KEN BATES''WINGS

"Nurflugelseglers tell no tales."

Lest we devote too many of our columns to European endeavors, particularly those going on in Germany, we've decided to trace the evolution of Ken Bates' thinking concerning tailless sailplanes by describing some of his designs.

Ken Bates' name is synonymous with tailless aircraft here in the United States. His notariety began with the "Windlord," a Standard Class (elevator and rudder, plus flaps) plank type sailplane which used the NACA 23009-75 airfoil. The "Windlord" won several contests, and a construction article for it appeared in the March 1978 issue of Model Aviation. With its relatively constant chord wing, radially ribbed wing tips, and "balsa block" fuselage, the "Windlord" was easily constructed. With its very light wing loading, the "Windlord" was an excellent soarer.

The "Manx" was also a plank, but of higher aspect ratio than the "Windlord." With a span of over 3.6 meters, it was definitely in the Unlimited Class. Ken used the NACA 23112 section with a modified camber line which had its crossover point at 75% chord. Some difficulties in maintaining the proper lower airfoil surface contour led to problems on early flights, yet once the solution was found, other problems began to arise. First, the nose had been built too long, so the moment of inertia got larger as weight was added to the tail in an effort to balance the airplane, and pitch authority suffered as a result. Second, the roll spoilers, used instead of ailerons, degraded performance each time they were used, and would not work at all when the ship was inverted. Finally, the "Manx" was destroyed during experiments to determine if it was sensitive to rearward tow hook location. (It was.)

Ken then began what turned out to be a several year excursion into swept wing designs, eventually achieving success.

Some early experiments with swept wings pointed to stability problems. Ken had started by using the same airfoils he had used on his planks, and he began to feel perhaps it was cross span flow which was hindering the reflexed sections' abilities to result in a stable platform. Additionally, Ken found the combination of wing flex and torsion (as described in "On the 'Wing...," RCSD 6/89) to be very difficult to control, and a long search for a method of building stiff, torsionally rigid wings ensued.

The "P" series of swept wings generated a lot of information regarding the behavior of this planform on tow, and methods of achieving coordinated turns and increasing thermalling ability. Tow problems occured because the winch did not feel the load of the 'wing, even when it was fully stalled. Ken's "P1" went through three variations, finally having a TD.051 engine installed; it proved to be both fast and aerobatic. "P2" was an exact scale Northrop N9M with a "simplex" symmetrical airfoil of 14% thickness. It had a bit better performance than the "P1." "P2" eventually was modified for electric power. Both "P1" and "P2" had spans of about 60 inches.

"P3" used a NACA 0012 section on a span of 104 inches, but it's biggest departure from its predecessors was its use of rotating wing tips for elevon control. Ken felt this would prevent tip stall on tow, even if full up was given, as the wing tips would be flying at a lower angle of attack than the main part of the wing. The first flight of "P3" was in April of 1982.

Low height on tow was a common problem of the "P" series, and the only visible hope was the use of a high speed winch which would catapult the 'wings into the air to a height matching their tailed competitors. Also in Ken's thoughts at this time was the use of undercambered rather than symmetrical sections. Ken felt once the tow problems were solved, 'wings could be very competitive in F3B and XC.

The "P3-B" featured a span of 125 inches, a root chord of 15 inches, and a tip chord of three inches. Control was once again by "tipalons." Tow problems had been reduced, a 60° initial climb angle was achieved, good stability and high airspeed were maintained, and height off tow was starting to get near that of a tailed sailplane. Due to susceptibility to damage, and flutter problems, Ken decided "tipalons" were not a good control method.

At this point Ken was looking for a competitive F3B 'wing design. "P4-A" and "P4-B" were styrofoam free flight models designed to test out potential airfoils. The "P4-A" used the Eppler 180 and turned out to be very stable and have a good glide angle. The "P4-B" used the Wortmann FX60-100 (undercambered) section and was very difficult to keep trimmed.

By 1986, Ken had flown the "P4-C." This 'wing used the Eppler 205. At the root the section was upright, at the tip it was inverted. By "stack sanding" the ribs, Ken was able to transition smoothly from one section to another. Forgetting about the aerodynamic washout caused by the inverted section, Ken put four degrees of geometric washout into the wing. The total aerodynamic washout then totaled about ten degrees; probably too much. Ken had difficulty turning the beast. For the first few flights, he would actually stall the glider, and then recover it headed in another direction! Adding to the turning problem was three degrees of dihedral per panel.

"After repairs," drag rudders were added. The ship now turned, but the glide suffered. Additionally, if the turn was made too tightly, the glide degraded into a spin. A number of consecutive problems while attempting to tow at high speed resulted in an equal number of crashes and eventual destruction of the "P4-C." A couple of lessons were learned, however: (1) Watch the washout and pay particular attention to the zero lift angles when doing the computing; and (2) Dihedral causes control difficulties in thermal turns, so reduce it to zero and use sweep if more yaw stability is needed.

Convinced yaw-roll coupling was the major cause of his swept 'wings' problems, Ken did some redesign work. When attempting to get good launch height, a 'wing must be able to withstand high launch speeds. The problem until this point had been that when the 'wing began climbing steeply it would also roll into the ground. Additionally, since Ken was looking for a contest airplane, he had to come up with a design which was inherently stable enough to not require high-tech stabilizing methods.

The design which eventually met these criteria was the "Keeper." "Keeper" had a two meter wingspan and used an Eppler 205 for the root section. The tip was also an E 205, modified to reflex form by Ken. Four degrees of twist were used, along with ten degrees of sweep. The big departure from previous ships was with the incorporation of anhedral. Anhedral cured the "yaw-roll" coupling problems of previous designs and allowed for zoom launches of such velocity the elevons would flutter. Even cross-wind launches proved not to be a problem.

"Keeper" had very good performance. It was able to thermal well, and it had 92% of the dead air time of the conventional tailed sailplane Ken tested it against, a two meter, E 205, flat winged Pilot "Harlequin" with ailerons.

By the end of 1986, Ken had built, flown and sold the "Sabre," a combination plank and swept wing using a slightly reflexed Eppler 205 and sporting a central fin. It flew well, but even with two large spars and thick balsa sheeting, flutter was still experienced when bringing the ship back upwind from a thermal. Not wanting to go to a foam core wing, Ken stuck with wood construction, but it seemed as though any increase in torsional strength brought on added weight which just couldn't be tolerated.

By the end of 1987, Ken had solved many of the problems which had plagued him from the beginning, and he had a new 'wing which towed and flew extremely well. The following points outline the improvements incorporated:

(1) The torsional rigidity of this new 'wing had been drastically improved with a new spar system. To give some idea as to this new spar's torsional rigidity, Ken recounted the following experience... During construction it was found the spar had been built with one degree too little twist; Ken tried to put the added degree of twist in while sheeting the wing and couldn't do it.

(2) No dihedral was used. Rather, the 'wing was built on a flat surface and there was a small amount of anhedral built in due to the tapered wing. The anhedral eliminated all of the yaw-roll coupling difficulties on tow, and no keel was needed.

(3) Elevons were placed in the outer third of the wing, for Ken found if they extend further inward there is increasing adverse yaw. Another advantage with this set up is no differential is needed.

(4) This model was not a pure flying wing, as it had tip fins. Quite often, when banking steeply, a true flying wing will slip in the direction of span and fall to the ground when flown at low speed. The tip fins on the new 'wing eliminated this behavior entirely.

(5) Ken added a "bat-tail" to the 'wing. This was accomplished by simply extending the root section with additional material so it followed the mean chord line of the airfoil. The trailing edge was then formed to produce a nice graceful curve leading from the center of the wing to the straight trailing edge. This smoothing of the quarter chord line very much improved the 'wing's thermaling ability.

(6) Sloppy linkages cannot be tolerated, so the servos were mounted in the wings with direct connections to the control surfaces.

At one of the MARCS Symposiums Ken said he at times "couldn't see the forest for the trees," and solutions to problems are obvious once discovered. A couple of things seem very clear to us, however; Ken learned from his experiences, whether they were successes or failures, and he has always shared with others what he has learned. In that regard, Ken Bates stands as a model for others to emulate. Unfortunately, we've not yet had the chance to meet Ken personally, but we are certainly eager for the opportunity!

The following table outlines the various sources of information used for this two part article:

Model	White Sheet FW Special	SOARTECH	MARCS Symp. Proceedings	Misc. Sources
Windlord	FWS#1 (#7)		1985	MA, 03/78 *
				Werner, 1984 **
				Pers. corr.
Manx	FWS#1 (#7)		1985	Werner, 1984 **
P1-A, B, C	FWS#2 (#20)	#1		
P-2	FWS#2 (#20)	#1		
P-3	FWS#2 (#20)	#1	1985	
P-3B	FWS#2 (#20)	#2		Pers. corr.
P-4A, 4B	FWS#2 (#20)	#2		
P-4C	FWS#3 (#36)	#4 & #7	1985	
Keeper		#7	1987	
Sabre			1987	Pers. corr.
'87 'Wing			1987	

* = Construction article with full size plans available from Model Aviation

** = "Nurflugelsegler Ferngesteuert" by Reinhard H. Werner