No. 389 JANUARY 2019

T.W.I.T.T. NEWSLETTER

French ace George Mix Madon, who had 41 dogfight victories in World War I, poses by the futuristic Simplex Arnoux racer of 1922. The pilot's vision forward and down was severely restricted by the Lamblin radiator perched on top of the fuselage and the expanse of the Arnoux "flying plank" Wing.

Source: http://www.century-of-flight.freeola.com/Aviation history/flying wings/europe_interwar.htm

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., **1901** means this is your last issue unless renewed.

THE WING IS THE THING (T.W.I.T.T.)

T.W.I.T.T. is a non-profit organization whose membership seeks to promote the research and development of flying wings and other tailless aircraft by providing a forum for the exchange of ideas and experiences on an international basis. T.W.I.T.T. is affiliated with The Hunsaker Foundation, which is dedicated to furthering education and research in a variety of disciplines.

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

President: Andy Kecskes **(619) 980-9831**
Treasurer:
Editor: Andy Kecskes
Archivist: Gavin Slater

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

E-Mail: twitt@pobox.com
Internet: http://www.twitt.org
Members only section: ID – **20issues10**
Password – **twittmbr**

Subscription Rates: $20 per year (US)
$30 per year (Foreign)
$23 per year US electronic
$33 per year foreign electronic

Information Packages: $3.00 ($4 foreign)
(includes one newsletter)

Single Issues of Newsletter: $1.50 each (US) PP
Multiple Back Issues of the newsletter:
$1.00 ea + bulk postage

Foreign mailings: $0.75 each plus postage

Wt/#Issues	FRG	AUSTRALIA	AFRICA
1oz/1	1.75	1.75	1.00
12oz/12	11.00	12.00	8.00
24oz/24	20.00	22.00	15.00
36oz/36	30.00	32.00	22.00
48oz/48	40.00	42.00	30.00
60oz/60	50.00	53.00	37.00

Gatherings are held on the third Saturday of every odd numbered month, 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).

TABLE OF CONTENTS

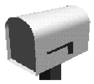
PRESIDENT'S CORNER

This month I decided to complete the BKB-1 article rather than cut it up any further. I hope everyone has enjoyed reading Stefanie's translation that helps fill in some of the blanks that people may have had over the years.

Due to the length of the BKB-1 material I only had room for one more page of the Karl Wood's 1935 paper on aircraft design. I should be able to finish it up next month unless something else comes in from the members that requires attention.

Not much else to report this month. I hope everyone had a safe and sane New Years celebration. We had some fireworks in our neighborhood, but it was otherwise a quite transition between years.

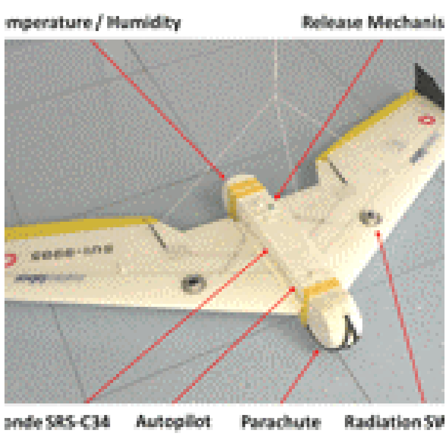
Andy



LETTERS TO THE EDITOR

Hello Andy,

Flying wings have attracted scientific and engineering attention in an area that I'd thought of a few years ago—returnable, reusable radiosondes. One student group has developed a steerable radiosonde that uses small electric motor-driven reels to selectively reel in and pay out the radiosonde parachute's shroud lines (see: http://phys.org/news/2018-07-clever-recover-weather-balloon-radiosondes.html). Others have developed a small, swept flying wing return radiosonde (see: www.google.com/search?source=hp&ei=yDI2XJvVFcHg8AOQjaiYDg&q=return+glider+radiosondes&btnK=Google+Search&oq=return+glider+radiosondes&gs_l=psy-ab.3...1223.16254..18652...0.0..0.145.3214.0j26......0....1..gws-wiz.....0..0j35i39j0i67j0i131j0i20i263j0i22i10i30j0i22i30j33i160.-NaYS0-4FjI). Technically, it's a swept-wing tailless glider, with wing tip-mounted vertical stabilizers and a rectangular-section fuselage, which houses the radiosonde instruments, and:



Someone—I forget his name *(ed. - Probably Al Bowers)* —from the NASA Dryden Flight Research Center once remarked, in a talk he gave to a T.W.I.T.T. meeting, that "The flying wing is a persistent weed in the garden of aeronautics." If that return radiosonde glider becomes ubiquitous, his statement will have become far more abundantly true (not just a weed, but the countless airborne seeds of the Dandelion) than he could have guessed! :-)

I hope this information will be interesting.

Jason Wentworth

CANADIAN TAILLESS SAILPLANE – BKB-1

Presented Mar 10, 1961 by Stefan K. Brochocki and George Adams to McGill University, Fluid Dynamics Symposium, by invitation of Professor B. Newman Transcribed by Stefanie Brochocka from original hand-written document

Aerodynamic Characteristics of the Wing

Controllable flight at low speeds and in tight turns demands care in selection of airfoils and wing planform. The choice of low drag sections possessing some degree of positive pitching moment is very limited. It is fortunate that the series of recently developed NACA low drag sections for use in helicopter blades conveniently fit the requirements.

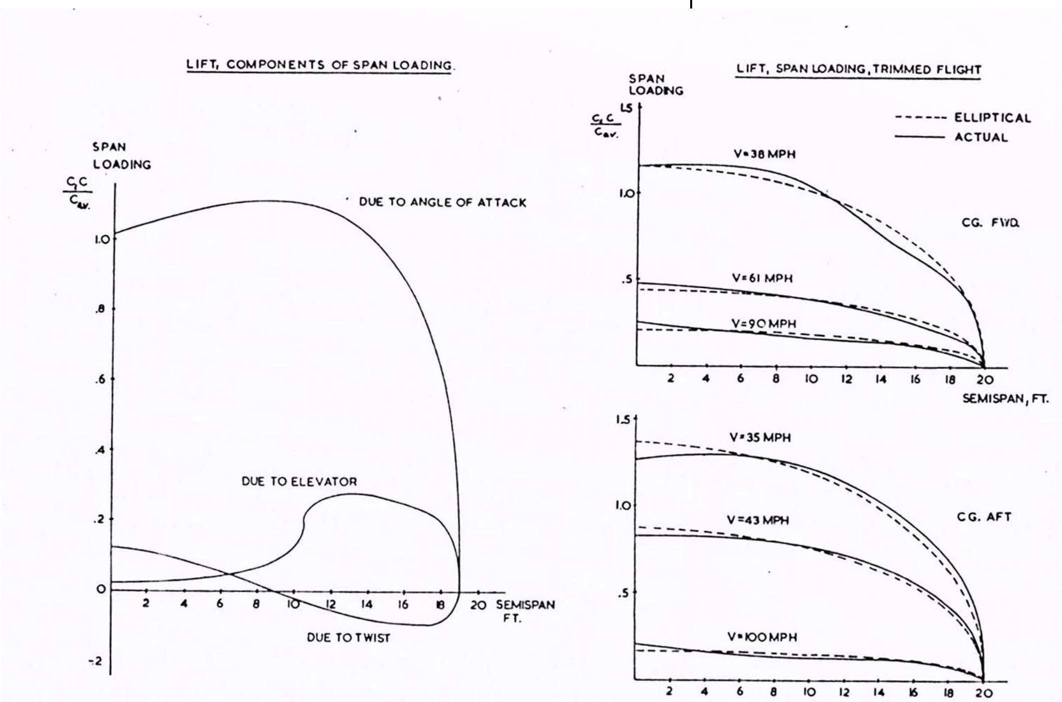
The chosen section is a 12% NACA 8-H-12, cambered to give low drag bucket at high lift coefficients, and reflexed to yield small a value of positive pitching moment. An additional characteristic is the constant, moderately high, maximum lift coefficient (for low drag sections), maintained throughout several degrees of incidence, even at Reynolds Numbers below one million. Curiously enough, the section seems sensitive to surface roughness for this type of airfoil.

With the span, aspect ratio, and sweep established, the remaining variables are the taper ratio and the twist. Weight economy favours highly tapered wings. For aerodynamic reasons, however, especially in conjunction with the swept wing, it is advisable to use large chords in the tip regions, thus ascertaining inboard location of the stall and its slow progression towards the tips.

Furthermore, this wing must be twisted to augment the sectional, nose-up, pitching moments for stability reasons. Un-tapered planforms therefore benefit by it, yielding nearly elliptical spanwise distribution with the minimum induced drag for the chosen aspect ratio.

Additional correction is necessary, of course, to maintain this lift distribution throughout the speed range. This correction is provided by the deflection of the elevators, located near the wing tips, necessary for trimming flight at speeds below or above that, corresponding to incidence at which the glider is trimmed with elevators neutral.

Spanwise lift distribution is affected by another type of loading resulting from aeroelastic deflection. It is known that a swept wing modifies its angle of attack distribution in proportion to its bending deflection. This distribution could be embarrassing; however, in this case it is considered insignificant in view of the low sweep angle and high stiffness of this wing. These individual contributions to span loading are calculated using the Heissinger method and shown below. *(ed. note: Jim Henry, Stefan's supervisor at Canadair and his longtime friend, maintains that the wing was not quite as stiff as Stefan thought. Jim felt it was more aero-isoclinic than had been hoped. That debate is unresolved. Certainly, this was a fatal flaw in Kasper's Bekas, his longer-span adaptation of the BKB. The spar was not strengthened proportionally to accommodate the extra 10 ft. of wingspan leading to uncontrollable flexing and its eventual crash.)*



Thus, by combining the wing planform with twist, elevator geometry, and deflection, nearly optimum span loading can be maintained throughout the speed range.

The profile of the nacelle was chosen to give least disturbance to the flow over the wing. The maximum cross-section of the nacelle is thus well-aft of the wing maximum thickness with the top, forward part of the airfoil completely exposed.

Drag Control

Low drag was pursued throughout the design by reductions of the wetted areas, use of geometry conducive to laminar flow, the above-mentioned induced drag control, and reduction of possible leaks at a cost of certain minor inconveniences.

It can be seen that the spanwise distribution of lift here, identical with the distribution of lift coefficient due to constant chord, gives the desirable center section wing stall, since the lift coefficient decreases toward the wing tips.

This wing is very conservatively done *(later-inserted comment by author (?) says "overdone")* in that respect, with the possibility of somewhat rapid increase of profile drag associated with the high lift coefficients which these sections attain. More judicious selections of airfoils in that region may eventually be required.

Longitudinal Stability and Control

As it was mentioned before, the configuration yields a positive aerodynamic pitching moment and requires a center of gravity located forward of the aerodynamic center. The degree of static longitudinal stability varies with the location of the c.g. with respect to the aerodynamic center. The feature of this sailplane is that the pilot's position coincides with the c.g. location of the empty glider; the inevitable large variations of weight have no effect on the degree of static stability. It can only be changed by the use of ballast whenever necessary.

The design range of the c.g. is 5% of the chord, minimum static margin being 5%. No calculations of the dynamic stability were attempted. It should prove to be of a satisfactory order, providing that the wing stiffness is up to expectations.

The longitudinal control is attained by means of the wing tip located elevons. These are simply hinged surfaces, true in contour to the basic airfoil and aerodynamically unbalanced. Their movement consists of the symmetrical deflections when used as elevators, with anti-symmetric deflections superimposed when used as ailerons.

Expected deflections will be predominantly due to elevator use since the lateral control is almost completely attained by use of the rudders, rendering ailerons virtually unnecessary.

Directional Stability and Control

The directional stability is attained chiefly by avoiding destabilizing orientation of the components in the chosen configuration. Thus, the directional stability arising primarily from wing sweep is augmented by locating most of the lateral area of the nacelle aft of the center of gravity. For this reason, the nacelle carries considerable dorsal area.

A small contribution to stability is also obtained from the wingtip rudders, also located somewhat aft of the c.g. These rudders are very small, winged surfaces of extremely small aspect ratio to avoid their stalling and buffeting when deflected almost normal to the airflow. These rudders have horn balances of large proportions arranged in such a way as to spoil the airflow over the wing at larger deflections. Thus, their action overlaps the function of the ailerons rendering them unnecessary, since coordinated turns are obtained by the use of rudder only.

The rudders are not interconnected; thus, it is possible to use them differentially for direction as well as glide path control. Their full simultaneous deflection, however, is not sufficient to limit terminal velocity of dive to the desired limit.

Structure of the Prototype

From the preceding description of the aerodynamic features, it can be seen that the design achieves great simplicity of form which is not completely matched as far as the internal construction of the prototype is concerned. There is today a great variety of manufacturing. Furthermore, the choice of structure and detail solutions depend heavily on the numbers anticipated for production. An unproven configuration did not warrant additional effort in that direction. With some exceptions, a conventional type of sailplane construction is employed.

The wing consists of a multi-laminated box spar, a leading edge molded of plywood, and conventional girder-type ribs which are closely spaced to maintain the wing contour with sufficient accuracy for maintenance of laminar flow.

The covering consists of sheets of plywood spliced to the leading edge and joined at the trailing edge. The plywood is birch, imported from Finland, and diminishes in thickness from 2.5 mm at the root to 0.8 mm at the tip. This method gives a very rigid leading edge, does away with difficult bending of large sheets around the nose, and reduces the chord-wise step at spar where, normally, the fabric starts. Resulting is a stiff if somewhat heavy wing. Weight penalty was agreed to as a price for maintenance of laminar flow without resorting to exotic types of structure.

The nacelle structure consists essentially of a heavy bulkhead forward and aft of the cockpit, designed to take landing loads. These bulkheads are interconnected and faired by a light, plywood-covered structure.

The ease of assembly and dismantling is an important feature of any sailplane. Here it can be accomplished by 3 men in a couple of minutes by bringing wings and fuselage together into contact and inserting a single tapered pin through the spar root fitting. This action automatically couples all the control circuits.

The prototype is equipped with small, oval wheels sprung with the skid. This apparatus permits safe landings in rough terrain as well as easy maneuvering on the runners.

Teething Troubles

The BKB-1 was completed in the spring of 1959. Although we all belonged to the Canadair Gliding Club operating from Hawkesbury, we decided to join the Gatineau Gliding Club, operating from Pendleton, for the convenience of permanent runways and hangars available there. Thus we committed ourselves to 90 mile trips for the nearest future.

After the final D.O.T. inspection, preceded by submission of the full aerodynamic and stress report and the set of drawings, an experimental license was obtained, which entitled us to commence the flight-testing program. Prior to the taxiing test, forward c.g. location was ascertained by actual balancing of the glider with the pilot, parachute, etc.

I must confess that first attempts of getting airborne, while towed by a car along the longest runway, were rather disappointing. In spite of attained speed, well above that needed for take-off, and the stick held fully back, the thing would just bump along, with apparently no intention of leaving the ground. The cause was easy to trace. The attachment point of the towline was located high, just under the wing near the center of gravity. This works fine once airborne, however while on the ground, a nose-down moment is created, sufficient to prevent the take-off. The change to a tow hook located at the nose cured this trouble completely.

The glider was flown several times near the ground for familiarization with controls. It appeared to be easily controllable directionally by rudders even below flying speed. At this stage however, a disconcerting response to the elevator movement was observed. A quite drastic response occurred on the first aero-tow, triggered by a sudden loss of the apparently unsecured canopy during take-off. The ensuing series of uncontrollable bumps proved the impact-resistance of the glider-pilot combination, as well as demonstrating the necessity of mass balancing of the elevons. Having eventually repaired the damages and made the elevons completely mass-balanced, no trace of similar trouble has occurred since.

Even at this early stage, there was an indication of difficulty in trimming within the design speeds. The glider persistently required varying amounts of pull at the stick even with the tabs fully assisting. A number of flights were devoted to tracing the cause and to eventual elimination of the symptoms. The original elevons, used at that time, conformed to the contour of the wing airfoil which had a reflex near the trailing edge. This resulted in unfavourable hinge moments which caused a dive when the stick was released. I admit that the opposite behavior was expected from aerodynamically balanced controls. These original elevons are now replaced by the new, flat-sided control surfaces, resulting in completely satisfying behavior.

Flight Tests

The BKB group is fortunate in having had two able and venturesome pilots performing these initial flights. The first group of aero-tow flights was completed in 1959 by Mr. (Dr.) David Marsden, sailplane and jet pilot, and aerodynamicist at that time employed by the National Research Council at Ottawa. I quote here from his report presented to the D.O.T.:

"After a considerable amount of ground testing, using car tows, and some minor modifications, the BKB-1 took to the air on its first aero-tow on the 10th of October 1959. During the following weekends up until the 15th of November, 10 flights were made for a total of 4 hrs. 15' in the air.

The BKB-1 handled well in the air both on tow and in free flight. First impressions were of sensitive, rapid response to elevator control, and surprising distances covered due to good penetration.

Gentle turns were attempted first, then the steeper ones. Good, coordinated turns could be made but strong rudder control was required to overcome adverse yaw. Ground tests had shown the directional control, by means of wing tip drag rudders, to be excellent.

The ailerons were made to continue the wing airfoil section including the reflex trailing edge. These acted as a fixed trim tab which gave a rather unpleasant nose down stick force which could not be trimmed out.

Fight tests were continued without correcting this condition as time before the end of the season was limited and more flight data would be a useful basis for changes.

Elevator control was sensitive with almost instantaneous response, a characteristic of tailless configuration due to low pitching moment of inertia and low aerodynamic damping in pitch.

Roll response was lively with an estimated 4 seconds to roll through 90 degrees at 50 miles per hour airspeed.

Directional stability was about normal, disturbances set up by kicking rudder or suddenly releasing the full rudder were highly damped.

Drag rudders used as spoilers were not as effective as might have been desired. A very steep approach could be made by side slipping, a maneuver which is safe to use on approach to landing because of the way the BKB returns smoothly to unyawed flight.

The aircraft proved to be easy to land. Good landings were made over the wide range of touchdown speeds with no tendency to porpoise or nose over.

The stalling characteristics were not fully explored on these preliminary flight tests. When the stall was *approached by gently reducing airspeed, only a controlled mush resulted.*

Tufts showed separation beginning at the wing root, near the trailing edge, and spreading spanwise.

The BKB group have been successful in building a sailplane which is easy to handle and rig, and, except for the difficulty with trim to be remedied, has satisfactory handling characteristics.

Performance tests have not yet been done, but the aircraft has noticeably better penetration than the medium performance sailplanes in the Olympia II, Schweizer 1-26 class."

---

180 *TECHNICAL AERODYNAMICS* [CHAP. VIII

the combined yaw and roll induce further yaw and roll. This is a *spin*. Satisfactory airplanes will recover from a spin by pushing forward on the control stick, giving opposite rudder, and pulling out of the resulting dive.

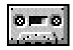
Quantitative analysis of forces and motions during a spin is beyond the scope of this text; a reasonably brief and simple treatment has been presented by J. M. Gwinn.[1] Gwinn's conclusions are quoted below. Other authorities disagree with Gwinn on a number of the points here listed, but this summary is believed to be practical if not exact, and verification or disproof of these items would be a valuable line of further research.

1. Wing loading is one of the major factors in uncontrolled spins.
2. The stalling of the horizontal tail surfaces is the distinguishing factor in uncontrolled spins.
3. For speedy recovery from uncontrolled spins the largest possible controlled variability in vertical fin areas is desired. This means a large rudder of high angular throw and a small fin. Unfortunately this combination also hastens entry into a spin.
4. If sufficient fin area in connection with a small rudder is put on to prevent entry into a spin, recovery from any spin produced by accidental circumstances would probably be impossible.
5. Center-of-gravity location is a secondary factor, being of more importance in the lighter wing loadings. [See Fig. 161.]
6. An autorotative couple is necessary both for starting a spin and for its continuance, there being damping couples due not only to vertical fin areas but also to the lift force.
7. The shape of the normal force-coefficient curve of the cellule is not a major factor in producing an autorotative couple, due to the tendency of the spin axis to shift and thereby eliminate the couple from this cause.
8. The major source of autorotative couples is the variation in slope of the resultant air force relative to the normal to the wing chord at varying angles of attack. Since this variation is greater on high-lift airfoils than on low-lift airfoils, high-lift airfoils have greater autorotative couples at higher mean angles of attack.
9. It is possible to recover from a spin at low altitude from which it might be impossible to recover at high altitude.
10. There are two possible positions of equilibrium in a spin for every center-of-gravity position, and both of these spins can be obtained if the wing will furnish the required autorotative couples in the two positions.

[1] *Trans.* ASME, 1933.

AVAILABLE PLANS & REFERENCE MATERIAL

VIDEOS AND AUDIO TAPES



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

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 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

FLYING WING SALES

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 $140, postage paid. Add $15 for foreign shipping.

U.S. Pacific (559) 834-9107
8104 S. Cherry Avenue mitchellwing@earthlink.net
San Bruno, CA 93725 http://home.earthlink.net/~mitchellwing/

COMPANION AVIATION PUBLICATIONS

EXPERIMENTAL SOARING ASSOCIATION

The purpose of ESA is to foster progress in sailplane design and construction, which will produce the highest return in performance and safety for a given investment by the builder. They encourage innovation and builder cooperation as a means of achieving their goal. Membership Dues: (payable in U.S. currency)

United States	$20 /yr
Canada (Air Mail)	$25 /yr
All Other Countries (Air Mail)	$35 /yr
Electronic	$10 /yr
U.S. Students	Free if full time student as defined by SSA)

Make checks payable to: Experimental Soaring Association, & mail to Murry Rozansky, Treasurer, 23165 Smith Road, Chatsworth, CA 91311.