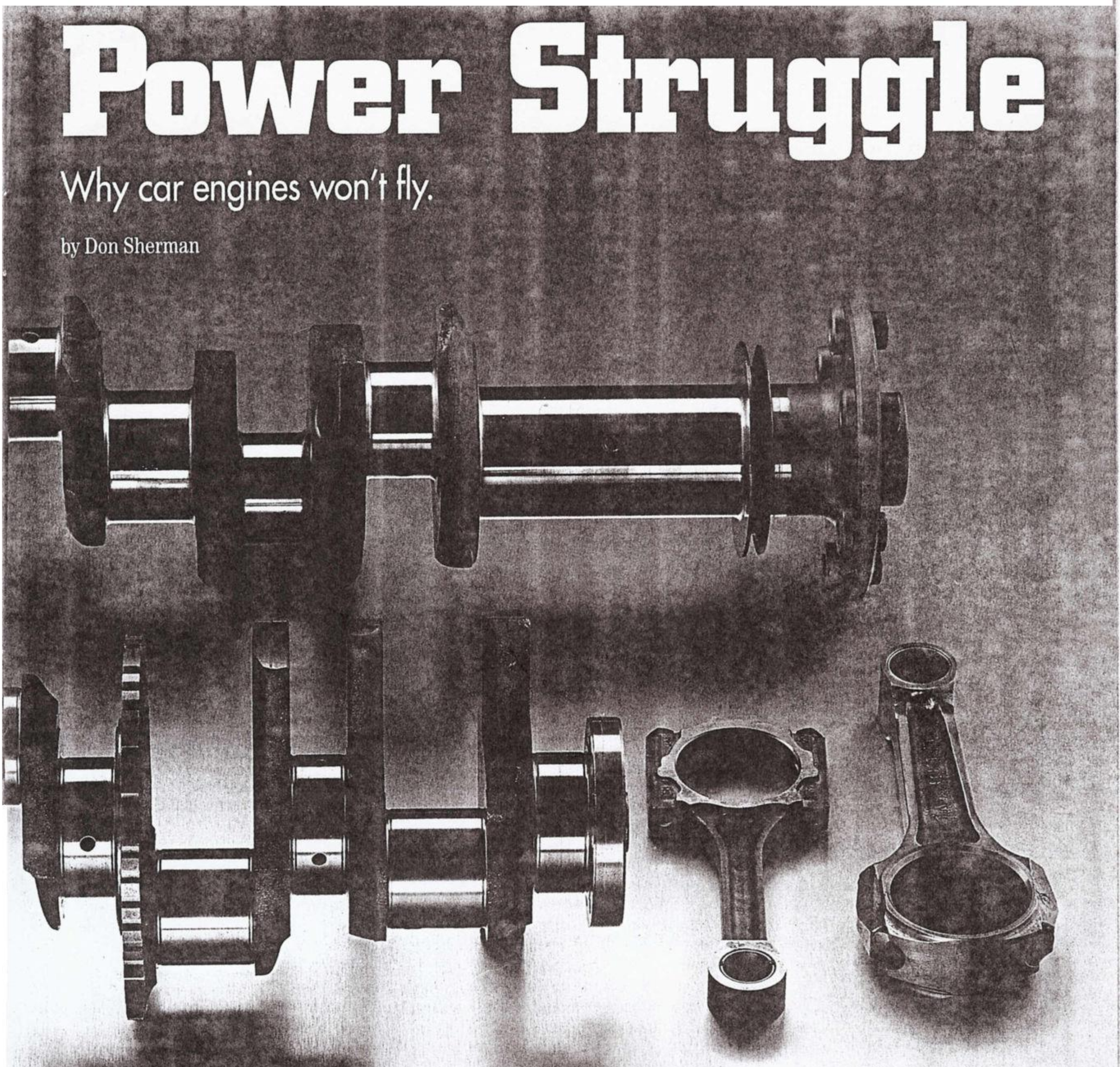
Power Struggle

Why car engines won't fly.

by Don Sherman



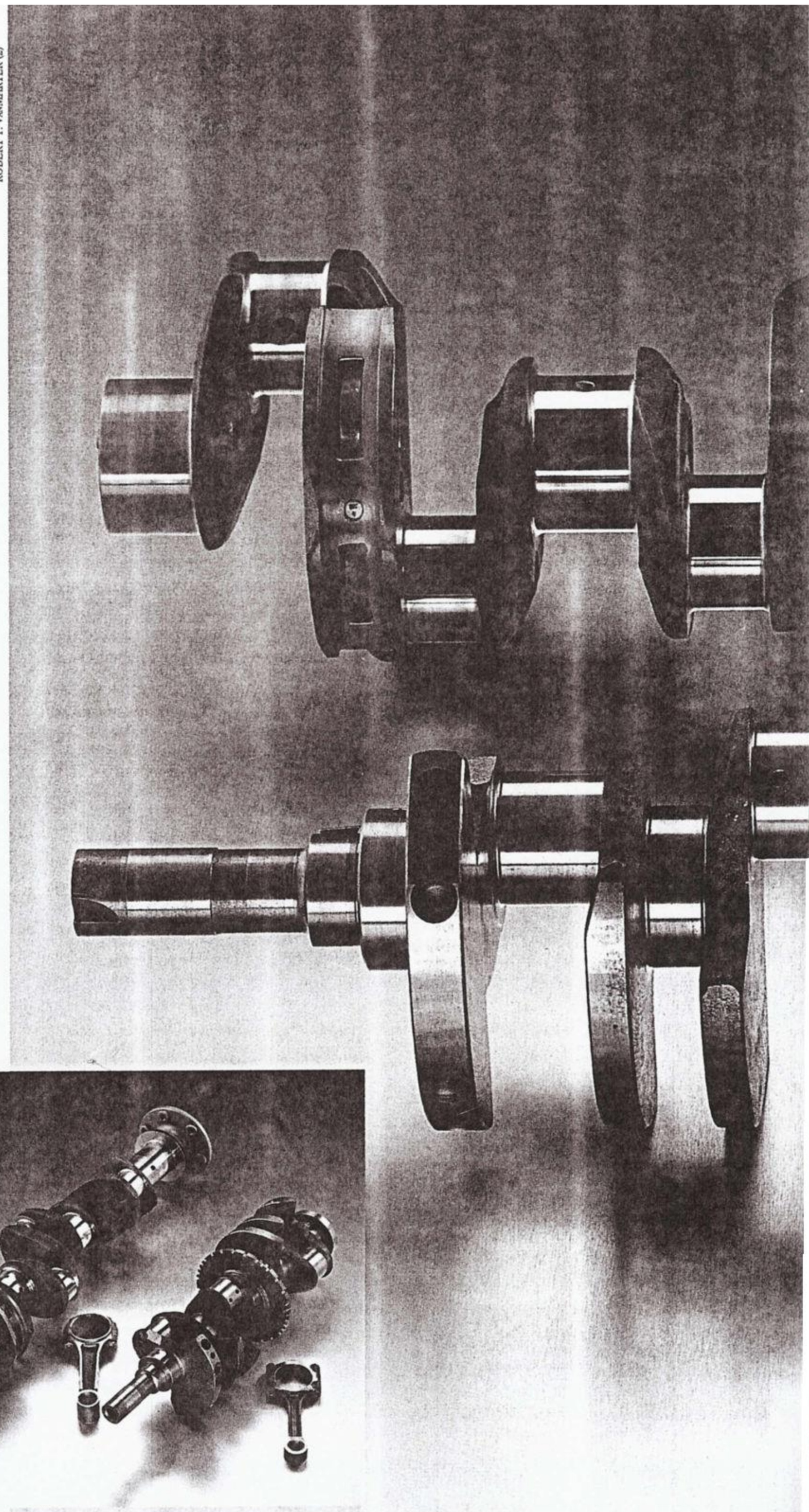
The crankshafts and connecting rods of two 300-horsepower engines illustrate the stark differences between automobiles and aircraft. The Cadillac Northstar V-8 crankshaft (foreground) has five main bearing journals, all narrower and of larger diameter than the four connecting rod journals, each of which is linked to a pair of pistons. The large toothed ring near the middle of the crankshaft governs spark timing. The Lycoming IO-540 crankshaft (background) has four main bearing journals, including the extra large one for the propeller at the front end (right) and six connecting rod journals, one for each cylinder. The cooling fins on each cylinder increase the engine's intercylinder distances, making the crankshaft considerably longer than the Cadillac's (inset). Because of their length, combined with a more severe operating environment, aircraft cranks must be made heavier than a car's.

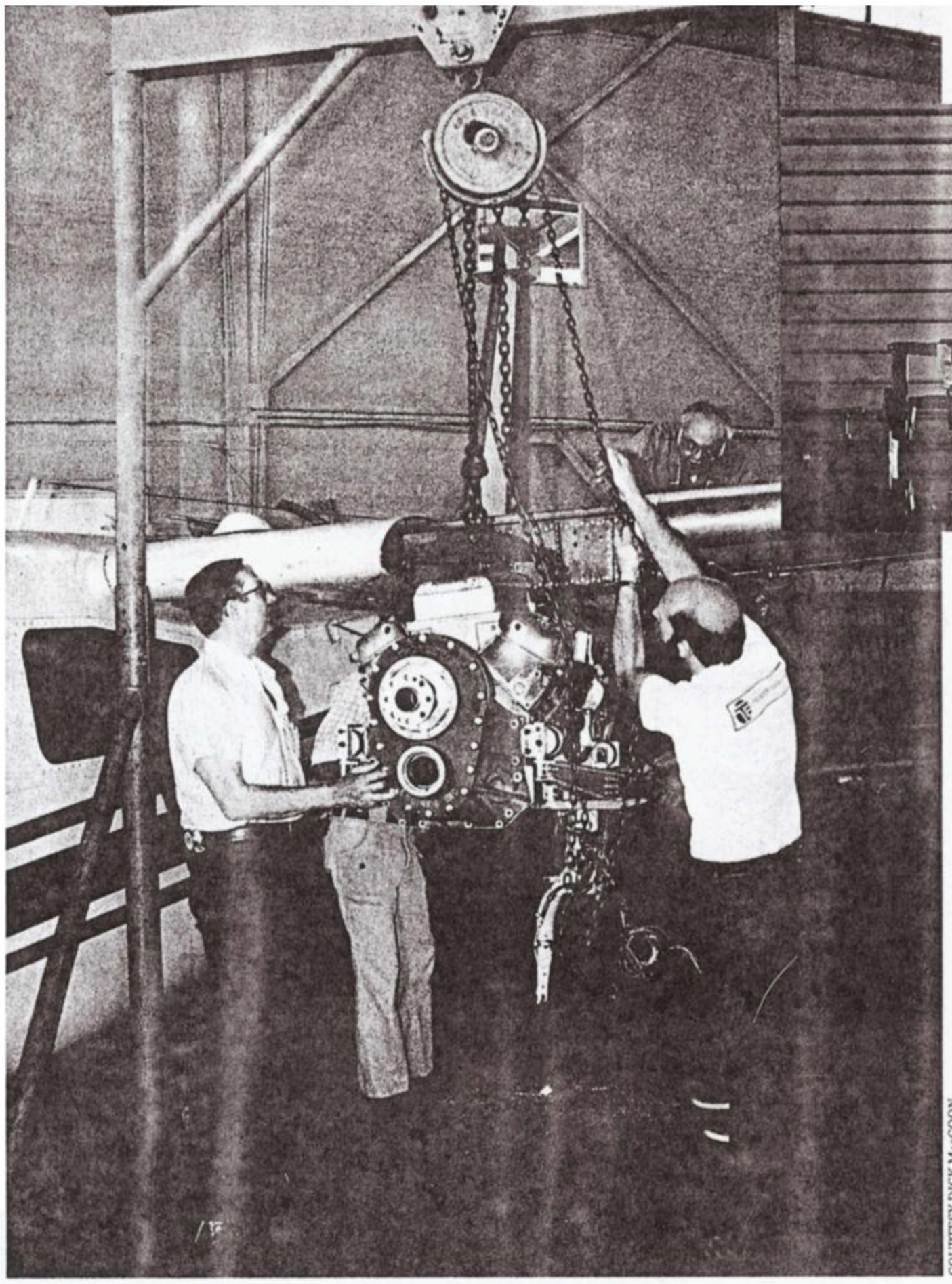
During World War II, liquid-cooled piston engines did more than their share to help secure victory. The U.S. Allison V-1710 in the P-40 Warhawk and P-38 Lightning and the British Merlin in the Hurricane, Spitfire, and P-51 Mustang were "fighter" engines: two banks of six cylinders arranged in a "V" not much wider than the pilot's shoulders, the whole thing shoehorned into a slim cowling that parted the air like a stiletto. The Allison notwithstanding, the Americans had a preference for air-cooled radial engines, and liquid-cooled engines were a primarily European technology. It was the license-built Merlin that made the Mustang a legend (see "Who Made the Mustang?" Aug./Sept. 1996), and after the Allisons, no American liquid-cooled V was produced in volume.

In the United States today the only aircraft piston engines of any kind in volume production—leaving aside for a moment the issues of liquid cooling and the V configuration—are produced by Teledyne Continental Motors (TCM) and Textron Lycoming. The two companies offer primarily air-cooled engines that have cylinders opposed in a horizontal, or "flat" layout, and produce 100 to 425 horsepower. They have been used primarily in light, general aviation single- and multi-engine airplanes. (TCM wraps the cylinders in water jackets to cool its "Voyager" series engines, but the layout is unchanged.)

With the exception of these small engines, the piston engine has been replaced in aircraft by the powerful, lightweight turbine. Even in Europe the liquid-cooled V has long been extinct, and today, not a single modern descendant of the thundering Merlin has made its way into a current aircraft. The largest U.S. piston engine for aircraft made today is the 46-inch-long eight-cylinder Lycoming IO-720 rated at 400 horsepower. An Allison 250-B17, the closest comparable turbine engine, produces 420 shaft horsepower but weighs only 35 percent as much as the big Lycoming. It makes up for the lower weight with a higher price,

ROBERT T. VANMARTER (2)







CHAD SLATTERY

COURTESY DICK MacCOON

Dick MacCoon (above) tapped the motor racing community to develop the Thunder engine from a racing version of a Chevrolet V-8. In tests on an Aero Commander twin (left), the engine developed horsepower without adverse vibration or overheating.

however. So between roughly 400 and 500 horsepower, where you might expect some overlap and active competition between pistons and turbines, there is instead a gap, and in terms of price alone, the gap is more like a canyon.

The inherently compact arrangement of two banks of cylinders in a V-shaped block lives on in the automobile, where it thrives today in V-6s, V-8s, and a few V-12s. Now two enterprises, working completely independently, want to take the liquid-cooled V back from the automotive industry so they can return it to the airplane and fill the piston-turbine gap. The problem is that the liquid-cooled V is an automobile engine now. There is no airplane left in it.

The idea of powering light airplanes with automobile engines is hardly new (see "Classical Gas," p. 76). For years experimenters and homebuilders have been drawn to converted automobile engines because they're relatively cheap and plentiful compared to aircraft engines, which are manufactured in much lower volume. Many also complain that while the "Lyconental" technology has grown stale, automobile engines have enjoyed rapid advances, with such innovations as overhead camshafts, multi-valve combustion chambers, and microprocessor-controlled fuel-injection and ignition systems, to name a few.

For aircraft, there are inherent advantages in both liquid cooling and the V layout. Liquid cooling allows cylinders to be packed closer together, which results in a shorter, stiffer crankshaft, and the V configuration is narrow. Although the only source for such engines is the automotive industry, neither team working on the two current projects will simply pull a Buick block out of a boneyard and stick it in a biplane. First they have to strip the car out of the engine and put some of the airplane back in.

One enterprise pairs United Technologies' Hamilton Standard division with the Toyota Motor Corporation. Hamilton Standard's effort employs advanced technology and enjoys the deep pockets of one of the world's wealthiest industrial groups. But the partners are so secretive that not much is known about their plans.

The second player is the Orenda Division of Fleet Aerospace in Ontario, Canada. There are no secrets about the Orenda team's plan. They have taken aim at nothing less than the world's most popular turbine: the Pratt & Whitney Canada PT6 family of turboprops.

To understand why something so seemingly easy as adapting an automobile engine to power an airplane isn't really easy at all, it's essential to acknowledge that all piston engines are not created equal, and that moving a car down the road has little in common with propelling an airplane through the air. The key difference between automobile and aircraft engines is the intensity and duration of loads placed on them, or their "duty cycles."

One of the most sophisticated automobile engines currently in production is Cadillac's Northstar V-8. Light and compact, this 279-cubic-inch prime mover generates 300 horsepower from a 400-

Why an Airplane Is Not Like a Car

Both cars and airplanes exact their share of torture on an engine, it's just that the nature of the torture is different. Because the output shaft of any engine is an extension of the crankshaft that turns the pistons' reciprocating motion into rotary motion, the crank is the place where stress and strain have the most direct effect.

When your teenager pops the clutch to make the tires chirp, there's a massive flywheel and built-in driveline flexibilities (tire slippage, for one) to protect the crankshaft from excessive stress. Automatic transmissions provide fluid-filled torque converters that keep the shock from the occasional pothole from being passed on to the crank (Figure 1).

Under normal circumstances aircraft engines have no shock loads to contend with. Instead, their cross to bear is torsional vibration. The simplest illustration of torsional vibration is a rubber-band-powered flying model. Like the rubber band, an airplane's propeller shaft has an inherent flexibility that extends all the way through the crankshaft and any drive system or reduction gearbox to the point where the propeller is attached. Every time a cylinder fires, portions of the driveline are twisted or wound up with respect to the rest of the system. And like the rubber band, these wound-up portions spring back. This repeated twist and untwist is torsional vibration in its simplest form.

On a car, flexible driveline elements such as the tires and the torque converter absorb torsional vibration. But the airplane's propeller is a large mass that can contribute torsional vibration of its own to the crankshaft. In fact, the flexibility of the propeller drive and the propeller's rotating inertia constitute a torsional system (Figure 2).

Every torsional system has a natural or resonant frequency analogous to the pitch of a plucked violin string. Rubber-band models have a very low natural frequency of only a few cycles (wind, rewind) per minute. Airplane engines and propellers have much higher resonant frequencies and usually several of them. The plot of torsional vibration versus speed for a Merlin V-12 is a roller coaster of a dozen or more peaks and valleys. In addition to firing impulses, other disturbances such as a change in prop pitch can influence torsional vibration characteristics. Problems arise when some vibrational disturbance coincides with the system's natural frequency. After the accumulation of so many twist cycles at its natural frequency, the crankshaft is susceptible to local cracking followed by total failure. Severe torsional vibrations must be analyzed by engineering tests and either eliminated or labeled "critical speed" in operational manuals so they can be avoided during sustained cruising.

Another means of avoiding torsional-vibration problems is to use a very short, very stiff crankshaft, one of the prime advantages of a radial engine. But in opposed cylinder arrangements or in V engines, air cooling mandates greater inter-cylinder distances to provide room for cooling fins. A liquid-cooled V has an inherently compact layout that leads, in turn, to shorter, stiffer crankshafts.

ILLUSTRATIONS BY FRANK KULCZAK

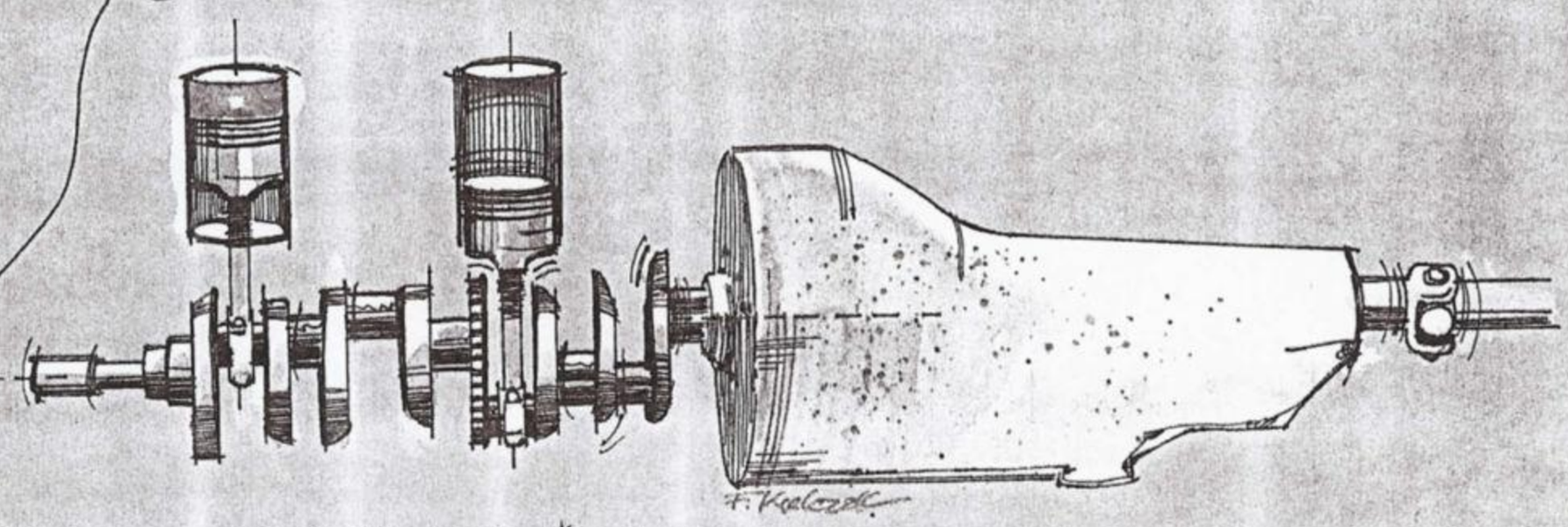


Figure 1 *Automotive engines are subjected to sudden acceleration, long periods at idle, and shocks from irregularity in the road surface that can be transmitted to the engine. When an individual cylinder fires, the force from the combustion of the fuel-air mixture causes a momentary twisting, or torque-wise, force to be imparted to the crankshaft. But just as the car's driveline tends to absorb road shocks, it also dampens the forces that create torque-wise vibration.*

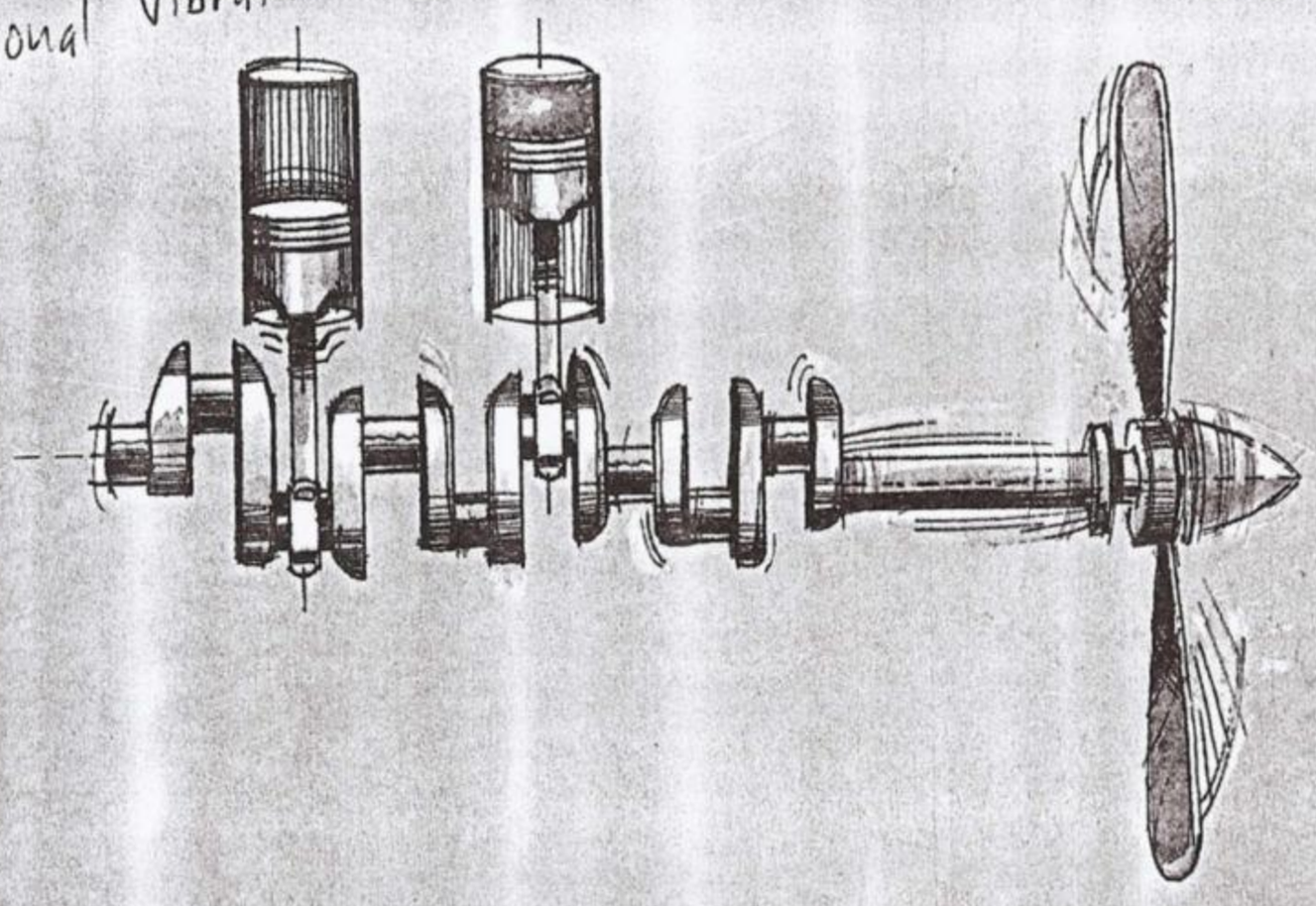
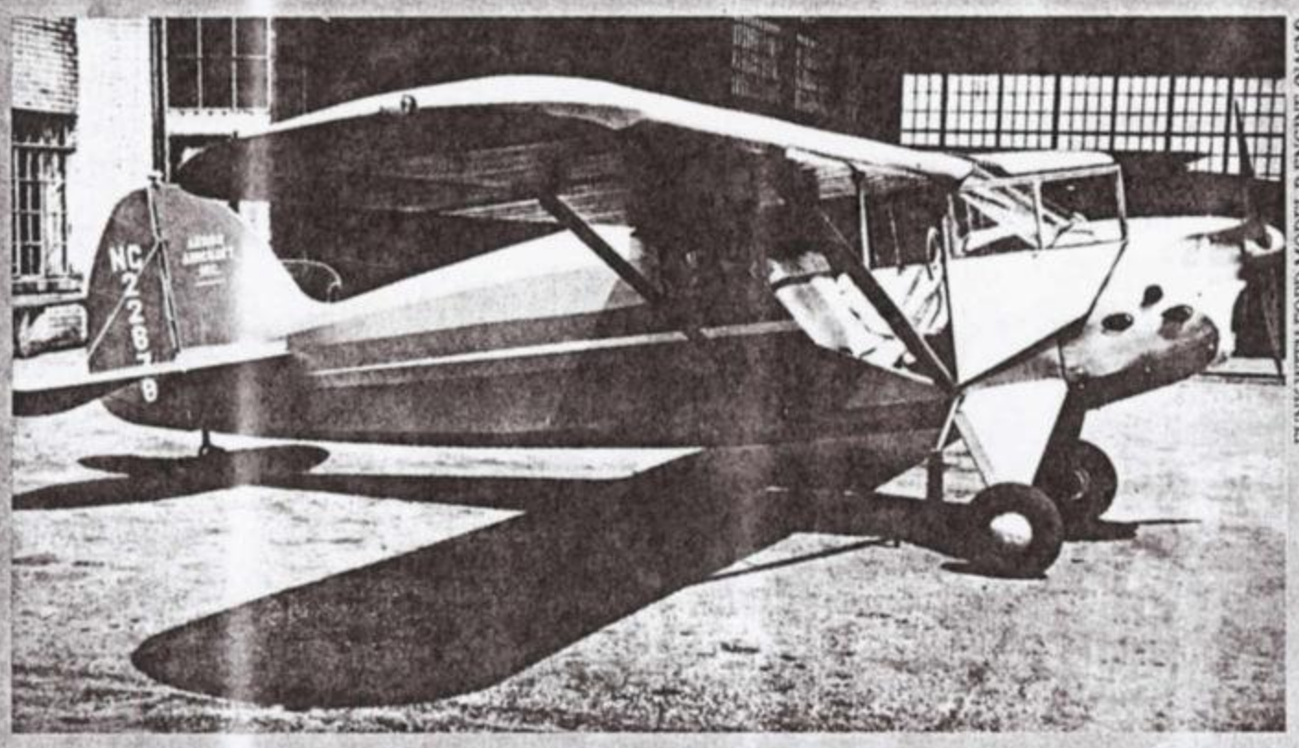


Figure 2 *The force created when combustion occurs in the cylinder also twists the crankshaft of an airplane engine. But in this case, the propeller blade may actually amplify the pulse by "ringing" at the same frequency and imparting a twist in reaction that travels back down the crankshaft. The propeller blade can flex along its length, and its center of mass is at a considerable distance from the propeller hub, an ideal combination to create a vibrating system.*



FUNK WITH FORD MODEL B ENGINE (NASM)

Classical Gas: Car-Powered Airplanes

Charles Van Auken's Ford Model T-powered flyer experiment of 1909 ended at an altitude of eight feet when the crankshaft broke and Van Auken landed in a tree. Bernard Pietenpol seized the baton in 1930 with the Air Camper, a two-seat wooden monoplane powered by a 40-horsepower Ford Model A engine. A simpler version called the Sky Scout was one of the first successful amateur-built designs. This single-seater used a 30-horsepower Model T engine and could be constructed from $200 worth of materials.

One of the first fully certified examples was the Wiley Post A, named after the famous aviator and the craft's powerplant, a Ford Model A engine. About a dozen were produced during the 1930s. Later, the Funk B2 used an aluminum-block version of the same engine in 330 production two-seaters.

Studebaker got into the act in the mid-1930s by backing the Waterman Arrowbile, one of the first flying-car attempts. Waterman was one of thirty respondents to the 1933 Vidal competition, a U.S. Bureau of Air Commerce program to stimulate low-cost aircraft development. To qualify for a type certificate a 100-horsepower Studie six was run for 150 hours under load. It passed that test with flying colors but only five craft were built before the program ended.

Another Vidal proposal, the SF-2 Plymacoupe, used a Plymouth six-cylinder engine driving a propeller at half speed through a bolt-on gear reducer. This 900-pound aircraft was capable of cruising at 85 mph.

One of the most successful Vidal-inspired airplanes was the Arrow Sport F, which used a modified Ford flathead V-8 producing 82 horsepower. After World War II, Mooney Aircraft certified the single-seat M-18 Mite with a 22-horsepower Crosley four-cylinder engine. Ten airplanes were built, all subsequently repowered with aircraft engines due to a lack of faith in the Crosley's crankshaft.

The success of the Volkswagen Beetle prompted U.S. car makers to respond with their first wave of small cars—the Chevy Corvair, Ford Falcon, and Plymouth Valiant—in the early 1960s. When Buick introduced a light, compact V-8 with an aluminum block and cylinder heads in 1963, the Cessna Aircraft Company deemed the engine worth a try. Test flights were successful but they led nowhere.

That didn't discourage amateur builders who, by the late 1960s, found salvage yards well stocked with engines far more suitable for their use than the classic big cast-iron American V-8s. There were Beetle and Corvair engines with at least three key design characteristics in common with a proper aircraft engine: cylinders arranged in a flat configuration, air cooling, and light-alloy castings for major components.

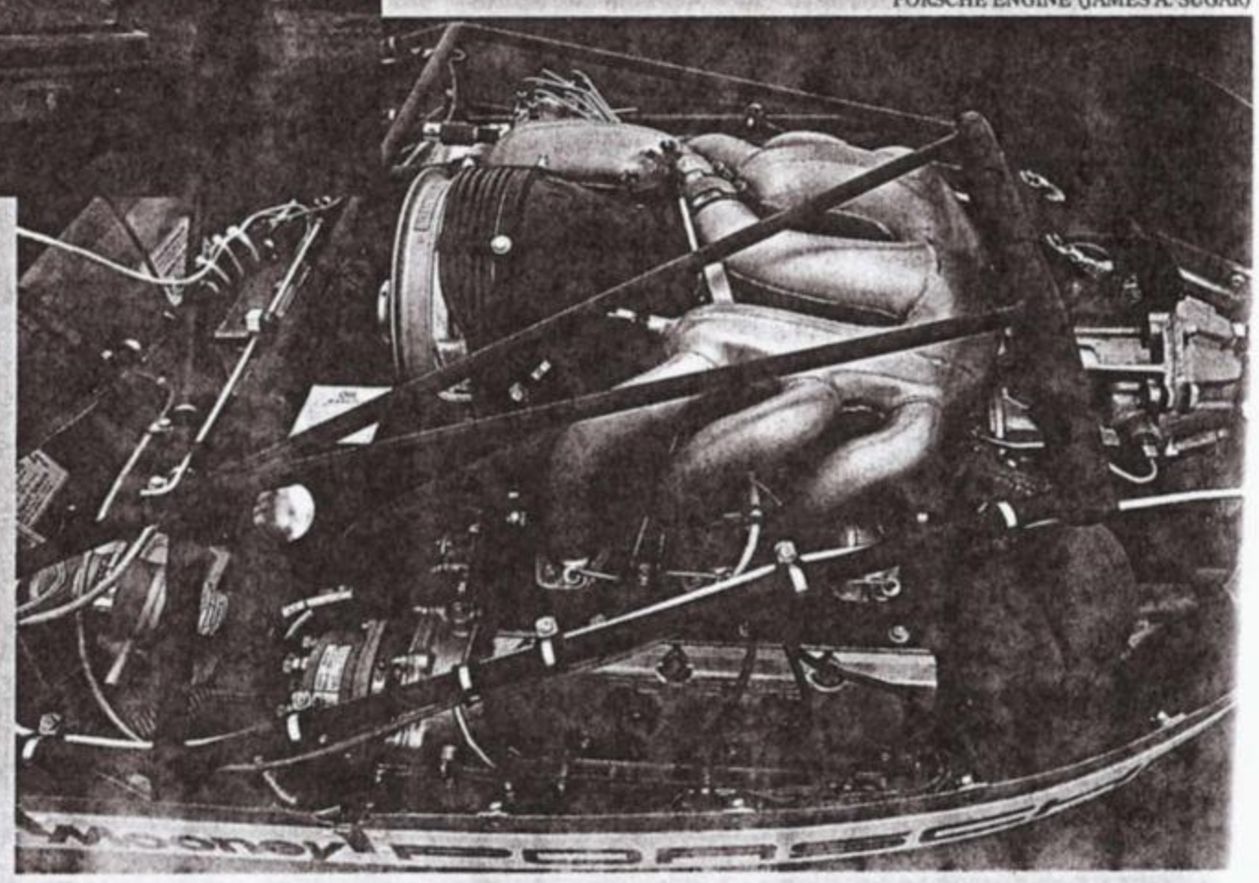
Fred Geschwender of Lincoln, Nebraska, experimented with various Ford V-8 engine conversions throughout the 1970s and again more recently. One of his discoveries was that a heavy flywheel in combination with a chain-driven speed reducer and belt-driven accessories combined to reduce torsional vibration problems. Ultimately shut down by the FAA, this self-made engineer identified a demand for affordable horsepower capable of replacing not only the old radials but also the new turbines in the agricultural airplane field. Another entrant in the same market was Joe Schubeck, whose Stage II engine was derived from a drag-racing block based on the Chrysler Hemi. Schubeck's engine flew on a Grumman AgCat.

The Porsche-Mooney project of a decade ago suffered from a different problem: not enough customers. In engineering terms, the conversion of a Porsche 911 engine to aircraft duty was a complete success. It passed muster with the FAA while demonstrating a few distinct advantages: reduced cockpit noise and the convenience of a single-lever electronic control system for engine speed, fuel-air mixture, and propeller pitch. The use of an engine-driven fan keyed air flow to throttle setting, thereby avoiding a standard aviation-engine bugaboo—shock cooling. Porsche had plenty of aircraft experience, having previously configured the same engine as a ducted fan for a blimp. The downside was diminished performance versus the standard Lycoming engine and a high price resulting from unfavorable swings in the currency-exchange rate. After selling only 46 units, Mooney shelved its Porsche-engine project.

PORSCHE AND MOONEY AIRPLANE POWERED BY PORSCHE ENGINE (JAMES A. SUGAR)



PORSCHE ENGINE (JAMES A. SUGAR)





COURTESY DICK MacCOON

The Thunder engine endured about 20 hours of test flying on the port side of the Aero Commander at left, but even the stresses of racing in a Can-Am sports car (below) were mild compared with aircraft duty.

pound package only 60 percent as bulky as the equivalent 300-horsepower Lycoming aircraft engine. (Two mass and volume contributors—the Cadillac's coolant and radiator—are excluded from this comparison.) The Northstar's weight and power rating look attractive for aircraft until you look at what it's asked to produce on the road. A mere 30 horsepower from the Northstar will propel a Cadillac at 65 mph all day long. The remaining 270 horses under the hood are rarely used, and at full throttle the car will accelerate from zero through the 100-mph barrier—the felony zone for speeding tickets—in a mere 20 seconds. But just to make sure the Northstar is tough enough to deliver more than 100,000 miles of faithful service, GM engineers devised one of the auto industry's most grueling durability tests. On a test stand, with a power absorber connected to the engine, the Northstar was run for 300 hours at full throttle, with the load being controlled on a schedule that allowed the engine to run at speeds that ranged between peak torque and peak horsepower.

In the world of aircraft, though, that's child's play. An aircraft engine typically runs more than a minute at full throttle during every takeoff. Even throttled back for cruise, an aircraft engine must deliver 60 to 75 percent of full rated power for hours on end. And while 300 hours was typical for engine life in wartime and still adequate for experimenters, owners of new light aircraft typically expect 2,000 hours of service before a major overhaul.

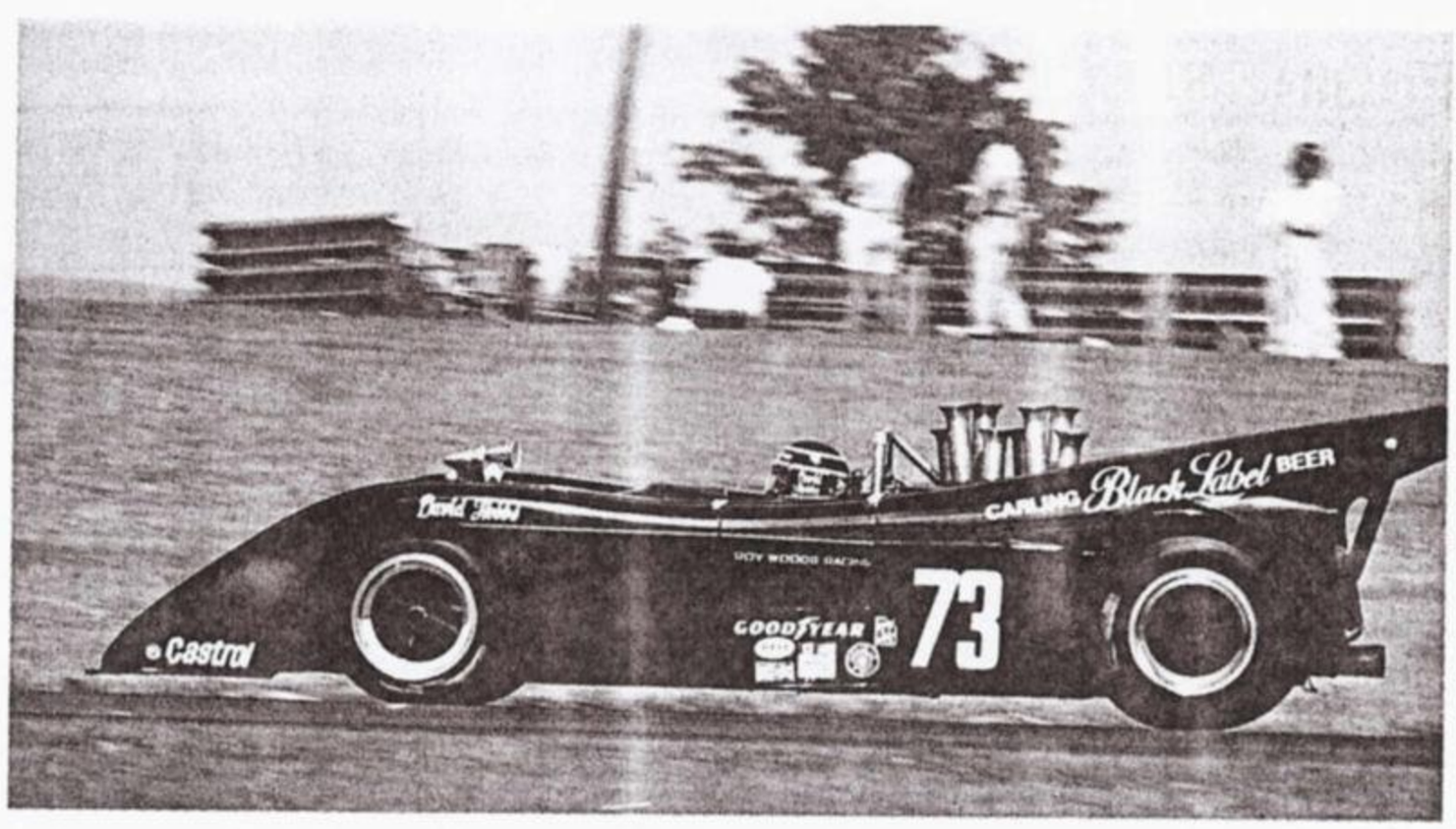
The duty cycle is much more strenuous for an aircraft engine because of two aerodynamic forces—lift and drag. Drag rises with the square of velocity, and light aircraft typically cruise about twice as fast as an automobile. Furthermore, the engine power needed to overcome that drag is proportional to the cube of the velocity. Let's use the Cadillac as an example again: if 30 horsepower is enough to maintain a 65-mph cruising speed, it takes approximately 240 horsepower to propel the same car at 130 mph.

Differences in lift forces are also dramatic. Rolling vehicles are supported by the ground and don't need lift. But every 100 or so pounds of lift produced by an aircraft's wing costs the average airplane one to two pounds of induced drag. A typical 3,200-pound aircraft flying at 150 mph consumes 18 horsepower just to overcome its induced drag.

In the end, the aircraft engine and the car engine are so different because their duty cycles necessitate differences in design, which lead to different economics. Engineering them is a fine art of determining a cylinder wall thickness here or a bearing width there so that the final product delivers just enough performance and durability without being too heavy, bulky, or expensive. Bearing dimensions and coolant flow rates that work just fine for 300 horsepower in momentary bursts are inadequate when that same output must be delivered continuously.

Aside from the marked differences in their duty cycles, the two engines also work in completely different environments, and while both powerplants must be engineered to handle the internal vibrations caused by irregular combustion forces and the inertia of pistons and connecting rods flailing around inside, the aircraft engine, which is attached to a propeller rather than a drive shaft and two wheels, operates under far more severe circumstances (see "Why an Airplane Is Not Like a Car," p. 75). Despite the fact that they start out looking so much alike, after you list the many differences, you begin to wonder whether the engines really have anything in common. In the 1970s, a small company in California mounted a serious attack on the problem of applying automotive propulsion to aircraft. And despite the legions of experimenters and engineers who had gone before them, they would discover that they were starting from scratch.

The Aero Commander won its early fame and reputation when it was entrusted with the life of a U.S. president: Dwight D. Eisenhower used one to commute to his Gettysburg, Pennsylvania farm. Richard MacCoon dates his affection for the airplane to a flight with his brother Grant in one of the big high-wing twins. He liked the airplane



DAN PATTERSON

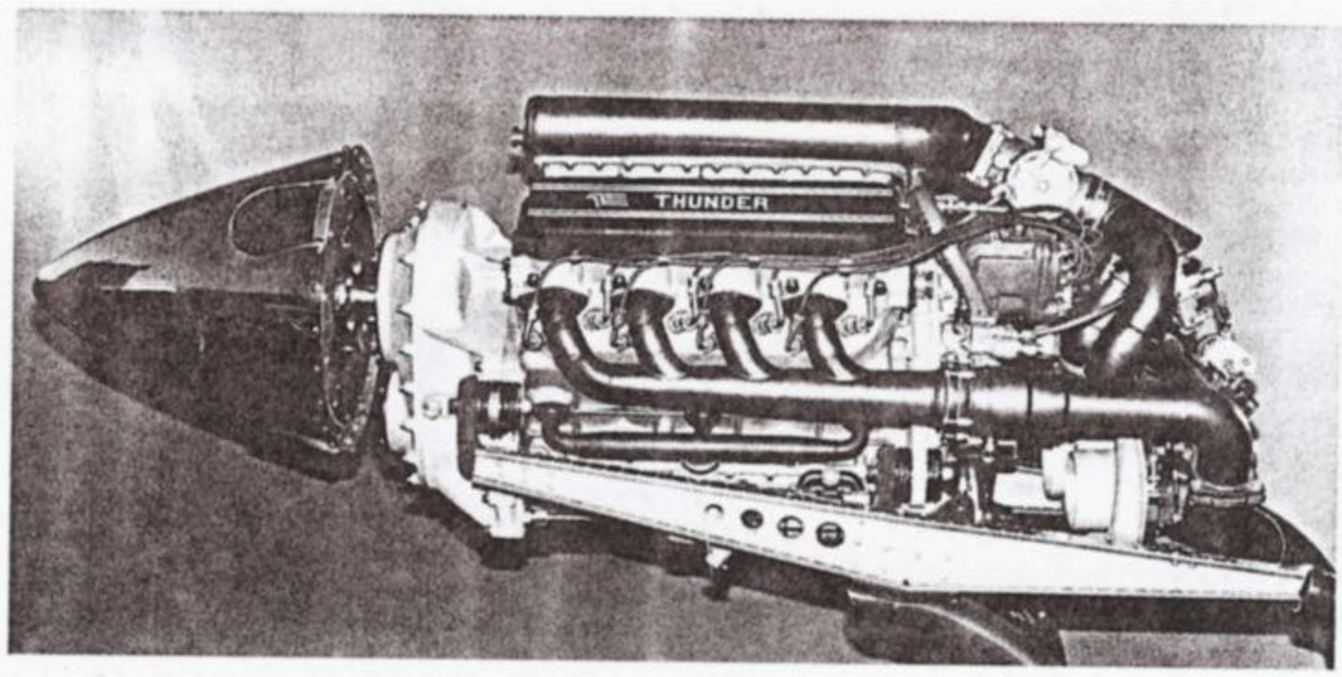
so much he began to work on improving it with systems such as air conditioning and turbocharger packages. He also began looking around for bigger engines. What MacCoon wanted fell in the gap between the largest piston engines and the smallest gas turbines. "We were constantly after Lycoming or Continental or anybody to build a bigger engine that would fill that 400- to 800-horsepower category," he says.

When the engine makers didn't respond, MacCoon and his brother formed Thunder Engines, but instead of creating an engine from whole cloth, they began looking outside of the aviation industry for an engine they could adapt. And the search began in a familiar community: the world of auto racing. "We didn't have the expertise to reinvent the wheel," MacCoon says, "but we did know about a joint effort between Reynolds Metals and General Motors to develop a big aluminum V-8 for Can-Am [Canadian American Challenge Cup] racing." The Can-Am series peaked in the early 1970s and featured big racers with enormous V-8s, which, in turbocharged form, generated more than 1,200 horsepower.

MacCoon rented a performance shop that had closed after the Can-Am series folded, and he parked an Aero Commander at a nearby airport. Then he hired Douglas Meyer, a jack-of-all-trades who had worked on the Can-Am cars and knew the engines well. "As race car guys and as hot rodders...it didn't seem to be that mystical." Meyer recalls. "I was running up against airplane guys, and they would say 'You can't do that; those engines won't work. You've got to have slow-turning engines, you've got to have big, beefy parts, you've got to have air cooling,' and the stuff you don't gotta have." To prove it could be done, MacCoon and his crew began to adapt one of the Can-Am racer engines for installation on the Aero Commander.

That was no small task, as two gearboxes had to be engineered, the more formidable being a reduction unit to drive the propeller. Late in the game, after the engine had already been installed, a major problem arose. It turned out that aircraft and automotive engines rotate in opposite directions, and the propeller was pushing instead of pulling. The expedient fix was a Hartzell propeller designed for pusher applications; bolted to the Can-Am engine, it pulled.

For its maiden flight, the engine was tuned to produce 550 horsepower with a single turbocharger to match the output of the standard Garrett AiResearch turboprop on the opposite wing. To cool the piston engine, MacCoon's crew installed a huge car radiator in the aft fuselage, fabricated air inlet and outlet ducts, and ran coolant lines connecting the radiator and engine along the outside of the fuselage, covering the plumbing with a simple fairing. MacCoon remembers that first day in the air some 15 years ago as if it were yesterday:



COURTESY DICK MacCOON

The Thunder (above) and the Orenda (right) look like mirror images, but there is no "car" left in the Orenda version, as aerospace suppliers have replaced the automotive racing parts suppliers whose products MacCoon relied on for the original version.

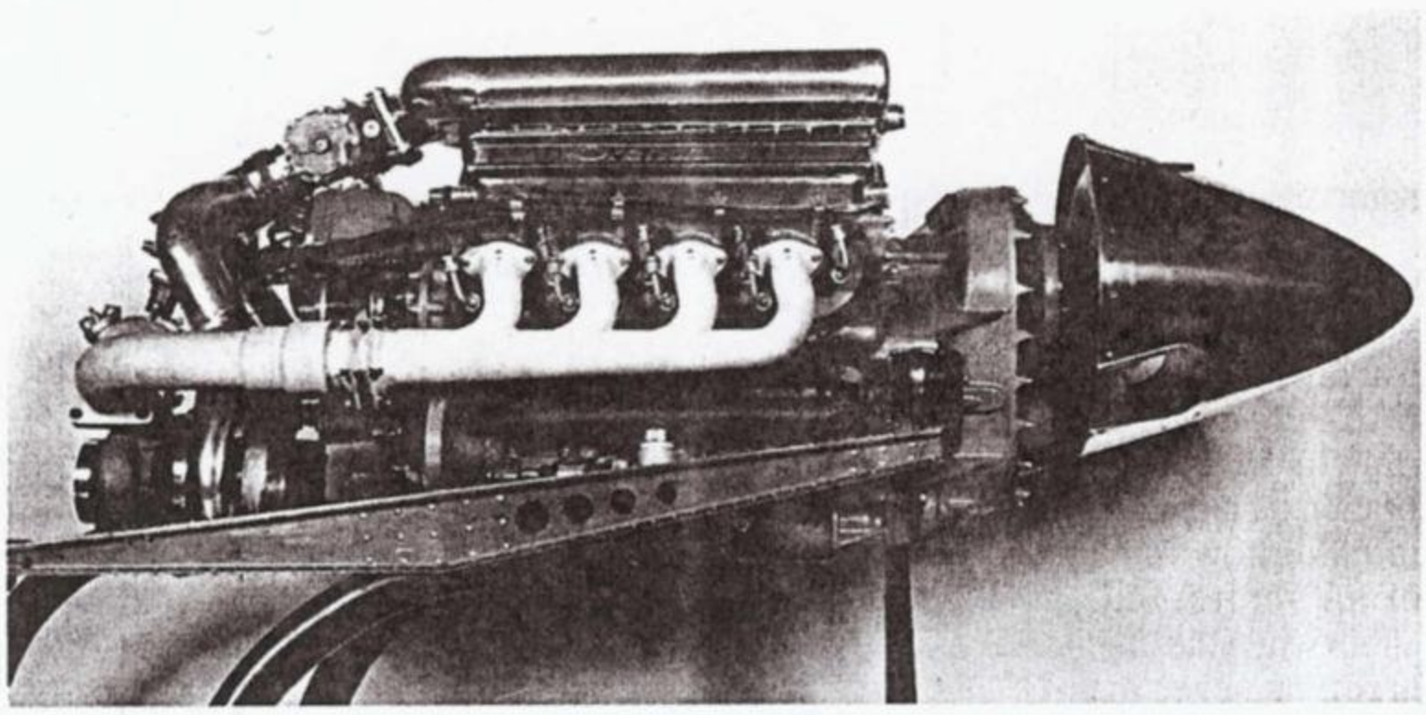
"The engine's throttle response was phenomenal," he says. "I could yank the lever up and down—something you can't normally do with aircraft engines—and it would reach full power in less than two seconds. In fact, the throttle response was so immediate that it controlled the yaw of the plane much better than the rudder pedals.

"On the takeoff roll, I said to myself *This is absolutely incredible* because our engine was as smooth and responsive as an electric motor," he recalls. On a later flight, they shut down the turbine and ran the prototype up to full power.

"All the vibration suddenly left the airframe," MacCoon says. "At first we thought both engines had stopped, but that wasn't the case at all. Pilots consider turbines super smooth, but they're not. Spin any piece of machinery at 36,000 rpm and you're going to get a

ENGINE SPECIFICATIONS

MANUFACTURER	WRIGHT BROTHERS	ROLLS-ROYCE
MODEL	1903 FIRST FLIGHT ENGINE	GRIFFIN 60 SERIES
Configuration	4-cylinder inline	V-12, supercharged
Supercharged/turbocharged	no/no	yes/no
Cooling	liquid	liquid
Displacement, cubic inches	201	2,239
Bore x Stroke, inches	4.00 x 4.00	6.00 x 6.60
Horsepower @ rpm	16 @ 1,200	2,035 @ 2,750
Torque @ rpm, foot pounds	70@ 1,200	3,886 @ 2,750
Piston speed @ redline rpm, feet per minute	800	3,025
Brake Mean Effective Pressure @ peak torque, pounds/in²	52.5	311.3
Crankshaft main bearing area, in²	39.5	122.0
Weight, pounds	180	2,090



COURTESY ORENDA AEROSPACE CORP.

lot of high-frequency vibration. But our engine was carefully balanced and spinning at only 4,400 rpm so it felt perfectly smooth and quiet." When they were done, MacCoon had flown the airplane for almost 20 hours.

The next task he faced was upgrading the engine to endure an aircraft duty cycle. The crew pulled the V-8 out of the airplane and mounted it on a dynamometer, where full loads could be applied safely and methodically for hours on end. Then they began making changes: The lower portion of the block was extended to stiffen the portions that support the crankshaft. To increase cylinder size and gain torque, they raised the upper surface of the cylinder block, increasing the "deck height." To make room for dual spark plugs (standard on aircraft; if one ignition system fails the engine will continue to run), they redesigned the cylinder head and relocated the valves. Virtually every component was upgraded to tougher materials and larger bearing surfaces.

Redesigning the original Chevrolet-Reynolds engine was frightfully expensive. Forging dies to hammer out new crankshafts cost $100,000. MacCoon admits spending $4.5 million in 28 months on the task, and even after the engine was upgraded, it still had to prove its durability. MacCoon notes that the team spent $2.5 million in one year stretching the engine's life from 7 to 17 hours. He says the engine never blew up, but signs of excessive wear were everywhere. When he finally realized they had "Peter-principled" themselves, he called in outside assistance.

First MacCoon coaxed former engineer Bob Earnest out of retirement. Earnest reached the 20-hour mark before he fell ill and had to abandon the program. MacCoon turned to a second friend, John Beck, who had worked for a diesel engine manufacturer. After examining valves, bearings, pistons, and piston rings like a paleontologist studying bones, Beck proclaimed, "Your pistons are in serious distress. You don't have a 600- or 700-horsepower engine by any stretch of the imagination." According to Beck, MacCoon had a 500-horsepower engine with a 500- to 1,000-hour service life. "And this is after two and three years and millions of dollars in this program—$10 million to be exact," MacCoon says. "I didn't want to hear this from someone of his caliber." MacCoon was crestfallen, but Beck assured him he had fixes. To cool the pistons, he used a technique common in the world of diesel (and aircraft) engines: a stream of oil squirted at the bottom of each piston to carry away heat. He called for more robust pistons, thicker rings, broader valve seats, and a different valve guide material—design changes aimed at ushering heat away from the hard-working parts.

Beck's changes took another six months, but the first durability test proved that they had worked: Piston temperatures plummeted 98 degrees, only two degrees less than his calculations had predicted. With internal temperatures under control, durability was in hand. Armed with that news, MacCoon thought the establishment might finally be interested in his project. He contacted every major and a few minor engine producers in search of the money necessary to take the next steps—Federal Aviation Administration certification and production. But no one was interested in sharing the cost. When MacCoon's funds petered out in 1987, he put his project in storage.

In 1989, Toyota introduced an all-aluminum, dual-overhead-camshaft V-8 to power the Lexus LS 400 luxury sedan. At the same time, engineers in both the United States and Japan began investigating aviation applications for the Lexus engine. Hamilton Standard was tapped to assist in the development of a suitable propeller and a single-lever electronic control system to manage throttle position, air-fuel mixture, and propeller pitch. Called FADEC (full-authority digital engine control), such systems are common in turbine applications, but the company says this was the first appli-

WRIGHT AERONAUTICAL	GENERAL MOTORS	ORENDA	TEXTRON LYCOMING
R-3350, CYCLONE 18	CADILLAC NORTHSTAR	600	IO-540-K
18-cylinder twin row radial	V-8	V-8	horizontally opposed 6
yes/yes	no/no	no/yes	no/no
air	liquid	liquid	air
3,348	279	495	542
6.12 x 6.31	3.66 x 3.31	4.44 x 4.00	5.12 x 4.38
2,200 @ 2,800	300 @ 6,000	500 @ 4,200	300 @ 2,700
4,127 @ 2,800	295 @ 4,400	625 @ 4,200	584 @ 2,700
2,946	3,586	2,933	2,067
185.9	159	190	163
n/a	29.2	55.6	65.3
2,780	400	753	470

cation to a reciprocating engine.

After testing both here and in Japan, the FAA issued a type certificate on December 21, 1995, for Toyota's FV4000-2TC 350-horsepower twin-turbocharged V-8. A probe of the market is currently under way to determine if anybody out there is interested in buying such an engine. Even if no one is interested, Hamilton Standard plans to apply for a production certificate.

But don't get out your checkbook just yet. Even though the engine has an FAA certificate and will have production approval, neither Toyota nor Hamilton Standard has announced plans to begin making engines—which, for the moment, leaves the field open. Enter Dick MacCoon. Again.

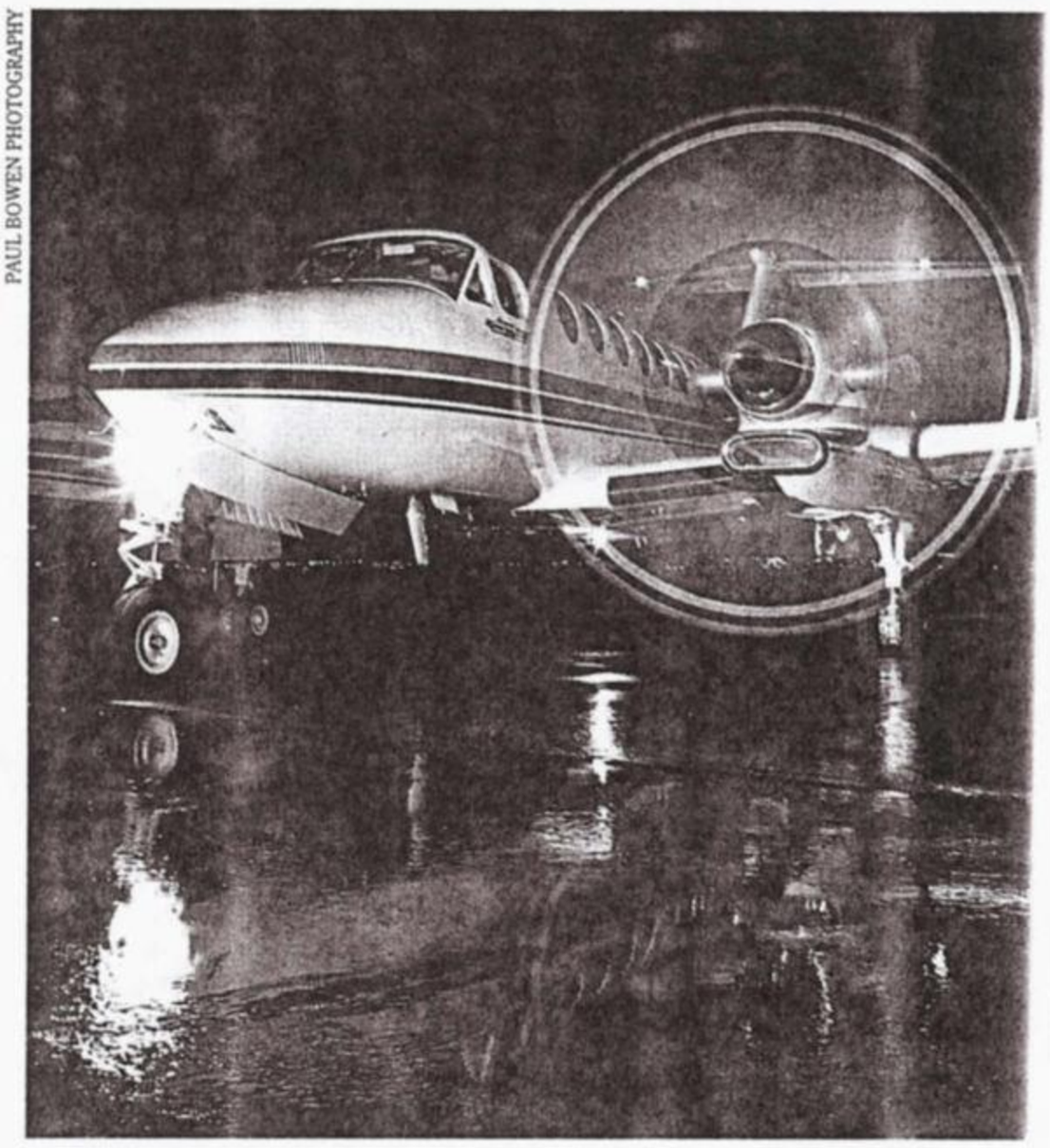
In 1994 he succeeded in finding a patron for his Thunder Engine project in the Orenda Division of Hawker Siddeley Canada, a turbine engine component manufacturer and overhaul center. Early in 1996 Orenda was sold to Fleet Aerospace of Fort Erie, Ontario. Orenda got one Thunder V-8 engine nearly ready for certification while MacCoon kept all future rights to install Orendas on his beloved Aero Commander twins.

But Orenda didn't just dust off MacCoon's blueprints and send his V-8 to production. The aviation world had progressed during the years the engine was in storage, so the design needed updating. For one thing, practically every component will come from aerospace suppliers, not automotive vendors. Notes Orenda's chief engineer, Larry Shiembob, "This is a true aerospace engine now. This is not a converted automobile engine. We created our own 'murder' cycle and identified a valve spring problem during a hundred or so hours of durability testing. That problem has been solved with a new material and slight changes in the camshaft. To log a thousand hours on our durability engine, we hired a dynamometer testing firm to run one around the clock."

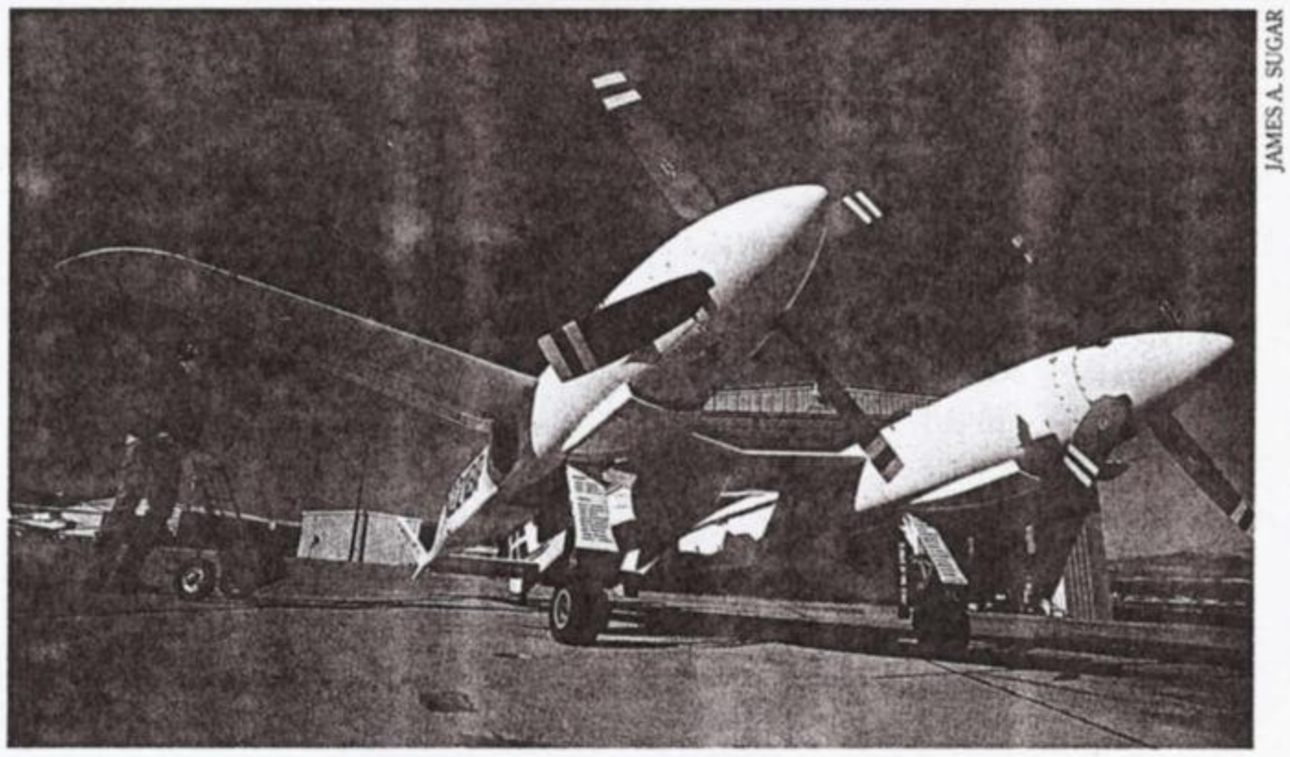
And there are tall hurdles to clear for FAA certification. During the torsional vibration test, engineers monitor how well the crankshaft handles strain when the engine is run on seven cylinders. Other studies address detonation ("knock") resistance. Connecting rods have withstood 10 million cycles of loading applied by a test fixture.

Meanwhile, independent modifiers are working on adapting the engine to the Beech King Air and deHavilland Canada Beaver, among others. While Orenda negotiates with

PAUL BOWEN PHOTOGRAPHY



JAMES A. SUGAR



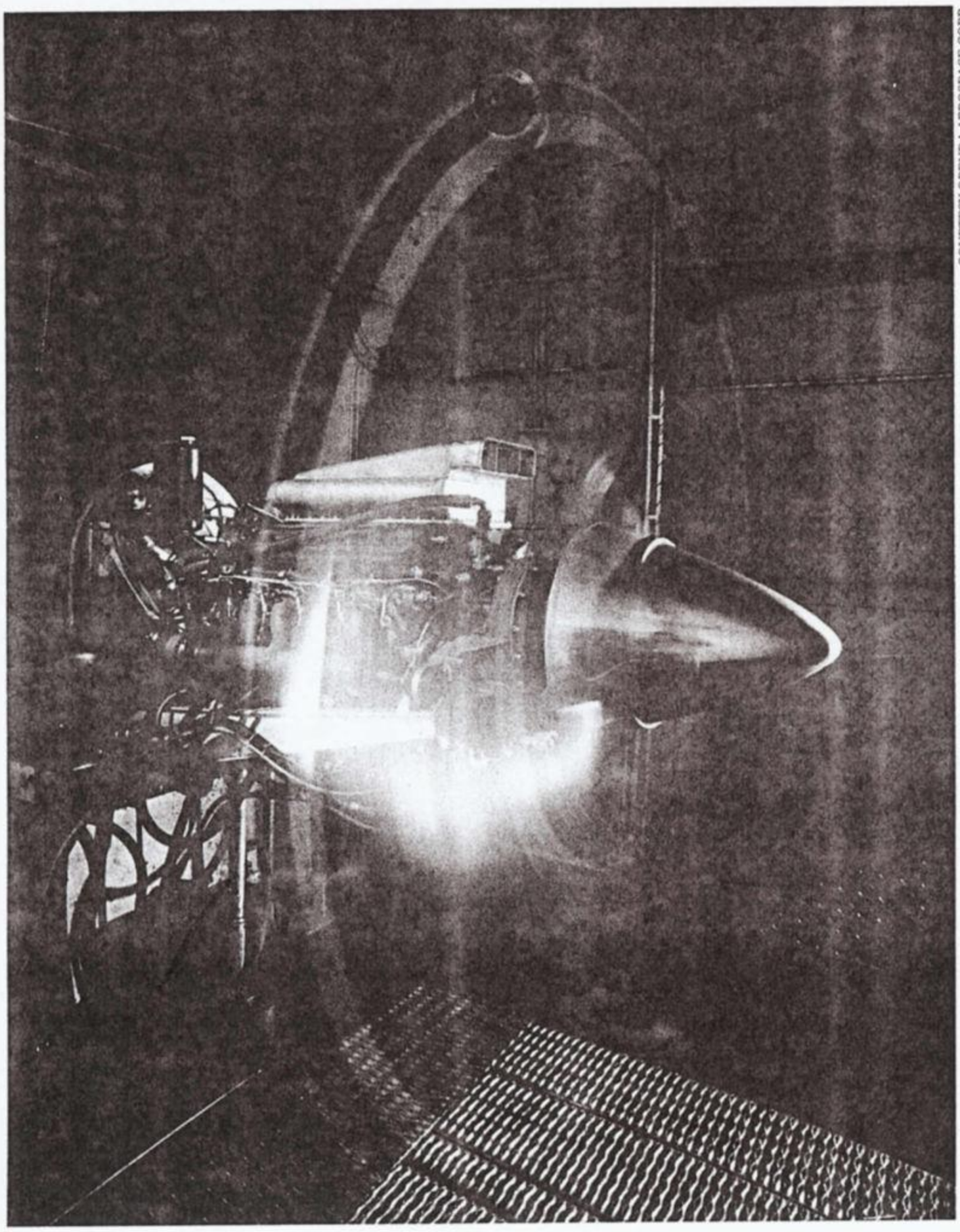
Orenda's target is the PT6 turboprop, which powers the Beech King Air (above), but the company has made offers of sample engines to experimenters. The auto-powered Pond Racer (left), lost in a crash, could have used a pair. Star Kraft's tandem twin (below) is a candidate for an Orenda if the airplane can get into production. It may be only a baby Merlin, but an Orenda at full cry will sound as sweet (right).

COURTESY STAR KRAFT



airframe makers to nurture interest in using the engine in newly manufactured airplanes, the focal point of the market seems to be in replacing overhauled turbines in existing airframes. Over 25,600 Pratt & Whitney Canada PT6 engines had been delivered by mid-1996, and Orenda believes that when their service life finally ends, some portion of the fleet can be re-engined with a new product. It can run to $300,000 to overhaul a pair of PT6s, more than some of the airplanes they are mounted on are worth.

Shiembob concedes that a new 500-horsepower Orenda engine costs about the same as a PT6 overhaul, but he insists it's still a good deal: Orenda claims lower fuel consumption, more power at altitude for a higher cruising speed, and better climb. "Our engine provides 500 horsepower continuously up to 25,000 feet, while PT6 output has dropped off to 300 horsepower at that altitude," he says. "The major payoff occurs at the next overhaul point. The turbine pilot faces the same $200,000 or more cost. But the Orenda V8 pilot will be able to rebuild both his engines for $50,000." It remains to be seen whether Orendas are durable enough to compete with the PT6, one of the most reliable engines ever built: one PT6A-20 engine has gone 15,000 hours between overhauls, and one maintenance program offers 8,000 hours of service life. Even if an Orenda runs for only 2,000 hours and requires four overhauls to the PT6's one, it could still break even under such a scenario, but the aircraft operator would have to accept more time in the repair shop. And the Orenda runs on aviation gasoline, which may become a scarce commodity as the worldwide market for it shrinks.



COURTESY ORENDA AEROSPACE CORP.

Initially, Orenda is planning on sales of 100 to 200 engines per year—that's less than one percent of the global PT6 market. The effort to certificate a modification for the Beech King Air—the airplane flying around with more PT6s than any other type—is already well under way at Merlyn Products of Spokane, Washington. Stevens Aviation, a South Carolina modification shop, recently ordered 140 Orendas destined for King Airs and has exclusive rights to distribute the modification. Crop dusters are the next target. According to Shiembob, "As their old radials wear out, some of them are spending $550,000 to $600,000 to hang a [new] PT6 on their aircraft. The 500-horsepower normally aspirated Orenda we have under development will do a better job for much less."

It's too soon to say whether liquid-cooled piston engines will ever regain their prominence or even that turboprop operators will accept a return to reciprocating power and forgo the trusty PT6 to risk something new and unknown. But Orenda's effort won't be lost on an aviation world hungry for lower operating costs and something different in the sky.

After spending a king's ransom and sweating over a hot test cell for a decade, you'd think Dick MacCoon might begrudge the Orenda logos all over his good idea. He doesn't. As long as he hears that thunder pealing from the exhaust stacks, he considers his mission accomplished. "When I started this program, it wasn't to build an engine, it was to get an engine for an airplane," he says. His father once gave him a motor scooter—or at least a pile of parts from which to build one. There was a lesson in it, he says: "If I wanted something or needed something badly enough, if I couldn't get it, I could build it.... From my point of view, I look at it as somebody taking [the engine] into production, and it's a super-duper deal for the industry, it's going to employ a lot of people, and yeah, indirectly there's kind of a personal satisfaction that I had a part in it....It's something that needed to be done."

* Smithsonian Air & Space magazine article "Power Struggle" by Don Sherman, January 1997, page 72. Excellent ten page article (with many pictures) about auto engines in airplanes. A brief history of all auto engines in airplanes and a more detailed history of the twenty year, twenty million dollar development of the Chevy V8 based, all aluminum Orenda liquid cooled aircraft engine. At this time (Jan 1997) and well after the article was written the engine failed its FAA 150 hour full power certification test due to a crankshaft problem after 20 years of very expensive development. It was finally certified in 1998 by Transport Canada.

Extensive changes have been made to the basic Chevy big block engine including a parallel cooling system with dual coolant pumps as opposed to the serial cooling system with single pump as typically found in automotive engines. Parallel cooling systems were considered to be essential in the 1920's on liquid cooled aircraft engines.

Engine length is almost everything to a car designer. Engine cooling compromises are made by simezing the cylinder walls in automotive engines. Crankshaft life at high continuous power is compromised by shortening the length, leaving too little room for adequate size journal fillet radii. In my opinion this engine will not be successful until it is re-designed from a clean sheet of paper to be a real aircraft engine. If that happens they might as well go to a horizontal opposed configuration for lighter weight.

Orenda is now in the process of moving the project to Nova Scotia and injecting another 32 million dollars of mostly Canadian government money. They are also attempting to market the engine to the homebuilt market. I don't expect many takers at over $100K per engine.

Recently Lancair gave up after spending a lot of money installing the engine in a special airplane called the Lancair Tigress. The engine and the Tigress were donated to the EAA museum as a tax write off.

The Orenda company is now bankrupt.

"Those that fail to learn from history are doomed to repeat it."