of the B-2 program, some of the technical data surrounding the aircraft and a couple of short videos. He has also indicated he will field our questions, so this will be your chance to quiz an expert on what makes a good flying wing.

So, get you pencil out and mark your calendar for July 20 to be at Gillespie to welcome Bruce.

This will be our Tenth Anniversary party with cake and ice cream to mark the momentus occasion of having survived that many years, so bring along your sweet tooth.

MINUTES OF THE MAY 18, 1996 MEETING

Andy opened the meeting by welcoming everyone to the warm hanger and by announcing the order of the day's program. He said that there would be two raffle tickets drawn today and the winners would have their choice from a selection of packs of absorbent shop rags, a roll of heavy duty buffalo rope, and ball of heavy twine, and a personal alarm device for use against muggers and purse snatchers.

Everyone was asked to introduce themselves since we had some distinguished visitors today, like Jack Lambie, Andy Bowers and Bud Mears. When it got to Paul Stahlhuth we had to say good-bye since this would be his last attendance at a meeting because he was moving to northern California. Bruce Carmichael indicated he had copies of his book available if anyone was interested, and that he had sold over half of the original printing so it is doing relatively well for a private venture.

Andy thanked Chris and Connie Tuffli for the boxes of pizza they put out before the meeting for refreshments. Everyone seemed to enjoy it very much.

Jack Lambie told us about one of his latest ideas for helping to document what happens on board airliners when an emergency condition arises. He thinks that an adapted version of the TV cameras used on race cars could be used to send real-time pictures via satellite to a control center which would then be able to record it for later analysis. This would be a supplement to the standard black box, but provide much superior information and significantly reduce the amount of guess work in trying to determine what happened if there was a major crash. Of course, one of the biggest hurdles is the cost per airplane which the airlines will use to put this type of intrusion into cockpit privacy off for as long as possible.

The first part of the program was a short video titled "Nothing's Perfect" which was a comical presentation of Ryan Aeronautical employees trying to launch various models of the Firebee target drone. Everyone seemed to get a kick out of it.

Andy then introduced Phil Barnes, our speaker for the day, who would be telling us about the latest developments in his software development. (ed. - since many of our members are not into computers, formulas, and highly technical material, I will cover only the major points made by Phil during the talk. Included in this newsletter are some of the viewgraphs he used which would be of interest to most of the members and correspond to some of the written material. I would like to thank Phil for including a basic script with the viewgraphs which made the preparation of these minutes much easier. For those of you who would like to hear the entire presentation with the questions from the audience, an audio cassette is available for $3.50 US postage paid, or for $5.00 US postage paid you can get a photo copy of the 21 pages of charts and script he used [$7 for the complete package].)

Phil's topic for the day was "Math Modeling of Airfoil Geometry". Phil started by explaining that all the airfoils on the cover on May's newsletter were done with the math modeling program and as he showed later on are exact duplicates of the original airfoils, and in some cases perhaps just a little smoother.

An airfoil that is smooth to the eye may not be smooth to the air flowing over it. In his book Airfoil Sections, Dr. Riegels points out that the velocity on an airfoil surface is primarily determined by curvature, and that discontinuities in curvature can lead to early transition from laminar to turbulent flow, thereby increasing the drag. By modeling airfoil geometry with suitable equations, we can avoid any discontinuities in the specified geometry.

In math modeling an airfoil, we need control over the leading edge radius, forward thickness buildup, maximum thickness, maximum thickness location and cusp depth and extent. Also, a finite trailing edge thickness should be modeled since it is unwise and impossible to manufacture the airfoil with zero trailing-edge thickness. The math model should also provide control over the shape of the camber line, including the maximum camber and its location.

With this in mind, Phil quickly went through the first six viewgraphs which contained the various formulas that comprise the core of the math model. The last of these incorporated what he calls a varabola, which is a exponent modified parabola. One application is to model the finite trailing edge thickness buildup by adding a small varabola to the previously defined half-thickness math model. The varabola is also applicable in math modeling the camber

line. By joining two inverted varabolas, skewed if necessary, we can control the characteristically broad camber lines of contemporary laminar airfoils such as the Somers and Wortmann designs shown.

Math modeling of existing airfoils with the "thickness plus camber" approach frequently runs into trouble near the leading edge where the designer may have introduced a sharp hook in the camber line. To get around this problem, we can separately model the upper and lower "half thickness" shapes with independent upper and lower leading edge exponents. If the original airfoil was drawn with a French curve, the math model will never completely converge on the tabulated coordinates. However, after reasonable convergence, the desired effect of aerodynamically smoothing out the airfoil will have been achieved. (Page 4 is Phil's viewgraph demonstrating this part of the theory using an Eppler 748 airfoil.)

Now that the geometry design tools are in place, we would like to verify the advertised smooth velocity distribution. It is also important to know what effects the geometry will have on key aerodynamic properties. Toward this goal, we will outline and apply Theodorsen's so-called exact potential flow method, which was developed in 1931.

Relative to contemporary vortex-panel methods, Theodorsen's approach is computationally fast and robust (via computer). It begins by calculating various geometry parameters as they relate to the polar angle, counter-clockwise from the trailing edge. We are indebted to both Thwaites and Goldstein for simplifying and translating Theodorsen's method to modern sign convention.

Key results are the zero lift line incidence, the ideal angle of attack, where the stagnation point coincides with the leading edge, and the lift coefficient, which is somewhat greater than the thin-airfoil prediction.

A question from the group right about here, brought up the point about what was trying to be accomplished through math modeling. Phil pointed out that tabulated airfoils often have zigzagging velocity profiles that must be manually corrected by moving various points and then trying the simulation again. Using equations to shape the airfoil eliminates this manual effort and achieves a smooth right from the start.

Moving on, Anderson, in his book Fundamentals of Aerodynamics, shows how the boundary layer sets up a vortex sheet on the airfoil surface. The local velocity just outside the boundary layer is equal in magnitude to the vortex density, or vortex strength per unit surface length. The density is clockwise on the upper surface downstream of the stagnation point, counter-clockwise on the lower surface, and zero at the stagnation point. Theodorsen's equation relates the normalized vortex density to the angle of attack and airfoil geometry parameters. Phil had a viewgraph that showed the results of these tests on a Somers NLF(1)-0416 airfoil with the math model version showing a good match with the plotted data.

As shown by Liebeck, the vortex density can be integrated, clockwise around the airfoil perimeter, to obtain the lift coefficient. This is a direct application of the Kutta-Zhukovsky Theorem. The lift coefficient is twice the area under the curve, After converting the velocity or vortex density into pressure coefficient we can use a vector-panel approach to integrate the quarter-chord pitching moment coefficient.

The results of a vector analysis of pitching moments is an expression which takes the counter-clockwise sum of panel pressure coefficient and geometry data. Applying this to the Somers airfoil, we might be surprised to learn that the quarter-chord pitching moment coefficient varies with the lift coefficient. This suggests that the aerodynamic center does not reside at the 25% chord position predicted by thin-airfoil theory.

Wrapping up this section, the calculated properties of the Somers airfoil are compared with test data. It is interesting to note that the aerodynamic center resides at almost 28% chord. The test data reasonably verifies the calculations for the aerodynamic center, the pitching moment at the aerodynamic center, the zero-lift line incidence, and the lift coefficient at two angles of attack. (Page 6 is the viewgraph showing the comparative results of test data and Phil's calculations.)

With the geometric and basic low-speed aerodynamics design tools now in place, we can design some new math-modeled airfoils. One example is the pmc-L15 which could be used on this laminar aircraft from a paper by Selberg and Rohksaz.

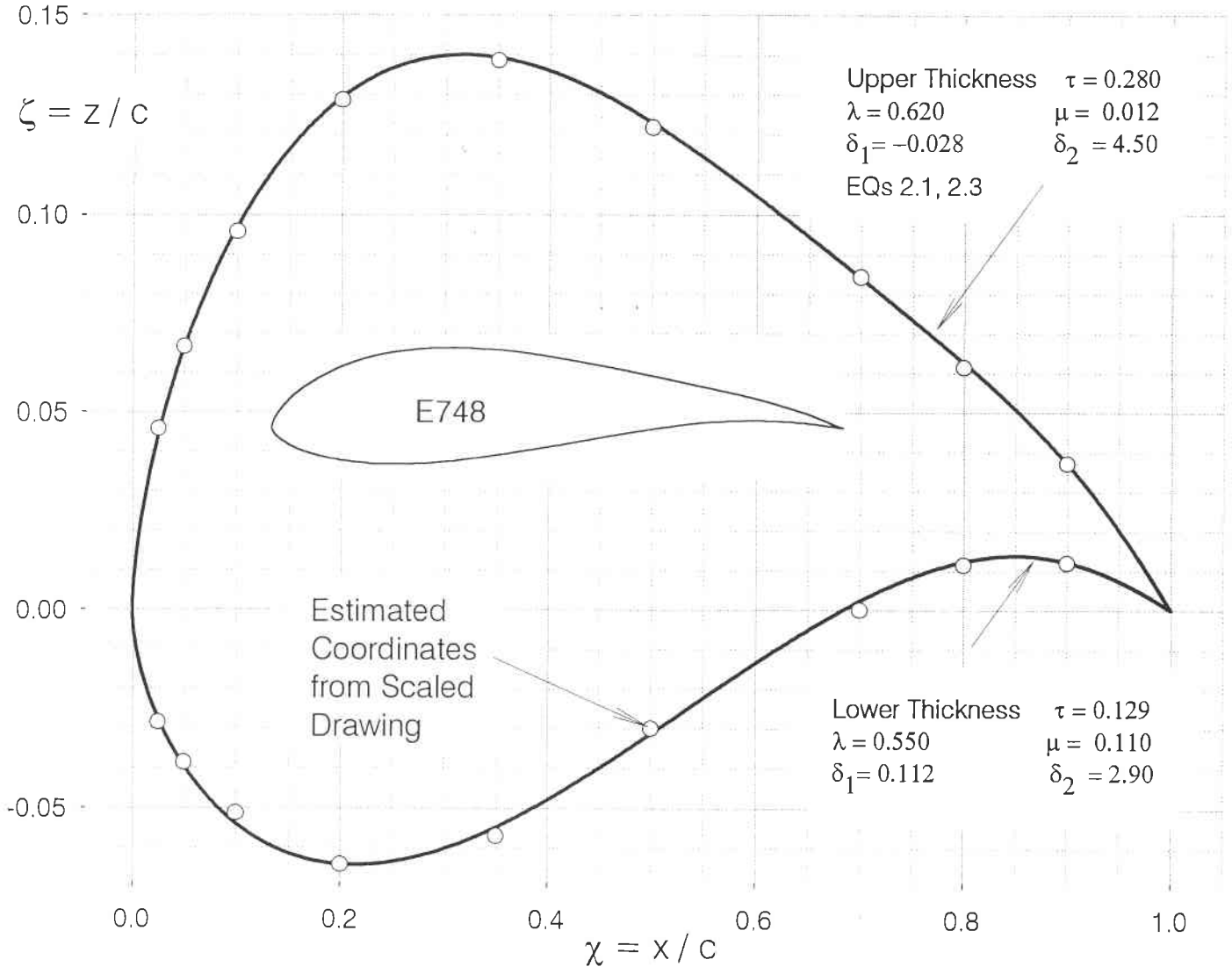
Bruce Carmichael in his book Personal Aircraft Drag Reduction states that natural laminar flow can extend up to 70% chord, given the best of conditions. Toward this goal, the pmc-L15 has been designed to have a favorable velocity gradient extending over much of the chord. This can be seen at the ideal angle of attack of 0.44 degrees, corresponding to a lift coefficient of 0.53. (Page 8 is the viewgraph showing the pmc-L15 airfoil, the various factors used to influence its shape, and a surface velocity graph for three angles of attack. The dark line shows the consistancy in surface velocity well back on the airfoil as invisioned by Bruce.)

In a second example, the pmc-Z15 math-modeled airfoil incorporates essentially an inchworm camber shape to obtain zero pitching moment. This airfoil could be applied to a swept and tailless design, such as the SB-13 glider, or to both lifting surfaces of a general aviation canard. Here, zero (or even positive) wing pitching moment promotes better lift sharing with the canard. As was shown in the velocity plot, the pmc-Z15 can attain a lift coefficient of 0.65 without a leading edge velocity spike. It is interesting to note that the velocity at the trailing edge nearly returns to free-stream velocity.

In summary, new math-modeling tools were presented for specifying new airfoil geometry or for closely matching and aerodynamically smoothing out existing airfoils. The techniques are applicable to a wide range of airfoil geometry's. It is Phil's recommendation that the

Math Modeling an Existing Airfoil

Upper / Lower "Half-Thickness" Equations



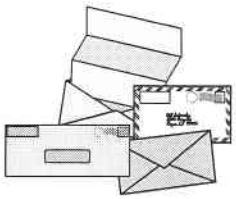
geometry of the next generation of airfoils should be math-modeled in some form. An adjustable finite trailing edge thickness should be included in the math-model. Ultimately, the math-modeling should be extended into three dimensions to characterize wings and blended wing/body configurations.

Phil commented that this presentation was only about one-third of that in his paper submitted to SAE (to whom he released the copyrights). The paper is available through SAE for about $10 for non-members. For those of you who are real techies, this might be $10 well spent.

At the end there was a prolonged discussion on the canard configuration shown in one of the viewgraphs. There were those in the audience who supported and those who scoffed at this configuration, so the exchange was rather interesting. As usual from this type of discussion, there were no definite conclusions reached on what airfoils or weight distributions between the two surfaces would be correct or optimal.

To close the meeting up, Andy conducted the raffle. The first winner was Alex Kozloff who selected one of the packages of workshop rags, and the second winner was Bob Noble who took the buffalo rope.

The group then broke up to finish off the pizza so generously provided by Chris and Connie, and to help Bob take one in wing off of the Ryan Cloudster motor glider and place it in a hanger. Bob would like to thank all those who stayed around to help with this project.



LETTERS TO THE EDITOR

May 21, 1996

TWITT:

I am sorry in the delay for renewing my subscription, but I have decided for a number of reasons not to continue - mainly lack of time to read and inwardly digest - also a slight transfer of energy to other hobbies.

I enjoyed TWITT very much while I was moderately active in the field and I learned a lot from your very informative and dedicated print. Congratulations to you and your committee who are doing and have done excellent work.

I will regret the decision to not continue subscribing.

Best wishes,

Bob Peirson
Chatwood NSW Australia

(ed. - We are sorry to see Bob leave our group since he has been a constant contributor to the organization. However, we recognize that other things sometimes take a higher priority and that you cannot do everything at the same time. We wish Bob good luck with his new hobbies and other interests.)

May 20, 1996

TWITT:

I'm very glad each time I get TWITT's newsletter. Please find enclosed by renewal.

Concerning TWITT No. 119, May '96, page 2, Library Contribution translation, "The 90 Years of Charles Fauvel". Les Cahiers DV R.S.A. means, "The Newsletters of the R.S.A." (RSA = Reseau du Sport de l'Air (French version of EAA homebuilders association).

The header line reads, "Engineer and pilot, Charles Fauvel has been the French pioneer of the flying wing formula. Although handicapped by the slow means of calculations (between the two world wars and just after WW II) this pioneer proved to be a real creative genius."

Continued on page 9 of the same issue, here is a quick translation of the bottom, signed - Helmut Winkler - that's a German design. Pure radial aspect ratio N 1 based on 5 radius, suited from the "Flying Sickle" of the Dutch of Arnheim, the flying Dutch in aspect of Sickle.

The top left corner is in German and French and is broken down as,

Stabilizing Part	Transition	Lifting Surface

and Vol Libre = Free Flight

Concerning your VHS cassette I from you - Ornithopter, Japanese manpowered flight, etc., - could you give me the address of the constructors of these ornithopter models, please.

If there is any translation form German or French, don't miss to ask me, but not too much at a time, please.

Yours sincerely,

Günther RUDAT

(ed. - Thanks for the translations, and I sure appreciate the offer for limited amounts of German/French work.

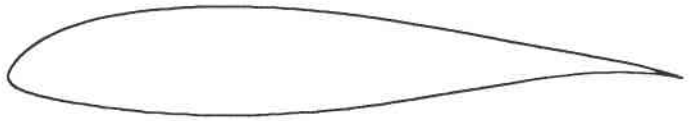
The name and address for the ornithopter is:

Ers G. DE RUYMBEKE
20 bd Bourre 13009 Marseille France
Tel: (33) 91 73 27 12
Fax: (33) 91 73 2597

SUMMARY -- CALCULATIONS VS. TEST DATA

NLF(1)-0416 AIRFOIL

- Test Data at Reynolds Number = 4 million
- Theodorsen's Potential Flow Method for Velocity
- Liebeck's Integration of Vortex Density for Lift
- Vector Integration of Pitching Moment c_{m4}
- c_m Referenced to the Aerodynamic Center



Aerodynamic Parameter	Calculation	Test Data
Aerodynamic Center, χ_{ac}	0.274	0.279
Pitching Moment @ac, c_m	- 0.084	- 0.089
Zero Lift Line Incidence, β^o	4.4	3.8
Lift Coefficient, c_l		
$\alpha = 0.01^o$	0.45	0.45
$\alpha = 8.16^o$	1.41	1.32

Being that both of you live in France, I will have to assume it may be easy for you to actually get together with him and discuss the designs. Good luck.)

April 1. 1996

TWITT:

Enclosed is U.S. Money Order for a one year subscription to TWITT.

I've been introduced to the above through a New Zealand contact, a Mr. Rob Germon and friends.

If possible should you have any other Australian subscribers, please pass on any contact's names.

I look forward to our newsletter and the other available information.

Sincerely,

Jeff Hancock
P.O. Box 136
Sth. Gate P.O.
Tamworth
ZIP. 2340. N.S.W.
Australia

(ed. - First of all we would like to welcome Jeff to TWITT. As you can see we lost one member in Australia, just to gain another. We hope you enjoy the material you find in the newsletter over the next year.

In order to safe postage I will include the names of our other Australian members right here:

Alan Lewis
PAL Engineering
P.O. Box 81
Paddington NSW 2021

Robert Marriott
P.O. box 194
North Strathfield
Sydney

Bob Pierson
13 Park Avenue
Chatswood NSW 2607

We hope that you are able to make contact with any or all of these members and exchange ideas, stories, etc., about flying wings. Please keep us informed of your flying wing activities so that we may share them with the rest of the membership (world).

Again, welcome to TWITT.)

N9M-B HITS EL CAJON

The Northrop N9M-B came to Gillespie Field on Wednesday, May 8, 1996, for a four day Wings Over Gillespie air show. The plane was flown by Ron Hackworth who managed the long restoration project for the Planes of Fame museum at the Chino airport.

The article in The San Diego Union-Tribune went on to give some of the typical background surrounding this test bed for the XB-35 and XB-49 flying wings. Retired Brig. Gen. Robert Cardenas (a former TWITT meeting speaker) commented that the N9M required very careful, tender and easy handling until you got it into the air where it became a fun airplane to fly.

It appears that the N9M will be making more airshows over the coming months (we would assume they will be California or western states shows to keep the wear and tear on the airplane down). You might want to keep an eye on show announcements in your area.

THE PRIMER

When Bob was at Tehachapi for the Vintage Sailplane Associations Memorial Day meet, he managed to get a 3-view drawing (on page 10) of Les King's latest design, The Primer.

It is a primary type with some obvious modernization, including the use of Liebeck airfoil, removable wing panels, and foam and plywood construction. No, your eyes aren't deceiving you, there is no nose wheel, just a skid.

Les hasn't flown it yet, and Bob didn't note how far along the construction was at the time he saw it. However, he has apparently got Les to agree to coming down and tell us about it once he has it successfully flying.

AVAILABLE PLANS & REFERENCE MATERIAL

Tailless Aircraft Bibliography

by Serge Krauss

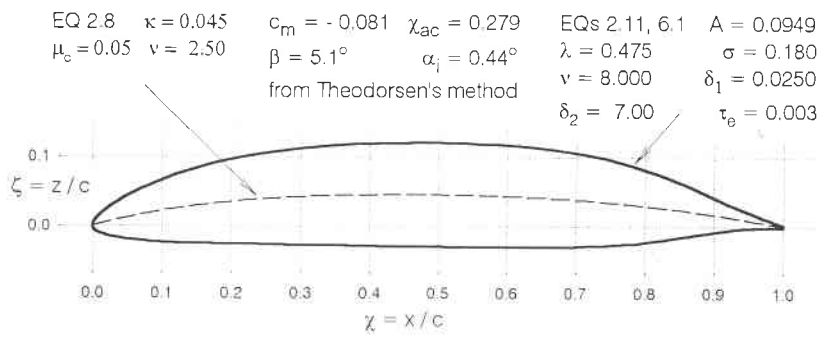
4th Edition: An extensive collection of about 2600 tailless and over 750 related-interest listings. Over 15 pages of tailless design dates, listing works of over 250 creators of tailless aircraft, and the location of thousands of works and

(continued on page 9)

NEW AIRFOILS

APPLICATION OF GEOMETRIC / AERODYNAMIC DESIGN TOOLS

Figure 6.1 pmc-L15 Airfoil



- Maximum thickness at 50 % chord
- Favorable velocity gradient to 60 % chord at the ideal angle of attack

Laminar Airfoil and Aircraft Application

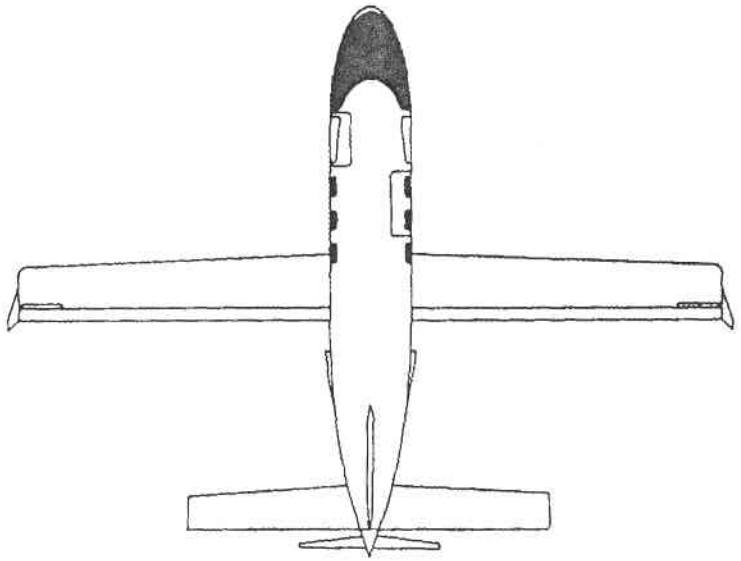
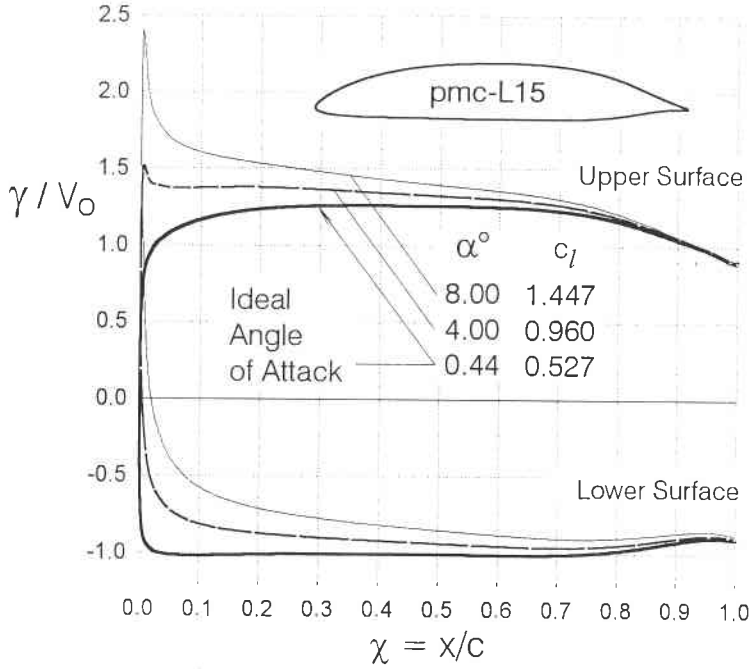
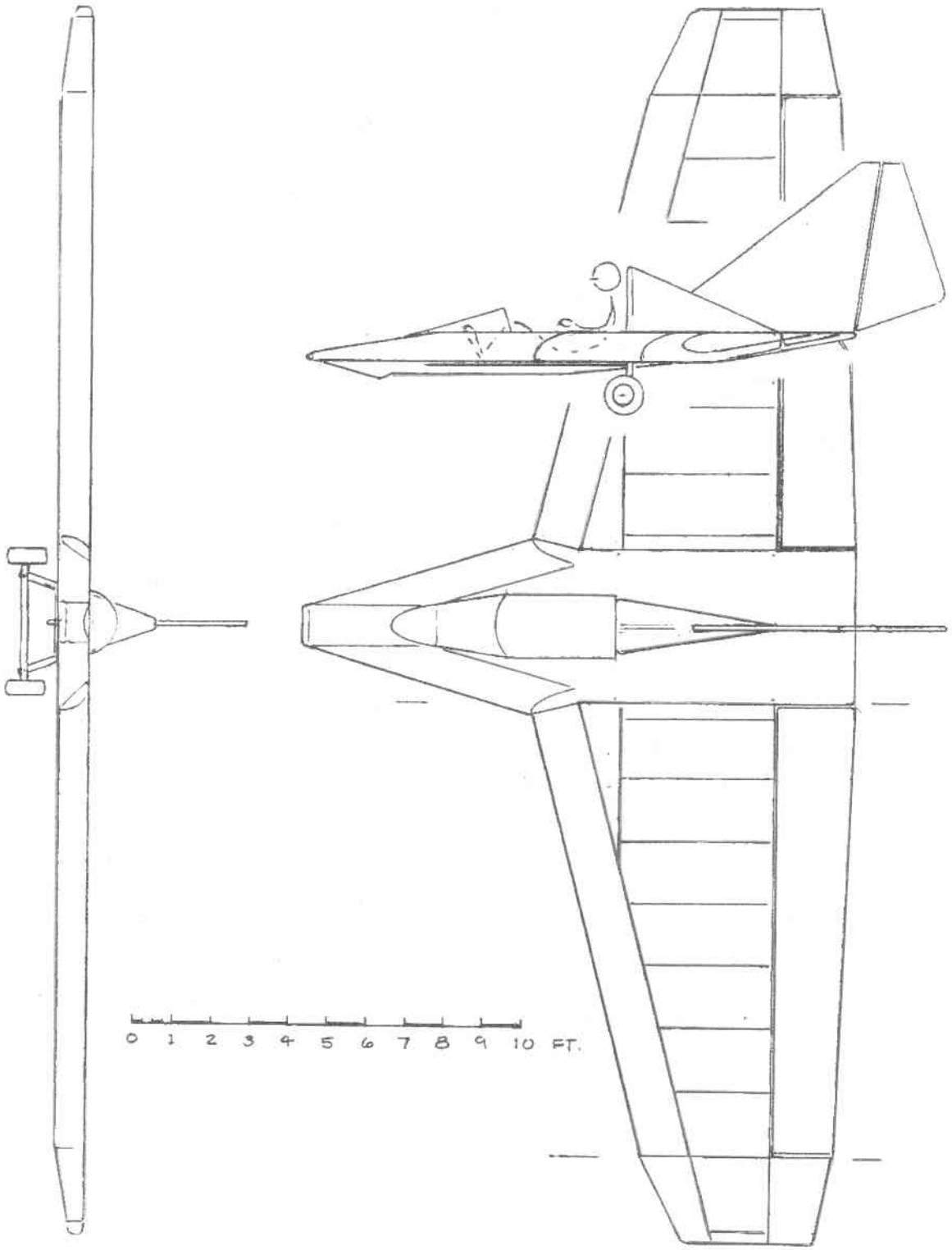


Figure 6.3
pmc-L15 Airfoil Surface Velocity
Theodorsen's Method





THE PRIMER WLK 1-16-96