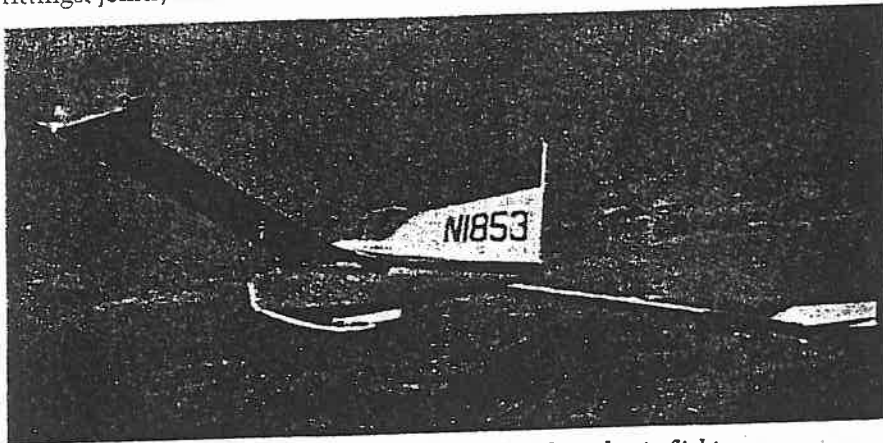


FLIGHT TESTING THE BEKAS N

By WITOLD KASPER

After obtaining all the possible information from the flight tests of the BKB flying wing, I built the next development of the same configuration, the Bekas "N." This time the aims were: higher L/D; easier handling on the ground, assembly, and disassembly; and for testing purposes, a flexible wing in order to study the influence of flexibility on the stability and controllability of this design.

Higher L/D was obtained by greater wing span (49 feet) and higher aspect ratio (15:1). Easier handling was realized by modifying the fuselage, incorporating a removable panel in front of the canopy, permitting easy access to the fittings, joints, and instruments.



Both the photos on this page (by Lynn Emrich) show the Bekas in flight.

The wing was designed to allow a bending flexibility and torsional flexibility. In order to decrease the pitch sensitivity of the glider, the aileron area was decreased to 60% of the BKB, besides incorporating the BKB high differential "mixer." In order to improve the L/D at high speeds, a movable pilot seat was designed, permitting—with appropriate shifting of the pilot—changes of speed from 50 mph to 90 mph without moving the aileron. To offset the high L/D, a set of air brakes was incorporated in the fuselage behind the trailing edge of the wing, moving out perpendicular to the airstream in or-

der to avoid any forces during handling.

Flight Tests

The first flight was made April 14th, 1968. The launching was made by air tow. Except for not perfect longitudinal balancing of the plane, which required pull on the stick, the flight was pleasant and uneventful, and the tow was continued to 3000 feet. After release, the plane was flown at an "estimated" speed because due to some wrong connections the only instrument which was working was the altimeter. The time being late afternoon, no thermals were encountered, and the time from 3000 to landing was recorded at 24 minutes; while the total time including

the tow was 32 minutes. The speed was approximately 70 mph, as was determined in the next flight with the airspeed indicator working.

After balancing the plane properly and restoring the instruments to working order, five flights were made the next day. The total flight time was 6 hours and 48 minutes, the longest flight being 1 hour 47 minutes at altitudes between 300 and 1500 feet (there was an inversion layer at 1700 feet). These flights were hampered by experiencing wing-tip flutter every time a vertical gust hit the plane. The phenomenon was closely studied during the five flights, and the con-

clusion reached was that it was a pure torsional flutter with no attenuation at a frequency of approximately 250-300 a minute. It was easily stopped by pulling up slightly. Speed 65 mph.

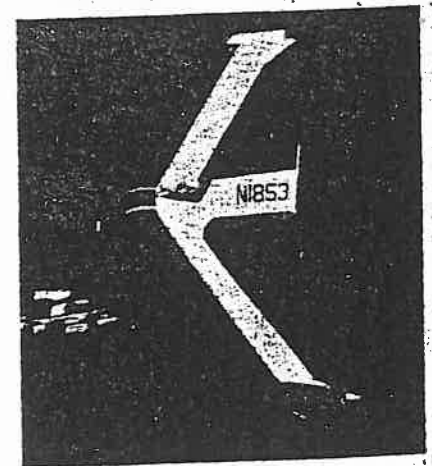
Air brakes were not used that day. Therefore, the landings were very long. Crossing the threshold at a height of four feet at 60 mph, the plane was stopping between 3000 and 3500 feet.

With regard to flying characteristics, only a general evaluation could be made. Pitch response is less pronounced than with the BKB, therefore closer to the response of a high-performance "flying tail" sailplane. The rolling rate using rudder only is 5.0 seconds while banking from 45 degrees to 45 degrees at 60 mph. Using both rudder and aileron, the time drops to 4.3 seconds, but the skid-bank ball goes off center; therefore, it is recommended that turns be made using rudder only.

The turn stability is very good. Directional stability—not enough. Slight pressure on both rudders is a great improvement; apparently more toe-in of the vertical stabilizers is required. Hands off, the ship maintains constant speed (60 mph), correcting automatically angle-of-attack changes due to updraft gusts. The lateral stability is adequate.

Bending Flexibility

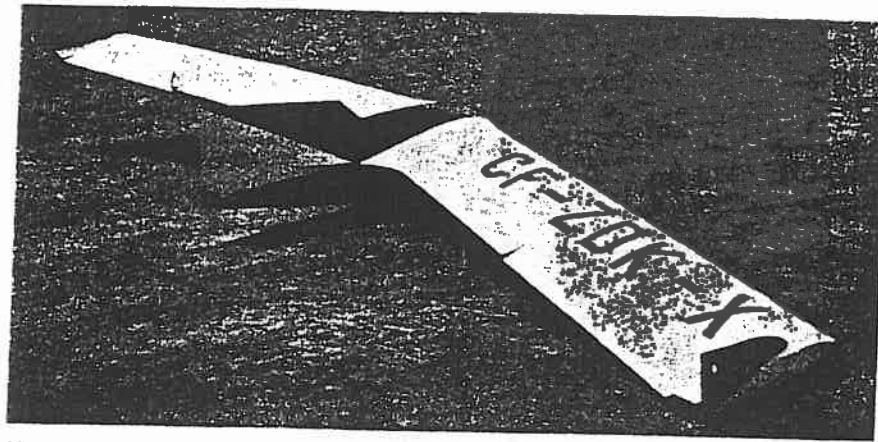
Response to vertical gusts: In the case of an updraft, the angle of attack increases, causing an increase in lift. Due to inertia the plane cannot follow the upward movement initiated by the wing, and the wing bends upward. Due to the swept-back geometry, a downward twist of the wing tip occurs causing a spillage of lift at the tip and conse-



quently an inboard and forward movement of the center of pressure, which consequently pitches up the plane. Because of the "constant angle-of-attack" stability, the plane at the moment of gust pitches down; the resulting movement is the difference between the pitch-up due to wing bending and the pitch-down due to stability. In the case of downdrafts, the opposite occurs.

Response to Horizontal Gusts:

In the case of horizontal gusts, the angle of attack decreases, causing a pitch-up due to the angle-of-attack stability. The speed excess due to the inertia of the plane causes a rise of lift which again bends the wing upward, causing an increased washout of the tip and a forward shift of the center of



Although both the BKB-1 and the Bekas N tailless sailplanes are of similar appearance, there are distinct differences. The BKB-1 (with the Canadian registration, CF-ZDK-X, on the wing) was designed to the philosophy of an economical sailplane of satisfactory-to-good performance, while the Bekas (N1853) was designed for high performance and as a research ship to explore the possibility of performance improvement through the use of wing flexibility. The BKB-1 has been described in detail in OSTIV's "The World's Sailplanes," Volume 2, and in a paper by S. K. Brochocki published in the November 1960 "Swiss Aero Revue" and reprinted in OSTIV Publication VI (which also carries a paper on the Horton IV flying wing and which is available from SSA for \$3.25). The Bekas is described in the accompanying article by Witold Kasper.

A moderate amount of sweepback has been used on both ships in order that a reflexed airfoil of the low-drag type could be employed and also to obtain the directional stability contribution of the swept-back wing at positive lift coefficients. The untapered planform, together with twist, provides both the necessary longitudinal trim and good lateral characteristics at the stall. This combination also results in an efficient spanwise lift distribution.

Both sailplanes have trailing-edge control surfaces on the outboard portion of the wing called "elevons," which serve a dual role of elevator and aileron. There are low aspect ratio tip fins on both ships, a large portion of which rotates outward only. The hinge lines on these are set back so that the lift near the tip of the wing is decreased by the spoiled flow caused by the inward motion of the area forward of the hinge line. This drops the inboard wing and produces a slight nose-down trim change. These sailplanes circle best through use of the tip rudders alone. The drag of the tip rudder on the inboard side of the turn produces the major portion of the yawing moment into the turn. The aft portion of the fuselage pod is shaped like a low aspect ratio fin but has no movable surface. The BKB-1 is a normally rigid wing, but the new Bekas is quite flexible, with the tip bending up two feet under a one-g flight condition. The wing fittings on both ships are at the center, and assembly and disassembly is very rapid. The spar on the Bekas is only 4.5 inches deep and 7.0 inches wide. The chord at the wing tip increases in a triangular manner as it approaches the tip fin. This extended section is reflexed up to provide a coarse longitudinal trim.

The BKB, which has a total flying time of about 100 hours, is mainly used now as a testbed to try out some new devices leading to flight above the stalling angle. (like birds do). The stall speed, originally 40 mph with a pronounced "mushy" sink of about 500 fpm, has been reduced to 20 mph with a 200-fpm sink. This permits a landing flare-out approaching zero speed with no run-out (again, like the birds). The ship has undergone so many changes that it is now called the BKB-1A (the "A" standing for "aerobatic"). It is being flown at various air shows, having received a document from the FAA certifying that Witold Kasper has "satisfactorily demonstrated his ability to perform the following maneuvers: tumbling, spin, loop, hammerhead, spiral, Cuban eight" at any public demonstration requiring a waiver of Part 91 of the FAR's.

	BKB-1	BEKAS		BKB-1	BEKAS
Span	39 ft.	49 ft.	Airfoil	8-H-12	8-H-12
Area	160 sq.ft.	200 sq.ft.	Length	9.6 ft.	12.5 ft.
Chord	48 in.	48 in.	Empty weight	410 lb.	400 lb.
Aspect ratio	9.5	12	Flying weight	610 lb.	600 lb.
Sweepback	13°	13°	Wing loading	3.81 lb./sq.ft.	3.34 lb./sq.ft.
Twist	5°	5°	Calc. max L/D	29.6	39.7

Witold Kasper was a leading soaring pilot in Poland prior to World War II. He wrote the first technical paper on optimizing cross-country soaring speeds. He spent many years in Canada after the war, where he designed the BKB-1 flying wing sailplane together with S. K. Brochocki. Later Mr. Kasper came to the Seattle, Washington, area—where he is employed by Boeing Aircraft. The Bekas was built and test flown in Washington.

It is clear from this paper that this modest individual remains today, as in decades past, a true pioneer in soaring flight.—Bruce Carmichael, Chairman of the SSA Aerodynamics Committee

pressure, resulting in additional pitch-up. When the plane slows down to normal speed, the wing unbends, and the plane returns to normal attitude without any movement of the controls.

When this phenomenon occurred for the first time, it was very surprising. The weather was gusty, and on the final approach to landing suddenly the plane pitched up and soared upward. Not knowing what happened, I pushed the stick forward, but even with the instant response of the plane, it was too late and the plane pitched back to normal. But with the new position of the stick, "normal" was about 30 degrees down. A fast pull back remedied the ticklish situation. A quick glance at the altimeter showed a gain of about 100 feet. I decided to wait for another gust and not act with the controls. The wait

was not long. The plane again pitched up, soared about 100 feet, and returned to normal, only to repeat it twice consecutively. The gain was 300 feet. This time I realized that I was soaring dynamically. I did not know yet the mechanism of this phenomenon, but decided to use it. The subsequent five flights ended with an average soaring time of 1 hour and 15 minutes, using only the gusts at an altitude of 300 to 600 feet to remain aloft. The lower I was, the stronger the gusts were, which is normal. During the landing approach of one of the flights (at roughly 100 feet), I was "blown" up to 400 feet, and only a fast opening of the air brakes permitted the continuation of the landing.

Summing up: The bending of the wing causes a more gentle flight in updrafts and, as an additional benefit, permits for the first time dynamic soaring of a sailplane; therefore, it is beneficial and should be maintained.

Torsional Elasticity

In the case of an updraft, the

tip is twisting to a higher angle of attack causing an increase of lift at the tips and a center-of-pressure shift outboard, consequently a pitch-down of the ship. This, combining with the inherent "angle stability," causes a much sharper pitch-down and results in a rough ride.

In the case of a *horizontal gust*, the same up-twist occurs with the same result (pitch-down), which is decreasing the dynamic soaring capabilities and consequently also detrimental.

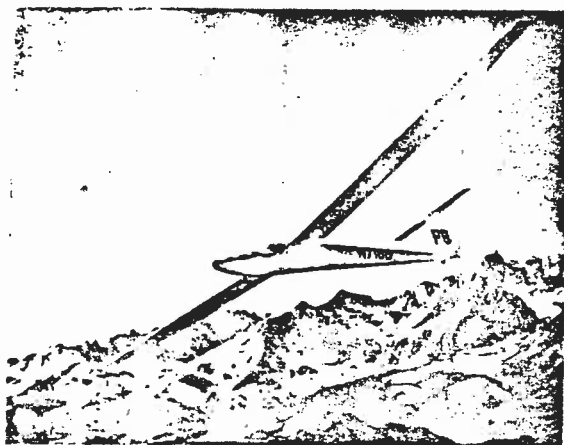
Control response (elevator and aileron): In the case of a torsionally flexible wing tip, a control deflection causes a twisting of the tip, decreasing the effectiveness of the controls ("rubbery" feel).

As was mentioned before, flutter (torsional) occurred on the first five flights, but this was "cured" afterward by novel means (proprietary) without stiffening the structure or otherwise "beefing up" the wing. I can mention only that during the test of the "antiflutter arrangement," I deliberately flew in the slipstream of the aircraft to

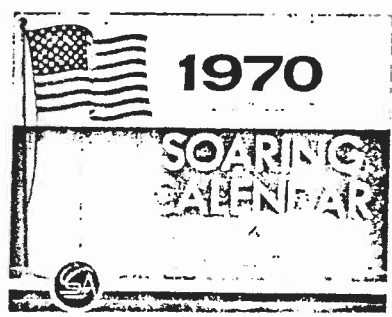
get a really strong impulse. The tips twisted up, but returned with half amplitude to the normal position. Inducing flutter was impossible. Naturally, a torsionally stiffer tip would be even better.

Proposed Changes

- 1) Increase the toe-in angle of the vertical stabilizers.
- 2) Stiffen the wing torsionally, maintaining full bending flexibility.
- 3) Replace the balancing weights at the end of the tail with a sliding weight in a plastic tube regulated from the cockpit, which will permit a wider hands-off speed range.
- 4) Seal all gaps at the wing tips, between the rudder and wing, and at the skid.
- 5) Construct a new pair of horizontal stabilizers (curved) to smoothen the air flow at the wing tip.
- 6) In a future design, eliminate the movable seat, the movable weight at the tip of the tail doing the same job, saving weight, and being much simpler.



1970 SSA Calendar



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