

NO. 142

APRIL 1998

T.W.I.T.T. NEWSLETTER

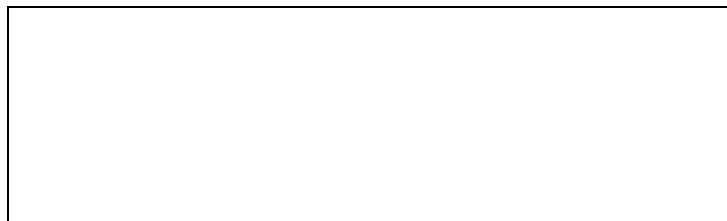
AeroVironment, Inc.'s Pathfinder solar powered flying wing just before landing at Edwards AFB after an early test flight.

The Pathfinder has since reached an altitude of over 70,000' as a proof of concept for even larger versions that are currently under construction.

Source: Dryden Flight Research Center website gallery page.

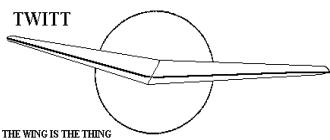


T.W.I.T.T.
The Wing Is The Thing
P.O. Box 20430
El Cajon, CA 92021



The number after your name indicates the ending year and month of your current subscription, i.e., **9804** means this is your last issue unless renewed.

Next TWITT meeting: Saturday, May 16, 1998, beginning at 1:30 pm at hanger A-4, Gillespie Field, El Cajon, CA (first hanger row on Joe Crosson Drive - Southeast side of Gillespie).



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

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

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Meetings are held on the third Saturday of every other month (beginning with January), at 1:30 PM, at Hanger A-4, Gillespie Field, El Cajon, California (first row of hangers on the south end of Joe Crosson Drive, east side of Gillespie).

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PRESIDENT'S CORNER

What a great meeting we had in March. There were over 40 people in attendance and we almost ran out of chairs which is something I never thought we would see. I video taped Paul's part of the presentation and will make it available to the membership (see the detailed information later in the newsletter). For those of you without a VHS tape machine, it is also available on audio tape, however, it does lose something without being able to see the photographs and videos he showed as he moved through his program.

I would like to thank Wayne Donaldson for allowing us to use his professional level video camera equipment that resulted in the quality video we have of the March meeting. All the automatic bells and whistles made it so easy to get a good picture and sound.

I would also like to thank my boss for allowing our company to donate a Buhl 2900 Overhead Projector to TWITT. Although it is inoperable, it appears to only need a simple switch replacement to get it back to showing viewgraphs in a much better manner than our current, and much older machine. We have had several speakers comment on the brightness and lack of clarity especially around the edges of our machine, and I am hoping this will overcome those conditions.

The membership renewal rate has been very refreshing over the past several months. We have remained at about 160 members which is very manageable from the standpoint of handling the newsletter mailing, while giving us a very diverse base of talent to extract information from on a number of subjects. I'm assuming it must also mean that we are doing something right to keep everyone coming back each year, with some of you subscribing for multiple years at a time. I hope we can continue with the same quality of programs over the years to come and provide you with an informative newsletter covering both the historical and modern day perspectives on flying wing/tailless aircraft. If we don't, I expect the membership to make sure to let us know when and where we are slipping so we can make the appropriate corrections.



MAY 16, 1998 PROGRAM

For the May meeting we are going to take a participant's look back at private, military and experimental aircraft as he has experienced them over the years. **Bob Fronius** is going to take us on a tour of his nearly seventy years of personal adventures and historical involvement with flying wings.

Some of these times were as a spectator and others as a white knuckled part of it. An unverified ancestor by the name of Phineas Pinkham helped John Montgomery and later the Wright brothers by selling or trading them ideas while flying east. A short stop in Elmira NY helped start a glider movement in that area. This experience is verified by official Washington documentation, the San Diego newspapers, the U.S. Weather Bureau, San Diego Aerospace Museum and, the book Progress in Flying Machines. He will be showing some video footage of the Horten machines, historic military aircraft and many of the flying wings from the San Diego area. These include aircraft by Phineas Pinkham, Waldo Waterman, Bill Schulte, Glenn Curtis and Charles Freil.

Make sure to mark your calendar for May so you don't let something else interfere with an enjoyable afternoon of flying wings and hanger flying.



MINUTES OF THE MARCH 21, 1998 MEETING

Andy opened by welcoming all the new faces to the March meeting, along with the regulars, and ensured everyone they were in for a most enjoyable afternoon. He covered the usual housekeeping items and then had everyone introduce themselves so that our primary speaker could get an idea of what to expect from them in terms of questions during or after the presentation.

The first item on the program was an update by **Doug Fronius** on the Teledyne Ryan Global Hawk project that recently flew its first test flight from Edwards AFB. He had briefed us at the beginning of the project, before any airframe had even been started and this brought it to closure since he has moved on to another project within the company. The flight was almost a total success, meeting nearly all of its objectives. There was a problem with the landing gear uplocks and the flight had to be made with gear down which shortened its duration. The flight profile was completely flown by the computer, including taxiing out to the runway for takeoff. The landing was accomplished through differential GPS which had a problem shortly

before touchdown, but was covered by backup systems. The aircraft touched 5-6 feet left of the center line, but watching the video you could see once it got relocked during rollout, the aircraft moved directly back to the centerline and braked to a stop.



ABOVE: Prototype Global Hawk promo piece showing all the various sub-contractors involved in the project.

The next item on the agenda was a brief video shot by **Ed Lockhart** from the cockpit of his "AirKnocker" over and inside of an open pit copper mine in Casa Grande, Arizona. He actually dove down into the center of the crater and started circling around the edges working his way up parallel to the roads used by the ore haulers years ago. These roads were almost wide enough to land the airplane on if they hadn't been so rutted from years of weather and disuse. Some spectacular shots from the dash mounted camera.

With all the preliminaries out of the way, Andy introduced **Dr. Paul MacCready** who would be talking about how flying wings occur in nature along with other flying wing projects he has been involved with over the years, including the most recent Pathfinder missions.

There was a little historical note here provided by Bob Fronius. In 1947, Paul set an international goal and return record of 230 miles which exceeded the 212 mile record held by the Russians. This occurred during the 1947 Nationals contest held at Wichita Falls, Texas. The record was set in the Screamin' Weiner/Lil Dogie which is currently being stored in the loft above TWITT's meeting area.

Paul led off with a short video on "Doing More With Much Less" that explained some of the many projects undertaken by AeroVironment, Inc., the company he founded researching energy efficient machines of all types. (*ed. - this video, about 8 minutes in length, is available by itself. Please see the details later in the newsletter.*) He commented that the film showed how far you can go when you care about efficiency, but about which we don't seem to care when it comes to cars. It also suggests you can do some unusual, way-out things that may not have any practical value at the time, but when come revisit them later find they truly do have some commercial value.

When he was young he thought flying wings were for the birds and that sailplanes should look like standard sailplanes. He felt a wing should be doing a wing's job with

a long span operating at high lift and efficiency when you need it. The body was needed to carry the pilot and by making it a little longer, provide a place for the tail so it could function as rudder trim and elevator pitch control so the wing could work at its best efficiency levels. He didn't think the Wortmann or Northrop flying wings had done anything out of the ordinary, so became a conventional aircraft devotee.

At this time he started his slide presentation (ed. - this part works so much better if you are looking at the video since it's hard to describe each slide, but I will do what I can to get the general point across). The first slide was of the Orlik sailplane off the Torrey Pines slopes illustrating a more conventional configuration. Then he moved to one of hanggliders like those designed by Tara Kiceniuk which were very basic structures that people could have a lot of fun with. Over the years these have evolved into regular flying wings with reflexed airfoils and more sophisticated structures.

During construction of the Gossamer Condor, many of the students had time on their hands so experimented with some unusual things. Some of these were small flying wing models so light that they would fly in the up currents generated by a moving object, such as a book tilted slightly to simulate a slope. Paul showed a series of slides that ended with his some Tyler walking along with a small flying wing flying in front of his forehead and reacting to changes in direction as he moved his head.

Getting back to the Gossamer Condor, it was basically a flying wing with a small pitch stabilizing surface stuck out on the front support wires pole. Due to the low lift coefficient on this stabilizer it did not create the usual problems associated with a canard configuration and yaw control was gained by tilting it rather than having an additional rudder surface.

The next slide showed a giant bone from a pre-historic bird (terrasaur). He had heard that an IMAX film was being shot for one of the aerospace museums on the evolution of flight, but it was only covering birds, bugs and bats as the evolution of natural flight leading up to man powered flight. He thought this was missing the terrasaur and managed to get a contract to produce a flying version of this pre-historic bird for the film. Most everyone has seen the pictures of this flying at the beginning of "The Wing Will Fly" program shown on the Discovery Channel over the years. It was a very complicated project but was a form of flying wing with the head acting as a yaw stabilizer (it was so far forward of the leading edge, Paul equated it to trying to shoot an arrow backwards in terms of maintaining overall flight stability).

In order to get this flying wing to fly properly, an active control system was needed. This was developed through a series of models that incorporated the fore and aft movements of the wing that would affect pitch and then added a tail for initial test flights. As experience was gathered, the tail was continually shortened until they were able to remove it all together and still have an aircraft that would fly in a stable mode. It turned out that this was a recreation of nature since the original terrasaurs evolved from being tailed for balance to being a pure flying wing.

The question was asked about a bird needing its tail feathers for flight. Paul indicated you can remove a bird's

feathers, throw it into the air and it will fly although not quite as well as before. It might be quite mad about the feathers, but it can fly. This demonstrates that some birds don't really use their tails to maintain stable, controlled flight.

Paul then showed a short video of the pterodactyl model actually flying as part of the IMAX filming project. He comments in the video about what a wonderful job mother nature does in adapting her animals for their particular environment.

Paul talked about his involvement with the Lindbergh Foundation which is devoted to the pursuit of achieving a balance between nature and technology. Lindbergh spent much of his later life looking into these concepts rather than technology just running away with us. At one time he pondered if there could only be birds or airplanes which should survive, and the bird won the contest in his mind. Paul feels that this balance of nature and technology is very important, even more so today.

AeroVironment does a lot of odd things that develop peculiar flying machines. His next slide was one of these, showing a flying telephone pole which could be considered the ultimate flying wing. It flies crosswise, not length wise, and could be used as an emergency recovery craft easy enough for even someone with no flying experience to assemble quickly and fly away in.

Pathfinder is another of these accomplishments. It has achieved an altitude of 71,500' which is higher than any other propeller driven aircraft has ever gone before. There is a 220' span version under construction that will fly higher than the SR-71 and stay airborne for long periods. They are also working on an intermediate size one using regenerative fuel cell technology that will allow it to stay at 65,000' for months at a time. These are all robotic aircraft, very complex and require extreme amounts of testing to perfect the hardware and software to ensure mission reliability.



ABOVE: Pathfinder on a flight over Hawaii.

He then quickly went through a series of slides on various manmade flying wings of various types, including the

Mitchell Wings and the SWIFT. One showed a Boeing concept drawing of a large scale flying wing that would be used for commercial transportation.

AeroVironment's aviation facility is in Simi Valley which is a hot bed of model airplane enthusiasts, hangglider and ultralight groups, etc. He showed a slide of one of his engineers concept model of a flying wing with about a 12' that has CG control for pitch but aileron control for roll with the pilot seated in a pod below the wing. This control method seems more desirable during the slow speed phases of landing where pitch changes can be made more quickly with the shift in CG.

Another series of slides went through various types of birds in flight showing how they do or do not use their limited tail feathers for flight control. These included the hawk, the albatross, and frigate bird (among the best soaring birds). The series continued with non-bird examples of flying wings which included the zanonia seed, the bat, a dragonfly, hawk moth and, the humming bird. One picture also showed a group of squid flying over the ocean's surface much like the flying fish most people are familiar with. This one picture generated a lot of discussion about "how they do that" and was good for a few laughs.

Paul now got into actual examples of small models that are used as demonstrators. The first one had a span of about 2' and when grossed out with radios, servos, propellers, motors and video cameras weighed in at around 3 ounces. One of their program sponsors had a requirement that the aircraft fit inside a bowling ball, so they designed several different configurations all of which are flying wings. One of these small models has flown 9 miles at 35 mph on just battery power and they will eventually have GPS and video cameras in them, although that is still part of the development work. A joint government and private venture has a requirement for building robotic versions of the dragonfly or hawk moth that actually flaps its wings through micro engineering techniques. This means AeroVironment is building the smallest and largest battery powered aircraft at this time.

One of the last slides was for a Kasper wing and Paul briefly went over the theory and results Kasper derived with his vortex generating devices. Even Kasper had acknowledged that some of it was transit in nature, but did result in some docile flying wing aircraft. There was also some discussion about whether or not the Kasper wing could be successfully tumbled and recovered. This capability has been documented. He compared the basic Kasper shape to that of the older Waterman Aeromobile with the high mounted wing with a passenger pod below. Paul left us with a very thick stack of Kasper wing material from his collection, which includes Kasper's own writings along with those of others discussing the vortex lift theory. (ed. - I will make a complete listing of what is in this material and see what reproduction costs would be for some of the key elements since I know there are members who would very interested it seeing it.)

He then commented that his enthusiasm for flying wings was rekindled when he was asked to speak before the Flying Wing Symposium at the National Soaring Museum in July 1997. The papers presented by Karl Nickel, Al Backstrom and others convinced him there were some real

virtues of the flying wing design, especially when you weren't concerned about carrying large numbers of people way in the front or rear of the aircraft.

Paul then pulled out some models he had brought with him to show what can be done with a little imagination. The first one he showed weighed in at about 1½ grams with a hollow carbon fiber leading edge spar, several light balsa ribs and a thin film covering. To get it to work right it has camber to keep things slow with wash out towards the tip which is also covered on the bottom. He flew it across the room very successfully.

He has another one which he didn't which has 2 spars with much more elegant airfoils, where the airfoils change over the span along with twist to create an elliptic lift distribution with a negative pitching moment. This one will eventually be fitted with a small video camera and made to fly around in rooms as a demonstration model.

He has also experimented with bi-plane versions since he was not concerned with achieving high speeds. The upper wing would be mounted ahead of the lower wing, with both of them highly cambered. The lower wing would continue to carry the washout which should be sufficient for both airfoils. One version also included using negative dihedral at the tips, so you can see he is doing a lot of experimentation to see how the various configurations interact with each other.

The wing he was using as the lower one also can be flown on its own. When powered by a little electric motor it can be flown on half a watt of electric power which is one eighth of a watt of thrust power to keep it airborne. One of Paul's goals for the coming year is to do a 24 hour electric flight which will use a 12' flying wing. This has no practical application whatsoever, but it is a fun challenge to do. It could be noted throughout the presentation that Paul and his sons have done many things that were just for the fun of it, but which worked very well within the realm they were working in.

He pulled out another bi-plane type of flying wing he slapped together with model airplane parts. It had the top wing staggered to the rear this time with end plate type struts holding the wings in position. This also allowed for changing the angle of attack and doing other types of experiments in balance and glide stability.

He is trying to learn the practical side of flying wings and spending a lot of time on the aerodynamics of low Reynolds number airfoils (35,000-40,000). These airfoils get very critical trying to get a high lift coefficient and not a bad pitching moment coefficient. The data on these airfoils is not widely available, but it is intriguing what you can do by using trippers to mess up the boundary layer here and there.

The last device he showed was a rubber powered ornithopter that he wound up for a short flight around the hanger. It weighs a gram and flies in a very tight but well controlled circle. This was provided to Paul by a friend of his that knew he would show it to school kids, or grown-ups who still think like school kids (which probably describes a lot of our TWITT members who are trying to come up with the ultimate flying wing).

Paul was asked about where he got the small electric motors they use on these small, extremely light weight

models. He indicated the servo motors are about the size of a grain of rice, are very expensive and come from a company in Germany. The small electric motors come in 3, 5 and 7 grams, require a speed reduction unit and well designed propeller to get the proper operation. They use nicad batteries for the demonstration models, but switch to some single use Lithium cells for the longer endurance type flights. These have about six time the energy level as the nicads and cost a bunch considering they are used once and throw them away item.

(ed. - He opened the floor to questions and there were plenty, but we will try to stick to those related to flying wings. However, Paul answered some relating to alternate energy source cars and some of the other projects being undertaken by AeroVironment.)

Bruce Carmichael asked for a little more information on the model one of the Simi Valley staff was developing. Paul indicated it is unpowered and almost hangglider type of construction but a little more elegant. He has been thinking of what the ultimate ultra-light glider, as have many other over time, and feels it will end up as a flying wing not as something like the Carbon Dragon. He thinks there are some tricks for getting rather effective speed range without too much complexity. This would probably result in about a 35-40' span glider that was light weight and would float around at about a foot per second sink rate, but have a high speed capability. With the light weight it wouldn't take much power to convert it to self-launching.

One of Paul's fascinations is to see the cost of miniature cameras, motors, servos, and radios get to the point where young people can use a model to fly with the birds and be able to observe it from the bird's point of view. This is almost possible now, but the costs are prohibitive for the amateur modeller.

Andy thanked Paul for coming down and giving us some insight into his wonderful world of experimentation and how we as human beings can do much more with much less and improve our quality of life at the same time.

At the end of the presentation, Andy conducted the raffle which was won by Carl Walters who selected the Halogen based shop light and Dominique Veillard who won the other fluorescent based overhead shop light. Paul then threw several Frisbee type toys into the raffle pot for the groups enjoyment, but we didn't keep track of who got to be a kid again for a few minutes.

Everyone adjourned to the coffee and cookie table for refreshments and discussion of the day's events. Paul stayed around for a short time and answered additional questions, but had to leave due to the long drive home and some other commitments for the evening.

MARCH MEETING VHS VIDEO TAPE

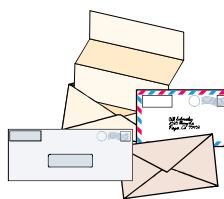
Due to popular request, we taped Paul MacCready's presentation for distribution to the membership. It has three parts and last approximately 2 hours.

The first part is "Doing More With Much Less", the AeroVironment Inc. promo video shown at the beginning of

his talk. The second part consists of Paul's presentation on wings in nature and other flying wings he has been involved with over the years. The last part are the presentations of Rudy Optiz, Dez George-Falvy and Jim Marske at the 1997 Flying Wing Symposium held in Elmira NY in July. Paul also gave this presentation at the symposium so it seemed like a good grouping of material.

This tape is available for \$6 US postage paid for destinations in the United States and \$8 US for foreign air mail delivery.

Paul MacCready has also indicated the "Doing More With Much Less" video (about 8 minutes long) is available by itself for those who might be interested. It shows the many experiments and products developed by AeroVironment over the years. The tape is free, but he asked us to gather together a large enough order for a bulk mailing to TWITT for redistribution. If you would like one, please send \$3 for postage and handling to TWITT and when we have about 15 requests we will get AeroVironment to send us enough to cover the orders.



LETTERS TO THE EDITOR

2/19/98

TWITT:

In the Sept-Oct 1981 issue of ULTRALIGHT AIRCRAFT magazine (pp. 34-39), Don Dwiggins wrote an article on the Kasper wing. I am sending you a copy of that interesting article.

Also, in 1977-78, I was distributor for the Mitchell Wing in Oregon. At that time, Steve Grossruck and Butch Walters, both good friends of mine, designed and built a set of Kasper wingtips for Butch's Mitchell wing B-10 (see the photos of these tips on page 9). I'll have to follow-up with Butch and find out how they worked.

Another item of interest, I am now flying my own B-10. I've had three flight sessions making adjustments and fine tuning and I'm happy to report that it's really a great little airplane.

After going through the necessary weight and balance procedures (CG 16-17 inches behind read face of front spar) and adjusting the stabalator linkage (7degrees trailing edge up from the wing chord line), we started with the low and high speed taxi tests.

When I built the undercarriage, I positioned the main gear about 1" forward from the drawings so that rotation would be easier, which it was and occurred at 22-24 mph indicated on my Hall windspeed indicator.

This B-10 weights in at 228 lbs with 2 gal of fuel on board, so with flying weight of approximately 425 lbs, the ship really wants to fly at 26-28 mph. The Zenoah 250cc, 22 hp (50x27 prop) provides great acceleration and I gently pulled the aircraft off at 30 mph. I let the speed climb to 35-38

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mph and flew down the long B-52 parking ramp at Castle AFB (now airport), at about 25' altitude and smoothly landed after about a 2000' distance flight. Man, what a thrill!

Did many touch-n-go's, made some adjustments, installed counter balances and trim tabs on the stabilators and took it around the pattern. Great fun this little ultralight motorglider. The third flying session consisted of pattern work, 360's, figure 8's at 300'400' altitude and many more touch-n-go's. With some additional minor fine tuning, it is now a hands-off fun flying machine.

And finally, the Mitchell Wing B-10 does not need any additional engineering, it does not need any additional fins or rudders or flaps or anything. Don Mitchell has designed a great flying wing airplane, I think the best one in the world, past or present. If you build the aircraft according to his instructions, you will have a truly great little airplane. There are many people who know Don personally and know that he was a great designer and builder of fine airplanes and especially flying wing airplanes.

I have the three model U-2 airplanes that Don built and I most definitely plan on putting them in flying condition.

If anyone would like any additional information on the B-10 or the U-2, I can be reached at:

892 Jenevein Ave.
San Bruno, CA 94066-4234
Phone (650) 583-3665
E-mail address: mitchellwing@earthlink.net
Web Page: <http://home.earthlink.net/~mitchellwing/>

Thanks,

Richard Avalon

(ed. - Thank you very much for the Kasper material. I found one little section on Mouillard that explains one of the pictures in the article and have reproduced it in this issue for others to see on page 10. I think I will have room in the newsletter to also include the two B&W pictures of the Kasper tip on a Mitchell Wing just to give everyone a general idea of what they look like without any covering. The article will go into the library.

The color picture you sent of the B-10 look great. It seems strange to see such a small aircraft on the ramp at a prior AFB normally meant to handle the big B-52 and supporting KC-135s. I went into the former Norden AFB with a Cessna 172 a year or so ago and it was almost like going into a ghost town. I was stationed there in 1968 and again in 1985, and it sure was different without all the C-141s.

I referred someone from the Nurflugel mailing list to you the other day who was interested in a two-place (side-by-side) version of the U-2. It is amazing that over all these years there is still so much interest in Don Mitchell's work. I guess it is a testament to his great designs.)

3/3/98

TWITT:

Last issue of TWITT has indicated again that some of our fellows are still building prototypes with beginning of the century techniques.

For Gerry Heflin and others, please dispatch (or give them copies) of the way I have, between 1st of November (beginning of plans) and 23rd of November (presentation to sponsors) built some more complex a craft than his: 60 working hours, \$200, 70 pounds.

I give again the techniques that has already been written into our reviews, but photographs give a better info about the method.

For a floating device, it is really useful: tape sticks even when facing some hours in the water, and if a longer humid period is needed, we know some 3M products, compatible with polystyrene foam, which is okay.

And for the flying experiments, shocks are really better suffered either by the pilot or by the wing: easy repairs.

Maybe of some help for all us.

Best salutations,

Alain MIROUZE

P.S.: Just a view of our 8' diameter half size inflatable "Surfair"; first experiments.

(ed. - As usual, Alain sends us all sorts of interesting stuff. We didn't get the colored photos half-toned so they won't show up very well in the newsletter, but I will include the material you sent along on disk.

You mentioned in one of your notes that aging of this kind of structure is quite good, either facing heat or humidity (10 years now for your old prototypes). My question to you is how well have they stood to the pounding of constantly being flown over the years? The construction always appears to be very basic and a bit rough, although I realize you are building a prototype. Has this had any impact on the structures ability to withstand abuse?

I will try to get some of the pictures half-toned for next month's issue where I will have a little more room to displaying them since their won't be any meeting minutes.)

3/24/98

TWITT:

Enclosed is my check for \$60 to pay for a two-year subscription to TWITT at \$18/year plus a bunch of back issues starting with the most recent.

It was a delight to be able to give an informal presentation for TWITT March 21. I regret that a commitment required me to leave fairly soon after the event. There were many people I wanted to talk with for much longer. No doubt I will get down again in the near future.

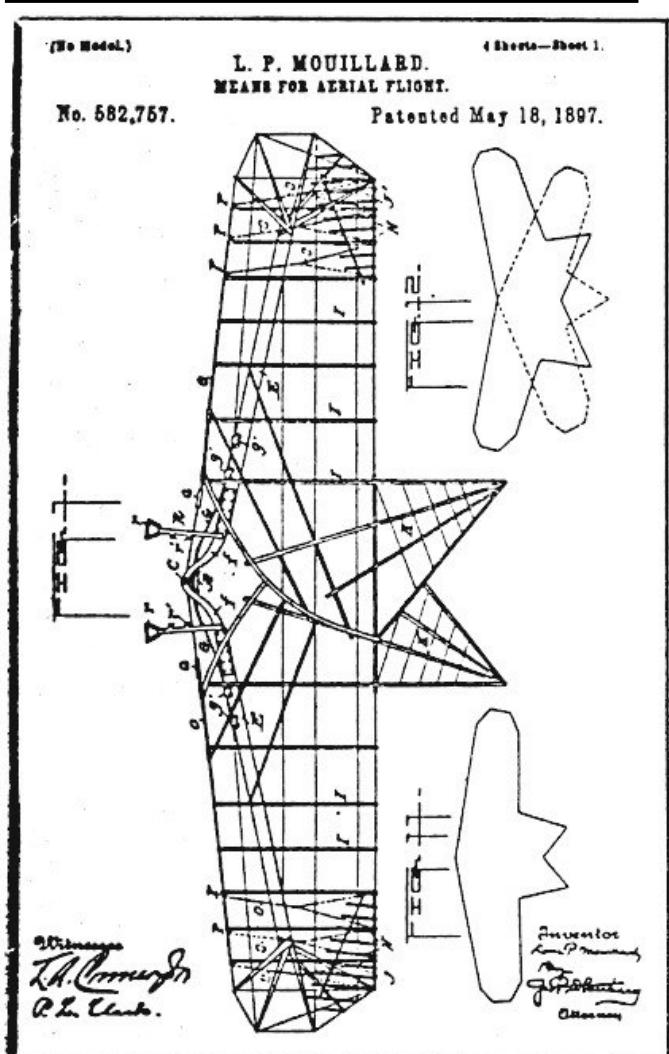
Sincerely yours,
Paul (MacCready)

(ed. - Thanks for the subscription. Bob will be getting you the back issues into the mail and I hope you enjoy what you see in them.

We certainly appreciated and enjoyed your informal talk on wings and things. The video turned out well and will make a welcome addition to the offering of things for our members who are unable to attend meetings.

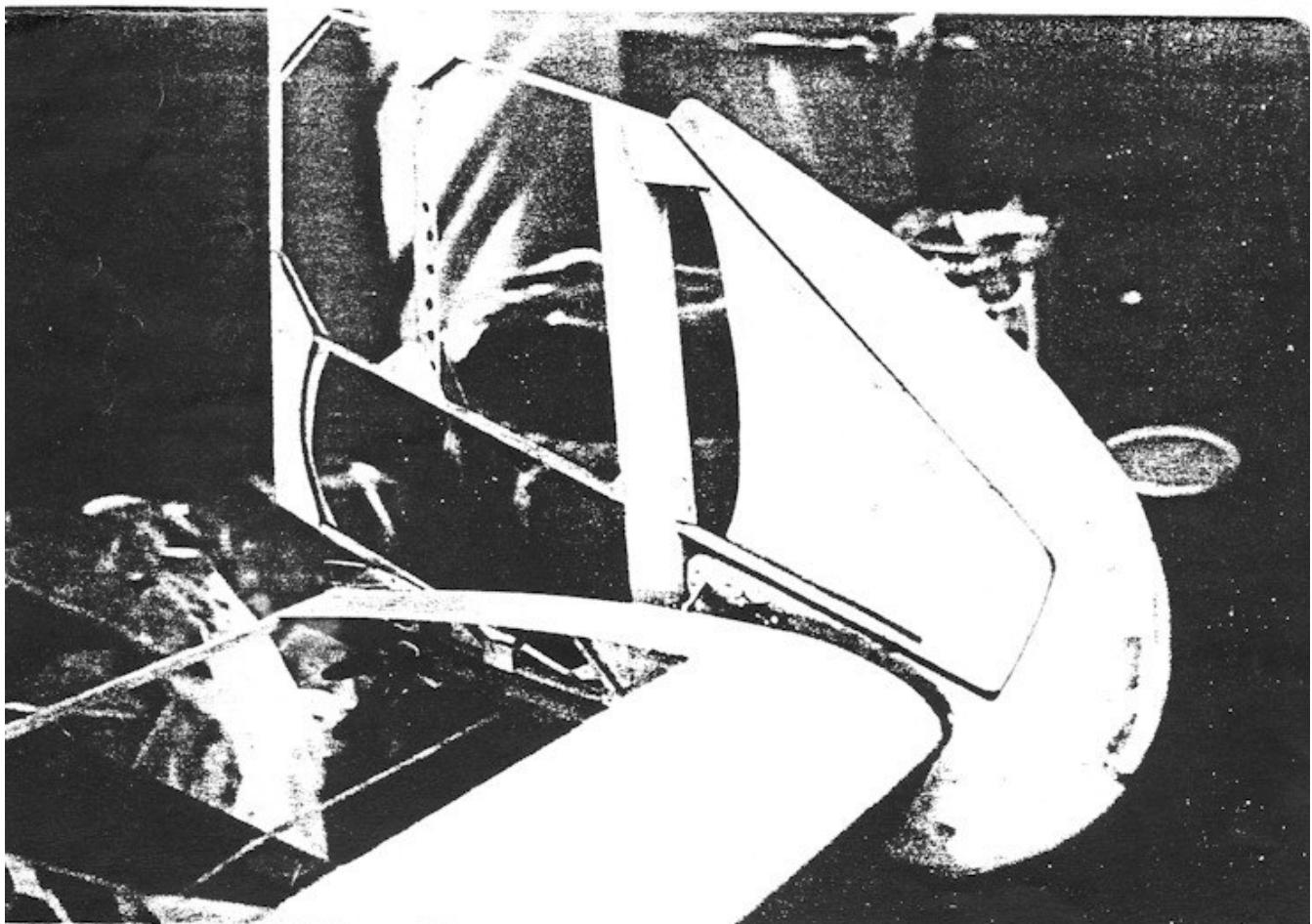
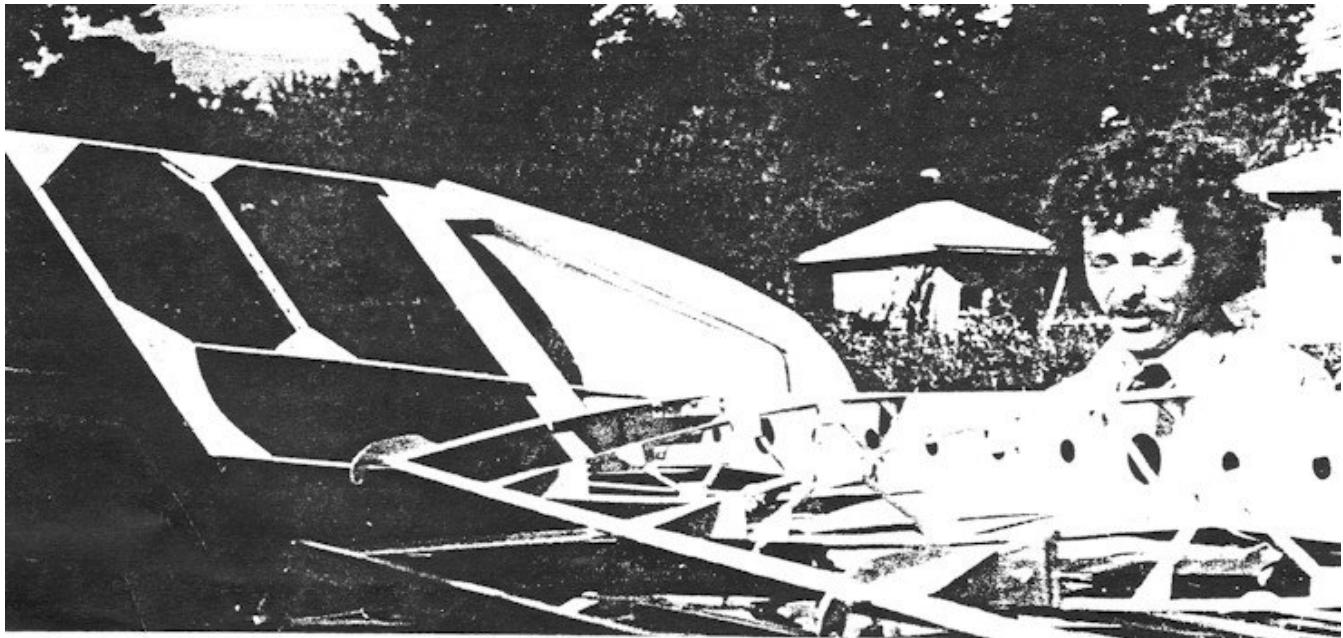
I will include an announcement in the newsletter about the availability of the "Doing More With Much Less" video and ask everyone to call or write us with their request. Once we have enough requests to make a bulk mailing effective, we will let you know who many are needed for redistribution. Unfortunately, we will have to charge them about \$2-3 to cover the cost of postage and handling since we don't have the funds to cover that level of mailing on a free basis. I hope this is okay with you.

Again, thank you for making the presentation, and we look forward to seeing you at future meetings.



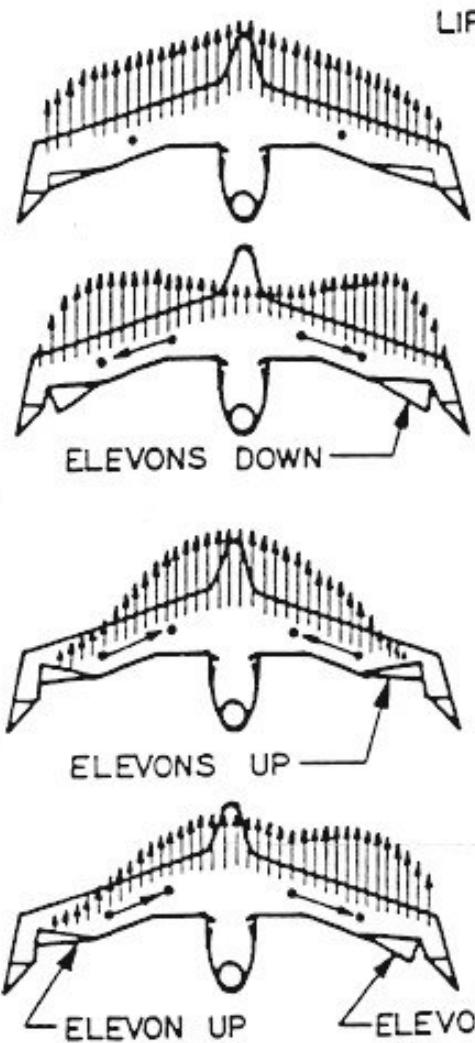
TOP: Butch Walters with his Mitchell B-10 fitted with a Kasper tip. Built with help of Steve Grossruck, 1978. Source: Richard Avalon.

BOTTOM: Another view of the Kasper tip on Walter's B-10. The front, inner part of the rudder moves inward to provide the vortex enhancement.

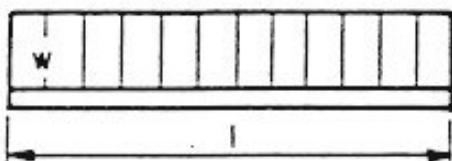
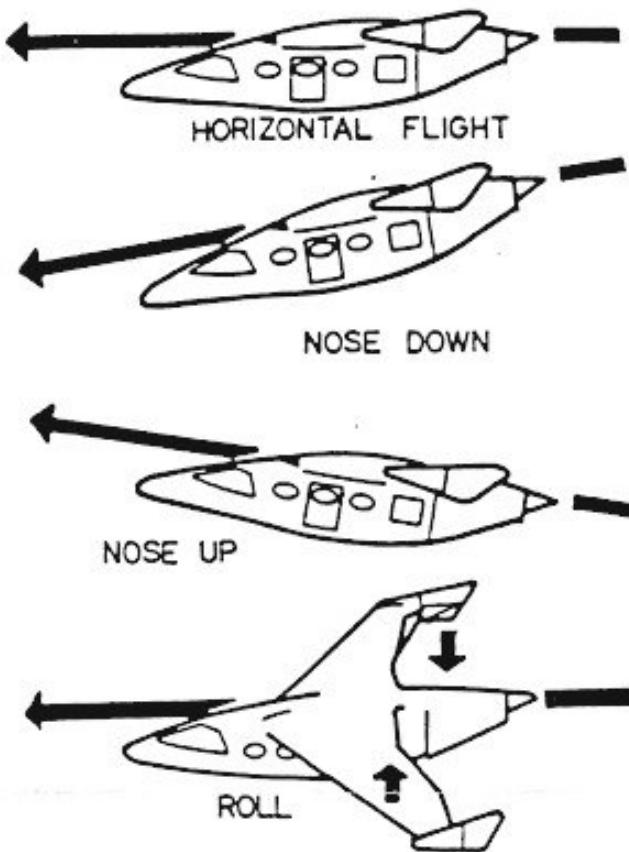


This is page 45 of the Kasper Wing, by Witold A. Kasper,
Edited by H. Joe Meheen, published by Meheen
Corporation,

Denver, CO. (circa. 1979) Material provided by Paul
MacCready.

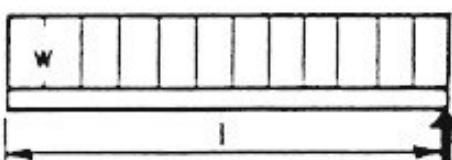


LIFT DISTRIBUTION

 M_{MAX}

$$M_{MAX} = \frac{wl^2}{2}$$

THIS REPRESENTS A CANTILEVER WING, WHERE THE MAXIMUM BENDING MOMENT IS $\frac{wl^2}{2}$

 M_{MAX}

$$M_{MAX} = \frac{wl^2}{8}$$

WITH THE ELEVATORS THEORETICALLY AT THE WINGTIP, THE MAXIMUM BENDING MOMENT IS ONLY 1/4 OF THE VALUE ABOVE