INJECTING

Electrons and Fuel

Check out these thoughts on electronic ignition systems and fuel-induction systems.

BY VANCE ATKINSON

My last otherwise-funfilled excursion to Jackpot, Nevada, for the annual Fourth of July -EZ race included an unexpected side trip to Salt Lake City to pick up a replacement for my hangar partner's failed magneto. Though I had 600 hours of trouble-free mag operation, I began to be concerned about being stranded with a planeload of angry passengers at some lonesome airport waiting for a new mag to arrive. Several fellow Long-EZ owners had fallen prey to mag trouble. Three weeks later I was talking to Jeff Rose at Oshkosh about his DIS-1 electronic ignition .

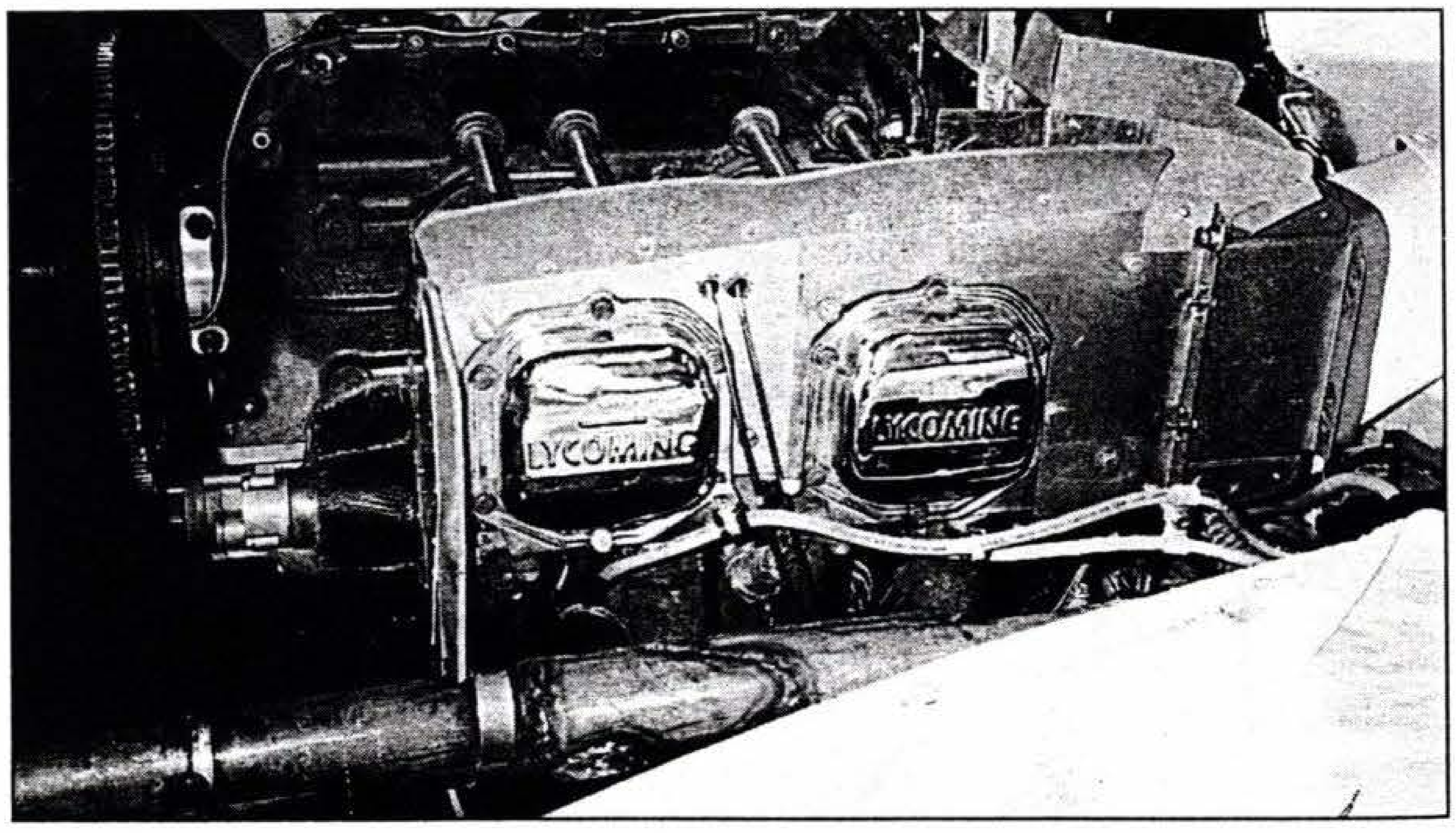
There are three basic electronic ignition systems on the market: Klaus Savier's capacitance system, Jeff Rose's inductive system and a Canadian-built AV Spark. Rose's Electro Air unit sells for $765 and AV Spark is $569. Savier's prices range from $595 to $1850, depending on options. I talked with builders running the other systems, and we all agreed they do a better job than the magnetos. After looking at what was available, I went with Rose's unit. Without getting into which of these units is better than the others, here's how the installation went.

As Rose had only a few units in the field, he insisted that I come to Chattanooga, Tennessee, for the installation. No sweat. I called Herb Sanders and asked if he wanted to join the installation team. Of course! We set the date and—wouldn't you know it?—the weather wasn't the best, but we made it to Chattanooga around Saturday noon.

Mounting the System

The unit requires two wires run from the instrument panel back to the firewall. I had installed these before arriving, along with a mounting pad for the coil assembly unit.

Without taking time out for lunch, the four of us began to sticking these funny-looking gizmos on the airplane. I mounted the coil assembly (3.5x8.25x3 inches high) on the aft-facing side of the -EZ's spar, just above the right aileron torque tube. If you have the standard rudder cable location, this won't work for you because it interferes with the rudder cable. My hangar partner, Ken Francis, bought this system for his Cozy and mounted his coil assembly on the firewall just aft of the accessory case. As the coils can fire the upper or lower plugs, you have a choice as to which you want. The spark is quite a bit hotter on the electronic unit, so I rea-



A new ignition harness (below the rocker arm covers) provides spark from the coils just out of view to the right. A magnetic pickup is bolted to a bracket to the right of the flywheel in this picture.

PHOTOS: VANCE ATKINSON

reasoned that the lower ones would benefit the most by keeping lead balls and crud burned off.

I had premounted the pad for the coils, along with two wires running from the battery to the on-off ignition switch on the instrument panel and back to coil unit. Meanwhile, Rose and his partner were busy installing the stainless steel, 60-tooth timing collar just behind the crankshaft flange. This unit times the electronic system with a magnetic pickup positioned 0.0018 to 0.0020 inch away from the collar's teeth.

Rose provides a small cable that runs down the engine's backbone from the magnetic pickup to the coil assembly, where the two meet via a two-prong plug. Sanders and I ripped out the old mag wires and re-positioned the remaining wires to fire the upper plugs.

Rose's unit will fire either aircraft or automotive spark plugs (he provides the latter). We decided to leave the aircraft plugs in and install the automotive ones later. The new harness that Rose provides gives you the option of screw-on ends (similar to aircraft harnesses) or snap-on ends. Because we retained the aircraft plugs, we used the hardware kit for those.

The DIS-1 Electro Air System uses two methods for advancing the spark beyond the stock range: a manifold pressure transducer (which is automatic) and rpm. As manifold pressure decreases, spark timing increases along with rpm. I won't attempt a big technical explanation (Rose will be happy to provide one for you), but at around 12,000 feet of altitude, the spark is advanced 40°.

This makes for a smooth and quiet-running engine. To complete the installation, we connected three wires from the coil unit, a manifold pressure line, the timing harness plug and the four spark plug wires. Sounds simple, but it took us 5 hours to accomplish. Routing, making new brackets and positioning all this stuff eats up a lot of time. In addition I ran a harness to display the number of degrees advanced on the unit. This is read digitally on a voltmeter and confirms all those little electrons are doing what they are supposed to do.

Checking It Out

We checked everything over three times and were ready to fire it up. We pushed back from the hangar (with a fire extinguisher handy) and commenced cranking. It fired right up, but did not sound quite right. We shut down and rechecked everything. After 10 minutes of examination, Sanders found that I had mistakenly run two spark plug wires to the wrong cylinders. A quick swap and presto! The engine ran smooth as Madonna's curves, and quiet, too!

Author Vance Atkinson's Cozy served as the testbed for electronic ignition and fuel-injection systems.

After several additional start-ups checked out, all agreed that everything was right, and it was time to fly.

By now it was growing dark, and Sanders and I were anxious to be on our way back to Memphis where our wives were standing by for a late dinner. (Funny how these episodes always wind up late.) We agreed that if the test flight went well, we would just continue on to Memphis. It did, and so on we went, radioing back to Rose that all was well.

The Longer View

Over the next several months I

collected the following data. My 160-hp, O-320-Lycoming-powered Cozy saves between 0.2 to 0.5 gallons of fuel per hour using the same power settings as before the electronic ignition. Top flat out rpm increased about 150 turns. Cylinder temperatures all increased 25-30°F. The engine runs and idles noticeably smoother and quieter.

I wound up replacing my keyed ignition switch with a starter button and two toggle switches. I also replaced the two wires from the battery to the ignition switch and back to the electronic unit with a shielded two-conductor cable because of ignition background noise coming in somewhere on the wires. It took about an hour to isolate this problem, and once again our stereo system is static-free. I grounded the shield at the battery.

I switched over to the automotive Bosch platinum plugs provided by Rose after using aircraft plugs for a month. I noticed no change with the Bosch plugs, and replacement cost is around $1.75 each. Rose has provided what he feels is a good quality ignition harness that can be replaced for around $35.

Currently the DIS-1 system provides no way to monitor the advanced spark like Savier's does. Rose does include instructions on how to run another wire from the ignition module to a voltmeter, and the pilot can read spark advance right from the volts scale. I happened to have a miniature volt-ohm meter bought on sale at Radio Shack for $20; it's about two-thirds the size of a dollar bill and a quarter inch thick and reads digitally. I monitored all the early flight data with this unit. It lies on my sidestick console just forward of the pilot's control stick.

Many pilots don't trust anything electronic because they can't see what's going on, and I'm no exception. But this meter allowed me to tell what the advance was doing during different phases of operation. Typically, with a stock 25° advance the engine would see 27° at 2000 feet, 31° at 3000 feet, 32° at 4000 feet, 33° at 6000 feet and so on. The highest advance I've recorded is 40° at 14,500 foot density altitude.

Owner Options

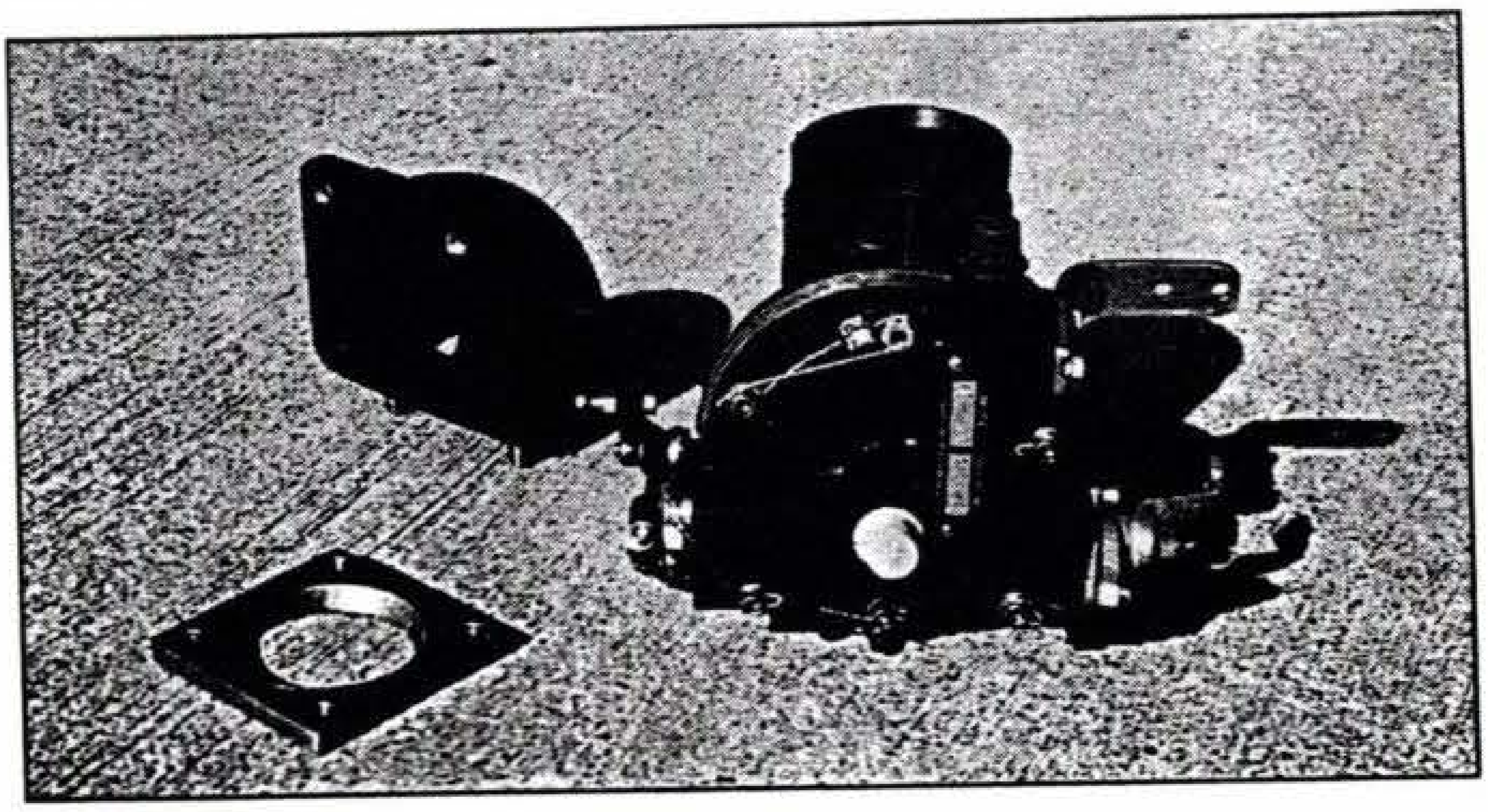
DIS-1 has provisions for the builder to adjust the timing phases. Rose has provided three potentiometers so you can tailor the advance to your liking. For example, if you do most of your flying at lower altitudes (6000 feet or less), you can get top advance in that range instead of the 12,000-14,000-foot range, provided your rpm is high enough.

The initial settings are determined by Rose when you buy the unit, and after several test flights and data-gathering, you can crank in the curves you want if you don't like what's in there.

Rose is working on a small display for the pilot so you know what's going on. He's also trying to come up with a suitable digital tachometer for the unit. Currently he provides a lead wire that will drive several different automotive analog or digital tachs.

Easier Starts

The last area of development is starting the engine. As it stands now, you should have an impulse coupling



Airflow Performance Company's throttle body unit is only part of the fuel-injection system. The author machined the squeeze-hole adapter seen at lower left.

on your magneto for starting. I have tested mine with and without an impulse and it will start with or without the starter. Rose has provided a 25-rpm lockout safety feature; below that, the electronic unit will not work. If you hand prop your engine (you never know when that battery will be low), you will be barely able to flip the propeller faster than 25 rpm. Therefore, this unit does not lend itself well to hand propping right now. However, Rose is working on a feature to allow this. After I completed a few months of testing, my hangar partner, Ken Francis, bought a DIS-1 unit for his Cozy. His findings pretty much confirm mine. Francis is an F-16 inspector at General Dynamics and was able to install the unit right in our hangar. Of course it helped that by then Rose was providing written installation instructions with the DIS-1. Francis took about a day and a half to install the system. He is also using the DIS-1 unit for starting as his remaining good mag has no impulse coupling.

I think that in three to five years, all the homebuilt community will be running an electronic ignition of some sort. The benefits are just too great not to have one on your engine. Reliability should be well proved (or disproved) by then.

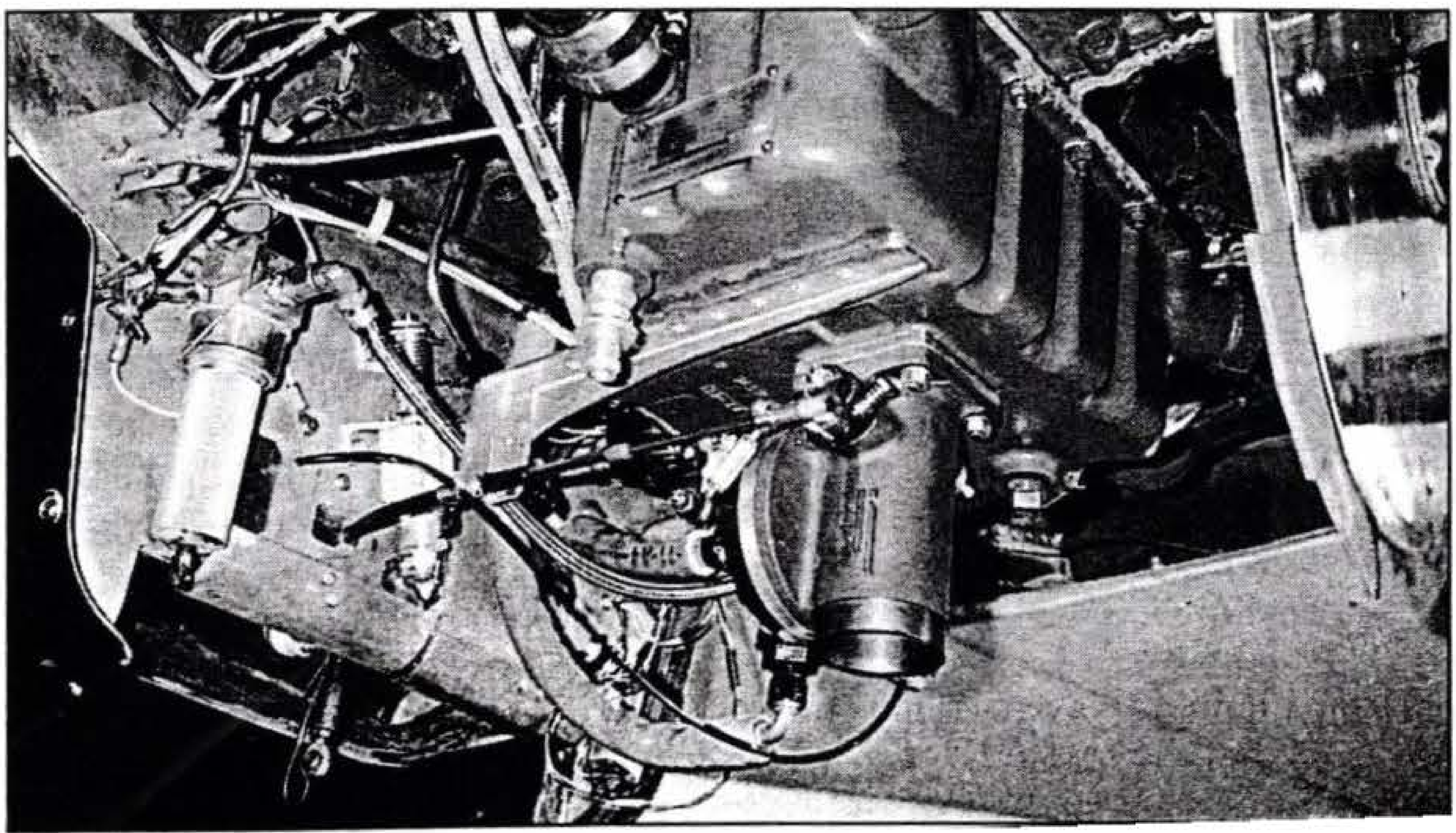
Another Goody

The next unit I bolted on my engine was an aftermarket fuel injection system, a mechanical piece of artwork that was shown at Oshkosh '91 by designer and president Don Rivera of Airflow Performance Company. This unit basically measures the air flow going past a throttle body and meters fuel under high pressure to be squirted in at the heads. All this is done mechanically with no electronic help. The unit is very rugged, uses aircraft hardware, safety wire where needed, is made of cast and machined aluminum and weighs a little more than 5 pounds. There is a mixture lever for leaning.

I have several thousand hours flying fuel-injected engines (mostly twins) and have always liked their smooth performance and freedom from worry about carb heat. Until now I could not afford such a system, but Airflow Performance Company made it possible.

I had looked at Rivera's ads in the aviation magazines and already had one of his information packs when our company had a trip over to South Carolina. I made a quick call to Rivera and he agreed to pick me up at the local Spartanburg airport for a tour of his facility. As is turned out, Rivera has a mechanical engineering degree and worked for Bendix on fuel injection systems on aircraft for 10 years. He started his own company and now produces several sizes of injection units. They go on any kind of engine with a horsepower range of

Looking up at the bottom of the Cozy's O-320, 160-hp, pusher-configuration engine shows the throttle body unit installed. The light-colored vertical cylinder to the left is the gascolator.



65 to 800.

The fuel controller body itself can be mounted anywhere, any position. It regulates or meters the fuel that is injected at the cylinder heads.

Rivera's system consists of six components: the FM100 throttle body, aircraft boost pump package, 90° adapter elbow, stainless steel fuel lines (to the heads), flow divider and fuel injectors. All this stuff, including the two fuel pumps, comes to $1500. In addition, you will need a 40-psi fuel gauge and a bigger circuit breaker and larger wire going to the electric pump than are used with standard carburetion.

Rivera proved to be extremely knowledgeable on fuel injection and is willing to work with individuals on their installations.

Installing the System

Here's how my installation went. After the tour I went home to locate and price the mechanical AC pump that bolts on your engine accessory case. For an O-235 and O-320 the part number of that pump is 41234. They cost about $170-$200 rebuilt, available at any pump shop. You can trade your old 6-psi pump in as a core with no extra charge. You will need some kind of a core for a trade-in. Otherwise it's another $50. Rivera will help you get a pump if you run into a problem.

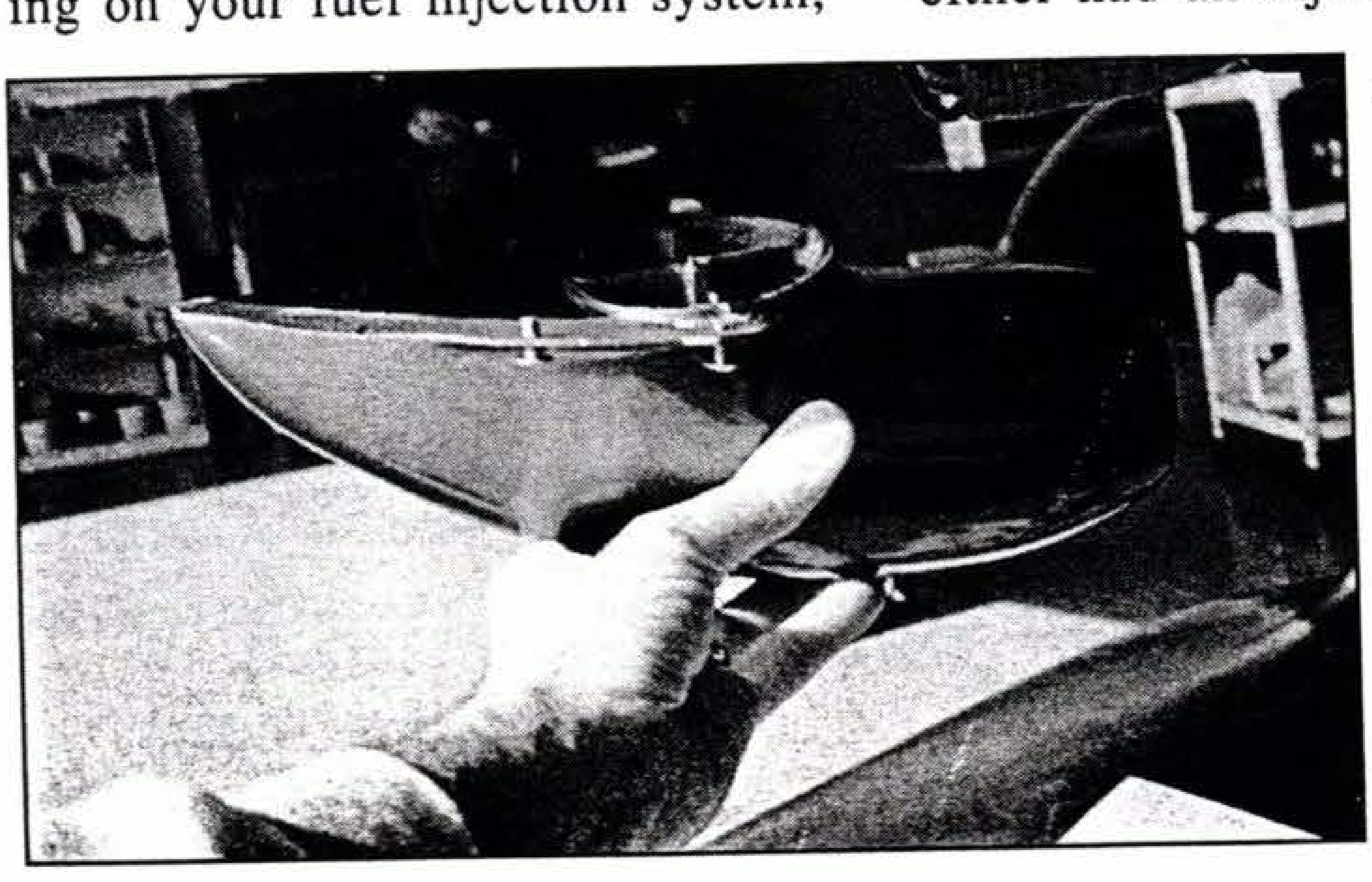
I called Rivera a few days later and ordered the FM100 System. He requires a $600 deposit before starting on your fuel injection system, and it takes about two weeks to get the package out the door.

He shipped the stainless lines, electric fuel pump, and the flow divider early so I could start ripping and tearing. Rivera will furnish the stainless steel injector lines any length and with the "button" not attached to the open end. This allows you to custom-bend and route your lines from the flow divider to your heads, cut the tube and attach the unfinished end to the injectors.

Rivera suggested running the stainless steel lines under the engine rather than on top for less heat absorption after shutdown. Length of the lines is not critical (one of mine was 4 feet long). I mounted the distribution block just below the right-hand mag (which now has a cover plate over the hole because of the electronic ignition).

You get two choices here: a fuel-flow divider block, such as used on production injection, at $250, or a fuel distribution block (which is what I bought) for $70. The difference? The flow divider needs to be used when the aircraft does not sit level; otherwise, you can substitute the cheaper block. I looked at both blocks, and the flow divider has 10 times the machine work in it, thus the higher price. Rivera recommends the cheaper unit for tricycle-gear aircraft but will sell you either one and trade back if you want to try the other.

When routing the stainless steel injector lines, I used the standard fuel injector ports at the head for termination. If you have an early engine you may have to use the primer port instead. All of the engines I've seen either had an injector port with



Atkinson shows how the ram airscoop he made will direct air into the throttle body unit with the engine cowl in place.

plug or a boss where you can drill and tap to inject. Rivera makes a special injector with a collar if you have to use a primer port. First choice would be the top-mounted injector ports as you get a slightly cleaner shutdown and startup.

After bending, routing and playing around with the stainless lines, I went on to the electric pump installation. For $189, Rivera provides a high-quality, high-pressure (45 psi) electric pump that is a cylinder about 2.5 inches in diameter and 6 inches long. It comes with what I call the fuel loop, which includes two AN check valves, eight AN fittings, and 8 inches of fuel line.

The electric pump is used for takeoff and landing; it is the backup for the mechanical pump. Unfortunately, when this pump is turned on, the fuel has to go somewhere. Yes, Virginia, there is a return line. Through the series of check valves, fuel returns to my left main tank. This means that on a standard EZ-type plane (left and right main tank only, no interconnect), if you turn the pump on and forget it you could be in for a nasty surprise! This pump puts out an awesome amount and will fill up the return tank—overflowing through the vent system.

I cut into my lefthand main tank line, installed a T and used that for my return fuel. All of this was accomplished in the hell hole in the landing gear area.

The fuel loop now exits the firewall into the regular fuel lines. From there it enters the fuel filter/strainer and the mechanical pump.

After installing all this stuff, it was time to pressurize the system. Surprise! No fuel was getting to the throttle body. I traced back and discovered that the 41234 AC mechanical pump flows fuel backward compared to the old 6-psi pump. I then had to change the hoses around to reflect a reversal of IN and OUT. The stupid pumps aren't even marked!

Mounting the Throttle Body

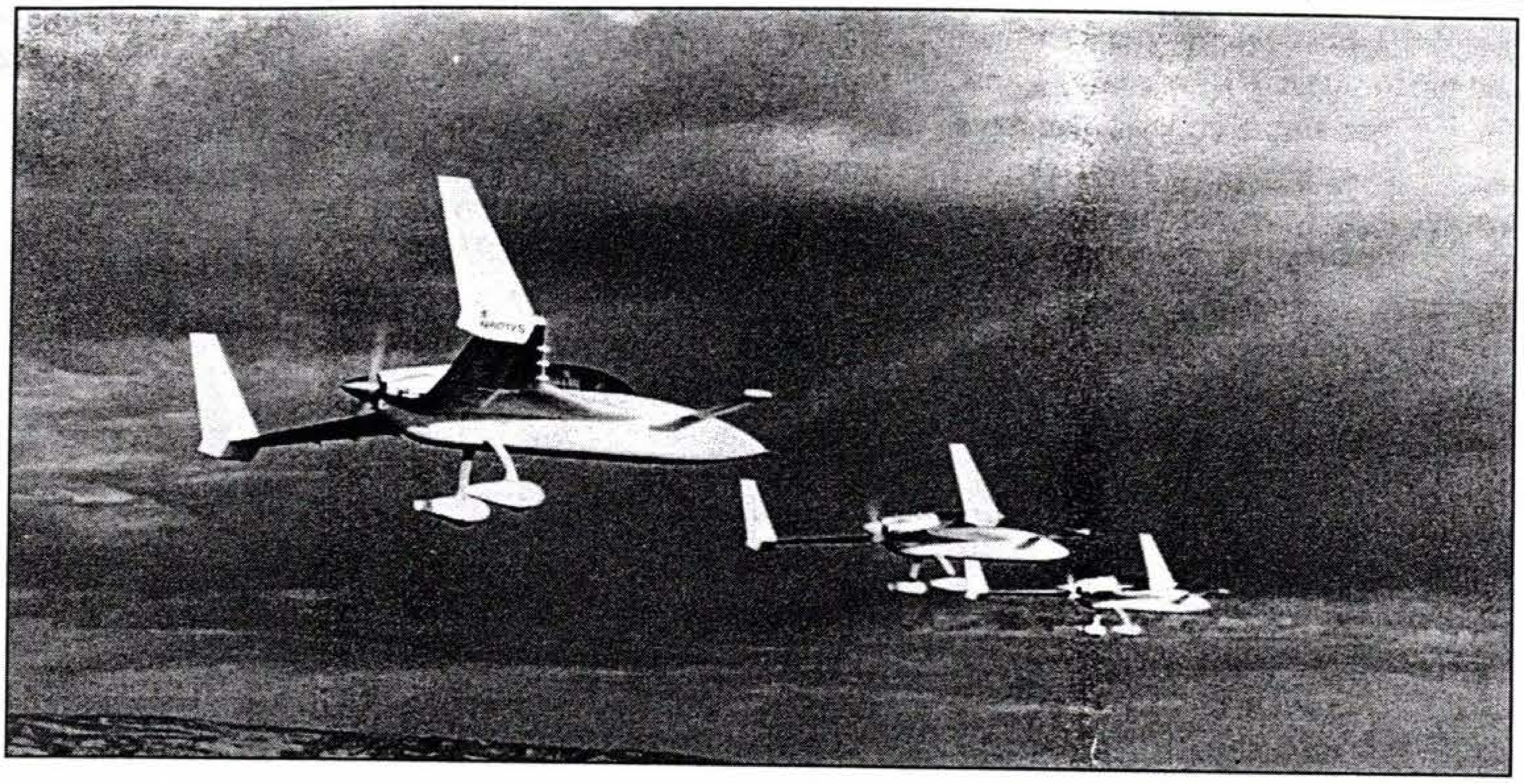
By this time, the throttle body had arrived and I was busy trying to figure the best position in which to mount it. As it turns out, if you mount it using the 90° elbow adapter so that the incoming air (for EZ-type aircraft) goes in the throat, you can mount it only one way because of the limited space and interference of the oil pan. If you have a tractor-type aircraft, several positions are possible. Even though I bought the 90° adapter, I didn't use it because it put the mouth of the intake of the body out of the incoming ram air and 6 inches away from the firewall.

I chose instead to mount it vertically like a standard carburetor and attach an external ram air horn. This has worked well. While trial mounting the body I discovered a quarter-inch spacer would be needed between the body and the oil pan. This was required because the linkage hits the bottom of the oil pan and will not allow full travel of the mixture rod. In addition, the air inlet hole in the oil pan is smaller than the throttle body by an eighth of an inch. So when I made the spacer block, I chamfered out a nice angle to allow the air to transition smoothly into the smaller opening in the pan.

Rivera is aware of this now and is addressing it. This unit is larger than a carburetor or an Ellison throttle body injector and when mounting it on my Cozy either vertically or horizontally, I had only 0.5-inch clearance between the lowest part of the injection body and the bottom of the cowl. Rivera will work with you if you order the wrong stuff. A couple of things I sent back or ordered extra were handled promptly and fairly.

You need a good throttle cable when using the injection system, so I replaced an old throttle cable with a new Cablecraft cable. Cablecraft is based in South Carolina and Washington state; the main company phone number is 803/655-7300. The company makes a super fine cable; you can tie it in a knot and it will still work. I called the main number, was referred to a local shop in Dallas that makes the cables, and was told that the cable would be ready in 30 minutes. A 106-inch cable cost $34: a bargain.

Finally, I had to find a fuel pressure gauge that fit my panel, and I



The author is hoping his new systems will help him do well in this year's Jackpot, Nevada, race for Long-EZ-style airplanes.

settled on a split-manifold/fuel pressure combo from Century Instruments in Kansas (phone 800/733-0116). Century built a custom gauge complete with range markings for $100. I didn't know it, but 90% of the split gauges read fuel units in gallons per hour. Very few are available in psi, and fewer still are in the range I wanted.

With this instrument—a new 7-amp circuit breaker, and 18-gauge wire to the electric fuel pump—I was ready to fire it up. The engine started on the second blade. Starting fuel-injected engines can be very frustrating. Normal starting is used when first starting a cold engine: mixture full rich, throttle cracked, boost pump on 3-4 seconds, start. When the engine is hot, it's a different animal! It goes like this: mixture full rich, throttle wide open, pump on until steady fuel flow, then mixture to cutoff and start. Usually it will catch. With the engine jumping off the mounts, you do the throttle mixture dance: mixture slowly to rich while simultaneously retarding the throttle. This works every time and is quite different from starting a carburetor-equipped engine.

The next several weeks included flying at different density altitudes and fuel flows to determine efficiency and speed. I determined that with the throttle wide open, you cannot lean below 6.5 gallons per hour at above 7500 feet. In fact, the lowest smooth-throttle setting is around 7 gph in the 7000-10,000-foot range. With an Ellison throttle body injector, you can lean the mixture and get fuel flows down to around 5 gph with the throttle wide open. With fuel injection, the engine stops! However, at the 7-gph mark, the speeds are relatively the same for both units. The Ellison unit allows for further reduction of fuel flow (and speed) where the injection absolutely refuses to go below 6.5 gph.

The injection system does not allow much leaning on climbout. With the Ellison, I would lean to 7.5-8 gph during climb. Fuel injection will allow only 9.5-10 gph. Once you pass 8000 feet, the fuel injection has a slight speed advantage as you climb. Around 12,000 feet, the injection system has a 4-knot gain over the Ellison system. Both systems used a ram air inlet. Higher altitudes (10,000-16,000 feet) result in a higher true airspeed gain for fuel burned.

Generally speaking, both systems are pretty close in performance and mileage. So why get injection? No messing with carburetor ice problems or heating ducts, the ability to custom-tune the EGT on each cylinder by changing injector nozzle sizes, and eventually I will have a 7% horsepower gain when I complete an induction system that's outside the oil pan.

Another injection advantage is a very positive midrange throttle response (great for aerobatics or formation flying). You can also use different kinds of fuels with this setup.

All my cylinder temperatures have gone back down 20-40°F and the CHTs are much closer. I assume that's because the fuel is injected at the port and there is no "dropout" of the fuel mixed with the air as it rounds the corners on its way to the head as there would be if it were mixed in the carburetor.

I've not meant to endorse or find fault with the above-mentioned products but merely to describe the basics of installing these two units and sharing what I learned. We never stop learning if we're paying attention.

In summary, I think the electronic ignition and fuel injection is a great combination on my airplane. Time will tell. Overall I gained 5 knots, so we'll see what happens at the Jackpot, Nevada, event this year! ❑

FOR MORE INFORMATION on the ignition system contact Jeff Rose at Electro Air, 105 Gardner St., Chattanooga, TN 37411; call 615/622-8825.

For Airflow Performance Company, write Don Rivera, P.O. Box 3364, 101 Belton Drive, Spartanburg, SC 29304-3364; call 803/576-4512.

her out.

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