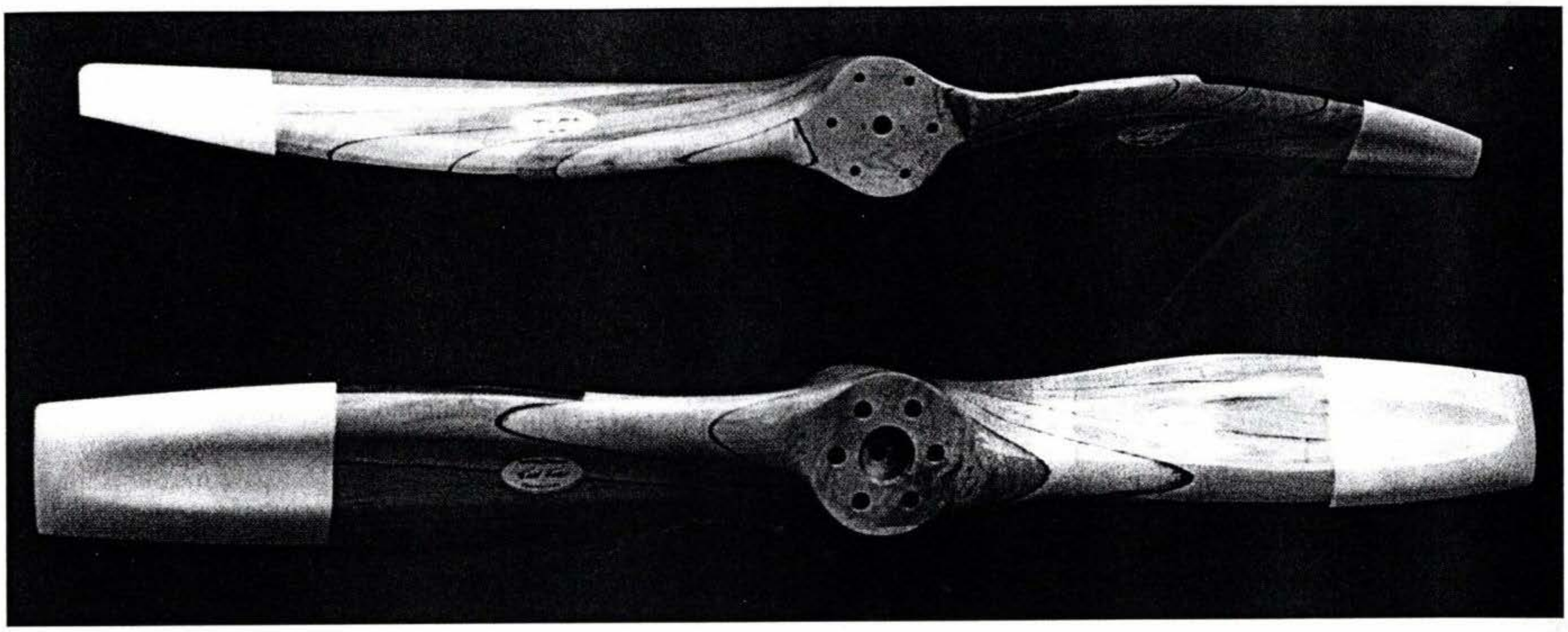


THE FELIX PROPELLER

BY FRED FELIX

A new idea displayed at the Oshkosh Convention this year is a lower-noise, higher-thrust propeller. Fred Felix of Felix Propellers has been awarded a patent on a very unusual airfoil which he has adapted to propellers. He displayed noise and thrust test results along with the propeller at the EAA Woodworking Workshop and gave a brief rundown of the tests and the airfoil at his propeller forum. There was plenty of interest, but little time to answer all the questions, so Fred has followed-up with an article to give more people an opportunity to learn about it.

The airfoil shape is the most interesting part of the propeller; otherwise it looks pretty much like any other propeller as can be seen in the photos. One is for an airplane and the other for an airboat. The profile of the airfoil contains two points of greater thickness with concave areas in between on both the top and bottom. Even a thousand words aren't able to convey the idea as well as a simple picture so refer to Illustration 1. I call it the Bicambered Surface Airfoil because both upper and lower surfaces have two raised convex sections on them with a concave section in between.

The air flowing across the airfoil surface follows the curves of the surface. Airflow separation is prevented by the second thicker raised section and by the concave area in front of it. By having concaves on both top and bottom, camber of the airfoil itself is not affected by the double surface cambers. Aerodynamicists could explain precisely how it works. It's easier for me to explain it by saying that when fluids flow they prefer to meander. Having a meandering surface to follow, the flow stays attached more readily.

When I first began experimenting with this shape I was making canoe paddles and was attempting to maximize drag. The concave areas were supposed to provide higher drag. I wasn't looking for a wing so was not looking for an aerodynamic shape with reduced drag. However, everything kept pointing to less drag when the shape was used as an airfoil. Empirical tests and computer simulations verified that the shape has equal or reduced drag at most angles-of-attack.

HOW WAS THE AIRFOIL IDEA DEVELOPED?

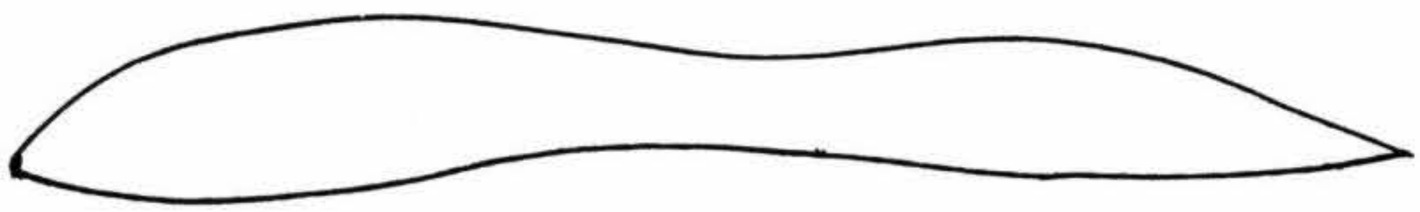
Lots of people ask how I ever came up with the idea for this unusual shape for an airfoil. It's a long story and being a short story person, I haven't ever really told it completely before, but now is a good time.

The idea started out as a small personal quest. Over time it kept growing bigger. When I first saw a compound bow (the one with pulleys and more than one string), I was amazed that through thousands of years of use, the bow and arrow hadn't been changed, but after all those years someone in the 20th century could come up with a great improvement to this common, simple tool.

It is said that necessity is the mother of invention. The bow was a weapon that had long since become obsolete as a necessary tool of survival. Now, when it wasn't a critical necessity, and perhaps totally unnecessary, someone had improved the bow, thus disproving the adage. That inspired me to believe there were other common, simple tools that might allow for improvement.

A common, simple tool I used a lot was a canoe paddle because I enjoyed white water canoeing and went on at least one trip every spring with Bill Ferko, my long time canoeing partner. I tried to think of ways a paddle might be made to do its job better. Over some years time I made paddles with lots of changes and tried them. Most seemed to work O.K., some a little bit better, some not as good. Finally, I hit on a design that really worked great. It was smooth in the water, worked well to keep the boat straight in winds and enabled me to paddle up-river better than ever before. I wanted to show it to Bill on our annual spring white water trip on northeastern Wisconsin's Peshtigo River. The first time he put it in the water it caught be-

PROFILE OF BICAMBERED SURFACE AIRFOIL



Leading Edge **Trailing Edge**

Illustration I

tween some rocks and the blade split so he didn't get to try it that spring.

In cross-section the paddle blade has a dogbone shape with pointed ends, sort of a little wing on each side of the blade and at the tip, thus being thicker along the edges with a thin, flat area in the center. it was tested in a large flow channel at the University of Wisconsin School of Engineering by students of Professor John Hoopes. They found it produced equal thrust with 12% less effort compared to the best traditional paddle we could find.

The paddles were raced once, by a women's team organized by Beth Schluter of Oconomowoc, WI. These were international races with competitors from Hawaii and California, as well as Scandinavia, Australia and other ocean front countries. Races were marathon events of forty-plus miles on the open ocean in six person outrigger canoes. Chase boats followed each canoe. Every twenty or thirty minutes or so two paddlers would be dropped ahead of the canoe and as the outrigger side passed over them they would climb aboard while two spent paddlers would bail out to be picked up by the chase boat. This way paddlers could rest while the boat kept going non-stop. Paddlers had an hour of furious work, then an hour of rest. The "Landlock" Wisconsin team almost won with those paddles, but other teams had knowledge of favorable currents that Beth's team didn't and this cost them the victory. They placed fourth out of seventeen teams.

At some point in trying to figure out how and why the paddles worked so well, serendipity set in. I tried the paddles sideways like a wing, in water and in the air outside a car window. The University flow channel tests showed that at parallel or near parallel angles to the flow, drag was lower on my paddles than on the others. The amount of lift at any angle was also surprisingly high. With these good things happening it seemed natural to investigate the use of the paddle shape (at least somewhat similar shapes), as wings.

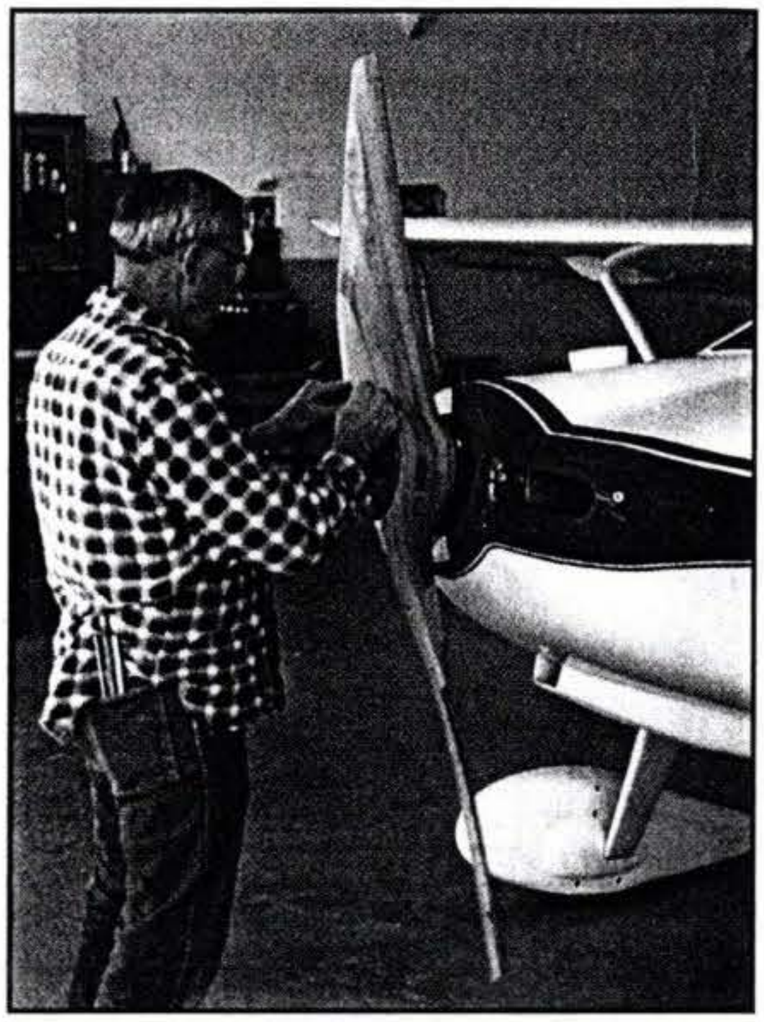
I had been very interested in airplanes in my youth, before discovering cars and girls. By this time, having lost interest in cars, I was ready to get back to my old diversion of airplanes and flight. One reference in a book on airplanes led me to the University Biology Library where I learned that inset wings, which have similar shape characteristics, have very high lift and do not stall. Steve Wittman said, when told that the bumble bee had too much weight to be able to fly, "Maybe nobody ever told him he couldn't." I made up a short poem to answer:

It's said the bumble bee cannot fly.
His coefficient of lift is impossibly high.
But fly he does, as we all can see.
Seems no one ever told the bee.
But his secret's out, I can tell you now.
It's the bee himself, never told us how.

One summer was spent building and testing model gliders by flying them from the sun roof of our car (my economy wind tunnel). These tests gave measured lift, velocity and angle of attack by suspending weights from the fuselage down into the front seat, using the car speedometer and using a gravity protractor to get angles. I was able to calculate lift coefficients and angle-of-attack, but unfortunately this provided no data on drag.

I spent many days at the University of Wisconsin Engineering library, studied aerodynamics, checked out volumes of aerodynamics texts, read patents and went to seminar sessions on patents. NASA Langley and Massachusetts Institute of Technology allowed me to use their Computer Fluid Dynamics (CFD) programs to do simulated wind tunnel tests. The CFD runs verified the high lift, low drag results of a wind tunnel test done under the direction of Dr. Mukund Acharya, aerodynamicist, at Illinois Institute of Technology. With a lot of help from the UW intellectual property librarian, Sarah Calcese, and a sympathetic, patient, patent attorney, Paul Hendrickson of Holmen, WI, I applied for and received US letters patent #5,395,071.

Thinking that real-world tests would tell more, quicker, cheaper (sounds like NASA's slogan, right?), we went straight to testing the airfoil on propellers rather than doing high level (quote "expensive") wind tunnel testing. Jim Clement flew several propellers on his CAFE tested Tailwind W-10, N6168X. The first flight was exciting in anticipation, but almost dull in execution. No one had ever used such an airfoil before. Jim was not going to takeoff if anything seemed out of the ordinary. Suspense built during a slightly longer than usual run-up. But, then he took off in normal fashion. We on the ground had no knowledge of what was happening because we couldn't raise Jim on the radio during the flight. We found out later that Jim hadn't switched his unit on. If he simply forgot to turn it on or just didn't believe it necessary, we'll never know. Jim is always relaxed,



Jim Clement installing an experimental propeller on his Tailwind.

Jon Krapfl and Diane Johnson with the U.S. Fish and Wildlife Service airboat at Horicon Marsh

never appears to get unstrung.

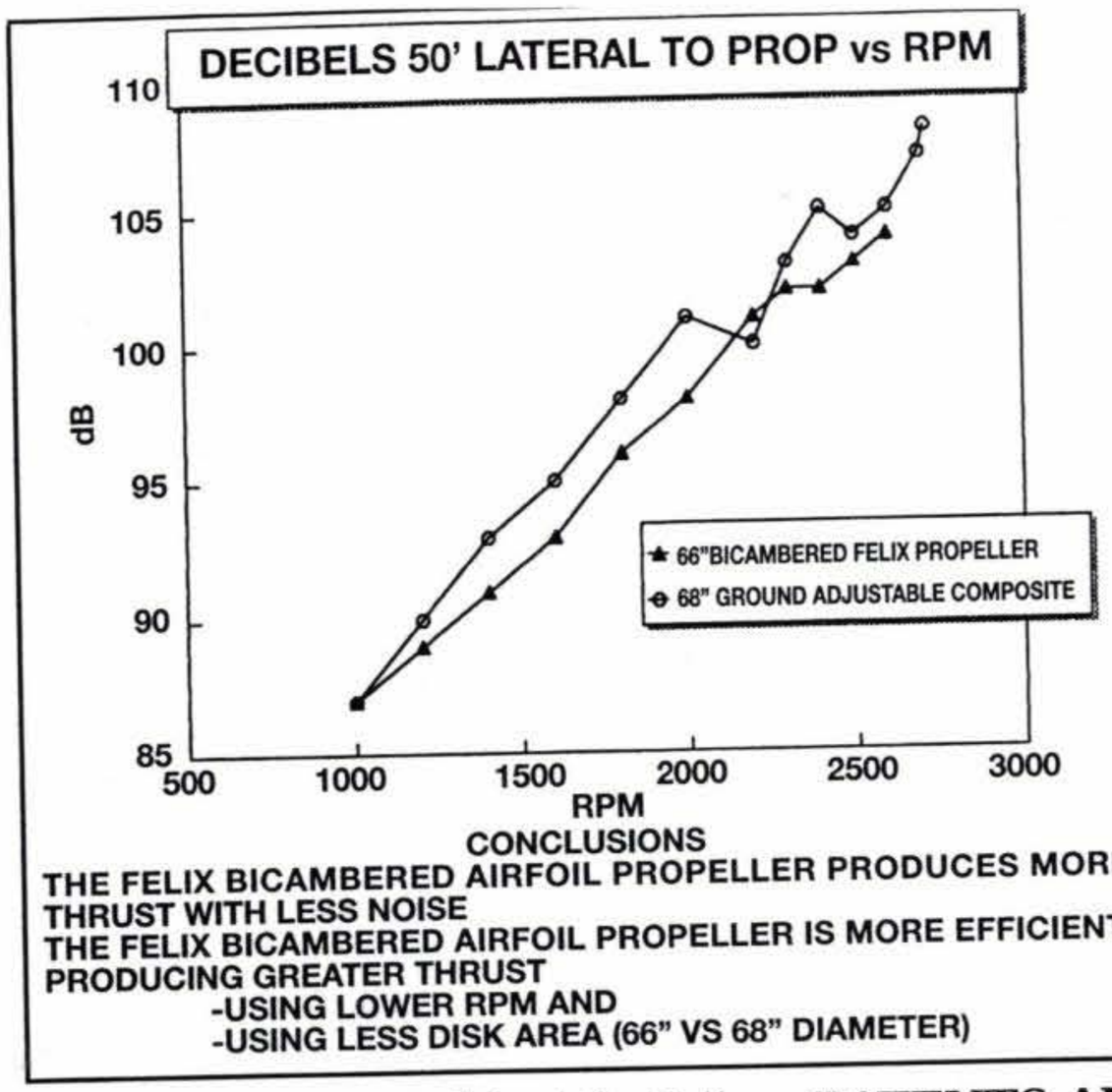
It seemed that everyone from four counties who had anything to do with flying was there that day to witness this strange looking propeller and its success or failure. Not at all the secret, reclusive, skunk works-type event I had envisioned, where only Jim and me would know what was happening. When Jim did his high speed pass over the Baraboo airport that Sunday morning everyone agreed: "It just isn't turning up the way it should. Sounds like a low speed cruise, 2500 rpm or so."

It was a cold day in February and Jerry Coughlin and I waited in his pick-up for Jim to land. Most everyone else had discreetly disappeared, back to their projects in various hangars. I was ready to call it quits and Jerry was consoling me. "If nothing else, at least you can sell it as a quiet propeller," he encouraged as the Tailwind taxied by us to the hangar. "It sure is quiet." And it was, going swish-swish-swish, rather than the staccato bark usually heard from Jim's airplane.

I walked up to Jim as he got out of the airplane, ready for the bad news and asked him how it went.

"Does everything a propeller is supposed to do," Jim replied. "Wound up to 2800 and went just as fast as the regular one."

With those brief words we learned that the Bicambered Surface Airfoil works as well on propellers as ordinary airfoils, with no undesirable results; especially no increase in drag at high speeds. It was better by being exceptionally quiet, so quiet that we tried several other versions of the airfoil to learn more about propeller noise. A second benefit was it seemed Bicambered Surface Airfoil propellers got off the ground quicker, but on airplane flights we had no good way to measure and verify this. Thrust measurements had to be made, so propellers to measure sound and static thrust were carved for airboats where these qualities (quiet and high thrust) are badly needed and more readily measured. The airboat tests are very encouraging, demonstrating substantially higher thrust and again, substantially lower noise. The U.S. Fish and Wildlife Service at Horicon Marsh uses one. Their regular propellers can be heard from their base no matter where the boat is on the 35,000



CONCLUSIONS

THE FELIX BICAMBERED AIRFOIL PROPELLER PRODUCES MORE THRUST WITH LESS NOISE

THE FELIX BICAMBERED AIRFOIL PROPELLER IS MORE EFFICIENT, PRODUCING GREATER THRUST

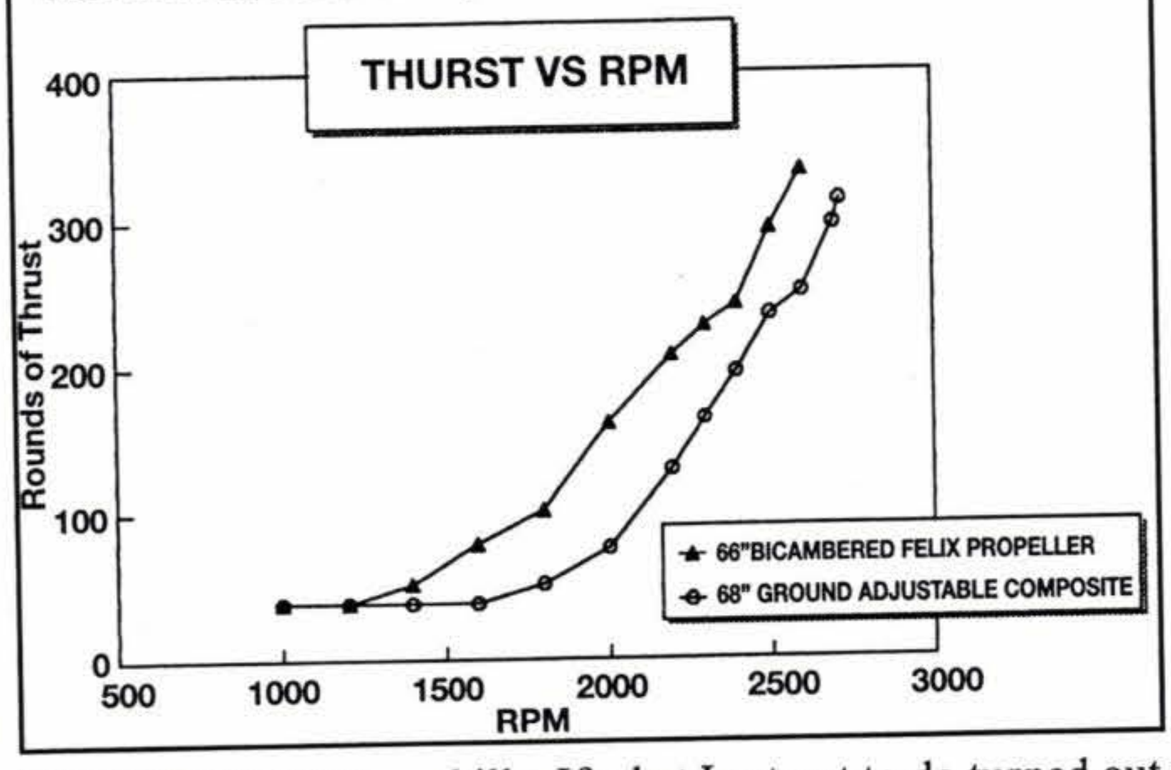
-USING LOWER RPM AND

-USING LESS DISK AREA (66" VS 68" DIAMETER)

STATIC THRUST AND NOISE TESTS

USING A FRANKLIN ENGINE, Model PZL-F
RATED AT 100 HORSEPOWER AT 2,600 RPM, 1,000' MSL

THE 68" TWO-BLADE, COMPOSITE, GROUND-ADJUSTABLE PROPELLER WAS ADJUSTED FOR MAXIMUM THRUST OBTAINABLE. IT WAS THE BEST PERFORMING COMPETING PROPELLER TESTED INCLUDING A COMPOSITE, GROUND-ADJUSTABLE, THREE-BLADE



acre refuge. The sound from the Felix Propeller practically disappears when it gets out 200 yards. It can't be heard at all when it is an appreciable distance away.

In various tests bystander reaction has been positive. Remarks have been received such as, "At least it doesn't sound like a machine gun going off," and, "It didn't shake the house like the other one did."

PATENTS AND INVENTIONS

I set out to improve the canoe paddle and ended up with improved propellers and a new-tech, high-tech airfoil. In retrospect it looks as though it's a combination of 25% determination, 25% seeing and recognizing an opportunity and 50% luck. The rest I attribute to mathematical skills. If what I set out to do turned out differently than I originally planned it, and with a different result, it was better than I could have dreamed. I had the good fortune to learn from lots of mistakes and the good fortune of having had help from a great many good people.

Eva, that's Mrs. Felix, just hates the word "invention." If she ever does refer to it she just calls it the "I" word. I can understand why because of all she has had to put up with and all the sacrifices she has made for this idea. When I first started thinking airfoils we were at first elated by the idea. Elation gradually changed to never-ending anticipation that soon the idea would be proved and I could turn to more productive pursuits, then disappointment when yet another obstacle reared its ugly head. Success was always around the corner, but there was always another corner. When I got discouraged and didn't know what to do, Eva consoled me and told me to follow my instinct. If I moped around long-faced for a few days, eventually she would tell me what my instinct was so I could follow it.

So around our house we never say the "I" word. But the process we went through was one of discovery, improvement, refinement, proof, patenting, testing, developing, all of which can be combined in only one word: invention. Invention was dealing with something new, something no one had ever dealt with before, and it didn't turn out the way we planned because something new is unplannable. It was a process of chaos in which one might find, but can seldom manufacture, opportunity.

We had the sympathy of our friends and family, even though at times they didn't understand me and occasionally appeared to