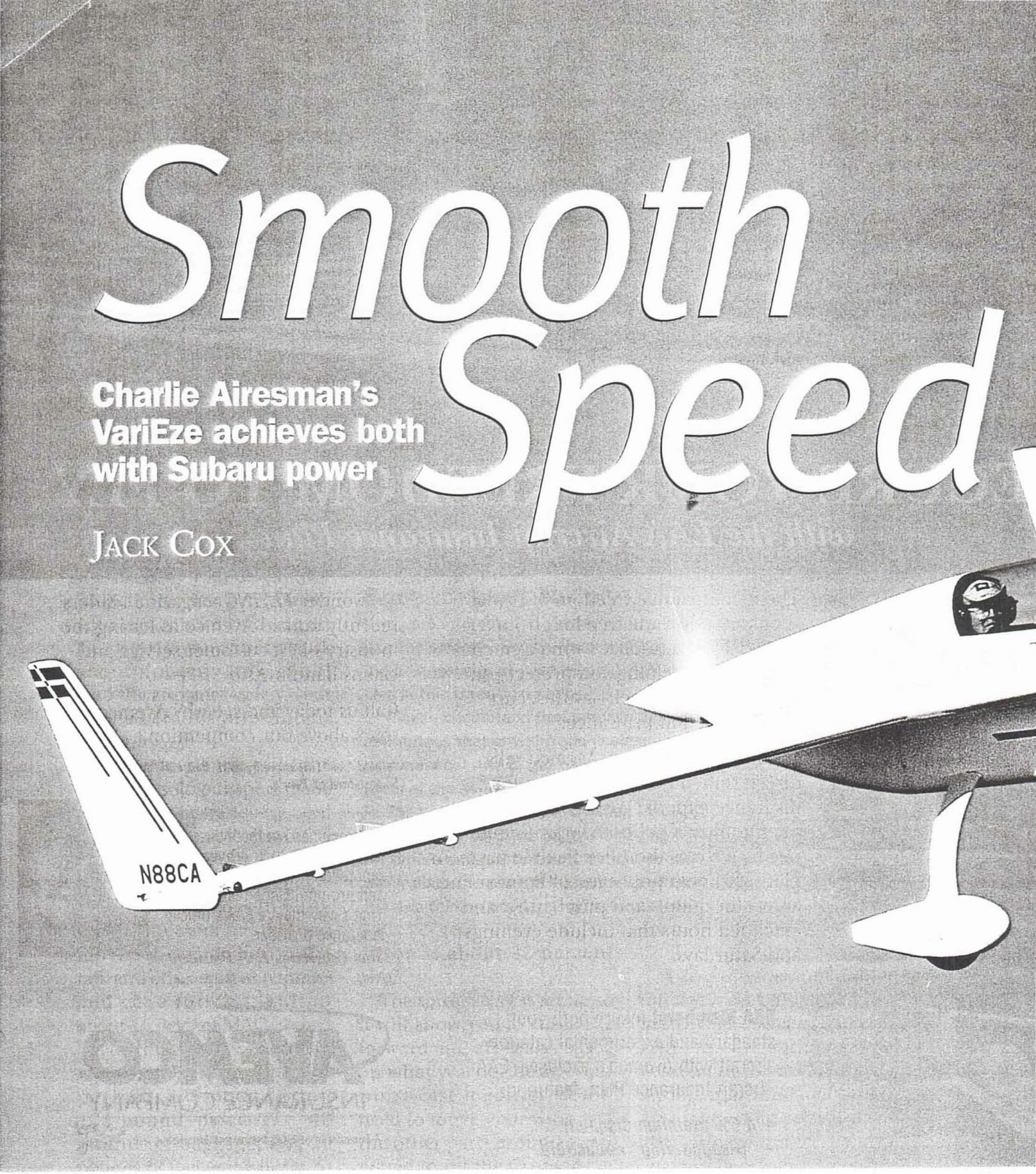
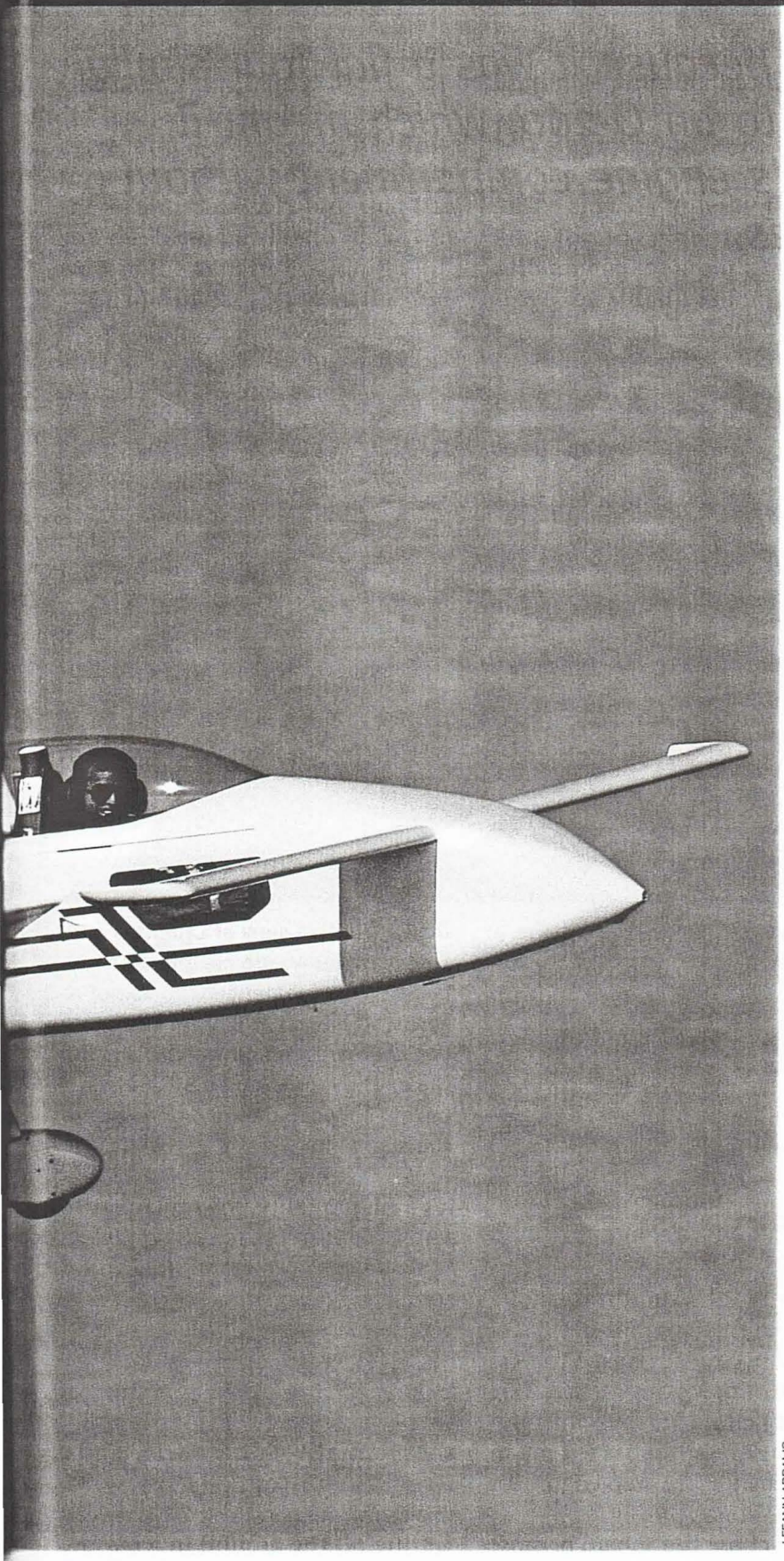
Smooth Speed

Charlie Airesman's VariEze achieves both with Subaru power

JACK COX





LEEANN ABRAMS

Charlie adapted several of Klaus Savier's VariEze airframe modifications, including side windows in the fuselage for a better view downward.

Most EAAers are familiar with the exploits of VariEze aces Klaus Savier and Gary Hertzler. They have set a host of records in their respective Ezes by refining their airframes, engines, and propellers to a degree that even designer Burt Rutan probably never envisioned when he introduced the revolutionary little canard airplane in 1975.

Though lesser known, others have chosen the VariEze as the test bed for their ideas on drag reduction and overall efficiency. Among them is Charlie Airesman of Cumberland, Maryland, who grabbed the attention of the EAA world in 1993 when he completed the Sun 100 race at a speed of 225.45 mph.

That speed garnered him only 17th place, but knowledgeable EAAers recognized that the 16 racers finishing ahead of him had the advantage of 120 to 340 additional cubic inches of engine displacement to power them around the triangular racecourse. No one else was close to Charlie in terms of miles per hour per cubic inch.

Charlie ran that race with a Continental O-200 boosted to 9-to-1 compression, with an Ellison throttle body injector and one of Klaus Savier's early electronic ignitions. He had also borrowed Klaus' composite racing propeller and pressure recovery spinner. The firewall aft modifications were only part of the story, however; Charlie put just as much effort into refining the airframe.

When he built the Eze Charlie narrowed the firewall to reduce the acuteness of the fuselage's aft end taper because he knew that trying to bend the slipstream more than 6 or 7 degrees back to the prop was a source of a lot of drag. A 6-inch prop shaft extension helped to stretch out that taper.

Charlie eliminated still more drag by means of a flush NACA belly air scoop for the engine, with the inlet reduced to 24 square inches;

Charlie chose the Subaru because it was a flat four similar in configuration and size to an O-200, which meant it would fit into the VariEze's engine compartment without extensive airframe changes.

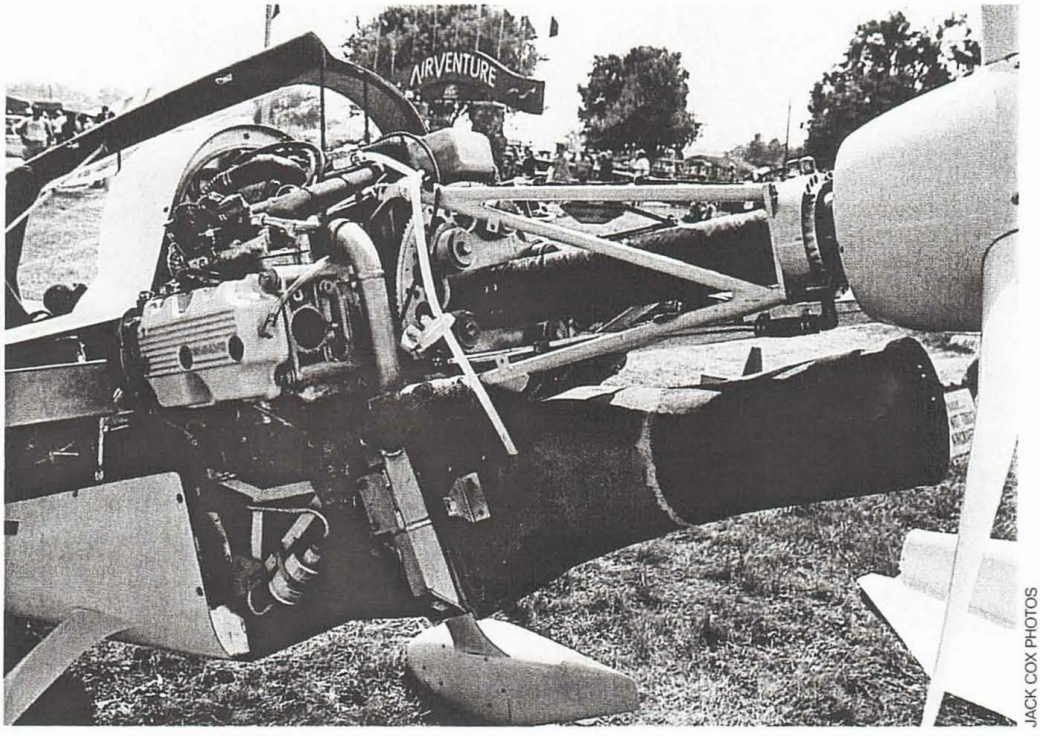
flush-fitting nose gear doors and belly board; and wider, airfoil-shaped main gear legs. He even machined his main gear wheels down to permit the use of narrower wheelpants!

While modifying his VariEze provided him with the means for satisfying his creative urges, Charlie was never satisfied with its engine. "I'd always been impressed with how the VariEze airframe cruised so fast on so little power," Charlie says, "but the torsional resonance of its aircraft engine drove me nuts. You'd land, get in your car, and its engine would be as smooth as glass—a contrast that bothered me every time I flew."

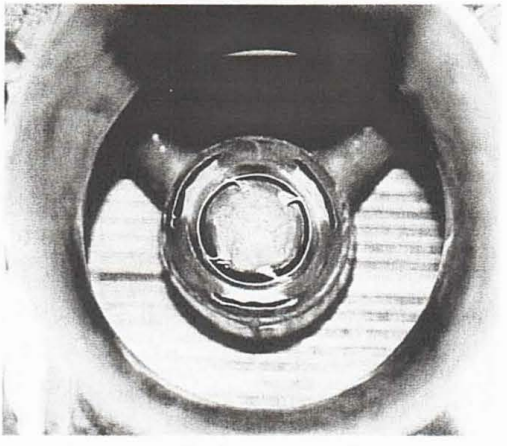
This is not a criticism aimed solely at the Continental O-200, Charlie points out. It includes all the flat fours used in lightplanes. The great Harold Morehouse designed the progenitors of all the current Continentals and Lycomings in the late 1930s (he was employed, successively, by both companies).

Morehouse had to work within the limitations imposed by the metals and lubricating oils available at the time. In practice that meant slow-turning engines with large displacement for the power derived. Unfortunately, that also meant that, compared to modern high-revving auto engines, they were—and are—real thumpers.

Charlie's radical solution for his engine's inherent roughness came as the result of a rare engine failure. "On a cross-country out west, the Continental ate a cylinder and caused a lot of internal damage. I was looking at a high dollar rebuild—new crank, new cylinders, the whole nine yards—so I decided it was time to do something different. I wanted the smoothness of a higher revving, smaller displacement engine, and I wanted to take advantage of the lower cooling drag I thought I could achieve with liquid cooling. This is what led me to adapt a Subaru EJ-22 auto engine for use in my VariEze."



JACK COX PHOTOS



Obvious in this view of Charlie's engine installation are his square tube, bed-type engine mount; the use of a flywheel; tubular mount for the carbon-fiber wrapped driveshaft; and the augmentor tube. Left, Charlie's bullet-shaped muffler is buried inside the augmentor tube.

Charlie chose the Subaru because it was a flat four similar in configuration and size to an O-200, which meant it would fit into the VariEze's engine compartment without extensive airframe changes. He was also impressed with the Subaru because it's a high quality powerplant with an excellent record for durability.

There were some potential showstoppers, however. As far as Charlie was concerned, the weight of a reduction drive in an airframe as small as the VariEze—and a pusher, at that—was out of the question. But the alternative, direct drive and a fixed-pitch prop, posed its own problem, the compromise between getting off the ground in a reasonable, safe distance and going really fast. It was a problem because Charlie knew his bias would be in favor of speed.

This was a real dilemma until he saw Bruce Bohannon out drag a

MiG-17 at Oshkosh in his Formula One racer, *Pushy Galore*.

"It was a pusher, it was direct drive, and it was getting its thrust from high rpm. I thought, by golly, the Subaru can easily turn that fast, so I ought to be able to make one work in the VariEze."

Charlie initially replaced the Continental O-200 with a 2.2 liter Subaru EJ-22 with a 19-inch long, 3-inch diameter, 0.125-inch wall, 4130 steel drive shaft; two of Klaus Savier's Lightspeed electronic ignitions; and a carburetor.

One modification Charlie really didn't want to undertake was fabricating a custom carbon fiber intake manifold, because it would mean losing the tuned lengths of the stock intake. But the custom intake was necessary to fit the engine in the VariEze's tight cowling. To avoid the probability of having to go through several fixed-pitch propellers to find the best pitch for takeoff and cruise, Charlie used a Warp Drive ground-adjustable propeller he cut down to a diameter of 52 inches.

Weight and balance became a problem once the heavier water-cooled engine was ready for installation, forcing Charlie to come up with an engine mount that would move the Subaru as far forward as possible. His initial efforts were to somehow adapt the O-200 mount, but he ultimately designed and built a totally new bed-type mount that tied into the landing gear structure—the configuration that flashed into his mind one night while lying awake puzzling over the problem.

One of the principal goals of the re-engine project was to significantly reduce cooling drag, and the setup Charlie settled on was an essentially straight-through passageway for the air. After entering the flush belly scoop, it would pass through an 8-by-1.75-inch inlet, expand to the 12-by-12-inch radiator, pass across the bottom of the airfoil-shaped, carbon fiber oil pan, and then exit through an augmenter tube 6.5 inches in diameter. The exhaust system consisted of straight pipes that dumped into the augmenter tube to help extract the cooling air.

The first flight of the re-engined VariEze was in 1999, and as is usually the case with so radical a transplant, some things worked well and some did not. The first problem manifested itself the instant the engine cranked up for the first time. It was LOUD! Straight pipes into an augmenter tube functioned like a megaphone, but at least there was little back pressure to reduce power output. A greater concern was a higher than desirable oil temperature, due in part to the lack of an oil cooler, which Charlie had hoped to avoid to save weight.

Another problem was the carburetor. Charlie says it was a nightmare from the start, and he was never able

to get the mixture distribution right. This was a contributing factor to the most serious operational problem of them all—"really anemic takeoff performance."

Initially, Charlie attributed that problem to his prop, which restricted the engine to 3500 rpm. He managed to get the revs up to 4000 by reducing the prop's diameter still more, but that only increased the top speed a bit. The takeoff roll just got longer.

There were some successes. As hoped, the engine was extremely smooth, and despite the carburetor problems, the fuel burn was slightly less than with the O-200. Top speed was about 200 mph. On balance, the engine was reliable enough for Charlie to fly to EAA AirVenture Oshkosh 1999, a trip that would result in a major improvement in the airplane's performance.

At EAA AirVenture Charlie sought out Tracy Crook, who had developed a controller for the electronic ignition/fuel injection system on his Mazda rotary engine conversions, and was pleased when Tracy agreed to build one for his Subaru.

"Tracy really came to my rescue, " Charlie says. "I installed his system, and it really worked well. It is totally redundant, except for the coils and injectors. If I lose an injector, I lose one cylinder, and if I lose a coil, I lose two cylinders. I could make those redundant, also, but it's such good quality stuff that I don't think I'll have a problem. To use Tracy's system I had to reinstall the stock Subaru starter (in a non-stock location), but I was tired of hand propping, anyway."

While he had the airplane down, Charlie decided to build a second, more powerful Subaru conversion for his Eze. It began as a 2.5 liter EJ-22, but to gain the greater efficiency of higher compression, he installed 2.2 liter heads, which raised the ratio to 11.5 to 1. High by aircraft standards, that much compression was not anticipated to be a problem in the Subaru because it's liquid cooled and Charlie intended to use 100 LL avgas rather than lower octane auto fuel.

Hoping to reduce the oil temperature, Charlie moved the radiator back behind the oil pan—and it worked. The coolant temperature had always been low enough that he felt secure in reducing the augmenter tube's diameter from 6.5 to 5.5 inches. Cooling remained adequate, but Charlie says he should have left the diameter at 6.5 inches, and he had to extend the prop shaft a bit to clear the repositioned radiator and augmenter tube.

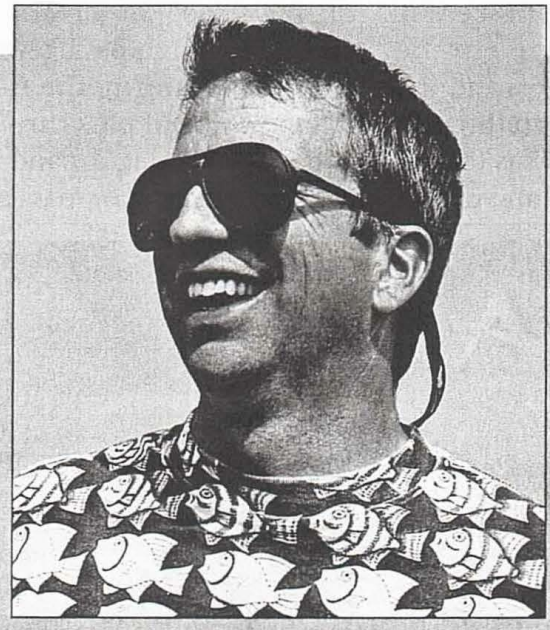
A significant decision was to revert to the Subaru's flywheel. Cut down to 10 pounds, it was required for the starter and to help dampen firing pulses that could lead to drive shaft failure. In combination, the flywheel and the rubber isolators Charlie used further added to the engine's smoothness and helped dampen torsional loads.

Charlie addressed the noise problem in a somewhat novel fashion. He built a bullet-shaped muffler into which the two-into-one exhaust pipes from each bank of cylinders extended, and he positioned the muffler in the center of the augmenter tube. It proved to be an effective (and necessary) solution, but he found he had lost several inches of water column negative pressure when he measured the flow through the augmenter.

For the second-generation engine Charlie built his own two-blade composite prop—composite laminate over wood, actually—with very thin tips. It was driven by a new 2024 aluminum extension shaft, 3 inches in diameter, 1/8-inch wall thickness, and wrapped with carbon fiber for additional stiffness.

When completed, the engine ran per-

Charlie Airesman


JACK COX

Charlie Airesman was born in Cumberland, Maryland, in 1956 and has lived there all his life. A controls technician for a gas transmission company, he works on complex equipment like industrial turbines. He built model airplanes as a youngster but always assumed that flying and aircraft ownership was out of his financial reach.

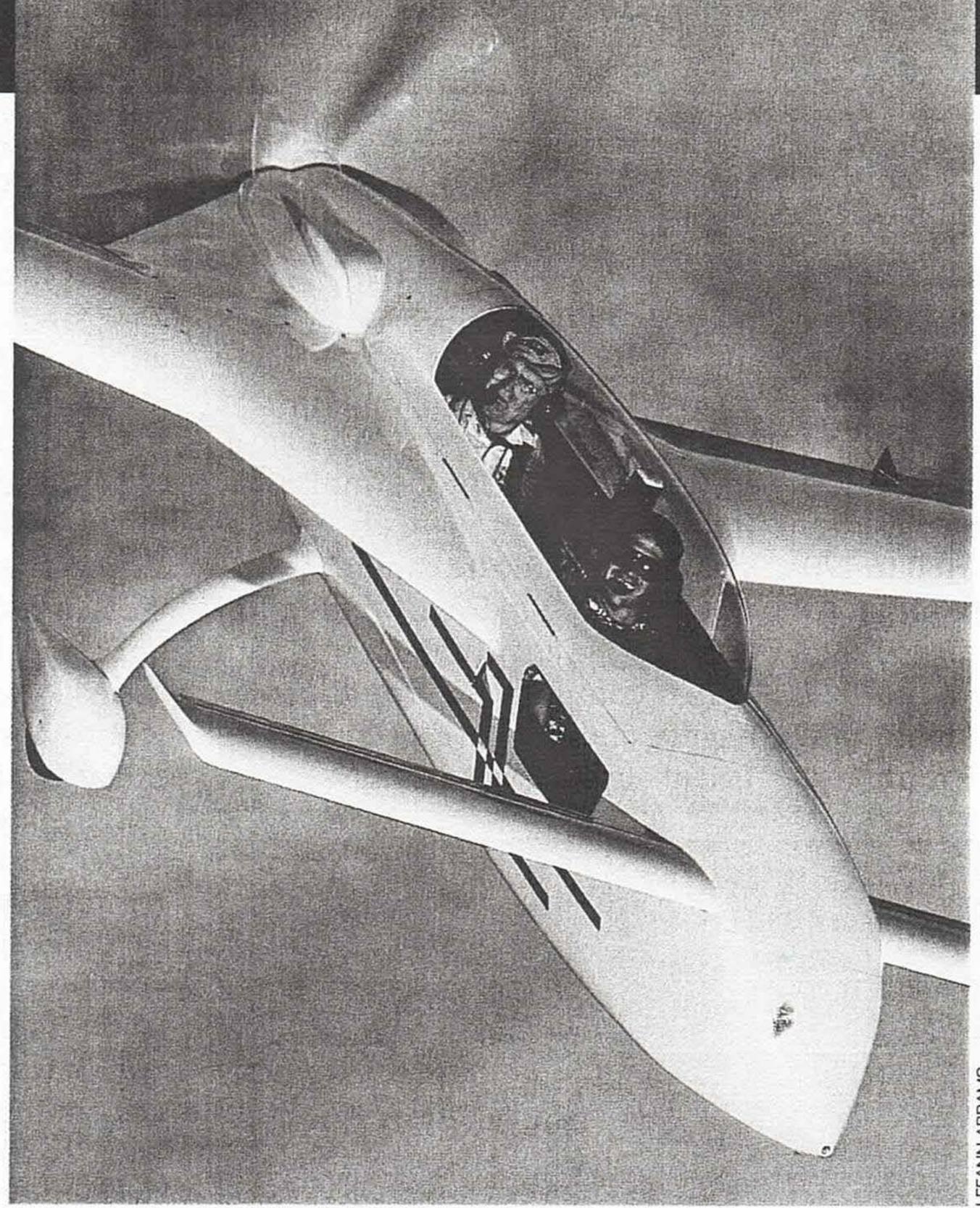
That changed when his friend, Greg Teeter, "dragged him off to Oshkosh" in 1986 and he saw a VariEze up close for the first time. Building was right up his alley, so he just had to have one. He and his father, Charlie Sr., built N88CA, an award-winning example of the type, and it flew for the first time in 1989 with the Continental O-200.

Charlie's wife, Dee, likes to fly as much as he does. In the years before the engine change they flew the Eze all over the place, out west, to the Bahamas, to Cape Hatteras for wind surfing, and to the Florida Keys (where they flew on their honeymoon). Change has come to the Airesman household, however. They now have two young children, so the VariEze no longer fills their aerial transportation needs. Charlie is now well along on a Cozy he intends to power with two Subaru EA-81 turbocharged engines, and it will look like a mini Beech Starship.

"I need two airplanes," Charlie says, "one to work on and one to play with. When I get the Cozy flying, maybe I'll get the VariEze the rest of the way up to speed. I think there's potential left in both the Subaru engine installation and the airframe for even greater efficiency."

fectly, boosting the Eze's top speed to 238 mph—but the takeoff roll was still too long. "With two aboard on a hot day, I felt I needed 4,000 feet of pavement to be safe on takeoff. I could get off in 2,500 to 3,000 feet, but the climb was such that I needed the extra runway to clear obstacles," Charlie said.

He still managed to fly to EAA AirVenture Oshkosh 2000, and, once again, a friend came to his rescue and solved a major problem. "Gary Hertzler is a good friend, and he agreed to design a three-blade propeller for me with airfoil sections that would provide a lot of lift. He sent me an e-mail spreadsheet, and I simply printed the sections out on the computer. Then I used them to cut a plug for each blade out of foam and pulled molds off the plugs. I put the molds together and built a prop that was all composite, except for maple drive lugs," Charlie says.



LEEANN ABRAMS

"Man, what a difference! When I first ran it up, I got about the same static rpm as with my two-blade prop—but I was shoving on the brakes hard and could feel the nose going down. 'This thing is going to work,' I thought—and it did. It

reduced my takeoff roll significantly and increased the rate of climb."

When he arrived at EAA AirVenture 2001, Charlie had achieved most of the goals he'd set for the Subaru conversion. "Gary had designed the three-blade prop for 4000 rpm. It is 53 inches in diameter, and the pitch is 61 inches. I get 2800 static rpm, and at low speed, just flying around sightseeing at 160 to 170 mph, it turns around 2800 rpm. At 3100 rpm I initially climb at 1,000 fpm. When climbing to altitude, I climb faster to get the engine rpm higher, typically at 175 mph and around 700 fpm. I have no problem climbing to 17,500 feet, and, yes, I have an oxygen system. I don't cruise any slower than 160 to 170 mph, and I'm at less than a quarter throttle there, burning around 2.5 to 3 gallons per hour. After all these years, people still don't seem to realize just how efficient the VariEze airframe is. The flat plate area is very small, and with the canard, you're not dragging a down-loaded tail through the air. Combine that with a high compression, liquid-cooled engine, and you have a very, very efficient airplane," Charlie says.

"At 10,000 feet I see 210 to 215 at 2450 rpm and 4 gph. On cross-country flights, if the weather and head winds permit, I usually cruise above 15,000 feet at full power—3600 rpm at 225 mph burning less than 5 gph. Top speed at sea level is down slightly from what I was getting with the two-blade prop—232 mph at a shade under 3670 rpm—but that's a more than acceptable trade-off for the increased takeoff and climb performance. The Subaru is as smooth as I hoped it would be and very economical to operate. While it is not as noisy as the Continental, it is still not as quiet as I had hoped for."

A question that always comes up regarding auto conversions is weight. Even with a starter, nav lights, a coolant radiator and the necessary connecting hoses, a gallon of coolant, two batteries (redundancy for the electronic ignition/fuel injection system), and little extra items such as a roll trim system Charlie built using a power window motor, the airplane weighs just 30 pounds more than when equipped with a Continental O-200. The new empty weight is 730 pounds. Charlie says he considers anything more than 700 pounds to be excessive for a VariEze, but notices little difference in the airplane's handling or performance.

Cost is another factor EAAers want to know about. Because his project stretched over several years, with a number of significant reworks and changes along the way, it is difficult for Charlie to put a number on the cost of his Subaru conversion, but it is less than a new or fully rebuilt O-200. He does caution other VariEze builders to think long and hard before starting a similar project, however.

"Unless they have the background and facilities to build a lot of things themselves, such as the carbon fiber intake manifold, prop shaft and its tubular mount, oil pan, etc., it's probably not a good idea to start such a project. It would cost a fortune to farm this stuff out to someone else. If, on the other hand, they like to tinker, it's a lot of fun."