No. 314 AUGUST 2012

T.W.I.T.T. NEWSLETTER

Waldo Waterman's Arrowbile flying car. The idea behind the Arrowbile was to develop a transmission drive system that could operate the propeller for flight and the rear wheels for ground operation. His flying car can be seen at the Smithsonian National Air and Space Museum. Source: http://thefrontblog.wordpress.com/tag/paducah/

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., **1208** means this is your last issue unless renewed.

Next TWITT meeting: Saturday, September 15, 2012, 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 or Skid Row for those flying in).

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PRESIDENT'S CORNER

I ran out of room in the letters section when this came in but I wanted to let everyone know the outcome of posting Clyde Reville's offer of a free Pioneer II. Below is some of what Bill Berle sent me after picking up the sailplane.

"Andy I wanted to update you on an item you published in the last ESA newsletter. Clyde Revilee's Pioneer IId glider project that was "free to a good home" is now in my garage. My thanks to Clyde for his generosity and trusting me with the stewardship of this aircraft. I'll try to live up to your trust.

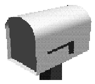
Myself and ESA Treasurer Murry Rozansky are going over it and figuring out how to proceed with it in a safe manner. Like many homebuilt projects, there are "a few issues".

We plan to balance the control surfaces for good measure, and install a sliding weight CG system (which has shown very significant gains in other Pioneers). We also plan on adding the 15 meter curved tips as installed on Mike Hostage's Pioneer. I've heard good reports about the high speed performance of this design being better than one would expect from a wood/fabric wing using an ancient airfoil."

We have some interesting conversation between Bob Hoey and Max Perrault on the Pegasus project and Bob's flying experience with the model. There still is no link to a video of the flights, but I imagine it will come soon.

Don't forget the ESA Workshop at Tehachapi, CA over the Labor Day weekend. They have a very good program lined up, so don't miss it.

Andy



LETTERS TO THE EDITOR

(ed. – I have included Bob Hoey's original e-mail from last month to keep everything in perspective with the following exchange of message between all of us. I have also included the photo I missing last month along with some new items sent along by Bob.)

July 3, 2012

Made one short flight on the Pegasus this morning. Flew in between steady, high winds, and gusty, convective winds that is the usual morning sequence.
Flight was a resounding success!!

Captive flight was normal except for a requirement for nose-up trim on the mother ship. Launched at about 300 feet and launch was clean. I was using high rates and the airplane responded quite well in both pitch and roll. Needed a little nose up-trim for normal flight and response was a bit sensitive, but it flew nicely. The glide angle was surprisingly good; quite flat, like a normal glider. Didn't try any stalls, but did do turns in both directions and had good control. Made a gentle landing with NO damage.

Unfortunately, there were no cameras at the flying site, but we'll get some videos next time and try to post on YouTube or somewhere.
If the wind stays down, may try again tomorrow, 4th of July.

Congratulations, Max!! Looked a lot like your XPlane video!

Bob Hoey

(ed. – My return message said: "Very interesting results. I guess I was expecting something really wild with a landing and minor damage. Does this lend some credibility to these software systems due to the unusual design?")

Andy

I don't understand your points for lack of elaboration. What software systems of unusual design do you refer to? You were expecting a bad landing and minor damage? Or you are somehow being tongue in cheek? Do you mean to say you expected success or you didn't expect it, or apparently even a minor level of non success?

To model this design in x-plane I had to make assumptions on the analysis engine and input my own lift curve slopes based on what I could gather of cascade interaction. I got this information from Javafoil, a free multi element capable program from Martin Hepperle. Then I tried to adapt this to x-plane by inputting lift curve slopes plus slight deflections that would hopefully reflect the interactive SYSTEM of the cascade. I knew this was the weakest point in the simulation validity. I didn't expect it to show the hoped for gains in LD since Prandtl and Munk theories will not account for it. At best it showed an LD of 19 but is often not more than 12 with the gear and non-optimum flight speeds. The idea is that this will improve to 24 given the same arrangements due to the mythical induced drag reduction of the feathers. Calculating by hand gives an ideal LD of close to 30 for this layout with no interference or parasite drag. Only a longer span version would be taken seriously as a soaring craft, yet I hope for a sink rate of 3 fps which should be adequate for many soaring conditions.

But frankly, much of what makes the design valuable is nothing out of the ordinary. It's simply having low wing loading and high power to weight ratio coupled with a powerful roll control. I put some time trying to eliminate adverse yaw due to whatever vector sums x-plane was coming up with and this comes from the dihedral angles but also generous fin area. In that respect I consider it a partial success only since birds don't need any verticals.

The hoped for improvement in performance due to span efficiency is around 5 points in LD, such that this aspect of the feathers is not a predominant leap. How I see it is that it allows a reduction in span from say 28 to 21 feet and this reduces roll damping for a crisper handling. At the same time, the chord goes up and pushing this a little further allows the lifting body which then eliminates fuselage drag....except for the dire interference drag at the feather roots. It is already a heavy compromise in span and thus performance degradation and only careful attention to streamlining would make it a viable soaring craft which is part of the design goal. Look at a Monarch flying wing, or a Goat or any of the ultralight gliders and you see spans often in excess of 40 feet. You will not compete with that using a span of 21 even with a span efficiency of 2. This leads one to think about what ideal soaring goals would be and this leads to solar and electric assist, in flight recharge from wind milling etc.

Something about either the feathers or perhaps just the low aspect ratio allows an ease of handling close to neutral stability. This coupled with good elevon control allows mush into deep stall. This is one of the truly different aspects of the design and something I had hoped to achieve with airfoils and leading edge extensions etc but happily found it as an inherent quality of the planform, at least in the simulation.

The simulation is nothing more than a college text put into rapid calculation, and in this respect its nothing more or less than one would laboriously be able to calculate the long way a few years back. Putting it into simulation form allows insight you would never achieve by mulling it over. Then real world models must take over and finally tweaking on a full size machine and the work is hardly ever done and seldom by a single person.

In good cheer,

Max

(ed. – My response to Max was: "I guess it goes to my lack of understanding of what these programs (x-plane, etc.) are capable of doing in terms entering parameters and then the program adjusting accordingly. I was thinking old school here looking at more conventional type of aircraft and not realizing the computer doesn't know the difference between a tube/wing or tailless configuration if the parameters are properly devised. I am not an aero engineer so sometimes insert foot in mouth when analyzing these things for a layman's perspective.

As to the actual performance of the model, it goes back to my ignorance of the simulation capabilities and the unusual configuration of your design. For elaboration I meant that Bob would have his hands full with keeping it under positive control through to the landing, but that it would only sustain minor damage to the point it would be repaired and tweaked as he has done with his bird models.

So the bottom line here is to think more unconventionally and perhaps elaborate more when making such comments in the future.

My apologies for it not being clear.")

Andy,

I see Max has already responded. My entire career has consisted of creating, programming and utilizing engineering simulators in support of flight-testing.

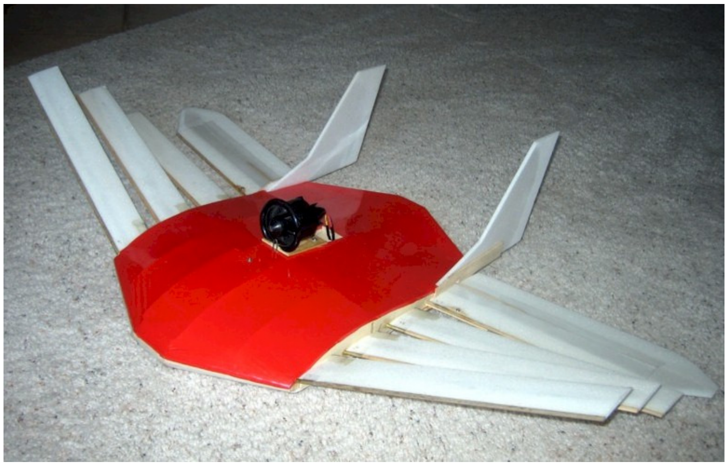
The equations of motion are pretty straightforward and well known. The trick is inserting the proper weight, inertia and aerodynamic data. Generally the simplified linear aerodynamic predictions are quite good for control effectiveness, and fairly good for static longitudinal and static directional stability. This appears to be the case for this configuration. These simple predictors usually fall apart when used to predict flight in the non-linear regions, such as stalls, spins or large sideslip angles.

I sort of expected that the Pegasus configuration would fly, but expected that the L/D would be quite low. The glide angle is quite good, indicating that it has an L/D similar to my birds which are 10 to 15. We just made a second flight this morning and hopefully have good video coverage of the flight. It is way too sensitive in high rate and also a bit too sensitive in low rate. (Some exponential in the transmitter should fix that). I did a full-aft-stick stall approach (16 deg of up elevon) which was controllable and resulted in a mushing descent at a moderate angle of attack, with reasonable lateral control. I'll send out a video clip when we get it edited.

Hoey

Andy

I didn't mean any contention. I'm just a humble enthusiast. I simply couldn't figure out your meaning.



It's interesting that straight flying wings exhibit a fourth range of motion besides roll pitch and yaw which contributes significantly to their stability. This is known as heave in the boat world. X-plane shows the effects of this action and was a good indication to me that it was modeling different configurations pretty well. You will see planks pitch down in updrafts for example. I also modeled a canard, Drliks Falcon, and it showed this heave action and exhibited the exceptional stall free stability and character of the plane. As you neared stall the main wing tips may stall momentarily. This brought the nose up slightly enough to stall the canard and bring the nose down. But a moment exists where the downwash from the canard is no longer on the main wing and this will surge upward slightly now that it has a greater angle of attack. As soon as the canard is working again the downwash ensues. But if there was too much delay in the stall of the canard, the wing could stall, drop out momentarily, and you would have a safe but bucking bronco feel as it bobbed between these modes.

X-plane is an inexpensive but wonderful tool despite its limitations. Such is life in the computer era. The Pegasus design was conceived when I was 16 years old but it took 40 years before I would return to it in the simulation world and realize its flying qualities.

Was just flying the simulation and advise against moving the cg back for now. Simply can't wait to see a video.

Thanks

Max

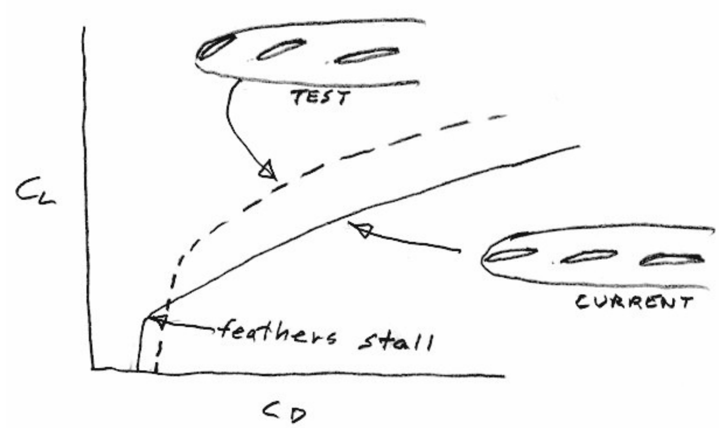
Max,

I think you are putting way too much reliance on the Xplane program. Remember the old computer adage is still valid -- GIGO = garbage in, garbage out! You have told me enough about your inputs to cause me to be distrustful of the predicted stall characteristics. Could be better, could be worse, but probably not well predicted by Xplane.

Hoey

Max,

Mounted the fanjet on top of the Pegasus and used a bungee-rail launch to get it airborne. The launch worked great with the fan at about half throttle. Still maintaining 80% expo on the elevons. Weight is now 19 oz. The airplane flew the same as the last air-launched flight. Low rates give good control. Did some turns, a couple of rolls and a loop. The fan provides good power for the model. The thrust line is high, so I may have to add some up-thrust to counter the trim changes with throttle. Full aft stick in low rate (16 deg elevator) produces a stable, gentle descent with adequate lateral control and no tendency to depart or spin. Full aft stick in high rate (33º elevator) produces a steep, high angle of attack descent, but still stable, and with adequate lateral control. Recovery is immediate with relaxation of aft stick.



On the basis of one flight, there is one observation that I'd like to pursue. Level flight at moderates speeds and low angle of attack requires quite low throttle settings, indicating that the drag is low. Initiating a climb, or steep turn, or just slowing down seems to dramatically increase the drag - not sudden, but noticeable. I suspect that the forward feather, (maybe all of them) are stalling as the upwash increases with angle of attack. (See attached sketch). I am going to try increasing the negative incidence on the first couple of feathers and see if I can detect a difference in the mid angle of attack range.

PS: The other modelers at the flying site, after watching the thing fly, think you should change the name from "Pegasus" to "Trilobite"!!

Hoey

This is probably from Tustin, CA. I thought it might be possible you haven't seen the photo. If not, it will probably make you happy to see it.

It's from the Orange County Public Library Historical Images collection. I now believe the photos were probably taken at the Orange County Airport, which is now John Wayne Airport.

You may find this to be interesting:

http://scripophily.net/hoaicone19.html

I found two more. I believe the shots of the plane flying are rare.

Best regards,

Marc Librescu
Irvine, CA

(ed. - Thank you for the picture. I recall seeing similar pictures many years ago but not one with this type of clarity. I will add it to the Horton section of our web site.)

(ed. – The Horton Wingless comes up from time to time but I don't recall having seen these images in the past when Russ Eckre gave us a couple of talks on his research into the design and what happened to Horton when the project was taken over by Howard Hughes. I also don't recall seeing any with the wing extensions retracted, which is what made it "wingless".)

I see that a new tailless winged space vehicle is in the works. Virgin Galactic is developing a new air-launched SLV (Satellite Launch Vehicle) called *LauncherOne* (see text, images, and a video here: www.virgingalactic.com/launcherone). This two-stage, kerosene/liquid oxygen (LOX)-powered SLV is intended to place small satellites into low Earth orbits and Sun-synchronous orbits (near-polar orbits whose orbit planes remain stationary with respect to the Sun, which allows satellite imaging of the Earth to be conducted under unchanging lighting conditions). Also:

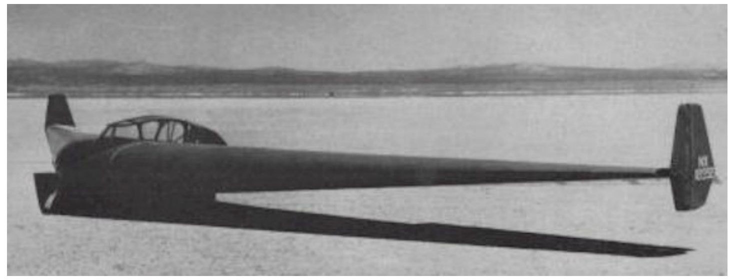
LauncherOne (see: www.space.com/16532-virgin-galactic-launcherone-rocket-images.html , http://www.space.com/16530-virgin-galactic-satellite-launches-launcherone.html , and www.designboom.com/weblog/cat/16/view/22352/virgin-galactic-launcherone-rocket.html) is a mid-wing monoplane. It has short-span swept wings that are located about halfway between its nose and tail, and it has *no* tail surfaces at all; its gimbaled first stage rocket engine provides active pitch and yaw stability. The vehicle soon exits the sensible atmosphere during ascent, so its lack of tail surfaces saves a significant amount of deadweight, thus increasing its payload capability to orbit.

I hope this information will be useful.

Jason Wentworth

Hello TWITT,

The glider's drawing shown in the April's Newsletter page 2 seems to be the Mitchell "Osprey" (or "Super Osprey") designed and built by Don in 1948 in his garage. The glider was then test-flown from Hayward Airport. Total four flights performed (towed from the ground) before the glider was completely destroyed by a hangar fire.

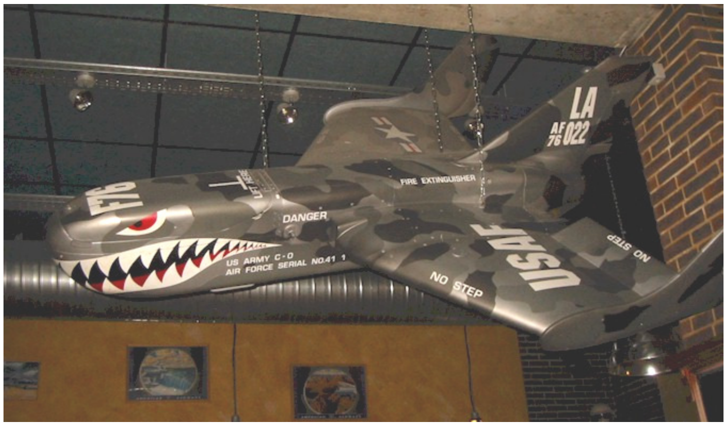


I take the opportunity wondering if some members have more information (specs, 3V drawing, etc) concerning the Mitchell Model 278 "Super Viking" registered NX18992 (photo here-attached from "Soaring" Magazine, dated May-June 1948) built by Mitchell in 1945 or 1946 as a glider, then modified in 1947 as a motorglider with a 28hp Nelson engine.

Thanks Serge for your kind words in the newsletter. I am presently digging Charles Fauvel's personal archives. Will re-contact you soon on that subject.

I have attached photos *(above & on next page)* I took recently in a restaurant "à la mode" named "Cockpit" at Flers (a small town in Normandie-France). This is not a fancy model but a true Belgium UAV manufactured by the company MBLE (for "Manufacture Belge de Lampes et Matériel

Electronique"), named "Epervier" and powered by a jet engine. This UAV was designed as a battle area surveillance drone. Ordered in April 1969, production run reached around 40 examples. It was used by the Belgium Army from 1976 and 1999.(It is now replaced by the IAV "Hunter"). Just the USAF' paint scheme is fancy. Span: 1.72m, length: 2.25m, Weight: 142kg, Engine: Rover TJ125.



Best regards from Normandy,

Philippe Vigneron
retrofitprsp@yahoo.com

(ed. – The following link was provided by Norm Masters in response to a question on the Flying Plank group bulletin board. I have included it here since it is generic to overall design and might be of interest to some of our members. *http://dl.dropbox.com/u/68700326/dive_brakes_naca-tm-1033.pdf*

Here is the first part of the NACA paper referenced by Norm. You can download the entire PDF file from the link he provided. My apologizies to those of you who have already seen this in Sailplane Builder.)

TECHNICAL MEMORANDUMS

NATIONAL ADVISORY COMMITTEE OF AERONAUTICS

No. 1033

WING TUNNEL INVESTIGATIONS OF DIVING BRAKES

By D. Fuchs

Vol. 15. Nos. 1-2, January 20, 1938
Verlag vo R. Oldenbourg, Muchen und Berlin

Washington
November 1942

SUMMARY

Unduly high diving speeds can be effectively controlled by diving brakes. But their employment involves at the same time a number of disagreeable features: namely, rotation of zero lift direction, variation of diving moment, and, the creation of a potent dead air region.

1. Braking Effect. The point of attachment at the wing (rear position) has the greatest influence on the braking effect; forward positions afford stronger braking action than rearward positions. At zero lift the effect is approximately the same whether the brakes are mounted on the upper or the lower surface; the mounting on the lower surface is accompanied by a marked slowing down of braking effect at increasing lift. The aspect ratio of the brake has as little effect on the braking action as the lateral position.

For the decision of the question of suitable location the braking effect can, therefore, be largely discounted, provided the brakes are placed as far forward as possible, the span being preferably so disposed that only one of the trailing edge flaps is hit by the dead air region.

2. Rotation of Zero Lift Direction. The mounting of diving brakes on top of the wing produces a positive rotation (sight impairing), under the wing, a negative rotation (sight improving) of zero lift direction. The absolute amount of the angle of rotation can be reduced by a greater aspect ratio or by locating the brakes closer to the fuselage.

3. Variation of Diving Moment. Limited to the explored backward positions of the brake up to about 30 percent of the chord, the sign of the moment change is (as under 2) determined by the disposition on the upper or lower surface of the wing. (Upper surface: nose heavy; bottom surface: tail heavy additional moments.) The limitation to the front portion of the profile was dictated by the fact that the split flaps mounted at the lower surface produce, as is known, additional nose heavy moments. It follows, moreover, that there always exists a point of attachment for the brake *on* the lower surface of the wing for which the additional moments become equal to zero. The absolute amount of moment change of the

investigated brake arrangements can be reduced, as before, by greater aspect ratio and placement closer to the fuselage.

Since the diving brakes must be mounted near the spars for reasons of strength, that is, in the fore part of the profile, the use of the bottom surface is advisable because the additional tail-heavy moment here unloads the diving moment. The sign of the additional moment can be explained by means of pressure distribution measurements. It was found that the low pressure behind the brake, when mounted on the lower surface of the wing, must furnish a tail-heavy additional moment. The pressure distribution measurements are invaluable for static purposes, since the conventional methods under such severe disturbances render a pre-calculation impossible.

4. Avoidance of Unwanted Dead Air Region Effects. Experiments in the dead air region of the brake indicate that the provision of a gap between wing and brake affords considerable amelioration of the unwanted effects of the dead air region. It was proved by measurements on a model airplane and on a normal wing that the provision of a gap is only beneficial, since the braking effect in any event does not slacken and the effect on diving moment and zero lift direction becomes at the same time less.

I. DISTRIUTION OF THE BRAKE SURFACES ON THE WING

a. Distribution on Upper and Lower Surface of Wing

Brakes of 105–millimeter span each and 36.7 square centimeter area, or altogether of 73.4 square centimeter *or* 1.65 percent of the wing area, were mounted on a model of 1.64 meters span with an elliptical area of 0.446 square meter on each wing half. The model wing had twist and was complete, that is, was fitted with horizontal and vertical tail surfaces, as the tests were intended to include the longitudinal moment changes of the whole airplane, hence inclusive of any eventual effects on the tail.

The tests were made with the following arrangements:

1. Brake 100 percent on lower surface.

2. Brake 57 percent on lower surface and 43 percent on upper surface.

3. Brake 43 percent on lower surface and 57 percent on upper surface.

4. Brake 100 percent on upper surface.

The reference quantities for the aerodynamic force coefficients are:

$F = 0.446\ m^2$ wing area
$t = 0.346$ m maximum chord

The moment reference point was 133.5 millimeters behind the envisaged wing nose in fuselage center, that is, at 38.6 percent of the maximum wing chord. The results of the tests made at v = 30 m/s air speed are provided with the usual correction's for open jets with elliptical section for drag and angle of attack (reference 1).

The test data are shown in Figure 1 along with a reference measurement of the model without brakes. The additional drag, referred to the brake area, is shown in Figure 2 (denoted with Δc_{wB}).

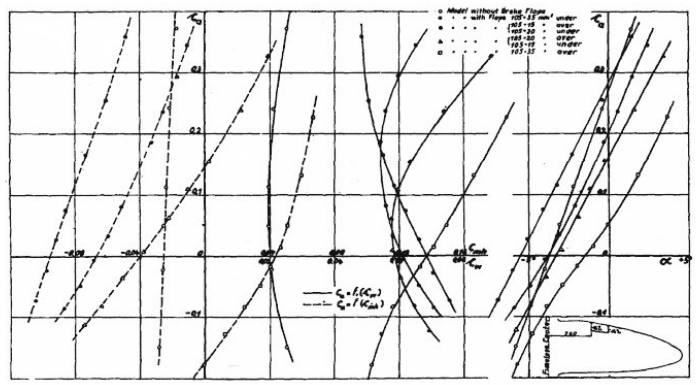


Figure 1.– Diving brakes mounted on top and under the wing.

1. Drag. The minimum profile drag of these arrangements is located at widely varying C_a values. Hence the polars, viewed from $c_a = 0$ in direction of ascending c_a values, present entirely different aspects.

While the drag increases continuously with the brakes disposed on the "upper surface only," there still is a considerable loss in braking effect with the brake mounted on the "lower surface only." Of the drag increment existing at $c_a = 0$ only 55 percent remain at $c_a = 0.3$.

This phenomenon is noteworthy, because of the marked decrease in braking effect attending a pull-out from a dive with brake flap extended on the lower surface. It is plainly visible in Figure 2.

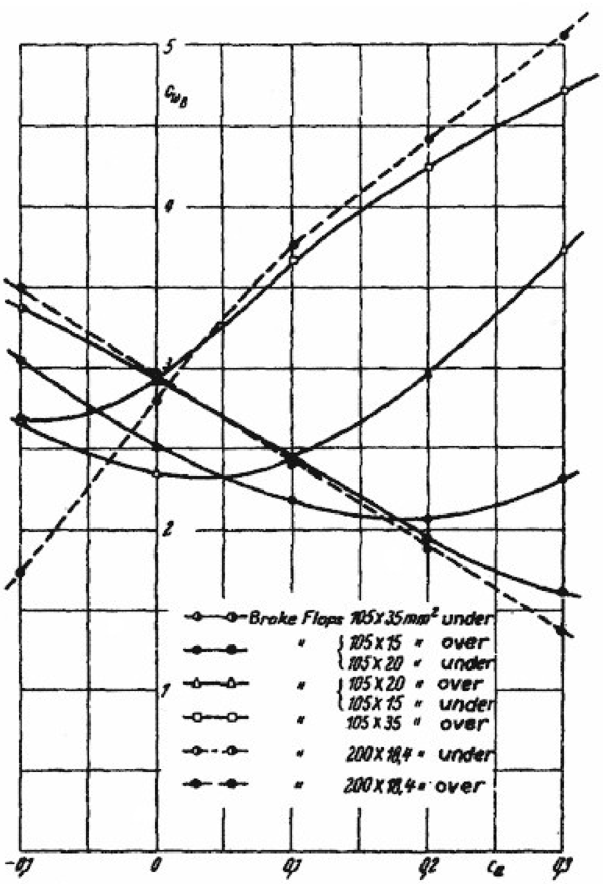


Figure 2.– Braking effect of diving brakes mounted on top and under the wing; effect of mounting at different positions.

An unusual feature is that the drag coefficients of the brakes assume such high values. Those of the same aspect ratios freely exposed give drag coefficients of the order of magnitude of 1.1 to 1.4 (reference 2). However, it is entirely comprehensible that a multiplication of drag is obtainable by mutual effect between brake and wing, especially if the former is located on top of the wing.

2. Variation of Longitudinal Moment. These variations are very considerable. To estimate the approximate magnitude of change of normal force coefficient necessary at the horizontal toil surfaces which balances the produced change in longitudinal moment, we put

$$\Delta c_n H = Ftq / F_H t_H q_H \, \Delta c_{mo}$$

(Subscript H denotes the horizontal tail surfaces.)

In our example it is:

$$\Delta c_n H. \approx 3 \Delta c_{mo}$$

Extension of the brake area with arrangement "flap below only" produces a variation in diving moment of $\Delta cmo = -0.07$ and of $\Delta Cmo = +0.07$ With arrangement "flap above only." Hence the normal force coefficient on the horizontal control surface must change by about $\Delta CnH = \pm 0.21$ which in any event requires an elevator deflection of about 6° on the assumption of $dc_n H / d\alpha = 4$ and $d\alpha / d\beta = 0.5$.

Noteworthy also is the sign of the moment variation, because it is contrary to natural expectation: A brake flap under the wing produces a tail heavy rather than a nose heavy moment. This is solely because of the change in pressure distribution on the profile, as will be explained elsewhere.

Still another noteworthy feature is the change of direction of the longitudinal moment line ($Cm = f (c_a)$ in the illustration) which is especially marked on the arrangement "brake flaps below only." Referred to maximum chord at mid—center of the wing there is in this instance a 11.3 percent chordwise backward displacement of the neutral point. The other moment lines of this picture are not rectilinear; hence the definition of the neutral point, that is, of the point in the airplane referred to which the longitudinal moment becomes independent of the angle of attack, does not apply to it.

3. Zero Lift Direction. The change in zero lift direction, so important for the visibility conditions, amounts to ±2 °with this arrangement. Notable also is the change in $dc_a / d\alpha$ which drops from 4.1 without brake to 2.8 with brake flaps, or almost by a third.

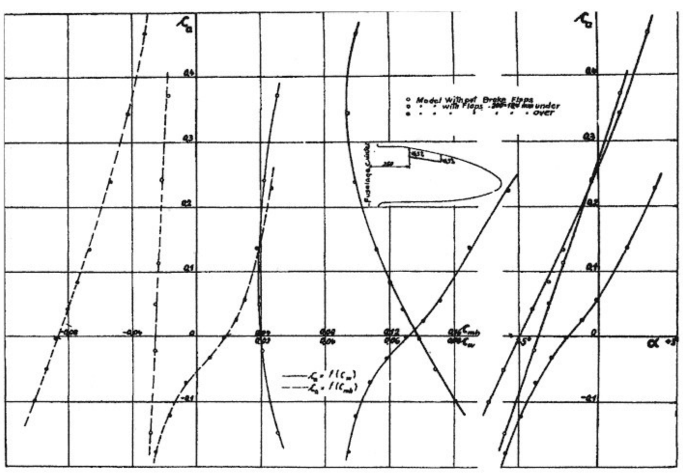
As to the advantages of mounting the brakes on top or under the wing it may be briefly stated that at vanishing lift the additional resistances are equal. For takeoff, that is, for increasing c_a, the mounting on top of the wing would be more favorable since here, in contrast to mounting it under the wing the additional resistance still increases. Nevertheless one is forced to mount the brake under the wing because there only the rotation of the zero lift direction is in negative, that is, visibility improving, direction. Added to that, the diving moment is decisive for the strength of the wing against distortion. But, in turn, this is decreased only when the brake flap is mounted under the wing; the change of moment due to the brake acts, in this instance, unloading on the diving moment. One of the investigated intermediate solutions with brakes fitted on top and under the wing is constructively much more difficult to achieve.

b. Effect of Brake Span and Lateral Position

The employment of brake flaps conditions the appearance of a powerful wake behind the brake. The modern airplanes are fitted with some sort of trailing edge flaps: which are struck by the dead–air region. One will attempt to so dispose the span of the brakes that only one of these is struck. But, inasmuch as a definite braking effect is to be achieved, a certain size is required.

The problem of effect of brake aspect ratio is therefore of as much interest as that of their lateral position.

The results Of such measurements are. Shown in Figures 3 and 4. Figure 3 (below) is for brakes mounted on top and under the surface. In figure 4, where the brake is mounted under the wing, the effects of three different arrangements are visible:



1. Two aspect ratios in fuselage vicinity.
2. Two aspect ratios approximately in the center of the semi-span.
3. Effect of the lateral position of brake.

The additional resistances referred to brake area are shown in Figure 5.

Comparing Figure 1 with Figure 3, the result is qualitatively the same. Quantitatively the additional resistance is also of the same order of magnitude (see Fig. 2) but the variations in zero lift direction and in diving moment have decreased somewhat.

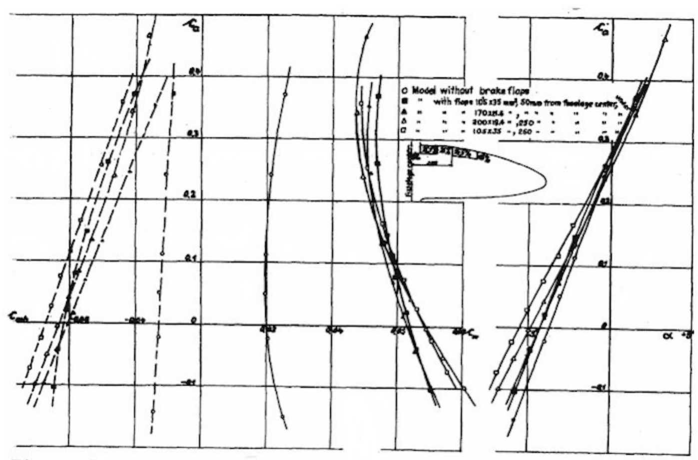


Figure 4.– Brakes of different spans and at various positions.

The data of Figures 4 and 5 show very little difference. Neither the aspect ratio nor the lateral position has any appreciable effect on the additional resistance. On approaching the fuselage, like for an enlargement of the aspect ratio, the variation in zero lift direction and in the diving moment decreases. But the effects are so small compared to constructive considerations and wake effect problems, that they are not decisive.

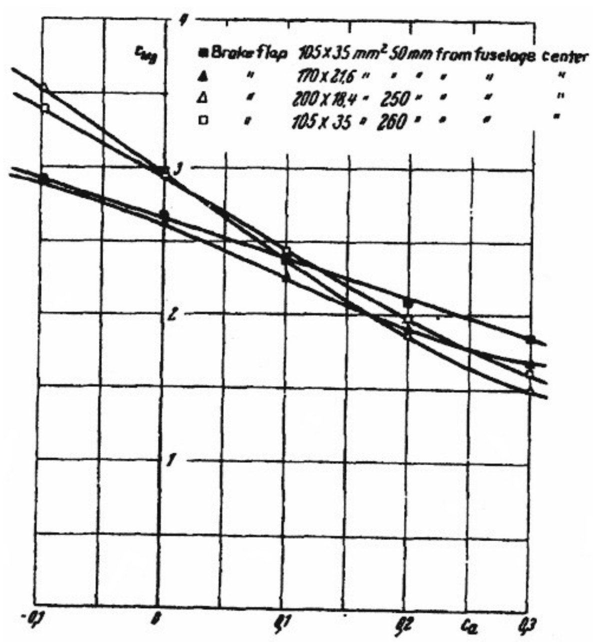


Figure 5.– Braking effect with brakes of different spans and positions.

AVAILABLE PLANS & REFERENCE MATERIAL

Tailless Aircraft Bibliography

My book containing several thousand annotated entries and appendices listing well over three hundred tailless designers/creators and their aircraft is no longer in print. I expect *eventually* to make available on disc a fairly comprehensive annotated and perhaps illustrated listing of pre-21st century tailless and related-interest aircraft documents in PDF format. Meanwhile, I will continue to provide information from my files to serious researchers. I'm sorry for the continuing delay, but life happens.

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Books by Bruce Carmichael:
Personal Aircraft Drag Reduction: $30 pp + $17 postage outside USA: Low drag R&D history, laminar aircraft design, 300 mph on 100 hp.
Ultralight & Light Self Launching Sailplanes: $20 pp: 23 ultralights, 16 lights, 18 sustainer engines, 56 self launch engines, history, safety, prop drag reduction, performance.
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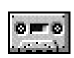
Capistrano Beach, CA 92624 (949) 496-5191

VIDEOS AND AUDIO TAPES



(ed. – These videos are also now available on DVD, at the buyer's choice.)

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).
Cost: $8.00 postage paid
Add: $2.00 for foreign postage

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.
Cost: $10.00 postage paid
Add: $ 2.00 for foreign postage

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.
Cost: $8.00 postage paid
Add: $2.00 for foreign postage

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.
Cost: $5.00 postage paid
Add: $1.50 for foreign postage

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".
Cost: $8.00 postage paid in US
Add: $2.00 for foreign postage

VHS of Robert Hoey's presentation on November 20, 1999, covering his group's experimentation with radio controlled bird models being used to explore the control and performance parameters of birds. Tape comes with a complete set of the overhead slides used in the presentation.
Cost : $10.00 postage paid in US
$15.00 foreign orders

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BLUEPRINTS – Available for the Mitchell Wing Model U-2 Superwing Experimental motor glider and the B-10 Ultralight motor glider. These two aircraft were designed by Don Mitchell and are considered by many to be the finest flying wing airplanes available. The complete drawings, which include instructions, constructions photos and a flight manual cost $250 US delivery, $280 foreign delivery, postage paid.

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