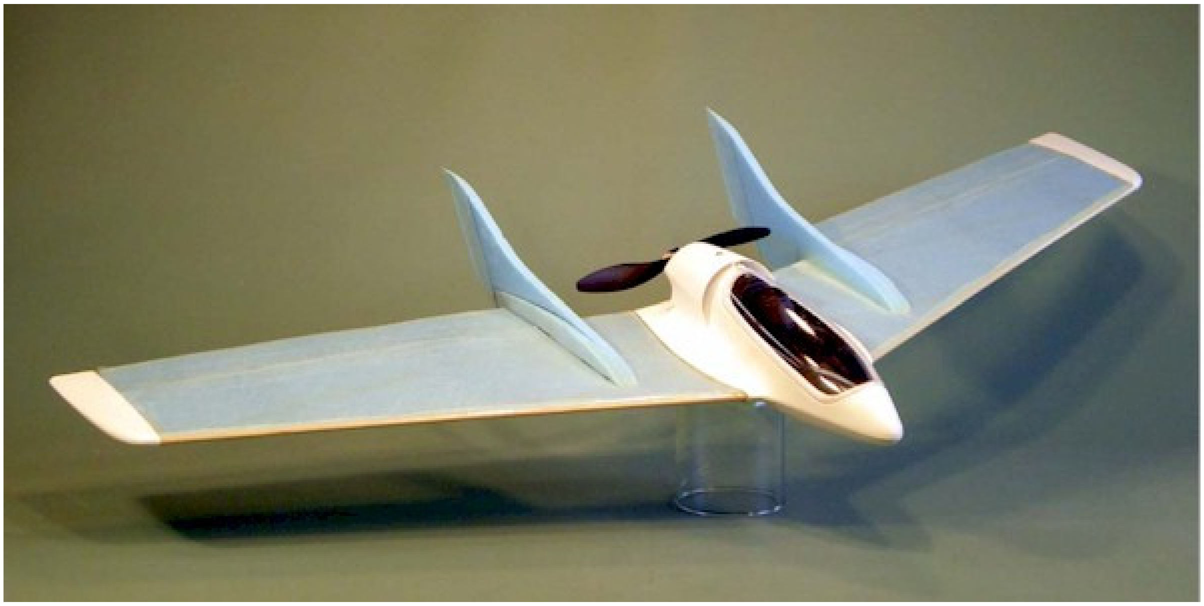
No. 298 APRIL 2011

T.W.I.T.T. NEWSLETTER



This looks like a really clean electric powered model that we haven't seen before. Check out the web site to see if this is something you would be interested in building.

http://www.rcgroups.com/forums/attachment.php?attachmentid=2556628

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., **1104** means this is your last issue unless renewed.

Next TWITT meeting: Saturday, May 21, 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.

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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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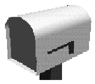
PRESIDENT'S CORNER

There is some interesting material in this issue so I hope you enjoy the mix of different interests. I have also included Part IV of the A.R. Weyl article on the Stalling Phenomenon of Tailless Airplanes. I do want to note that the XB-35 and Westland images included with the article are not the ones published in the original paper but are good substitutes. I found it strange that the actual images were not available off the Internet since they are fairly common ones that have been used in other papers over the years.

I am pleased to report that we have some new members and I appreciate that fact that everyone is renewing their subscription each year. This helps keep me motivated to produce an issue each month knowing that everyone is enjoying the material.

Speaking of material, I could sure use some project reports and pictures to share with the other members. There are only three more parts to the Weyl paper so I will have to find more of this type of material in our archives to fill the space. While this is interesting stuff it is not always up to speed with current technology that is more in line with what people really want to use in building their favorite project. So please contribute if you can.

Andy



LETTERS TO THE EDITOR

March 9, 2011

(ed. – This message was directed to Chuck Bixel about his paper on Flat Airfoil Flight Characteristics with TWITT as a cc: addressee.)

I have just read your paper on the subject and find it extremely interesting. I have recently at age 79 1/2 started building and flying conventional radio controlled models (fixed wing) and being an inquisitive type looked into what the conventional wisdom (of my earlier days) was on why "airfoils" work.

I read an online paper from NASA, which shed some light on the subject but as I recall did not even mention "flat" airfoils.

Your description of the experts response as to why paper airplanes fly as they do did nothing to increase my confidence that experts are NOT always right.

You mentioned that in your earlier training you were not encouraged to use flat air foils. Could that be a remnant of the "ancient" insistence that Bernoulli had the answer?

My question (finally) is, what do you think exactly is the design rationale (or aerodynamic advantage) for using a pronounced under cambered or flat bottom or symmetrical curved airfoil at all?

Finally I believe that the answers to airfoil vs flight characteristics lies somewhere between those of a ballistic body and a parachute.

Finally, did you ever drop a very light, rigid or even flexible sheet of material in perfectly still air and observe its flight characteristics. Sort of like your foam model, which stalled then "slid" backwards to resume its glide.

Again, Many Thanks for a "brain stirring" paper.

Regards

Warren Whittmore
<wwhittemore@stny.rr.com>

March 13, 2011

The model delta wing held by Dr Lippisch appeared in the Dec. 1951 issue of Model Airplane News. The article about the Collins Aeronautical Research Laboratory included the plans for two delta wing models. I built the Jetex 50 version, the one Dr. Lippisch is shown lighting off. When that little solid rocket was working right the model gave smooth, stable flights.

Thanks for tickling my memory.

Christopher Denny
<kd6htv@att.net>

(ed. – It sounds like you had a good time going back in your memory and enjoying the flights again. Thanks for sharing.)

March 17, 2011

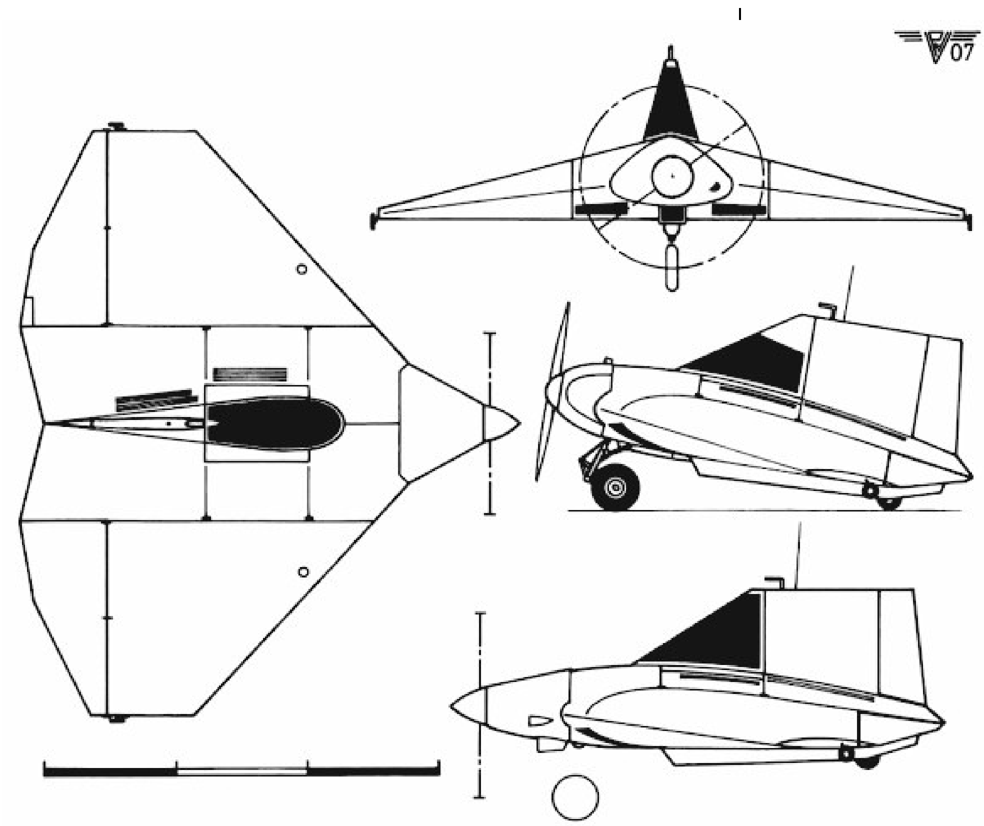
I have attached a drawing of Bart Verhees "Delta" (November 2010 newsletter's front page photo) made from a Bart's sketch. The two profiles concern the Delta in its original form with a 60hp Hirth 2-stroke engine, and in its 2006 modified form with a 58hp Subaru 4-stroke engine.

Is there more information available from members on the Dale Walter "Jeep" (June 2010 newsletter's front page photo). Its nickname dates it back to March 1936 (first appearance of "Eugene the Jeep" character in Popeye cartoon) or later. But Aerofiles only mentions two Walter's aircraft dated respectively 1929 and 1932.

Thanks in advance,
All the best from Oslo,

Philippe Vigneron
<nurflugel@yahoogroups.com>

(ed. – I have included Philppe's sketch at the top of the next page so it would be large enough for a good look. If anyone has more information on his question about the "Jeep" please let him know and include TWITT in your addressees so we can pass the it along to the rest of the group.)



March 29, 2011

(ed. – This was in response to a member who was looking for information on the Horton Wingless, is working on a design, but is not quite ready to have any of his work published yet. I have included Serge's reply since I was in desperate need of filler material and we haven't had any interest in this design for a while so I thought it would be good to re-surface it.)

Andy forwarded your request to me tonight. The reason you could not reach me is that you used an obsolete e-mail address. I switched several years ago to this one: skrauss@ameritech.net

I do have some Horten Material in my bibliography - not a lot, but most of it is in my files too (items marked either 'ex.o.' or 'ex.c.'). I don't know what is in my boxes of unentered items, but I have attached what is there now. Also, a great site for unconventional aircraft, including extensive material on the Horten "Wingless" was/is(?) David Dodge aka "Dannysoar's". Unfortunately tonight when I did a search for both the Horten material and his home site, I came up empty. Either he has a new web address, or he has discontinued it. That would be a shame, because his research was good and his imaginative and completeness were second to none. Fortunately I had printed out what was there around the year 2000. The old one began with...

"http://home.att.net/-Dannysoar/..."

but that does not work now. "horton2.htm" and "horton.htm were the rest of the original URL's for the "Wingless.There are videos of the Horton available on the web through searches.

There was another California Sawyer (Ralph) who built a low-aspect-ratio rectangular, slotted tailless back in the 1970's. 'any relation?

The problem with each of these is that unlike the more semi-elliptical types, like the Arup, Hoffman, Zimmerman, et.al. designs, it seems that even with "tip" plates, the more rectangular ones had a lot of induced drag. I don't think the Horton climbed at all well, without the extended wings.

Well, if I think of more, I'll let you know.

Serge Krauss
<krauss@ameritech.net>

(ed. – See the bibliography information referred to by Serge on Page 11.)

March 30, 2011

Thanks for the note. I'm a 70 year old private pilot that is building a 10.5M (115%) Pietenpol Air Camper, restoring Model A Fords, a Diesel electric locomotive and a boat. I have really exercised no control since I retired. When the subject presented it's self again I had to ask myself, "Why not dig into my long-time interest in flying wings a little deeper."

I'm just old enough to have seen the YB-49 in the news reels. During the early 1960s I started modifying stick models into canard and flying wing configurations as a relief from the drawing board during work breaks. I was impressed with the soft and stable flight of the reflexed flying wings. These pleasant qualities were not at all what was expected, according to common myth. Actually, I thought them rather boring in a hand thrown model.

I remember the Backstrom Plank and the Minibat efforts showing up in EAA publications. Basically, I have watched the flying wing with little more than a academic interest, but it is a long term interest.

Two weeks ago a flying friend loaned me Kasper's Flying Wings book from the 60s and the fire was lit again. I have been doing an extensive web search on flying wings and have found that there has been considerable practical experience and advancement in concepts since I last followed flying wings. I am especially impressed with the efforts in RC modeling, I believe that you are right, "The Wing is the Thing."

Should I decide to do anything practical in this area, I would be especially interested in developing something in the motor glider/Light Sport category that could fit in my 42 foot hangar. This would mean relatively low aspect ratio (darn!) I would certainly model any concepts to within an inch of their lives.

Thank you for your good works.

Lauren Williams
<petalumatrolley@sbcglobal.net>

(ed. – Lauren is a new member and I always ask about their interests especially related to flying wings. Sounds like full retirement and lots of fun to me.)

Nurflugel Bulletin Board Threads

Hello,

I am trying to re-contact Barney Vincelette (designer of the YV-49 2 seat aircraft and related to the PUL-10 and H-3000 from Horten Aircraft) and Kevin Renshaw (designer of the "Komet" glider) but cannot find the current snail or e-mail address.

If some members of the group can help (by private mail), I will greatly appreciate it.

Best regards,

Philippe Vigneron
<nurflugel@yahoogroups.com>

(ed. – I sent Philippe the last known mail addresses I had for Barney and Kevin so he could continue with his research if able to make contact.)

Hello to all of you,

I am new to this group and have a few questions in relation to the PUL-10: Does anyone of you have some contact details in relation to the PUL-10? Does somebody have a set of plans? I am especially interested in the set of plans as I would like to study the ability of this Nurflugel for a homebuilder (myself).

With my bets regards and thanks in advance for your help.

Karl Senn
<karl_senn@yahoo.com>

Hello Karl,

You can find more info (PUL 10 brochure) on Nurflugel page (www.nurflugel.com), but no set of plans has been published for the PUL-10.

Horten Aircraft has a web-site (http://horten-aircraft.com/) but with a login code and... no information concerning the login procedure?

Philippe

Hello and thank you to all of you!

This late afternoon I had a very interesting discussion over the phone with Mr. Mattlener. As I promised yesterday I will give here a short version of it; I think it may be quite interesting for many of you.

I asked about the PUL-10 and Mr. Mattlener responded that the PUL-10 as shown on the web, while having good characteristics, is not intended to get it into production; however the negatives (forms) are still there. The project H3000 is discontinued.

The PUL-10 has been further refined and new negatives will have to be produced (the wingspan is widened). There are still some details like the gear to be developed, drawn and calculated.

The issue that caused the most of concerns is that the PUL-10 (as all Nurflugels) is very critical to the CoG and requires planning ahead of each flight with changes in load and a new weight and balance calculation.

Now to the good things. Mr. Mattlener will be present on the Aero Friedrichshafen. He does not have his own set-up but is a guest to the Oskar Ursinius Vereinigung! This is the LLA of Germany!

The Aero Friedrichhafen opens April 13, 2011 and lasts till April 16th. Mr. Mattlener hopes to make many contacts with interested persons. He is especially interested in future builders that could help with design and construction; all this can be discussed with him personally.

A further point to look into will be financing of the prototypes; is there a willing sponsor between any of you? Just get in contact with him!

Well, for tomorrow I have to check my work schedule, then; if it would be possible I will have to find a flight. For accommodation I am easy and very, very flexible (at least in my mind, my bones sometimes are a bit different).

As soon as I know more I will tell you again

Karl

THE AEROPLANE JUNE 27, 1947

AERONAUTICAL ENGINEERING

Stalling Phenomena and the Tailless Aeroplane IV

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

For the following discussion of the stalling properties of swept wing systems, the consideration of problems of stability and trim at the stall is essential. Static stability is the faculty of a system to return to a position of equilibrium when a disturbance has displaced it from this position.

This general definition obviously loses its value when considering longitudinal stability at the stall. For the pilot it is of no use if his aeroplane assumes a position of equilibrium at an incidence within the critical range of stalling incidences and tends, when disturbed, to return to this incidence. Moreover, the unsteady flow conditions prevailing at the incipient stall would make such a conception quite incompatible with static stability. Hence, qualification of the conception of static longitudinal stability is desirable before considering the stall.

The pilot will be satisfied if the aeroplane from any stalled attitude, tends to return to incidences which are associated with smooth flow over the wings, i.e., below the incidence of maximum lift. Stability in stall shall hence be presumed when, at the stall, the aeroplane tends to decrease its incidence when left to itself ("stick-free" stability). If the reverse is the case, so that tail heaviness appears, the aeroplane shall be considered unstable in pitch at the stall. The.condition of return to a state of equilibrium is thus being disregarded for our purpose, even if the aeroplane should go from the stall directly into a dive—as stable conventional aeroplanes usually do.

Static longitudinal stability is best considered in relation to the "aerodynamic centre." This is the point about which, for all incidences of normal flight, the pitching moment remains unchanged. When the centre of gravity coincides with this point, the aeroplane has neutral static longitudinal stability. When the centre of gravity is in front of the aerodynamic centre, the aeroplane is statically stable in pitch. When the centre of gravity is aft of the aerodynamic centre, the aeroplane is longitudinally unstable.

The conception of a stationary aerodynamic centre holds only for an incidence range well below that at which separation phenomena occur at the wing. And even this statement has to be qualified for aerofoils for which the linear relation between the pitching moment and the lift (or, more exactly, normal-force) is retained over a substantial range of incidences, for example, from that of steep glide to that of best climb. It may, for instance, not hold for many laminar flow (low drag) aerofoils, which often exhibit a kink in the lift curve (Ref. 72), due to a sudden forward movement of the transition point towards the leading edge at incidences well below the stall. Such a sudden shift in the aerodynamic centre will, of course, greatly affect the stability quantities: when the aerodynamic centre shifts forward, the longitudinal stability is decreased or even lost; if it shifts back, the stability is increased.

In this connection, partial flow separations near the trailing edge will also become of importance for the longitudinal stability of tailless wing systems. This is to be considered when choosing laminar-flow aerofoils for a tailless aeroplane.

At incidences near to the stall, i.e., when separation phenomena begin to occur at the wing, the conception of a fairly stationary aerodynamic centre does not hold. Hence the consideration of stability has to be based entirely on the direction in which the previously nearly stationary aerodynamic centre shifts. When it shifts towards the leading edge, a tail-heavy tendency will appear; the aeroplane becomes longitudinally unstable and tends to raise its nose. Thus, the aircraft tries to increase its incidence, and if not corrected, the stall will be aggravated. Only the effectiveness of the elevator can then extricate the aeroplane from the stalled attitude.

LARGEST TAILLESS.—The Northrop XB-35 bomber is the most ambitious tailless aircraft so far produced. With a span of 172 ft., and a gross weight of 162,000 lb., the XB-35 is powered by four 3,000- b.h.p, Pratt and Whitney Wasp Majors. It has built-in slots and split flaps at the wing-tips for control in yaw.

When the aerodynamic centre shifts backwards towards the trailing edge, the stability is increased, and, unless corrected, a nose-heavy moment will return the aeroplane to a smaller incidence. This stability at the stall is thus making the aeroplane unstalled. Since, however, the static stability is greatly increased in its magnitude, the elevator control will have to be powerful in order to overcome a tendency to fall into a dive. For judging the behavior of a wing system at the stall, the shape of the curve of the pitching moment as a function of the normal-force (or, approximately, the lift force) is clearly helpful.

Sweptback Wing Systems

Sweepback gives to the stall of a wing similar qualities as does symmetrical taper in plan, only to a rather aggravated extent. Under otherwise equal conditions, a premature stall at the tips increases in severity with increase in the angle of effective sweepback.

Since with tailless, sweptback aeroplanes, two- or three-purpose controllers are located in the regions of the wing-tips, the consequences of incipient stall in these regions are severe. An aggravating factor is that the incipient stall at the wing tips shifts the aerodynamic centre farther forward. The consequences of this have been mentioned.

The stall at the tips of a sweptback aerofoil is premature; it sets in long before the rest of the aerofoil is affected. For this. several distinct and yet interconnected phenomena are responsible:—

(a) Outwards flow components acting in the boundary layer on the negative-pressure side of the wing;

(b) The appearance of higher section lifts at the wing tips;

(c) Variation in the effective aerofoil section shape at the tips, due to the span-wise outward-flow components on both wing surfaces;

(d) Interaction of the inward flow due to the wing-tip vortices on the boundary-layer material accumulated over the wing tips, at the negative-pressure side.

The intensity of this inward flow increases with approximately the square of the lift coefficient, and is reinforced by the outward flow on the lower wing surface which is induced there by the sweep-back of the wing. This was shown by the experiments of G. T. R. Hill on the adjustment required for rudders located underneath Pterodactyl wings. The interaction of this inward flow on the upper wing surface and the outward-directed flow at the wing-tips has the effect of (1) bringing the stale boundary layer to stagnation and hence to accumulation at the tips; and (2) changing the character of the stall locally over the tip region, by reason of induced turbulence.

(e) In addition there is a local increase of the effective Reynolds Number at the tip region, by increase of the effective aerofoil chord. This, too, is an effect, which is due to the outward flow of the swept-back wing.

FORWARD SWEEP.—This tailless glider, the Cornelius XFG-1, his a swept-forward wing and Is Intended as a flying fuel tank for the Superfortress behind which it is towed. During these long-range operations, the XFG-1 is pilotless although, of course, for ferrying purposes, a pilot is carried.

(f) When, as generally maintained, the outward flow is mainly restricted to the boundary layer, between the latter and the flow stratum above it, a vortex sheet can be expected;

(g) When wing-tip disc fins are attached to the swept-back wing, the factors that would affect the stalling characteristics area: (1) accumulation of boundary-layer material inboards of the fin; (2) formation of an expanding passage which will promote premature separation at the tip; (3) mutual interaction between the circulations about .the wing' tip and the fin, at attitudes other than that for zero-lift; and (4) sweep-induced inflow in the region of the leading edge of the wing.

(h) When partial-span, split, or trailing-edge flaps are deflected at a swept-back wing the character of the stall changes. It occurs at a smaller incidence and shows a tendency to become more abrupt. The pertinent factors would seem to be:-(1) An increase in the effective washout from wing root to wing tip; (2) increased outflow on the upper wing surface outboard of the flapped region, while that over the centre of the wing is reduced; (3) tendency to premature stall just outboard of the flap, due to the discontinuous lift distribution along the span; (4) increased outward flow on the lower wing surface, due to the inclination of the flap to the plane of symmetry (sweep effect of the flap); and (5) variation of the inflow over the wing-tips from pressure equalization at the tip, which, in this case, exceeds that predicted by Prandtl's " lifting-line " theory, due to the gross lift discontinuity caused by the flap.

The span-wise flow components in the boundary layer are due to the sweep of the leading edge. Directly at the leading edge and somewhat above it, the airflow has an inward-directed component. This changes to a pronounced outward span-wise flow, which increases as the flow approaches the trailing edge. This span-wise flow is simply the result of pressure gradients between equal-chord stations along the span. The region of the inward flow at the leading edge is very small and, for all practical purposes, without significance. It is due to the steep rise from high to low pressure on the upper surface of a lifting aerofoil immediately aft of the leading edge. Farther along the chord the negative pressure decreases towards the trailing edge. The chord wise flow in the boundary layer is hence slowed down, and since the neighboring outboard chord station has a smaller pressure, the flow will assume a definite outward direction.

As a result of this span-wise flow, stale boundary-layer material is transported towards the tips, where it accumulates, especially in the region of the trailing edge. It accumulates because, at the tips, there is an inflow velocity component due to the exchange of pressure around the tip, from the lower surface of the wing to the upper surface. The thickened boundary layer thus created over the tips of a swept-back aerofoil is greatly inclined to break away from the wing surface, i.e., to cause a premature stall. On the other hand, the centre portion of the wing experiences delay in the stall, because the boundary layer over it is continuously being removed in a span-wise direction and replaced by more vigorous flow material.

The character of the premature tip stall is influenced by the pressure-exchange flow around the tips. At the square-cut tip, the inward flow is greatest near the leading edge, where the maximum negative pressure is developed at a lifting aerofoil, and as in the case of the induced drag, it increases in intensity with the square of the section lift. The result is that by the mixing of this flow component with the outward flow component due to the sweep, a region of vorticity is presumably formed at the tip. Consequently, a violent "front" stall will occur locally, when the incidence is sufficiently high.

The hypothesis put forward above seems in good agreement with experimental observations. It is also in agreement with observations of Soule on the influence of sweepback and aspect ratio (Ref. 74). It explains the surprising increase in the negative slope of the pitching moment/ incidence curve, which was found at sweep angles approaching 66 degrees and aspect ratios of about 2.5. The negative slope suggests a stall nearer to the root than to the tip, and this might be caused by a vorticity region farther inboard from the tip (due to the small aspect ratio). At larger incidences, the slope becomes positive because the inflow from the tip vortices is then no longer sufficient to delay the stall at the tips. Possibly, this is only a part explanation of what actually happens in this case, but it may help towards a clearer understanding on the basis of more experimental research.

Connected with the interaction between two opposing span-wise flows in the boundary layer is also the observation that, for the wing system mentioned, beyond a certain characteristic incidence, the lift increment with incidence improves. This does in fact occur at the identical value of incidence at which the negative slope of the pitching moment is found. This would suggest that the tips were partially stalled at the smaller incidences (small inflow and large outflow) and became unstalled at the characteristic incidence due to the "scouring" effect of the more intensive inwards flow arising from the pressure equalize- lion around the tips.

That the effect of the abrupt "front" stall at the tips is not relieved by the provision of wing tip discs, is probably due to the fact that the latter form expanding passages at the wing tip near the trailing edge and hence cause a stall there too.

The effect noted under (b) i.e., that untwisted sweptback aerofoils have the property of higher effective incidences, hence higher lifts, at the tips, is due to the intensity of the vortex sheet which represents the swept aerofoil in respect of the induced drag. As the result of the higher effective incidences, the lift grading over a swept-back wing is, at incidences well below the stall, fuller than that corresponding to the elliptical shape. Consequently, when the wing incidence approaches higher values, the tip regions reach their maximum section lifts first and hence stall first. This effect of premature stall is present with tailless aeroplanes, but in practice is far less important than the effect of the span-wise flow components. In fact, in most cases it is well neutralized by the wing twist required for stability. It does, however, necessitate the adoption of a somewhat higher effective washout than stability would demand for a straight wing having a tailplane in lieu of the sweptback tips.

The effect under (c) is, more or less, the result of the span-wise deflection of the flow at both surfaces. The result is that the aerofoil' section which becomes effective for the relative airflow has a larger chord but equal thickness and camber. Hence the reduction of the effective section thickness and section camber reduce the value of the local maximum lift and also its critical incidence. The effective section is also made liable to display an abrupt "front" stall. The effect is not very pronounced, but would, however, deserve of a closer investigation, since it may well lead to improved wing-tip designs. - German investigations have, shown that, at the tips of swept-back aerofoils, the chord wise pressure distribution shows more pronounced peak pressures. Such peaks in the pressure distribution give larger adverse pressure gradients in the chord-wise direction and hence promote early flow separation.

On a swept-back wing, the deflection of a flap affects the stalling characteristics at least as much as the deflection of a flap on a straight wing, while the lift increase diminishes with the angle of seep. At larger angles of sweep, the stall occurs much earlier, when a flap, either of the split or of the plain type, is deflected. This is just as valid for part span as for full-span flaps.

As to the nature of the stall, the experimental evidence is still scarce and contradictory. The U-wing type seems to be the most promising both for high-lift and character of the stall, when the flap extends over the straight portion of the wing. in general, the stall experienced with partial-span flaps leaving the tips without flaps seems to be better than with flaps up. G. H. Lee (Ref. 84) has attributed this to the diminished delay of the stall at the wing root which follows from the span--wise removal of boundary layer material in this region: in the case of deflected flaps, this removal is reduced.

Many tailless aeroplanes and gliders of the Dunne type have been afflicted by these effects. The Horten brothers, for instance, found (Ref. 15) that their first glider with swept-back, pointed wings displayed uncontrollability in circling flight and began to spin against all control maneuvers. They appreciated later that premature tip stall had been the primary cause of the trouble. During all their later development work, the retention of a substantial wash-out under all control combinations has formed one of the principal design considerations.

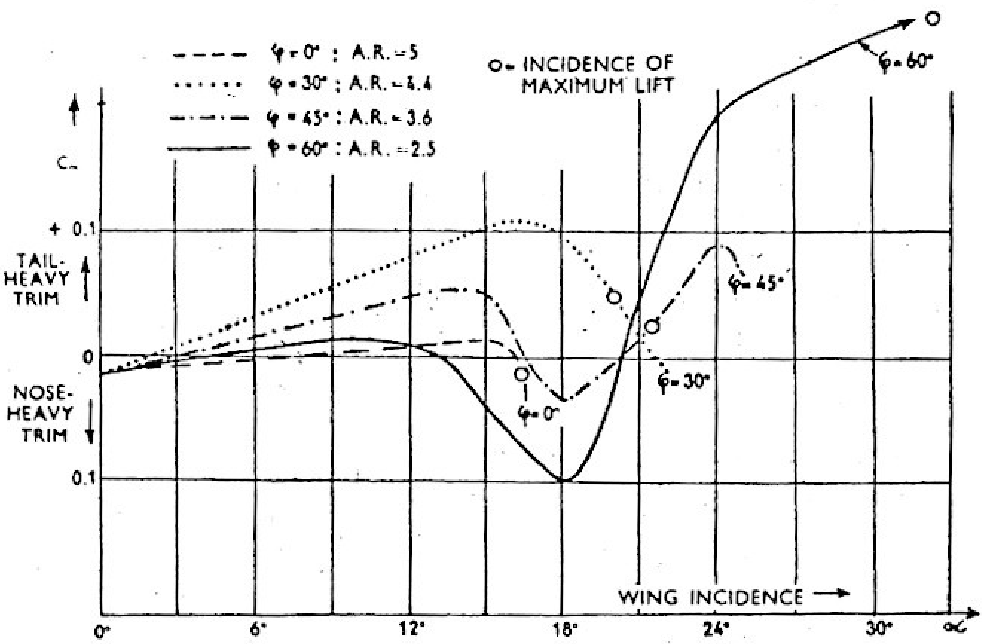


FIG. 7.
SHAPE OF PITCHING-MOMENT CURVES IN RESPECT TO WING INCIDENCE, FOR DIFFERENT COMBINATIONS OF SWEEP-BACK AND ASPECT RATIO (A.R.)
[FROM N.A.C.A. TECH. NOTE No. 1088]

G. T. R. Hill investigated about 20 years ago, in a wind tunnel, a series of tapered wings with different angles of sweep (Ref. 73). The aerofoils had R.A.F. 30 section, an aspect ratio of 6, a taper ratio of 3, and effective angles of sweep of 5 degrees, 24 degrees and 34 degrees respectively. He found that, contrary to the behavior of standard rectangular aerofoils, the centre of pressure moved forward when the stalling incidence was reached, and that this forward shift aggravated with increasing angles of sweep. In other words, Hill discovered that, at the stall of swept-back wings, the aerodynamic centre shifts forward, producing a pitching moment, which tends to increase the incidence still further, while decreasing the static longitudinal stability.

For this reason, Hill has since given preference to the U-wing, instead of straight tapered and swept-back wings. The U-wing has a rectangular centre-section to which swept-back and tapered outboard wing panels are attached. The behavior of each portion tends to counteract that of the other at the stall.

On the other hand, Hill discovered that an increase in the angle of sweep diminished the abrupt and severe drop of lift, which occurs at the stall beyond the incidence of maximum lift. Various investigators have since confirmed this phenomenon, and double peaks in the lift curve have also been observed. N.A.C.A. test results prove that, with increasing sweepback, the lift curve becomes more gradual at the stall and free from abrupt discontinuities. This again is in good agreement with flight tests of swept-back aeroplanes and gliders, which in general have given evidence that the stall becomes more gradual when the sweep becomes more pronounced. This observation has, however, nothing to do with the longitudinal instability to which we referred above.

G. T. R. Hill has, incidentally, made another attempt to prevent the unstable forward movement of the aerodynamic centre near the stall, by the provision of a cut-out at the centre-section of the Westland-Hill Pterodactyl Mk. IA (1927). The attempt was, however, not successful, as, at the same time, it increased the induced drag unduly.

For many design purposes, a consideration of the curve of pitching moment as a function of the incidence
seems instructive.

During the War, the N.A.C.A. have made systematic wind-tunnel tests and tests in the free-flight tunnel with swept-back wing systems having sections of the N.A.C.A. 230 family. Moreover, they have carefully collected and sifted the results obtained on swept-back wing systems for other purposes, and from the tests made in Germany. This comparative work is given in an important paper of A. Soulé (Ref. 74), and in several Technical Notes by W. Letke and A. Goodman (Ref. 75), and by J.A. Shortal and B. Maggin (Ref. 76).

The systematic investigations carried out by the N.A.C.A. were based on the structural consideration that the ratio of the wing-panel length to the thickness of the wing at the root should not exceed a figure ("criterion of structural efficiency") which was beyond the domain of practical possibility. Present-day values of this criterion are up to 30 to 35, but, in one case at least, a value of 50 has been obtained. Hence the Americans took a value of 50 as a possible optimum for the near future and based the variation of their aerofoil plan shapes on this. In other words, they varied the angle of sweep as well as the aspect ratio, in order to retain a value of 50 for the ratio between the wing-panel length and the wing-root thickness. Consequently, an aerofoil with a root section of 12 percent thickness gives an aspect ratio of 8 with a taper ratio (root chord/tip chord) of 2, without sweep. With sweep, the panel length is increased.

The structural consideration indeed proves that large angles of sweep imply low aspect ratios. The systematic variation observed by the N.A.C.A. is hence of immediate practical value. It is, however, less amenable to basic research which tries to investigate the factors of aspect ratio and of taper separately.

(to be continued)

1934 EXPERIMENTS.—The Westland-Hill Pterodactyl Mk. V appeared in 1934. Powered by a 700-b.h.p. Rolls-Royce Goshawk steam-cooled engine, It was the last of a series built between .1926 and 1934. and was designed by Professor G. T. R. Hill.

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

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VHS tape of July 15, 2000 presentation by Stefanie Brochocki on the design history of the BKB-1 (<u>B</u>rochocki,<u>K</u>asper,<u>B</u>odek) as related by her father Stefan. The second part of this program was conducted by Henry Jex on the design and flights of the radio controlled Quetzalcoatlus northropi (pterodactyl) used in the Smithsonian IMAX film. This was an Aerovironment project led by Dr. Paul MacCready.

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

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

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Horton "Wingless" Citations from Tailless Aircraft Bibliography – S. Krauss (2000)

Regular Citations (Through 2000):

1. Horton "Wingless" article; Science and Mechanics; 2/51; cover (painting), pp.67-9 (Douglas Rolfe cutaway, drwgs.)(unex.)
2. Horton "Wingless" Plane; Air Trails; 6/51; p.25 (ph of first prototype, dr., 2 3V's of proposed variants)(ex.nc.)
3. Horton "Wingless" article; Popular Mechanics; 12/52 (incl. photos of Cessna T-50 based prototype)(unex.)
4. Additional Illustrations and Short Items of 1953; ...**Air Trails**: 1/53, p.22 (Horton 'Wingless'; ph)...
5. Horton "Wingless" article; Popular Science; 2/53 (photo)(unex.)
6. Ron St. Jeans F.F. Model; Air Trails; 8/53; p.68 (low-A/R; looks like Horton 'Wingless'; ph, cap. only)(unex.)
7. Horton "Wingless"; Flying; 10/54; cover, p.45 (4 par, painting, ph)(ex.nc.)
8. Horton, W.E.; U.S. Patent No. 2,734,701:"Airplane with Retractable Variable-Incidence Wings"; 2/14/56 (filed 5/13/52;"Horton Wingless"; roadable aircraft consisting of low-A/R, thick, lifting fuselage with end plates and small, retractable, variable-incidence and -sweep wings; 5 figs., 1 claim)(ex.c.)
9. O'Leary, Michael;"Horton Wingless"; Air Classics; 3/67; pp.? (4 par., 2 ph)(ex.nc.)
10. "Fabulous Flying Flops" (Air Classics 'Spl.Rpt.'); V.2, 1985; ...pp.58-59 (Horton 'Wingless'; 2 ph); ... (ex.o.)
11. "Horton Wingless"; Air Classics; 3/87; pp.66-67 (see "F.F.F.", 1985; 2 ph)(ex.nc.)
12. Additional illustrations and short items of 1999... **AAHS Journal**: Summer/99, p.155 (Horton 'Wingless' ph)./....(n.c.)
13. Anon. (captions); Bowers, Peter (photos) "Unconventional Flight!"; Wings, Vol.30, No.1; 2/2000; ...p 22 (Horton; ph), (ex.o.)
14. Horton, W.E.; Horton V-16 "Wingless" promotional brochure; ca. 1951 (unex.)
15. "Horton HW-X-26-52 'Wingless' - Bimoteur Expérimental (USA)"; Aviation Magazine; ca. 1952-60's; p.20 (par., 3V, ph, specs; page marked with '...No.57298 du 1-3-57)(Vigneron-ex.c.)
16. Horton Wingless; Air Classics; V.23, No.3 (1986?); p.66 (same as 3/67?)(unex.)

Unknown Merit:

17. Flight; 10/5/50; p.377 (Horton, low-A/R, or roadable-acft related; cited in Horton patent)(unex.)

Internet and e-media (Before 2000):

18. ***David Dodge;*** 10/2000: http://home.att.net/-dannysoar/; pages for ***Bel Geddes #4*** (paintings, s.d.'s, specs, cutaways); ***Burnelli*** (phs, model plane), ***Colani*** (multiple joined-wing powered'race glider': model photos, descr.); ***J.W. Dunne*** (phs, full-pg. vintage sd's); ***W. E. Horton "Wingless" Pages*** ('The Horton Story': 2 3V's, 11 ph/drs.; 'The Test of the First Horton': 7 FAA/Backstrom phs; Horton Cutaway: Douglas Rolfe from Science and Mechanics, 2/51); ***Lee-Richards*** (models, phs), ***Payen*** (many 3V's, bio. and model links), ***Rogallo*** (model plans), ***"Things to Come"*** (plans for tailless fighter model), ***Warren-Young*** (Woolls Aeromodeller article + 'Ace of Diamonds' plans), and a wide variety of other imaginative aircraft/models, incl. a ***tailless bipe pusher***, ***"Mystery Tailless"***, and related plans; links to **Ader**, **Edwards**, **Hill**, and other sites.

Appendix I:

HORTON, W.E.: U.S.; rectangular-planform, low-A/R lifting body, w/chord-length flow fences, twin vert. fins, and sespended elevons: **prototype "Wingless"**, fl.? 1951; Cessna T-50-based twin-tractor second prototype having low-A/R near-rectangular wing w/swept l.e., fences, and protruding, retractable wing tips: **HW-X-26-52 "Wingless"**, fl.1952 or'54 (Aero D.:'51); **V-16** production proposal, ca. 1951; **U.S.Patent**: 2/14/56 (5/13/52).