What Happened To The Kasper Wing?

(Dick Cavin Photo)
The Kasper Wing before its first test flight on May 28, 1974. It was rather severely damaged on its first take off attempt (see text) but is presently being rebuilt. Originally a two-place tandem ship, N88818 had a slice of fuselage cut out to cure a CG problem, making a single placer out of it. It is powered by a 125 Lycoming. Strictly a R & D vehicle, the Kasper Wing has more than a normal amount of access doors and panels to facilitate adjustments and changes.

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(With pictures and editorial assistance from Willard Blanchard, Jr. and Witold Kasper)

IN THE ARTICLE "The Revolutionary Kasper Wing" (July 1973, *SPORT AVIATION*), Jack Cox reported on a new concept in lift generation which promised to reduce the lower boundary of the fixed wing flight envelope almost to zero forward speed permitting birdlike landings. Through the use of upper surface leading edge and trailing edge flaps, Witold Kasper, a retired Boeing aeronautical engineer, claimed to be able to generate spanwise vortices above the wing to lower the pressure, increase lift and prevent stall up to 90 degrees angles of attack. This sounded too good to be true, like the proverbial carburetor some backyard mechanic regularly comes up with which he claims will get 100 miles per gallon. I wondered if the Kasper wing would quietly fade away into that land of Oz with all those pipe dreams, perpetual motion machines and carburetors. Therefore, on a recent trip to Seattle, I couldn't resist visiting Mr. Kasper to get a progress report on his development program. I had seen the powered version of his flying wing in early 1974 when it was nearly ready for the first flight and I wondered what had happened to it.

There was both good news and bad news from Mr. Kasper. His powered aircraft had been damaged on the first flight, but encouraging research and testing were being conducted in both America and Europe on the vortex generated lift concept.

Initial taxi tests of the powered wing revealed that the nose wheel could not be lifted off the runway even at relatively high airspeeds, so modifications were made. A section was removed from the fuselage to shift the CG aft and the main gear axle location was moved forward. This proved to be so effective in lightening the empty weight nose wheel load that a spectator accidentally tumbled the aircraft over backwards when it was parked on display at an air show.

Following modifications which took a considerable length of time, the test pilot lined up at the end of the runway with Witold Kasper and an observer, Dr. Robert Woodson (EAA 71868) of St. Paul, Minnesota, posted midway along the field to record events on film. Little did they anticipate the scenario that was about to unfold. On the first pass, the pilot applied full power to the 125 hp engine, rapidly accelerating the small aircraft straight down the runway. Remembering the difficulty he had previously experienced getting the nose wheel off the ground, he pulled the stick all the way back. At what he reports was an airspeed of 65 mph, the aircraft suddenly rotated and climbed at a 70° angle. Power was immediately cut, and the stick was pushed forward. According to the movie pictures, the aircraft responded properly to the forward stick movement and pitched over to a slight nose-up attitude and started descending almost vertically from an altitude of about 175 feet. With throttle still closed, the pilot applied full right rudder in an attempt to maneuver onto the grass which must have looked a bit softer than the pavement. Again the aircraft responded as commanded. It contacted the runway pointed 90° to the right of runway centerline in a 40° right wing down attitude. Movies showed that the upper surface flaps were partially extended due to what subsequent examination revealed was bent brackets in the mechanism. This possibly accounts for the relatively moderate rate of descent which resulted in only landing gear and wing damage, but no injuries.

(Lu Sunderland Photo)
FIGURE 1 — Witold Kasper at work on a new wing for his powered tailless aircraft.

The most unbelievable part of the whole episode was that the airplane landed only about 75 feet from where it left the ground. Mr. Kasper calculates that the airspeed at rotation must have been 80 mph for the aircraft to have gained 175 feet of altitude power off. In a written report, the pilot expressed confidence in the aircraft and attributed the completely controlled, parachute-like descent to the special Kasper wing design features. Mr. Kasper feels that the incident served to prove his claims of good control and high lift at extremely high angles of attack. Analysis of the movies appears to show that the aircraft did what the control surfaces told it to do and the accident resulted from piloting technique. There certainly is little question about what the outcome would have been if a conventional airplane had been maneuvered in a similar manner. It goes without saying that this first flight should have been preceded by a progressive series of taxi tests on the aircraft following the rather significant modifications.

Wing rebuilding work was delayed for a number of months due to the death of Mrs. Kasper and the serious illness of Witold. Now, he is feeling much better and has a new wing presently being covered. Figure 1 shows Mr. Kasper at work on the wing. He is very optimistic about the flight characteristics of his powered wing design contending that any other aircraft would have gone into a stall-spin condition after being zoomed power off at a 70° angle.

Now let's look at the good news. Interest is growing around the world in the Kasper vortex lift concept. Wind tunnel tests have been run on models in Sweden and at NASA Langley while both gliders and powered full-size aircraft are being built in Europe.

What do these tests show about the Kasper wing? Does it perform as advertised? Again we have a good news-bad news situation. Wind tunnel tests on models don't seem to duplicate the full scale model performance claimed by Mr. Kasper, but they do reveal some remarkable aerodynamic characteristics. The big problem according to Mr. Kasper, is that vortex systems don't seem to behave the same as ordinary air foils when scaled down. Little is known about vortex theory, except that it is rather illusive.

VORTEX LIFT

What is so different about the Kasper wing and what is vortex lift anyway? Mr. Kasper happened onto the effect by accident when he was performing stall tests on his flying wing glider, model BKB-1A. He had placed a row of tufts at about 70% chord and 70% span to observe flow patterns as speed was reduced to near stall. At 40 mph, the tufts curled up and the sink rate increased to 600 ft./min. As the stick was pulled back further an amazing thing happened. The sink rate decreased. The variometer showed a decrease in sink rate to only 200 ft./min. while the speed dropped to 30 mph. The tufts pointed forward indicating a strong flow at the surface opposite to the direction of flight. This maneuver was repeated several times and the same thing happened.

Additional tufting with four spanwise rows of tufts on the outer half of the panel showed that as the stick was progressively pulled back, first the aft row would reverse at 40 mph and the sink rate would increase to 600 fpm, then the third and second rows would all reverse direction. The front row located at 25% chord continued to point aft, but pointed up tangentially to the leading edge curvature. Airspeed dropped to 25 mph and the angle of attack indicator showed 35 degrees. The most astonishing thing was that the three variometers on board registered only 100 fpm, which is only half the sink rate experienced in normal flight.

Mr. Kasper was convinced that he had discovered a previously unknown phenomenon which cut both sink rate and stalling speed of the glider in half. He reasoned that a huge vortex was forming over the wing creating additional lift. A search of the technical literature did not produce much theoretical material to help explain the vortex lift process, so he performed a study and compiled a report including some theoretical background information. It is entitled "Vortex Motion and Its Application to Aircraft" (available as part of an information package on the glider plans from Witold Kasper, 1853-132 S.E., Bellevue, Washington 98005 for $5.95). Here are a few of the points it covers:

On straight or swept wing aircraft operating at angles of attack of at least 30 degrees, flow separation occurs at the crest of the upper surface of the airfoil. A flattened vortex is formed along the upper surface that does three things according to Mr. Kasper:

1. It maintains lift at angles well beyond the stall angles for potential flow.
2. Because of the forward flow of air on the upper wing skin, the direction of drag is reversed.
3. The vortex action moves the center of lift aft generating a stable nose down moment about the c.g.

In order to generate the vortex, flow must separate at the crest of the wing leading edge. A high angle of attack will cause this separation, but there are other mechanisms which can be used to advantage. As shown in Figure 2 a baffle may be used on the upper surface at the leading edge to produce a deeper leading edge curvature and provide a sharp edge from which the vortex may be generated. However, this vortex will vary in size due to gusts and variations in speed that affect the air flow over the wing. It can be stabilized by the use of various flap configurations along the trailing edge to limit the size of the vortex and trim off its outer periphery. This leaves a slightly smaller vortex circulating between the baffle and flap with a minimum of variation in strength. Reducing the size of the vortex compromises the maximum amount of lift which can be generated in favor of more stable lift. A further increase in lift can be obtained by providing slots to direct high velocity air from the underside in a forward direction along the upper skin. This adds energy to the vortex by increasing both its mass and velocity. The effects of upper surface flaps and split trailing-edge flaps on the Kasper wing are still largely a matter of speculation for they have not been tested in flight. The two Kasper gliders, the BKB1 and BKB1A, did not use flaps at all. Only the powered wing had them and its single flight was rather inconclusive.

Mr. Kasper feels that birds employ the vortex lift principle when they open their tip feathers during landing. In pictures of landing birds, we can see the ruffles in feathers on top of the wing caused by reversed flow.

The reader may wonder at this point, if vortex lift is such a great thing, why isn't anyone jumping on the band wagon to build a stall-proof plane that can land like a bird. Or is it like the Bourke engine?

Indications are that in this case, someone besides the original inventor can produce the phenomenon. A number of laboratories have been running tests and some have produced encouraging results. As yet, tests have not been conclusive but indicate that there is something to Kasper's claims.

For instance, Ulf Clareus and Rolf Westesson ran wind tunnel tests on a Kasper wing at the Kings Technical University, Institute for Aeronautics at Bromma near Stockholm, Sweden in the fall of 1973. On the wind tunnel model, they were not able to get the vortex going without introducing blowing, just aft of the leading edge flaps. But with moderate blowing, they were able to achieve a lift coefficient of 5.5. This compares to a maximum possible lift coefficient (C_L) of about 3.5 with slotted flaps on conventional wings. But what is even more amazing is that the air flow did not break up causing a stall at angles of attack up to 80 degrees. Figures 3 through 8 show the model during the tests. No wonder the powered Kasper airplane settled down like a parachute on its ill-fated first flight.

Willard S. (Woody) Blanchard, Jr. is an aerodynamicist who recently retired from NASA Langley Research Center where he had conducted tests on a 4 foot wing span 0.1 scale model of the Kasper BKB-1A sailplane in a 12 foot wind tunnel. These tests did not produce the extremely high values of C_L claimed by Kasper, but they did convince Woody that there was a very unusual phenomenon. The wing, utilizing the NACA 8H12 airfoil without flaps and having an aspect ratio of 9.5 should have obtained a C_L of about 1 and should have stalled at an angle of attack of about 12 degrees with no elevon deflection. As angle of attack was further increased, the C_L should have steadily decreased.

The Kasper model, however, did a surprising thing. With elevons not deflected, it reached a C_L of 1 at 12 degrees as expected, but then maintained essentially the same C_L up to 55 degrees angle of attack! Subsequent test runs with various elevon deflections exhibited the same phenomenom at somewhat lower values of C_L. Woody is convinced that this was caused by a spanwise vortex. At Woody's invitation, Kasper came to Langley to try to determine the reason the model tests did not produce higher lift coefficients. He crawled into the tunnel holding apiece of yarn and demonstrated that a vor tex was forming but it was being blown away from th wing. The problem was, that to obtain the proper V/C (velocity over chord) ratio Kasper says is needed to mair tain a vortex, the tunnel would need to be slowed dow to about 2.5 feet per second. But it couldn't be operate below about 20 feet per second.

Mr. Blanchard then decided to build a 0.3-scale radic controlled model and install a small engine to permit fre flight testing at Kasper's V/C. In tests to date, weathe conditions have not been suitable to obtain quantitiv data, but indications are that the model performs muc like the full scale airplane. See Figure 9. Directiona lateral and longitudinal stability are excellent, bu rudder control is a bit sluggish. Woody speculates tha this is because he has not ventilated the rudder hing lines as, he since discovered, Kasper did on the sai plane. Before the next flight, gaps will be provided be tween the fins and rudders for this purpose. He has ol tained very low speed flight and has been able to tun ble the model backwards and recover just as Kasper doe at air shows. He says the axis of rotation appears to b about through the canopy. But he hasn't yet tried t tumble forward. This will come later, after quantitativ data are obtained to establish the magnitude of the max mum attainable steady-state C_L.

In addition to discovering a new lift generating mech anism, Mr. Kasper claims to have solved several seriou control problems which have plagued flying wing de signers for many years. Two of these are the uncontrolle backward tumble and adverse yaw.

The backward tumble results from a forward shif in center of pressure at stall. Kasper says that 7 pilot lost their lives in flying wing aircraft due to this prol lem. Using a moderately swept wing, an inherently sta ble 8H12 airfoil designed for use on helicopter blade and elevons on only the outboard half of the wing, h has achieved a rearward shift in cp at stall. In additio a small fixed triangular extension to the wing trailin edge is located at each tip. This surface he calls a st bilizer has an upward deflection which causes the tip t

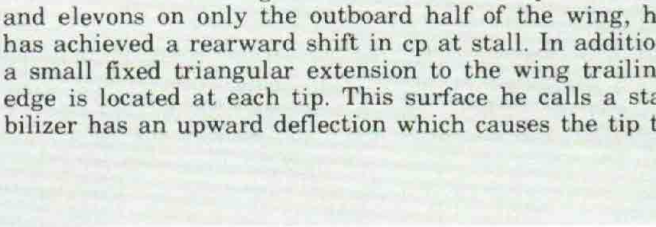


FIGURE 2 — Kasper Flaps

operate at a lower C_L than the inboard portion of the wing. This combined with an upward elevon deflection does not permit the outer wing to stall until after the inboard portion of the wing has stalled. Although there appears to be nothing new or startling about these features, thousands of spectators at the air shows in the Northwest will attest to the fact that Kasper can tumble his sailplane both forward and backwards and execute instant recovery. Also, pilots who have flown the sailplane report that it has excellent longitudinal, directional and lateral stability.

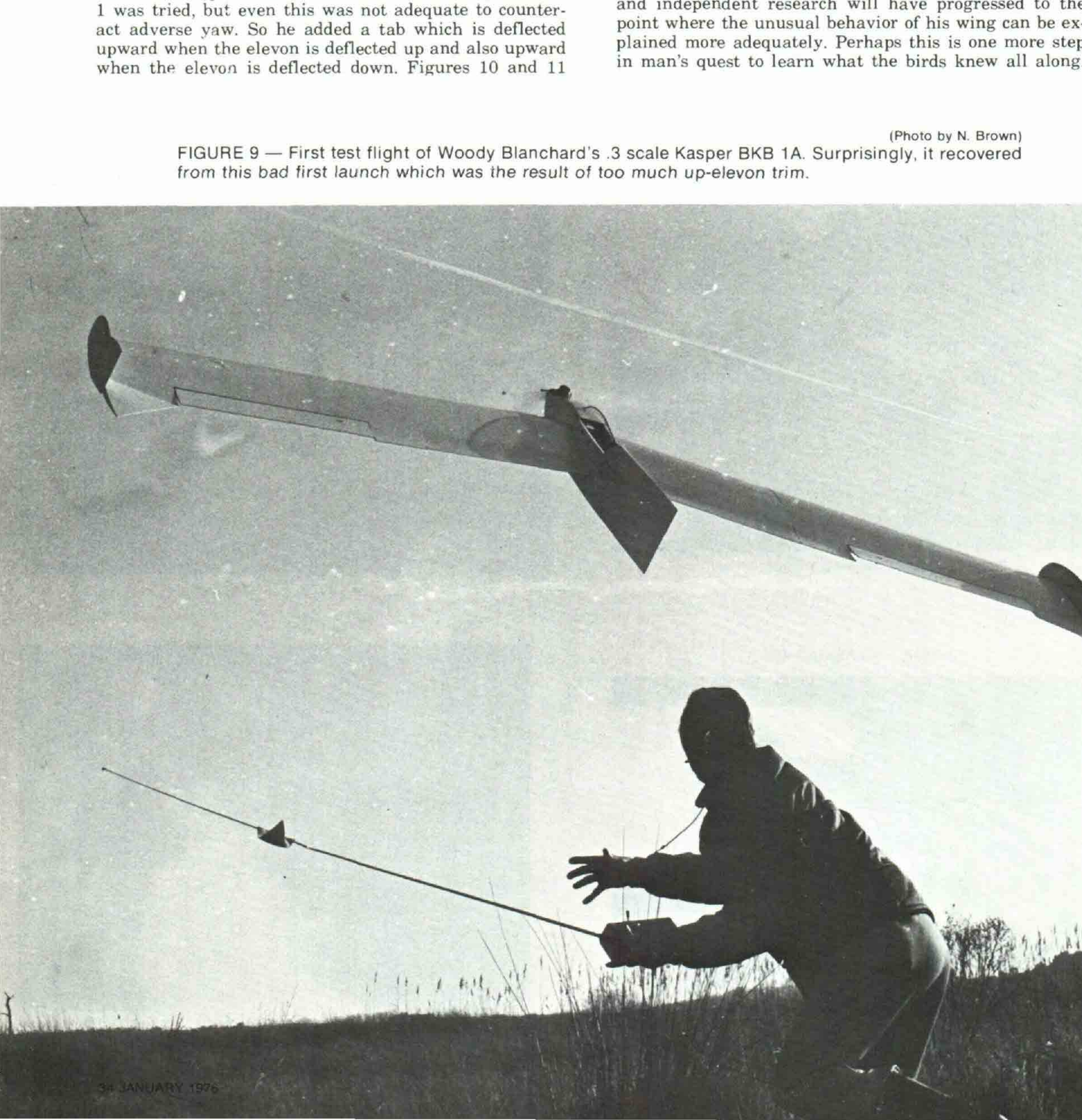
Adverse yaw has been conquered with a Kasper invention he calls an anti-anti-servo tab. Pitch and roll control of the wing is accomplished through elevons located along the trailing edge just inboard of the stabilizers. An up to down differential ratio as high as 5 to 1 was tried, but even this was not adequate to counteract adverse yaw. So he added a tab which is deflected upward when the elevon is deflected up and also upward when the elevon is deflected down. Figures 10 and 11 show the glider wing elevon with tab deflected. Note th fixed stabilizer.

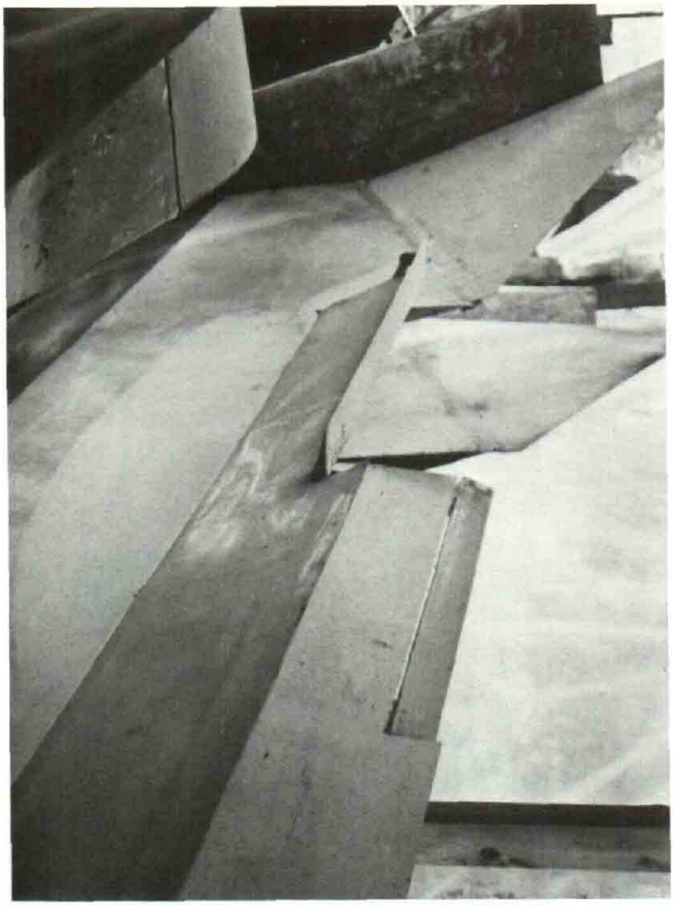
A fin and aerodynamically balanced rudder are lo cated on each wing tip. These are oriented at an opti mum angle to minimize drag and improve stability. Th fin leading edge is toed in to align the surface with th outflowing airstream at that point. Each rudder deflect trailing edge outward only. In the closed position, th rudders and fins form large end plates which reduc drag. When the rudder is deflected, the forward aerody namic balance portion swings inboard creating a spoil er effect over the stabilizer and producing a rolling mo ment in the proper direction.

At this point it is not possible to make any definit conclusions about Kasper's inventions, but within th near future his powered aircraft will be back in the ai and independent research will have progressed to th point where the unusual behavior of his wing can be ex plained more adequately. Perhaps this is one more ste in man's quest to learn what the birds knew all along

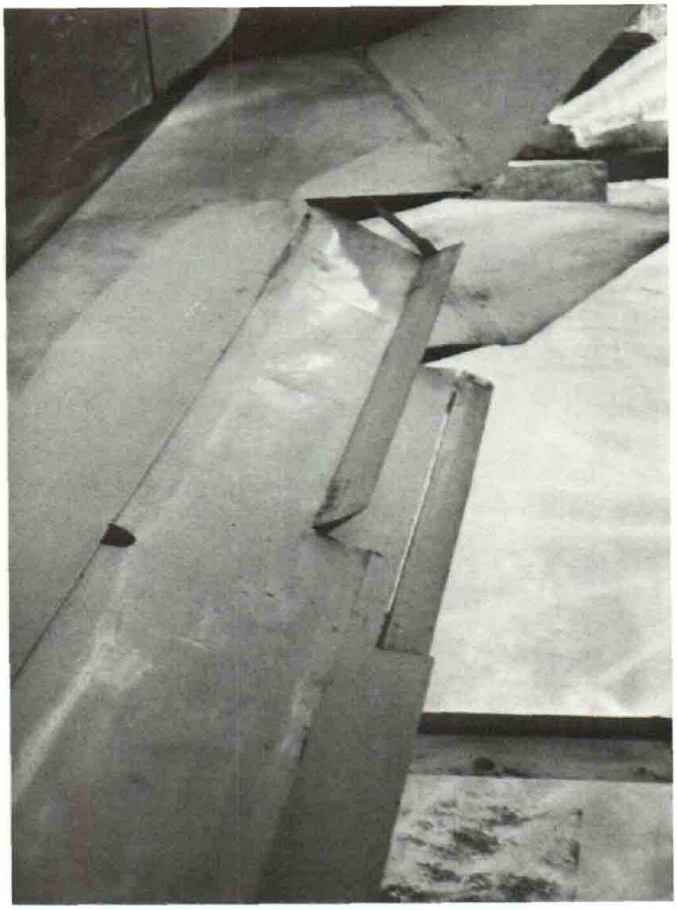
(Photo by N. Brown)

FIGURE 9 — First test flight of Woody Blanchard's .3 scale Kasper BKB 1A. Surprisingly, it recovered from this bad first launch which was the result of too much up-elevon trim.





(Lu Sunderland Photo)
FIGURE 10 — Anti-anti Servo Tab, up elevon.



(Lu Sunderland Photo)
FIGURE 11 — Anti-anti Servo Tab, down elevon.

ABOUT THE AUTHOR – Lu Sunderland is a regular contributor to SPORT AVIATION and this fact has not gone overlooked by his fellow EAAers. At Oshkosh '75 he was awarded the George Gruenberger Memorial Award sponsored by Milwaukee's Chapter 18. This award is for literary contributions to SPORT AVIATION and the homebuilt/sport aircraft world in general. Lu qualifies on both counts. In addition to his reasoned, highly instructive articles for SPORT AVIATION, he is the long-time editor and publisher of the T-18 newsletter. A Flight Control Systems Engineer for General Electric, Lu is Designee No. 60 and is a member of Chapter 53.

(Dick Cavin Photo)
Witold Kasper points out the trailing edge devices that help generate, contain and control the vortex-induced lift.

(Dick Cavin Photo)
These huge upper leading edge devices are vortex lift generators. They are actuated from the cockpit.