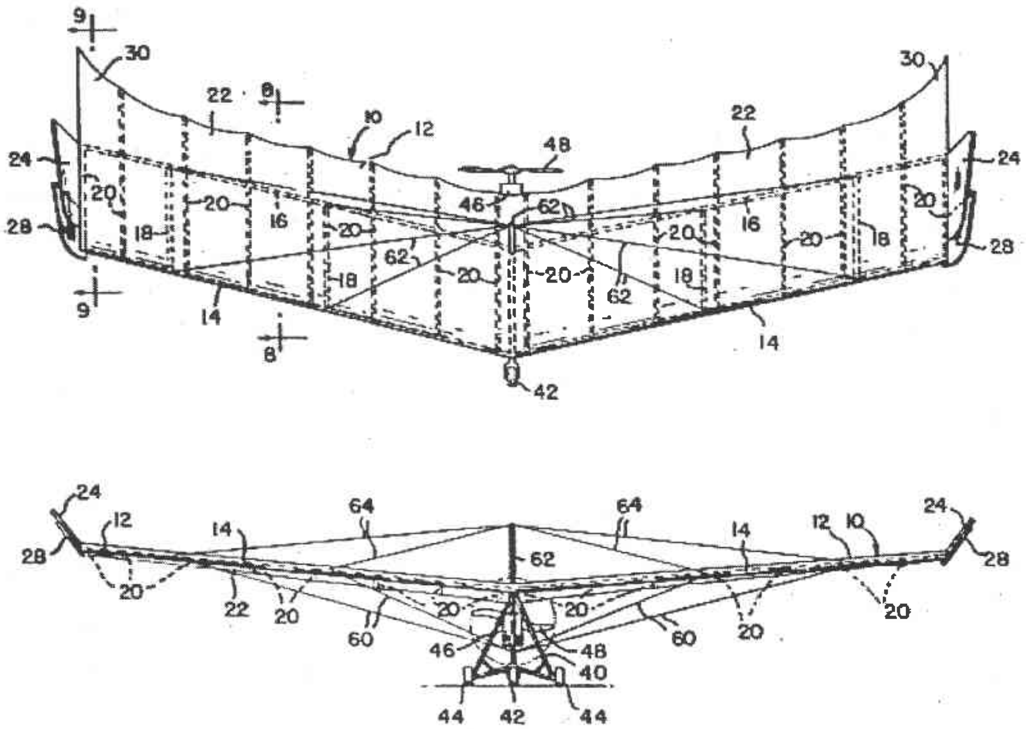
No. 150 DECEMBER 1998

T.W.I.T.T. NEWSLETTER

Flying Wing Aircraft
Inventor: Witold A. Kasper
Patent #: 4,781,341
November 1, 1988

An ultralight aircraft having a generally rectangular swept-back, single-surfaced wing which is formed by fabric mounted on exposed spars and ribs, with a reflex profile to provide pitch stability which is further augmented by horizontal stabilizers projecting rearwardly from the wing adjacent the tips. The rudders tilt upwardly and outwardly in a dihedral configuration to provide roll stability. Pitch control is made by shifting the pilot's body forward and back. A chassis mounted beneath the wing supports a pilot and gasoline engine driving a pusher propeller.

(See inside for more.)



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

HAVE A JOYOUS HOLIDAY SEASON

AND A HAPPY NEW YEAR

The number to the right of your name indicates the last issue of your current subscription, e.g., **9812** means this is your last issue unless renewed.

Next TWITT meeting: Saturday, January 16, 1999, beginning at 1:30 pm at hanger A-4, Gillespie Field, El Cajon, CA (first hanger row on Joe Crosson Drive - Southeast side of Gillespie).

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

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

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

President:	**Andy Kecskes**	**(619) 589-1898**
Vice Pres:	**Bob Chase**	**(818) 336-5485**
Secretary:	**Phillip Burgers**	**(619) 563-5465**
Treasurer:	**Bob Fronius**	**(619) 224-1497**
Editor:	**Andy Kecskes**	

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

(619) 596-2518 (10am-5:30pm, PST)
(619) 224-1497 (after 7pm, PST)
E-Mail: twitt@home.com
Internet: www.members.home.net/twitt

Subscription Rates: $18 per year (US)
$22 per year (Foreign)

Information Packages: $2.50 ($3 foreign)
(includes one newsletter)

Single Issues of Newsletter: $1 each (US) PP
Multiple Back Issues of the newsletter:
$0.75 ea + bulk postage

Foreign mailings: $0.75 each plus postage

Wt/#Issues	FRG	AUSTRALIA	AFRICA
1oz/1	1.00	1.00	1.00
12oz/12	5.00	6.75	5.00
24oz/24	9.00	12.25	9.00
36oz/36	14.00	19.50	14.00
48oz/48	16.75	23.00	16.75
60oz/60	21.75	30.25	21.75

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, east side of Gillespie).

TABLE OF CONTENTS

PRESIDENT'S CORNER

I would like to thank John Mitchell for coming down and giving us a personal insight on Witold Kasper. Also, thanks go to Bob Fronius and Gavin Slater for going that extra mile and getting the KasperWing moved from Brown Field up to the hanger in time for the meeting. It was a welcome addition and it appeared many people were quite intrigued by it and the Sachs rotary engine mounted on the rear of the pilot cage.

Last month I published a listing of the Kasper material we had in the library. What I didn't get a chance to include, due to space limitations, were the projected costs to reproduce and mail each one. This month I will include this information in the classified section which I have to reduce anyway in order to get all of November's meeting and the last part of Al Bowers' presentation into this newsletter. If you want more than one item, simply add the amounts together and send in that amount.

With all of the backlog in minutes completed this month, I will use the January issue to publish a new membership roster. I will be changing the format to put each member on a single line, but will still sort them by location so you can quickly see who is in your area without having to go through the entire list.

In order to ease the shock, it looks like we will be raising the subscription rate after the first of the year. This is partly due to the increase in postage rates and partly due to an increase in printing costs that hit us a few months ago. When coupled together our slim margin of revenues over costs basically went away.

I would like to wish everyone a very Happy Holiday Season and a Merry New Year. I can see from other sources that it is going to be a good year for flying wing enthusiasts, so don't go away, at least not yet.

Andy

JANUARY 1999 PROGRAM

As of publication date it looks like we will have **Rick Keller** of the local EAA Chapter 14 talking to us about aerodynamic drag. From our sources who have heard him speak, this should be a good program to kick off the new year. Please mark your new January calendar right now so you don't forget.

MINUTES OF THE NOVEMBER 21, 1998 MEETING

Andy opened the meeting welcoming everyone on a simply gorgeous day in Southern California. We started with a round-robin of introductions since there were a number of people in the audience that hadn't been here before. Of note were Larry Witherspoon and Bill Hinote,long time members who were able to finally attend their first meeting. We were glad to see them and hope they will find opportunities to come back in the future (long distance travel not withstanding).

Bill Hinote mentioned that he had a handout for anyone who wanted one on his project called the Alphagrif. It embodies the latest in materials and aerodynamic technologies to create an ultra-efficient airframe. His goal is to create an safe and easy to build aircraft for the kit-aircraft industry. (ed. - I will publish more on this in future newsletters as room and graphics permit.)

Paul Ross, who works for Alturair which owns the Kasper 1-80 ultralight flying wing sitting outside the hanger, introduced himself and told us a little bit about the aircraft which was purchased about 15 years ago to test the Sachs single-stage rotary engine being used for power. The engine puts out about 23 hp at 6000 rpm and 21.7 hp at 4800 rpm and was originally built for snowmobiles. Engine life is about 3000 hours and uses a 25:1 mixture on the fuel/oil. As soon as they get the matched set of belts necessary to drive the propeller, they plan on getting the aircraft back in the air.

We watched a short video of the Centurion during its second test flight at Edwards AFB (this was footage taken from a recent CBS news broadcast). This is the next generation of the Pathfinder and is designed to fly at altitudes of 100,000 feet for several months at a time doing research and other types of atmospheric observations, like hurricane watch, etc. This is another product of Paul MacCready's AeroVironment company and is an example of flying wing technology taken to the extreme of technological development.

With no other contributions from the group, Andy introduced John Mitchell who would tell us all he knew about Witold Kasper and his revolutionary aircraft.

John began by explaining how his father had met Kasper about sixteen years ago. His father had been in commercial aviation and switched to commercial electronics with Bell Helicopter in Texas. He began looking for something fun do to on weekends and decided that flying and selling ultralight aircraft was just the thing.

After looking through brochures he decided to take John's brother to Issaquah, Washington, to meet Witold Kasper and discuss Kasper's ultralight designs. They were also met by Steve Grossruck who was assembling a KasperWing 1-80 ultralight. Steve ultimately gave them a demonstration of the aircraft's performance including the famous "mush mode" of descending. John's father described it as a guy who comes in over the field at 200', throttles back and gets partially out of the harness to shift the CG as far back as possible. This puts the nose into a very high angle of attack and the aircraft begins a very high rate of decent. About 25' above the runway the pilot shifts his weight back forward, adds a little burst of power and settles softly onto the ground with about a 25' rollout. Although this was impressive, John's father didn't buy a Kasper wing since he really wanted something with full 3-axis control.

After hearing about all of this from his father, John read through Kasper's book (published by Meheen Corp.) and became fascinated with it. Kasper was born about 1907, got a degree in mechanical engineering in Switzerland in 1929, and in 1939 completed a degree in aeronautical engineering. Between 1936 - 1939, Witold was a member of the Polish soaring team, winning the Polish championship four years in a row. Also during this time he had designed several gliders as part of his love for mechanical and aeronautical engineering. An interesting story involved his desire to go home one weekend so he used one of the clubs gliders to fly back to his home town. Upon arriving the local airport manager asked were he had come from and after Kasper told him the manager said he had just flown abut 30 kilometers further than the current world record distance held by the Germans. Apparently Kasper really wasn't impressed by any of this since it was just a fun flight for him and records didn't interest him.

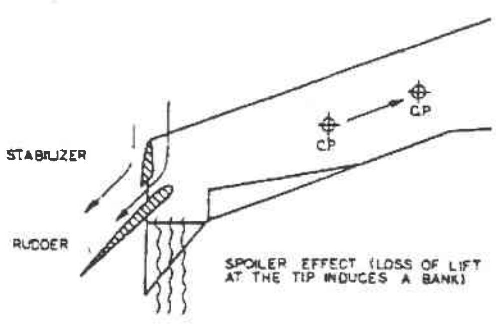
Witold was in the Polish Air Force at the start of WWII and managed to escape to Finland shortly after the war began. He indicated he acted as a Polish secret agent for the Finnish government for the next 5 years. After the war he immigrated to Canada and eventually moved to Seattle and went to work for Boeing in their low-speed aerodynamics section.

In the late 1940's he got the notion to design a tailless glider which eventually became known as the Bekas BKB-1. One of the things that concerned Kasper was the tendency of flying wings to tumble with often drastic results for the pilot and/or aircraft. He studied this problem very carefully and applied what he had learned through his study of birds and insects over the years. What he had discovered was that birds never stall although they can tumble. This was done through their ability to shift the CG and CP. He knew he had to design a wing that was stable but independent of forward airspeed.

Kasper looked at one of the most stable bodies around, a cone. If you drop a cone it always goes the same way, pointy end down, so this drogue stability was what he decided to apply to his glider design. Therefore, the BKB-1 was designed to have drogue stability in all three axes and, either through shear luck or very good engineering their center coincidentally converged in the middle of Kasper's head as he sat in the cockpit. This meant that any abrupt maneuvers, like tumbling, would have a minimal affect on the pilot's inner ear and be much less disorienting than in most other types of sailplanes.

John showed us a picture of the BKB-1 from Kasper's book, where it has a dark leading edge and lighter colored upper surface. Later on, Kasper painted the upper surface all silver and the bottom all black since he was exploring how to do controllable tumbling in a tailless glider. He did his backwards, which was different from what others had tried in the past where they pushed the CG as far forward as possible and then initiated a forward tumble. Kasper also theorized that if you didn't have enough control surface authority to overcome the inertia of the rotation, then you could not recover the aircraft from a tumbling maneuver.

His procedure for tumbling the BKB-1 started with a dive into a loop. At the top half of the loop he would push the stick forward to start the nose moving up then bring the stick to the full back position. This would then cause the glider to tumble backwards. The configuration of a 13 degree swept wing with control surfaces at the outer portions of the trailing edge gave him the moment arm necessary to create this "flight" condition and recover. The first time he did it it was disorienting and he slowly moved the stick forward which caused the glider to stop the tumble after loosing about 300' of altitude. In later flights he went from doing half tumbles to full revolutions and started timing them to determine the rate of rotation. He found that the glider was tumbling at 60 rpm, which was about 2 g's on his



body, but not having a great affect on his spatial orientation.

In another test flight he decided to try making it tumble forward by putting a 10 lb. weight in the nose to move the CG. Unfortunately, in the BKB-1 this also shifted the center point of the other axes and he ended up having a rotation point at about his hips. This caused him to have the extra g-forces on both his upper and lower body and, he commented after the experience that he felt a little taller.

The other unusual thing about the BKB-1 was the way in which on the controls worked. Kasper knew how to fly it and without having a 2-place version could only tell other pilots about the use of the control surfaces. The only times the glider crashed was when others were flying it. Contrary to a conventional glider, the BKB-1's controls couldn't be neutralized after making the initial input, but rather they had to be left in the desired position to prevent the glider's natural stability (the drogue/cone effect noted earlier) from

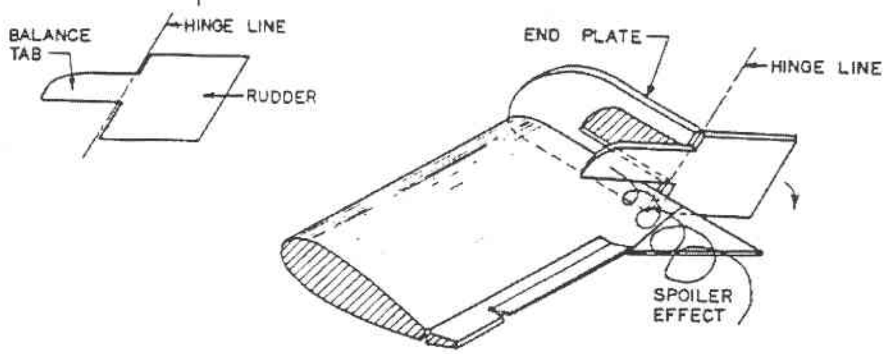


Fig. III-8

returning it to straight and level flight. This was disconcerting to many pilots and they would end up in a PIO situation and claim the aircraft couldn't be flown properly. Another part of the positive stability was provided by the 4 degrees of toe-in on the end plates.

It has good pitch stability since the wing is built flat and the airfoil doesn't have washout in the traditional sense. In order to achieve the affect of washout, he put a non-moving stabilizer at the trailing edge of the wing tip at an angle to create reflex on a wing with 4 degrees of incidence. The airfoil is a Wortmann from a helicopter blade and he was able to make them work with this new reflex stabilizer at the tips.

Kasper later took this one step further with the BKB-N where he installed his vertical spoilers on the end plates (see above and left). These were not meant to control the L/D, but rather to make the aircraft turn. With movement of the balance tap towards the inboard area, it causes a loss of lift over the stabilizer tap and the elevons, which are also mounted closer to the wing tip than in other flying wings. The outboard movement of the rudder portion of the spoiler causes drag and helps turn the glider in that direction. Kasper found he could get a fully coordinated turn by just using the appropriate rudder pedal. These spoilers could also be used for glide path control by pushing on both pedals at the same time, which caused a pitch up mush mode. Just before reaching the touch down point on a landing, the pedals could be released and the glider would automatically flare for a normal landing and roll out.

The other thing Kasper discovered was that this combination of controls actually created triple redundancy, since any one of them would allow him to fly the aircraft. He also noted that you really didn't need an elevon with his system since the vertical spoilers, when combined with just an elevator placed out towards the tips, was enough to adequately control the glider.

John apologized for not having the video tape of a Kasper wing actually tumbling in flight. However , he noted that the BKB-N was the first aircraft to be certified for a tumbling maneuver (this was in 1970). Kasper did many airshow demonstrations with the BKB-N and would finish with a tumble just before the landing.

To accomplish this feat, he would come down the runway on his "downwind leg" at about 300' inverted. He would then initiate the tumble by pushing the stick forward then pulling back, allowing the tumble to last until about 50' where he would pull out it and land into the wind for a normal touch down. The FAA commented that he had to do a 180 degree turn at the end of the runway to prepare for landing, which he wasn't doing during these early airshows. Kasper solved the problem by just coming in lower and, on reaching the end of the runway would do just a half tumble (180 degree turn) into a landing.

John related the story of how Kasper achieved his tumbling certification from the FAA. He did a touch-n-go at 80 mph right in front of the examiner then pulled up into a half loop of about 300' where he commenced the tumbles. First there was a half revolution backwards, then a half revolution forward followed by another half backward tumble. This left him in a position to accomplish a landing and roll out to put himself on the spot he originally hit on the touch and go. After such a display the FAA examiner had no choice but to issue a certificate.

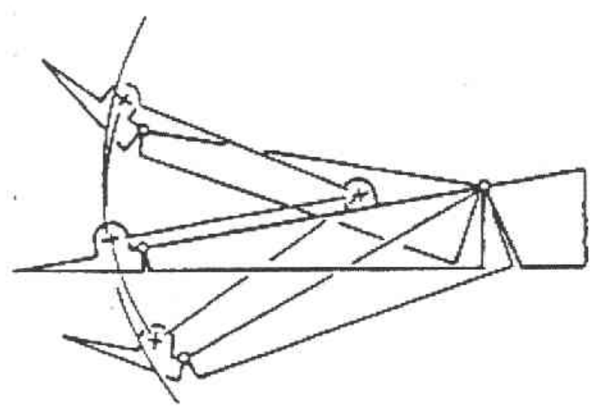
John showed a plan view of the BKB-1 that had some of the original dimensions. The span was 39', with about 155 sq. ft. of area, an aspect ratio of 10:1 and, an empty weight of 375 lbs. (although the plan view had this crossed out and a weight of 458 entered which may have been due to modifications or a heavy paint job).

The next slide covered some of the material presented in one of Kasper's books on the Bekas aircraft. Kasper commented that the glider had a different behavior than other types he had flown and it required learning a new flying technique. It couldn't be stalled even at a high angle of attack like 40 degrees to the relative wind, since in this attitude it would go into the "mush mode". John said that the video his dad had showed a tuft test session where the airflow was actually coming back over the wing. Kasper noted that lateral, longitudinal and directional control were affective and solid at airspeeds as low as 15 mph even though the calculated stalling speed was 42 mph. It didn't have any dynamic stability, but showed an uncanny stability returning to the original position within half an oscillation when disturbed by a gust or pilot input. This was the results of Kasper designing in the drogue stability mentioned earlier.

One of the more interesting comparisons made by Kasper was in relation to conventional aircraft. He said the a shift of the center of gravity causes a change in the static margin moment and it has to be compensated for by the balancing moment of the force on the horizontal stabilizer. This limits the allowable CG movement to about 12% of the MAC. For flying wings (John noted that Kasper treated flying wings as a separate class than his Kasper wings), because of the lack of horizontal stabilizers they are extremely sensitive to CG shift. For canards, he said the design allowed the greatest permissible movement of the CG in relation to the CP. And, for birds he noted that by moving their wings forward and back in the direction of the CG, the CP was always ahead of the CG.

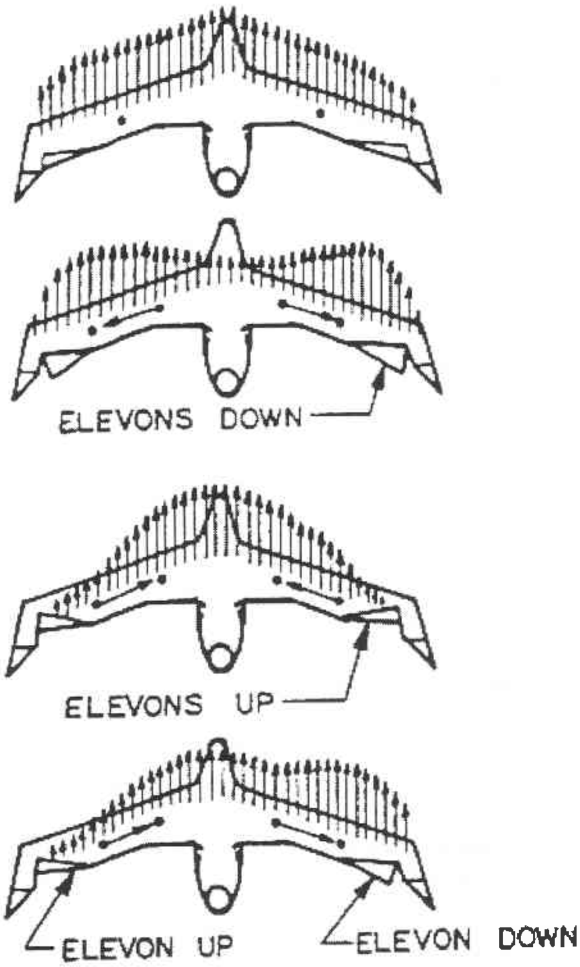
On the Kasper wing he commented, it was equipped with horizontal stabilizers at the wingtips. In the case of a shift of the CG, the stabilizer is moved up or down as in a conventional plane; however, it not only creates a stabilizing moment but also shifts the center of lift in the same direction as the CG movement, keeping the "static margin" constant. This permitted a CG shift of 24% MAC on the BKB-1A glider, which is about twice as much as in a conventional plane. It was obvious to John that Kasper had managed to solve many of the problems with flying wings through his design innovations.

The next couple of slides showed some of the control surfaces on the BKB-1 and one of these is shown here.



ABOVE: Adverse yaw is eliminated in the following manner: A special trim tab or flap is hinged to the trailing edge of each aileron. The connecting are between the wing and the flap is positioned to always move the flap up when the aileron is deflected. The tab remains neutral when the aileron is neutral. The ailerons have 1:5 differential in the up and down movement. The peculiar flap has an additional beneficial effect. When the elevons are used as elevators, the sensitivity of the up movement is increased and the sensitivity of the down movement is decreased which equalizes the sensitivity in pitch at high and low speeds.

John then put up a slide showing the changes in lift distribution as explained by Kasper. This diagramed the



distribution based on various control inputs on what look like birds, since he had based his design somewhat on how birds operated (see above). He preferred rectangular planforms, again based on the wing of a hawk and the way in which a hawk uses its wingtip feathers to control the airflow around them.

About five years ago John called to talk with Kasper and found out from the housekeeper that he could no longer talk due to a series of strokes he had recently suffered. However, she told John to call Arnold Anderson who could probably tell him everything he needed to know about the Kasper wings. However, no one seems to know what happened to either of the BKB models over the years. There was even a motorized version at one point which was financed by Kasper's brothers. It was subsequently crashed by one of the tests pilots, and John thinks that one of Kasper's nephews may still have all the pieces stored somewhere in Washington. Apparently there are still a number of people in the Evansfield area of Washington that have information related to Kasper and there are still some Cascade Kasperwings in use in the area. As a footnote here, John mentioned that Kasper passed away about four years ago, having returned to Poland shortly after suffering the strokes.

The next slide was one of the Wortmann FX05-H-126 that is reflexed. Someone had taken the information and developed the stations values for both a 48" and 100" chord. There was also a note on the paper that said the elevator and rudders were okay and that elevons are not needed.

John summed up with another antidote about Kasper's experiments with tumbling. When he moved the CG forward the revolutions went from about 60 to 120 rpm and increased the g-load on him to about 4gs. On one of these trials he heard a loud crack so stopped the tumbling to take a look at everything and determine how much trouble he might be in. After giving it a good once over the only thing he noticed was his seatbelt was a little loose. As he tightened it up he heard another crack and quickly determined that the seat wasn't stressed for 4gs and had broken under the load. With that experience behind him he removed the forward weight and never flew the glider at that CG location again.

Gavin asked if John knew anything about a Swedish study. Kasper had two patents issued, one on the BKB-1 and the other on vortex lift generation, since he had figured out what was happening on the upper surface of his wing. He had designed several airfoils that used high pressure air from the bottom of the wing that spun up through a little camber and injected it into the airstream on top creating vortices. The way Kasper explained it, at high angles of attack high pressure air is formed on the bottom and this pressure being bled off helps promote the size of the counter-rotating vortex on the top. As the angle of attack goes up the bubble gets bigger and maintains a very nice flow over the upper surface allowing for even greater angles of attack to be achieved.

Apparently this drew some interest in Sweden in the early 1970's, when they took a large jet aircraft and modified the wing to incorporate this theory with Kasper acting as a liaison to the project. The aircraft's original approach speed was 130 kts and the new test wing brought this down to about 30 kts. However, nothing ever became of the experiment since it was decided it would probably be too hard and expensive to tool up for production.

John also noted that a wind tunnel test of a model version of this type of wing didn't show the same results as predicted by Kasper. However, there was no way to telling if the wing was really configured as planned by Kasper.

Andy asked John if this was the same airfoils that used a cusped leading edge and generated several vortices along the upper surfaces. He commented it was, but that it was never used on a full scale aircraft, even though it had been tested in a wind tunnel with mixed results. John had tried something like it in a model, but couldn't get it to work either.

The question was asked if the CG needed to be moved in order to generate the vortex lift. John explained that it was more a function of the wing design than the CG location and that as angle of attack was increased to a certain point the vortices would begin to form. This is demonstrated on the BKB-1 which normally has a sink rate of 200 fpm at 60 mph, but in the mush mode with active vortices is reduced to 100 fpm at zero airspeed. However, due to the drogue stability you still have complete control of the glider.

In the tumbling mode, you might wonder how he manages to recover it consistently when compared to other types of flying wings. If you recall the CG in all the axes is right at the pilots head, but the wings are swept 13 degrees. Kasper calculated the speed the tips were traveling at the normal rotation rate of the glider and found they were doing about 40 mph, which meant he had full control, since that's where all the control surfaces are located.

Bruce Carmichael commented that in one instance a trapped vortices did what had been calculated by mathematicians. A wind tunnel diffuser was needed in a short coupled wind tunnel to slow the air flow down and no conventional method was working. However, when they installed a diffuser that created a vortex affect, it had the desired results and allowed the wind tunnel to be effectively used. John also related a story of watching a wild fire in his area one day that created a vortex along a ridge line that was quite evident. Another person in the audience also noted that he had an experience in a Twin Otter where he was able to achieve a very high angle of attack while in a very aft CG mode with 24 jumpers gathered at the rear door. He indicated he had gotten to a least a 40 degree nose up attitude with full controllability.

The question was asked about whether or not Kasper had gotten a fair hearing from Boeing on his radical ideas. Although John didn't know anything about this part of Kasper's career, another person indicated that he had heard Boeing basically gave the information to Kasper even through some of it had been developed on Boeing time. (ed.- Perhaps others may know more about this.)

The final question was in relation to John's business as a composite builder which was of interest to at least one member of the audience who will eventually need parts for his planned project. (ed. - I will stay in touch with this member to see if we can learn more about it as he progresses.)

At this point Bill Hinote indicated he had just donated a set of Bekas BKB-1 plans to the TWITT library. In these plans is an extended wing version of the glider, so Kasper did have a conceptual plan for an improved version. There is enough information on the plans to actually build the aircraft. (ed. - I will pass on more information about the plans in another newsletter.)

Andy closed the meeting reminding people we had some handouts on the Kasper wings and patents and the Kasper library material was also available for review (just don't take any of this stuff since it is our only copies). On that note, we broke up for coffee, donuts and some good old hanger flying.

(NOTE: The Kasper Wing, by Witold Kasper is apparently still available from: Meheen Engineering, 1562 S. Parker Rd. #228, Denver, CO 80231-2720, phone (303) 337-4040. Cost is about $10.)

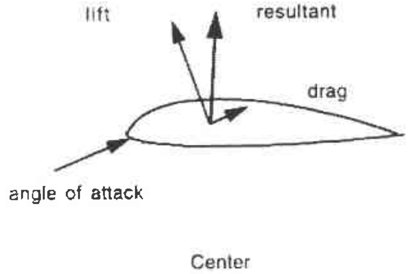
MINUTES OF THE SEPTEMBER 19, 1998 MEETING (Finale)

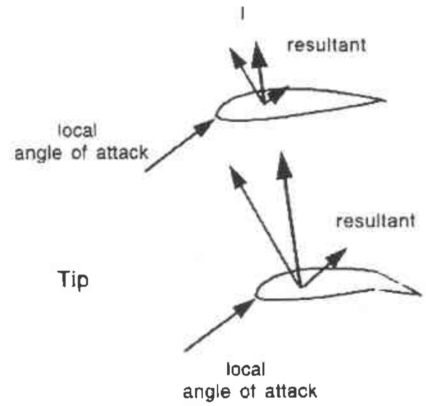
(ed. - This is the last part of Al Bowers' presentation on "The Horten H X Series: Ultra Light Flying Wing Sailplanes." The previous two parts are included in the October and November newsletters. Those parts marked AHB: are remarks added by Al as he proofread the text before publishing.)

There is a problem with this in the lift coefficient. As you increase lift you go to higher and higher angles of attack, increasing the dihedral effect, and this increases your dynamic directional stability. This means, conversely, that as you fly faster you have a decrease in the lift component which means you have the adverse yaw factor creeping in at the same time as there is a decrease in the dynamic directional stability. The end result is an aircraft that doesn't handle as well at the higher speeds. Phil added that by putting flaps down about 5 degrees you shift the CG aft a little bit to increase the upwash at the tip as you increase the speed. Al noted this was one way of solving the problem, but again pointed out that it doesn't take into account the aeroelastics of the airframe. He referred back to the Horten aircraft with the two elevon surfaces and the inboard one could possibly be rigged to act as a flap to move in such a way as to minimize the impact of adverse yaw at higher speeds. This might not work real well for very dynamic maneuvering, but for trim conditions when running between thermals it might work very well.

Now he moved on to the airfoil analysis. He used the Profile program from Dr. Eppler which had a flap option that gave nice clean little surface deflections to look at. He then took the vortex lattice results, looked at what the local lift coefficient was at seven span stations for each wing and matched these with the control surface deflections and then the profile drag. As a reality check he integrated the profile lift components from the Profile program to see what he got for his spanload distribution and, then went back to his vortex lattice program and compared the two results. At max L/D and lower lift coefficients he ended up with about a 2-3% error rate. He did two other steps that yielded up to about a 7% error rate with the differences being in the separation on the wing, since the vortex lattice can't handle the separated flow. The integrated lift coefficients matched really good so he could sum up both the roll and yaw moments based on profile curves since he knew where they were at the span stations.

Now we get to the bottom line. Remember the 30:1 and 80 fpm, well the maximum L/D Al got was 31.9 not including the drag of the pilot, with a minimum sink of 85.2 fpm, again not including the pilot. He felt that these





ABOVE: Vortex Lattice Analysis: Span loads (longitudinal trim & asymmetrical roll); Proverse/Adverse induced yawing moments; Force vectors on tips (twist & upwash); use 320 panels - 40 spanwise/8 chordwise.

---

figures showed Horten was in the ball park with this aircraft.

The final thing that Al did was to approach it from the argument about the difference between an elliptical and bell shape lift distribution on the L/D. He stayed with the same airfoil, aspect ratio and wing area and did the calculation all over again. What he found was the elliptical gave about a 37:1 L/D versus the 32:1 of the bell curve, which is a 13% penalty using Horten's methods. The gains for an elliptical distribution comes from longitudinal stability and lateral directional handling qualities. The only thing he didn't check for the elliptical was how bad the adverse yaw characteristics were, since you have to use a different planform to change the tip chord. Al commented that he had thought this aircraft wouldn't be worth building if it didn't get at least 30:1, and when his number crunching came up with 31.9 he said the people in his shop could hear him giving out a big whoopee.

In summing up the past hour or so, Al noted that the bell shaped span load produced proverse yaw at the expense of about a 13% penalty in drag. However, this was probably a good trade-off due to the other benefits gained and Reimar Horten was willing to live with the difference. Horten had been a student of Prandtl's elliptical span load theories, but chose to disregard them for his own bell shape distribution. You have to remember how much yaw you get out of a particular amount of roll so the differences between the Cnda/Clda have to be considered as engineers, in order for pilots to always have enough rudder. (Phil Burgers injected a little humor noting that in Horten designs you run out of rudder in a hurry.) Al thinks there is still some optimization of the upwash distribution (sin^n), but this hasn't been done yet. He just assumed a value of 3, but Horten and Nickel have done some work with other values. You have to consider the effect of the coefficient of lift on dynamic directional stability and this may have been one of the problems with Northrop's designs when flying at higher speeds where the nose had a tendency to wander around a little.

His concluding remark was that the Horten H Xc is a very high performance ultra light sailplane and somebody has got to build one someday, since it's just too good of an airplane to let lay around on a piece of paper. He then thanked his list of supporters like: Bruce Carmichael for getting him into it: Dr. Paul MacCready for his help; Rheinhold Stadler for calculating the twist distributions; Gregg MacPherson (in New Zealand) for supplying the Udens notes; Juan Manuel Mascarello (in Argentina) for some of the Horten photos; Russ Lee at the Smithsonian for supplying the Horten airfoils; Geoff Steele for his support; Doug Bullard for help in scanning some of the photos; David Lednicer for coaching on some of the analysis pieces; Jan Scott for the Horten drawings, and; Dr. David Myhra and Dr. Karl Nickel for their support during this project. And with that he concluded the formal part of his presentation and opened the floor for questions.

The first question asked was when Reimar Horten designed the H Xc and Al stated it was in the early to mid 1950s, but there is no specific date on the drawings.

Bruce added a historical note here on large span, large aspect ratio aircraft. When he worked for Chance-Vought, he was moved to Grand Prairie, Texas where he discovered the Texas Soaring Association (TSA). On his first day there he ran into Dr.'s Raspert and Lippisch, and Lippisch gave a talk that night at a meeting of the aeronautical sciences people and covered the history of the Wasserkuppe.

One story Bruce remembered from the account was Lippisch's meeting with a guy by the name of DeJoiner who knew how to make good glue joints since he was a furniture maker. DeJoiner listened to Lippisch while at the Wasserkuppe and then the next year returned with an aircraft that had a larger span and higher aspect ratio than anyone had ever seen at that time. The engineers at the time told him it wouldn't hold and probably would break. So he pulled out about 50 reams of butcher paper to show them his calculations, but Lippisch couldn't make heads or tails of it and said they would have to proof load it to find out how much it could take. The proof load held and his techniques led to the development of bigger and higher aspect ratio sailplanes in the coming years (early 1920s).

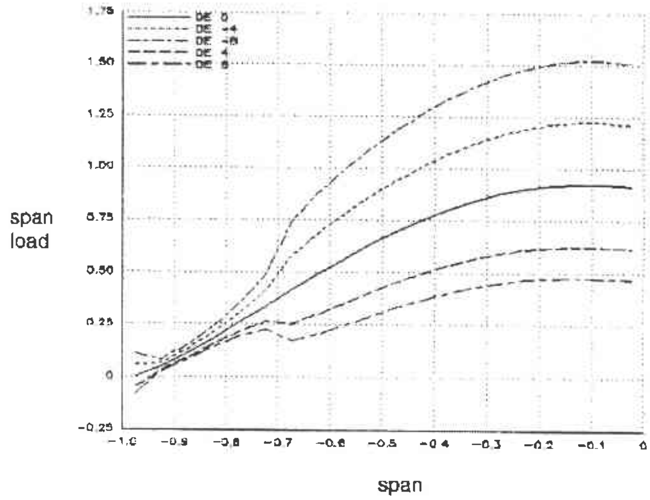
Bruce commented that the H Xc looked like a very interesting approach to the concept of micro lift soaring like that being done with the Carbon Dragon. It can often stay up in the early morning hours by just meandering around like a vulture without really circling. So we need a ship with a very low sinking speed and good turning ability. Dr Paul MacCready had said back in 1959 that if he had a sailplane that sank at 1 fps he could fly anywhere at anytime during daylight hours and not worry about coming down. Bruce did an analysis on this concept and found that he had to get the ratio of the gross weight divided by the square of the wing span down to about .08 to get 1 fps. The Carbon Dragon has about .165 and the new Light Hawk has about .145, but the Carbon Dragon has already been able to conduct micro lift soaring so the Light Hawk should be even better. He summarized that the H Xc could get down to about .10 with a light pilot, assuming the structure can be kept in the 90-100 lb area.

Ed Lockhart mentioned that he hadn't seen any type of diagonal bracing in the Horten designs and that this method provides much better torsional stiffness with a slight increase in weight. Al point out that the H Xb had some cross bracing in the elevon area, but he thought this might have been because the bell crank was at the inboard end and Horten may have been worried about its effectiveness. Al was intrigued by some of the talk by the Carbon Dragon guys where they are using wood laminated with carbon fiber and then making it into a D-tube structure. It looks normal but had good torsional stiffness.

Al commented he was amazed that Horten had come up with his designs based on the constraints of construction materials of the day. The fact that the Hortens actually flew the H VI was a significant event, since aspect ratios like this took years to come into their own. Even today, sailplanes with aspect ratios higher than the H VI and H Xc still use straight wings, and no one is doing it with a swept wing which makes the job a lot harder.

Dominique Veillard asked what was the ratio between effective span and the physical span of the H Xc. Al said he hadn't done the calculations on that yet, but that David Lednicer did do it for the H IV. He found that the number was about .64, which is pretty bad. To some extent this number could be misleading since you are trying to compare a flying wing with a conventional aircraft where the tail surfaces are not considered in the aircraft's overall area. On a flying wing you still have the tail surface but it's just integrated into the wing and therefore calculated as part of the area. These types of comparisons may sell the flying wing short since it has other positive aspects that overcome some of these limitations. He loves the absolute simplicity of the flying wing and that everything you need is all in one package with no extra pieces tagging along for the ride. However, flying wings take a lot more engineering work to make the combined package work, where a conventional aircraft wing works well when you stick the tail out there to stabilize it.

Phil Burgers commented that with elevons we are trying to increase the lift of a flying wing, but in the H VI due to the sweep back the aeroelastic effects are going to decrease the lift gain. He thought it would be interesting to take the technology developed with the X-29 Forward Swept Wing project which actually directs where the torsional axis is in the structure, called aeroelastic tailoring, and apply it to something like the H VI. An H VI built with composite materials and improving the structure was one of the things Horten would have liked to see, but obviously it hasn't happened.



ABOVE: Symmetrical Span Loads - Longitudinal Trim: Elevon Trim & CG Location.

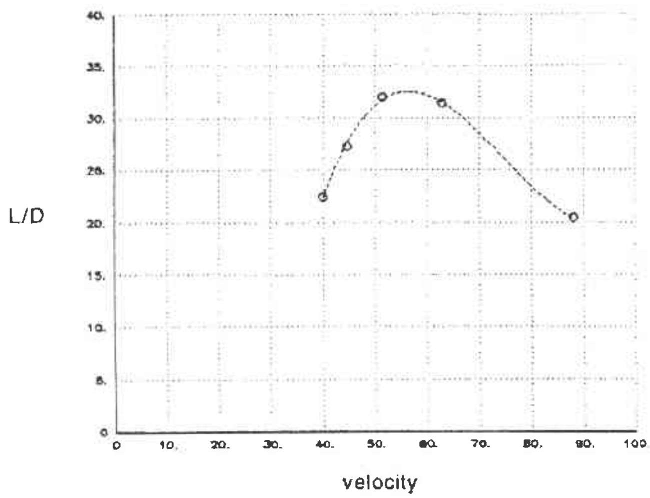
Gavin Slater noted that in the Dez George-Falvy analysis on the H IV from Mississippi State (MSU), it seemed the loading went negative at the tips under certain flight conditions. Al said it does become negative at very high lift coefficients, and in the case of the MSU results it appears to be due to aeroelasticity. David Lednicer had found distinct differences between the flight test data and computational data and, the only thing it could be attributed to was the aeroelastics. This has given them a very good model for what the aeroelastic deformations are in the H IV, but they don't know what they would be for something like the H Xc.

A comment was made about the small vertical surfaces on the H Xa. Al noted that they were used as stall fences because of some control surface problems. They do contribute a lot of drag but were necessary to improve the effectiveness of the elevons. Horten did get rid of them on the H Xb and the drawings of the H Xc also don't show any fences. Phil Burgers noted that the Urubu (H Xvc) that is being restored in Argentina was used as a prototype tester of these fences for eventual use in the I Ae 38 cargo plane so it would have a positive yawing moment.

Bob Chase noted that some of the early ultra light sailplane designers built in a lot of aileron differential and he wondered if Horten had used this technique in this designs. Al said Horten used zero since it would cause pitch trim problems. The differential they had existed between the amount of elevon deflection you got with pitch stick versus the amount you got with yaw stick and in the case of the H Xc it is 3:1.

Phil offered that Horten always used reflexed airfoils and that the one time he used a laminar airfoil (H IVb) there was a tragedy with it. So, he vowed to never fly in an airplane with a laminar airfoil and when the

Argentinean Air Force would offer an Fokker F-27 to take him some place he would ask for a DC-3.



ABOVE: Performance Analysis: Maximum L/D 31.9 (does not include pilot drag); Minimum sink 85.2fpm (does not include pilot drag); L/D Penalty - Bell vs. Elliptical (assuming same aspect ratio, wing area & airfoils) Max L/D Bell = 31.93/Max L/D Ellipitcal=36.98 (~13%).

Apparently there are no drawings available of the H Xc except for what he had on his slide. So far he hasn't found anyone with drawings. He was asked what he would use for an airfoil and Al said he would use exactly what Horten did and, he would build it accurately to the 1954 design but probably with more modern materials (which Horten had wanted to see), although it would be interesting to try an replicate the exact wooden construction. [AHB: As mentioned earlier, Bill Moyes' H Xc is all composite, but it weighs in at about 110 lbs.]

The question was asked whether the H Xc would operate at about the same Reynolds numbers as the H IV since the airfoils would be the same. Al noted that the Gottingen airfoils are appropriate since they only get about a 30% laminar run, but the pressure recovery is very benign on them and they behave very nicely at low Reynolds numbers. His analysis work included the Reynolds numbers from the H IV. When Al saw Horten's numbers of 30:1 L/D he immediately thought about the Flair 30 and SWIFT sailplanes and noted that Horten was coming up with the same performance almost 40 years earlier, so when he confirmed the performance numbers you can understand why he was pleased. The only drag component he hasn't been able to calculate is that of the pilot hanging out from part of the structure.

Asked if you would actually build one, Al was non-committal, however, he said a 1/5 scale model would give him about a 10' span for testing purposes. Asked if he would foot launch it he said he would probably prefer an autotow. The next logical question was how about landing it? This is one of the questions he has considered since the lowest L/D number is about 20 and you can't slip it like a conventional aircraft since there isn't any rudder. He noted this could be a very entertaining project, Bruce mentioned using a drogue chute and Al said there could be small landing skid somewhat like the Flair 30.

And with a few chuckles about how the pilot would be positioned in the HXc and things like hitting sprinkler heads in alfalfa fields on out landings, Al brought this program to a close.

[AHB: In discussions with Bill Moyes, I understand the Moyes design has adverse yaw, so much so that Bill is considering some sort of vertical surfaces. However, while Bill appears to have the correct twist, he has enlarged the elevons inboard, which may be the source of the adverse yaw. Bill has flown the H Xc to 2000 ft agl, usually launches on auto tow, has foot launched it though it is awkward, and plans to continue work on the design. Bill reports performance of about 30:1 L/D and a minimum sink of 120 fpm.]

TWITT's Library of Kasper Pricing Table

(ed. - The following numbers correspond to the listing in the November '98 newsletter listing of Kasper papers.)

1.	$1.00	10.	$ .50
2.	$ .90	11.	$1.00
3.	$ .50	12.	$1.20
4.	$8.50 **	13.	$ .75
5.	$1.00	14.	$1.00
6.	$ .50	15.	$ .50
7.	$ .75	16.	$ .75
8.	$1.00	17.	$ .50
9.	$ .50	18.	$1.00

** Or you can order an original from Meheen Engineering at the address shown on page 6.

AVAILABLE PLANS & REFERENCE MATERIAL

Now Available: <u>Tailless Aircraft Bibliography</u> Edition 1-e

Over 5000 annotated tailless aircraft and related listings: reports, papers, books, articles, patents, etc. of 1867 - present, listed chronologically and supported by introductory material, 3 Appendices, and other helpful information. Historical overview. Information on sources, location and acquisition of material. Alphabetical listing of 350 creators of tailless and related aircraft, including dates and configurations. More. Only a limited number printed, the first new edition since 1994. Not cross referenced: 336 pages.

This book is spiral bound in plain black vinyl. By far the largest ever of its kind - a unique source of hard-core information.

Prices: $35.00 US and $45.00 Overseas (checks payable on US bank)