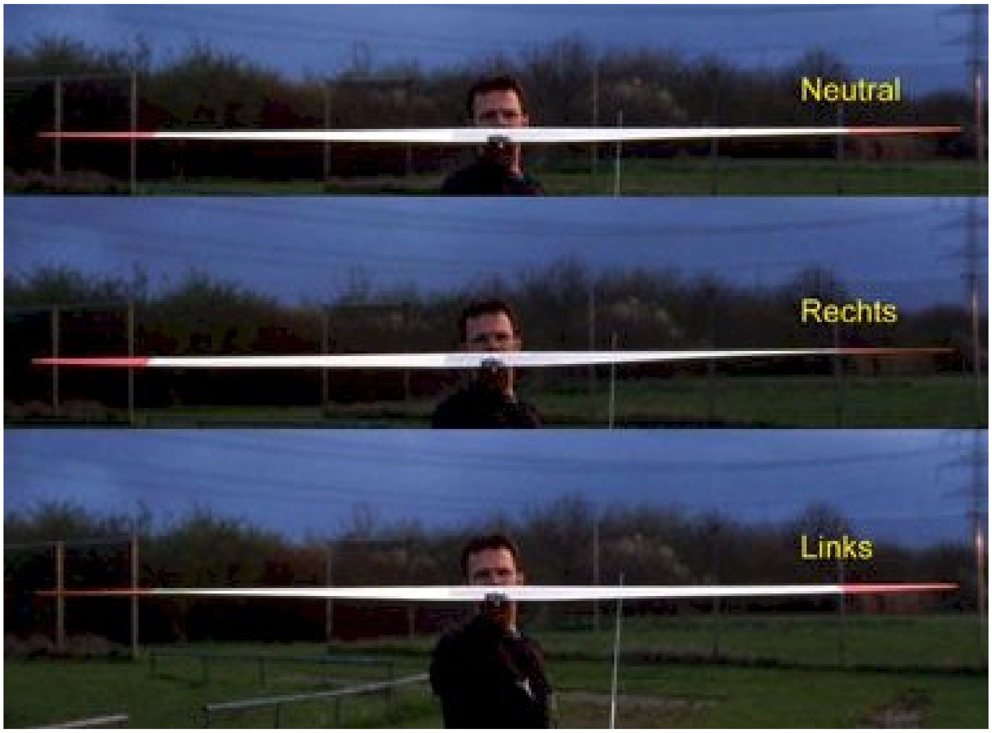
No. 297 MARCH 2011

T.W.I.T.T. NEWSLETTER



See the letter on this Horten like design on page 10.

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

The number after your name indicates the ending year and month of your current subscription, i.e., **1103** means this is your last issue unless renewed.

Next TWITT meeting: Saturday, March 19, 2011, 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).

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:

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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 or Skid Row for those flying in).

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PRESIDENT'S CORNER

THERE IS NO ON-SITE PROGRAM PLANNED FOR THE MARCH MEETING DAY.

I had almost forgot I was running the flying wing stalling phenomena paper written by A.R. Weyl so I have included Part III in this issue. This is the first time I haven't been able to find the exact or almost exact pictures or illustrations for an article like this off of the Internet. Therefore I had to substitute what I thought were acceptable alternatives to the originals. In one case I couldn't find anything that was even close although the I could have put in an ARUP picture to illustrate the design type for the Canova Rhomboidal Wing. It always amazes me how much you can find on the Internet so it surprised me that these images were not included somewhere.

I think there is an interesting mix of things this month so everyone should get something they like out of it. Not many letters for our members, but the Nurflugel group had some items that I thought were good and the piece from the Mitchell U-2 group has a link to what looks like a really nice model. I didn't have enough room to include a picture inside so I have included the one showing how the wing twist looks from the rear for the cover shot. This should give you a perspective when reading the entry on page 10. (Links = Left, Rechts = Right)

Please keep your letters coming since they are the lifeblood of the newsletter.

Andy

LETTERS TO THE EDITOR

February 21, 2011

I ran across what I think is a copy of a lecture by Dr. Lippisch on Wing Sections for Flying Models. I was wondering if this was a published work of his. Included was his business card and written on it was "to my dear friend Ray Orr". I also have pictures of a delta wing model with rocket motor and ducted fan. Would you know who would have any information on this? The caption with Dr. Lippisch states he is the Director of the Collins Aeronautical Research Laboratory and the ducted fan has Collins on the tail.

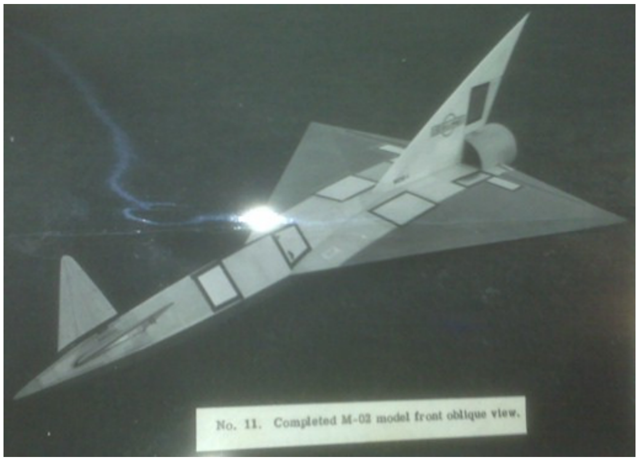
Thank you,

Larry Routson
<frogone69@hotmail.com>

(ed. – I replied with, "I am not familiar with the particular written account of this lecture so really can answer to whether it was ever formally published. Perhaps we have a copy of the paper in our archives, but I won't be able to get to them until Friday when I go the hanger again.

The same holds true for the pictures you mention and I don't ever recall seeing a Lippisch design with a ducted fan if that was what you were referring too. If it is another designer, perhaps you could e-mail me a copy of the pictures and I could include them in the March issue of our newsletter and see if anyone has more information. I will also mention the Lippisch paper to see what I can find out that way."

He then sent along the following photos, so if anyone out there can provide more information on the paper and these designs, we would like to hear from you.)


No. 11. Completed M-02 model front oblique view.


No. 35. Dr. Alexander Lippisch - Director of the Collins Aeronautical Research Laboratory.

February 5, 2011

Chuck Bixel sent along a PowerPoint presentation of vintage airplanes that has some really beautiful shots from an early AVRO to WWII fighters and bombers. I can't put any of the pictures in the newsletter, but if anyone would like a copy of the file (4.5 megs) I will be glad to forward it to you. Simply drop me an e-mail and I will attach it a reply message.

Nurflugel Bulletin Board Threads

I just came across this group and thought I'd give it a try.

I am a retired electrical engineer who spent the majority of his career in aerospace. I have been building model airplanes since I was a youth. Free Flight then U Control to RC back to U Control and now Electric RC.

I had always remembered a flying wing free flight I'd seen in an old "Air Trails" magazine. After much research and buying dozens of old Air Trails on E Bay I found it. It was in the Jan 1948 issue. "A Successful Flying Wing" by Bernard Gross. Because I have "Autocad" software in my computer I decided to "import" the design into it. It turned out to be a daunting task as the plans were sketchy and not very accurate. It will utilize electric power as the sound of internal combustion engines are discouraged on Long Island. After many months, almost a year, I started building it. It will have a 9 ft wingspan with a 30 degree sweep. It should weigh less than 4 lbs depending on the battery used. Refer to photo's

Bill Froeb
<wfroeb@optonline.net>

(ed. – The photos that Bill posted start in the right column.)

I am from Poland. I'm looking for plans for flying wings named " HAI-3 " and " Only Wing II ". Maybe someone has plans that are no longer needed and will want to help me? If so, please write to me off the list. My e-mail: mnazimek@op.onet.pl

Sincerely

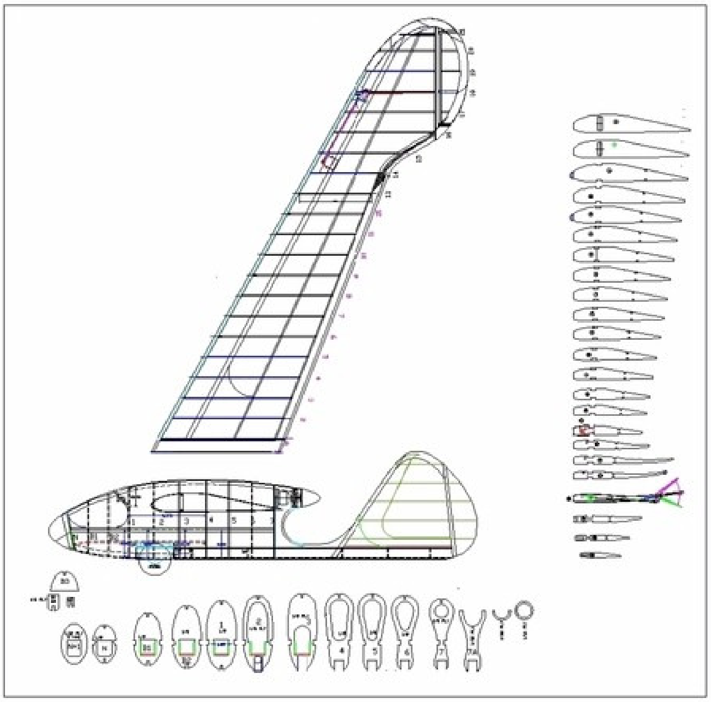
Martin

UCCESSFUL
ING WING

by BERNARD GROSS
Member A.M.A.

The well-designed high aspect ratio wing and smooth flowing lines of the pod give this ship a realistic climb and superb glide.

MODEL WHICH IS A CONSISTENT FLYER
ORATES SEVERAL INTERESTING FEATURES



AutoCAD recreation of original magazine plans

Fuselage being "Planked" When was the last time you planked a fuselage?

Right Wing Plugged Into Fuselage

Forgot if I asked if a version or mod to Flight Simulator had any Nurflugels in them. I figured an aficionado would have come up with some authentic controls etc.

Greg B.
<evolbaby@aol.com>

RealFlight has a HO-9 that can be down loaded from the share site.

Dennis
<Denoferth@aol.com>

There are a few models flying in x-plane. Horton's and Northrop. I don't know how accurate they are, but people are working them.

Butch Waymire
<bwaymire@charter.net>

There's also a Mitchell U-2 for X-plane that you can get from the files directory on the yahoo U-2 group

Norm Masters
<nmasters@acsol.net>

Combination Equation Motion of Airplane and Ship for WIG

I am new here. I am an undergraduate student from UTM Malaysia and am currently doing the WIG (wing in ground effect) craft longitudinal dynamic stability simulation but don't know the equation combination. I wish to ask for the reference paper or the example as the reference.

Thanks

Tan
<tys_1987@yahoo.com>

Very old fashioned, but you can still look in Dommasch Airplane Aerodynamics, seaplane section, for a rough introduction to mixed water/wing effects

I believe any text with seaplane aerodynamics will give you good mechanics. Search the NASA NTRS online archive too. There are other people in the list who have more experience with Ekranoplans (WIG). I hope some of them will give you some directions

Marco
<mrk@karenfuxia.com>

Try :

http://www.se-technology.com/wig/html/main.php?open=eages

There is a Russian program that does everything, but I don't remember the name sorry...

Matthieu Scherrer
<matthieu.scherrer@free.fr>

I believe it was AutoWing.

http://www.se-technology.com/autowing/

Russian Ekranoplane

Rick Page
<rick-page@shaw.ca>

On another list we were talking about a flying plank concept. I proposed the use of the steering system of the Horten Hxb as it is 3 times less sensitive to pitch as to roll.

Did somebody else use this system recently? If yes, what is the angle you used? About 70° like I mentioned in my old website?

Greetz,

Koen
<salsa_dancer@live.be>

X-47B Flies

http://www.theblaze.com/stories/navys-first-unmanned-stealth-bomber-completes-29-minute-test-flight/

Bob Storck
<bstorck@sprynet.com >

So does that just have one single jet engine in the center?

Doug Holverson
<dholverson@cox.net>

Note thought it is the X-47B. Single engine design on the centerline.

Mark
<nankivil@covad.net>

Right on both accounts. My error on the model.

Note that all the really successful VTOL jets use one engine.

Cheers,

Bob Storck

AeroVironment Nano-Hummingbird

Incredibly realistic tailless ornithopter spy drone.

http://www.huffingtonpost.com/2011/02/18/nano-hummingbird-spy-drone_n_825248.html

Bill & Bunny Kuhlman
<bsquared@centurytel.net>

Dr. Joachim Kuettner died Thursday evening. He was 101. He was the first sailplane pilot to make a high altitude wave flight. In 1938 he soared to 22,400 ft msl. Without oxygen (!). He was one of the leaders of the Sierra Wave Project, and was a leader of NCAR...

Al Bowers
<Albion.H.Bowers@nasa.gov>

Thanks for letting me know ... and for remembering.

I hope he gets a big mention in SOARING, which has often abdicated their
role in keeping our heritage alive.

Cheers,

Bob Storck
<bstorck@sprynet.com>

(ed. – For more information on Dr. Kuettner you can click on the link below.

https://www.archives.ucar.edu/exhibits/kuettner)

THE AEROPLANE MAY 9, 1947

AERONAUTICAL ENGINEERING

Stalling Phenomena and the Tailless Aeroplane III

By A. R. Weyl,: A.F.R.Ac.S,

For any plan shape of a wing, an elliptical lift grading over the span may be achieved by means of wing twist or by appropriate variation of the aerofoil section along the span. In such cases, however, the lift grading will remain strictly elliptical only for one particular incidence. For the condition of simultaneous stall, this incidence should be identical with that of maximum lift. At incidences other than that for which the lift grading is elliptical, there will be an increase in the induced drag although, in practice, these differences are not great. A more serious factor, especially for tailless wing systems, is that all wings with twist or section variation give lower values for the maximum-lift coefficient than the local section lifts would allow. More serious still is the fact that, in practice; the current design methods for such wing systems fail to take into account the mutual interaction of neighboring span-wise sections with different incidence (due to the twist), and with variations of the aerofoil sections.

At incidences sufficiently below the stall, these influences due to twist or aerofoil section shape, express themselves only in increases of the wing profile drag (wing interference drag) and in decreases of the slope of the lift curve (dCL/dą). The interaction most probably forms one of the causes for curvatures of the lift curve at low incidences observed on composite wing systems composed of aerofoil sections which otherwise show a strictly linear dependence of the lift on the incidence.

At the stall, the interaction effects along the span tend to be aggravated. They greatly contribute to premature stall, and hence give cause for the origin of the incipient stall.

A similar form of span-wise interference between neighboring regions of the span is caused by the direction, which trailing and leading edges of the wing assume to the direction of flight. This interference differs from the first form of interaction in that it may be detrimental or beneficial. The first form is, as far as, experienced, always harmful.

In spite of the failure of present theory to consider the effect of mutual interference between neighboring span-wise regions, the results of the elaborated " strip " theory are nevertheless valuable as a guide for the designer.

Shih Chang Zien investigated in a thesis (Ref. 8) the possibilities for an elliptical lift grading on trapezoidal wing shapes under the condition that the stall should originate at the centre (root) of the wing. The analysis was based on R. Fuchs's trigonometric solution of Prandtl's integral equation for the circulation along the span. Zien found that the condition for elliptic lift grading (for incidences representing high-speed flight) and for stall inception at the root, could be satisfied for taper ratios up to 3 either by twist, or by section variation, or by a combination of both.

TWIN PUSHER—(Above) An early Northrop all-wing design was this little N1M single-seater of 1940, which had a span of 38.5 ft. and supplied valuable data for the XB-35 program. Power plants were two 65 h.p. Lycomings, later replaced by two 120 h.p. Franklin engines.

PUSH AND PULL—{Below) Unlike Its prototype, the "Hermann Kohl." which had a triangular wing, the Lippisch Fieseler F.3 "Wespe" of 1932 had a trapezoidal-shape wing. Power plants were two 75 h.p. Pobjoy engines. Slotted control flaps were along the entire trailing edge.

For taper ratios exceeding a value of 3, an elliptical lift distribution was found to be possible only by variation of the aerofoil-section shape (cambered aerofoil sections at the wing-tips), or by a combination of section variation with twist; even in this case, the effectiveness of flap-type controllers at the wing-tips would be impaired. The expedient of cambered aerofoil sections at the wing-tips for the purpose of enforcing a root or mid-span stall with efficient lift grading at small incidences will be considered more fully later.

The interrelation between undisturbed flow and fully separated flow at neighboring strips of the span has a very important bearing on the inception and the progress of the stall along the span. An investigation by P. Jordan (Ref. 9) has greatly contributed to the information on this subject.

According to the vortex-line theory of lift, the occurrence of high lift and low lift at adjoining strips of the span must necessarily have an effect on the three-dimensional flow pattern, since lift is the result of pressure differences at the aerofoil. Hence adjoining regions of high lift (unstalled wing strip) and low lift (stalled wing strip) must modify the induced incidence of the strips. Moreover, when "dead-air" regions adjoin regions over which high negative pressures (lift) exist, span-wise flow components result, which will influence flows that are of an unstable nature. In general, the boundary between strips of smooth flow and those with disturbed flow will travel along the span when the incidence is increased. The rate of this travel and its uniformity are, as pointed out above, of great importance in connection with the character of the incipient stall.

Jordan's tests have established that the differences caused in the induced incidences across such a boundary between stalled and unstalled span-wise regions, are quantitatively of less importance than the span-wise flow.

Moreover, Jordan found, from water-channel tests at effective Reynolds Numbers of 0.15 x 10^6, that a transition vortex occurs near the leading edge, at the incidence of maximum lift when the laminar boundary layer breaks down into the turbulent state, and that this vortex exerted a major influence on the phenomena of the front stall. He observed that a widening of the vortex under the intake of more stale boundary-layer material, gave rise to the separation of a laminar boundary layer.

This separation is, as already mentioned, not a steady phenomenon: the transition vortex is periodically expanding and contracting, due to the quantity of boundary-layer material rotating in it. Consequently, at a certain constant incidence of the wing, regular changes between smooth flow and flow separation occur at the same strip of the span. This shows how misleading it is to rely on the interpretation of steady force measurements, as far as stalling phenomena are concerned.

When the particular incidence of separation instability was slightly increased (by an amount of only 0.25 degrees in Jordan's tests), a change from the slow periodic fluctuation in the flow pattern to a rather fast and less defined one, was observed. Beyond this incidence, the burbling flow of the separated boundary layer became predominant, and at still larger incidences it persisted.

There is, then, an incidence range of complete instability of the flow pattern at the stall, where periodic fluctuations govern the resulting aerodynamic forces and moment of a wing system. For reasons of safety, the designer of tailless aeroplanes should take care to decrease or to abolish this critical range of stalling incidences, since it does not permit stability or a continuation of a steady flight path.

Jordan's observation would also provide an explanation for the existence of secondary lift maxima (double peaks in the lift velocity was observed to occur not at the wing but behind the curve) to which W. S. Farren referred at an earlier date (Ref. 10). Such secondary lift maxima (which sometimes even exceed in value the fist and true lift maximum) have also been observed to occur when a wing was swept back by 30 degrees, keeping the same aspect ratio, aerofoil section and wing twist (Ref. 71).

Secondary lift maxima attained beyond the critical wing incidence, may reach higher values than the steady primary lift maximum. The reason for this lies in their unstable nature: at the instant when the expanding transition vortex extends over the entire chord, it transforms the aerofoil section to virtually one of greater camber, in its effect on the outer potential flow. Higher negative-pressure peaks follow, hence greater lift. But this lift disappears as quickly as it has been formed, leaving only the effect of greater strain on the wing structure.

Application of these observations on the mechanics of laminar boundary-layer separation (" front " stall Form " A ") to the problem of the span-wise spreading of the stall indicates that the periodical stalling and unstalling of a wing strip will cause flow impulses over neighboring regions of the span. First of all, negative pressure will be exchanged, i.e., equalized, in a span-wise direction, when lift peaks are being reached over the critical region of the span. This will transfer stale boundary-layer material into the transition vortex which subsequently further expands and causes front separation (deep stall), with breakdown of the circulation. The same will happen when tired boundary-layer material assumes transverse flow at chord stations nearer to the trailing-edge where the boundary layer is already turbulent. But there it will only thicken the turbulent boundary layer and promote a gradual "rear," or shallow, stall. Since the pressure differences are smaller in this chord region, the rear separation is bound to be more gradual and not quite as unsteady.

From this, seemingly, the "rear" stall should give a smaller rate of travel in span-wise spreading than the "front" stall originated by the transition vortex. It might also provide some explanation of the fact that wing twist generally tends to result in a more gradual spreading of the stall over 'the span, quite distinct from the effect of the incidence difference.

Experimental investigations of the interaction between smooth flow and flow with separation, were also made by W. Fabricius (Ref. 11), another collaborator of the Gottingen circle. The Reynolds Number of these tests was fairly low, at about 0.3 x 10^6. The investigations were made on a rectangular wing with end discs and with a narrow centre-section, which had 7 degrees more incidence than the rest of the span, so that the stall became incipient at this narrow-chord centre section. There was, as a result, a definite boundary region between an unstalled wing strip adjoining the centre section and the stalled centre section, which lent itself well to the specific observation of interaction phenomena.

Within the boundary between stalled flow and smooth flow, the absence of backward flow in the boundary layer (the first indication of the inception of boundary-layer separation from the surface) was noted as evidence that no flow separation occurred in this critical strip of the span. The thickness of the boundary layer in it, however, was greatly increased. The development of flow patterns was found to depend largely on the shape of the aerofoil section. This is in agreement with N.A.C.A. experiments, which proved how greatly the rate of span-wise spreading of the stall is influenced by the aerofoil section.

Thickening of the Boundary Layer

The enormous thickening of the boundary layer in the region intermediate between a stalled and an unstalled strip of the wing is caused by transverse flow components which deposit stale fluid particles in this region. As a consequence, the circulation over the critical region of the span is decreased, and the lift approximates to that of the stalled wing region. The boundary layer, even near the trailing edge at the critical span region, however, exhibits no backwards flow. Within this boundary layer, a flow component directed inward towards the stalled centre section was found, while, near the leading edge, the flow was towards the tips. The maximum transverse-flow velocity was observed to occur not at the wing but behind the trailing edge. There, flow persisted from the under-surface of the critical region to the upper-surface of the stalled centre.

Such oblique flow around the trailing edge would seem of importance, by reason of the consequences of partial stall on a tailless aeroplane. It will affect the action of reflexed camber on the stability in pitch, and also the effectiveness of controllers mounted with a slot behind portions of the wing, which are adjacent to parts of the wing likely to stall first.

The oblique flow velocities around the trailing edge reach, according to Fabricius, values which are higher than that of the undisturbed outer air flow. It is thus conceivable that trim changes observed with " stable " aerofoil sections near the incipient stall are connected with this phenomenon. The rate at which the stall spreads over the span depends on the various factors mentioned above. Of these, the aerofoil section shape (and its variation along the span) appears to be dominant.

Full-scale wind-tunnel tests made by H. J. Goetz and W. K. Bullivant (Ref. 12) seem to shed some light on this part of the problem (see Fig. 5, p. 478, May 9 issue). The tests were made on rectangular aerofoils, slightly rounded at the tips, with no twist and with symmetrical sections of different thickness.

The wing with the 9 per cent. thick section had the stall spread over practically the entire span within an incidence range of only 1.6 degrees exceeding that of maximum lift. For the 12 per cent. thick wing, the span-wise spreading extended to an incidence range of more than 2.5 degrees measured from the maximum lift angle. A rear break-away of the flow was, however, already beginning at the trailing edge in the centre of the wing. The 18 per cent. thick wing developed the stall within an incidence range of not less than 9 degrees. The lift curves shown clearly exhibit the difference between stall form " B " (abrupt, turbulent front stall) and form "C" (gentle, turbulent rear stall). In the latter case, the pilot will obviously have ample warning of the incipient stall. In addition, the lift-loss at and beyond the incipient stall is least with the thickest wing.

For the latter, an initial breakaway preceded the incidence of maximum lift to a greater extent than for the thinner ones. Thus the range of incidence between the incipient flow separation at the wing and the complete stall was actually about 12 degrees. This phenomenon, incidentally, indicates that the common conception of a " critical incidence" needs a revision. Usually, the critical incidence is associated with the occurrence of maximum lift, and it is at the same time tacitly assumed that when this incidence is exceeded, the stall is incipient. Actually, stalling phenomena may set in long before the maximum-lift angle is reached, and this angle becomes "critical" only in so far as, beyond it, the lift becomes smaller.

With conventional, aeroplanes, this differentiation between maximum lift and separation inception is hardly, if ever, noticed in flight. But, with tailless aeroplanes, it may become worth consideration for investigation in flight. It also may have a bearing on the ability to reach the incidence of maximum lift in flight.

(ed. – The image for this was not of copy quality and a replacement version could not be found on the Internet.)
AERODYNAMIC DINNER-PLATE—This is the Canova Rhomboidal Wing, built and flown in Italy during 1935. The pilot sat on a skid slung under the wing, which had a fin and rudder attached to the upper surface; elevators and ailerons were provided. The aspect ratio was about 2. Stability longitudinally was satisfactory but laterally was deficient.

Another result from the N.A.C.A. full-scale tests is that the 18 per cent. thick aerofoil exhibited no " hysteresis loop " in the lift curve, i.e., no double lift values for the same incidence in the stalling region. How far this really means that there is no critical range of incidences with periodically fluctuating lift at fixed incidences is difficult to judge. Obviously, however, if this is so, then there is no extended incidence range with gross instability in the flow pattern; i.e. one and the same lift value is associated with an incidence value, regardless if this incidence' is reached from a higher one or from a lower one. Seemingly, on this aer6foil, the smooth flow pattern is more readily reestablished than on the thinner aerofoils. Perhaps this is a result of the greater tendency of the boundary layer to become turbulent.

Stalling observations made by M. Kohler at Göttingen (Ref. 13) with a rectangular wing of Göttingen 420 section at effective Reynolds Numbers of 0.22 x 10^6, gave an incidence range of about 5 degrees for the span-wise spreading of the stall, with a typical "rear" stall. From the maximum value of 1.35 at 15 degrees incidence, the lift coefficient dropped to about half this (0.72) at an incidence of 35 degrees. Beyond this, it decreased slowly to smaller values, without an apparent discontinuity. The span-wise lift grading of this aerofoil had at maximum lift already assumed a saddle-like shape (incipient root stall). The depth of this central saddle deepened with increasing incidence, but became less marked when the stall spread along the span; yet it was still noticeable in the lift distribution curve when the incidence grew to a value of 30 degrees. This would indicate that the stall at the wing centre was deeper, i.e., more extensive in a chord-wise direction, than farther outboard.

The influence of the Reynolds Number on stalling phenomena is quite marked. Pressure-distribution measurements made by the N.A.C.A. by R. M. Pinkerton (Ref. 1) on a N.A.C.A. 4412 aerofoil proved that the shape of the chord-wise loading varies greatly with the Reynolds Number at incidences at which stalling phenomena occur. At greater Reynolds Numbers, for example, about 1.9 x 10^6, the shape of the chord-wise pressure distribution curve retains, beyond the stall, some similarity with that at sub-critical incidences. This being so, at the complete stall, apparently, the longitudinal trim of a tailless aeroplane need not be gravely upset, while model tests at low Reynolds Numbers tend to indicate a different behavior.

However, beyond the stall, the flow loses, as mentioned, its steady character. No uniform flow pattern and lift may thus be expected, and it would seem precipitate to arrive at such conclusions on the basis of pressure-distribution tests. On the other hand, experience has shown that tailless aeroplanes may be flown and controlled when completely stalled. G. T. R. Hill has reached with one of his earlier Pterodactyls, controlled flight at an incidence of 45 degrees, and there were reports of Lippisch indicating similar experiences.

Characteristics of the Plan Shape of the Wing

With tailless aeroplanes in the flying-plank category, i.e., without any aerodynamic sweep, the problem of the incipient stall is most easily understood. In this case, taper of the wing in chord will exert the greatest influence.

With symmetrical taper, the stall would tend to set in at the tips and spread from there over the span. The higher the taper ratio (root chord/tip chord), the more pronounced the tendency to tip stall will be. A triangular wing plan should, in theory, be the worst, as the tip will be stalled at all incidences. This quality, however, is greatly modified by the aspect ratio of the wing, when it is small. Small-aspect ratio wings, therefore, do not obey the general rule given above, and will be discussed later.

In the case of a rectangular plan form, the stall sets in near the wing root and spreads from there to the tips (Ref. 5). This quality of the plain, rectangular wing may be seen as the result of the pressure-equalizing flow around the wing tips (wing-tip vortices), which promotes an inward-directed flow component along the upper wing surface. In the region of the tips, this flow component adds energetic flow material to the boundary layer near the tips, and hence delays flow-separation in that region. As a consequence, stalling will set in first near the wing root, towards which stale boundary layer material is directed along the span. The root stall of the rectangular wing is therefore the immediate outcome of the higher induced drag (as compared with an elliptic aerofoil). Theoretically, it is the greater effective incidence of the classic aerofoil theory, which makes the wing stall at the centre, first.

When controllers are located near the wing tip and at the wing root, as often found practical with tailless aeroplanes in the flying-plank category, a desirable feature would be to have the stall beginning half-way between wing root and wing tip, with the tip stalling simultaneously with the wing root. 'Wash-out will remedy the premature stall of the wing tips; the application of cambered win tip sections would, however, seem preferable to neutralize le effect of moderate taper.

As already pointed out, the main, though not the only, reason for the different behavior of rectangular wings and metrically tapered wings is the existence of span-wise flow components, which affect the boundary layer. With the tapered planform, it is the sweepback of the leading-edge which gives cause to a flow-deflection towards the tips on the upper wing surface. Near the tips, the tip vortices counteract this flow movement with the result that de-energized boundary layer material accumulates in this region. The boundary layer, therefore, thickens and is liable to separate from the wing surface. To a certain extent, sweep-forward of the trailing-edge is neutralizing the effect of the swept-back leading-edge. A tapered wing with a straight leading-edge and a swept-forward trailing-edge is less likely to exhibit tip stall.

H.A. Soulé and R. F. Anderson have worked out design charts relating to the stall of unswept tapered wing systems (Ref. 14). These charts, however, take into account only the point along the span at which flow separation will occur first when the incidence of the wing is slowly increased. It has been rightly argued that the charts are inconclusive, since they fail to consider the rate at which the stall is spreading along the span and the loss of lift associated with it (shallow or deep stall). Both factors determine the rate of wing dropping for a conventional aeroplane. With a tailless aeroplane, they are even more important, since longitudinal stability and control are also affected.

Nevertheless, the N.A.C.A. charts are of some value as they permit of a quantitative comparison of the influence exerted by the various design factors, for unswept tapered wings with aerofoils of the N.A.C.A. 230 class, upon the span-wise origin of the stall. The charts also include the remedy of tip stall by the incorporation of various devices. These will be referred to later when discussing swept wing systems.

Clearly, wing taper is the predominant characteristic. Quite apart from the effect of leading- and trailing-edge sweep which impress span-wise flow components upon the boundary layer, taper directly affects the lift-grading over the span at the incidence of maximum lift by its influence on the local aerofoil thickness and on the local Reynolds Number. Since the minimum flying speeds, and hence the landing speeds, are confined to practical limits, the Reynolds Numbers near the wing tips tend to decrease the values of the maximum section lifts in that region when the taper increases.

FIRST WAR-TIME HORTEN (Above)—We gather, from German test-flight reports, that this Horten IV tailless sailplane had fair handling characteristics, but the main drawback was over-sensitivity in the controls and insufficient directional control. A small number of Horten IVs were built, and many hours flown in them — conclusions drawn being that the type was not suitable for inexperienced pilots. A later version, with a laminar-flow wing, was designated the Horten IVb.

For wings having thin aerofoil sections at the root, the maximum section lifts tend to decrease from root to tip. The reverse is the case when the root sections are thick. This is valid for all taper ratios, including those commonly found in sailplanes. Root thicknesses exceeding 15 per cent. of the local chord cause the origin of the stall to move inwards, except when the Reynolds Number is below 4 x 10^6. Aerodynamically and structurally, the flying-plank type would seem superior to all tailless systems, which rely on effective sweep. An elliptic lift-grading over the span, i.e., minimum induced drag, can be achieved for lift coefficients of practical flight. Structurally, taper would allow the bending moment to be kept low; the torsional load on the wing structure may be reduced to a minimum.

Charles Fauvel, who preferred the triangular wing shape, seems to have retained control in pitch by locating the elevator flaps in the wing root, and the rather long ailerons had their greatest chord inboards. Theoretically, the tips of a pointed wing should be always stalled. The flying qualities of the Fauvel tailless have, however, not given the French authorities the impression that the behavior was unsatisfactory when the stall was approached.

(To be continued)

Mitchell U-2 Group Item

I found the link to a discussion of some experiments with flying wing models which have no moveable surfaces. Control was maintained solely by twisting the surfaces.

The link is http://das-nurfluegelteam.de/ Click on "Steuerung durch Flächentorsion" {Control by twisting surfaces) It is in German, but the pictures alone are interesting.

The article is based on three powered glider models that were built and flown.

Here's a translation of the summary:

"An all-wing aircraft built on Horten principles can be controlled essentially without separate control surfaces, simply by twisting the flying surfaces. This method provided the tested models with a good pitch control, but a barely adequate roll control. With "torsion" control, the contradiction between the need for construction that is twistable and yet stiff and strong in bending. It is not easy to find an optimum between a too weak (FlexNF1) and a too torsion-resistant (FlexNF2) structure. From this it is clear that the control method would not permit a heavily loadable and very maneuverable stunt-type sailplane. Nevertheless, it could be quite applicable for light thermaling flying wings. The control method described is applicable to flexibly-covered rib-type construction as well as balsa-planked foam surfaces. The torque tube, necessary in any case, should be very stiff, and could serve double duty as a wing spar."

Dave G.
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Coming Soon: Tailless Aircraft Bibliography
Edition 1-g

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

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

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VHS tape of Al Bowers' September 19, 1998 presentation on "The Horten H X Series: Ultra Light Flying Wing Sailplanes." The package includes Al's 20 pages of slides so you won't have to squint at the TV screen trying to read what he is explaining. This was an excellent presentation covering Horten history and an analysis of bell and elliptical lift distributions.
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VHS tape of July 15, 2000 presentation by Stefanie Brochocki on the design history of the BKB-1 (Brochocki,Kasper,Bodek) as related by her father Stefan.

The second part of this program was conducted by Henry Jex on the design and flights of the radio controlled Quetzalcoatlus northropi (pterodactyl) used in the Smithsonian IMAX film. This was an Aerovironment project led by Dr. Paul MacCready.
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