No. 186 DECEMBER 2001

T.W.I.T.T. NEWSLETTER

Wing section sample built by Eric Raymond. This was done without molds. The dark Panel on the top surface is a solar cell unit. See more inside on this building technique.

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

HAPPY HOLIDAYS TO ONE AND ALL

The number after our name indicates the ending year and month of your current subscription. i.e., 0112 means this is your last issue unless

Next TWITT meeting: Saturday, January 19, 2002, 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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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).

TABLE OF CONTENTS

PRESIDENT'S CORNER

As you have seen by now the newsletter is put together a little differently this month. If yours got damaged during mailing I would like to know right away so I can make any necessary corrections to the publishing process.

The reason for the change was to improve the quality of the pictures by producing the newsletter directly through a copier electronically rather than making a copy of a master printout. In essence each newsletter is an original of the file I use to make a master. My ultimate goal is to create the electronic file in the previous 11 x 17 format since it will work with the printers equipment, but right now I an having formatting problems.

The second thing you may have seen by now is that the website could be down and you are not getting through by e-mail. The company supporting both items, Excite@Home, went into bankruptcy and the courts felt customer support was not as important at preserving assets for the creditors. So my cable company that provides the high-speed Internet connection will be taking over these functions, but I have no idea when this might occur. The transition could be only days or it could be several weeks. Once completed the website will have a different URL and the e-mail address will also be changed. After we are back up it will take time to get the new URL recognized by the many search engines out there, but I will let as many people as possible know of the changes via e-mail and the Nurflugel mailing list.

None of this will affect the newsletter publication since it is totally separate from the website.

If you can't find us, please give us a call at one of the numbers in the newsletter and we will give you the latest information.

Andy

JANUARY 19, 2002 PROGRAM

The program for January will feature Gary Fogel who will make a presentation on the Altostratus project featured in the November 2001 Soaring magazine. This was also a dream of John McMasters in the February 1981 Soaring magazine, but Gary has collaborated with Chris Silva to actually put a 1/5 scale (5m span) into the air. The model was constructed by Chris and his farther with Gary doing computer generated flight testing before he flew the model at a slope west of Tehachapi, California (below).

Photo from: http://www.geocities.com/altostratussailplane/

This should be a very good program as Gary tells us about constructing this high performance flying wing and some of the problems they encountered during their first flight.

So make sure to mark your new calendar now for January 17, 2002 so you don't miss this exciting program.

NOVEMBER 17, 2001 MEETING RECAP

Andy opened the meeting by telling the group about a recent e-mail he had received from Fernando Siarez in Buenos Aires, Argentina, who was going to provide us with English translations of Reimar Horten articles. These were published in the 1950's in Revista Nacional de Aeronautica (National Aeronautics Magazine) and he has received permission from them to recreate the articles in our newsletter and website. *(ed. – The first one from October 1953 is now on the website.)*

Pat Oliver provided a set of BKB-1 drawings he completed and will be used on the website to allow people to build their own version of this famous flying wing glider. *(ed. – These are now on the website for those of you with access. I am researching the best method for presenting these in the newsletter for those not electronically connected.)*

One of the group *(ed. – I am horrible with remembering names)* asked if anyone had information on Horten designs that could be applied to micro aircraft vehicles (MAVs). He is looking for measurements, performance data or any other type of data that would be useful in such a project and he would appreciate being contacted. Send a letter to TWITT and we will publish it. He is putting a paper together for presentation to DARPA on this subject.

Bill Hinote brought along a video tape of the N-9M flying at the Chino Planes of Fame museum.

With the end of the video, Andy introduced Eric Raymond, our speaker for the day. Eric's presentation was to include information on constructing light, moldless composite structures for the average homebuilder and an update on the current state of solar electric power for sailplanes.

Eric began with a slide show of some early flights he made around the world in hang gliders and then moved into his interest in flying wings. In the 1970's he and his friends were avidly interested in flying wings and each of them championed a different design philosophy. One preferred Lippisch, another Kasper *(ed. – assume his ultralight design)* and Eric always favored Horten. They built about 25 R/C models, but were finding it extremely hard to get any information and what was available seemed to be in decline. He was able to find some from the RAE in England and used documents from MSU on the Horten IV testing. This comprised all he had for over a decade. He did go to Argentina and spent a day with Reimar and looked over the existing gliders, but none were in flyable condition at the time. Eric has a large number of slides he took during that visit and has offered to come back sometime in the future and give us a show.

Eric went on to say his purpose today was to provide an alternative to mold type of construction. His two greatest earlier influences were Paul MacCready and Günter Rochelt who both believed in quick and dirty construction without ending up with big heavy molds that take a lot of time to build. If you have an idea and want to approach having a finish similar to those from molds, sandwich construction is one avenue. The horizontal stabilizer shown on the next page was built in two-days and is comprised of carbon spar cabs and urethane type surfboard foam wrapped around a white foam core. It is also a good example of how tight a radius can be achieved with this technique.

Eric went through a series of slides showing some of the earlier aircraft he built or that influenced the techniques he was about to describe. He noted when doing load testing, make sure to put the aircraft high enough above the floor to allow plenty of room for the wing tips to flex to maximum deflection. He recommends going several feet higher than you think you need. Also make sure to secure the weights in such a way that they won't move during the bending and cause loading problems that might result in unexpected damage.

Most of his construction is done with pre-preg carbon fiber cured in solar heated ovens. The pre-preg is used for spar caps and wet lay-up for the skins. He showed several different versions of ovens he has used over the years that could achieve temperatures of about 350 degrees F. from sunlight in the summer and about 250 degrees year-round. The ovens also include vacuum bags to tighten down the structure for proper bonding. Eric was asked about the type of foam that could take this level of heat and he commented it was Rohacell from Germany. Standard urethane foams can't take the heat and vacuum without deforming.

ABOVE: Eric showing the sandwich built horizontal stabilizer to Lyle Maxey.

The way he makes his spar caps is to take the pre-preg carbon tapes and lay them into an aluminum channel the same width and insert a square aluminum tube on top. The top tube is drilled out along its length to allow air and resin to escape. The aluminum expands when it heats up and re-tensions the carbon so you get very straight fibers. He had a couple of his caps professionally compression tested and achieved results in the range of 160,000 to 204,000 PSI which is about what the manufacturer claims. He related a story about accidentally wrapping the carbon around the ends of the channel and the aluminum expanding so much it snapped the fibers in tension during the curing process. They estimated it took between 6-8 tons of force to cause the failure, but it gives you a good idea of what kind of forces can be reached with this process.

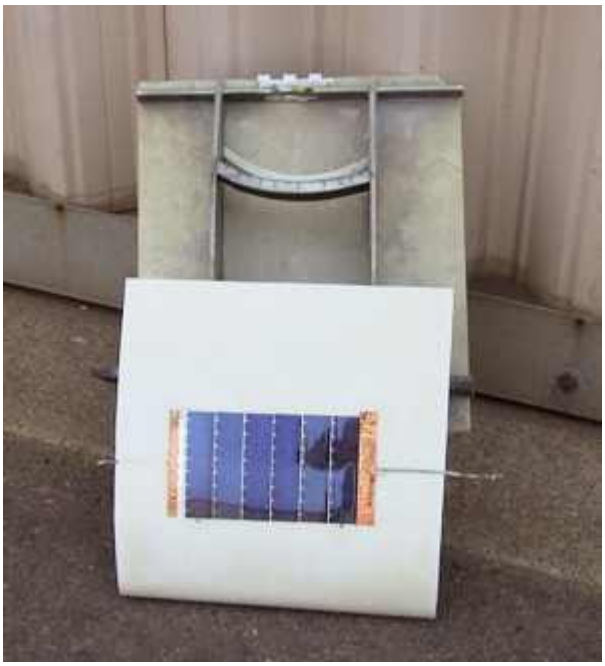
While showing slides on wing construction he commented that he wouldn't use plain foam ribs anymore since they have a tendency to fracture during rough handling of the wing. He now uses a sandwich of foam and a hybrid carbon-Kevlar fabric since when cut with a diamond band-saw that leaves a furry edge. This gives an incredible secondary bond on the wing skins.

The ribs are built by starting with a 1" thick sheet of foam and hot-wiring the airfoil section. He then explodes them out to where each rib should be along the span. He noted that some in his picture are not quite at the right angle but this can be taken care of by block sanding.

The construction table is covered with .001" mylar film similar to the type used in balloons. On the original SunSeeker he had used push rods with bell cranks for control of the flaps and ailerons, but he indicated he is not using this method anymore. He now builds the control surfaces with enough torsional stiffness to use direct drive at the wing root, even for the airbrakes. The ailerons on his new wing are 24' made out of high modulus carbon fiber.

The question was asked by Bill Hinote about whether the cloth fiber edges were being overlapped. Eric noted that while the fabric is dry you can spend as much time as you like aligning the fibers so they are sort of intertwined with each other between the pieces. You are then going to put on another layer in the opposite direction and create a sandwich between an outer and inner skin. This method will yield a strong structure without bumps due to cloth overlaps. Large overlaps would also cause problems when it was time to bend the sandwich around the leading edge. *(ed. - There is a little confusion here in that Eric is discussing some techniques that are both old and new and some that he no longer uses. So please try to read through the entire text to see if all your questions are answered by subsequent discussions.)*

The next picture showed the outer skin in a rolled up state ready to be applied over the rib structure and bent around the leading edge radius. This sheet is about 6' x 12' and will cover half the semi-span sort of like a sheet of aluminum. There is a tube mounted to the edge of the table in such a way that it can expand lengthwise as it is heated to about 250 degrees F. to allow the skin and Rohacell foam to bend around it to form the leading edge. During a discussion of how to get the inner skin layed up and bent around the leading edge, Gavin asked why the solar cells couldn't be added after the structure is complete. Eric commented that in the current project they are striving for a perfect laminar flow wing with the cells integrated in a high-temperature resin that is impervious to heat and weather. They are trying for a surface that is so smooth anyone running their hand over it would not detect any cells or wires.



ABOVE: Example of a wing section using the techniques described by Eric. The dark patch on the top surface is a single solar cell panel.

One of the things Eric does on all his designs is to build the control surfaces into the wing structure and then carefully cut them out for final build-out and re-installation. At first he was using a jig saw to make the cuts but has now found that a Makita diamond wheel circular saw is a fine tool for cutting a precise, thin line to separate the surface from the wing.

As mentioned earlier he has stopped building bell cranks for control surface activation. He has also gone away from using metal fasteners to attach hardware to the structure. He has gained a lot of faith in bonding metal to the structure so no holes have to be drilled through the glass and there is no risk of crushing the sandwich by over-tightening a fastener.

A question was asked about the aileron airfoil section shown in one of the pictures. Eric noted this was a Wortmann section modified for Gunther Rothel's manpowered airplane and wasn't intended for use in a control surface. Eric is still using this section because he likes its stall characteristics and the way it flies. With Bruce Carmichael's help the aft portion was flattened since they plan on spending long periods at high speeds and the reflexed surface had too much drag. He also had another motive related to the direct drive of the ailerons in that by taking out the reflex he gained area and additional torsional stiffness. He acknowledged that it is not the perfect airfoil since in high-speed flight the bottom surface is basically flat and while in slow speed flight the top surface is basically flat. Another question was asked about how much deflection there would be at the opposite end of this stiff aileron and Eric indicated he hadn't reached the point of testing that specific parameter yet.

The wing tips he is now constructing weigh in at only a pound and are formed by slowing vacuum bagging the skins over a Rohacell foam core. The foam has a tendency to crack during the process, but it wasn't really a problem since this was not a structural member. Once the inner skin was completed, then another layer of carbon was added to finish off the tip. They are of the clipped elliptic planform that came for the model airplanes of decades ago. Winglets are not practical since they can cast a shadow over parts of the solar cells and are also much harder to optimize. He noted that even the original champion of winglets, Burt Rutan, was now going to this new type of tip on his latest designs.

He did deviate from moldless construction in building the original fuselage. Because he didn't have room for a space frame structure he did a build-up of blue foam and shaped out the fuselage with a NACA 21% thick airfoil configuration at the recommendation of Bruce. One thing they did that shouldn't be done is remove the pieces from the mold before they are joined since they will never really fit together properly outside the rigid structure of the mold. They layed up the rear portion of the fuselage out of fiberglass since it would be the location for a vertical radio antenna and was ejectable for a ballistic parachute. The inside of the shell was Nomex honeycomb except in those areas where bulkheads or other hardware was to be attached. He has learned that bulkheads don't really need to be attached to the outer skin especially since it causes finish problems. So now he only goes to the inner skin for bulkhead attachments and hasn't had any problems.

The next series of slides covered construction of the bulkheads used for supporting the retractable landing gear. Although the bulkhead is made up of low density foam, any point where there will be loads a section of high density foam was inserted and extra carbon placed around it for support and strength. They try to achieve a 15 G load factor in this area. He also puts in a plastic tube to provide a bearing for the support rod as if rotates upon retraction. He also noted that carbon fabric is cut at a 45 degree angle to use for taping the bulkheads to the skins. Carbon is used to save weight over regular glass and the angle allows for easier forming around corners.

Eric moved on to the construction of the tail boom. This is initially layed up in pre-preg carbon over a tapered aluminum tube that used to be the top of a flagpole whose bottom section had been damaged in an accident. It has diameters of 3.5" to 7.5" and is available for use if anyone is interested. The next layer is pre-preg epoxy with over-expanded Nomex honeycomb, which is much better at curving around this shape than regular foam. The final layer is again carbon layed up in the opposite direction from the inner layer. The obvious question was how do you separate the aluminum mandrel from the composite structure. It turns out that as the aluminum cools down for the curing cycle is almost automatically releases itself from the composites. This is one of reasons Eric uses aluminum for all his tooling now since it breaks loose so easily on cool down.

Eric explained that he puts his control surface hinge points slightly behind the geometric hinge line so there will be some control extension above the wing surface on deflection. This gives a positive pressure recovery region that helps get the air over the hump and has proven to be better than more conventional hinging.

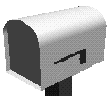
ABOVE: Bill Hinote, Gavin Slater, Bob Recks and Ed LaBahn talking with Eric during the program break.

He then showed a short series of slides that included the brushless electric motor components and the various pieces of mounting hardware that hold the motor in the tail and transmits the rotation to the folding propellers. The motor requires a lot of cooling so the brackets have many holes that he spent time filing into airfoil shapes to enhance the airflow. The electronics for controlling the motor were mounted under the pilot's seat in part to help keep him warm since it generates a lot of heat. Eric found it put out so much heat he began sweating to the point that the unit was grounding out to the carbon structure and giving him small electrical shocks. And with so much carbon, including the seat, there was no way to effectively get away from it short of shutting off the power.

The propeller turns at about 600 rpm and is centrifugally deployed. Bill Hinote asked if there were any problems with slap open against the stops that was of concern. Eric commented that it was and they had added high-density foam rubber blocks to take the opening loads. He also noted that the blades have quite a slap to them when closing, but so far he hasn't found any problems with the blades breaking. They had originally thought about a planetary drive but ended up settling for a system of gears, chains and belts that provides the "transmission" for driving the propeller. It has also turned out to be a little more adjustable.

The batteries for powered flight are rapid charge D-cell nicads mounted in a tube behind the leading edge of the wing. They cover almost the full span. Eric said the Germans are using sub-C cells since they are about half the weight and have almost the same amount of power. These have resulted from the powered hand tool market that has been trying to maximize the power and longevity of these batteries. There was a general discussion of various types of batteries, but it seems the nicads provide the best compromise between cost, weight and recharging cycles. Eric is trying to come up with a design that uses the cheapest solar cells and batteries so the aircraft is achievable for the average builder. One problem with nicads is that they can create a lot of heat and start a fire if they malfunction. So Eric is looking for some low temperature wire, around 200 degrees F., that could be run along the batteries and set off a cockpit light if the circuit were to open from an overheated battery. He hasn't found this type of wire yet, so if anyone knows of some he would appreciate a call.

At this point we took a short break so everyone could stretch their legs, have some coffee and snack on the donuts. When we got back together Eric showed some video about his flight school business in Hawaii using a Stemmi motorglider. The video then blended into some footage of his solar powered motorglider during testing and while doing the cross-country (US coast-to-coast) flight it was originally designed for. There was some general discussion during the video about various components of the SunSeeker and general performance capabilities. We then wrapped up, thanked Eric for an excellent presentation and headed for home.



LETTERS TO THE EDITOR

November 1, 2001

TWITT:

As I expressed via e-mail I'd like to join TWITT, enclosed are USD 60 – for 2 year membership. Some words about me and why I'm interested in TWITT.

I am 36 years old and work as an avionics technician in a governmental-owned company doing maintenance on Swiss Air Force jets. I'm an airplane modeler since 1979, having built a lot of electric powered semi-scale models, also some tailless designs as gliders. In 1991 I obtained my glider license, having flown about 350 hours so far. Other areas of interest are: aviation history; history in general; photography; reading; caravaning and; folding kayaks.

Why I'm interested in flying wings!! About 15 years ago I was offered a partly dismantled Fauvel AV-36, as I did not fly then I turned the offer down (stupid as I was), but soon afterwards I built my first tailless model, a Windfreak. After this some more unswept wings followed. When Peter Selinger's book Nurflugel hit the market, I got fascinated about the Horten wings, having built a 10 ft. Ho-III soon after. Also for some years now I dream about building a 1:4 scale Urubu. Last year I started to investigate what happened with the sole Horten that was in Switzerland in the 1950's. It's this specific Ho-XVc that draws all my interest for the moment.

The Ho-XVc was originally built in Germany as a glider by a Tuebinger Soaringclub, it was later sold to Mr. Walter Kirschsieper from Zurich, Switzerland. Mr. Kirschsieper modified it to a motorglider which got the immatriculation HB-SAA. Little is known whether it flew or not, finally the plane was scrapped in the 80's.

I hope to find some more information about the history of this aircraft, probably to find someone who was in touch with it or it's owner.

Yours,

Markus Christen
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(ed. – First, I would like to welcome Markus to TWITT and hope he enjoys his subscription to the newsletter over the coming years.

As for more on the Ho-XVc the only information we had were some plan drawings that ended up in the hands of Marc dePiolenc. Markus has indicated he contacted Marc and I would assume discussed the possibility of obtaining copies of what Marc has in storage. I have put Markus' request on the website to see if there are any others out there with information and, he has also placed an inquiry through the Nurflugel mailing list for the maximum level of exposure to the flying wing community.)

November 17, 2001

TWITT:

I am enclosing a bank check to cover my subscription for the year 2002.

I keep reading the TWITT Newsletter with extreme interest, although I have to contend with the TMB syndrome problems (Too Many Birthdays). Recently my wife Pia and myself celebrated our 50th anniversary of marriage, this is a whole life with aviation and flying objects of all kind.

Keep up with the good work.

Needless to say, we fully sympathize with the American people, hoping those responsible will be soon eliminated.

Best Regards,

Ferdinando Galé
Baveno Italy

(ed. – Thanks for the renew and we are glad you enjoy the newsletter. Congratulations on your anniversary. You were obviously lucky of find a life partner that allowed you to follow your passion.)

November 21, 2001

TWITT:

Thank you very much for printing my letter of October 20th in the November newsletter and, thank you also for your answer in that copy. I am quite happy that you published it. Hence all Horten interested readers of the newsletter are informed about my background. I am quite willing to answer any question concerning the Horten aircraft – as far as I am able to do so.

Just for the record: I do not have E-mail and I am not connected to the www. So connection has to be made by snail mail to:

Karl Nickel
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GERMANY
Tel – 0(1149)-761-40 31 59

You suggested that I should tell as much as I can about the Hortens via the newsletter. Unfortunately, I am afraid that this won't work. It is my long time experience that one can not anticipate the questions people might ask. Hence, I can not answer them beforehand. Very often I thought that something was "trivial" or "self explanatory" until I found out that even Horten enthusiasts really did not know it.

Let me give an example to this: Two years ago I have been asked why the Horten sailplane H IV had such large dive brakes. It is well known that it would have been disastrous to try a landing with them fully spread. A pull out was then impossible and the plane would have touched down with a too high sinking speed. I know quite well the answer to this from discussions with Reimar Horten. Until WW II it was the usual practice for pilots in a sailplane competition to enter as early as possible clouds in order to use the higher inside climb rates. Everybody knew that this could lead to dangerous flight conditions. Therefore, in the case of emergency, it was useful either to be able to start a stable spin with high sinking speed or – in case that your sailplane was spin-proof as all Horten gliders were – to have powerful air brakes. Those of the earlier Horten types, e.g., Horten H III, were too weak which in one case proved to be fatal (pilot Werner Blech in 1938). Therefore Reimar Horten inserted stronger ones from the H IV on. For me this fact was "common knowledge" and trivial. I never would have anticipated such a question.

As to your remark about photos, movie film and historical documents relating to the Horten aircraft, everything I possessed has been copied several times and has already been given to friends of the wing in Germany such that it will be protected for future historians. But this cannot be done with my personal memory.

Sincerely yours,

Karl Nickel

(ed. – Thank you for your letter. It will be interesting to see how many people will be taking you up on your offer to provide Horten related information that is not already part of the general public records. Please keep us informed on what you receive and how you answer it so we can share it with everyone.)

(ed. – On the October cover I included a picture of the LEA 23 project and offered a little more about it in my November column, but hadn't received detailed information from Thomas Bircher. Now we have his description of the project and its current status.)

November 25, 2001

TWITT:

Flight testing the LEA 23, first results.

1. Roll, Liftoff - On a beautiful evening in May the little airport at the village of "Bad-Ragaz" was made available to us, to have the biggest possible area for a first flight.
Everything looked good so we taxied it out to centerline. Taxiing is very simple and smooth with the steerable nosewheel.

ABOVE: LEA23 on takeoff roll. Good view of the wing planform.

Accelerating with the full power of the 29 cell Nicad 2400 Batteries, LEA took up speed fast, got un-steerable and broke of into the grass. Pulling on the stick did not change anything. Result:

A - The lever of the elevator was to short you could not rotate the aircraft, you just pushed the wheels into the ground.

B - The inertial mass of a wing-only type is so small that it starts to move quickly around the vertical axis, if it is allowed to do so.

Changes: Increase the angle of attack of the wing and use flaps down for take-off,

ABOVE: Another view showing the span and before the wing started achieving lift.

First Flight: May 23, 2000

In Thannhausen, Germany there is a very nice model flying club with their own runway(250 feet asphalt). Best place now for the first flight. Results:

A - It behaved as expected. For take off we had to use a second pilot "at the flaps" because with full power and flaps down a great pitch-up moment was expected and nobody was sure if it would be possible to counteract with elevator only.

B - The flight was rather uneventful and the landing took place right in the middle of the runway. It flies!!!.

2. Later Problems:

A - Structure: The carbon fiber joints between the inner and outer wing were too weak in stiffness, allowing vibrations off the outer wing panels.

B - The layout of the antenna and the nearness of the carbon parts caused a interruption of signals on approach, giving a crash landing (bank angle blanked out the antenna's reception). Finally in February 2001 the prototype was totally destroyed in trying to fly at 4,000 ft above sea level with floats attached. This caused a combination of too much additional drag, and bad contrasts in low sun conditions furthermore aggravated by the tendency of the model to turn very fast around the Z-Axis if rudder was applied.

3. Final conclusions:

A - Theoretically: On Track

B - Performance: None yet measured.

C - Decision: Build another prototype with some detail improvements.

D - Expected to fly: Summer 2002

Merry Christmas and Happy New Year to all TWITTers.

Thomas Bircher

(ed. – As you can see we have also included a few more pictures of the LEA-23 before the unfortunate crash. However, it seems the new version will have some additional changes to the outer wing panels for more control authority and, of course, a new layout for the radio antenna so the carbon structure won't interfere with reception.)

(ed. – In all the PELICAN material from last month Hugh Lorimer asked a question about using the Abrial airfoil. Serge Krauss provided some information on the airfoil through the Nurflugel mailing list and I am passing it along to those of you who do not subscribe.)

A question resurfaced recently (on this List and in the current TWITT Newsletter from Hugh Lorimer) regarding the Abrial wing section. To the best of my knowledge, Abrial was a French designer of tailless aircraft, whose designs dated from the late 1920's through post-WW II. He is said to have done pioneering experimental work in developing reflexed profiles. I would welcome any further information, since my files are pretty anemic on his work.

I am currently familiar only with four of the Abrial aircraft designs:

1) A trapezoidal (deltoid) low-wing, cabin pusher, with reflex and tip fins. Designated by A.R. Weyl as the "A-Viii light aeroplane of 1930", it was probably not built. A 3-View of this one, with a small wing section (profile apparently by Abrial) appeared in Aircraft Engineering, 4/45, p.111.

2) A trapezoidal, swept-back, low-wing, cabin pusher with reflexed airfoil (again presumably by Abrial) and tip fins: the "A.83". I only know of a wind-tunnel model and tests recorded in an article by Dufaure de LaJarte (6/35), translated as NACA TM 794, "Chief Characteristics and Advantages of Tailless Airplanes", in 5/36. The author characterizes this as a design "dating back to 1930."

3) The open "plank"-style A-12 "Bagoas" glider, which flew 6/25/32. An article in the 11/33 issue of L'Aerophile shows a 3-View and photo of this plane, with a small profile and polar of the Abrial #17 wing section. This section has a large reflex, apparently somewhere around 70% chord.

4) A post-WW II design for an enclosed, shoulder-wing "plank" type w/central fin. Called the A.13 "Buse", it was not built.

There was supposed to have been a 1931 "Rhon glider" too - configuration unknown to me.

With regard to the Abrial profiles, although Munk ("M-" sections, NACA, 1925) and Arnoux had experimented with reflexed sections and "plank"-type tailless aircraft respectively, La Jarte (TM 794 above) credits Abrial and Fauvel with pioneering reflexed airfoil work. Quote: "...the characteristic properties of doubly cambered profiles, or more exactly, those having a negative zero-lift moment coefficient Cmo [our present convention is to call this 'positive' - SK], were now at the disposition of inventors and engineers after the theoretical work of Von Mises [based on Jokowski theory - SK] and the experimental investigation of Abrial. Based on these more accurate data, a number of serious studies were undertaken in 1929-30 giving rise to a large number of patents, the most important being those of G. Abrial and Ch. Fauvel. The former has furnished a concrete basis for further study by constructing a sufficient number of excellent profiles with negative Cmo [see note above - SK] and utilized these profiles for the construction of a small touring airplane having all the advantages that could be derived from the tailless type principle." The author later remarks that such "auto-stable" sections had been used earlier, "long before detailed characteristics were known..." Considerable discussion and stability theory follow in TM 794, before wind tunnel results are discussed for the Abrial (briefly) and Fauvel designs.

I have not quite exhausted the possibly pertinent USPTO patent classes, but so far I have run across none of these Abrial patents in the U.S. system and do not know the dates of his early airfoil work. Of course, Arnoux may be irrelevant here, having used elevon stops to create his reflex, at least in his earliest attempts (through 1924?).

I think that the one conclusion to be drawn here is that the Abrial sections are archaic; there are a lot better newer sections. Even the NACA five-digit sections, like the 23012 and variants (dating to the 1930's), have been shown in the excellent performance of Jim Marske's "Pioneer" series sailplanes to be vastly superior to the Fauvel sections. Interestingly, the author of TM 794 also says, "Fauvel, who in his studies employed the data of Abrial on [such] profiles...".I do not know whether the post WW-II Abrial aircraft designs included suitably evolved sections. Does anyone else?? Jim Marske, by the way, seems to have found improved performance in the Fauvel type sections by slimming them down from 17% (the DeBreyer Abrial's thickness) in his computer simulations. I'm sure that like the Fauvel sections, Abrial's can be used to produce light aircraft, like the DeBreyer "Pelican", with good stability and handling characteristics, but that better performance would result from use of more refined sections, even if built slightly heavier due to thinning. When trying to fly on minimum power, this improved efficiency would be important and should predominate. Finally, modern materials can more than make up the weight difference.

Abrial's work was apparently respected by the aviation press of his time - especially in France. Without consulting my Bibliography, I can guess that there is more specific (quantitative) data on his sections in St. Cyr reports or the like. French patents cited in general in the Lajarte document might tell something. I would very much appreciate good Bibliographical data on any such research from European members of this list.

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