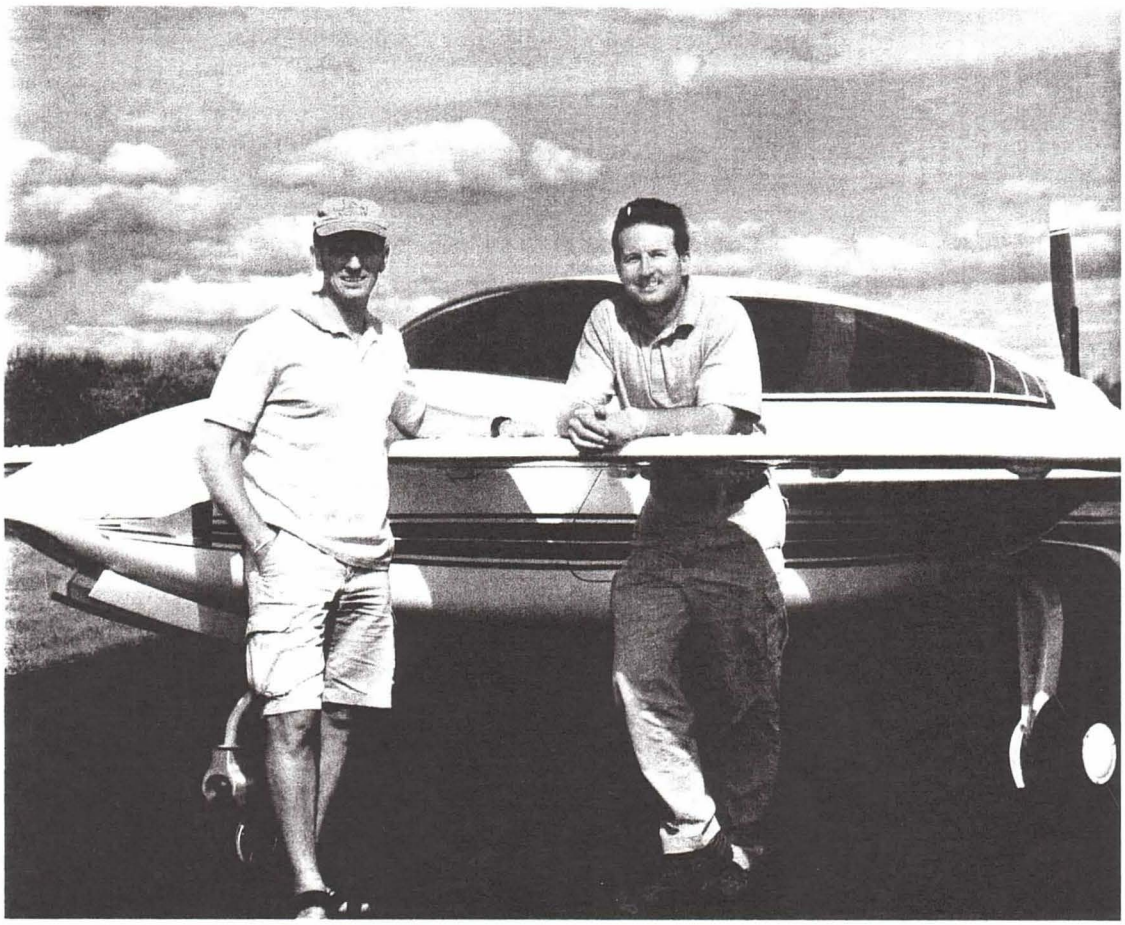
PHOTOGRAPHY BY **JIM KOEPNICK**



For Bill Mulrooney (left) and Dan Horvath, motor heads from way back, their engine choice was easy; a small block Chevy.

CHE VELOCITY

A Velocity meets Detroit

BY BUDD DAVISSON

YOU DIDN'T EVEN HAVE to look up to know who was in the fly-by pattern at EAA AirVenture Oshkosh 2009. If it sounded like Jeff Gordon running the back straight at Talladega, it was Bill Mulrooney or Dan Horvath (maybe both) in their newly completed Velocity. At least it looked like a Velocity. It was the 427-cubic-inch Chevy V-8 pushing it that made it sound anything but aeronautical.

BRETT BROCK

BILL, A FIREFIGHTER, AND DAN, A CHEMICAL ENGINEER, both of the Detroit area, are nothing if not determined. And ambitious. But mostly industrious and wildly detail-oriented. The two of them, along with their Detroit guru/consultant/friend Paul Bergholtz, put together a Velocity like no other, which in the field of canards is saying a lot. They are also good at telling the story of how it all came about: what we have come to call the "CheVelocity" in tribute to its Chevy powerplant.

BILL: This whole thing started in the mid-90s. A number of the guys at work were pilots, and one was building a Midget Mustang. I started reading some of his magazines and decided I really wanted to build an airplane even though I hadn't even started taking flying lessons yet.

DAN: Actually, Bill and I had been interested in airplanes for quite some time prior to learning about the homebuilt options. We discovered the incredible variety of aircraft available to builders and couldn't believe it was actually possible to build your own. We ordered the Velocity kit shortly before we completed earning our pilot's licenses. We picked the Velocity because we were looking for speed, economy, safety, and the ability to carry four people.

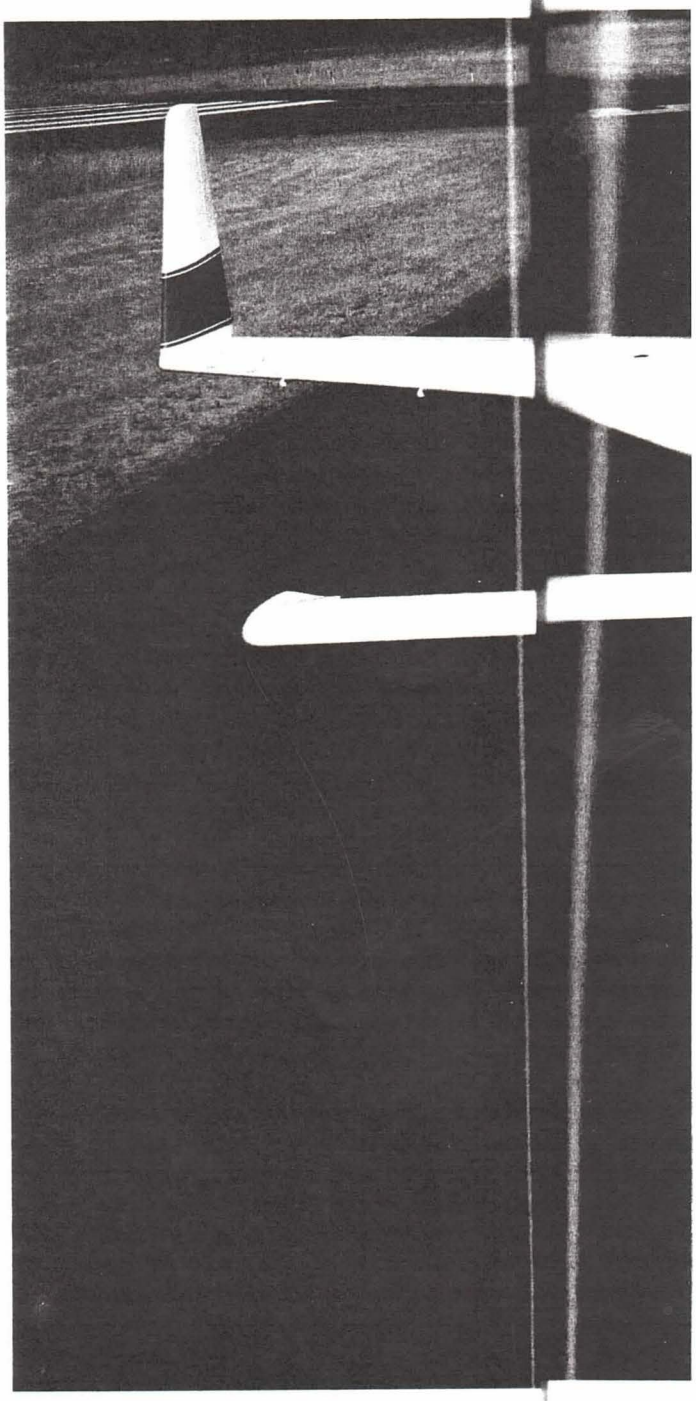
BILL: We were planning on using an auto engine right from the beginning. We have a long history of building up extremely fast street cars, like 'Cudas, and I even had a turbo'd Buick Grand National engine in my Jeep Cherokee. Dan and I are both hot rodders at heart, so going with a Detroit motor just came naturally even though neither of us had any background at all in building airplanes. We thought, 'Hey, it's mechanical so we can figure it out.'

DAN: I do have a leg up over a lot of first-time builders in that much of my professional career has focused on adhesive materials, so I understand a lot of the chemistry that goes into composites, and that was yet another reason why we chose the Velocity. Composites are part of my comfort zone. We felt even more comfortable about it when we went to Florida and inspected the factory-built models before placing our order, which was Velocity number 368.

It was delivered October 15, '96, which I remember was a Sunday. We were like two kids waiting for Santa to bring the big Christmas present, but instead the kit arrived in a long utility trailer pulled by a pickup truck. The wings were in a jig and the rest boxed. We immediately started setting up the shop in the garage of Bill's new home. We were very formal about it and organized and inventoried all the parts so we knew exactly where and what they were. The only glitch was we had to cut a hole in the drywall for the winglets.

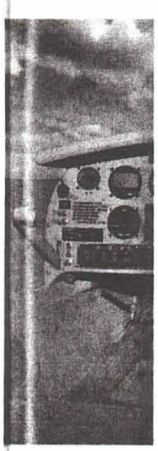
Dan's chemical engineering and adhesive background was applied to the Velocity in a way seldom seen in homebuilding projects.

DAN: We set up a formal testing procedure in which we did shear tests on every batch of epoxy we got in. Since we were building in a cooler climate, I wanted to make sure we were getting consistent epoxy strengths from batch to batch, so we made up steel pull strips and tested the strength of each batch using various temperature conditions to simulate seasonal effects.



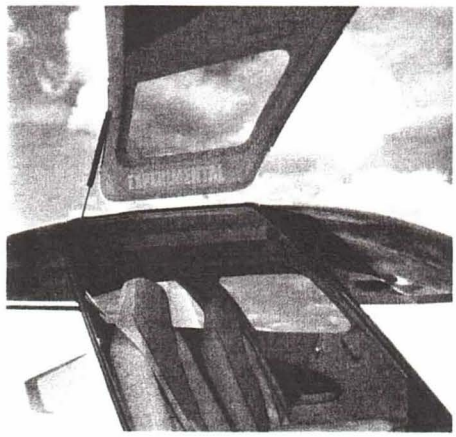
With a striking paint job and its canard design, the Velocity is a stand out at any airport.

Dan describes the Velocity's panel as simple, with standard instruments and a Garmin 430 GPS.



To view a CheVelocity photo gallery, visit *www.SportAviation.org*.

"We were looking for speed, economy, safety, and the ability to carry four people."



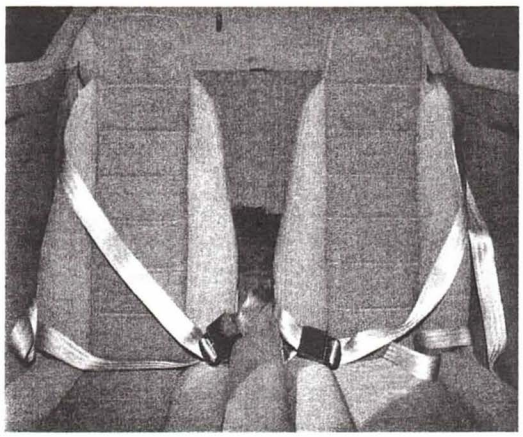
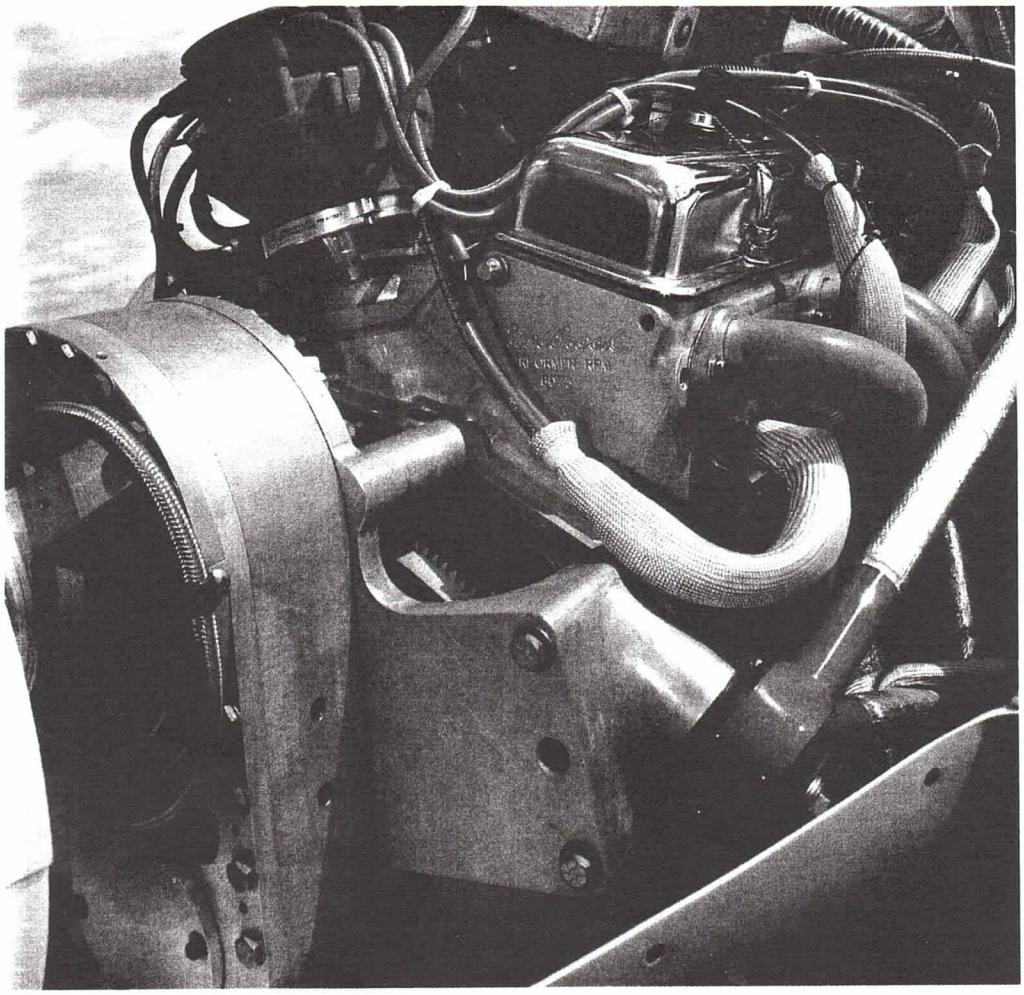
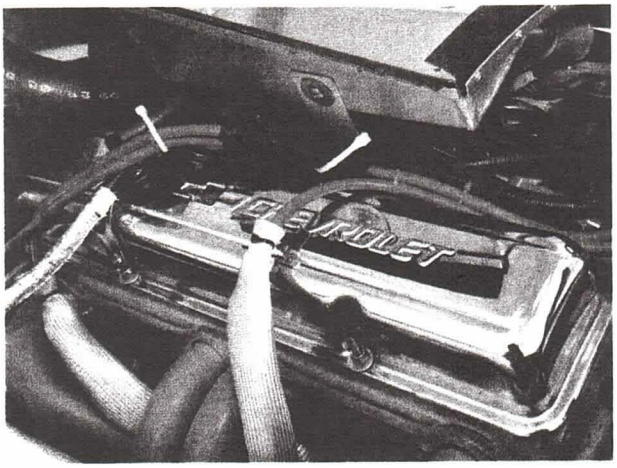


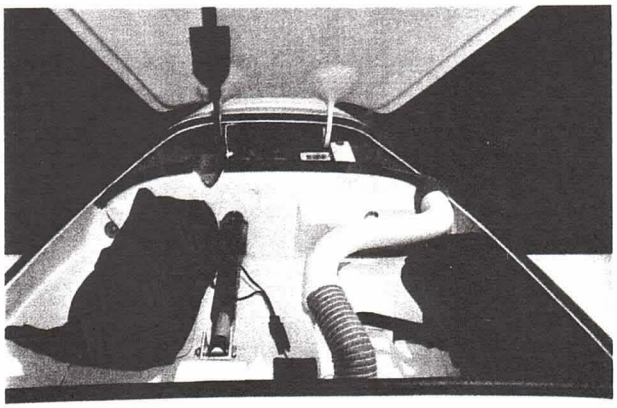
PHOTO BY **BRETT BROCK**



Not what an aviator typically finds when peeking "under the hood." Ram air induction, tuned port fuel injection, multiple spark discharge ignition system, and ceramic coated exhaust tubes provide the essential ingredients for efficiently extracting horsepower from the 427 cubic inch V-8.



Dan and Bill offer this design idea to all Velocity builders, a remote opening hatch that allows for easy maintenance and pre-flight inspection of critical systems.



"Dan and I are both hot rodders at heart, so we thought, 'Hey, it's mechanical so we can figure it out.'"

Dan, being the chemicals expert of the group, was methodical about developing ways to systematically ensure that each lay-up was thoroughly wetted and as safe as possible.

DAN: First, cut your lay-up materials to shape and, depending on conditions, warm the surface you're applying lay-ups to with a heat gun. Add a little Cabosil, which is a thickener, stiffening material to the epoxy resin and wet the warmed surface. Don't apply resin to the lay-up strip prior to application. After positioning the fiberglass strip, use a stiff brush to stipple it and absorb as much of the resin that's on the surface as possible, then follow up with adding resin to dry areas of the lay-up until the glass fibers are completely wetted. This method ensures full resin saturation of the glass fibers with no resin run-out. Resin run-out leads to dry lay-ups and poor bonding conditions.

Dan said they were concerned with strength because of the airplane's potential speed.

DAN: We were constantly asking Velocity how we could make it stronger and not add unnecessary weight. If the manual said a particular area was critical, we'd lay on one or two extra glass layers.

Every way we could, we tried to make the fit and finish of the airplane equal to that of a high-quality production car. That meant minimizing all door-gap dimensions and really focusing on sealing those gaps well. The auto engine is fairly quiet to begin with, so you don't want a lot of wind noise. For that reason, we sealed all the retract gear openings behind the doors and did our best to keep air from coming into the cabin. We re-engineered several parts to get it as perfect as possible.

PHOTOGRAPHY BY **BRETT BROCK**

BILL: One of the things we learned that we'd like to pass along to anyone trying to get tight, even-fitting doors is to make sure you have the engine, or equivalent weight, hanging on the mount, because fuselages flex. They don't flex much, but enough that your doors probably won't fit if you minimize the gaps without that weight in place. We found that out the hard way.

DAN: We had hoped we'd be able to fly without headsets, but when we put one of the better muffler systems on it, we found it generated too much heat and was threatening to scorch the cowl. So we went back to straight pipes, which are much louder but at least they make the airplane lighter and faster.

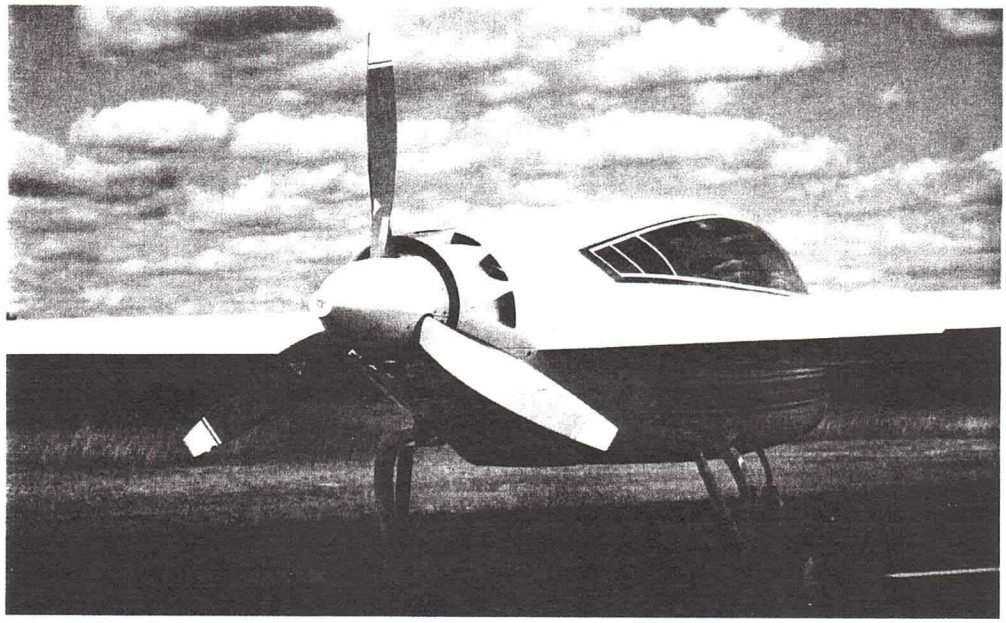
While fitting the doors they changed the geometry of the gas strut arrangement so that it was pushing in such a way that doesn't try to flex the door. At the same time, they stiffened up the doors so they can now taxi with them open and not worry about them being damaged.

BILL: Another little hint...when installing the hydraulic system and lines for the retractable gear we found out quickly that hydraulic fluid looks exactly the same as a wetted-out lay-up so you can't see the leaks very well. So, we painted all of those surfaces white to make the oil stand out immediately. We also modified the gear mechanism slightly to prevent the cables from jumping off the pulleys. We found that out the hard way, too.

When they were doing the basic airframe, they kept an eye on future maintenance and tried to provide easy access wherever possible.

DAN: Among other places, we put a big access door in the nose, so we can pull a lever and have a lot of systems, like the gear system, filters, etc., right there in front of us where we can service them.

The big challenge on their airplane obviously was the engine. At the time they started the project, there were a few Velocitys flying but none with a Chevy, so they had to pioneer their own path.



Dan and Bill chose a 72-inch MT electric constant-speed prop.

BILL: Originally we were going to go with a turbo'd V-6, but we couldn't come up with an ignition system that would give us the backup that we were satisfied with. The next move up, which would add 60 pounds but give access to a world of proven equipment, was the aluminum small-block Chevys [SBC]. I had one sitting in the shop, so we put it up there to see if the outside dimensions would fit, and it was a little tight, but very doable. So we went the small-block route.

When Bill said "small-block Chevy" everyone knew what he meant, and most thought the displacement would be around 350 cubic inches, since that's the quintessential Chevy V-8. Bill and Dan, however, wanted the name Velocity to really mean *velocity*, so they went a slightly different route.

BILL: There is a wild little aluminum block, called the Dart Aluminum Rocket block that is used in Can-Am racing, in which the oil pan rails are widened 1 inch and the cam is raised in the block high enough to allow a much bigger bore and stroke. So, what you have is a whopping 427 cubic inches in a block that is the same size as any other SBC, and the same weight. It's a block the racers love, so there is tons of racing stuff available for it. It has a four-and-one-eight bore, and a 4-inch stroke-billet steel crank from Eagle with 6-inch-long Trick Flow mid-weight rods. The cam was ground custom by Crane, and it's running tuned port injection [TPI] from Edelbrock. The injection system has a dial on the dash with 'lean' and 'rich' lights that lets you fine-tune the system in the air.

DAN: The ignition uses dual pickups, and the primary ignition is an Edelbrock MSD 'off-road' unit. Paul Bergholtz, our tech guy, suggested that for the backup ignition we use an entirely different unit, specifically the Crane ignition box, so we wouldn't be running two systems that have the same weak point. We have another knob on the panel that lets us change the ignition parameters, so between that and the mixture control unit we can really get the fuel burn down and the power up.

One of the real problems with running auto engines is coming up with a reduction unit that doesn't cause more problems than it solves. And the CheVelocity guys had their share of problems.

BILL: (with not a lot of enthusiasm) We bought a kit from a well-known supplier, and it looked okay on the surface. We got it together and on the airplane, and it lasted a total of eight hours. I was on takeoff and felt a strong vibration, so I chopped the power and aborted. When I coasted to a halt the propeller was freewheeling: it had broken the input shaft. Dan and I looked at each other and said almost in unison: 'We can do better than that.'

They were in the right location to come up with the talent and the knowledge to

AIRCRAFT DATA

AIRCRAFT MAKE & MODEL: Velocity 173 RG Elite
CERTIFICATION: Amateur-built experimental
LENGTH: 19 feet
WINGSPAN: 31 feet
HEIGHT: 7 feet, 9 inches
MAXIMUM GROSS WEIGHT: 2,900 pounds
EMPTY WEIGHT: 1,800 pounds
FUEL CAPACITY: 68 gallons
SEATS: 4

POWERPLANT MAKE & MODEL: Small block Chevy
DESIGN: Dart Racing Aluminum Rocket Block 427 CID coupled to 1.68-to-1 ratio reduction drive (2-inch width Hy-Vo chain)
HORSEPOWER: 450 hp @ 4500 rpm, 840 pound-foot torque @ prop

PROPELLER MAKE & TYPE: 72-inch MT electric constant-speed

CRUISE SPEED/FUEL CONSUMPTION: 200 knots true @ 8,500 feet/15 gph @ 21-inch manifold (65 percent power)
POWER LOADING: 6.44 pounds/hp @ gross
WING LOADING: 20.0 pounds/square foot @ gross

EQUIPPED FOR: Night instrument flight rules
V_{NE} 220 knots indicated airspeed
V_{SO} 65 knots indicated airspeed
V_X 80 knots indicated airspeed
V_Y 100 knots indicated airspeed

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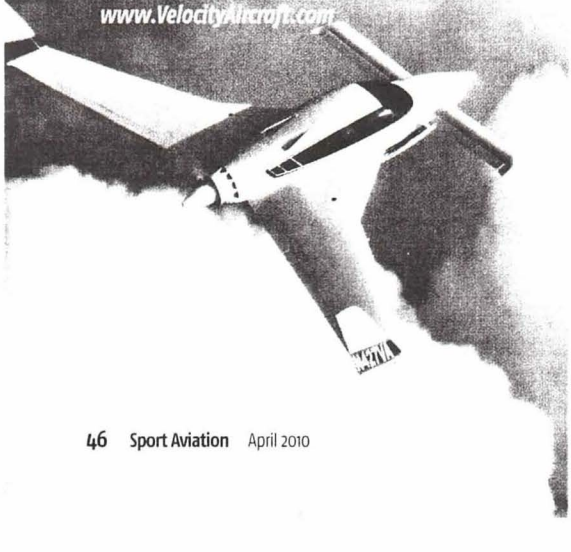

des d their own reduction unit and Paul Bergnoiz, led the charge.

BILL: Between Paul and all the people he knew in the car business, we designed a reduction unit that used Hy-Vo chains and has a tapered bearing on both sides of the output shaft. One is for positive thrust loads and the other for negative loads. We have a spray bar between them. But we had our own problems with this one, too, and they were kind of surprising.

The first was that the aluminum expands differently with heat than steel, so the bearing cups were loosening up. Then we were getting end play, and when we took everything apart, [we] found that the prop shaft was 0.0075 off center so it was working everything in an eccentric fashion. We took it over to Paul's son, who has a machine shop, and were able to fix that problem only to find that the pilot bearing we were using in the crankshaft came out of the factory 0.008-inch out of round and was one of the reasons we were wearing out the damper plates that we were using to absorb the engine pulses. We were using high-end automotive parts, but when we measured a bunch of them, they were all off to 1 degree or another. It seemed as if every vendor item we bought was out of whack.

We solved that problem by hooking the input shaft of the reduction unit directly to the crankshaft with a heavy flywheel in between to absorb the pulses. We really hated all that extra weight, but it seemed like the prudent thing to do. At 100 hours we took everything apart to add a second alternator and found it only takes four hours to take the engine out and get it apart, plus the reduction unit looked perfect inside. Problem solved!

rpm.

BILL: At 3300 rpm we're getting 200 knots, 230 mph true at 15 gallons. If we turn up the heat, it'll show 220 knots, which is around 250 knots true, but the airplane isn't happy at that speed. 200 knots indicated is the speed we attain optimized performance.

Certainly the [illegible] how much [illegible] saving for [illegible] engine, with [illegible]

BILL: We use two aluminum plate radiators, one above and one below the engine, each having two small fans. It can run indefinitely at idle with the fans. As for weight, we weighed a 200-hp IO-360, and it weighed 360 pounds with a constant-speed prop. An IO-540 adds about 70 pounds to that. Our engine, including the radiators and everything to make it run including two alternators, weighs 423 pounds, so when put against a 200-hp IO-360, we're 60 pounds heavier and about even with a -540. The engine generates 450 hp and 500 pound-feet of torque at 4400 rpm. Multiply that 500 pound-foot figure by the reduction drive ratio of 1.68, and that gives us 840 pound-feet of torque at the prop shaft on takeoff. In our eyes, there's no comparison, and going through all we went through to get this engine working the way it does was well worth the aggravation.

DAN: We came in at 1,826 pounds empty with a gross weight of 2,900, allowing us to carry four full-size people at close to full fuel. Our rate of climb at gross is 2,800 feet per minute, and light, we're just under 4,000 feet per minute at 80 knots and 2,500 feet per minute at 120 knots; so it really performs!

The goal was to build a really solid airplane that we'd feel safe taking our families long distances, and it would be an airplane that reflected our own thoughts and capabilities. I guess we wanted something a little different. I think we got it, and we're proud of it.

The Mulrooney [illegible] case study in well-[illegible] sides that, it's the tough [illegible] at the airport. EAA

Budd Davisson is an aeronautical engineer, has flown 300 different types, and has published four books. He is editor-in-chief of *Flight Journal* magazine. Visit him on *www.AirBum.com*.

JIM KOEPNICK