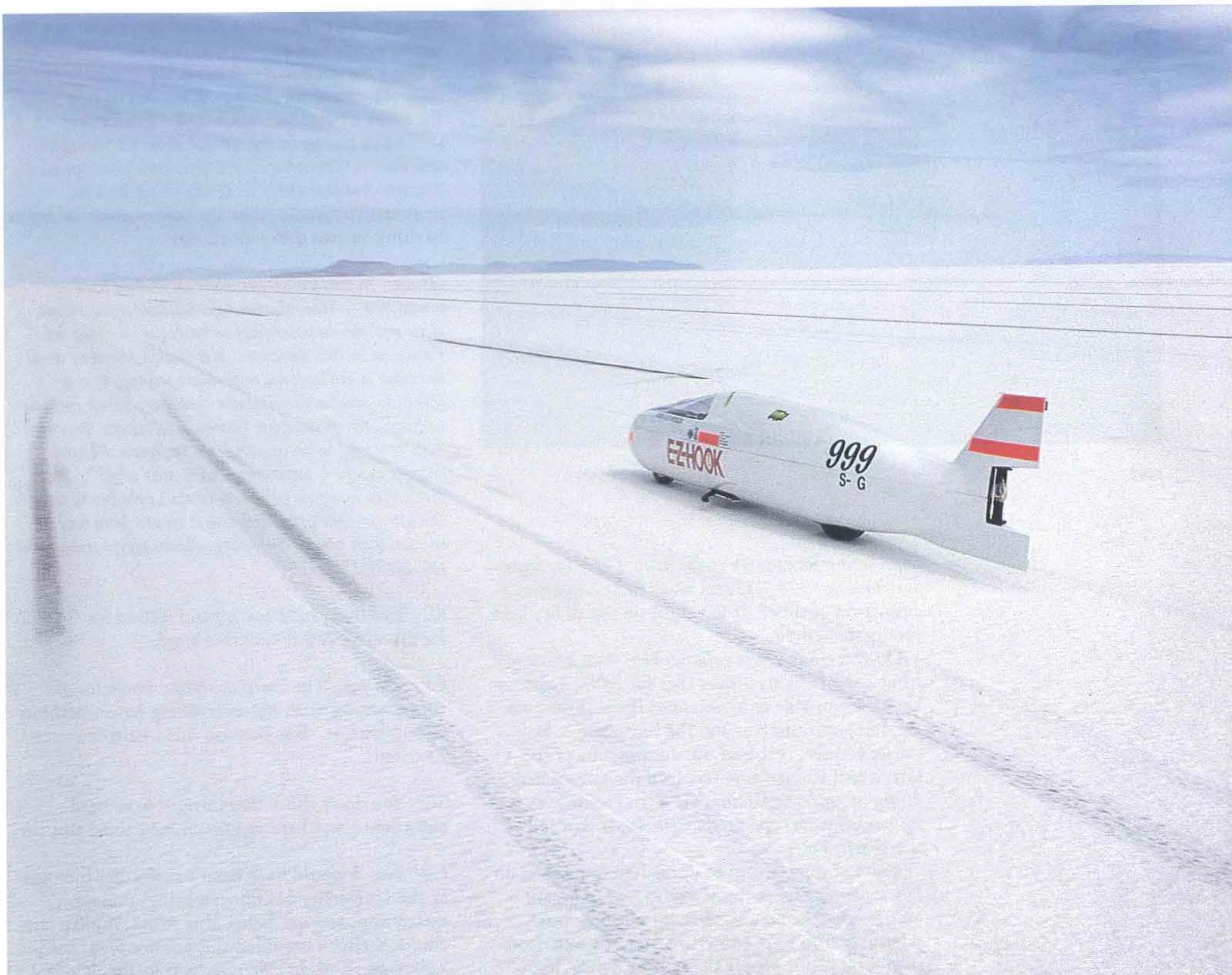
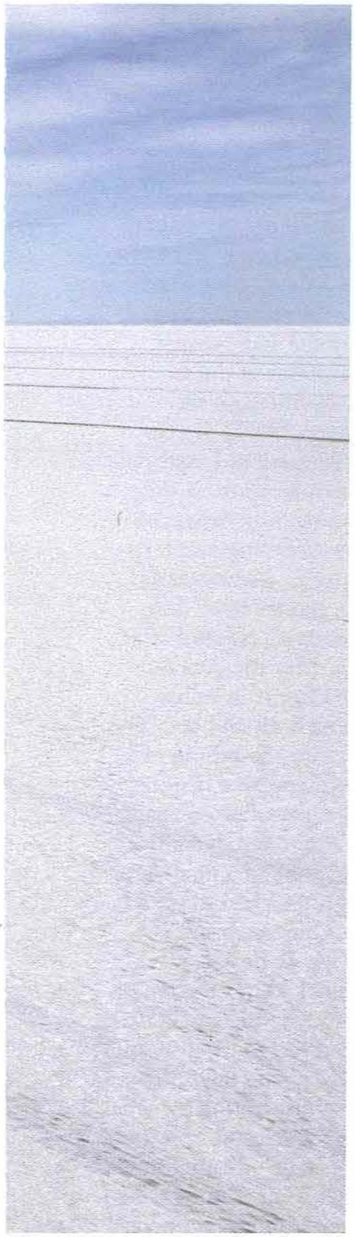
The machine that resulted from all this effort is a motorcycle only in the sense that it has two wheels, one in front of the other, and an engine that sends power to the rear wheel through a drive chain. Otherwise, the 18-foot, 4-inch vehicle looks like a wingless 1950s-vintage jet fighter—complete with a scoop-nosed air intake, a cockpit canopy of clear, shatterproof plastic, and a fuselage tapering to a vertical-finned tail.



I'm Not Driving Fast, I'm Just Flying Low

by Douglas L. Smith



In September 1996, Sam Wheeler returned to the Bonneville Salt Flats to break the record he had set only a month before.

On August 19, 1996, a streamlined motorcycle whose aerodynamic shell was designed by a bunch of Caltech grad students as a class project set a land-speed record at the Bonneville Salt Flats International Speedway. The flats, about 100 square miles in extent, lie entirely in Utah, but the closest hotels—or habitation in any form!—are in Wendover, Nevada, just over the state line. (Nevada's more liberal approach to gambling and liquor may have influenced this.) The flats are part of the Great Salt Lake Desert, the desiccated corpse of Lake Bonneville, which in the late Pleistocene epoch covered most of Utah west of what is now I-15 and spilled over into Nevada and Idaho. The drying lake's bequest of dissolved minerals that had washed down from the surrounding mountains left a dead-level salt pan that, after baking under the summer sun, is as hard as concrete and ideally suited for going way too fast—there's absolutely nothing to run into for miles and miles. Numerous speed and endurance records have been set there since 1935. And there are records galore—in the interest of equity, all competing vehicles are classified by body configuration, engine size and type, and fuel type. Each class has its own record, and there are also overall records.

Back in 1970, a gent named Sam Wheeler set a class record there of 208 miles per hour in a streamlined motorcycle. (To be classified as a streamliner, the vehicle must have the front wheel or wheels covered by an aerodynamic skirt, and must be powered by a mechanical drive train (as opposed to jet and rocket cars, whose wheels merely support the vehicle's weight).) This historical footnote would have nothing whatsoever to do with Caltech, except that some 15 years later, Wheeler would once again catch record fever. He had long since retired from racing by then, and had become chief engineer for E-Z-Hook, a manufacturer of test probes and leads in Arcadia, California. His boss, company owner and Caltech Associate Phelps Wood, quickly agreed to underwrite him. Wheeler designed and built the motorcycle's frame in E-Z-Hook's machine shop on evenings and weekends over the next three years. Meanwhile, Wheeler and Wood became concerned about the possibility of going airborne, and not in a good way. Wheeler's earlier bike had handled well enough in its record run, but subsequent wind-tunnel tests had shown that its front end was generating a lot of lift—perhaps enough to flip the bike on its back at higher speeds. As Wheeler says, "At 300 miles an hour, you can make a rock fly." In the spring of '89, Wood mentioned this concern to another motorcycle enthusiast, Elliott Andrews, Caltech's division administrator for Engineering and Applied Science. Recalls then-graduate student C. Dennis Moore (PhD '96), "Upside-down and backwards is not really a good way to set a record. So Andrews called Professor [Hans] Hornung [Johnson Professor of Aeronautics and director of the Graduate Aeronautical Laboratories (GALCIT)]. Professor Hornung said, 'Hmmmm, Dennis rides a motorcycle.' I came in one morning and found a note on my desk saying call Sam

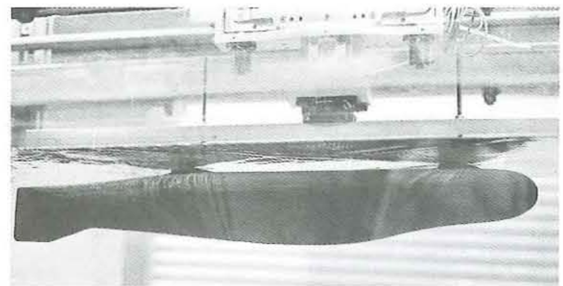
Above: (from left) Grad students Roderick Daebelliehn, Michael Dominick, Elizabeth McKenney, Yvan Maciel, and Dennis Moore with the 1/4-scale model in the 10-foot wind tunnel's test section. Right: In the water-channel experiments, a 1/8-scale clay model of each proposed body shape was submerged upside-down with its wheels just touching the water's surface.

Wheeler. Who is this Sam Wheeler guy and why do I have to call him?" But call he did, and quickly got hooked.

Determining how the bike would handle was clearly a wind-tunnel exercise. But the bike's stability would depend on what sort of body was put on it. Since the body hadn't been built yet, Andrews proposed to Hornung and Gerald Landry, manager of GALCIT's 10-foot wind tunnel, that designing the body and determining its handling characteristics would make a good assignment for Aeronautics 104 (Experimental Methods). At Ae 104's first meeting, the professors hawk a bazaar of term-length projects, from which five or six actually get chosen by the students. This project made for a nice confluence of interests—the students got a real-world project of manageable scope (most of the offerings tend to be academic), and Wheeler couldn't afford to use the 10-foot tunnel at the outside rate. "E-Z-Hook only had $2,500 to spend," recalls Landry. "Normally, $2,500 gets you one day." But interdepartmental charges for tunnel time at the student rate are much lower, so the company donated the money to the class. The class kicked in some of its operating budget as well, and the project wound up in the 10-foot tunnel for two and a half weeks. Moore TA'ed the assignment, which was offered in the spring of 1990, and sold it to the class.

The students who bought into the project—Yvan Maciel (MS '90), Roderick Daebelliehn (MS '90), Elizabeth McKenney (PhD '95), and Michael Dominick (MS '90)—were given carte blanche to try any shape they liked, provided that it fit around Wheeler's frame. The goal was to find the shape with the lowest possible drag that was still aerodynamically stable—no lifting, no pitching, and no flopping over sideways. The choices were endless—rounded nose or blunt nose? Are tail fins good? How many? How big? How oriented? And what about the windshield? A near-vertical one would give better visibility but significantly increase the drag. A more horizontal one would have little drag but might be hard to see through.

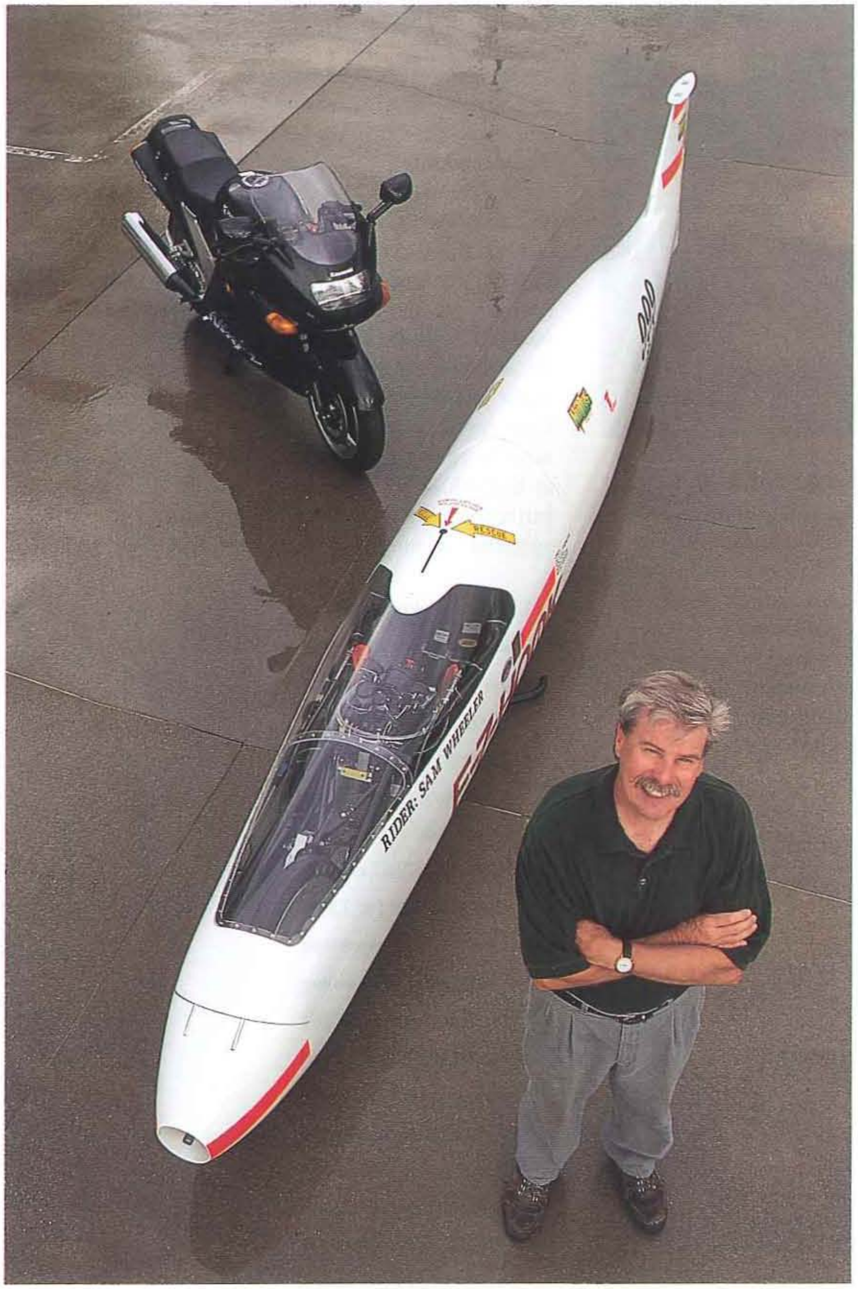
The students sculpted a variety of 1/8-scale clay models around a wooden armature that represented the frame members and such other givens as the engine, wheel, and drive-chain clearances, and tested them in the low-speed water channel in Karman Lab. The tests were run by hanging the model upside-down in the channel, so that the wheels' bottoms just touched the water's surface, which stood in for the ground. The class tested six bodies "based on airfoils, previous streamliner



designs, and wild ideas" says Moore, beginning with the variant with the largest nose and tail—it's a lot easier to shave clay off accurately than to stick it on. The winner was then scaled up to 1/4 size for further tests in GALCIT's 10-foot wind tunnel. In the 1/4-size tests, the students even worried about the engine's intake and exhaust. Plastic tubes scaled to the diameter of the air ducts ran from the intake scoop through the model's interior. Recalls Moore, "We'd dig the tubes out of the clay, move them around, and check the effect of the exhaust's location on drag." Yvan Maciel did the mathematical modeling of stability that guided the clay modeling and testing done by the rest of the group. For example, a big fin would lend stability but increase drag. The final design was a compromise, reached after several iterations. "We'd give him the data out of our wind tunnel. He'd go plug it in to his computer simulation and come back and say, 'The bike's not stable. You have to do something else.'"

Designers of land-speed vehicles have historically favored brute horsepower over finesse. Says Moore, "People don't worry about aerodynamics. They'd much rather spend $5,000 on a new set of pistons and stuff for their engines, than to spend $5,000 to reduce the drag." One exception is *Goldenrod*, a streamlined car whose design was also tested in the 10-foot tunnel. The creation of Walter Korff, a Lockheed aerodynamicist, *Goldenrod* held the overall land-speed record of 409 miles an hour for over 25 years. But most streamliners are laid out by eye, based on a gut feeling for what looks fast, leavened with experience and imitation.

Streamliners tend to have needle or bullet noses and stubby rear ends, because using a blunt tail so the thing will fit in the garage is of greater practi-



Wheeler, the streamliner, and the street bike that the streamliner's engine normally comes with.

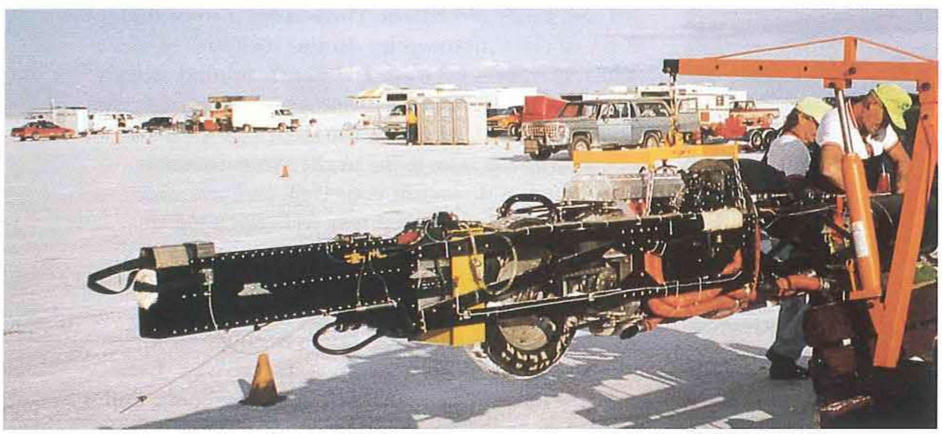
cal importance than the aerodynamic virtues of a tapered tail. A cut-off rear end also makes it easier to install things like exhaust pipes, parachute tubes, and push bars. (Twin parachutes are required at Bonneville if you'll be running over 250 miles per hour; between 175 and 250, you only need one. A push bar is a stubby projection bolted to the rear of the chassis—remarkably, very few of these speed machines can get under way unassisted because of their extraordinarily high gear ratios. Most streamliners come with oversized, testosterone-oozing pickup trucks, sometimes with matching custom paint jobs, to push them until they get up enough speed to engage first gear. But the GALCIT bike is light enough that a couple of people running alongside and pushing suffices to get Wheeler up to 10 mph, where he can slip the clutch and power away from the starting line.)

However, the laws of aerodynamics say that it really doesn't matter what you do to the front (as long as you round the corners)—it's what's out back that counts. The airflow off the rear of the vehicle tends to keep going straight, even though the body isn't there any more, just as Wile E. Coyote can run for some distance off the edge of a cliff as long as he doesn't look down. Wherever the flow separates from the body, a partial vacuum forms, creating drag. But a properly tapered tail guides the flow and prevents separation. A typical streamliner has a drag coefficient of 0.15–0.20. This is pretty good, actually—for comparison, a VW bus has a drag coefficient of about 0.45, while an '87 Camaro scores a sleeker 0.30. A sheet of plywood held perpendicular to the wind has a drag coefficient of approximately 1.0.

The Ae 104 design has a mean drag coefficient of 0.103—the lowest ever measured for a stable land vehicle in the 10-foot tunnel—and no visible separation. (The rear tire did generate a wake, but it reattached itself to the underside of the bike further downstream; there was no observed separation off the front wheel or the body.)

And what of the stability, which was why Caltech had gotten involved in the first place? With lift and pitch zeroed out, there remain three basic ways to tip a motorcycle. In the "wobble" mode, a wheel oscillates ever more violently around its axis until the bike falls over sideways. Then there's the "capsize" mode, in which the front tire kicks to one side as the bike leans in the same direction. The bike lies down (on your leg), and you slide to a stop. This is a good way to break a leg if you don't have a roll cage, but otherwise it's a comparatively safe crash. And finally, in the "weave" mode, which makes for the most spectacular video footage, the bike's front wheel kicks one way as the bike leans the opposite way. Centrifugal force brings you back but overshoots, and the sideways swing gets wider each time. Eventually the front wheel digs in and the bike vaults skyward, rear wheel first, and tumbles end-over-end for some distance before coming to rest. Maciel predicted, and tests in the 10-foot tunnel confirmed, that the final design was extremely stable against wobbling and capsizing. It was unstable in weave mode, but only under 40 mph—above that speed, it was rock-steady.

The machine that resulted from all this effort is a motorcycle only in the sense that it has two wheels, one in front of the other, and an engine that sends power to the rear wheel through a drive chain. Otherwise, the 18-foot, 4-inch vehicle looks like a wingless 1950s-vintage jet fighter—complete with a scoop-nosed air intake, a cockpit canopy of clear, shatterproof plastic, and a fuselage tapering to a vertical-finned tail. The wheel has turned full circle, in a way, because the body for Wheeler's previous record-breaking bike was



Right: Phelps Wood and the streamlined body pose in his backyard. Below: The frame hanging around in the pit area on the salt. From left: the parachute tubes (only the top one is loaded), the gas tank (with red cap), the radiator enclosure (yellow), the rear wheel and drive chain, the engine (between the silver air box and the orange air-intake hoses), and the firewall. The driver lies forward of the firewall (where the people are standing), but most of his roll cage is obscured by the hoist.

fashioned from a drop tank off an old fighter jet.

The new body, however, is a sandwich of carbon fiber, foam, and carbon fiber—the same material they make surfboards and racing-yacht hulls out of. Within that body, the frame, which doubles as the roll cage, encloses and protects the front wheel, the driver (who lies feet-first, straddling the wheel), the engine and drive train, the rear wheel, the radiator, and the fuel tank. The parachute tubes, bolted to the frame's rear, are enclosed in the tail beneath the fin.

This basic layout was copied from Wheeler's old bike, with one key difference: the old bike had a full-sized motorcycle wheel in front, which blocked Wheeler's view of the course ahead. Wheeler was traveling almost twice as fast as Charles Lindbergh did in the *Spirit of Saint Louis*, but both steered by looking out the side windows. Of course, at 208 miles per hour—305 feet per second—you don't steer so much as aim. This time around, the front wheel is small enough that Wheeler can look out over his toes to steer.

Turning the frame and a bunch of computer files into a motorcycle took another year; although the class had ended, Moore remained involved. Beth McKenney printed out full-sized cross sections of the bike, spaced at 10-inch intervals from nose to tail. Wheeler glued the printouts onto 0.030-inch aluminum sheets that became templates for carving 10-inch-thick Styrofoam blocks with a hot wire. The Styrofoam shapes, glued together, became the full-sized pattern. R. D. Boatworks in Dana Point created a mold from the pattern, and built the body up layer by painstaking layer. Recalls Moore, "Four months later, we got back a shell. We then had to make all the wheel cutouts and stuff, which took a significant amount of time." Furthermore, because of the custom design, virtually every part that went into the motorcycle had to be machined by Wheeler by hand. Commercial steering linkages wouldn't fit, and you couldn't buy drive sprockets with the right number of teeth for the gearing ratios the bike needed—the list goes on and on. Moore, who by now was spending almost as much time at E-Z-Hook as he was at GALCIT, designed and built the bike's electrical, pneumatic, and coolant systems. Meanwhile, Andrews, who used to

The bike melds high- and low-technology, Caltech cleverness and real-world pragmatism. Moore's pneumatic system, which operates the parachute doors and the parking skids, uses the roll cage as the reservoir for 1,000 cubic inches of compressed nitrogen. His cooling system runs the engine's exhaust through a Venturi tube to suck outside air into the radiator. On the other hand, a Coke can was pressed into service as an overflow chamber for radiator water.

run a Kawasaki dealership, persuaded Kawasaki to donate the engine—a four-cylinder, 1,052-cc Ninja, the highest-horsepower engine Kawasaki makes for a motorcycle—and cover the cost of making the mold, as well as provide some money for general expenses. (E-Z-Hook sprang for the body.) The bike finally reached the salt in August 1991.

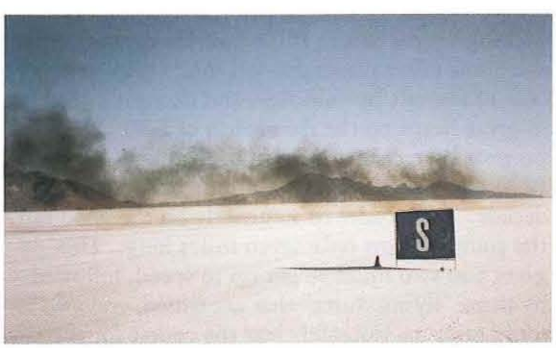
The Bureau of Land Management (BLM) opens the flats to the Southern California Timing Association (SCTA), which organizes the meets and certifies the records, one week a month from July through October—weather permitting. Wet salt often cancels the July meet, which is usually seen as a tune-up for Speed Week, held in August. Speed Week is Woodstock for gearheads. Bonneville is the last bastion of mom-and-pop

Above: The pit area just goes on and on. Below: Here's something you don't see every day—a six-door pickup truck. It's pushing a much-altered 1930s coupe.

Speed Week is Woodstock for gearheads. Bonneville is the last bastion of mom-and-pop racing, and the pit area consists of rank upon rank of motor homes and utility trailers, interspersed with tarps pitched by homegrown mechanical geniuses to shade the products of their ingenuity from the blistering sun.

racing, and the pit area consists of rank upon rank of motor homes and utility trailers, interspersed with tarps pitched by homegrown mechanical geniuses to shade the products of their ingenuity from the blistering sun. (Try picking up a socket wrench that's been sitting out in the 100-degree glare of midday some time. Sunglasses are de rigueur, and it's important to wear sunscreen on the underside of your chin and ears, or the reflected light off the salt will burn some really sensitive skin really fast. "Many people are surprised when their tan lines don't stop at the bottom edge of their shorts," says Andrews.) People spend more time working on their machines, cruising around the pit area to see how everybody else is fixed, swapping lies with old pals, and offering sage advice to newcomers than they do actually racing. You can see every sort of rig imaginable—from stock Trans Ams and tricked-out, chromed-to-the-max street rods with snappy paint jobs that have no business being on the highly corrosive salt, to the semi with a tug-boat engine that set a record for diesel trucks at 238 miles per hour. But the streamliner is king.

The racecourse itself, which is located several miles from the pit area for safety reasons, used to be 11 miles long, but the salt (originally about three feet thick) has been getting very thin of late. In some places, the dirt beneath is starting to show through. For the past 50 years, a mining concession on the east side of the flats has been sucking up the salt as brine, extracting the potash and some other minerals—all told, only a few percent of the salt by volume—and dumping the rest in great heaps on the flats south of I-80. Despite protests by racers and environmentalists alike, the BLM has just renewed the mine's lease for another decade. So in order to stay safely on the good salt, the course is now only seven miles long. This gives you two miles to get up to speed, followed by three "flying miles" that are timed, and two more miles to stop and clear the course for the



Left: Brute force personified—the only concession to aerodynamics is the small spoiler on the hood. And this guy don't need no stinkin' push truck, either!

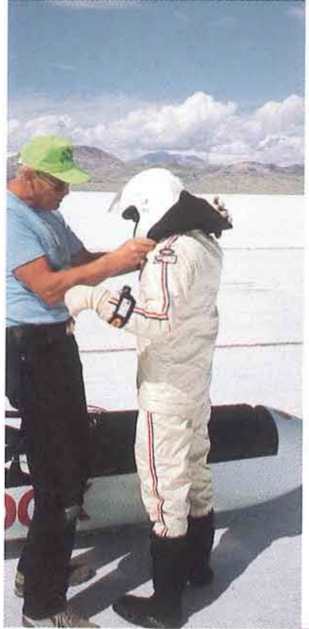
Right: Racing apparel can get awfully hot, as this rider of a partially streamlined motorcycle can tell you.

next guy. You break a beam of light at each end of each flying mile, and this information is relayed through a wireless system to the timing booth, which is actually a couple of folding tables under a sunshade pitched at the three-mile mark. The fastest of the three flying miles is your official time. The electronic timing system is accurate to one one-thousandth of a mile per hour.

It used to be that in order to set a record, you had to cover the same piece of real estate twice, in opposite directions, and take the average speed. But in 1996, for the first time, all runs were made heading west, away from the potash works—the salt had shrunk so much that the company's dikes were getting uncomfortably close to the course's eastern end. However, an average speed over two runs is still required for a record.

To run the course, you register once your vehicle has undergone an elaborate safety and technical inspection—a ritual that often takes an entire day—and you join the staging line by the timing booth. (On the first couple of days of Speed Week, you can wait in line all day for one run. The line shortens considerably over the week, as people break down, crash, or give up.) The stager sends the vehicles, a dozen or so at a time, out to the starting line to wait their turn. Going fast enough to qualify for a record attempt sends you to an impound area to await a second run. Otherwise, it's back to the tail of the staging line—or, most likely, back to the pits to see what went wrong.

And lots can go wrong. The maiden run in August 1991 was literally a flop. The problem wasn't *sta*bility, but *visi*bility. The cockpit canopy slopes a mere 10 degrees from the horizontal when lowered into position, and ripples in its plastic that were imperceptible when it was upright suddenly caused the horizon to waver worse than a heat-shimmery parking lot on the Fourth of July. Undaunted, Wheeler tried to balance the bike by feel but wiped out at about 60 mph. He was unhurt, which is a tribute to the SCTA's stringent



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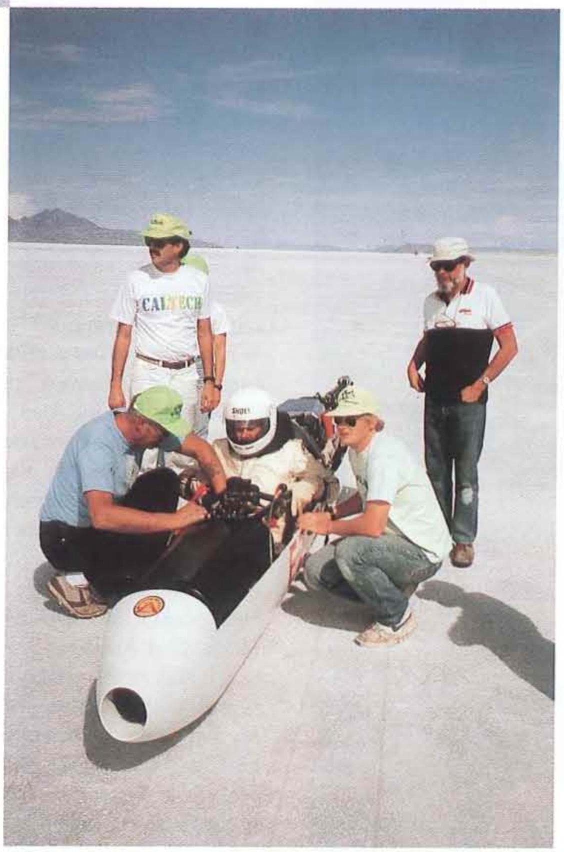


Above: Besides a fireproof suit, the SCTA requires drivers to wear fireproof boots and gloves, a helmet, a neck brace (here being adjusted by Joe Von Harten), and wrist restraints to keep your arms safely inside the roll cage in the event of a crash. Right: You don't sit down in a streamliner as much as put it on. Clockwise from left: Von Harten helps Wheeler with the seven-point safety harness (another SCTA requirement), while Andrews (standing in front of his wife, Jill), Frank Sherrill, and Moore stand by.

safety rules—drivers routinely walk away from crashes at much higher speeds—and the bike suffered less than $300 worth of damage.

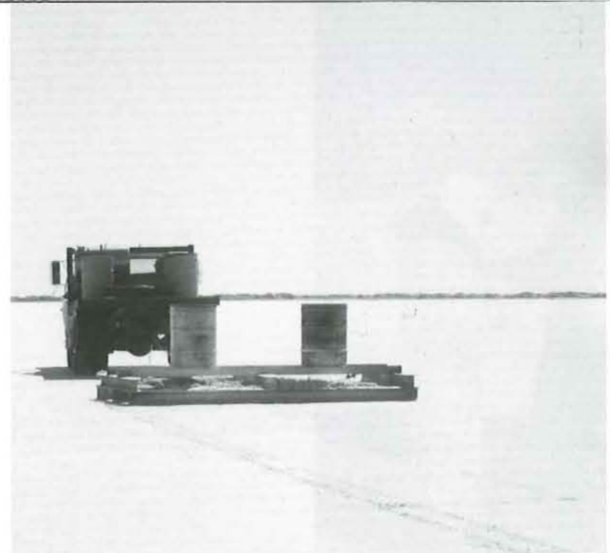
"What did do damage, however, was when we were inspecting for damage back [at E-Z-Hook] in Arcadia," says Moore. "We slung the bike up on straps that were rated to 3,000 pounds apiece; the bike, with Sam in it, weighs 1,000 pounds. The straps, which admittedly were old, broke, and dropped the bike four feet onto concrete. We sprung some welds, bent up the parachute doors, and dented the front wheel." Rubber doesn't dent, of course, but aluminum does. You see, the SCTA requires all Bonneville racers to use tires rated for the appropriate weight and speed, and some sizes—including those small enough to see over—are very hard to get. Thus the streamliner had been designed around a solid front wheel machined from aircraft-rated aluminum—a decision that was to dog the project. (The rear tire is the front tire off a funny car.)

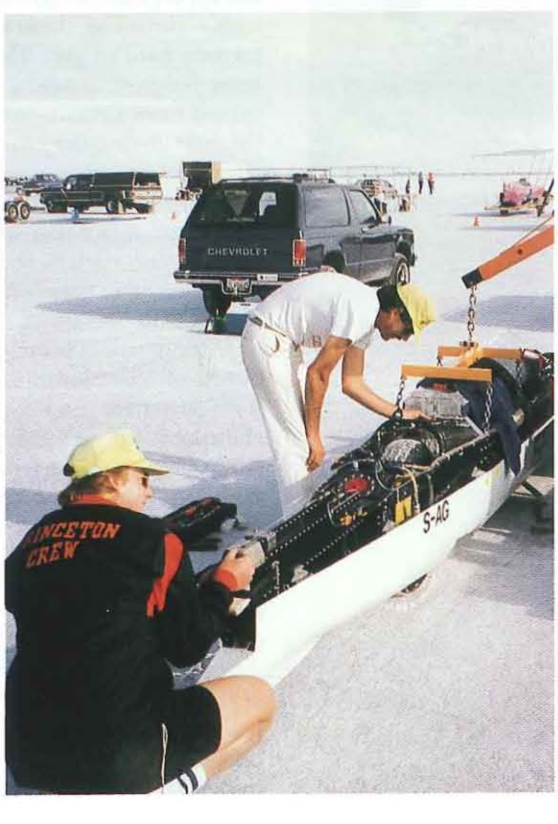
The fall had also subtly screwed up the wheel alignment, a fact that wouldn't be discovered until the next trip back to the salt in September. (One might ask why these teething troubles couldn't be worked through closer to home, instead of towing a trailer nearly 700 miles to Utah. The answer hinges on that aluminum wheel—you can't run it on pavement, gravel, or even hard dirt without chewing it up. It's only good for salt or really soft silt.) Even so, Wheeler managed to clock 178 mph—in second gear with the canopy off. The ripples, which had been polished out in Arcadia, reappeared in Bonneville's drier, thinner air. Wheeler whiled away the winter by rebuilding the canopy with a narrow inset of thinner, more optically perfect plastic in his line of sight.

"1991–1993 was the most discouraging period of the project," Wheeler recalls. There were endless late nights and early mornings to prep the bike before each meet, followed by a 10-hour drive to the flats to discover that Murphy still wouldn't

Below: The reason for all that safety gear—the driver didn't suffer so much as a scratch. That's his front suspension system sitting on the salt behind his door. His other door got so thoroughly folded that it would easily fit in his trunk.

Right: Whenever somebody crashes, or the salt gets a little rough, they groom it with this saline zamboni: a grid of welded-together I-beams weighted down with drums of salt.





Right: The crew tried everything during those frustrating post-crash months. Here, Moore and Andrews use a piece of string to do a quick-and-dirty rear-wheel alignment check between runs.

leave them alone. It took most of '92 to solve the alignment problem, at which point "I found that we hadn't been getting any stiction between the salt and the front wheel," says Wheeler. "But before I discovered this, I probably solved a whole lot of problems that didn't need fixing." In the final analysis, that inch-and-a-half-wide aluminum wheel just wasn't getting a very good grip on the salt, making the bike hard to steer. That winter, Wheeler whittled a wider wheel with a more aggressively grooved "tread" zone. No sooner was the new wheel finished, than the elements turned sour. Lousy weather and wet salt wiped out the entire '93 season. It wasn't so bad if the crew knew in advance that the meet was off—as in July, when the salt was still under 18 inches of water from the winter's snowmelt—but sometimes, to find out, they had to caravan up there and spend a day or two waiting in line not to run. Moore and Andrews were regulars on the prep team, and nearly always on the running team as well during those years. (The crew's other regulars—Frank Sherrill, Bill Ocheltree, Mike Holliday and Chuck Bullwinkle—were racing cronies of Wheeler's.) But as '94 rolled around, Moore's thesis research and Andrews' involvement in the construction of the Gordon and Betty Moore Laboratory of Engineering left no time to spare for the streamliner.

Ronald Howe, of JPL's atmospheric research group, picked up the slack. Howe, a mechanical engineer and machinist who designs and builds components for instrument packages flown on high-altitude balloons, had actually come to bat for the project once before. "I made a maximum of maybe five percent of the [bike's] parts in my machine shop at home when Sam got rushed towards the end." Howe used to drag-race motorcycles back in the '60s and '70s and had known Wheeler by reputation then, but the two didn't meet until much later. "I met Sam about 15 years ago, out in the desert with a bunch of JPL guys

"He was still accelerating because the course is too short. That makes him the third-fastest bike ever—the fastest single-engine, fastest on gasoline."

Moore checks the tail fin's alignment. The fin, which was damaged in the crash, eventually had to be rebuilt completely; sadly, only one set of GALCIT decals had been made.

riding motorcycles. I'd been trying to go up to Bonneville for years, but I never got there before I went up with Sam." However, their dads, both test engineers/machinists and lifelong JPL employees, had worked together in the '50s, building a hypersonic wind tunnel (since decomissioned). The two also helped construct the Space Simulator, a high-vacuum chamber 25 feet in diameter and 85 feet tall in which full-sized spacecraft can be tested.

The salt was wet during most of '94, too, but in the one dry meet—September—Wheeler did 206 mph with the new wheel and the bike handled as well as it had before it got dropped. At the same time, the SCTA started talking about banning metal wheels, on the grounds that they rutted the salt and made it unsafe for other racers. This sparked a quest for yet *another* wheel, this one with a rubber tire. Goodyear's racing division eventually donated a set of undersized tires that had been custom-built for a streamlined motorcycle that proved to be too heavy to use them. The smallest tires Wheeler could find, they were still four inches in diameter larger than the aluminum wheel, so an entirely new suspension system had to be built. In September 1995, with the rubber tire in hand, or rather on bike, Wheeler beat the class record, but it didn't count—the salt at the far end of the course was still soft from a rainstorm a few days earlier, and he couldn't make a return run. That was the bad news. The good news was that the bike handled even better with the rubber tire, and he was still only in fifth gear. The October meet got canceled for lack of entries.

In 1996, everything finally clicked. July got rained out again, but during Speed Week in August, Wheeler set the class record at 256 mph. On September 25, the first day of that month's meet, he raised it to 285 mph. Then, says Andrews, "Two days later he went 295 mph one-way, with an exit speed of 301 mph. He was still accelerating because the course is too short. That makes him the third-fastest bike ever—the fastest single-engine, fastest on gasoline." The record for any kind of motorcycle is 323 mph, held by a 2,600 pound behemoth sponsored by *Easy Rider* magazine and powered by twin 1.5-liter Harley-Davidson engines (a total of 3,000 cc) burning 80 percent nitromethane. Wheeler thinks he can take the Easy Rider; he'd just barely gotten into sixth gear at 301 mph. But he's going to need those missing miles of salt—Moore has estimated the drag based on the vehicle's performance in coast-down runs, in which they timed how the bike slowed down when Wheeler shifted into neutral at a predetermined speed; knowing the bike's weight and the deceleration rate allows you to calculate drag. Moore's estimate is slightly below the values predicted in the Ae 104 class. "If there were two more miles of salt, or 25 more horsepower in the bike, we'd be there," he says. Absent the salt's miraculous healing, a switch to alcohol fuel would get them the extra horsepower. But that's a project for the coming year—the October meet got canceled, so the books are closed on 1996. □